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Putting Fishers' Knowledge to Work

Conference Proceedings

August 27-30, 2001

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Fisheries Centre, University of British Columbia, Canada

Edited by

Nigel Haggan, Claire Brignall and Louisa Wood

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DEDICATION TO DR ROBERT (BOB) JOHANNES

This Volume is dedicated to the late Bob Johannes who inspired the conference reported in these pages. His 1981 book 'Words of the Lagoon' opened the eyes of fisheries scientists to the knowledge, insight and values of those who spend their working lives on the water. The attendance of more than 200 people from 60 countries, Indigenous peoples and Aboriginal organizations is a direct tribute to his ability to bring people together. A fearless and prolific researcher, Bob put tremendous effort into getting natural and social scientists and fishers to harness their collective wisdom to solve management challenges. In spite of serious and ultimately terminal illness, Bob attended the conference long enough to make a keynote speech and challenge us to establish an institute for the research and application of Indigenous fishers' knowledge at UBC. We're working on it!

Dr Bob Johannes being presented with Kwakwaka'wakw artwork by Kla-kisht-ke-is Chief Simon Lucas at the 'Putting Fishers' Knolwedge to Work' workshop in Vancouver, 2001. Dr Johannes was keynote speaker.

Photo by Laurie Ryan

PUTTING FISHERS' KNOWLEDGE TO WORK: PROCEEDINGS FROM THE CONFERENCE, AUGUST 27-30, 2001

Edited by Nigel Haggan, Claire Brignall and Louisa Wood

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Fishing the Tower of Babel

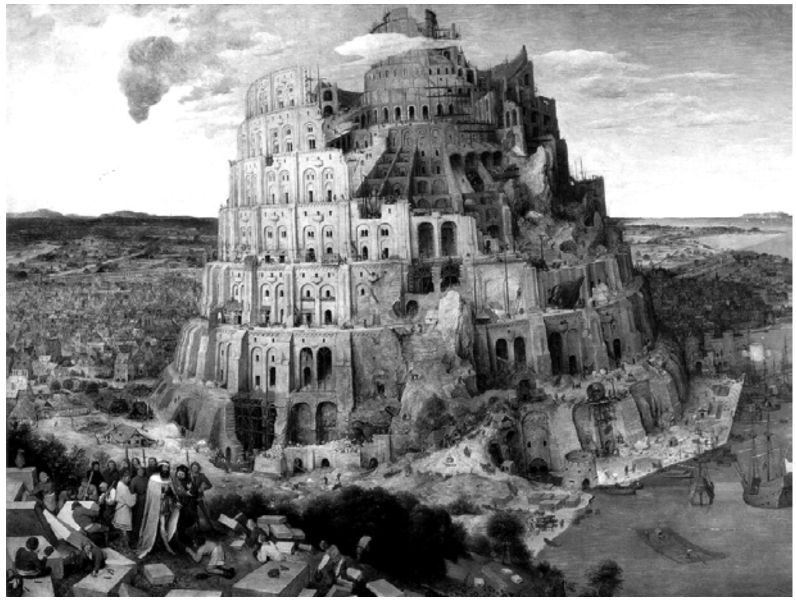

Figure 1. The Tower of Babel, as imagined by Breughal in the 16th Century. The tower stands for the mutual incomprehension of human languages and hence hostility, cacophony and chaos. Pieter Breughal the the Elder, 1563. 114 x 155 cm. Kunsthistorisches Museum, Vienna.

In the Tower of Babel[1] myth (Figure 1), early humans set out to build a tower tall enough to reach heaven, but were punished by a wrathful God for this blasphemous endeavour by causing the builders of each separate compartment to speak a different language. Hence the Tower of Babel causes a previously single and easily communicable human language to become split into many, leading to failure of communication, hostility and even war (Haggan 1998). The story of the Tower of Babel epitomizes the mutual incomprehension, incompatible cultural values and innate hostility of those who speak different languages. The depth of feeling engendered by all this can extend to the belief that only oneself has the true language, and therefore only oneself has a correct understanding of the world.

The ancient Greek natural philosophers made a good job of dealing with it, but nowadays it is very hard being interdisciplinary. Those who attempt to work across disciplinary boundaries often feel they have encountered the Tower of Babel syndrome in their travels, as they are rebuffed, rebuked and chastised for failing to pay homage to some cherished theory, or do not use esoteric jargon understood only by a devout group of practitioners. Accounts in plain language that are understandable to all are often derided as naïve and anecdotal. Yet, as those ancient Greek, Arab and early European Renaissance thinkers understood, true insight may come from simply comparing the same phenomenon from several perspectives. Interdisciplinary workers are brave explorers and should not be chided if they sometimes appear naïve. In fact, a more helpful myth for the interdisciplinary journeyman to muse upon is that of the Babel fish (Figure 2), a symbiotic organism that facilitates complete mutual comprehension[2].

[1] In the bible, the Tower is reported as being built in the land of Shinar (or Sennar = Babylonia) some time after the Deluge. The story of its construction in Genesis 11: 1-9, attempts to explain the existence of diverse human languages. The Babylonians wanted to express their success and dominance by building a tower: *"Go to, let us build a city and a tower, whose top may reach unto heaven; and let us make our name famous lest we be scattered abroad upon the face of the whole earth"*. An angry and anxious God (*"now nothing will be restrained from them which they have imagined to do")* responded by so confounding the language of the workers that they could no longer understand one another. As a result of the confusion, the tower was never completed, and humans were dispersed over the world. The myth may have been inspired partly by an actual Babylonian tower temple north of the Marduk temple, and mentioned in one of the first histories of the middle east written by a Babylonian priest called Berosus writing in Greek in about 290 BC (his writings have been corroborated in part from ancient cuneiform tablets). In Babylonian the tower was called Bab-ilu ('Gate of God'), of which the Hebrew form is Babel, or Bavel. The other contributing factor in the origin of the Tower of Babel myth is perhaps a play on words between 'bavel' and 'balal' meaning to 'to confuse'. This play on words can be seen in Genesis 11: 9: "*Therefore the name of it was called Babel, because there the Lord confused the language of all the earth.*"

[2] Readers may be interested to learn that the Babel fish has been used as a proof that God does not exist. Adams writes: "It is such a bizarrely improbably coincidence that anything so mind-bogglingly useful could have evolved by pure chance that some thinkers have chosen to see it as a final and clinching proof of the non-existence of God. The argument goes something like this: "I refuse to prove that I exist," says God, "for proof denies faith, and without faith I am nothing." "But," says Man, "the Babel fish is a dead giveaway isn't it? It could not have evolved by chance. It proves you exist, and so therefore, by your own arguments, you don't. QED." "Oh dear!" says God, "I hadn't thought of that" and promptly vanishes in a puff of logic." Readers may speculate as to what the God of the Tower of Babel incident might have done about Adams or his books in the face of this clever argument.

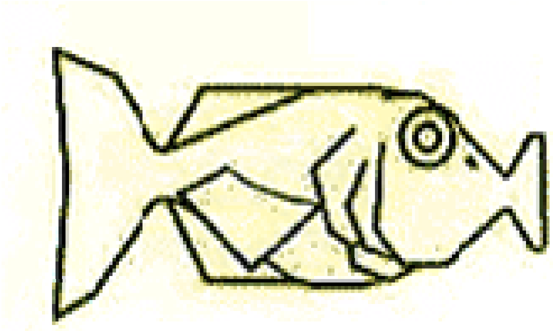

Figure 2. The Babel fish (Adams 1979) is small, yellow and leech-like, and probably the oddest thing in the Universe. It feeds on brainwave energy then excretes into the mind of its carrier a telepathic matrix formed by combining the conscious thought frequencies with nerve signals picked up from the speech centres of the brain which has supplied them. Hence with a Babel fish in your ear you can instantly understand anything said to you in any form of language, and it would be of incalculable help to those seeking to carry out interdisciplinary work. Note that, following Adams, the multilingual Web-based translation engine has been named 'Babelfish'. *[http://babelfish.altavista.com]*

Those who seek to report and find uses for local and traditional environmental knowledge (LEK and TEK) soon encounter the Tower of Babel syndrome. Scientists concerned with ecology and stock assessment are not used to talking to the sociologists, anthropologists and historians who traditionally study TEK and LEK. Equally, social scientists face challenges when reconciling their own research philosophies and perspectives with the results of traditional science's methods and analyses. In the face of such conflicts, and the frequent use of language that obfuscates, it is small wonder that the members of the public-at-large find it hard to understand why things that seem patently obvious to them cannot be used in managing marine resources (Haggan 1998). Generally, those who can overcome the disciplinary Tower of Babel syndrome, and are able to incorporate, and relate to, the public view are those who have engaged in some form of meta-analysis[3].

Throughout his career, Bob Johannes thought broadly, used tools from several disciplines and has shown clearly (Johannes 1978; Johannes *et al.* 2001) that fishers' knowledge can be very precise and helpful to fishery management, in many cases providing more information about fish species, catches, ecology and habits than is officially reported in the scientific record. A good example is that of bonefish (*Albula glossodonta),* which in Kiribati were reported as not being in danger, whereas Johannes found that fishers knew of boatloads of fish being landed after dusk. Likewise, in Lake Malawi, Government 'beach recorders' go home at dusk, missing most of the catch of usipa *(Engraulicypris sardella),* a small planktivorous pelagic fish (Lewis and Tweddle 1990).

In short, LEK and TEK can provide very helpful and accurate information that is easily missed, or could not even be gathered, by official surveys. Moreover, it provides a way for fishers to perceive that they are an essential and important part of the management process and not just the recipients of directives and controls. This was the theme of an international interdisciplinary conference held in Vancouver in September 2001 on *Putting Fisher's Knowledge to Work*. This report publishes over 45 papers as the proceedings of that meeting: as many papers again were delivered orally, listed here by their titles.

The oral papers, discussion sessions, posters and informal gatherings at the conference showed that the use of LEK and TEK is a practical proposition, and is being actively explored in many parts of the world. The authors are a truly interdisciplinary lot; they include government and university fishery scientists, economists, anthropologists, sociologists, historians, fishers and members of Aboriginal nations. Many of them had such a good experience at the meeting that they must have inadvertently gotten a supply of Babel fish to put in their ears. (Did I see a stall in the lobby selling them..?)

And, far from the Tower of Babel syndrome, Aboriginal people were a powerful presence at the conference, and provided us with presentations resonant with knowledge, culture and information. It is a major challenge to resource management to provide equity, support and advice that can be used in fisheries by Aboriginal peoples, while they can provide today's managers with wisdom such as 'seventh generation thinking' and language that expresses stewardship and respect for natural resources as integral parts of whole functioning ecosystems.

Given our theme of overcoming the Tower of Babel, it is fitting that this volume is dedicated to Bob Johannes, a pioneer interdisciplinary researcher who was always ready to listen to and acknowledge different languages or disciplines. Sadly, Bob passed away soon after the meeting.

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3 My personal experience of interdisciplinary projects is that theologians can have more practical insight into how people behave and react than either natural or social scientists (Coward *et al.* 2000).

The Fisheries Centre Research Reports series publishes results of research work carried out, or workshops held, at the UBC Fisheries Centre. The series focusses on multidisciplinary problems in fisheries management, and aims to provide a synoptic overview of the foundations, themes and prospects of current research. Fisheries Centre Research Reports are distributed to appropriate workshop participants or project partners, and are recorded in the Aquatic Sciences and Fisheries Abstracts. A full list appears on the Fisheries Centre's Web site, www.fisheries.ubc.ca. Copies of the reports are sent to all meeting participants, and all papers are available for free download from our web site as PDF files. Paper copies of the reports are available on request for a modest cost-recovery charge.

Tony J. Pitcher
Professor of Fisheries
Director, UBC Fisheries Centre

REFERENCES

Adams, D. (1979) The Hitchhikers Guide to the Galaxy. Chapter 6. Heinemann, London.

Coward, H., Ommer, R. and Pitcher, T.J. (eds) (2000) Just Fish: Ethics and Canadian Marine Fisheries. Institute of Social and Economic Research Press, St John's, Newfoundland, Canada. 304pp.

Haggan, N. (1998) Reinventing the Tree: reflections on the organic growth and creative pruning of fisheries management structures. Pages 19-30 in T.J. Pitcher, P.J.B Hart and D. Pauly (eds) Reinventing Fisheries Management. London, Chapman and Hall. 435pp.

Johannes, R.E., Freeman, M.M.R, and Hamilton, R.J. (2001) Marine biologists miss the boat by ignoring fishers' knowledge. Fish and Fisheries 1(3): 257-265.

Johannes, R.E. (1981) Words of the lagoon: fishing and marine lore in the Palau district of Micronesia. University California Press, Berkeley, USA.

Lewis, D.S.C. and Tweddle, D. (1990) The yield of usipa (*Engraulicypris sardella*) from the Nankumba Peninsula, Lake Malawi (1985-1986). Coll. Rep. Fish. Res. Malawi Occ. Pap. 1: 57-66.

EXECUTIVE SUMMARY

This Report documents the presentations given at the World's first international conference on the management value of the resource knowledge of small scale, indigenous and commercial fishers. The conference was inspired by Dr Robert (Bob) Johannes, whose 1981 Book 'Words of the Lagoon', was the first serious study in this area, and was co-hosted by the UBC Fisheries Centre, UBC First Nations House of Learning and the BC Aboriginal Fisheries Commission. Over 200 people representing 23 countries and 36 North American First Nation representatives attended. The conference sought to provide a way to 'step beyond' fishers' frustration that their knowledge is ignored and scientists' standard position that the knowledge is anecdotal, and can not easily be captured in the reports, tables and graphs they are used to.

In total, 48 papers and 26 abstracts of papers were presented during the three days of the conference. These case studies and presentations included Indigenous, Artisanal, small scale and industrial marine and freshwater fisheries in tropical and temperate environments. Species range from turtles and dugongs, through temperate trawl and tropical multi-species fisheries to the aquarium trade. The conference followed themes relating to the use of fishers' ecological knowledge about fishing practices in environmental management; the relationships between fishers' expertise (knowledge) and management; methodological issues/methods for obtaining and accurately representing fishers' knowledge; the ethical issues relating to collaboration between TEK practitioners, managers, academics and industry; and the valuation of fishers' knowledge from an ecological, economic and social approach.

ACKNOWLEDGEMENTS

The conference hosts gratefully acknowledge the following organizations whose financial contributions made the Conference possible: BC Hydro; BC Ministry of Environment, Lands and Parks; The David Suzuki Foundation; the Department of Indian and Northern Affairs, Canada; Fisheries and Oceans, Canada; Fisheries Renewal BC and the 'Coastal Regions and Small Islands Platform' of UNESCO.

We also acknowledge the above organizations and the 'Coasts Under Stress' project funded by SSHRC and NSERC for intellectual input to the conference design. Thanks are also due to the organizing committee for abstract review and to the Fisheries Centre and BCAFC staff who coordinated travel and the 1,001 other arrangements these events involve. We also thank Pam Brown, UBC Museum of Anthropology for input to the evolving '*Fishers' Knowledge at Work*' concept.

My Grandfather's Knowledge: First Nations Fishing Methodologies in the Fraser River.

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My grandfather's knowledge deals with First Nations fishing methodology in the Fraser River and Lillooet, heart of Stl'atl'imx territory. My grandfather's world was ten miles of the Fraser River, the three ranches that he ran, and the livestock that he owned. For the purposes of this presentation I will try to stick to my grandfather the fisherman.

My earliest recollections of going to the river include riding on the old two-wheeled horse-drawn cart. On the way to the river, my grandfather would point out various plants and animals in the ecosystem around us. The earliest fishery was the Zumak or Chinook salmon which were the first to swim up river. I can recall my grandfather getting ready for this first fishery, making his nets. We lived in a house with one-room. This one-room would be full of gill nets in various stages of completion, dip nets, hoops and poles. Everywhere you look there were needles and wooden spacers of different sizes for different nets. He had a sense of excitement about him at that time of year and he would speak in hushed tones "The Zumak are coming, they are coming!" You could sense his excitement. He was my whole world. When he had the spring Zumak gear ready – nets with 6 to 8 inch mesh - we'd head down to the river. That is where he pointed out the various bushes along the way.

We would catch enough for supper and for a couple of days. We had no refrigeration back then and we were not big on canning and drying spring salmon because it is hard to dry. Springs were a break from salt and dry salmon that sustained us through the winter months.

The second fishery my grandfather was involved in was the sockeye. During the interval from catching spring to the sockeye season, he would be working on his ranch. I recall the water system he built, a ditch which was probably about 5 miles long to catch the water from the mountain to irrigate his fields. The man was a magician. The water ran uphill, following him. It was a constant activity of fishing and farming in the summer months. And so in the early summer when the rose petals begin to bloom, he would go fishing for sockeye. I remember him pointing out the rose petals to me.

It was a really busy time because we had to put away enough salmon for the winter months. I don't know how many racks of dry salmon we had. Each rack would hold about 200 a time and we would replenish them 3 times over. So there would be about 600 dried salmon. Salting and drying were the main preserving methods. Getting the fish and cutting it up was a lot of work, from the crack of dawn right to dusk. In this way you went through an apprenticeship as a young person. These recollections come from when I was 4 to 5 years old and my main job revolved on packing fish guts and hanging up the smaller strips of dried salmon. I was a productive little guy back then, it is amazing what a four year old can do!

As you get a little older you begin to pack the salmon to the drying rack. When you are older still, you can handle the ropes and gillnet which are not as dangerous as the dip-net style. The crowning moment of glory would be when you are twelve or thirteen when you handle the dip-net. This was dangerous work because of the fast flowing river. You were then considered a man.

I regret learning how to cut and dry salmon because I got stuck up there with the old ladies. My young buck buddies where down there fishing and I was with the old ladies cutting – but it came to be a useful skill and hopefully I will teach my grandchildren to do that.

In the later part of the year the Hane', pink salmon, would come in. By the time they got to our territory they were basically useless for human consumption. It took me awhile to learn they had a role in the ecosystem and they were there to feed the animals. I hated them because they died right outside my doorstep. I lived right up halfway between the confluence and the spawning ground and they were dying everywhere.

In the grander scheme of things my grandfather's knowledge might be worthless. But it has given much to my family. It allowed us to survive and thrive and to continue to exist. For that it is very useful. It has given me the knowledge of the benefits of hard work and perseverance, the simple pleasure that you get from feeding yourself and your family. I am sure my grandfather was very proud of that fact.

I'd like to speak about my grandfather's father for a bit and his role in Stl'atl'imx history. His name was Ulhwa and he was one of the chiefs that signed the 1911 Stellat declaration of sovereignty. The declaration basically pointed out the perspective that my grandfather's people had regarding their territories and the fact that those territories were being invaded by white people and their impacts upon the fishery. You need to understand that the industrial fishery on the Fraser River started in 1888 with the first legislation that disallowed First Nations people to sell salmon. 1911 is 23 years after. In 23 years, the Fraser River fishery had been decimated to such a degree that interventionist measures such as fish hatcheries were being utilized. In the 1911 declaration my grandfather questions why we arrived at such a state in such a short time. I think that if I fast forward to the future that is very much what I presently see with regard to the salmon aquaculture industry. I view both of our efforts as efforts to preserve wild stocks of salmon that our family has always depended upon for sustenance. So again reflecting upon the comment of utility of this knowledge, I have come to learn that well over 50 percent of the world's fisheries are the so called artisanal fisheries. These fisheries, much like my grandfather's fisheries, only entail small pockets of the ecosystem. The trick for us is to figure out how knowledge from these small pockets of artisanal fisheries relates to the rest of the world to make sure that the importance of these fisheries for the continued survival of our peoples is recognized.

The tools of the trade that my grandfather made were specific to those ten miles of the Fraser River. He knew every back eddy, riffle and run in that ten-mile stretch. He knew which net should be used in which specific spot. He moved upriver as the level of the river receded, and when the fish were very plentiful, he would just use his dip-net and then he could catch as many in one day as with his gillnet. I guess this could be viewed as adaptation to your specific requirements. And again that is very much the nature of most artisanal fisheries. The amazing thing about these simple technologies of small gillnets and dip-nets is that they are still as useful today as they were in my grandfather's time. I still make my dip-nets in the same manner as my grandfather and I pick those same fishing spots in the Fraser River that he utilized. This is termed in modern day vernacular as intergenerational equity – simply, the passing down of knowledge from one generation to the next. So in retrospect, I have been very fortunate. I have had a very good teacher and all I hope to do is to pass on my grandfather's knowledge to my grandchildren. All I want is the same as yesterday, just like my grandfather.

In closing I would like to acknowledge the people who came from all over the world to participate in this conference. We are talking about a world indigenous center that we have hope of bringing together. It can do great things. I always think that if we were to look after our respective backyards and work together in concert we can indeed make this world a better place.

A NATIVE CHANT

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INTRODUCTION

My name is Kla-Kisht-ke-is, I am the seventh ranking chief of the Hesquiat Nation on the west coast of Vancouver Island. The chant I just sang for you goes a long way back in time, but is just as important today. Some of the chants were made while sitting on the shoreline, some in the forest listening to the movement of the trees, some were made listening to ripples and waves on shore, and some of them while looking up at the stars. Our history goes back a long time. In my tribe, they have done an archaeological dating, where we laid our people to rest in a cave. After two years of doing digs, they were startled: "This isn't changing and we have gone back five thousand years". Among the remains were 75 different marine resources. Some people argue that we have no Aboriginal right to certain species. They say we never used them, so I think that they were hoping that those remains were not going to be there. Along with those remains were cedar bark, old masks and different rattles that our people used. I say that to you to make you think about how far back our knowledge and experience reaches. I am not telling you that ours are the best methods. What I am telling you is that we have alternatives to offer: that we saw with our own eyes and learned from our grandfathers.

My dad told me that he started taking me out on a fishing boat that he owned - a thirty-one foot troller[1], and that I was so active on the boat that he had to tie me to the mast for fear of me falling overboard. There is an assumption that our people did not have nets or gear. But different forms of shells were used to troll and seining is nothing new to our people. At 5, I knew all the fishing banks in our territory, including Estevan Point. Banks were different. You knew where to get the cod, the bass, and the salmon. We know the landmarks. There is a great place that has all the food chain - everything literally stopped at this place to feed and it was almost a perfect circle, 3 miles long all around. It is an incredible place for needlefish. There were reefs. You had to know landmarks to get there. My grandfather used to say that this place is important. When I got modern sounding gear, I found out he was right, because when I go there in the morning there is no sign of life, but in certain times of day the needlefish rise up. We knew that there were all sorts of salmon species hanging around there and many other landmarks. We knew that herring, shrimp and needlefish were there. A lot of fishermen would say that they knew there were salmon there and shrimp. The saddest thing in BC was when they commercialized the shrimp, DFO (the Department of Fisheries and Oceans) didn't look at the impacts on the coho salmon. The reason why this area was so popular with fish was because of the tidal currents. My grandfather said that you got to understand the movement of the sea. The moon is an incredible indicator of when the fish start migrating. My dad used to say, 'don't ever go fishing when the flood tides are happening because everything goes behind the reefs.' So the reef is important to us because it offers protection for migrating and local stocks.

If we went up the coast to fish at Kwa-Kwa-wha-as, there is one of our landmarks, a mountain between Gold River and Campbell River. It has a very sharp peak. Once you see the mountain there, you are getting close to the bank. That is important because this bank drops down from 70 to 80 fathoms. Our people knew before the radars and sonars told that this depth of water was important. The food chain is great at that depth.

A little west along this bay is an incredible landmark. When the mountains appear backwards, you know you are at the bank. The bank is just under 100 fathoms, in my young days littered with food chain. It is where we used to see so much shrimp.

We go further, and there is another landmark, with four peaks. When you come to the first peak, that is when you start to put your lines down, and at the fourth peak, you are 22 miles off shore and at an incredible resource bank. 45 fathoms deep, littered with food chain. It is there where many of the migrating stocks from the Fraser River will be. You know that you are going to be catching lots of salmon especially if the moon is right. Sometimes, two days before the full moon, the fish will be nuts, and two days after it will be a lot crazier.

So we went from the traditional fishery to a more technological fishery. The coastal tribes now own some huge fishing boats, for gill netting and

[1] Fishing vessel used in the hook and line fishery for Pacific salmon

trawling. Some fish offshore for tuna. There is an assumption that the Indian people did not go that far. Our archaeology digs show that our people were there. Some people say black cod were not part of Indian food fishery. But Barbara Lane, an archaeologist, showed how black cod was important to our women. Women with nursing children used black cod broth to enrich their milk.

There was a spiritual component of why we did what we did. There was a physical and mental reason why we harvested those resources. Our grandfathers say, 'always look at the day, this is where you learn to look at what you are doing, during the daytime'. You don't just do things without thinking about the consequences of the consequences. What we found out, as we are trying to implement how our grandfather saw it, we have a tremendous struggle. We have some tribes that are affected by development of dams who will never be able to can fish again for their winter food.

Our grandfathers say 'listen to the day - sometimes it talks to us'. Do we really take our time to listen and to look, and see understand what is happening in our area? When the herring industry started, our tribe had twelve people fishing in the harbor before spawning. We went to see this old Chief in Nuu-chah-nulth and he said "What are you people doing? What are you involved in? You are fishing these fish when they are near spawning!" He told us it was the ultimate crime. He was right. Our people put out hemlock branches to collect herring roe for food, it used to be rally thick. Today when we lift the branches we are lucky to have half an inch of herring roe.

In our tribe we talk to the commercial fishermen. We are involved in something our ancestors have never done. Sometimes the DFO listens. Our tribe negotiated for 2 years. We wanted our harbor closed to fishing. They asked us if we had a plan. No, we said, we just wanted it closed. They closed it for us. And I saw what my grandfather saw. When the herring come in so do hundreds of seagulls and ducks of every kind. Everything was there without a plan. There are times when things have to be totally natural, and how we fit into that scheme is important. I don't know who developed "endangered species". Our ancestors said to us that our tribe number over 3000 people. The Europeans came in with a plan to exterminate our people. We went from 3000 to 198. Now we are back to 700 and working harder.

So I think it is important for you to listen. We have talented, educated First Nations people, in BC. We have people who understand about our grandfathers. We have biologists who work for our tribes who understand and listen to the teachings of our forefathers. Our people are not talking about total isolation, because we recognize the fact that the people that are here now are here to stay. We do not want to create an imbalance. Nuu-chah-nulth territory is an example of what happens when we create imbalance. DFO said that the sea otters were extinct from the west coast of Vancouver Island, so they brought some from California. There are more sea otters now in Kyuquot and they are eating all the sea urchin. The people of Kyoquot are almost extinct; compared to the sea otters, we are now the endangered species. We as humans are not as important as sea otters and the sea otters aren't even indigenous. They came from somewhere else.

Some of our people have done very well. They have become very competitive; competition has become part of us over the previous ninety years. Over the past three years our people have been badly affected by regulations, but some of us are still out there. We have one person left who has a halibut license, we have one person who is still involved in the black cod fishery, and one person left in the crab fishery. The list goes on. So our people lived off the sea and we sustained ourselves.

So I leave you with this: think for a moment. You are in a forest. Listen to what it might be saying to you. As you are in the forest, you are beside a little brook, making these little sounds. We're of the same people as those who have been here as long as the rocks have been here.

Thank you.

Fishers' Knowledge and Management: Differing Fundamentals in Artisanal and Industrial Fisheries

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Abstract

Differences in characteristics of industrial and artisanal fisheries should be better understood for improved communication between those who do research on local ecological knowledge in these different fisheries. Artisanal fisheries often differ from industrial fisheries in that:

1. Per unit of catch or of areas fished, the numbers of fishers, species caught, gear types used, landing sites and distribution channels are typically far greater, especially in the tropics. Local ecological knowledge is of particularly great value to biologists in such complex settings where conventional biological knowledge is poor.
2. In some areas limited entry (marine tenure) has been well established for centuries. In these areas ethical questions concerning the publication of local ecological knowledge, while by no means non-issues, are often less problematic because the exploitation of this knowledge by outsiders is much less likely.
3. These fisheries are often managed (or mismanaged) by the fishers; in cooperative management arrangements government fisheries personnel are usually the junior partners.
4. Among artisanal fisheries researchers there is an even greater need for closer collaboration between biologists and social scientists. Biologists are much better trained to ask useful questions about local ecological knowledge, put the answers into broader biological context and help restrain social scientists from framing management recommendations that ignore critical biological realities. Social scientists are better skilled in achieving good collaboration and rapport with local people, in interviewing, and in restraining biologists from drawing management conclusions that ignore equally critical cultural realities. The two types of researchers should be working more often in teams.

Introduction

Members of a group often share assumptions that are valid within that group, but inappropriate when extended beyond it. Such over-generalizing is the bugbear of all trans-disciplinary communication. It is hard to avoid, but we need to try to minimise it.

In this connection some key assumptions of those whose research focuses on industrial fisheries may be inappropriate when extended to indigenous fisheries. Fisheries textbooks, which are often disproportionately concerned with temperate zone industrial fisheries, tend to foster this overgeneralizing.

Here I discuss some examples of this, in an attempt to help improve communication between researchers who study fishers' knowledge and its uses in management in industrial and indigenous fisheries. I, too, run the risk of overgeneralizing, since my perspective is influenced by my greater familiarity with the indigenous fisheries of the tropical Asia-Pacific region than elsewhere. This, at least, is where most of the world's indigenous marine fisheries are found.

Access

One of the most common generalizations is that the fundamental problem with fisheries lies in their open access nature. But in much of Oceania and parts of Northern Australia, Africa, Asia, and Latin America, limited access has long been a feature of indigenous fisheries management (reviewed in Cordell 1989; Ruddle 1994; McGoodwin 1990). Some such systems, like those of the native fishers of the Pacific coast of North America, have largely disappeared. But many others persist[1]. This has several implications for how fishers' knowledge is obtained and employed in management. Who controls the management process is one of them.

Industrial fisheries researchers often make generalizations concerning the need to "empower" fishers, or to "let fishers in on the management process". But in indigenous fisheries, especially on tenured fishing grounds, management is already often largely in the hands of the fishers. Fishers have been thus empowered in the Pacific Islands, for example, for many centuries (Johannes 1979; Johannes *in press*).

[1] Also, some countries' governments are recognizing the need for indigenous fishers who operate under open access conditions to control their fishing grounds and are making appropriate laws. The Philippines, for example, enacted a government code in 1991 that makes coastal management a major responsibility of coastal municipalities.

All the basic marine conservation measures developed in the west only a century ago were used in the Pacific Islands hundred of years ago. Because of their geographic settings, some Pacific Island cultures discovered their marine resources were limited long before Europeans did; unlike Europeans, they had neither a continental shelf fishery nor a large source of terrestrial animals on which to depend for animal protein.

In addition, tropical nearshore fisheries are characterized by many more species, methods, fishers and landing sites per unit of catch than industrial fisheries. Centralized government management is generally quite impractical under such conditions (Johannes 1998).

In some Pacific Island countries, villagers make far more fisheries regulations than governments (e.g. Johannes and Hickey 2002). Governments may still pass some laws pertaining to indigenous fisheries. But government enforcement is typically low to non-existent. In the Solomon Islands for example, single fisheries officers with a small canoe and insufficient fuel, are responsible for government enforcement, among other jobs, in districts encompassing many dozens of small villages and hundreds of kilometres of coastline.

This is not an unusual situation. The cost of centralized government management in these numerous tiny fisheries is generally prohibitive, except in a few high-value export fisheries where the product may be adequately monitored at central collection sites prior to export. If most government fishing laws are to be enforced effectively, it must be done by villagers, and they will do so only if they perceive the benefits (e.g. Johannes and Hickey 2002).

Here, accordingly, it is not fishers who need to be "let in to the management process", but rather fisheries researchers and government fisheries managers. This can be accomplished, as in industrial fisheries, via co-management arrangements. But whereas fisheries researchers are inviting industrial fishers into the management process as they recognize their own limitations, the opposite trend is developing in indigenous fisheries.

In the Pacific Islands, for example, fishers are increasingly inviting government personnel to collaborate with them in devising management measures. This happens when they recognize that their traditional knowledge and management measures, while often still valuable, are no longer adequate to enable them to cope with new problems brought by increasing populations, improved technologies, new export markets, cash economies and other consequences of westernization (e.g. Toloa *et al.* 1991; Johannes and Hickey 2001; see also Purnomo, this volume, for an Indonesian example).

Johannes (1979) foresaw the "demise" of traditional fisheries management in Oceania due to the various impacts of westernization on its cultures. Fortunately he was wrong. Fishers' knowledge of resource depletion and the increasing need for better management, plus a growing recognition that co-management offers a promising way to achieve it, has resulted in a renaissance in village-based fisheries management in the region in the past decade

For example, in 21 Vanuatu villages surveyed by Johannes (1998) and resurveyed by Johannes and Hickey (2002), village-based marine resource measures had more than doubled in eight years. A total of 40 of these measures were operating in 1993. Most had been initiated within the previous three years due to the encouragement of the Vanuatu Fisheries Department. By 2001 five of these measures had lapsed but 51 new ones had been implemented.

In Samoa in the mid 1990s, the Samoa Fisheries Division triggered an upsurge in village-based conservation by giving village regulations formal by-law status. Designed and enforced by the villagers, these bylaws are monitored more effectively than regular government fisheries laws. Within three and a half years of the program's introduction, 52 villages had established their own sets of bylaws (Fa'asili and Kelokolo 1999).

There is still a long way to go before the nearshore resources of Oceania are all well managed, but the current trend is promising.

Collaboration of Researchers

To usefully evaluate fishers' knowledge concerning the species they catch, one must first have a good grasp of what is already known scientifically about those species. For this, social scientists who study industrial fishers' ecological knowledge need only 'bone up' on the published information on one - or at most, a handful, of species and one, or few, methods used to catch them. Learning enough about the many species, methods and habitats that characterize tropical indigenous fishers is not so easy.

As Freire and Garcia-Allut (2000, p. 376) point out:

> *"Fishing strategies in artisanal fisheries are based on flexibility, with a diverse pattern of activity (with respect to the species exploited, location of fishing grounds, and gears used) throughout the yearly fishing cycle. Industrial fisheries present a strategy of intense and continuous exploitation of the same resources in similar habitats using one or a few gears"*

Needless to say, collaboration with fisheries biologists can be especially valuable in studying indigenous fisheries.

Biologists who work with industrial fishers are often of the same general culture and speak the same language. This is seldom the case with those who study tropical indigenous fishers. Accordingly, understanding local culture and custom is more demanding and the input of social scientists if often vital in this connection. Social scientists also tend to be more adept in local languages than biologists.

In short, the need for collaboration between biologists and social scientists in studies of the ecological knowledge of indigenous fishers is even greater than it is in typical industrial fisheries.

Ethics

Security of indigenous tenure over fishing grounds means that dealing with local knowledge ethically is less often a burning issue than it is in industrial fisheries (Nor is it as important as in terrestrial settings where ethnobotanists seek traditional plant-based medicines[2]).

In areas where indigenous fishers hold secure tenure over their fishing grounds, there is less risk in their revealing their specialized knowledge. Indeed, they are sometimes proud to do so (e.g. Johannes 1981; Hviding 1996). This openness stems in part from the fact that these fishers can often exclude outside competitors who might exploit this knowledge[3] from their fishing grounds.

Also, for reasons discussed above, fisheries personnel have little opportunity to use this knowledge to support the imposition of unwanted regulations on indigenous fishers. Important exceptions to this, however, are fourth world fishers, that is, indigenous fishers in countries ruled by industrialized, usually western, powers. North American Native Peoples, American Samoans and Australian Aborigines, for example, may well have justifiable fears in this connection (e.g. Wavey 1993, p. 16).

Knowledge Characteristics

Indigenous fishers are physically closer to their prey than industrial fishers. They see them while gleaning or pursuing them with a spear or castnet on foot, from over the side of their canoes, and from underwater as they spearfish. Their knowledge of the behaviour of fish and invertebrates is thus more intimate than that gained in wheelhouses via echo sounders. But it is limited to shallower waters and smaller areas.

Economics

Indigenous fishers' knowledge is less often "commercial in confidence" than it is in industrial fisheries. For example, although fishing for profit is gradually increasing in Oceania, Dalzell *et al.* (1996) found that subsistence catches were more than twice as valuable as commercial catches in the nearshore fisheries of 22 Pacific island countries. Here in many fishing villages, only a few of the many species harvested are sent out for sale. These tend to be highly valued species that do not need refrigeration, such as various shells and shell products and beche-de-mer (dried sea cucumber). Otherwise, economic activities are often organized along kin-based lines with catches being distributed within extended families[4].

McGoodwin (1990 p. 63) states, *"In traditional subsistence systems, where the main goal is to*

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[2] Although tropical marine biota bristle with pharmacologically active compounds, there are surprisingly few examples of indigenous medicines being made from them. Here, therefore, the need to ensure appropiate recompense for information on locally-used, marine-based medicines seldom arises.

[3] In certain circumstances, however, such knowledge could be used to the advantage of outsiders and the detriment of its possessors. I do not document such knowledge even in reports to the agencies that fund my research (e.g. Johannes and Kile 2001) because even in-house reports have a way of migrating eventually into the wrong hands.

[4] Similar findings have been reported in connection with aboriginal fishers in Canada (e.g. Pinkerton 1987; Usher and Weinstein,1991).

produce food, there is a finite and thus satisfiable demand for the product. But for people living in a market economy ......there is no upper limit on the demand for cash." In indigenous villages, then, profit does not always motivate, capital is not always the engine of production and subsistence economics do not compute in economic models based on assumptions more appropriate to industrial fisheries (Johannes 1989; McGoodwin 1990).

Like open access, overcapitalization is an enormous problem in industrial fisheries. But capital is usually scarce in indigenous societies. Indigenous fisheries involve orders of magnitude less capital per job than industrial fisheries (D. Thompson in Maclean 1988) and under-capitalization has often been said to be a problem.

Management

Industrial fisheries management has typically focused heavily on the population dynamics and physical dynamics of fish stocks and on the quantitative regulation of stock removal. Traditional indigenous fisheries management has focused almost entirely on qualitative controls such as closed seasons and closed areas. This is at least in part because obtaining the necessary information for quantitative management has been beyond reach in these fisheries. Indigenous knowledge tends to be qualitative. Biological management here is not about achieving optimum sustainable yields; it is about preventing serious declines.

Ironically, as we come to recognize that adequate quantitative knowledge for stock-based management is also quite beyond our reach in most industrial fisheries (Walters 1998), the older, more qualitative management approaches used in indigenous fisheries are gaining increasing support from social scientists, economists and fisheries biologists for use in industrial fisheries (e.g. McGoodwin 1990; Pinkerton 1994; Wilson *et al.* 1994; Sainsbury 1998). In addition, Pauly (1997) and others recommend the "rediscovery" in industrial fisheries of the virtues of the decentralized, "place-based management" of indigenous fishing communities.

Mobility

Industrialized fisheries are dominated by large, mobile, largely corporately owned fleets. Owners can move their fleets or their capital elsewhere when a fishery is no longer profitable. The incentive to manage sustainably is thus relatively weak.

As discussed above, indigenous fishers can often exclude outsiders from their fishing grounds. (The 'sea nomads' of eastern Indonesia are a striking exception). The flip side of this practice is that they cannot easily move if their fishery becomes unprofitable. Their incentive to manage sustainably is thus stronger[5].

Such localization of fishing also means that many generations of indigenous fishers have operated in the same limited area over centuries, refining and passing on their knowledge. In the process this knowledge has become encyclopedic in some of these cultures (Johannes 1981; Hviding 1996; Johannes and Hviding 2001).

This UBC meeting was an exceptional opportunity for a large number of researchers on industrial and artisanal fisheries to compare experiences and perspectives. During the meeting it became obvious that some fundamental differences in the nature of the fisheries that the two groups study result in important differences in their approaches to research on and use of fishers' ecological knowledge as well as to other subjects. It also became obvious that each group can learn much of value from the other. Communication between our two groups will proceed much faster, however, if we become more aware of some of the differing perspectives and assumptions that underlie our thinking and methods. This short paper, written after the meeting, is a preliminary attempt to improve that awareness by demonstrating how differences in such things as access rules, biodiversity, fishing methods, mobility, intellectual property issues, and co-management power relations influence the thinking of our two groups.

REFERENCES

Cordell, J. (ed.) 1989. A Sea of Small Boats. Cultural Survival Inc., Cambridge, Mass.

Dalzell, P., T. J. H. Adams and N. V. C. Polunin. 1996. Coastal Fisheries in the Pacific Islands. Oceanography and Marine Biology: An Annual Review. 34: 395-531.

Fa'asili, U. and L. Kelokolo. 1999. The use of village by-laws in marine conservation and fisheries management. SPC Traditional Marine Resource Management and Knowledge Bulletin. 11: 7-10.

Freire, J. and A. Garcia-Allut. 2000. Socioeconomic and biological causes of management failures in European

[5] This incentive can be overwhelmed, however, by the condition of Malthusian overfishing (too few fish to feed a desperately hungry population). The problem is concentrated in parts of Asia and Africa.

artisanal fisheries: the case of Galicia (NW Spain). Marine Policy 24: 375-384.

Hviding, E. 1996. Guardians of Marovo Lagoon. Pacific Islands Monograph Series 14, Honolulu, University of Hawaii Press.

Johannes. R .E. 1981. Words of the Lagoon: Fishing and Marine Lore in the Palau District of Micronesia. University of California Press.

Johannes, R. E. 1989. Managing small-scale fisheries in Oceania: unusual constraints and opportunities. Pp. 85-93 In: Campbell, H., K. Menz and G. Waugh. (Eds.) Economics of Fisheries Management in the Pacific Islands Region. Canberra, Australian Centre for International Agricultural Research.

Johannes, R. E. 1998. The case for data-less marine resource management: examples from tropical nearshore fisheries. Trends in Ecology and Evolution 13: 243-246.

Johannes, R.E. (in press) Use and misuse of traditional ecological knowledge and management practices: Pacific island examples. In: D. Dallmeyer (ed.) Values at Sea: Ethics for the Marine Environment, University of Georgia Press.

Johannes, R.E. and F. R. Hickey 2002. Evolution of Village-based Marine Resource Management in Vanuatu between 1993 and 2001 Report to the Environment and Development in Coastal Regions and in Small Islands Bureau, UNESCO.

Johannes, R.E. and E. Hviding. 2001. Traditional knowledge of the fishers of Marovo Lagoon, Solomon Islands, concerning fish aggregating behavior. SPC Traditional Marine Resource Management and Knowledge Information Bulletin 12: 22-29.

Johannes, R. E. and N. Kile. 2001. Grouper spawning aggregations that are a potential target of the live reef food fish trade in Ysabel and Wagina Islands, Solomon Islands. SPC Live Reef Fisheries Information Bulletin 8: 5-9.

McGoodwin, J. R. 1990. Crisis in the World's Fisheries. Stanford Univ. Press, Stanford, Calif.

Maclean, J. 1988. Thanks for using Naga. Naga, The International Center for Living Aquatic Resources Management Quarterly 11(3s): 16-17.

Pauly, D. 1997. Putting fisheries management back in places. Reviews in Fish Biology and Fisheries 7: 125-127.

Pinkerton, E. 1987. The fishing-dependent community. p. 293-325 In: P. Marchak, N. Guppy, J. McMullan (eds.) Uncommon Property: The Fishing and Fish-Processing Industries in British Columbia. Methuen, Toronto.

Pinkerton, E. 1994. Local fisheries co-management: A review of international experiences and their implications for salmon management in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 51: 2363-2378.

Ruddle, K. 1994. External forces and change in traditional community-based fishery management systems in the Asia-Pacific Region. Maritime Anthropological Studies 6(1-2): 1-37.

Sainsbury, K. 1998. Living marine resource assessment for the 21st century: what will be needed and how will it be provided? Pp. 1-40 In: F. Funk, T.J. Quinn, R.J. Heifetz, J.N. Ianelli, J.E. Powers, J.F. Schweigert, P.J. Sullivan and C. -I. Zhang (eds.) . Fishery Stock Assessment Models. Alaska Sea Grant College Perogram Report No. AK-SG-98-01. University of Alaska, Fairbanks.

Toloa, F, Gillett, R. and Pelasio, M., Traditional marine conservation in Tokelau. Can it be adapted to meet today's situation? Working Paper No. 7, South Pacific Commission 23rd Technical Meeting on Fisheries. Noumea, New Caledonia 1991.

Usher, P. J. and M. S. Weinstein. 1991. Toward Assessing the Effects of Lake Winnipeg Regulation and Churchill River Diversion on Resource Harvesting in Native Communities in Northern Manitoba. Canadian Technical Reports on Fisheries and Aquatic Sciences. No. 1794.

Walters, C. 1998. Designing fisheries management systems that do not depend upon accurate stock assessment. Pp. 279-288 In: Pitcher, T.J., P. J .B. Hart and D. Pauly (Eds). Reinventing Fisheries Management. Kluwer Academic Press, London.

Wavey, R. 1993. International Workshop on Indigenous Knowledge and Community-based Resource Management. Keynote Address. p. 11-16. In: J. T. English (ed.), Traditional Ecological Knowledge: Concepts and Cases. International Development Research Centre, Ottawa.

Wilson, J.A., J. Acheson, M. Metcalfe and P. Kleban. 1994. Chaos, complexity and community management of fisheries. Marine Policy 18: 291-305.

Questions

Saudiel Ramirez-Sanchez: You assume that the conservational ethics of indigenous people existed in the past and then decayed with contact, but that they can go back to those ethics. How do you go back? These cultures and ethics are no longer isolated from outside influences.

Bob Johannes: I didn't mean to suggest that at all. Times have changed. Traditional conservational efforts would not work in these altered circumstances that use a cash economy. However, the conservational ethic can be used as a foundation. That's what is happening in Somalia in a big way. There's still ownership of fishing grounds and that is an incentive to conserve, because no one else can come in and fish. I didn't mean to suggest that these cultures are frozen in time.

The Role of Fishers Knowledge in Implementing Ocean Act Initiatives in Newfoundland and Labrador

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Abstract

Emerging community-based approaches to management reflect the changing role of government. As a basis for Integrated Management in Newfoundland and Labrador, a program was initiated in 1997 to prepare an inventory of coastal resources. In order to make the initiative inclusive and ensure input of local knowledge, a community-based approach was developed. Community groups have used the information for planning economic development activities that may help diversify local economies and sustain rural settlements. Eco-tourism, including whale and seabird watching, kayaking, and hiking, has been highlighted and opportunities for diversification and development in the fisheries have been recommended. The results of the work have also been used extensively by DFO in planning and conflict resolution in the aquaculture industry, environmental assessments related to coastal developments, and sensitivity mapping for environmental emergencies.

Communities have also played a key role in the identification of Marine Protected Areas in Newfoundland and Labrador. The Eastport Peninsula Lobster Fishermen's Committee proposed closing two critical areas of lobster habitat to all fisheries. The goal of the project is to sustain and enhance the local lobster fishery for commercial harvesters in the area. In October 2000, Eastport was officially announced as an Area of Interest in the MPA Programme. In 1999, representatives of the communities of Port Hope Simpson and Williams Harbour, proposed the establishment of a MPA in Gilbert Bay, a long narrow inlet adjacent to the two communities. Concern was expressed that the genetically distinct cod stock in the Bay could be eliminated during a pulse fishery. The goal of the project is to increase understanding of the cod stock and its habitat requirements and determine what sustainable harvest options may be available. In October 2000, Gilbert Bay was officially announced as an Area of Interest in the MPA Programme.

Background

Newfoundland and Labrador, located on the Atlantic coast, is the most easterly province in Canada. It has a landmass of 400,000 sq km and 28,800 km of coastline. The majority of the province's 539,000 people reside in coastal communities.

In the early 1990s, groundfish stocks were at such low numbers that severe restrictions on catch limits were introduced, and a moratorium on the commercial harvest of Northern cod (*Gadus morhua*) was implemented.

The implications for rural Newfoundland and Labrador, which rely so heavily on the fishery, were devastating. Unemployment rates rose to 18.3% provincially as compared to 7% nationally, and a subsequent outmigration of residents in search of employment resulted.

In recent years, fishing efforts have been redirected towards other species including northern shrimp (*Pandalus borealis*) and snow crab (*Chinoectes opilio*). In fact the value of fisheries landings in 2000 was $538M, the highest landed value ever recorded in the history of the province. However, the shellfish fishery is not as labour intensive as traditional fisheries, and therefore has not brought significant relief to rural communities where unemployment remains a concern. Also, these fisheries are often prosecuted offshore by larger ships in areas that are not within reach of the traditional inshore fleet.

New activities are arising along the coasts of the province. Aquaculture, eco-tourism, recreation, and the oil and gas industry now compete for ocean space that was historically restricted to the traditional fishery and marine transport sectors.

The potential for conflict among these ocean users requires that an open process involving all interested and affected stakeholders be established to promote conflict resolution and prevention.

In 1997, Canada introduced the *Oceans Act*. The *Oceans Act* identifies the geographical boundaries of Canada's oceans areas, identifies the Department of Fisheries and Oceans Canada (DFO) as the lead federal authority in oceans related issues, and lays the groundwork principles for Canada's future management of its oceans.

The *Oceans Act* is based on the premise that oceans must be managed as ecosystems, and that all activities that occur within estuaries, coastal,

or offshore waters are managed through a collaborative effort by all stakeholders. Supporting principles include sustainable development, integrated management, and use of a precautionary approach. The *Act* also includes provisions for the establishment of Marine Protected Areas and the establishment of Marine Environmental Quality guidelines, objectives, and criteria.

The economic, social and cultural significance of the fishery to the lives of the residents of Newfoundland and Labrador requires that fishers, as key stakeholders, contribute to and collaborate in the management of ocean resources.

INTEGRATED MANAGEMENT (IM)

Integrated Management is an ongoing process which brings stakeholders together to collaboratively manage activities within and affecting the oceans and resolve/ prevent conflict. It incorporates the social, cultural, environmental, and economic values of the stakeholders involved.

COMMUNITY BASED COASTAL RESOURCE INVENTORIES (CCRIS)

In 1997 a program was initiated to develop an inventory of coastal resources which would form the basis for integrated management in the province. It was decided that a community-based approach would be adopted. This would ensure that communities were included and encouraged in the collation of local knowledge. A procedures manual for community based coastal resource inventories in Newfoundland and Labrador was developed in 1998 to guide the process.

Community groups, in partnership with Fisheries and Oceans Canada, have been involved in project planning, soliciting funding, training, project monitoring, and quality control. The primary focus of these projects has been the collection of information required in the management of the oceans. Individuals and groups targeted for interviews have included those having special knowledge, interests, or expertise in the oceans, including local environmental or recreational groups, diving clubs, and so on. However, local fishers have been the primary target group. The interviews have focussed on the collection of such information as the types of fish, marine mammals, marine plants, spawning areas, types of commercial fisheries, the locations of wharves, fish processing plants, and boat repair facilities, etc. The scope of the inventory may also include the collection of information of cultural and/or recreational significance, or any other category that time and money permit and local people consider relevant to the inventory. The deliverables of the Community based Coastal Resource Inventories include both a final hardcopy and digital report, along with a database of coastal resource information.

Information from the database can be extracted to create a series of atlases, or maps, illustrating key resource information. CCRIs have been completed for nearly the entire insular portion of the province and work has begun in Labrador.

Interested and affected stakeholders can use the coastal resource inventory information for planning economic development and diversification activities, and highlighting emerging eco-tourism, recreational, or fisheries prospects.

MARINE PROTECTED AREAS (MPAS)

Marine Protected Areas are areas that require special protection. In order for an area to be designated as an MPA under the *Oceans Act*, it must meet one or more of the criteria outlined in the *Act*. These include the conservation and protection of commercial and non-commercial fishery resources and their habitats, endangered or threatened marine species and their supporting habitats, unique habitats, areas of high biodiversity or biological productivity, or any other resource or habitat deemed to require special protection by the Minister.

MPAs have no minimal level of restrictions. Any activity restrictions are determined on a site by site basis by stakeholders in conjunction with Fisheries and Oceans Canada. MPAs can be flexible in time and size, and are important because they are proactive and precautionary, contribute to an ecosystem-based management approach, and form the basis for marine conservation, education, and research.

There are currently 3 pilot projects also referred to as Areas of Interest or AOIs under the Marine Protected Areas Program in Newfoundland and Labrador. Two of these are located on the island of Newfoundland in Eastport and Leading Tickles, while the third is located on the southern coast of Labrador in Gilbert Bay (see also Gosse *et al.* this vol). All of these initiatives were grass roots driven with proposals being received from local community sponsor groups requesting that these areas be considered under the MPA Program.

Eastport

On the Eastport Peninsula of Bonavista Bay, lobster fishers were concerned about declining lobster (*Homarus americanus*) catches. In 1995, they formed the Eastport Peninsula Lobster Protection Committee (EPLPC). They approached DFO with an interest in implementing conservation and protection measures that would promote a sustainable lobster fishery. The fishers implemented a program of v-notching[1] egg carrying females. The retention of v-notched lobsters is illegal, thus these spawners were excluded from the commercial fishery in subsequent years. Also, the fishers decided to explore the idea of closing areas to lobster fishing to promote egg production in local populations and increase recruitment. Local lobster fishers had great knowledge of the locations of potential juvenile lobster rearing habitat appropriate for such closures. They undertook consultations with other fishermen from surrounding communities to inform them of the committee's plans and to determine historical fishing boundaries. Subsequently geographical boundaries were established that recognized traditional fishing areas. Fishermen from the Eastport Peninsula created a management area in which they agreed to restrict their lobster harvest. Fishers from surrounding communities who did not have an historical claim to this area agreed not to fish within the boundary. In 1997, the EPLPC approached the DFO to close the area around 2 small islands (approx. 2 sq. km) to lobster fishing. By choosing Round Island and Duck Islands for closure the EPLPC hoped to strike a balance by maximizing the benefits of increased egg production and recruitment, while minimizing the number of fishers that would be impacted by displacement from these areas.

DFO staff have worked closely with the EPLPC and other partners including Memorial University of Newfoundland to monitor and evaluate these conservation and protection initiatives. These groups have collaborated on projects that include lobster tagging and the collection of detailed catch per unit effort information from lobster fishers. Based on commercial fishery monitoring (log books and at-sea sampling) and research around Round Island and Duck Islands, it is estimated that approximately 20% of the total population egg production in 1999 was attributed to v-notching and area closures (Ennis, G.P. personal comm.). This success illustrates how traditional knowledge and scientific knowledge can complement and enhance each other.

1 A 'V-notch' is punched out of the tail of female lobsters. This notch persists through successive moulting so that females can always be identified and returned to the sea.

In 1999, the EPLPC submitted a proposal requesting that DFO consider Round Island and Duck Islands under the Marine Protected Areas Program. Following an internal review of the proposal, the Round Island and Duck Islands were officially identified as Areas of Interest or pilot projects on October 13, 2000. Building on their success, the EPLPC is now considering expanding their conservation and protection initiatives to include other species such as lumpfish (*Cyclopterus lumpus*) and sea urchins (*Strongylocentrotus droebachiensis*). The Department is working with the fishers in setting up a Steering Committee co-chaired by a representative from the fishers committee and DFO. This steering committee would be comprised of representatives from interested and affected stakeholder groups such as the local town councils, provincial government departments, tourism associations, schools, etc. with the local fishers as the sponsor group being most represented. DFO would assist the Steering Committee in undertaking public consultations, developing a management plan for the area, soliciting funding, etc. The Steering Committee members, including the local fishers, would provide local knowledge and expertise in identifying potential conflicts, identifying information gaps, providing project coordination, etc. Local fishers support the inclusion of other stakeholders on such a steering committee recognizing that it will add breadth and depth to the management of local oceans resources and the potential for economic spin offs that would benefit the community.

DFO has used this success in Eastport as an example for other groups interested in similar initiatives, not only from a scientific or technical perspective, but to illustrate the importance of community support and resource stewardship, transparent consultations, and information exchange.

Gilbert Bay

In Labrador, the residents of the communities of Port Hope Simpson and William's Harbour have expressed concern about the status of a genetically distinguishable population of Atlantic cod that resides year round in adjacent Gilbert Bay.

Historically, migratory northern cod would intermix with cod from Gilbert Bay in the outer portions of the bay where a trap fishery was prosecuted. Despite the moratorium, the numbers of migratory Northern cod in this area have not returned to historic levels. With the

opening of the commercial index fishery in 1998, significant fishing effort has been directed solely at the Gilbert Bay population, whereas historically fishing pressure was shared between both stocks.

Residents of the local communities of Port Hope Simpson and Williams Harbour approached DFO to consider Gilbert Bay under the Marine Protected Areas Program and on October 12, 2000, this site was officially identified as an Area of Interest or pilot project. As with Eastport, the sponsor groups are currently working with DFO to set up a steering committee, undertake consultations, and develop a management plan.

Staff from Memorial University of Newfoundland have been conducting research in Gilbert Bay for several years and have worked closely with the sponsor groups and DFO. The Department recently interviewed fishermen from the area using a semi-structured approach guided by a questionnaire (Morris et al., 2001). Until recently, little fisheries information had been recorded in Gilbert Bay so the traditional knowledge gained as a result of these interviews was helpful. Fishers were asked about specific topics including background information, fishing methodologies, and commercial and non-commercial fish stock status. In addition, general discussion and dialogue was encouraged and in many cases, those being interviewed asked as many questions as the person conducting the interview. Those interviewed had questions about the Gilbert Bay cod, and the role of the Marine Protected Area with respect to commercial fishing activities. It was noted that some fishers were more inclined to share information in an informal setting as opposed to a public forum. Additional discussions after the interview often revolved around the importance of information transfer between scientists and local resource users. As limited fisheries information had been recorded in the area, the traditional knowledge gained as a result of these interviews helped determine the species of fish present in the area, types of commercial fisheries, and the types of gear used. Traditional knowledge was also compared to scientific information to see if similar observations or trends were supported.

Leading Tickles/Glovers Harbour

A coastal area adjacent to the town of Leading Tickles, located in Notre Dame Bay, is the third Area of Interest under the Marine Protected Areas Program in the province. In 1997 the local fishers committee and the Town of Leading Tickles submitted a proposal to DFO requesting that the Leading Tickles/ Glovers Harbour area be considered under the Marine Protected Areas Program. On June 8, 2001 the Minister officially identified the site as an Area of Interest. Fishers expressed a desire to promote a sustainable fishery resource, particularly for lobster, flounder (*Pseudopleuronectes americanus*) and cod, and to protect critical habitats. Using the Eastport example as a model, the fishers decided to initially concentrate on lobster conservation. Discussions were held regarding the possible future closure of some areas surrounding Leading Tickles to lobster fishing. Potential sites for closure were chosen by fishermen given their knowledge of local juvenile lobster rearing habitat, prevailing winds, and currents. Sites chosen included small islands and sheltered coastal areas. DFO staff, representatives of the sponsor groups, and staff from the local economic development corporation worked together to implement a lobster tagging and retrieval project. A lobster logbook program was also developed whereby local lobster fishers would record catch and fishing effort data to establish baseline information from which to monitor future conservation and protection initiatives. In order to create more detailed maps the collection of georeferenced bathymetric information was initiated around specific islands and coastal areas. These maps will be used in the future to create grids and assist in the collection of detailed habitat information such as substrate type and composition, presence/ absence of aquatic vegetation, etc. using underwater cameras and divers.

Bilateral consultations have begun with potential stakeholders, and a steering committee has been formed and has had its first meeting. The mission statement for the area has been developed by the fishers and town council and reads "To work in partnership with stakeholders to develop, enhance, and manage the future of local fishery resources and supporting habitats". As with the other projects, the steering committee is co-chaired by a representative from the sponsor groups and DFO.

CONCLUSION

These are just a few examples of how the knowledge and expertise of local fishers can be used in ocean management. Both scientific and traditional knowledge are important and the benefits of availing both in collaborative efforts is apparent.

While the fishery still plays an integral role in the economy and culture of Newfoundland and Labrador, other users of ocean space are emerging. *Oceans Act* initiatives such as the compilation of coastal resource inventories and

the siting of marine protected areas require the involvement and support of both local fishery interests and other emerging interests in coastal communities.

REFERENCES

Anderson, T.C. 2001. The role of coastal communities in integrated coastal zone management, Newfoundland and Labrador, Canada. Fisheries and Oceans Canada. Paper presentation. Integrated Coastal Zone Management Workshop. May 14-16, 2001.Universidad de Oriente, Santiago de Cuba, Cuba.

Ennis, G.P. Personal Communication. Science, Oceans, and Environment Branch, Fisheries and Oceans Canada, St. John's, NF Canada

Morris, C., J. Simms, and T. C. Anderson. 2001. Overview of commercial fishing in Gilbert Bay, Labrador; fishers local knowledge and biological observations. Can. Manuscript Rep. Fish. Aquat. Sci. (submitted)

O'Brien, J.P., M.D. Bishop, K.S. Regular, F.A. Bowdring and T.C. Anderson. 1998. Community-based coastal resource inventories in Newfoundland and Labrador: Procedures Manual. Published by Fisheries and Oceans, Marine Environment and Habitat Management Division, P.O. Box 5667, St. John's, NF Canada A1C 5X1. 65p.

Statistics Canada. 2000. http://www.statscan.ca

QUESTIONS:

Chad Paul: My question has to do with your comments on traditional knowledge and the socio-economic overview. When you speak of Traditional Ecological Knowledge, are you referring to aboriginal people as well, or just fishermen?

Annette Power: In Labrador, most fishermen are aboriginal and they will certainly be included.

Chad Paul: Will they be included in the socio-economic component as well?

Annette Power: The department's role is to lead facilitation of the Oceans Act's initiatives. We contribute funding to them. We told the groups that are interested in establishing MPAs that that we will look at the bio- and socio-economic overviews. These overviews are compilations of existing information. Once the information is compiled, the steering committee, in which aboriginal groups are encouraged to be involved, will identify information gaps and guide the resources that we'll spend in the future.

James Bryant: Why is it that fisheries take information from local fishermen only when there is complete collapse of fisheries on both coasts? Fishermen have tried to work hand in hand with fisheries managers, but they don't take their knowledge into consideration.

Annette Power: I'm not in a position to answer that.

Closing the Loop: Commercial Fish Harvesters' Local Ecological Knowledge and Science in a Study of Coastal Cod in Newfoundland and Labrador, Canada

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Abstract

The intercouncil SSHRC/NSERC research project Coasts Under Stress (CUS) is investigating historical use and management of natural resources (e.g. fish stocks, forests and gas-oil reserves) on the east and west coasts of Canada, focusing on interactions between changes to the natural environment and social changes, as well as the ways these have affected human and environmental health. One goal of CUS is to document the local ecological knowledge (LEK) of resource users in order to investigate how LEK and science combined can help us understand changes in environmental health and develop effective strategies for future ecological recovery. LEK is a rich source of information on natural resources that is often not readily available in written form. Scientists often overlook the value of LEK for documenting long-term trends in local resource availability and the factors responsible for those trends.

The ecological knowledge of fish harvesters consists of facts obtained through firsthand experience during years of observation while fishing. Harvesters' inductive-deductive reasoning, however, may lead to an incomplete understanding of how nature works. The value of the scientific approach to understanding nature lies in the rigors of hypothesis testing, which exposes those areas of a paradigm where knowledge is incomplete. Thus LEK, when integrated with results derived from formal scientific research, can often provide a fuller understanding of the natural environment and more complete information for management decisions. This paper diagrams the benefits of this two-way flow of information between scientists and local experts. Our research methodology combines scientific and harvesters' knowledge of cod coloration to obtain a fuller understanding of the stock structure of coastal cod in Newfoundland and Labrador, Canada.

Introduction

In the process of living and working in marine environments, fish harvesters acquire a detailed knowledge of that environment and their local fish resources. In general little of this information has been used within scientific study relative to what is available, or to what might be used (Berkes 1993, Pinkerton 1994). The participation of fish harvesters in research is usually not explicitly acknowledged as a methodological approach in scientific publications (Fischer 2000). Fisheries scientists have generally not systematically collected, recorded and evaluated the knowledge from harvesters. In addition, where more systematic LEK research *has* been carried out, this research has rarely been followed up or combined with systematic scientific research intended to verify, where possible, the observations and interpretations of harvesters and to extend this knowledge (for an exception to this general pattern, see Sutton 1998).

With the failure of management plans to prevent the collapse of the cod fishery on the east coast and the salmon fishery on the west coast of Canada, many fish harvesters have lost faith in the ability of scientists as well as government to protect their livelihoods (Coward *et al.* 2000). This lack of confidence, manifested by industry wanting more say in issues that concern it, makes it imperative to devise new approaches to stock assessment and management (Gendron *et al.* 2000). One approach is the active involvement of local experts with scientists and managers in research activities and management planning.

Finding ways to compare fish harvesters' observations and data drawn from more traditional scientific sources could improve the potential for more informed and more accepted decisions of stock status and management (Neis *et al.* 1999a). This paper outlines a framework for how LEK and science can be combined to produce effective knowledge about fisheries and fish ecology. It then uses the CUS coastal cod project to illustrate the basis for this general argument. The primary goal of the coastal cod project is to use a combination of LEK and science to identify locations along the northern peninsula and west coast of Newfoundland and along the southeast coast of Labrador where coastal populations of Atlantic cod (*Gadus morhua*) may exist or may have existed in the

past. Towards this end we investigate the reliability of cod coloration as an index of bay stocks.

ELEMENTS OF LEK

The ecological knowledge of resource users consists of facts obtained from firsthand experience during years of observation and interaction with their local environment. Fishery resource users develop a detailed knowledge of their resources, their environments and their fishing practices (Neis *et al.* 1999a; 1999b). Throughout their careers, fish harvesters observe fish morphology (e.g. coloration and body size), fish behavior (e.g. spawning and migration), trends in fish landings and changes in fishing effort. From patterns and trends observed over time, many fish harvesters use a process of inductive-deductive reasoning (Figure 1) to distinguish between different runs of fish, to explain observed behavioral differences and changes in behavior, and to account for trends in abundance and effort. They then make predictions about the state of resources and arrive at assessments of different management initiatives. This inductive-deductive reasoning of harvesters, however, is limited where it lacks means to validate deductions and interpretations about how nature works and how nature interacts with human behavior.

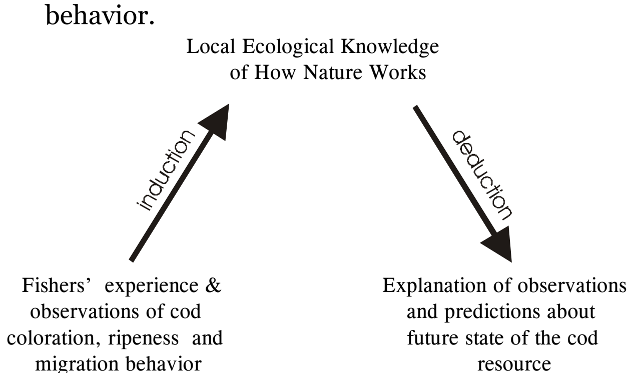

Figure 1. The inductive-deductive method of reasoning used by many fish harvesters to distinguish between different types of cod, to explain and account for their observations and to make predictions and assessments about the future state of the cod resource.

Scientific Hypothesis Testing

The value of the scientific method of investigation lies in the rigors of hypothesis testing, which can test the validity of theories through experimentation and field studies. This involves the checking and rechecking of procedures, elimination of sources of error, and further testing by colleagues of experimental or field study results published in journal articles. Theories are then refined or refuted on the basis of how well they stand up to this testing. Occasionally new theories arise to replace existing theories. Through the scientific method (Figure 2) science closes the induction-deduction loop of knowledge development used by fish harvesters, providing a more complete understanding of nature.

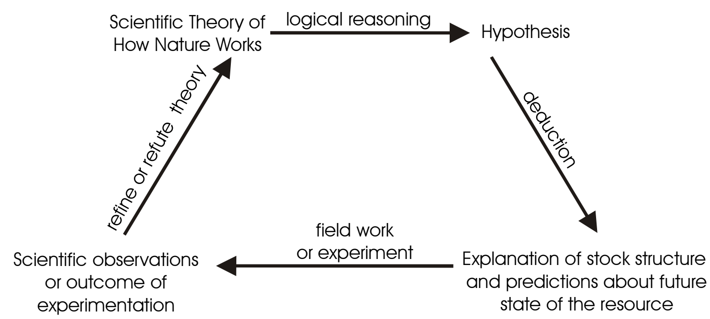

Figure 2. Method of hypothesis testing used by fisheries scientists to validate theories regarding stock structure (adapted from Wroblewski 1983). Science closes the loop of inductive-deductive reasoning used by many fish harvesters.

However, despite its strengths, there are many limitations to science. A major limitation can be an insufficient observational base to verify theories and scientific hypotheses. Such a situation may result from the monetary and time constraints that often limit the amount of scientific research that can be conducted (Fischer 2000), and from limits in the spatial and temporal scale of scientific observations. In this context, the knowledge and observations of local resource users can supply a wealth of information for scientific hypothesis testing.

Temporal and Spatial Dimensions of LEK and Scientific Knowledge

Scientific knowledge is often based on sporadic observations covering large spatial scales whereas local expertise is based on continuous observations within small local fishing areas (Fisher 2000). The strength of fish harvesters' knowledge lies in their years and sometimes generations of continuous interaction with local environments, whereby they acquire a wealth of information that is often not readily available to science. The strength of science lies in the rigorous procedures that allow scientists to test some of the assumptions found in harvesters' knowledge and the validity of their interpretations. Science can do this by trying to "extract" LEK from harvesters and then testing it, but a potentially more fruitful approach involves scientists and fishers working together in participatory research projects (Fisher 2000). Joint research teams combine LEK and scientific

knowledge, leading to a more complete understanding of nature and the effects of our interactions with nature.

Fish Harvesters LEK, Science and Management

The observations and detailed information fish harvesters provide, combined with the method of validation used by science, allow for improved predictions and assessments of the state of our marine resources. Through this two-way flow of information, scientists and harvesters can work together to provide a more detailed assessment of stock structure to be used in management decisions for utilization and conservation of the resource (Figure 3). Harvesters, scientists and managers potentially benefit from management regimes that are based on more informed estimates of the state of our resources and shared responsibility for management or stewardship (Felt, Neis and McCay 1998). It is this flow of information we are attempting to achieve with the Newfoundland and Labrador coastal cod project we are carrying out with the Coasts Under Stress research program.

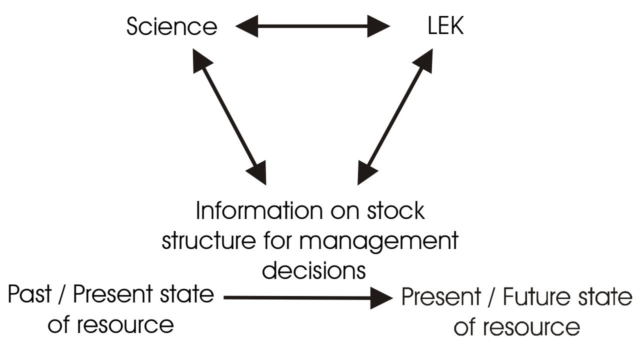

Figure 3. Idealized flow of information between local resources users, scientists, and managers.

Case Study – Newfoundland and Labrador Coastal Cod

Since the collapse of the northern Atlantic cod stock in the early 1990s, most of the adult cod remaining in Newfoundland waters are found in coastal areas. Historically, offshore components of northern cod stock would migrate to the coast in a summer feeding migration (Rose 1993),and contribute to the inshore catch during summer and fall (Lilly 1996). These fish would then migrate back offshore to overwinter and spawn near the edge of the continental shelf (Myers *et al.* 1993; Wroblewski *et al.* 1995) (Figure 4). During the summer feeding period, cod from offshore components would mix with inshore cod, which are year-round residents of coastal waters (Ruzzante et al 1996; 1997). Before being decimated by overfishing between the 1960s and the 1990s,(Hutchings and Myers 1995; Myers *et al.* 1997), the offshore components constituted the major portion of the population (Lear and Parsons 1993). Coastal components associated with the bays and headlands of the coastline, Templeman and Fleming 1956; 1963) had been documented but were considered of minor importance in managing this resource (Lilly 1996). In Newfoundland and Labrador, as elsewhere and with different marine species, cod were managed in very large spatial units and, within these, were treated as though they were panmictic (Wilson and Kornfield 1997). As a result, until recently, limited effort was directed towards the systematic scientific study of coastal components and there were no separate management units for such components.

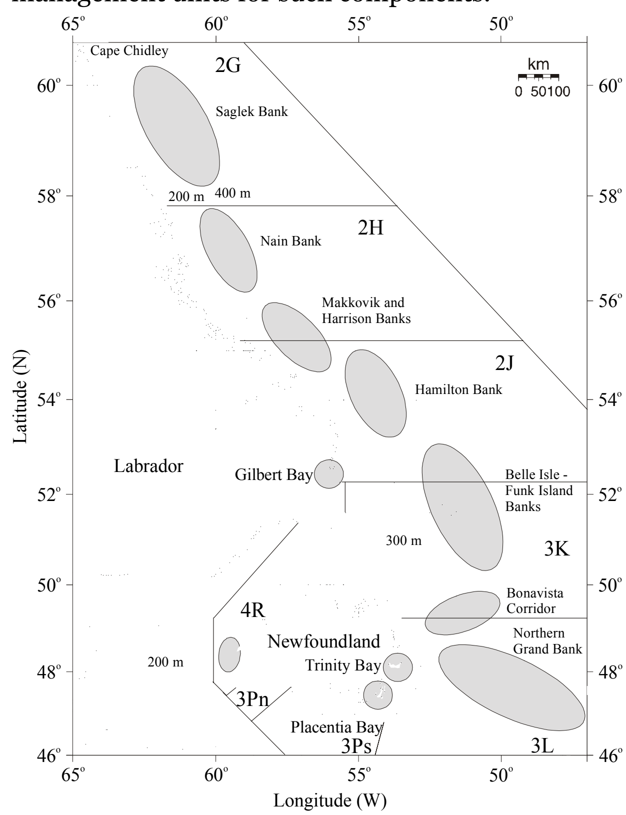

Figure 4. Bathymetric chart of the Newfoundland and Labrador shelf, showing the major banks and the Northwest Atlantic Fishery Organization (NAFO) management units (2GHJ, 3KL, $3P_sP_n$, 4R). Shaded regions represent the approximate locations of subpopulations of Atlantic cod, associated with scientifically documented inshore and offshore spawning grounds (modification of Fig. 1 in Smedbol and Wroblewski, in press).

The collapse of the offshore components of the northern cod stock off Newfoundland's northeast coast and the coast of Labrador in particular, (Atkinson *et al.* 1997; DFO Science Stock Status Report 2001), and scientific and harvester documentation of aggregations of cod in the major bays of eastern and southern

Newfoundland (Rose 1996; Smedbol *et al.* 1998) have heightened scientific interest in the population structure and ecology of coastal cod. Recent research has indicated that inshore overwintering/spawning components exist in Trinity (Smedbol and Wroblewski 1997) and Placentia Bays (Bradbury *et al.* 2000), Newfoundland and in Gilbert Bay, Labrador (Ruzzante *et al.* 2000; Green and Wroblewski 2000) (Figure 4). Research has also revealed that populations of Atlantic cod inhabiting the marine waters off Newfoundland and Labrador consist of genetically distinct offshore and inshore or coastal spawning components (Taggart *et al.* 1998 and references therein). This research suggests that these localized spawning groups may be relatively independent subpopulations. Such populations may have been endangered after the collapse of the commercial fishery offshore when fishing effort was redirected towards these inshore areas. This has critical management implications. In order to manage such stocks effectively, it is necessary to assess them independently, understand their relationship to other populations and establish a management regime that will prevent localized overfishing and promote the recovery of depleted local stocks (Wilson and Kornfield 1997).

Table 1. Categories of Newfoundland and Labrador cod, based on overwintering and spawning habitat, post-spawning migratory behavior, and body coloration.

Overwintering habitat	Location of spawning grounds	Post-spawning migratory behaviour	Colouration
1. Offshore- continental shelf [1]	continental shelf [1]	migrates to coast to feed [1, 2]	countershaded [3]
2. Offshore- continental shelf [1]	continental shelf [1, 2]	non-migratory - remains on shelf [1]	countershaded [3]
3. Inshore- bays (e.g. Trinity, Placentia, Gilbert Bay) [4,5]	bays [5,6,7]	remains at coast [3, 4]	countershaded (deep) brown (shallow) [8,9,10]
4. Coastal- headlands [3]	coastal deeps [11]	remains at coast [11]	countershaded [3]
5. Salt-pond (e.g. Holyrood Pond; Occasional Hr.) [12]	salt ponds [12]	non-migratory, landlocked [12]	brown [12]
6. Inshore juveniles -bays and coast [11]	no spawning (juveniles of types1-4) [11]	immature- non-migratory [11]	brown[13]

In recent years, some scientists researching local stocks have drawn on information from fish harvesters obtained either directly from these harvesters or from published sources quoting these harvesters (Ames 1997, Wroblewski 2000; Maurstad 2000). Over the past decade, LEK research in Trinity, Bonavista, Placentia and Fortune Bays and historical, archival research involving documents quoting fish harvesters, have provided information related to inshore populations of cod as well as to factors fish harvesters have associated with trends in those populations (Hutchings, Neis and Ripley, forthcoming; Neis *et al.* 1999b). Previous work with harvesters (e.g. Neis *et al.* 1999b) and recent scientific work (e.g. Green and Wroblewski 2000; Ruzzante *et al.* 2000), suggest the presence of six categories of cod in Newfoundland and Labrador, distinguished by overwintering and spawning habitats, post-spawning migratory behavior and coloration on their wintering grounds (Table 1). For our research we are interested in the different coloration of cod in each of these six categories.

[1] Templeman 1974,
[2] Lear 1984
[3] Templeman 1966
[4] Green and Wroblewski 2000
[5] Smedbol *et al.* 1998
[6] Morris 2000
[7] Lawson and Rose 2000
[8] Neis *et al.* 1999b
[9] Wroblewski 2000
[10] Bradbury, I. pers. comm., Memorial University of Newfoundland. September 2001.
[11] Templeman 1979
[12] O'Connel *et al.* 1984
[13] DFO 1995

Although significant variation exists between individual fish, there are two general color patterns, countershaded and brown, that dominate. Countershading, a color phenomenon of gradual shading from light underneath to darker on the back, is seen in cod inhabiting deep (100-500m) waters (Table 1 categories 1-4; Figure 5). Countershading provides camouflage to a pelagically swimming cod in deeper offshore waters, as well as in deep water trenches of some bays and off headlands.

Figure 5. Countershading provides camouflage to a pelagically swimming fish in deep waters.

Distinct from this, shallow water cod have a characteristic red to yellow-brown coloration (Table 1 categories 3,5-6; Figure 6). These cod are generally referred to as brown cod. The brown coloration allows the fish to blend in with its shallow water habitat, a phenomenon known as adaptive coloration. Brown colored cod are found in shallow water bays and salt-ponds. The recently identified cod in Gilbert Bay are often reddish or golden-brown. These represent a genetically distinct population of cod (Ruzzante *et al.* 2000) that were first recognized by local resource users based on their presence year-round and their distinct coloration (Wroblewski 2000). Scientific research suggests the red-brown coloration results from an abundance of red pigments (carotenoids) obtained through ingestion of invertebrates containing carotenoids synthesized by plants and passed through the food chain (Wroblewski 2000).

Figure 6. Brown coloration in inshore Atlantic cod.

This research illustrates that LEK is valuable in discerning stock structure in Newfoundland and Labrador cod (see Wroblewski 2000). The discovery of a genetically distinguishable population of cod in Gilbert Bay implies that other such populations may exist or may have existed in the past in similar oceanographic areas in Labrador and coastal Newfoundland. Our knowledge of fish coloration and the fact that color is readily observable leads us to ask whether or not cod coloration can be used as a reliable indicator of stock components.

Fish coloration is very complex, changeable, and many gradations of color exist between the two general patterns shown in Figures 5 and 6. This fluidity is widely recognized by fish harvesters. Indeed, one fisherman noted during an interview:

> *"There's a lot, they're not all the same thing. You know what I mean, not all the same color… There's no one of the cod all the same color"* (unpublished research transcript #7, 2000).

For a discussion of some harvester observations of cod coloration see Neis *et al.* (1999b), Hutchings *et al.* (1995) and Potter (1996). Nonetheless, color has been successfully used to indicate bay-scale population structure in Gilbert Bay, which in turn prompted the necessary scientific research that distinguished these cod from other populations (Wroblewski 2000). The identification of bay stocks, such as the one in Gilbert Bay, has implications for management. Recently, Gilbert Bay has been declared an "Area of Interest" under DFO's Marine Protected Areas (MPA) program (DFO press release, 13 October 2000) and efforts of scientists and local residents are now directed toward establishing Gilbert Bay as eastern Canada's first MPA. A goal of the CUS coastal cod project is to combine fish harvesters' knowledge with scientific knowledge to identify other locations in coastal Newfoundland and Labrador where local inshore stocks of cod may exist or may have existed in the past. For the purpose of this paper, an inshore stock of cod is defined as cod that are resident in the inshore environment year-round (i.e. overwinter, spawn, and feed inshore; category 3 in Table 1).

Our attempt to identify other inshore populations of cod began with interviews of retired fishermen in areas along the coast of southern Labrador and northern Newfoundland. Interviews with fish harvesters living between Lark Harbour, Newfoundland and Cartwright, Labrador, were conducted to learn about the location and history of inshore Atlantic cod. Retired fishermen, 26 in total, were interviewed during 2000. These interviews were conducted to create a baseline of information from which to generate further questions and research objectives. Information recorded was from

memory and not from logbooks or other sources. Interviews were tape-recorded. Interviewees were shown a series of pictures of different fish species and asked questions and encouraged to talk about whether they had observed the species. If so, harvesters were asked where they had seen them, what time of year, and if they had noticed any changes in abundance over time. Many questions were asked regarding spawning and migration patterns for cod.

To obtain information on inshore cod, color was used as an entry point into a discussion of cod stock structure. Interviewees were shown a picture of the reddish-brown Gilbert Bay cod and asked whether they had seen cod like this in the area where they fished. Positive responses led to further discussion about the abundance of these brown cod, what time of year they had seen them, if they fished them, where and how they were caught (i.e. if they ever fished for them through the ice) and also whether they had seen them in a ripe condition (i.e. running with eggs or milt). This discussion provided information on the historical presence/absence of inshore cod. As anticipated, interviewed fishermen from southern Labrador and coastal Newfoundland were very knowledgeable about cod within the region. Most had heard of, or had seen, what they referred to as "bay cod" and were able to differentiate between resident inshore cod and migratory offshore cod by color and season of capture. Various names were used by fishers to refer to these inshore cod including foxy, red and shoal-water cod, kelp fish, or simply brown cod. Here are comments from two fishermen interviewed:

> *"You get the black cod. You go up where they calls up there off of L'Anse aux Meadows... There's shoal water there, four or five fathom of water... seem like that fish stays on that ground there.... Kelp fish, some people calls them. The old people call them shoal water fish right."* (unpublished research transcript # 7, 2000).

> *"I've seen red cod... In the fall, odd one we caught it..... Just call them red cod"* (unpublished research transcript #5, 2000).

From our interviews we generated maps plotting reported locations where inshore cod had been observed by fishermen throughout their fishing careers. Areas where there was an indication of overwintering brown cod were Lark Harbour and Bonne Bay, Newfoundland (Fig 7a) and St. Lewis Sound, Occasional Harbour and Sandwich Bay, Labrador (Fig 7b).

Harvesters' explanations for the occurrence of these brown colored cod vary. Some speculate

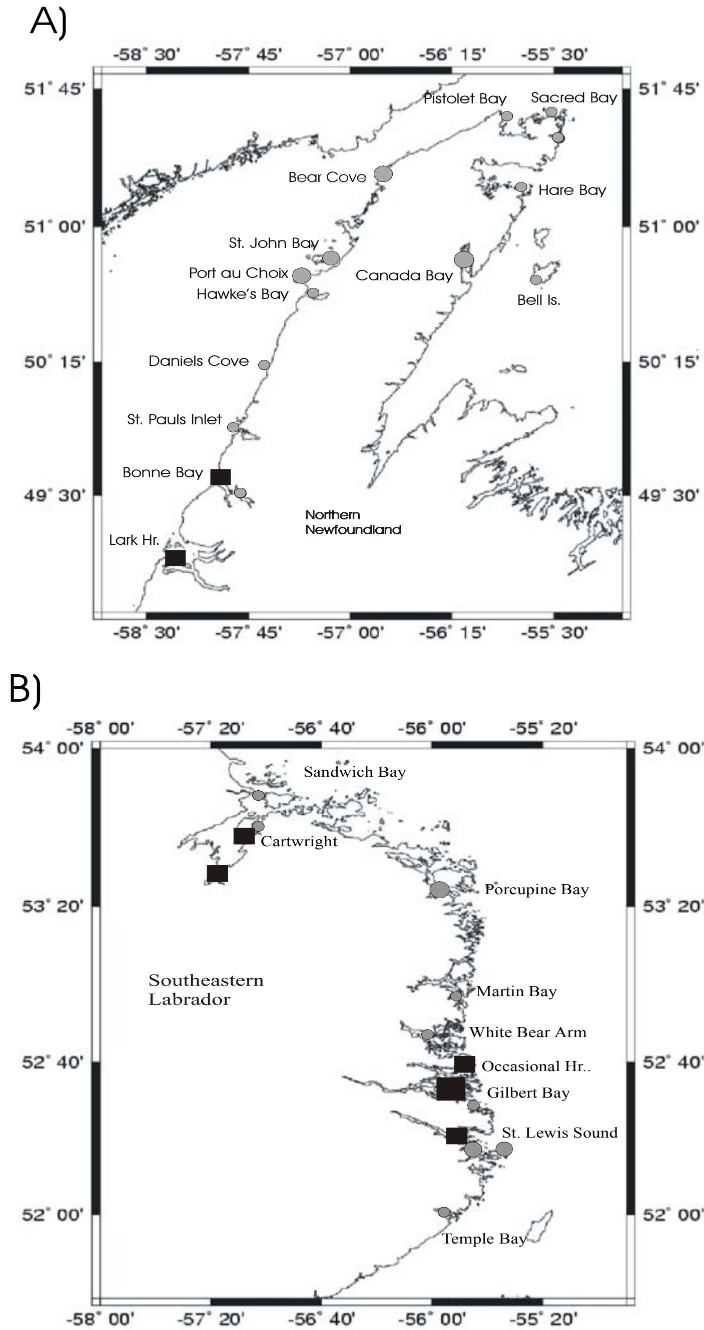

Figure 7. Enlargement of (a) the northern peninsula of Newfoundland and (b) southeastern Labrador, showing locations of brown cod sightings, a possible indication of a local population, revealed from interviews with retired fishermen. Circles represent areas where cod were observed at various times of the year and squares represent areas where there was an indication of overwintering brown cod. The size of the circles/squares suggests the amount of detail surrounding the observation (the certainty of each sighting) where larger shapes represent a greater amount of information.

that their distinctive color has to do with migration into freshwater. Others mention the

influence of diet, bottom substrate, water coloration (clear vs. murky), duration in freshwater, or the presence of kelp. One fisherman in particular was quite eager to offer his opinion:

> *"Do you want me to tell you the reason that cod got a different color from that one? That [brown] fish was caught in shoaler water than this one. This fish came up out of the deep water, [the one] with the white belly"* (unpublished transcript # 10, 2000).

Interviews also suggested that some fish harvesters believe offshore, countershaded cod move into the bays to feed during the spring/summer and change color (become either darker or more brown in color). One noted:

> "*If it's in shallow water so long, it will turn right dark...I always thought that the fish changed its color when it came in shoaler water and I can't believe anything else.*"(unpublished research transcript # 10, 2000).

Another fisherman, when asked when brown cod would be observed, commented:

> *"Brown ones? In the summer time. They get into the bay, up at the end with freshwater. They used to turn it then, they turn burnish a bit eh? That's in the fresh water see?"* (unpublished research transcript # 16, 2000).

Our research raises the question "how can fishers' knowledge of cod coloration be used to indicate the existence of local bay stocks of Atlantic cod?" Using a combination of information from local experts in the area and scientific literature about fish coloration, a color change experiment has been conducted in an attempt to answer this question. In particular, this study considers the questions "How quickly does cod coloration change?" and "To what extent?"

In August 2001, scientists and students from Memorial University, and local fish harvesters from Williams Harbour and Port Hope Simpson, Labrador, worked together to set up a color change experiment. Our goal was to capture what harvesters refer to as offshore colored and inshore colored cod to document if, and to what extent, color changes over time. Harvesters from the area set up holding pens at a location near the mouth of Gilbert Bay (Figure 8, location A). One resident of Williams Harbour was hired to take university researchers fishing in areas known by local residents to be "good fishing grounds." Most residents in the area were interested in our research and participated by providing helpful advice and comments that aided the success of the experiment.

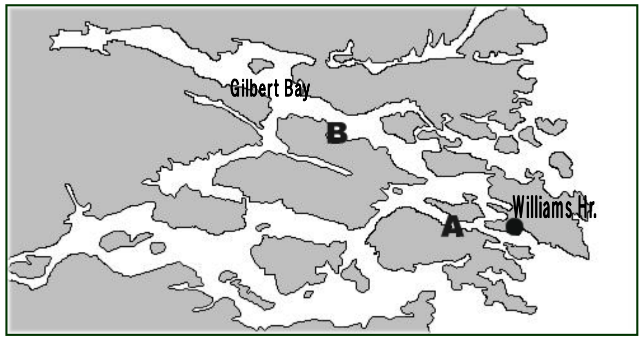

Figure 8. Map of Gilbert Bay showing locations of fish pens from August-October 2001 (A) and October 2001-Spring 2002 (B).

In total, 238 Atlantic cod were captured live and placed in holding pens in Gilbert Bay. Of these fish, 95 were considered by residents to be undoubtedly offshore cod and 73 unmistakably Gilbert Bay cod. Each individual fish was tagged for later identification, measured and weighed, and given a score based on color (ranking from 1-5, where 1 is a countershaded offshore cod, 3 is a brown cod and 5 is a cod with significant red pigmentation), photographed at the time of capture, and placed in a holding pen. Fish were fed a diet of capelin and herring. A second examination of each individual fish took place in October 2001. Lengths, weights and photographs were taken and each fish was again given a number based on color. Additionally, blood samples were taken from each individual. Some fish were sacrificed to obtain otoliths for length at age analysis. The fish were relocated to overwinter at a second location further up within Gilbert Bay (Figure 8, location B).

Visual analysis in October revealed a change in color had occurred, in particular among the brown colored cod. Average initial and final color (based on the color scale of 1-5) for both groups (brown and countershaded) were calculated to quantify the observed change. The average color of the initially countershaded cod decreased from 2.1 to 1.7, indicating these fish became slightly more countershaded in appearance. The change in color of the brown cod was more significant. The average color score of the initially brown cod decreased from a

3.6 to a 2.3. Thus, the "inshore" cod had lost their brown coloration and become countershaded in appearance. Our results demonstrate that if inshore cod are fed a piscivorous diet (a typical offshore diet primarily of capelin), in less than 2 ½ months the brown coloration would be lost. Or restated, the brown coloration results from cod in the bay environment feeding on a diet of crustaceans and other invertebrate species rich in carotenoids.

DISCUSSION

Our interviews revealed that fish harvesters possess a wealth of knowledge concerning cod coloration, spawning behavior and migratory patterns, and that color can be used as an entry point into a discussion that provides information critical to the understanding of stock structure. Fish harvesters' knowledge of cod coloration and migration patterns (i.e. non-migratory bay cod and migratory offshore cod) set the rationale for our color change experiment.

Coloration in fishes is primarily due to skin pigments. A fish acquires its red, yellow and orange pigments (carotenoids) through food – the only way they can obtain them (Bagnara and Hadley 1973). The reddish-brown coloration of Gilbert Bay cod results from a diet rich in carotenoid-containing invertebrate species (Wroblewski 2000). Morris (2000) has shown that cod in Gilbert Bay feed predominantly on benthic invertebrates such as shrimp and mysids, amphipods and various crab species. In the color change experiment, fish were held in net pens and fed a diet of capelin and herring. The loss of red coloration from experimental fish confirms the role of diet in the coloration of Gilbert Bay cod. Despite the information available on fish coloration, there is no known scientific literature investigating coloration as an indicator of stock structure in Newfoundland cod. Our research suggests two hypotheses: 1) brown cod represent offshore cod that came into the bays in spring/summer, feed on carotenoid-rich invertebrates, and turn brown; 2) brown cod represent cod that remain in the bays year round, feeding predominantly on carotenoid rich benthic invertebrates.

The paradigm surrounding the behavior and migration of northern cod (i.e. offshore cod migrate inshore guided by migrating capelin on which the cod feed (Lear and Green 1984) does not support the first hypothesis. Research in Bonavista Bay has shown that offshore cod migrating inshore in the spring feed intensively and almost exclusively on capelin (Lilly and Botta 1984). This suggests that an offshore cod migrating inshore and acquiring a reddish-brown coloration is possible but unlikely due to the preference for a capelin diet. The results from the color change experiment demonstrate that a reddish-brown cod will lose its red color in a period of less than 2 ½ months when feeding on a piscivorous diet. Harvesters' observations of brown cod, therefore, are indicative of cod that were at the time of the observation, or had recently been, feeding on invertebrates in the inshore environment. Whether or not cod stay year round in the bays cannot be determined on the basis of brown color alone. Note that cod resident in the deep waters of Trinity Bay are countershaded (see category 3, Table 1). Overall, a brown coloration suggests that cod are of the inshore group rather than the offshore group. As such, that cod is of concern to management plans for inshore stocks.

CONCLUSIONS

Commercial cod fishers use their experience and observations to explain patterns and trends in the fishery. The detailed observations related to fish coloration, spawning and migration they acquire are highly valuable to science. This knowledge, however, has to be blended with scientifically rigorous forms of research that close the induction-deduction loop, providing a more complete understanding of nature. Local ecological knowledge of brown cod, when integrated with a formal scientific study of cod coloration, can play an important role in the identification of local stocks of cod. The variability of coloration, however, allows us only to make general conclusions regarding the duration of cod in the inshore environment through its diet of benthic invertebrates. Thus color is a useful, but not-conclusive indicator of cod stock structure. The existence of a genetically distinct population of cod in Gilbert Bay suggests that populations may be present in other bays in Newfoundland and Labrador. Further research is needed to identify the location and status of these populations, and new management strategies that preserve these fish populations, such as the establishment of marine protected areas, should be encouraged.

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REFERENCES

Ames, E.P. 1997. *Cod and haddock spawning grounds in the Gulf of Maine from Grand Manan Channel to Ipswich Bay*. In *The implications of localized fishery stocks. Editors* Hunt von Herbing, I., Kornfield, K., Tupper, M. and Wilson, J. Ithaca, N.Y.: NRAES, 55-64.

Atkinson, D.B., Rose, G.A., Murphy, E.F. and Bishop, C.A. 1997. Distribution changes and abundance of northern cod (Gadus morhua), 1981-1993. *Canadian Journal of Fisheries and Aquatic Sciences*. **54**(Suppl. 1): 132-138.

Bagnara, J.T. and Hadley, M.E. 1973. Chromatophores and color change. Englewood Cliffs., N.J.: Prentice Hall.

Berkes, F. 1993. Traditional Ecological Knowledge in Perspective. In *Traditonal Ecological Knowledge: Concepts and Cases*. Ottawa: Canadian Museum of Nature, International Program on Traditional Ecological Knowledge.

Bradbury, I.R., Snelgrove, P.V.R. and Fraser, S. 2000. Transport and development of eggs and larvae of Atlantic cod, *Gadus morhua*, in relation to spawning time and location in coastal Newfoundland. *Canadian Journal of Fisheries and Aquatic Sciences*. **57**: 1761-1772.

Coward, H., R. Ommer, and T. Pitcher. 2000. *Just Fish: Ethics and Canadian Marine Fisheries*. ISER Books, Memorial University, St. John's. 304p.

Department of Fisheries and Oceans. 1995. *Coastal Zone Species Profile No. 11: Juvenile Atlantic cod*. Ottawa: Fisheries and Oceans Canada.

Department of Fisheries and Oceans. February 2001. *DFO Science Stock Status Report A2-01*. Fisheries and Oceans Canada Newfoundland Region.

Felt, L., Neis B. and McCay, B. 1998. *Comanagement*. In *Northwest Atlantic Groundfish: Management Alternatives for Sustainable Fisheries. Editors* Boreman, J., Nakashima, B.S., Wilson, J.A. and Kendall, R.L. Bethesda: American Fisheries Society.

Fisher, J. 2000. Participatory research in ecological fieldwork: A Nicaraguan study. In *Finding our sea legs. Editors* B. Neis & L. Felt. St. John's, NF. ISER Books: 41-54.

Gendron, L., Camirand, R. and Archambault, J. 2000. Knowledge-Sharing Between Fishers and Scientists: Towards a Better Understanding of the Status of Lobster Stocks in the Magdalen Islands. In *Finding our sea legs. Editors* B. Neis & L. Felt. St. John's, NF. ISER Books: 56-71.

Green, J.M. and Wroblewski, J.S. 2000. Movement patterns of Atlantic cod in Gilbert Bay, Labrador: Evidence for bay residency and spawning site fidelity. *Journal of the Marine Biological Association of the United Kingdom*. 80: 1-9.

Hutchings, J.A. and Myers R.A. 1995. The biological collapse of Atlantic cod off Newfoundland and Labrador: An exploration of historical changes in exploitation, harvesting technology, and management. In *The North Atlantic Fisheries: Successes, failures and challenges. Editors* Arnason, R. and L. Felt. pp 37-93. Institute of Island Studies. Prince Edward Island, Canada.

Hutchings, J., Neis, B. and Ripley, P. 1995. The nature of cod (Gadus Morhua): Perceptions of stock structure and cod behavior by fishermen "experts" and scientists from the nineteenth century to the present. In *Marine Resources and human societies in the north Atlantic since 1500. Editor* D. Vickers St. John's, NF. ISER Books: 124-188.

Lawson, G.L. and Rose, G.A. 2000. Seasonal distribution and movements of coastal cod (*Gadus morhua* L.) in Placentia Bay, Newfoundland. *Fisheries Research*. **49** (1): 61-75.

Lear, W.H. 1984. Discrimination of the stock complex of Atlantic cod (*Gadus morhua*) off southern Labrador and eastern Newfoundland, as inferred from tagging studies. *Journal of Northwest Atlantic Fisheries Science*. **5**: 143-159.

Lear, W.H. and Green, J.M. 1984. Migration of the "northern" Atlantic cod and the mechanisms involved. In *Mechanisms of Migration in Fishes. NATO Conference Series*. Series IV: Marine Sciences, Volume 14: 309-315.

Lear, W.H. and Parsons, L.S. 1993. History and management of the fishery for Northern cod in NAFO divisions 2J, 3K and 3L. In *Perspectives on Canadian marine fisheries management. Editors* L.S. Parsons and W.H. Lear. *Canadian Bulletin of Fisheries Marine Science*. no. 226. Dept. Fisheries and Oceans, Ottawa.

Lilly, G.R. 1996. Observations on cod in the inshore environment of eastern Newfoundland. *NAFO SCR* Doc. 96/59. Serial No. N2735.

Lilly, G. R. and Botta, J.R. 1984. Food of Atlantic cod (*Gadus morhua* L.) near Bonavista, Newfoundland in 1983. *NAFO SCR* Doc. 84/VI/51. Serial No. N838.

Maurstad, A. 2000. Trapped in biology: An interdisciplinary attempt to integrate fish harvesters' knowledge into Norwegian fisheries management. In *Finding our sea legs. Editors* B. Neis & L. Felt. St. John's, NF. ISER Books: 135-152.

Morris, C. 2000. *Biology of a resident cod (*Gadus morhua*) population in Gilbert Bay, Labrador*. M.Sc. Thesis. Memorial University of Newfoundland. St. John's, NF.

Myers , R.A., Mertz, G. and Bishop, C.A. 1993. Cod spawning in relation to physical and biological cycles of the northern North-west Atlantic. *Fisheries Oceanography*. **2** (3/4): 154-165.

Myers, R.A., Nicholas, J., Barrowman, J. and Hutchings, J.A. 1997. Inshore exploitation of Newfoundland Atlantic cod (*Gadus morhua*) since 1948 as estimated from mark-recapture data. *Canadian Journal of Fisheries and Aquatic Sciences*. **54** (Suppl. 1): 224-235.

B. Neis, L. Felt, R. Haedrich, D. Schneider, 1999a. An interdisciplinary methodology for collecting and integrating fishers' ecological knowledge into resource management. In *Fishing Places, Fishing People*, edited by Diane Newell and Rosemary Ommer (Toronto: U. Of T. Press), pp.217-238.

Neis, B., Schneider, D.C., Felt, L., Haedrich, R.L., Fischer, J. and Hutchings, J.A. 1999b. Fisheries assessment: what can be learned from interviewing resource users? *Canadian Journal of Fisheries and Aquatic Sciences*. **56**:1949-1963.

Neis, B. and L. Felt. 2000. *Finding Our Sea Legs-Linking Fishery People and Their Knowledge with Science and Management*. St. John's: ISER Books. 320 p.

Northwest Atlantic Fisheries Organization. 1997. *Scientific Council Reports 1996*. NAFO. Nova Scotia, Canada.

O'Connell, M.F., Andrews, C.W., O'Brien, J.P and Dawe, E.G. 1984. Aspects of the ecology of the fishes of Holyrood pond: a coastal lake with occasional access to the sea located in St. Mary's Bay, Newfoundland. *Int. Revne ges. Hydrobiol*. **69**(3): 333-360.

Pinkerton, E. 1994. Local fisheries co-management: A review of international experiences and their implications for salmon management in British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences*. **51**: 2363-2378.

Potter, A.J. 1996. *Identification of inshore spawning areas: Potential marine protected areas?* Graduate project, Dalhousie University. Halifax, NS.

Rose, G.A. 1993. Cod spawning on a migration highway in the north-west Atlantic. *Nature*. **366**: 2458-461.

Rose, G.A. 1996. Observations on cod in the inshore environment of eastern Newfouondland. NAFO Scientific Council Meeting. *NAFO SCR* Doc. 96/59.

Ruzzante D.E., Taggart, C.T., Cook, D. and Goddard, S.V. 1996. Genetic differentiation between inshore and offshore Atlantic cod (*Gadus morhua*) off Newfoundland: A test and evidence of temporal stability. *Canadian Journal of Fisheries and Aquatic Sciences*. **54** (11): 2700-2708.

Ruzzante D.E., Taggart, C.T., Cook, D. and Goddard, S.V. 1997. Genetic differentiation between inshore and offshore Atlantic cod (*Gadus morhua*) off Newfoundland: Microsatellite DNA variation and antifreeze level. *Canadian Journal of Fisheries and Aquatic Sciences*. **53** (3): 634-645.

Ruzzante, D.E., Wroblewski, J.S., Taggart, C.T., Smedbol, R.K., Cook, D., & Goddard, S.V. 2000. Bay-scale population structure in coastal Atlantic cod in Labrador and Newfoundland. *Canadian Journal of Fisheries and Aquatic Sciences*. **56**: 431-447.

Smedbol, R.K. and Wroblewski, J.S. 1997. Evidence for inshore spawning of northern Atlantic cod (*Gadus morhua*) in Trinity Bay, Newfoundland, 1991-1993. *Canadian Journal of Fisheries and Aquatic Sciences*. **54**(Suppl. 1): 177-186.

Smedbol, R.K., Schneider, D.C., Wroblewski, J.S. and Methven, D.A. 1998. Outcome of an inshore spawning event by northern Atlantic cod (*Gadus morhua*) at a low stock level. *Canadian Journal of Fisheries and Aquatic Sciences*. **55** (10): 2283-2291.

Smedbol, R.K. and J.S. Wroblewski. Metapopulation theory and northern cod population structure: interdependency of subpopulations in recovery of a groundfish population. In Press.

Stephen, R.L. 1999. Stock complexity in fisheries management: a perspective of emerging issues related to population sub-units. *Fisheries Research*. **43**: 247-249.

Sutton, S. G. 1998. *The mystery fish of Bonavista North: A multidisciplinary approach to research and management of a unique recreational salmonid fishery in Newfoundland*. M.Sc. Thesis. Memorial University of Newfoundland. St. John's, NF.

Taggart, C.T., Ruzzante, D.E. and Cook, D. 1997. *Localized stocks of cod (Gadus morhua L.) in the Northwest Atlantic: The genetic evidence and otherwise*. In *The implications of localized fishery stocks*. *Editors* Hunt von Herbing, I., Kornfield, K., Tupper, M. and Wilson, J. Ithaca, N.Y.: NRAES, 65-90.

Templeman, W. 1966. Marine resources of Newfoundland. *Bulletin of the Fisheries Research Board of Canada*. 154: 170p.

Templeman, W. 1974. Migrations and intermingling of Atlantic cod, *Gadus morhua*, stocks of the Newfoundland area. *Journal of Fisheries Research Board of Canada*. **31**: 1073-1092.

Templeman, W. 1979. Migration and intermingling of stocks of Atlantic cod, (*Gadus morhua*), of the Newfoundland and adjacent areas from tagging in 1962-66. *International Commission for the Northwest Atlantic Fisheries Research Bulletin*. Bulletin No. 14.

Templeman, W., and Fleming, A.M. 1956. The Bonavista longlining experiment, 1950-1953. Ottawa: *Fisheries Research Board of Canada*. Bulletin No. 109.

Templeman, W. and Fleming, A.M. 1963. Longlining experiments for cod off the east coast of Newfoundland and southern Labrador, 1950-1955. Ottawa: *Fisheries Research Board of Canada*. Bulletin No. 141

Wilson J.A. and Kornfield, I. 1997. Introduction: Conference Overview. In *The implications of localized fishery stocks*. *Editors* Hunt von Herbing, I., Kornfield, K., Tupper, M. and Wilson, J. Ithaca, N.Y.: NRAES, 3-8.

Wroblewski, J.S. 1983. The role of modeling in biological oceanography. *Ocean Science and Engineering* 8: 245-285.

Wroblewski, J.S., Bailey, W.L. & Howse, K. 1994. Overwintering of adult Atlantic cod (*Gadus morhua*) in nearshore waters of Trinity Bay, Newfoundland. *Canadian Journal of Fisheries and Aquatic Sciences*. **51**: 142-150.

Wroblewski, J.S., Kulka, D.W., Narayanan, S., Oake, A.M., Collier, A.G., and McGrath, B.D. 1995. Winter distribution and movements of northern Atlantic cod (*Gadus morhua*) along the Newfoundland-Labrador shelf edge derived from observations on commercial trawlers. *Fisheries Oceanography*. **4**: 128-146.

Wroblewski, J. 2000. The color of cod: Fishers and scientists identify a local cod stock in Gilbert Bay, Southern Labrador. In *Finding our sea legs*. *Editors* B. Neis & L. Felt. St. John's, NF. ISER Books: 72-81.

QUESTIONS

Saudiel Ramirez-Sanchez: In your diagram you talk about what fishermen know about the environment in a materialistic way. Traditional Ecological Knowledge also has an ethical component attached to it. Why is it not in your diagram? The values that are attached to it are severed.

Nigel Haggan: To rephrase the question, there is an ethical dimension to Traditional Ecological Knowledge but it doesn't seem to be reflected in your diagram and your approach. How would you incorporate it?

Karen Gosse: We're continually interacting with fishers, not just taking their knowledge. We use their advice and their ideas. They are the main people up there. I was mainly a bystander on my own project. The project is not to just take knowledge and run away with it. Coasts Under Stress is organized in such a way that we work continuously with the people, have meetings and tell them what we found. My goal is to find other areas where co-management works. The people in Gilbert Bay are the ones who wanted the MPAs.

Robert Chriseiger: Species on the east coast are different from those on the west coast. We can't apply the science from one to the other. No one is using the experience that we acquired here. Knowledge is a wonderful thing. I attended a meeting about taking salmon fry out of the river with Carl Walters and Mike Harcourt among the attendees. This was in October 1999, two years ago, and nothing has been done. We have lost the entire year class. We should have a national symposium to let everyone know what's happening. The salmon fishery used to be a $2 billion dollar industry but this year I only fished two days. I hope that Mr. Haggan will find time to discuss this during this conference because British Columbia is very reliant on salmon. I'm

sorry to distract from the east coast, but we have our own problems here.

Karen Gosse: Our project is on both the east and west coast. My case study is on the east coast, but there are similar studies on the west coast.

Applying Local and Scientific Knowledge to the Establishment of a Sustainable Fishery: the West Coast Vancouver Island Goose Barnacle Fishery Experience

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Abstract

Goose barnacles were commercially harvested in British Columbia from 1978 until 1999 in a high value, passively regulated fishery with no limits on the number of licenses issued or the total allowable catch. The fishery was closed by the federal Department of Fisheries and Oceans in May 1999 due to concerns about the lack of (1) biological and stock assessment information on goose barnacles, (2) information on the ecological impacts of harvesting to the rocky intertidal community, and (3) consistent catch reporting by harvesters. Several goose barnacle harvesters had also expressed concern that localized stocks were being overfished. Under federal Acts, ecosystem-based management and a precautionary, phased approach to data collection and fishery development are now required before the fishery can be re-opened. Harvesters are playing an active role in the development of assessment and management frameworks for a sustainable fishery by participating in a multi-stakeholder working group that was formed to address issues among First Nations, management agencies, and harvesters, and to co-ordinate the implementation of relevant biological studies. Harvesters provided previously unreported information about the locations and characteristics of marketable and non-marketable populations, food fishing areas, and harvesting practices. This information has been used in developing currently on-going stock assessment and ecological impact assessment studies and determining experimental harvesting sites. Harvesters' knowledge has also provided insight into why previous management strategies and license conditions, such as catch reporting, were not successful. How both harvesters' knowledge and scientific knowledge are being incorporated into the development for a sustainable goose barnacle fishery is discussed.

Introduction

In British Columbia, licensed invertebrate commercial fishers have long been involved in the stock assessment and management of their respective fisheries. Most invertebrate fishers' organizations participate in stock assessment surveys. Fishers help select the general locations of surveys and often provide logistic and personnel support for these surveys. For some fisheries, geoduck for example, fishers also advise in setting quotas for the management areas from a range of options.

In 1998, the goose barnacle (*Pollicipes polymerus*) fishery was identified as lacking the biological understanding and the stock assessment and management frameworks necessary for precautionary management. Within the Stock Assessment Division of the Department of Fisheries and Oceans Canada (DFO), a framework has been developed for the provision of scientific advice for the management of new and developing fisheries, including established fisheries whose expansion is limited due to a lack of information of the species distribution and abundance (Perry *et al.* 1999). This framework includes three phases for the precautionary development of a fishery:

Phase 0: collection of all available information on the target species, and from similar species elsewhere, to provide a baseline with which to advise on alternative management options and to identify areas where information is lacking;

Phase 1: surveys and experimental fishing with the objective of the collection of data required to fill in the information gaps identified in *Phase 0* and to explore the fishery potential;

Phase 2: a limited commercial fishery is developed, while stocks are monitored and management strategies are evaluated.

Lauzier (1999) recommended the mandatory participation of trained harvesters to collect data for stock assessments, including on-going surveys and gathering of biological information. Such involvement would give harvesters some understanding of the requirements to collect scientifically rigorous information, and allow DFO the opportunity to incorporate and confirm historical, traditional, and anecdotal information. Harvesters would be given an active role in stock assessment activities and would assist in developing management

strategies for a stable, sustainable goose barnacle fishery. This paper describes how knowledge from former commercial goose barnacle harvesters was gathered and used in *Phases 0* and *1* of the new and developing fisheries framework.

Goose barnacle biology

The goose barnacle (*Pollicipes polymerus* Sowerby, 1833) (Subclass Cirripedia, Order Thoracica, Suborder Lepadomorpha, Subfamily Pollicipinae) is a stalked, or pedunculate, barnacle, characterized by a pliable, muscular armoured stalk (peduncle), with a strong attachment system, and a series of thick plates covering the rest of the body (capitulum) (Figure 1).

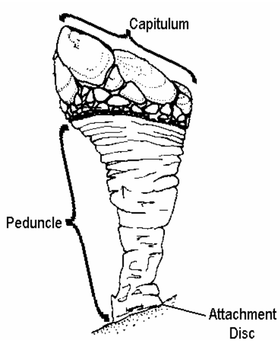


Figure 1. Schematic lateral view of the goose barnacle (Bernard 1988).

Goose barnacles are found from Sakhalin Island in the Northwest Pacific Ocean, throughout the Aleutians, and down the west coast of North America to Cedros Island, Baja California Sur, Mexico (Bernard 1988). The rocky open exposed coast is the preferred habitat of goose barnacles, where they are typically closely crowded (Barnes and Reese 1960, Ricketts and Calvin 1968, Newman and Abbott 1980). Goose barnacles often occur in distinct rosette-shaped clusters 20-40 cm in diameter (Figure 2), with large older individuals at the centre, surrounded by a gradation of smaller younger individuals at the edge (Bernard 1988).

Figure 2. Distinctive clumps of goose barnacles on the West Coast of Vancouver Island, June 2001. (J. Lessard photo)

Goose barnacle populations are usually concentrated in the mid-intertidal zone, but a few occur from over one metre above the highest high water level down to the shallow subtidal (Austin 1987). Goose barnacles are often found closely associated with, and attached to, California mussels (*Mytilus californianus*) and acorn barnacles (*Semibalanus cariosus*) (Austin 1987).

In the lower mid-intertidal, goose barnacles often occur interspersed in dense aggregations with California mussels to form the distinctive *Pollicipes-Mytilus* community, or matrix (Barnes and Reese 1960, Hoffman 1989). There have been a number of extensive studies of this community and the effects of competition, predation and disturbance on succession in this ecosystem (Dayton 1971; Paine 1974, 1980; Paine and Levin 1981; Wooton 1992, 1993, 1997).

The exposed rocky intertidal community is subject to continuous physical and biological disturbance, creating periodic free space, and allowing a large number of species to utilize the same potentially limited resource. Mussels beds do recover from disturbance, and the rate of recovery depends on size of the gap, season in which the gap was formed, intertidal elevation, angle of the substratum and intensity of larval recruitment (Seed and Suchanek 1992). Major disturbances in the mid-intertidal range may require 8-35 years to fully recover (Paine and Levin 1981).

Commercial fishery history

First Nations people have historically harvested goose barnacles on the west coast of Canada (Ellis and Swan 1981). There is traditional knowledge from First Nations harvesters that only specific sites were harvested, and that repeated harvesting was thought to improve subsequent harvests. Goose barnacles are still harvested for nutritional, social and ceremonial purposes.

In British Columbia, goose barnacles have been fished commercially since 1978 and landings have been reported since 1985. Initial rapid growth peaked in 1988, with 467 licences issued and reported landings of 49 t. From 1995-1998, landings were 8-10 t/yr. The commercial goose barnacle fishery was concentrated on the West Coast of Vancouver Island, with sporadic landings from the Central and North Coasts. A strong market demand exists for goose barnacles in Spain, estimated at 2,000 t/y (Proverbs, 1979) and substantial demand in Portugal for live

barnacles of ~ 4 cm overall length. Stocks in Spain have been severely depleted and are now managed under strict conservation measures.

Before its closure in 1999 (see below), this fishery was passively managed. It had unlimited entry, no size limits, no quotas or total allowable catches (TAC), and was open year-round. DFO assumed that the fishery was limited by market demand and accessibility to suitable product. It was also estimated that less than 10% of the stock was available to the fishery due to inaccessible harvest areas, and/or unsuitable size and quality of product for the market (Clark, 2001). Management measures included small permanent area closures (e.g. for Parks), a gear restriction limited to hand tools or hand picking, and catch reporting requirements. There was relatively low compliance of catch reporting. The high initial participation rate and high reported catches, followed by a decline to low levels, are classic signs of a "gold-rush" fishery. Much of the decline in landings, however, can be attributed to the loss of markets in Spain.

1999 Fishery Closure

DFO closed the commercial goose barnacle fishery on May 30, 1999, due to concern over the ecological impact on mussel beds and on goose barnacle stocks and lack of data on the fishery. Insufficient stock assessment data (e.g. biomass, distribution and abundance), biological data (e.g. recruitment, growth and mortality), and inconsistencies in fishery data resulted in a lack of confidence that the resource was being managed in a precautionary manner. Examination of export records from the Canadian Food Inspection Agency (CFIA) showed considerably larger amounts of product being reported as exported, compared to the amount of product being reported as harvested on sales slips or harvest logs (Figure 3). However, exported weights were not verified, and some export certificates may have been cancelled, therefore the actual amount exported is not known. Reported sales slip landings were also considerably higher than the reported harvest log landings, which was another major inconsistency that could not be resolved.

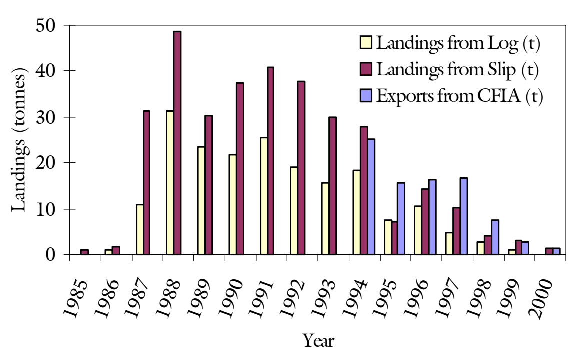


Figure 3. Goose barnacle fishery landings 1985-2000 and exports 1994-2000

Experienced harvesters also expressed concerns about local stock damage caused by inexperienced harvesters attracted by the high value of the fishery, and who were only interested in short-term high yield gain. There were reports of relatively large areas of rocks (>2 m^2) cleared of mussels and barnacles. Results from a test fishery during the mid-1980s showed that on average, 50% of the harvest was not acceptable product (the level of experience of participating harvesters is unknown) (Austin 1987). Austin (1987) also observed that harvesting goose barnacle adults attached to mussels and acorn barnacles resulted in a higher quality product, and probably caused the mortality of the substrate species. From the limited information available on the commercial goose barnacle fishery, and the concentrated effort of the fishery in particular areas due to accessibility, it had become apparent that the past passive management approach to the BC goose barnacle fishery was not precautionary. An appropriate management framework had to be designed and implemented, to actively monitor total catch and stock conditions, set appropriate exploitation levels, and respond to changes in a timely manner.

Methods

Systematic sampling to gather harvesters' knowledge for Phases 0 and 1 of the New and Developing Fishery Framework, was not possible because there was no list of all the people that had harvested goose barnacles. For example, many unlicensed harvesters were known to have sold their product to a licensed fisher. Harvesters tend to be localized i.e. they harvest close to where they live. Geographical coverage could only be obtained in areas where there had been a commercial fishery.

Working group

In response to the fishery's closure in May 1999 and following recommendations from Lauzier (1999), DFO and the Nuu-chah-nulth Tribal Council (NTC) initiated a multi-stakeholder "Goose Barnacle Working Group" (GBWG). GBWG has representation from goose barnacle harvesters and buyers, DFO, First Nations, and other government management agencies such as Parks Canada and BC Parks. Two harvesters' organizations have been formed to date, but independent harvesters remain. The "Canadian

Goose Barnacle Cooperative" was established shortly before the closure of the fishery and the "West Coast Goosenecks Association" was formed in the spring of 2000. Several meetings have been held since the spring of 2000 with approximately 25 harvesters from coastal communities who identified themselves as experienced commercial harvesters.

The GBWG operates under the guidelines of a joint policy framework to establish area-based management in the NTC/West Coast Vancouver Island area. The goals of the GBWG are to 1) determine opportunities for developing a sustainable, ecosystem based, commercial goose barnacle fishery on the West Coast of Vancouver Island; 2) establish cooperative relationships for the ongoing management of a fishery; and 3) work towards the goals, principles, and objectives of the GBWG and the West Coast of Vancouver Island area based management board. To date, the GBWG has focused on defining the scope and location of stock assessment, ecological impact assessment activities, and experimental harvests.

Informal conversations

During the data gathering of the *Phase 0* of the New and Developing Fisheries Framework, known experienced harvesters were contacted by phone and through the GBWG, and were asked to provide information on their understanding of the biology of goose barnacle, methods of harvest, and data lacking in the logbooks.

Interviews

In total, 21 harvesters were informally interviewed. Josie Osborne (NTC) conducted the interviews at three different locations on Vancouver Island (Kyuquot, Parksville and Ucluelet). Harvesters were asked to provide information on the distribution of goose barnacles, using nautical charts, and to indicate whether they fished there often, occasionally or never. Data were then digitized into a geographical information system (GIS) by DFO staff. For this study, harvesting areas falling within boundaries of overlaid federal and provincial parks and Ecological Reserves were removed for the survey site selection (see Figure 4).

Survey and experimental fishery

DFO staff designed a two-part survey: stock assessment and habitat impact assessment, to collect the necessary scientific data on goose barnacle biology and distribution, and on the ecological harvesting impacts. To assess the biomass available for a harvest, survey sites had to have goose barnacles of good harvesting quality and quantity. Conversations with harvesters had revealed that they tend to be very localized and harvested close to home. Harvest log records substantiated this with landings concentrated in specific areas. For these reasons, the West Coast of Vancouver Island was separated into three study areas: Ucluelet, Tofino and Kyuquot (Figure 5). Specific survey sites were selected with the help of local experienced commercial harvesters. Each survey crew consisted of two DFO staff and two or more experienced harvesters. Data needed for collection were identified in the *Phase 0* study. Field data sheets from other species' surveys were modified based on discussions with harvesters.

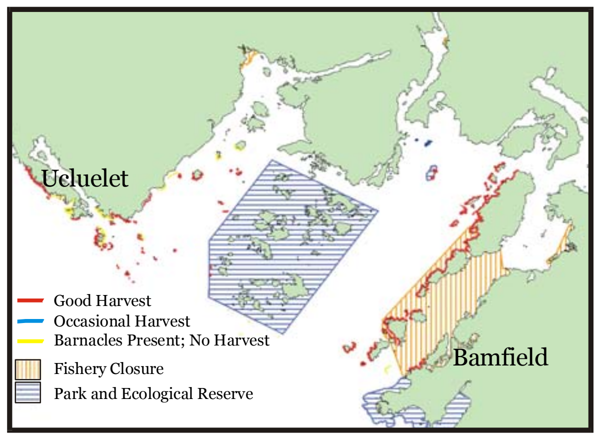


Figure 4. Goose barnacle fishery distribution in the Ucluelet area

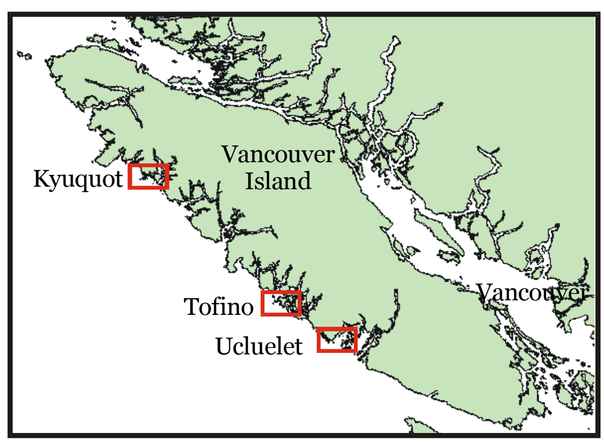


Figure 5. Study areas off the west coast of Vancouver Island.

A bed, defined as a continuous patch of goose barnacles, was delineated at each site to allow for manageable assessment units that could be surveyed in the limited time between low and high tide. Specific beds were selected for their

representativeness as an area index site and/or suitability for experimental harvest. At each bed selected, an initial transect was laid out along the middle of the bed's longest axis. Bed width was measured at selected points perpendicular to this transect. Time and bed size permitting, additional transects were laid parallel to the centre line transect. Twelve 0.25 m^{-2} quadrats were placed at random along each transect. In each quadrat, all goose barnacles were counted, tidal elevation and matrix depth were measured, and harvest potential was assessed by an experienced harvester. Six of the 12 quadrats were randomly chosen for biological sampling. A 0.04 m^{-2} quadrat was placed within each selected 0.25 m^{-2} quadrat, and all goose barnacles within the smaller quadrats were taken for later processing at the field laboratory.

In conjunction with stock assessment procedures, "habitat" samples were randomly taken from two of the six 0.04 m^{-2} quadrates along each transects. In addition to goose barnacles, all biota was placed in plastic bags, frozen and transported to the Pacific Biological Station. Species identification and enumeration was then analyzed in detail for ecosystem assessments.

Experimental harvests were opened on September 12, 2000, in all three areas. Scientific licences were issued to the two harvesters associations. Individual participation was determined by the harvesters' organizations.

Harvests were conducted during low tide cycles in September, October, and December 2000, at previously surveyed sites or at new sites that were surveyed just prior to harvest. A harvest monitor familiar with the sites had to be present during the harvest. During the experimental harvests, prescribed stock assessment protocols and habitat assessment procedures were followed. Harvests continued at each site until harvesters considered that there were few marketable goose barnacles remaining. Dockside weights were recorded on DFO harvest log forms for the catches of each harvester from each site.

During each harvest cycle, the catches of each harvester were sampled at four random times. Harvesters were asked to separate each of these catch samples into marketable-sized barnacles and discards. The samples were processed at the field laboratory to determine average harvest and discard weight, and abundance. Marketable barnacles were returned to the corresponding harvester.

Results and Discussion

The detailed survey results will be reported later in a document that will outline management options for a commercial fishery. Since harvesters had little to contribute on the design of the habitat impact assessment, these data are also not included here. This discussion will focus on integrating what was learned during the surveys with traditional knowledge.

Discussions with experienced harvesters and observations of their fishing techniques revealed that harvesting impacts are probably less than previously thought by DFO science staff for three reasons. First, harvests which resulted in large bare patches of rocks, or "clearcuts" in forestry terminology have mostly been the work of inexperienced harvesters. Second, on acorn barnacle substrate, what appears as a "clearcut" may actually be a natural process that occurs when acorn barnacles age and die. The acorn shell weakens and fractures, and the whole community attached to the acorn barnacle substrate is lost when the shells detach from a rock substrate. Third, the actual harvested clumps of goose barnacles in mussel-dominated matrix usually consist of only 4-8 adults, and the size of holes left by experienced harvesters on the matrix were quite small, analogous to divots on a golf course. During the June 2001 survey in the Tofino and Ucluelet areas, it was observed that specific sites experimentally harvested in the fall of 2000 could no longer be identified. During the experimental harvest, sites with repeated visits, also showed little harvest impact only a month or two later. Evidence of First Nation's harvests for Mothers Day celebration was barely visible six weeks later.

Experienced harvesters provided information to DFO science staff on rapid recruitment and recovery times (about one month) of goose barnacle beds at particular locations. First Nations harvesters have long thought that harvesting improved the productivity of goose barnacles at particular locations. Initially, this information seemed to conflict with information gathered from the scientific literature and the results of past scientific experiments (see Austin 1987). Science staff assumed that recruitment and recovery mechanisms were driven by mainly by processes outside the goose barnacle bed. While this may be the case with goose barnacles on acorn barnacle substrate, it was quickly realized that rapid recovery of the harvested sites and recruitment to the fishery in the sea mussel matrix is probably from internal processes within the bed. As the mussel matrix shifts to fill in gaps on the surface, smaller goose barnacles

below the surface of the bed quickly start growing, and their capitulums quickly reach the surface of the bed. A hole provides previously hidden goose barnacles with improved access to their food source, thereby accelerating their growth. However, not all newly exposed goose barnacles necessarily recruit to the fishery, especially those anchored deep in the matrix.

Product quality is another important factor. Goose barnacles vary considerably in body shape and size due to local conditions such as wave exposure. Stalk configuration, not overall weight, determines consumer product quality, thicker stalks are considered to be higher quality product.

Goose barnacle distribution and fishery maps

Harvesters willingly shared their particular harvesting areas. Figure 4 shows the distribution of goose barnacle fisheries in the Ucluelet area identified through the interview process. Most experienced harvesters have developed an understanding among themselves, as to who can harvest a particular site. Therefore, harvest location does not appear to be a major issue *among* experienced harvesters, however, confidentiality is an issue *between* experienced harvesters, who have developed the knowledge over time, and newcomers to the fishery.

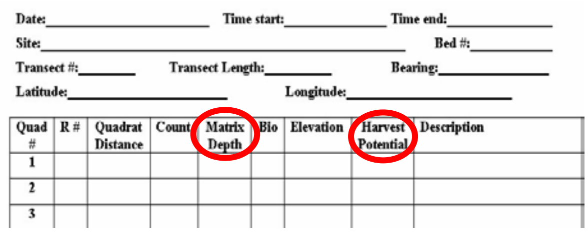
Information on the locations of goose barnacle beds was from harvesters' memories, and sometimes individuals did not agree on what constituted a good fishing location. It was also revealed that several harvesting areas did not appear on charts (i.e., rocks not documented on charts), and several harvesters had difficulty identifying area on charts because they did not navigate with charts on the water. They noticed that goose barnacles on some rocks recovered from harvesting extremely quickly and could be visited as often as once a month. However, other rocks had to be left for several months before they could be harvested again.

Not all former harvesters could be interviewed, therefore the maps developed represent a preliminary assessment of goose barnacle distribution. There may also be areas where harvesting has never occurred, and therefore the presence and distribution of goose barnacles in these areas remain unknown.

Overall, interviews provided useful information that was previously lacking. Harvest location reported on harvest logs was mostly by DFO Statistical Areas and Subareas, which do not provide bed-specific information. Georeferenced harvest locations were seldom obtained, as the majority of goose barnacle harvesters did not have Global Positioning System (GPS).

Modifications to the survey design

Based on discussions with harvesters on their understanding of the biology of goose barnacle, two data fields were added to survey sheets (circled in Figure 6). It was recognized that preferred, harvestable, goose barnacles are mostly attached to mussels or acorn barnacles. Therefore, the depth of the mussel and/or barnacle community was added as a data field to give a measure of the matrix constituents. Within a specific quadrat, not all goose barnacles are of good quality. To reflect this, and to eventually adjust the harvestable biomass estimate, an experienced harvester participating in the survey assessed the amount of harvestable barnacles in each quadrat.


Date:________ Time start:________ Time end:________
Site:________ Bed #:________
Transect #:________ Transect Length:________ Bearing:________
Latitude:________ Longitude:________

Quad #	R #	Quadrat Distance	Count	Matrix Depth	Bio	Elevation	Harvest Potential	Description
1								
2								
3								

Figure 6. Example of data sheet used in the field survey. Data fields added based on discussions with harvesters are circled in red.

Concerns were expressed by harvesters as to why low density or empty quadrats would be enumerated in a random survey design of a delineated bed. Experimental survey design and statistical analysis are concepts that are difficult to explain and justify to people with no formal scientific training. The immediate goals of science staff and harvesters appeared to diverge. On one hand, harvesters wanted to see results showing relatively high densities. However, using only high-density quadrat data in extrapolations would have resulted in a high biomass for a relatively small area and exclusion of potential biomass in lower density areas. In contrast, researchers strive for the most realistic estimate, with valid confidence intervals. This is achieved by enumerating an appropriate number of quadrats (including low and zero density quadrats), extrapolating densities over the total bed area, and obtaining a total harvestable biomass estimate. The long-term goal of both harvesters and researchers is to establish a sustainable harvest and to achieve long-term stability of harvested beds.

Experimental harvest - Fall 2000

In total, eleven harvesters participated in an experimental harvest of 1,800 kg of goose barnacles. Valuable information was collected on the amount and type of discard, methods of harvest (acorn barnacle substrate vs California mussel substrate), recruitment processes, recovery time, and the ecosystem impacts of harvests.

When comparing pre- and post-harvest biomass estimates, only the Food Island site in the Ucluelet area showed a significant difference (Figure 7). Level of harvest varied from 0.15 kg/m² (Nicolaye Channel site, Kyuquot area), to 1.44 kg/m² (Starlight Reef site, Ucluelet area). 3 to 36% of the estimated site biomasses were harvested in 2000. Fishers' concerns about concentrated effort in limited areas during the experimental harvest, lead to design changes in the 2001 experimental harvest, resulting in an expansion of the areas permitted for harvest.

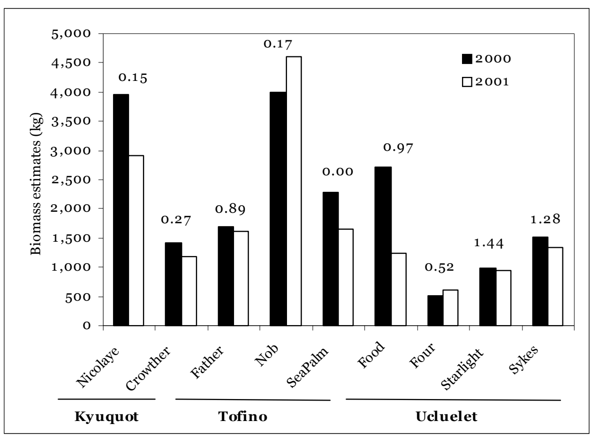


Figure 7. Biomass estimates for the 2000 and 2001 surveys by sites. The amounts of goose barnacle harvested during the fall 2000 experimental harvest are in black.

Conclusions

It is difficult to assess the completeness and accuracy of anecdotal data, but this does not detract from its importance for consideration when assessing a traditional fishery. Anecdotal data used in this study is the result of long-term (years and generations) personal observations. There were disagreements amongst experienced harvesters as to what constituted a good fishing area or a harvestable clump of barnacles as personal perspectives vary. Some anecdotal information may be flawed. However, absolute terms or values are not always necessary if trends are all that is required to direct a scientific study in the right direction or to formulate the relevant questions for an investigation. One of the lessons learned in this study is that a large amount of anecdotal information provided tendencies and directions that would have taken years to assimilate in a scientific study.

Collecting anecdotal information has also provided an opportunity to establish improved communication among stakeholders. Harvesters provided information to researchers and resource managers that was not otherwise available, and information was provided to the harvesters as to the information requirements for a sustainable fishery. Consulting with harvesters before and during surveys, integrating their knowledge in the study design, as well as soliciting and seriously considering their advice greatly increased their cooperation with DFO. With improved working relationships, common short-term and long-term goals have been established. The GBWG is expected to continue to have a significant role in defining who will participate in any future commercial fishery. It will also actively influence the development of the final management strategy.

In conclusion, integrating traditional knowledge and anecdotal information with the scientific information derived from literature surveys and biological surveys has been a positive experience that has lead to better understanding of the dynamics of the goose barnacle community and the impacts of harvesting activities.

Acknowledgements

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References

Austin, W.C. 1987. A feasibility study for the commercial harvesting of the goose barnacle *Pollicipes polymerus*. Final report prepared by NOPSA Enterprises Ltd. and Khoyatan Marine Laboratory for the Department of Fisheries and Oceans.

Barnes, H. and E.S. Reese. 1960. The behaviour of the stalked barnacle *Pollicipes polymerus* Sowerby, with special reference to its ecology and distribution. J. Anim. Ecol. 29: 169-185.

Bernard, F.R. 1988. Potential fishery for the gooseneck barnacle *Pollicipes polymerus* (Sowerby, 1833) in British Columbia. Fisheries Research 6: 287-298.

Clark, D.G. 2001. Goose barnacles 2000 fishery update. PSARC Fishery Updates Document. 10 pp.

Dayton, P.K. 1971. Competition, disturbance, and community organization: the provision and subsequent utilization of space in a rocky intertidal community. Ecol. Monogr. 41: 351-389.

Ellis, D.W. and L. Swan. 1981. Teachings of the Tides: Uses of Marine Invertebrates by the Manhousat People. Theytus Books. Nanaimo, B.C. 118 p.

Hoffman, D.L. 1989. Settlement and recruitment patterns of the juvenile stages of the pedunculate barnacle, *Pollicipes polymerus* Sowerby, of La Jolla, California. J. Exp. Mar. Biol. 125: 83-98.

Jamieson, G.S., R.B. Lauzier, and G. Gillespie. 1999. Phase 1 framework for undertaking an ecological assessment of the outer rocky intertidal zone. Canadian Stock Assessment Secretariat Research Document 99/209; 32 pp.

Lauzier, R.B. 1999. A review of the biology and fisheries of the goose barnacle (*Pollicipes polymerus* Sowerby, 1833). Canadian Stock Assessment Secretariat Research Document 99/111; 30 pp.

Lauzier, R.B. 1999. Framework for the goose barnacle (*Pollicipes polymerus* Sowerby, 1833) fishery in waters off the West Coast of Canada. Canadian Stock Assessment Secretariat Research Document 99/198; 24 pp.

Newman, W.A. and D.P. Abbott. 1980. Cirripedia: the barnacles. pp. 504-535 *in* R.H. Norris, D.P. Abbott, and E.C. Haderlie [eds], Intertidal Invertebrates of California, Standford University Press, Standford, California.

Paine, R.T. 1974. Intertidal community structure: experimental studies on the relationship between a dominant competitor and its principal predator. Oecolodia 15: 93-120.

Paine, R.T. 1980. Food webs: linkage, interaction strength, and community infrastructure. J. Animal Ecol. 49: 667-685.

Paine, R.T. and S.A. Levin. 1981. Intertidal landscapes: disturbance and dynamics of pattern. Ecol. Monogr. 51(2): 145-178.

Perry, R.I., C.J. Walters, and J.A. Boutillier. 1999. A framework for providing scientific advice for the management of new and developing invertebrate fisheries. Rev. Fish Biol. Fish. 9: 125-150.

Proverbs, T. 1979. A status report on the recent British Columbia gooseneck barnacle industry. M.S. Interdepartmental Report, Department of Fisheries and Oceans, 10 pp.

Ricketts, E.F. and J. Calvin. 1968. Between Pacific Tides. 4th ed.; revised by J.W. Hedgepeth. Standford University Press, Standford, California.

Seed, R. and T.H. Suchanek. 1992. Population and community ecology of *Mytilus*. p. 87-169, *in* E.M. Gosling [ed.]. The Mussel *Mytilus*: Ecology, Physiology, Genetics, Culture. Elsevier Scientific Publ. Co., Amsterdam.

Wooton, T.J. 1992. Indirect effects, prey susceptibility, and habitat selection: impacts of birds om limpet and algae. Ecology 73(3): 981-991.

Wooton, T.J. 1993. Size-dependent competition: effect on the dynamics versus the end point of mussel bed succession. Ecology 74(1): 193-206.

Wooton, T.J. 1997. Estimates and tests of per capita interaction strength: diet, abundance, and impact of intertidally foraging birds. Ecol. Monogr. 67(1): 45-64.

Questions

Ron Hamilton: I'm from the area where most of your slides were taken. My mother's people have been fishing in that area, according to archaeologists, for 4000 years. The title of your talk says putting fishers' knowledge to work, but you didn't say anything about using the knowledge of my people, or the traditional methods for fishing. Have you done any work in our community?

Joanne Lessard: Yes. Some are involved in the working group.

Ron Hamilton: Your slide says "Fisheries", but you only referred to the commercial fishery. It seems that our history in the area is always ignored. You didn't find it important enough to put it in and the only thing you thought was important enough was the commercial fishery. Do you know about the war between the Maaķtlayt-h and the Hachaa-at-h over the gooseneck barnacle? Have you read about it? It shows how important the species is to us.

Eduardo Espinoza: How do you appraise the quality of your information?

Joanne Lessard: This is a big problem. There is no easy way to verify the information. For the other anecdotal knowledge, hopefully an ecosystem assessment will verify it. I don't know the results of that assessment. When the fishery was closed, we couldn't get much information.

Participatory Research in the British Columbia groundfish fishery.

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Abstract
The benefits of full participation by fishers in stock assessment research are demonstrated through two examples from the groundfish fishery in British Columbia, Canada. The first example summarizes a joint acoustic study to estimate the biomass of a shoal of widow rockfish (*Sebastes entomelas*) in BC waters. In this example, the fishers posed the initial experimental hypothesis, provided the essential background information needed to plan the study, and were full participants in the conduct, analysis, and documentation.

The second example describes the impact of a fisher critique of a stock assessment of silvergray rockfish (*S. brevispinis*). They argued that the observed trends in size and age could have been caused by the introduction of Individual Quota Management, because IVQ's had led to subtle shifts in the spatial distribution of catches. In response to their criticism, a preliminary study was jointly conducted; the results of which partially supported their concern. These results are now being used to improve the sampling and assessment techniques.

We suggest that it is a mistake to focus on fishers simply as data collectors or knowledge sources, thereby ignoring their skills in hypothesis formulation, research design, and interpretation. Phrases such as "incorporating fisher (local, or traditional) knowledge" are not only incorrect but are pejorative in implying that fishers are limited in what they can contribute to the scientific process. We suggest that Participatory Research represents a more effective intuitive framework for incorporating their full expertise into fisheries research. In this paper, we have summarized the characteristics of two studies that facilitated the participation.

Introduction
Fisher Knowledge is a pejorative phrase!
There are demands from many quarters that fishery research and management be more effective in collecting and using "local" or "fisher" knowledge. As commented by Roepstorff (2000), any catchy first word and "knowledge" will suffice in this context (see also Agrawal 1995 and Sillitoe 1998). The premise is that individuals who are intimately associated with the resource have a wealth of knowledge that can enhance research and improve management. Mackinson and Nøttestad (1998) state that this knowledge is either overlooked or dismissed immediately without consideration, apparently by all researchers and managers. It is widely asserted that continued failure to use these assets will lead to poorer research and management failure (Dyer and McGoodwin 1994, Gavaris 1996, McGoodwin *et al.* 2000).

The previous papers have emphasised the role that fishers can play both in data collection and demonstrate the wealth of *-knowledge that fishers possess (McGoodwin *et al.* 2000, Ruddle 1994, and particularly, the exceptional work of Johannes 1978). Some emphasise specific topics for which fisher knowledge is most useful. For example, Neis *et al.* (1996) report on the knowledge of stock structure changes in catchability, information on abundance in a closed fishery, and the potential impacts of re-opening. Fischer (2000) identifies the information available on "local fishing performance" and the "physico-chemical environment and living aquatic resources".

Governmental policy commitments also acknowledge the potential value of *-knowledge. The Department of Fisheries and Oceans (DFO), Canada instituted the fisher-based sentinel survey program in 1994 for East Coast groundfish, in part to: "... blend the traditional knowledge of fishermen with the objective rigour of scientific data gathering." (Hon. B. Tobin, Minister of Fisheries and Oceans, Sept 1994). In the same year, DFO also made a commitment to bring *-knowledge into the peer review and advisory process (Boulva 1994).

This trend is not uniquely Canadian. The International Council for Exploration of the Seas (ICES), the principal marine and fisheries science advisory body for the North Atlantic, is in the process of bringing resource users into its review and advisory processes. To the south, the U.S. National Marine Fisheries Service has funded a large number of collaborative programs. These include US$5 million allocated for the "Cooperative Research in the Northeast" program, and the US$90 million allocated for cooperative research projects on salmon with fishers, tribal councils, and communities in the Pacific Northwest (OMB 2001). The International Pacific Halibut Commission

(IPHC) has also established an industry-composed Research Advisory Board that not only reviews IPHC research programs but actively participates in the design and implementation of many research programs (B. Leaman, pers. comm.[1])

The call to make better use of *-knowledge is justifiable; however, the greatest gains may come from changing the nature of the interaction. We suggest that compartmentalising and confining the potential contributions from resource users as cheap data collectors or as sources of background knowledge is missing the point, if not condescending. It ignores the greater potential benefit and enrichment that comes from working with equals, rather than with unpaid technical help. The literature from agricultural extension work has, for some time, emphasized that these same possessors of knowledge are also effective at hypothesis formulation, experimental design, and interpretation (Sajise 1993, Sillitoe 1998). This premise also has a history in terrestrial ecology, where "amateur naturalists" have long had a respected role as observers of nature, and as framers and testers of hypotheses about the areas that they knew well. As posed by Sajise (1993), how could knowledge accrue (as opposed to just being passed on) without someone applying elements of the scientific method:

> *"There is ample evidence now [in the field of agriculture] that local people do their own research; maybe not in the same formal and rigorous way that researchers do it in terms of having statistical designs, replications and anlaysis but they do* research" (Sajise 1993, p.3)

Even the simple process of data gathering should be viewed as a cooperative task. To gather new information, people must be involved emotionally in the process (Zajonic 1980). In field ornithology, the astuteness of the observations of dedicated naturalists has long been acknowledged as a touchstone for observations and theories of "professionals". This potentially rewarding interplay between those closest to the resource and those conducting scientific studies also underscores the need to create a willingness among all parties to share data, and collectively reach a better understanding of the resource (Brown 1988).

Although the scientific skills of resource users are now well recognised in agricultural research, they are rarely acknowledged in fisheries literature even by those who emphasize that fisher knowledge is under-utilised. Exceptions include comments that fishers are effective at formulating testable hypotheses (Neis *et al.* 1996, Hutchings 1996, Ames *et al.* 2000).

The tendency to compartmentalise the potential contribution by fishers results from a reliance on the "data collection" model for linking fisher knowledge (Fischer 2000) to other sources of information on stock status. It assumes that for local knowledge to contribute it must be systematised, stored, manipulated, and made intelligible to others in a manner similar to treatment of data from conventional monitoring sources (Ferradás 1998). Although there is a place for this model, it represents an appending of fishers to conventional scientific research as junior partners. It maintains for researchers, the "we vs they", and the "*-knowledge vs science" dichotomies (see discussion notes appended to Sillitoe 1998). We argue that fishers' experiential knowledge is not only sophisticated, but also derived from their skills as experimenters. Fisheries research should move towards the Participatory Research (PR) model long recognized in agriculture (Chambers *et al.* 1989, Sajise 1993) but only recently acknowledged in fishery research (McGoodwin *et al.* 2000, Neis and Felt 2000).

As outlined by Fischer (2000), PR is a joint exercise by a team, in which the so-called researcher is an influential member but does not occupy the top position in the traditional hegemonic framework. The participation can be "full" wherein all players participate in development of questions, hypotheses, design, and execution. Participation can also be marginal; consisting of simple data collection such as completion of logbooks, or assisting with tag recovery activities. This model already has well-established precedents in multi-disciplinary scientific research wherein fisheries scientists, physical and biological oceanographers, statisticians and modellers have collaborative projects. A single team member may be accountable for administrative aspects of the project, but acknowledges other team members as peers in planning, conducting, and interpreting the science. It should not be considered revolutionary to view partners from the fishing industry in a similar light.

In this paper, we describe two examples of PR from research on the groundfish fishery off the

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West Coast of Canada. We suggest that they indicate the effectiveness of PR and show that the distinctions made between data collection, knowledge gathering and application of scientific method, cease to be meaningful within the context of genuine participation. The paper is written in the narrative style of chronicling the studies as they transpired as opposed to the usual methods-results-discussion sequence of scientific articles. It seems more effective in this case, because the message lies in the process as much as in the results. The narrative style captures the interpersonal nuances that increased the effectiveness of the studies. Following the two examples we summarize the characteristics of the work that facilitated the participation and conclude with general commentary on the role that PR can play in fisheries research. Although our discussion relates to commercial fishers, we suggest that the principles apply equally to other harvesters or knowledgeable partners.

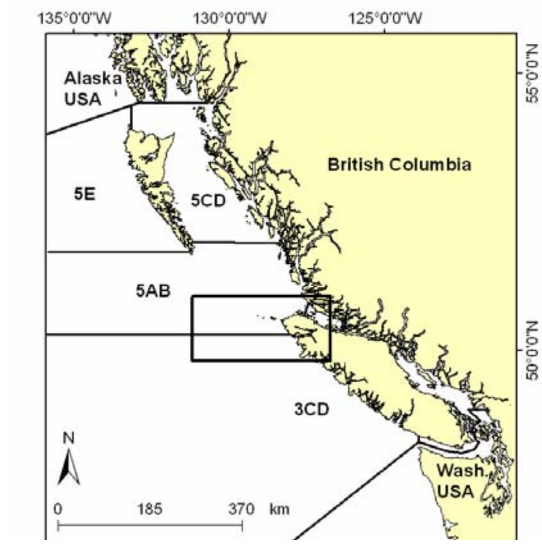

Figure 2. Location of widow rockfish study area and silvergray rockfish assessment regions. Inset indicates area shown in Figure 2.

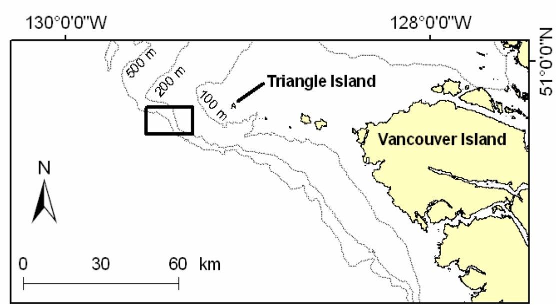

Figure 1. Location of widow rockfish study site off the northwest coast of Vancouver Island. Inset indicates area shown in Figure 3.

Example 1: Acoustic estimation of widow rockfish (*Sebastes entomelas*)

Background

We first present a two-year study of a mid-winter shoal of widow rockfish off the central coast of British Columbia (BC) Canada (see Stanley *et al.* 2000 for details on the acoustics and estimation methodology). Figures 1 and 2 illustrate the study site. Rockfish (*Sebastes* spp.) are a particularly appropriate genus for PR because there have long been differences of opinion between stock assessment staff and industry experts regarding biomass estimates and quotas. (Leaman and Stanley 1993).

Rockfish are thought by government assessment staff to have been severely overfished by foreign fleets before 1977 (Archibald *et al.* 1983). Furthermore, age composition of catches also implied a low natural mortality rate (M); probably less than 0.05 (Archibald *et al.* 1981). The implied low productivity and history of overfishing has led DFO implement conservative harvesting regimes for trawl-caught rockfish for more than two decades. From the industry perspective, there is no corporate memory among fishers of "proven" overfishing for these stocks. This combined with the strong acoustic sign and high catch rates of these aggregating species imply to fishers large biomasses relative to other species, inconsistent with the "low" rockfish quotas.

Unfortunately, many of these shoaling rockfish species show a fondness for untrawlable bottom, which presenting severe problems for swept-area survey methods for estimation of abundance. The shoals also show an affinity for near-bottom distribution, limiting the effectiveness of acoustic estimation methods, although the shoals can reflect a strong acoustic signal. With general distrust of commercial CPUE as an abundance index, there was no means for resolving the issue to either party's satisfaction.

In this context, the senior author, a government biologist, made a trip aboard a commercial trawler in 1996 to discuss recent stock assessments with the skipper, Captain Brian Mose, an industry advisor on groundfish management. During the many long discussions in the wheelhouse, Capt. Mose commented that most fishers felt that widow rockfish quotas (Stanley and Haist 1997) were overly conservative. The fishers were aware of one shoal of widow rockfish, which, if estimated, would probably indicate by itself that coastwide biomass estimates for this species were too

conservative. Furthermore, this shoal, which regularly formed each winter off the central coast of BC, was predominantly widow rockfish, off bottom at dusk, and predictable in its occurrence, thus making it a reasonable candidate for acoustic estimation. Captain Mose noted that even if the study failed to indicate a large biomass, the study could only help since it would be the first directed field research on this species in Canadian waters. It was also noted that the estimation of one rockfish shoal would provide a much-needed quantitative reference point for enhancing dialogue between fishers and biologists about what fishers observed on their sounders and in their nets. Finally, while not explicitly thought of as PR, the principals hoped that the program would serve as a model for developing closer research collaboration between industry and government staff.

Methods and Results

Surveys of the shoal, located at the edge of the continental shelf, were conducted in early February of 1998 and 1999 (Stanley *et al.* 2000, Wyeth *et al.* 2000). Timing and location were based on fishers' knowledge. Two commercial trawlers, the "Frosti" (1998) and the "Viking Storm" (1999) were the catcher vessels and provided the acoustic scouting. During the study, these vessels conducted mid-water trawl hauls to identify species and size composition of the shoal. They also sounded the perimeter of the study site for evidence of movement to and from the area. Costs of these vessels were provided by a trawl fishery association, the Canadian Groundfish Research and Conservation Society (CGRCS). In addition to the activities of the charter vessels and concurrent with the study, the team requested that all active fishers communicate the location and dimensions of any other widow rockfish shoals that were observed.

A fisheries research vessel, the "W.E. Ricker", provided the acoustic platform. In addition to the captain running the charter vessel, an additional trawl-fishing captain was on board the W.E. Ricker in both years. The captains participated equally with regard to survey design and assisted with scrutinizing the acoustic data. For example, they recommended that a deeper acoustic sign at 225 m was that of yellowmouth rockfish (S. reedi) and should be excluded from the biomass estimate.

Prior to the arrival of the W. E. Ricker, the study team on the commercial trawler scouted the site to select the acoustic transects. An important element of the interaction was to circumscribe the shoal to the satisfaction of all participants while still accommodating sea conditions and orienting the transects perpendicular to the longitudinal axis of the shoal.

The team selected 11 transects in 1998. These extended across the shelf break (Fig. 3) and covered a total area of about 25 km². The set of transects were travelled in the same direction and order. At the completion of each of 20 replicates, the vessel returned to the start point. During each return trip, the fishing captain piloted the W.E. Ricker over the longitudinal axis of the shoal, to re-affirm the general location of the shoal. Each replicate and return trip required two hours. The design was similar in 1999, except that the transects were spread over a broader area to encompass additional acoustic sign to the northwest (Wyeth *et al.* 2000).

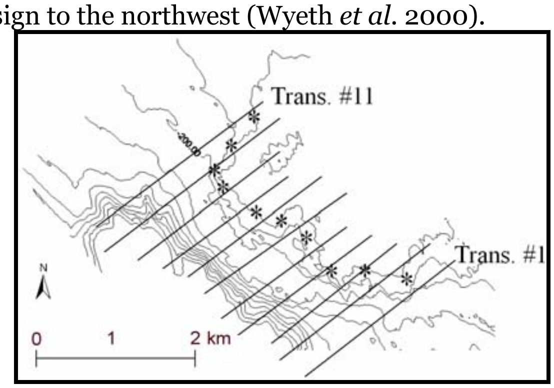

Figure 3. Location of transects relative to longitudinal axis of the widow rockfish shoal (*= approximate shoal location).

One of the most exciting and effective aspects of the study was that acoustic specialists on the W. E. Ricker were able to provide biomass estimates of the shoal during the cruise. Thus, by the completion of the 10th replicate in 1998, the team was aware that the estimates were consistently indicating about 2,000 t of widow rockfish. While disappointing to the team, since these values did not disprove an implied coastwide biomass of 15,000-30,000 t, the immediate feedback provided the opportunity to vary the design to see if some of the biomass was being missed.

The fishing captains questioned in particular whether the 11 repeated transects were, by chance, consistently missing the denser portions of the shoal. They hypothesised that the biomass estimates could be highly sensitive to transect choice owing to the variable density within the shoal. The team had planned to repeat the same transects to study diel vertical movement, however, since the credibility of the estimates was at stake, the team chose to vary the design. Starting with replicate #11, the entire pattern

was progressively offset to the northwest by approximately 180 m. While the new sets of transect still indicated about 2,000 t, making the modification not only tested the robustness of the estimates, but assured the fishing captains that they were equal participants in the study. The fishers' concern about the representativeness of the transects was viewed as a valid scientific question that should be addressed.

Although changing the transects helped reduce scepticism about the estimation process, the fishing captains remained concerned that the survey spent too little time over the shoal and too much time where there were no fish. Therefore, they surmised, it could lead to a biased estimate. The team accommodated this concern by extrapolating a biomass estimate from each return trip that ran over the longitudinal axis of the shoal. Fish density estimates for these transects were extrapolated under the assumption that the shoal was 0.5 km wide, the approximate average width of the shoal. The team found in both years that although these single transects concentrated on the shoal and provided a consistent display on the monitor, the extrapolations did not indicate any more biomass estimates than the standard design.

Finally, the fisher captains questioned whether a 2000 t estimate was consistent with the fact that they could catch from this shoal up to 50-100 t in a few minutes. The team therefore convened a small meeting aboard the W.E. Ricker during the 1998 cruise. The observed density estimates were converted to potential catch rates based on the net specifications and simplified assumptions of catchability. These estimates were found congruent with the catch rates the fishers had observed. The importance of this interaction was that the referential ground-truths of all participants were given their due. Scientists might have responded that commercial catch rates were simply not a concern. They had used an acoustic methodology that is documented, peer-reviewed, and scientifically sound. However, what comes up in a net is the real point of contact between those who fish and what is in the sea. The fishers were correct in suggesting that acoustic estimates of densities and maximum catch rates had to be congruent, or somewhere there was an incorrect assumption or calculation.

Encouraged by the success with one shoal in 1998, the senior author was ready to expand the approach and attempt a coastwide biomass estimate in 1999. However, during the follow-up meeting, the industry commented that while widow rockfish were caught elsewhere on the coast, they were so unpredictable in time and space that a large-scale survey would likely be unproductive. Thus, within the course of this project, the fishers not only identified a fruitful direction of research, but also prevented a wasteful one.

Instead of an expanded survey, the team re-examined the same study site in 1999. The two main objectives were to ensure that the 1998 estimates were not anomalous and to obtain estimates during days with stronger tides. In reviewing the 1998 study, fishers commented that the shoal had been estimated only during days of the weaker neap tides. They typically saw more acoustic sign and had higher catch rates on days when the tides were strengthening, just prior to the new or old moon. The 1999 results indicated a similar biomass as 1998, and provided no evidence of a significantly larger biomass during days with stronger tides. At conclusion of the study, there was a consensus that the project had exhaustively addressed the initial question of estimating the biomass of the shoal.

The team's success in 1998 also led them to examine the potential for conducting acoustic biomass estimates directly from commercial vessels. The practicability of adapting commercial fishing vessels to acoustic research platforms had already been demonstrated for herring on the Canadian East Coast (Melvin *et al.* 1998). The 1999 field trip successfully connected digitising equipment to the sounder on the Viking Storm. The calibration was successful and inter-calibration with the W.E. Ricker system indicated that the acoustic output was comparable (Wyeth *et al.* 2000). This confirmed that future shoal estimation could be conducted directly from commercial vessels.

EXAMPLE 2: SILVERGRAY ROCKFISH (*SEBASTES BREVISPINIS*)

Background

The second example chronicles the events related to an assessment review of silvergray rockfish (Stanley and Kronlund 2000). This species is a minor element in the BC bottom trawl fishery with annual coastwide harvests of approximately 1000 t from four areas (Fig. 4). Although the harvest is small, the choice of quota is contentious. Each vessel requires sufficient individual vessel quota (IVQ) of silvergray rockfish to accommodate the bycatch of silvergray rockfish that accrues as they target

other species. If an increase in abundance of silvergray rockfish is not matched by a higher quota, the species becomes an increasing nuisance in that other species cannot be fished without the vessels exceeding their IVQ's for silvergray rockfish. With 100% observer coverage, vessels may have to stop fishing completely when they reach their area-specific silvergray rockfish IVQ although they may not have captured the remaining IVQ's for other species.

Assessment information on silvergray rockfish is limited. Commercial CPUE is not assumed to index abundance and fishery independent indices are not available for a variety of reasons (Stanley and Kronlund 2000). The lack of a credible abundance index forces assessment staff to rely primarily on untuned catch-at-age stock assessment. These analyses indicated that the fisheries on three of the four stocks are currently relying on a strong recruitment mode centred on the 1981 yearclass. Although difficult to distinguish from increasing recruitment, the analysis indicated a modest fishing down of older age classes. This apparent reduction in the older ages was interpreted as indicating that exploitation has been at, or above, a sustainable rate, at least prior to the current recruitment pulse. Hence, although the stock is currently benefiting from the presence of a large yearclass the estimates of instantaneous fishing mortality (F) indicated that harvests should not be increased.

The trawl fishery representatives commented that silvergray rockfish were becoming harder to avoid, which implied to them that biomass was increasing and therefore the quotas should be raised. Furthermore, they suggested it was incorrect to assume comparability in the age composition over time, because the fishing locations had changed. They noted that samples had been collected from commercial landings on an opportunistic basis, such that sample location was determined by the fishery. With the introduction of IVQ's in 1997, the small individual quotas for silvergray rockfish had forced the fleet to move away from areas of higher catch rates. Most of the catch, and therefore the samples, were now being collected from other locations where silvergray rockfish catch rates were lower. They reasoned that the age composition might differ in the new locations. Therefore, it was incorrect to infer population dynamics from trends in the age composition.

The senior author responded that a simple review of the distribution of the samples had not revealed gross changes in area or depth of capture. Because there was no demonstrable bias in age composition, the stock assessment advice was accepted as the basis for the management plan.

Methods and Results

Following the review process, the senior author conducted an observer trip on another commercial trawler, the "E.J. Safarik" in February 2001 with another industry associate, Captain Reg Richards, one of the principal trawl fishers operating in Area 5E. Captain Richards had been an advisor during background work on the assessment, and was critical of the resulting quota. The objective of the trip was to provide the senior author with an opportunity to discuss the assessment as well to provide Captain Richards the opportunity to demonstrate how IVQ's might have changed the sampling of silvergray rockfish in Area 5E.

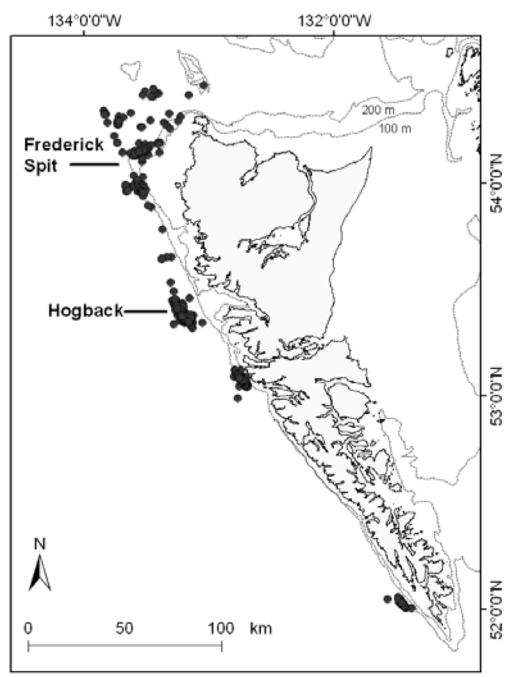

Figure 4. Locations of bottom trawl tows which captured at least 200 kg of silvergray rockfish. Data are from 1996 to September, 2001.

Captain Richards explained that the fishery for silvergray rockfish had traditionally concentrated on the "Frederick Spit" grounds near the Canada/Alaska border (Fig. 4). With introduction of IVQ's in 1997, the fishers had switched to the "Hogback" grounds to avoid high

catch rates. There they targeted on redstripe rockfish (S. proriger) while slowly accumulating their IVQ of silvergray rockfish. He questioned whether the relative absence of older fish from recent samples might have resulted from the shift in source of the samples from the Frederick Spit to the Hogback fishing grounds. He offered to conduct 1-2 tows on both spots so that the senior author could obtain a comparison of the age composition.

When the three samples were collected and analysed, they indicated a significant difference in age composition (Fig. 5). The Hogback sample indicated the typical 1981-recruitment mode, whereas the two samples from Frederick Spit were much older. This led the senior author to look more closely at the spatial distribution of the samples used in the stock assessment. These indicated that through 1998, the samples were representative of the entire area and consistent in age composition over time and space (Fig. 6). Thus, the assessment, based on data through 1998, was not biased in that respect. However, as of 1999, the samples were restricted to the Hogback. Thus, the fishing captain's concerns had revealed that the fortuitous representativeness of the commercial sampling was deteriorating and future assessments would be compromised.

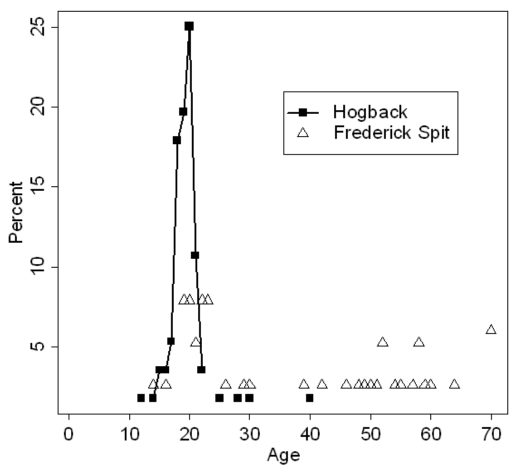

Figure 5. Percent composition by age of silvergray rockfish samples taken during February 2001 observer trip.

The concern that age composition might vary with changing fishing patterns led to discussions with Captain Richards over how to consistently obtain representative samples from the whole area. The senior author could not envision a survey that could provide the samples without capturing most of the 5E quota of about 200 t. Captain Richards proposed a solution wherein he would trawl a set of specified tow locations but avoid excessive catches by cutting a hole in the forward part of the codend. This mini-survey is planned for January 2002. In addition to this attempt to modify sample collection, the senior author noted that future assessments would pay more attention to the fine-scale spatial distribution of the samples.

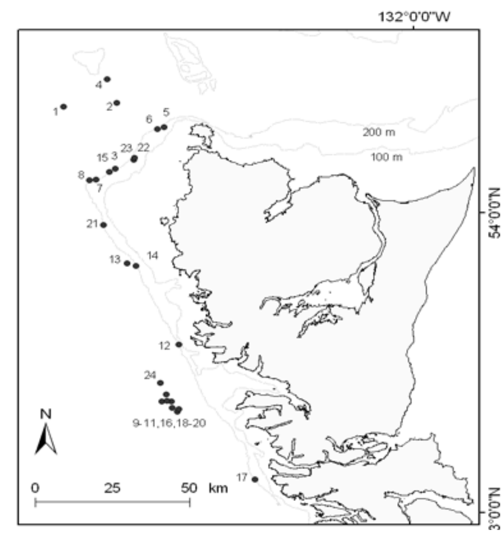

Figure 6 Location of silvergray rockfish samples used in 2000 silvergray rockfish assessment for area 5E (Stanley and Kronlund 2000).

Further analysis indicated that the two 2001 Frederick Spit samples differed not only from the 2001 Hogback samples but from all previous Frederick Spit samples. They differed although they were collected within a few kilometres, in the same months, and only a few meters shallower than previous samples. When informed of the results, Capt. Richards commented that these slightly shallower locations were rarely fished. While attempting to provide the silvergray rockfish samples from the Frederick Spit sound, he had moved slightly shallower in hopes of also obtaining canary rockfish (S. pinniger) to sample. He hypothesised that the older fish represented an unfished group of "homesteaders". There has long been a suspicion among biologists that some rockfish species may exhibit a range of behavioural modes, ranging from highly mobile to refugial (MacCall *et al.* 1999).

Discussion

Data collection, fisher knowledge and science

The two cases provide numerous examples of the data collection opportunities provided by commercial fishers and the role that fishers' knowledge can play in assessment research. Background information and integrative thinking was required to conceive and conduct

the widow rockfish survey. Fisher awareness of how the fishery was evolving in response to IVQ's led to the perspicacious critique of the silvergray rockfish assessment.

More importantly, the two examples show that fishers bring far more to research than cheap data collection and background knowledge. The initial hypothesis for testing the biomass of the widow rockfish shoal was generated by the fishers. Similarly, the request by fishers to examine the sensitivity of the estimates to transect choice enhanced the credibility of the estimates to all participants. The critique by fishers following the 1998 survey also led to the test of tide effects in 1999. Furthermore, their knowledge about the coastwide distribution of widow rockfish prevented a pointless and wasteful expansion of the scale of the project

In the second example, it was the fishers' comments about the comparability of samples over time, which led to an examination of the spatial distribution of the samples and illustrated the need for a more rigorous sampling design. In this case, the quality of future assessments will be improved because the fishers used their knowledge to pose alternative hypotheses and suggest ways to test them. Participatory Research thus integrates questions raised by the observations of traditional users with typical activities of government and academic researchers (Pinkerton 1994).

The participatory nature of these two studies also provided benefits beyond the stated objectives. Fishers aboard the research vessel, and those that visited during harbour days were introduced to high quality digital acoustic equipment and to the methodologies and assumptions that are required to convert digital backscatter measurements to biomass. They not only became educated about the strengths and weaknesses of acoustics for assessment, but also learned that output from split-beam sounders can provide information on fish size frequencies. This equipment is now being purchased by the trawl fleet to help reduce bycatch during midwater trawling (B. Mose, pers. comm[2].). Conversely, fishers educated acoustic staff about the nature and variability of the echo sign they have observed and the extent to which side-lobe interference over high relief bottom can generate false fish sign. Although this phenomenon is well known, the actual examples surprised acousticians leading to changes in how echograms are scrutinized following surveys of near-bottom species (R. Kieser, pers. comm.[3]).

Tactics which facilitated participation

The participation was facilitated by a variety of attributes of the studies; however, we emphasize that the following discussion is largely from hindsight. None of the participants was aware of the extensive literature pertaining to *-knowledge or PR, nor was the present document a planned outcome.

Both initiatives were facilitated through joint meetings during observer trips and stock assessment meetings and therefore, represent time away from traditional roles and being on the other's "turf". Both initiatives required that participants question each other in their areas of expertise. Just as the questions had to be posed with appropriate respect, the answers had to be complete and non-defensive. The scientists had to abandon the attitude of "leave the science to us", as the fishing captains had to accept that that objective, quantitative verification of viewpoints is essential to resolving differences in points of view or hypothesis testing.

The participation was also facilitated by computer technology. This included our ability to provide biomass estimates during the survey and the use of 3-dimensional graphics to present the finished results (Stanley *et al.* 2001). While not available to all studies, they illustrate the benefits in participatory research of rapid feedback (Zwanenburg *et al.* 2000) and the value of mutually understandable graphical images (Walters *et al.* 1998).

Much of the previous discussion relates to enhancing communication. While an obvious goal, an interesting example of the cost of not communicating is provided by a retrospective look at the early days of stock assessment in BC from approximately 1980 to the mid 1990s. During those years, fishers were excluded from assessment meetings because, among other reasons, it was felt that their presence would promote biased interpretations of results and inhibit debate among the scientists.

It was believed that bias would be promoted because it was assumed that the financial interests of fishers would render them unwilling to contribute objectively. This risk cannot be ignored, but we have found that trust and respect among fishers and assessment staff can be a sound foundation for candid and objective

[2] B. Mose. 641 Hollywood Rd, Qualicum Beach, BC. V9K 1M3.

[3] R. Kieser. Fisheries and Oceans, Canada. Pacific Biological Station, Nanaimo, BC. V9R 5K6

exchanges in many settings, including assessment meetings. Moreover, it is well documented that scientists do not have a flawless record of objectivity. For example, instances of confirmatory bias are very common in science (Nicholls 1999). Even when scientists specify the error rates that are the basis for traditional hypothesis testing, or the probabilities associated with Bayesian decision support (McAllister and Kirkwood 1998), fisheries data are highly uncertain. This makes the tails of the likelihood profiles poorly determined, and the reliance on formal use of probability-based methods more form than reality (Patterson *et al.* 2001). Often the nature of the dialogue in an assessment meeting must focus more on the justification for assuming that alternative information sources and interpretations are reliable and credible, rather than on statistical nuances that have weak empirical foundations. Hence, without actually lowering their standards of rigour, the science participants may find other grounds for accepting and rejecting ideas that are both sounder and more meaningful to their research partners.

An example of an overly ambitious attempt to invoke rigour relates to estimation and mis-use of relative error from biomass surveys. In the 1980's, government and industry assessment consultants estimated relatively tight precision around the biomass estimates following 3-week surveys. Fishers questioned how scientists could be so sure of the precision, when fishers observed for some species, an order of magnitude variation from one set of lunar tides to the next. The assessment staff were using the relative error calculated from individual surveys as a surrogate for the expected "within-year" variance of the abundance index. Although discontinued for these stocks, this remains a common practice in stock assessment although numerous studies have shown much greater variance among replicate surveys than what is inferred from individual surveys (Stanley *et al.* 2000). This statistical short-cut obviously results from the prohibitive expense of conducting replicates or extending the duration of surveys. Nevertheless, fishers' intuition was correct in that precision inferred by assessment staff could not truly reflect the background "noise" that should be expected in the index.

The fear that debate would be suppressed by the presence of industry representatives arose because it was assumed that fishers would equate "uncertainty" with a lack of knowledge (Preikshot 1998) and that this would further erode credibility in the assessment advice. However, excluding fishers from the healthy debate reinforced their belief that researchers overestimated the accuracy of their stock assessments.

Once fishers observed and participated in the debate, they became reassured that researchers and managers understood the limitation of the data, the techniques, and the advice. Fishers were already experientially aware of how hard it must be to estimate abundance. What worried them was the possibility that research staff did not know it. Fishers may become more sceptical of the science the more they know; but scepticism is a good thing when it prompts constructive follow-up (McGoodwin *et al.* 2000). While still evolving, the process for BC groundfish has now progressed from where fishers and other interested groups were present only at the final review meeting, to being present at a series of meetings. These include workplan prioritisation and a pre-assessment meeting in which authors outline the data sources and methods that will be used.

This trend is not limited to the research on Canada's Pacific coast. As stakeholders have taken an increasing role in assessment meetings in Canada, documents from the Canadian Stock Assessment Secretariat Proceedings provide growing evidence of their interpretative skills. Summary documents frequently include a section on "Industry Perspective" (see Stock Status Reports on http://dfo-mpo.gc.ca/csas).

Strategies which facilitated participation

A strategic issue that contributed to these studies was the growing role of industry-funded research. It not only increases the available resources, but also by decentralizing the control of resources leads to new research directions (Chambers 1989). We do not argue that industry should control all or most resources, but do argue that there are benefits when they have significant influence.

These industry-based research organisations also provide venues for fishers to discuss scientific ideas, directions, and hypotheses apart from the tense atmosphere of stock assessment or management meetings (B. Turris, pers. comm.[4]). It has been conjectured that an essential step to maximising the value of resource users as research partners is to support mechanisms that encourage the users to seek excellence and test

[4] B. Turris. Canadian Groundfish Research and Conservation Society. 333 Third St., New Westminster, BC. V3L 2R8.

ideas together, on their own terms, and in their own language (Rice 1998). The research collaboration is then the blending of ideas that meet standards of excellence applied by both the scientific and user communities. These meetings are thus industry analogues to scientific conferences and workshops. Assisting the blending of ideas is the growing tendency for these industry organisations to fund science-industry liaison positions (V. Boudreau, this volume) and hire fisheries data analysts. The liaison positions work to keep communication lines open. The consultants provide an increased opportunity for fishers to question and understand technical issues. The "tutoring" process is especially important because of the technical syntax employed during official meetings. Fishers often complain that technical staff should make a bigger effort to make their presentations more understandable. Finally, the allocation of research funds by these groups has educated them in the cost of science (and educated scientists in the cost of fishing), just as joint authorship of a primary paper (Stanley *et al.* 2000) conveyed to fishers the commitment required to communicate research results.

Using examples from our work and that of others, we have identified some means for enhancing communication and building relationships that lead to PR. Tactics notwithstanding, PR ultimately relates to the process of building mutual respect. The most important attribute of the two examples, was the willingness of both parties to view and identify the problems with respect to each party's terms of reference. Both studies benefited from the collaborative atmosphere in which neither "scientific" nor "fisher" interests felt threatened, and all parties were assured that they brought vital skills and knowledge (Sillitoe 1998).

Participatory Research can thus be both a means and an end (Sajise 1993). It appears to be a means for coping with the "Conflicting dogma of the omniscience"...that researchers know better because of their formal education, and fishers know better because of their experiential background. It tends to break down the hierarchical vision of knowledge wherein the higher order science is considered the work of the privileged and the business of people formally trained in public institutions (Pálsson 2000).

Developing this working relationship is a two-way process (see many other papers in this volume). As government staff work to change their style (McGoodwin *et al.* 2000), and mature the relationships with their clients, so must their clients. Candid commentary from either harvesters or environmentalists can only be expected in an atmosphere of respect (B. Dickens, pers. comm.[5]), and when all participants share a goal of finding solutions, not merely getting attention. A commitment to PR fortunately makes this an attainable goal.

The costs and risks of participatory research (PR)

While we extol the potential benefits from PR, we acknowledge its costs. While we argue that "one cannot communicate too much" and endorse the idea of paid liaison positions, we must acknowledge that these resources could also be directed at an endless number of other beneficial initiatives. Biologists have much to learn by making observer trips on commercial vessels, but time at sea is time away from detailed likelihood profiling, complex ecosystem modelling, and career-advancing research projects.

We have noted the benefits of having fishers participate in the assessment review, but these same fishers are now complaining of meeting fatigue and are attempting to rotate others into these roles (as, indeed, are many assessment staff). Strategic planning has to cope with these conflicting needs. Our underlying belief is that any initiative that brings more research assets into the process has to be cost-effective.

As PR may incur different costs, it also incurs risks. Building relationships is not a simple matter of parachuting biologists on fishing boats or dragging fishers to stock assessment meetings. All participants need to learn how to critique each others' hypotheses and information, jeopardising neither rigour nor respect. In peer review meetings, there are frequent instances of ill feelings arising among scientific peers due to particularly critical reviews and debate. Even after individual fishermen and scientists have learned to respect and value each others' creative hypotheses, criticism and sources of new information, the relationship can be strained by the challenge function of peer review.

> *"The problems that attend interdisciplinary research are, however, legion; it regularly founders on the rocks of misunderstanding and the unwillingness of specialists to generalize*

[5] B. Dickens. 1678 Admiral Tryon Blvd. Qualicum Beach, BC. V0R 2T0.

> *and compromise. An integrated perspective implies a willingness to learn from one another...."* (Sillitoe 1998, p. 231)

Leaman and Stanley (1993) describe an attempt to improve stock assessment science through PR that partially failed because of a lack of preparation and abundance of naïveté. We could provide similar examples of failures to create working relationships between governments and academic institutions, or academic institutions and harvesters. These initiatives were well intentioned but paid too little attention to project preparation and conditioning expectations, and spent too little time nurturing the relationship. They also may have suffered from attempting too much, too fast. The two examples presented in this document clearly benefited from being small and narrowly defined in scope. As learning to fish can be thought of as a journey by Icelandic fishers, so can we perceive PR (Pálsson 2000). It is part of a long process of small steps wherein harvesting and research could become the same thing (J. Prince, pers. comm[6].).

We have provided two examples of PR and summarized the elements and approaches we think that facilitated the process. It seems like a dazzling glimpse of the obvious, but if it were so obvious, examples of PR in fisheries and marine science would be common, not rare. The overall issue is building effective working relationships, a goal than indeed should be "dazzlingly obvious".

ACKNOWLEDGEMENTS

We note that the two examples provided above are only two examples of many similar activities currently underway within the Department of Fisheries and Oceans, Canada on the Pacific coast. In fact we are obliged to comment that participatory research or studies using *-knowledge have a long history on Canada's Pacific, as we are sure they have had elsewhere. Although these keywords never identified in the publication titles, many fishery researchers over the courses of their careers have accrued extensive commercial fishery time in the process of joint conduct of fishery research with fishers. These would include in BC waters, Neil Bourne, Dan Quayle, Terry Butler, Keith Ketchen, and Bruce Leaman. In fact, the sharing of knowledge and joint participation in fishery research has a long history. It is to be remembered that the first coelacanth specimen was obtained because of shared interest in fishes between a young museum curator and a trawl skipper (Weinberg 1999).

As did the studies summarized above, the present paper benefited greatly from discussions and fishing trips with trawl fishing captains including Captains Kelly Anderson, Brian Dickens, Brian Mose, Reg Richards, and John Roche. Review comments from Bruce Turris, Norm Olsen and Bruce Leaman greatly improved the manuscript.

REFERENCES

Agrawal, A. 1995. Dismantling the divide between indigenous and scientific knowledge. Development and Change. 26(1995): 413-439.

Ames, E., S. Watson, and J. Wilson. 2000. Rethinking overfishing. Insights form oral histories of retired groundfishermen. pp. 153-164. In Finding our sea legs. Linking fishery people and their knowledge with science and management. Edited by B. Neis and L. Felt. ISER books, Memorial University, St. John's, Newfoundland. 318 p.

Archibald, C.P., W. Shaw, and B.M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. waters, 1977-1979. Canadian Technical Report of Fisheries and Aquatic Sciences. No. 1048. 57 p.

Archibald, C.P., D. Fournier, and B.M. Leaman. 1983. Reconstruction of stock history and development of rehabilitation strategies for Pacific ocean perch in Queen Charlotte Sound, Canada. N. Amer. J. Fish. Manage. 3:283-294.

Boulva, J. 1994. A Renewed Process for Assessment of Atlantic Stocks. Dept. Fisheries & Oceans. 16 pp.

Brown, R.C. 1988. Community-based cooperative management: renewed interest in an old paradigm. pp. 185-194. In Reinventing Fisheries management. Edited by T.J. Pitcher, P.J.B. Hart, and D. Pauly. Kluwer Academic Publishers, London. 646 p.

Chambers, R. 1989. Reversal, institutions and change. pp. 181-195. In Farmer First: Farmer Innovation and Agricultural Research. Edited by R. Chambers, A. Pacey, and L.A. Thrupp. 1989. Intermediate Technology Publications. Short Run Press, Exeter. 218 p.

Chambers, R., A. Pacey, and L.A. Thrupp. 1989. Editors. Farmer First: Farmer Innovation and Agricultural Research. Intermediate Technology Publications. Short Run Press, Exeter. 218 p.

Dyer, C.L. and J.R. McGoodwin. 1994. Editors. Folk management in the world's fisheries: lessons for modern fisheries management. University Press of Colorado. 347p.

Ferradás, C. 1998. p. 239 In appended discussion notes of: Sillitoe, P. 1998. The development of indigenous knowledge. Current Anthropology. 39(2): 223-252.

Fischer, J. 2000. Participatory research in ecological fieldwork: a Nicaraguan framework. pp. 41-54. In Finding our sea legs. Linking fishery people and their knowledge with science and management. Edited by B. Neis and L. Felt. ISER books, Memorial University, St. John's, Newfoundland. 318 p.

Gavaris, S. 1996. Population stewardship rights: decentralised management through explicit accounting of the value of uncaught fish. Canadian Journal Fisheries Aquatic Sciences 53: 1683-1691.

Hutchings, J.A. 1996. Spatial and temporal variation in the density of northern cod and a review of the hypotheses for the stock's collapse. Canadian Journal Fisheries Aquatic Sciences 53: 943-962.

[6] J. Prince. P. O. Box 168. South Fremantle, WA 6162. Australia.

Johannes, R.E. (1978) Words of the Lagoon: Fishing and Marine Law in the Palau District of Micronesia. Berkeley, CA: University of California Press. 245 p.

Leaman, B.M. and R.D. Stanley. 1993. Experimental management programs for two rockfish stocks off British Columbia, Canada. pp. 403-418. In Risk evaluation and biological reference points for fisheries management. Edited by S.J. Smith, J.J. Hunt, and D. Rivard. Canadian Special Publications Fisheries Aquatic Sciences 120. 442 p.

McAllister, M.K. and G.P. Kirkwood. 1998. Using Bayesian decision analysis to help achieve a precautionary approach for managing developing fisheries. Canadian Journal of Fisheries and Aquatic Science 12: 2642-2661.

MacCall, A.D., S. Ralston, D. Pearson, and E. Williams. 1999. Status of bocaccio off California in 1999 and outlook for the next millenium. Appendix to Status of the Pacific Coast Groundfish fishery through 1999 and recommended acceptable biological catches for 2000. Pacific Fisheries Management Council. Oregon, U.S.A. 45 p. http://www.pfmc.org

Mackinson, S. and L. Nøttestad. 1998. Combining local and scientific knowledge. Reviews in Fish Biology and Fisheries 8: 481-490.

McGoodwin, J.R., B. Neis, and L. Felt. 2000. Integrating fishery people and their knowledge into fisheries science and resource management. Issues, prospects, and problems. pp. 249-264. In Finding our sea legs. Linking fishery people and their knowledge with science and management. Edited by B. Neis and L. Felt. ISER books, Memorial University, St. John's, Newfoundland. 318 p.

Neis, B., L. Felt, D.C. Schnieder, R. Haedrich, J. Hutchings, and J. Fischer, J. (1996) Northern cod stock assessment: what can be learned from interviewing resource users? DFO Atlantic Fish. Res. Doc. 96/45. 28 p.

Neis, B. and L. Felt. Editors. Finding our sea legs. Linking fishery people and their knowledge with science and management. ISER books, Memorial University, St. John's, Newfoundland. 318 p.

Nicholls, N. 1999. Cognitive Illusions, Heuristics, and Climate Prediction. Bulletin of the American Meteorological Society. 1385-1397.

OMB. 2001. NOAA FY 2002 Budget Summary. Published by Office of Management and Budget, United States Government.

Pálsson, G. 2000. Learning, the process of enskilment, and integrating fishers and their knowledge into fisheries science and management. pp. 26-40. In Finding our sea legs. Linking fishery people and their knowledge with science and management. Edited by B. Neis and L. Felt. ISER books, Memorial University, St. John's, Newfoundland. 318 p.

Patterson, K., R. Cook, C. Darby, S. Gavaris, L. Kell, P. Lewy, B. Mesnil, A. Punt, V. Restrepo, D.W. Skagen, and G. Stefannsson. 2001. Estimating uncertainty in fish stock assessment and forecasting. Fish and Fisheries. 2(2):125-157.

Pinkerton, E.W. 1994. Summary and conclusions. pp. 317-337. In Folk management in the world's fisheries: lessons for modern fisheries management. Edited by C.L. Dyer, and J.R. McGoodwin. 1994. University Press of Colorado. 347p.

Preikshot, D.B. 1998. Reinventing the formulation of policy in future fisheries. pp. 114-123. In Reinventing Fisheries management. Edited by T. J. Pitcher, P.J.B. Hart, and D. Pauly. Kluwer Academic Publishers, London. 646 p.

Rice, J. 1998. Fostering sustainable development and research by encouraging the right kind of institutions. pp. 195-200. In Reinventing Fisheries management. Edited by T. J. Pitcher, P.J.B. Hart, and D. Pauly. Kluwer Academic Publishers, London. 646 p.

Roepstorff, A. 2000. The double interface of environmental knowledge. Fishing for Greenland Halibut. pp. 165-188. In Finding our sea legs. Linking fishery people and their knowledge with science and management. Edited by B. Neis and L. Felt. ISER books, Memorial University, St. John's, Newfoundland. 318 p.

Ruddle, K. 1994. Local knowledge in the folk management of fisheries and coastal marine environments. pp. 161-206. In Folk management in the world's fisheries: lessons for modern fisheries management. Edited by C.L. Dyer, and J.R. McGoodwin. 1994. University Press of Colorado. 347p.

Sajise, P.E. 1993. Participation in research or research for participation: its relevance to sustainable development. Out of the Shell. 3(2): 1-5.

Sillitoe, P. 1998. The development of indigenous knowledge. Current Anthropology 39(2): 223-252.

Stanley, R.D., R. Kieser, K. Cooke, A.M. Surry, and B. Mose. 2000. Estimation of a widow rockfish (Sebastes entomelas) shoal off British Columbia, Canada as a joint exercise between assessment staff and the fishing industry. ICES Journal of Marine Science. 57:1035-1049.

Stanley, R.D. and V. Haist. 1997. Shelf rockfish assessment for 1997 and recommended yield options for 1998. Canadian Stock Assessment Secretariat Research Document 97/132. 76 p.

Stanley, R.D. and A.R. Kronlund. 2000. Silvergray rockfish (Sebastes brevispinis) assessment for 2000 and recommended yield options for 2001/2002. Canadian Stock Assessment Secretariat Research Document 2000/173. 116 p.

Stanley, R. D., R. Kieser, and M. Hajirakar. 2001. Three-dimensional visualization of a widow rockfish (Sebastes entomelas) shoal over interpolated bathymetry. ICES. Journal Marine Science. 59: (in press)

Walters, C. J., J.H. Prescott, R. McGarvey, and J. Prince. 1998. Management options for the South Australian rock lobster (Jasus edwardsii) fishery: a case study of co-operative assessment and policy design by fishers and biologists. In Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. Edited by G.S. Jamieson and A. Campbell. Canadian Special Publication Fisheries Aquatic Science. 125: 377-383.

Weinberg, S. 1999. A fish caught in time. The search for the coelacanth. Fourth Estate Limited. London. 239 p.

Wyeth, M.R., R.D. Stanley, R. Kieser, and K. Cooke. 2000. Use and calibration of a quantitative acoustic system on a commercial fishing vessel. Canadian Technical Report of Fisheries and Aquatic Sciences. 2324. 46 p.

Zajonic, R. 1980. Feeling and thinking: preferences need no inferences. American Psychologist 35(2):151-175.

Zwanenburg, K., P. King, and P. Fanning. 2000. Fishermen and scientists research society. A model for incorporating fishermen and their knowledge into stock assessment. pp. 124-132. In Finding our sea legs. Linking fishery people and their knowledge with science and management. Edited by B. Neis and L. Felt. ISER books, Memorial University, St. John's, Newfoundland. 318 p.

QUESTIONS

Robert Chriseiger: What is the base of the food chain? What is the source of food for rockfish and hake?

Richard Stanley: They are mostly shrimp from the deep scattering layer.

Robert Chriseiger: Why is it that Americans have banned fishing of krill, but we're taking 10,000 tonnes? That is part of the food chain. It is killing part of the food chain.

Richard Stanley: They assessed the amounts just as they did other species and set a maximum amount to catch.

Robert Chriseiger: We're fishing an unknown quantity. That could be the last of the food chain. How do we deal with it?

Richard Stanley: There are stock assessments done.

THE DISCOURSE OF PARTICIPATORY DEMOCRACY IN MARINE FISHERIES MANAGEMENT

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ABSTRACT

Participatory marine fisheries management systems bring together diverse stakeholders to share knowledge, authority, and responsibility for regional planning. As such, the intent of participatory or cooperative management endeavors is to move away from top-down, non-participatory governance systems that exclude local people and fail to meet conservation objectives. Case studies from the United States and Kenya are used to argue that despite official claims to the contrary, revamped fisheries management systems fall short of being genuine participatory democracies, fail to include stakeholders in substantive ways, and do not meet conservation goals. Means to share information in new, more effective ways and build truer, more equitable coalitions are offered.

INTRODUCTION

Since the mid-1970s, a growing number of specialists have considered the inclusion of local communities in environmental management necessary for successful conservation. These experts contend that conventional resource management policies fail because local communities pay the greatest cost for conservation in the form of lost access to resources, but receive few benefits from species protection (Fairhead 1991, Chambers 1997).

Governments have aspired to eliminate the historic antagonism of local people toward resource management plans and instill a sense of responsibility for resources through changes in management that allow for greater local participation. Yet, even seemingly enlightened participatory management initiatives have often failed to appease local people or halt species declines (Little 1994).

In this paper, we argue that there is an inherent flaw in calling for more participatory forms of management when the specific goals are predetermined. Under such conditions, local people's role in the management process necessarily remains prescribed and largely symbolic. The authors contend that, whereas there is a discourse of participatory marine management, the practice remains hierarchical and inclined toward use of the knowledge of those with the most formal education and the least experience at sea. As with flying an airplane or farming a field, the approach to solving fisheries problems must incorporate the practical experience of interested and affected parties. Based on case studies from the United States and Kenya we offer a means to share knowledge in new, more effective ways to build genuine and more equitable coalitions that can perform more effectively.

RESEARCH APPROACH AND METHODS

Political ecologists view environmental crises as inextricably linked to a much wider development crisis, including a growing gap between rich and poor and the increasing number of people globally living in abject poverty (Dorraj 1995, Bryant and Bailey 1997). In this context, environmental change is viewed as meaningful to individuals and user groups largely in terms of whether it provides an opportunity or presents a problem (Blaikie and Brookfield 1987). Stakeholder groups in participatory marine management systems, including local people, state agencies, businesses, and environmental organizations, often share the long-term goal of fish stock recovery, but differ on the best means of achieving it. Central among the conflicts over how to best sustain fish stocks are the relative weight that should be given to: fishers' knowledge gained via observation and informal experimentation at sea, the institutionalization of the fishers' knowledge within the decision-making process, and the more formal training of fisheries agents, researchers at universities, and conservationists.

For this paper, Heidi Glaesel, a Ph.D.-holding University professor, draws on library research and dozens of semi-formal interviews with stakeholders from various levels of authority in fisheries management in Kenya (1994-1996) and the United States (2000-2001); Mark Simonitsch draws on experiences as a New England commercial fisherman of more than 35 years, grassroots activist with fisher organizations and worker cooperatives in the United States, Canada, Belize, Guatemala,

Honduras, and Spain and as a well informed citizen.

The Structure of Marine Management in the United States

The Magnuson-Stevens Fishery Conservation and Management Act (1996), or Magnuson-Stevens Act, is the federal legislation under which the US Congress delegates responsibility for marine resource management to the Department of Commerce. The National Marine Fisheries Service (NMFS) is the federal agency within the Department of Commerce's National Oceanographic and Atmospheric Administration (NOAA) with responsibility for managing fish from three to two hundred miles from the offshore (www.nmfs.noaa.gov). Individual states manage nearshore waters.

In 1976, the predecessor of the Magnuson-Stevens Act, the Magnuson Fisheries Conservation and Management Act, created eight regional fisheries management councils to advise NMFS on issues identified in the federal legislation and to access regional knowledge in developing this advice. Each council has approximately twenty appointed members who vote. The voting members include mandatory appointees from each state, representatives from each state's fishery agency, and at-large appointees from any of the states from within the region. Appointees are nominated through a political selection process that concludes with the various regional state governors independently submitting nominations to the Secretary of Commerce for final selection.

The fundamental task of the fisheries councils is to produce recommendations for fish management plans (FMPs). Local knowledge, in the form of public input, is solicited during the council's preparation of the FMPs. All council actions are in the form of recommendations to the Secretary of Commerce, a member of the President's cabinet and one of the nation's twelve most powerful political appointees. A process exists whereby NMFS reviews the council recommendations prior to their arrival on the desk of the Secretary for final approval. Enforcement of the approved regulations is the primary responsibility of the Department of Commerce. The US Coast Guard and the state fisheries enforcement organizations assist Commerce with enforcement responsibilities, but the primary regulatory effort to recommend, review, approve, implement and enforce fishery laws is accomplished within the Department of Commerce (Wallace and Fletcher, second edition).

How the existing system fails to meet the criteria for a participatory democracy

NMFS, regional councils, SeaGrant Institutes, and mainstream conservation organizations have produced literature on the federal marine management process that promotes a belief that the Magnuson Act and Magnuson-Stevens Act encourages local-level participation and representative democracy (Fowle 1993, McKay and Creed 1999) We contend that opportunities for authentic local-level participation are not as available as the literature suggests, and that the current institutional structure of the marine fisheries management system is far from being a true representative democracy in that the opportunities it provides are largely symbolic.

Democracy has well-accepted criteria, and if all of the criteria are not present then democracy does not exist. First is the right to be included as a full citizen of the organization making the collective decisions to which one is subject. Second, is the right to voting equality. Third, is an equal opportunity for participating effectively in decision making. Fourth is a full opportunity for acquiring an understanding of one's personal interest in the decision and last is the right to exercise with fellow citizens final control over the decisions. (Dahl 1989, p. 170).

No part of the council process fits the criteria for democracy. Council members are appointees and are not elected. By virtue of their formal oath, the appointed members are held to maximizing benefits to the nation, generally interpreted as stricter conservation of marine resources. No council member is permitted to represent any one affected party over any other interested group or place (Fowle, 1993).

Without elections for council membership, the council has no consent from a body politic. Lacking consent, the council has no claim for a constituency. Apart from the council appointees, all other interested parties in the council are without any formal relationship to the fisheries management political process. In this unusual situation, the individuals most affected have no formal political connection with respect to the council process, as citizens, subjects, or members. How can it be claimed that council members are representing the political interests of these people?

The status of membership in the council closely follows the formula recommended by Plato for seeking justice in a totalitarian society. Only "philosopher kings" (seekers of wisdom) were considered fit to practice the "royal science" of

politics. Plato deemed the average citizen's "virtue" insufficient, and would have appointed only the few wise people judged to have the highest amount of "civic virtue," to government decision-making positions. Plato, unlike regional councils, left little doubt regarding his belief of the usefulness of local-level knowledge and participation with the statement "Equal treatment of un-equals must beget inequity." (Popper 1962, p. 96).

Many council committees have industry advisory groups. Can the utilization of advisors be the justification for claiming the existence of local level participation? The following conditions exist: First, advisors are volunteers; second, the Council Executive Committee appoints the volunteer advisors in closed sessions. Third, no mechanism or requirement exists for advisors to gather local knowledge using formal or informal methods prior to attending advisor meetings. Advisors are not required to disseminate meeting results locally, nor could they do so given the relatively small number of advisors, large areas and limited council budgets.

Hearings to collect public input are held on occasion, but since council members are not elected and staff members are heavily involved in holding these "hearings," the rich content and useful meaning of a public hearing with an elected representative is not achieved. Meeting attendees have no institutional political connection with the councils at these gatherings that are conducted to obtain "public input" and moderated by a few appointees and staff. The best that can be said for attending public input meetings is that if the attendee is selected to be a speaker (s)he has an opportunity to use his or her knowledge to persuade those few appointees who may be present.

Further loss of meaningful political input occurs when the hearings to gather public input are subjectively summarized by council staffs and lightly reviewed by council members. On more than one occasion, minutes from public input sessions have been verbally summarized and presented to the council when time constraints between the hearings and the council meeting did not permit preparation of a written summary of the public input (MAFMC 1998).

Why Congress chose not to have a Participatory Democracy

How did the situation come about whereby the fisheries governance system chosen by Congress only permits symbolic use of fishers' knowledge? Congress's action to have decision-making by fisheries experts may have come from a concern about ability to achieve national environmental goals if local communities or their representatives shared decision-making authority. Legislators may have understood that inherent with any form of deliberative democracy (representative or otherwise) is the inability to predict outcomes. In short – Congress may have believed a struggle between the desired outcome (sustainable resource goals) and procedure (local-level participation in self-government) to be an unsolvable paradox for a democratic process (Dryzek 2000, p. 141).

The US Congress selected a form of guardianship governance that leaned heavily on a guiding concept of experts managing marine resources for their maximum sustainable yield (MSY). This governing process depended principally on fisheries scientists and managers controlling the technique, distribution and amount of all fishing efforts from a large-scale vantage point. Within ten years of the enactment of Magnuson, it became very apparent that MSY could not be consistently attained by depending solely on scientists and fisheries statistics. Despite the demonstrated poor management performance the entrenched decision making method continued without authentic participation of many of the affected parties (Ludwig, *et al.* 1993, p. 17). If fishers' knowledge is to be put to work in the system, it is essential to understand why the US did not institutionalize authentic local participation and deliberative democracy.

Four elements combined to influence the choice of a governance system where decision making was given to appointed experts, while the public role was reduced to providing "input" to the experts (Scott 1998, p. 4). The first element was the administrative need to document harvesters and marine resources. Official records of names and licenses of boats and captains were developed. A system of maps and charts was combined with the electronic capability to repeatedly and accurately locate geographical positions thereby enhancing enforcement.

The second element was the development of a very strong societal belief in the abilities of scientists and professional managers. This belief was reinforced not only by the economic progress in the United States, but also the actual life experiences of the members of Congress. Many of the legislators voting for Magnuson in 1976 were veterans of World War II where victory depended heavily on the centralized use of expert managers, engineers and scientists. The results of the Marshall Plan's success in

rebuilding the economies of war torn Europe was one of a number of examples of remarkable outcomes that could be achieved with a centralized command and control process utilizing professional managers and experts.

A third element militated against developing a process that shared power with communities and incorporated their knowledge. The federal government was strong, authoritative and confident that it could solve any problem. Institutionally guaranteed local participation was not considered vital to good decision-making. By 1976, despite the lack of experience of grappling with common property resources (CPR) solutions, few people in Congress doubted the ability of the federal government's experts to solve any complex problem from a position of centralized control.

Fourth, and very important, is that the seafood industry did not have a functioning network of informally organized representative groups. As a result, Congress received only minor resistance to establishing a top-down governance-structure as it proceeded to enact legislation where the public focus was largely on the benefits from the establishment of a 200-mile exclusive economic zone for U S fisheries.

Large scale management areas thwart democratic input

In New England there are few, if any experienced fisherman who have not belonged, at one time or another, to at least three different fishing organizations. Despite this predisposition "to join", few fishing organizations enjoy a long and vigorous existence and there is little disagreement that fishers' attendance within the council process is poor.

Shouldn't this odd situation raise questions among the managers let alone our Congressional representatives? Fishermen are obsessed with catching fish and are compulsive in discussing fish, fishing and fishing regulations, on the radio, with the cell phone, at the shore, the pier and the coffee shops. In New England there are some 15,000 seafood industry workers (authors' estimate) vitally affected by council decisions, yet, the New England Fisheries Council meetings rarely attract more than 75 people and frequently no more than 25 unless a crisis is in the making. Why is fishing organization and participation so feeble when there are hundreds of fishing communities and businesses intensely interested in the council's performance and who could benefit from engagement? We suggest that the level of participation has very little to do with the traditional and trivial 'rugged individual' stereotyping of fishing people repeated in council literature. This very repetition suggests it is the cultural fate of the majority of fishing people to be non-participating because they are rugged individualists. Fishermen respond to the same social impulses as other Americans. They have retirement savings plans, get divorced, eat at Burger King, visit Disneyland and complain about taxes.

What distinguishes fishing from other occupations is the tremendous self-confidence (not individualism) required to earn a living in a hostile and dangerous oceanic environment (McGoodwin 1990). Fishers understand that, throughout every part of their careers, they will continually confront the necessity to be resourceful when faced with an endless stream of difficulties before returning safely to port with sufficient fish to earn a living.

The amount of engagement of non-appointees with the fisheries decision making institution is like "everything else in organized society, it remains, to a significant extent, the product of particular (institutional) arrangements on which, once established, it continues to depend…" In New England the majority of fishing people are oriented toward a small local community life style, yet the council system is single level, regional and national. "…The failure to press, or even to imagine alternative arrangements makes the resulting approach to politics seem natural" and the fishermen's response seem unnatural (Unger 1998, p. 219)

Dividing the United States into eight large regions for marine fisheries management was a small but incomplete step towards devolving federal power. The regional ocean area governed by the approximately twenty appointed Council members meeting two days every six weeks is generally larger than the combined land area of the member states of the council region. The council areas of responsibility are simply at too large a scale for effective management across culturally and biophysically diverse subregions.

Council meetings are often held at fine hotels in rooms that are largely empty of those who are most affected by the decisions (Bohman 1996, Introduction) The elitism of the present system discourages attendance and participation at meetings. The physical layout of the room at council meetings also serves to intimidate potential speakers who must come forward to an isolated table with a microphone that is surrounded by a large horseshoe shaped council

table. A person subjectively chosen by the council chair to comment often finds that his or her time at the microphone is very limited, not occurring at a time relevant to the debate, or interrupted if (s)he is repeating a point previously made by any other attendee.

In short, fishers recognize that their own voice or their voice through smaller-scale organizations is often ineffectual at council meetings; and they recognize that there is little reason to continue to pay dues, attend local meetings, and collectively bring ideas to the regional level, when local organizations do not have a formal place within the region council system. Frequently the principal reason for attending is fear that appointees at the council level do not understand the variety of the consequences of their decisions from Maine to Connecticut.

We have attended many meetings with fishermen in their communities over the years. The most common complaint is that it does no good to attend council meetings. Why? Because attendees intuitively understand that their participation is symbolic – that their attendance or the numbers of people in attendance is not synonymous with participation and that the ability for participation exists only in the role of appointed expert or with the few articulate people who are comfortable with the system and who are known to the principal actors in the council process.

The consequences of being excluded from authentic participation are not neutral. The dearth of opportunities to be involved in the routine tasks of resource decision making has diminished the capacity of fishermen and others to participate in deliberations. Often the result of being excluded is to be distrustful, apathetic and cynical, as the hopelessness of an outcome based on genuine collective deliberations becomes apparent (Brower 1993). The vast majority of harvesters view themselves as politically included only by virtue of having to comply with council's rule making. When fishermen reveal these traits and feelings "the powers that be" view their behavior as that of people lacking the skills and impulses necessary to be participants in co-managing. Fishing people have become burdened with a self-fulfilling prophecy. The less they are involved, the less they understand. The more incompetent they appear the more justification exists for continued exclusion from the process (Simonitsch 1998).

Large scale management areas restrict opportunities to put fishers' knowledge to use

By 1985 it was fairly clear to any serious fisheries observer that the concept of attaining maximum sustainable yields (MSY) for the fisheries was unattainable. Without the collaboration and participation of people with practical knowledge the expert rule makers had been devising plans that lacked an understanding of what made the fish harvesting business actually work. The various rules and regulations were, to a large degree, an abstraction and failed to include recognition of the resourcefulness and competitive nature of fishing, the marketplace, and fishing people. Fishers immediately found many loopholes. Simply having to follow the rules, rather than having been genuinely involved with identifying and incorporating actions for achieving sustainable fishing practices, led to a disaster.

Having excluded the working fisheries public and other affected parties from authentic rule making, Congress unintentionally created the classic "us and them" dilemma. Despite the rather obvious institutional failure, the lobbying of national environmental interests influenced Congress to view the deteriorating situation as a result of an inadequate number and selection of rules rather than a situation requiring institutional changes that promote a distributed social process for making decisions. Congress dutifully enacted a "Sustainable Fisheries Act" (SFA) in 1996 that implemented valuable habitat concerns, but also established rigid goals and timelines that further reduced the potential usefulness for incorporating fishermen's knowledge and authentic local level participation in deliberations (Wallace and Fletcher, second edition). SFA also precipitated a large increase in legal actions by green groups and fisher organizations against NMFS and the Department of Commerce regarding conservation objectives.

Why is there a reluctance to institutionally incorporate practical knowledge? The first reason is that the more the fisher knows the less important is the specialist. Secondly, if the specialist is less important his or her funding is less secure. The third reason is that science is involved with the future and less concerned with the past. Fishing knowledge is history. Fourth is that the knowledge of fishers is not collected into scientific format. Experts often view practical knowledge as a collection of "cracker barrel" information. Scientists are most comfortable with knowledge that is the product of controlled experiments that can be repeated.

Although science is theoretically egalitarian, most scientists have little experience and confidence in the skills, intelligence and experience of ordinary working people. Pascal correctly observed that the failure of rationalism is "not its recognition of technical knowledge, but its failure to recognize any other." (Scott 1998, p. 340).

The structure of Marine Management in Kenya

Despite significant differences in per capita income and length of democratic tradition in the United States and Kenya, the two countries share a very similar history with regard to participatory marine fisheries management. As in the United States, the Kenyan government has relied on large-scale management plans, mapped the seas, licensed fishers and boats, and felt little threat from scattered informal fishing and seafood industry organizations. The discourse of participatory management has been in place in Kenya since the 1970s, but authentic bottom-up management has yet to be implemented (Peluso 1993)

The first notable move toward potentially giving local people greater voice in marine management came in 1979 when two of Kenya's conflict-laden marine parks, Malindi and Watamu, were re-zoned and designated biosphere reserves. The change from parks with no legally sanctioned extractive activities to multi-zone park and reserve complexes with traditional forms of fishing allowed in reserves included plans to incorporate local people into a more participatory management structure. Although the Kenyan government secured United Nations Man and the Biosphere funds for the rezoning, management remained in the hands of the Kenya Wildlife Service (KWS).

By the mid-1990s, additional areas had been set aside as parks without consulting the local communities they displaced. Tensions had mounted to the point of armed assaults on marine park rangers, arson of beachfront park structures, and blatant poaching, all of which threatened Kenya's valuable tourism industry. To gain control of the situation, the director of KWS who publicly opposed participatory management, was replaced by a man known for his people-friendlier approach (Baskin 1994), and a seven million dollar World Bank loan was used to implement a Community Wildlife Officer (CWO) program at each protected area. The sole CWO duty was to understand and assist resident communities to meet their needs (Snelson 1993). Due to widespread corruption and a lack of will for true participatory management, funds for the CWO program "disappeared" within a few years. (www.transparency.org). Additional external funds were secured for local communities living near marine protected areas (MPAs) to provide input into marine resource management in "bottom-up" Integrated Coastal Management (ICM) initiatives. After initial consultations with stakeholders in informal settings and using local languages, additional meetings were held in English at fine hotels. Invitations were not extended to local fishers based on the notion that their will was already known from the initial input sessions (Glaesel 1999).

"Participation" for fishers in the management process is thus a limited type of pseudo-participation which includes consultation and informing, but precludes true partnership through delegated power and cooperation. Local input into marine management is even more restricted along the approximately 95 percent of the Kenyan coast where there are no marine parks or reserves. In this substantial area, the understaffed Fisheries Department governs fisheries management. Whereas many officials in KWS express interest in participatory management, those in the Fisheries Department generally do not. Indeed, several Fisheries Department officials openly express disrespect for fishers and disbelief that they might have anything to learn from unlettered people (Glaesel 2000).

Modifications to the Existing Systems that May Not Put Fishers' Knowledge to Work

Whereas MPAs are certainly an area in which governance structures could be modified to include fishers' knowledge in meaningful ways, this has not been the case in Kenya or the United States. Initial indications are that the newly created US MPA Advisory Commission will likely remain top-down and heavily weighted toward experts with limited inclusion of fisher representatives. Fisher representatives will not be put forward by their own communities but be selected by degree-bearing experts. (John Poppalardo, Fish Expo 2001 NOAA MPA Booth)

Individual Transferable Quotas (ITQs) are currently under discussion in the United States by the Pew Oceans Commission and marine fisheries management councils. ITQs represent a relatively radical economic and social change in the management of marine resources that proponents claim might reduce perplexing allocation issues but would maintain the dysfunctional decision-making process. An

additional disturbing aspect of ITQs is that where they have been implemented, such as in New Zealand, Iceland, and Canada, they have favoured the development of large-scale commercial interests. (White 2001).

Very little enthusiasm exists within the US (fisheries management council system, NMFS) or in Kenya (KWS, or the Fisheries Department) for promoting fundamental changes that would insure use of fishers' knowledge. Apparently, change can be considered, but not if it is change to the arrangements for the established order. Neither MPA nor ITQ approaches currently outline clear ways in which fishers' organizations and the knowledge generated from them would have an institutionalized place in the decision-making bodies that generate legislation that, in turn, affects activities in ITQ and MPA areas.

Alternatives that Put Fishers' Knowledge to Work

How can a transformation from the present systems to ones that include actual institutionalization of both fishers' knowledge and participation take place? The present council process will not disappear overnight, nor should we wish for it to vanish. Agreeing now on what the future should look like enables a phased implementation of change in logical manner. By agreeing now, we can create a road map for ourselves and our leaders in government, that would reveal our thought-out desires for coastal life, retention of small family corporations, incentives for good stewardship, recovery and preservation of the habitat, and development of vigorous economic activity that is at the heart of maintaining communities. If we agree now to eventually institutionalize fishers' participation in the decision making process then it becomes easier to strategize and plan the steps necessary to accomplish future goals.

Institutionally guaranteeing the involvement of fishers and the use of their knowledge is imperative and fundamental to creating sustainable fisheries. Failing to formally incorporate this structural change will result in a return to the "old ways" whenever funds are not available for collaborative work or when strong personalities in the system are inclined to have it their way.

Previously in this paper we have benefited from John Dryzek's observation of the paradox "that to advocate democracy is to advocate procedures, to advocate environmentalism is to advocate substantive outcomes." (Dryzek 2000, p. 140) One US NGO has directly confronted the paradox between procedure and outcome. Its concepts could serve as a model to others in the United States, Kenya, and elsewhere, especially if it, and groups using similar bylaws, were formally incorporated into the marine management decision-making process. The organization to which we refer is the Northwest Atlantic Marine Alliance (NAMA), a New England group with diverse multi-state membership that has constructed a self-governing constitution that is specifically designed to provide for sustainable outcomes for the commons and protection of individual rights (NAMA Constitution 1999)

NAMA members work to develop connected, self-governing community based organizations that are interested in achieving sustainable and abundant marine resources in New England. The organization's members include commercial and recreational fishers, conservationists, educators, seafood industry members and ordinary citizens who work together to promote a secure future for individuals and the coastal communities in which they live. Their unique constitutional effort is built on a set of ethical principles, comparable to the US Constitution's Bill of Rights, that provide the moral authority to protect and promote individual rights and responsibilities and the sustainability of common property resources.

One of the important characteristics of the NAMA constitution is its requirement for all decisions to be made at the "most local level possible" by a diverse group of interested and affected parties. The bylaws create authentic bottom-up self-governance structures, while insuring that local, regional and national fisheries governance provides justice for the resource. Considerable energy was spent to avoid dangers from the false supposition that populations are homogenous and therefore majority rule is fair because the minority and majority would have similar basic interests. (Goldwin 1997, p. 66). Although the NAMA governance system requires effective participation of recreational and commercial fishers it is not a plan for fishing interests to control the decision-making process and internally works to prevent the formation of unjust majorities. (Visit www.namanet.org).

A few public examples of marine resource management that nurture participation by groups with a diverse composition are beginning to emerge as success stories in ways that confirm the NAMA belief that affected parties can act accountably if given responsibility. The Mid-

Atlantic Fisheries Management Council's real-time management of Illex squid is a development with exciting promise for increased effective participation. Massachusetts' Striped Bass Advisory Committee is working extremely well to generate responsible recommendations by interested parties that are largely self-organized. Maine recently succeeded in passing legislation that divides the states waters into small-scale lobster and sea urchin management zones. The small-scale zones have enhanced management through putting local knowledge to use (LaPoint 2001) Although zoning won't be the answer for all species, the devolution of power to more local levels will. (Pendleton and Simonistsch 1999).

DISCUSSION

Genuine political participation has much more to recommend for itself than the mere justification that it is the preference of well-meaning people. Using the knowledge of fishers and other interested parties in authentic and fair deliberation forces the involved parties to justify their decisions and opinions by appealing to and defending chosen goals with reason. It is with effective participation in deliberations that a democratic society develops its civic capacities for cooperation, confronting contradictions, tolerance for pluralism and the ability to disagree without anger.

There are three characteristics that must exist before a person can be considered an effective participant in a collective decision making process. First, the individual must have an equal opportunity for placing matters on the agenda. Second, the participants must have an opportunity, equal to every other person's, to engage in full discussion. Third, an equal opportunity must exist to participate in making the final decision, either by voting or by consensus. (Dahl 1989, Chapter 8).

It is through the development and exercise of this kind of public reasoning that mature and effective political responsibility is developed and maintained and not with the accumulation of power and resources and action based on what the majority is presently thinking. The kind of deliberative democracy that evolves from political arrangements with checks and balances, such as the NAMA constitution provides, requires governance decisions and the fair distribution of benefits and burdens not solely on the basis of majority rule, but based on a fair reasoning process that is "public-regarding." (Sunstein 2001).

We believe that the lack of participation is due in large part to the inability of fishers to authentically participate in the decision process. In the United States, the institutional arrangements dictated by Magnuson do create a useful role for the Secretary of Commerce, NMFS, and the council appointees, but fail to give the affected and interested parties any genuine political roles in the governance system. Deliberative shortcomings are easily predicted when similarly thinking people only spend time in dialogue with one another. When diversity of participants is not present, then governance power is not available to those with competing views (Sunstein 2001).

In Kenya, the KWS, the Fisheries Department, and multi-national organizations dictate how marine resources will be managed. In both the United States and Kenya, local knowledge, when formally gathered, is generally undertaken by social scientists, but it is knowledge gained by narrowly defined experts in the "hard" sciences that informs policy making (Huntington 2000). Fishers and other interested parties understand their place in this information hierarchy and see little practical benefit from individual efforts or supporting association efforts when those actions continue to be viewed as producing knowledge that is illegitimate in the current system.

A worst-case scenario has resulted from not institutionally incorporating fishermen's knowledge in the management process. The composition and dominance of the existing governing structures have become taken for granted and the established interests have not only taken on a semblance of naturalness, but have also defined each other as their rival. A part of the mentality of the established interests is to view their wellbeing as connected to the preservation of their positions with respect to membership in officially recognized decision-making bodies, including council and its committees or Kenyan state agencies. Desiring their own survival, the relatively few established players often view initiatives in terms of maintaining their status quo. Political creativity is stifled except where the initiatives do not de-stabilize the existing institutional structure (Unger 1998, p.214).

Authentic democratic deliberations have long been recognized for achieving three important goals with respect to good government. First, self-governance legitimizes the laws we make. Secondly, the very best reason for compliance with the rules is when you make them yourself.

Third, acceptance of accountability in complex situations has been identified as a principal benefit from receiving and assuming responsibility (Boven 1998, chapter 9).

US Fisheries Council literature claims of representative democracy and local participation are simply incorrect. The literature put forth in support of Kenya's ICM plans is similarly incorrect in claiming that a participatory process was used to reach broad consensus on how to address critical coastal management issues (www.crc.uri.edu/field/esa/kenya_current.html)

Literature that merely discourses about participatory marine management is a serious impediment to the real thing. It serves to reinforce distrust between fishers and those with degrees and positions of relative power in fisheries governance who produce the materials. The inaccuracies can also raise false expectations for authentic participation among newcomers to the industry thus alienating new generations of fishing people before truly participatory management systems are implemented.

CONCLUSION

Our experiences in the United States and Kenya reveal an alarming and discouraging state of public participation that respects no border or economic status. Top-down management and coercive conservation will not benefit the environment in the long run. Fishers, fisheries managers, conservationists, and researchers are all experts in that each group has specialized, relevant knowledge that the others do not. All must be harnessed to improve fisheries management locally, regionally, and nationally (Mauro and Hardinson 2000, Johannes 2001). How this knowledge is gained might include everything from fisher-run workshops for state employees, to swapping a day at work periodically with someone in another area of fisheries management, to establishing centers for indigenous fisheries knowledge, and formally reconstituting the management process with internal mechanisms that decentralize authority and create authentic participatory roles for fishers and all other interested parties.

Considering the cultural and political history in the United States the widespread disaffection with the council form of government was inevitable. Rule making by an appointed elite group having no institutionalized connection with those who must follow the rules is generally recognized as politically illegitimate (Bell 1976).

It is time to destroy the durable myth repeated in US. fisheries management literature, that fisheries councils encourage representative democracy and local level participation. Until members of Congress recognize and publicly confront the political reality of the shortcomings of how fisheries people are governed and then understand the undesirable consequences of the present meager process, no useful improvements in the governance process will occur and the performance of the councils will not achieve their potential. Congressional and state representatives have a major responsibility for implementing useful change in the participation and methods for deliberations used in the institutions for managing marine resources. Legislators who do not make every effort to improve our institutions and promote fairness for our resources and citizens weaken their moral claims as protectors of justice and as representatives for citizens and common resources.

It is not sufficient for government to increase the numbers of the fish in the oceans. Fishing people's lives from Kenya to the United States have been unnecessarily and irretrievably altered by the feeble abilities of inadequate centralized command systems. By transforming the fisheries governance system fishers, and all of the parties with vital interests in marine resources, will begin to build an improved relationship with the ocean (Norse 1993). The authors of this paper do not contend that use of fishers' knowledge in democratic deliberations will guarantee desired outcomes. We do believe that with fishers fair inclusion among a diversity of decision makers, who work within the constraints of a reason-demanding constitution, that society can better achieve its social, economic, and environmental goals than with the present system. Our basic task at this conference should be to create fundamental changes for a positive relationship between the ocean's inhabitants and users.

At the heart of governance is the human obsession to control our future on this planet. Since humans alone have the power to significantly alter this earth, we have the primary responsibility for its future care and protection. Our system of fishery laws has been developed by extension of the same unique abilities we possess that created abstract concepts like equality and justice. Only humans, not the aquatic creatures, are responsible for the quality and performance of these laws. It is one of our major ethical responsibilities to improve the governance institutions we have created and

know to be inadequate. (Simonitsch 1997 and 1998).

References

Baskin, Y. (1994). There's a New Wildlife Policy in Kenya. Science, Vol. 265, No. 5173, p. 733.

Bell, D. (1976). The Cultural Contradictions of Capitalism, Basic Books, New York, NY.

Blaikie, Piers and Harold Brookfield (1987). Land Degradation and Society, Methuen, London.

Bohman, James, (1996). Public Deliberation, MIT Press, Cambridge, MA.

Boven, Mark, (1998). The Quest for Responsibility, Accountability and Citizenship in Complex Organizations, Cambridge University Press, Cambridge: United Kingdom.

Brower, Barbara (1993). Co-Management vs. Co-Option: Reconciling Scientific Management with Local Needs, Values, and Expertise. Himalayan Research Bulletin, 13(1/2): 39-49.

Bryant, R.L. and S. Bailey (1997). Third World Political Ecology, Routledge, London.

Chambers, Robert (1997). Whose Reality Counts? Putting the First Last, Intermediate Technology, London.

Dahl, R.A., (1989). Democracy and Its Critics, Yale University, New Haven, CT.

Dorraj, M. (1995). Introduction. In The Changing Political Economy of the Third World, edited by M. Dorragj, 1-13. Lynne Rienner, Boulder.

Dryzek, J.S., (2000). Deliberative Democracy and Beyond, Oxford University Press, inc., New York, N.Y.

Fairhead, James (1991). Indigenous Technical Knowledge and Natural Resources Management in Sub-Saharan Africa: A Critical Overview, Natural Resources Institute, Chatham, United Kingdom.

Fowle, S. (1993). Fish for the Future: A Citizen's Guide to Federal Marine Fisheries Management, Washington, Center for Marine Conservation.

Glaesel, H. The Developed—Developing Divide and Coastal Management in Kenya, presented at the ASA (African Studies Association) Annual Meeting, Philadelphia, PA November, 1999.

Glaesel, H. (2000). State and Local Resistance to the Expansion of Two Environmentally Harmful Marine Fishing Techniques in Kenya. Society and Natural Resources, Vol. 13, pp. 321-338.

Goldwin, R.A. (1997). From Parchment to Power, AEI Press, Washington.

Huntington, H.P. (2000). Using Traditional Ecological Knowledge in Science: Methods and Applications. Ecological Applications, Vol. 10, No. 5., pp. 1270-1274.

Johannes, R.E. On the Need for the Study of Indigenous Fishers' Knowledge. MPA News, Vol. 3, No. 5. November 2001, p. 5.

Lapointe, G., Lobster, Urchin Management Zones: Are they Working? Commercial Fisheries News, Vol. 29, No. 3, p. 4B. November, 2001.

Little, Peter (1994). The Link Between Local Participation and Improved Conservation: A Review of Experiences. In Natural Connections: Perspectives on Community-Based Conservation, edited by Western, D. and R.M. Wright, 347-372. Island Press, Washington.

Ludwig, D., Hilborn, R., Waters, C., Uncertainty, Resource Exploitation, and Conservation: Lessons from History, Science, Vol. 260, 2 April 1993, p. 17.

Mauro, F. and P.D. Hardison (2000). Traditional Knowledge of Indigenous and Local Communities: International Debate and Policy Issues. Ecological Applications. Vol. 10, No. 5, pp. 1263-1269.

McGoodwin, J. R. (1990). Crisis in the World's Fisheries: People, Problems, and Policies, Stanford: Stanford University Press.

McKay, B.J., Creed, C.F., (1999 revised). Fish or Cut Bait, How to Participate in the Fisheries Management System, The New Jersey Sea Grant Program.

Mid-Atlantic Fisheries Management Council, Fisheries Management Plan for Scup, Sept 28, 1998, Philadelphia, PA.

Norse, E.A. (Ed.) (1993). Global Marine Biological Diversity: A Strategy for Building Conservation into Decision Making, Washington: Island Press.

Northwest Atlantic Marine Alliance, Saco Maine, NAMA Constitution/bylaws, 1997, www.namanet.org

Peluso, N. L. Coercing Conservation? The Politics of State Resource Control. Global Environmental Change, June 1993, pp. 199-217.

Pendleton, C., Simonitsch, M.A., A New Initiative For Fisheries Management, Commercial Fisheries News, Volume 26. Number 6., February, 1999.

Popper, K.R., (1962). The Open Society and Its Enemies, Princeton University Press, Princeton, N.J.

Scott, J.C., (1998). Seeing Like A State, Yale University, Binghamton, New York.

Simonitsch, M.A., Calling the Shots: Bottom Up vs. Top Down, Commercial Fisheries News, Vol. 25. No. 6. February, 1998.

Simonitsch, M.A. How to Cut the Cake, All Must Have A Say, Commercial Fisheries News, Volume 24. Number 6. February, 1997.

Snelson, D., (1993). Protected Area Conservation Strategy: Assessing the Training Needs of Protected Area Managers in Africa. Country Report: Kenya. Washington: United States Agency for International Development, World Wide Fund for Nature, African Wildlife Foundation, Wildlife Conservation Society.

Sunstein, C.A., (2001). Designing Democracy, Oxford University Press, New York, N.Y.

Unger, R.M., (1998). Democracy Realized, The Progressive Alternative, Verso, New York, N.Y.

Wallace, R.K., Fletcher, K.M. (Second Edition) Understanding Fisheries Management: A Manual for Understanding the Federal Fisheries Management Process Including Analysis of the 1996 Sustainable Fisheries Act, Sea Grant, Auburn University Marine Extension and Research Center and Mississippi-Alabama Sea Grant Legal Program.

White, P.D. , Fishing Quotas . FDCH Congressional Testimony before the Senate Oceans and Fisheries Subcommittee of the Commerce, Science and Transportation Committee. May 2, 2001.

Questions

Ted Ames: has there ever been a survey of fishermen and their feelings toward the council in New England?

Heidi Glaesel: Mark could probably answer this better than I. I spent about a month in New England and had some informal chats with the fishermen there. There was not a single fisherman who was satisfied with the council. At best, the fishermen were resigned to working with the council. People took time off work to attend their meetings.

Saudiel Ramirez-Sanchez: You were criticizing the top-down approach because it is undemocratic. Is it possible, even at a local level, to exclude politics?

Heidi Glaesel: I think it'll be better if it were more local. That way, you hear more voices. Certainly, you will get some local squabbles. When I was working in Kenya, there were lots of small-scale groups, and certain folks weren't speaking up. One such group is the women, because it's not in their culture to do so. But at a local level, you hear different voices than from further up. It's not perfect, but it's a start.

THE ROLE OF INDIGENOUS KNOWLEDGE IN DEPLETING A LIMITED RESOURCE – A CASE STUDY OF THE BUMPHEAD PARROTFISH (*BOLBOMETOPON MURICATUM*) ARTISANAL FISHERY IN ROVIANA LAGOON, WESTERN PROVINCE, SOLOMON ISLANDS.

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ABSTRACT

This study highlights the way in which new technological and economic inputs into indigenous artisanal exploitation systems can have negative ecological effects on a fishery, and the fact that traditional ecological knowledge is not always used sustainably. The fishers of Roviana Lagoon (Western Province, Solomon Islands) fished Bumphead Parrotfish (*B. muricatum* or topa in the Roviana language) for generations, using a targeting strategy based on precise knowledge of its aggregating behaviour built up over centuries. During certain moon phases at specific shallow water sites where the fish aggregated to sleep at night, fishermen speared them from dugout canoes by the light of dried burning coconut leaves. Catch rates were well below the maximum sustainable yield. When the underwater flashlight became widely available in Roviana Lagoon, however, this traditional fishing method was quickly replaced by night-time spear fishing using goggles and a steel hand-held spear. With this method, fishers could easily take four to five times as many topa as before. In the late 1980's, new pressures were placed on the topa stocks when local markets developed, ironically under the umbrella of NGO sustainable development projects. Today artisanal spear fishers use their sophisticated indigenous knowledge of topa behaviour and ecology to move from one known aggregation site to another, spearing as many topa as possible in a night. A Catch-Per-Unit-Effort (CPUE) survey of night-time spear fishing trips in Roviana Lagoon reveals that this resource is heavily overfished, with the majority of topa caught today being juveniles. Extensive interviewing with past and current spear fisher's reveals that this modern fishing method has caused major declines in topa numbers. The introduction of simple but new technologies coupled with small scale economic restructuring has thus thrown the system out of equilibrium.

INTRODUCTION

The concept of a traditional marine conservation ethic existing among indigenous coastal people (Hviding 1996, Ruddle *et al.* 1992) is one that has been losing favor in recent years. An increasing amount of anthropological, archaeological and marine biology literature suggests that subsistence fishing communities are also implicated in the problems of environmental degradation and resource depletion (Foale and Day 1997, Jackson 1997, Aswani 1998, Foale 1998, Jackson *et al.* 2001, Wing and Wing 2001). In some ways this was to be expected, as the original romantic assumptions that all indigenous people had an intrinsic conservation ethic that allowed their societies to remain "in balance" with nature, is a naïve and somewhat patronizing over-simplification of indigenous life ways.

There is however, a real danger in lumping all subsistence fisheries back into the unsustainable basket. If we do this, fisheries biologists and managers, who are often pessimists by nature, may overlook many of the potential management values of Customary Marine Tenure (CMT) and Traditional Ecological Knowledge (TEK) systems that are a common component of many coastal subsistence communities (Johannes 1988, Foster and Poggie 1993, Hviding 1991, Johannes *et al.* 1993, Lalonde and Akhtar 1994 and Christie and White 1997). It would also be an over simplistic response to an extremely complicated situation. In the last 50 years globalization has brought new technologies and new markets to virtually every remote society on earth (Suzuki and Dressel 1999). This, coupled with an exploding global population has put unprecedented pressure on all the world's resources. It is little wonder then, that small-scale indigenous fisheries have also began to show signs of ecological stress.

In this case study, I focus on the Bumphead parrotfish (*Bolbometopon muricatum*) fishery in Roviana Lagoon, Western Province, Solomon Islands. An overview of this species biology and global conservation status is given, and an historical overview of the topa fishery in this region is provided. Particular attention is brought to highly detailed and elaborate body of TEK of topa that is contained within Roviana spearfishing communities, and the way in which this TEK is used by Roviana spearfishermen to capture nocturnal aggregations of topa. The current status of the Roviana topa fishery is assessed using a combination of ethnographic and scientific data. The issue of whether or not Roviana fishers possess a traditional

conservation ethic and use TEK to ensure sustainability is addressed.

Environmental background

The Solomon islands are a double-chained archipelago lying east of Papua New Guinea that extend over 1,400 kilometers across the South West Pacific (Figure 1). The islands display remarkable diversity in both terrestrial and marine environments.

The Solomon Island archipelago comprises over 900 islands, mostly volcanic in origin. Extensive lagoon systems occur in the Western Province. The population of the Solomon Islands is approximately 400,000, the vast majority live in rural villages, with their livelihood depending on subsistence production.

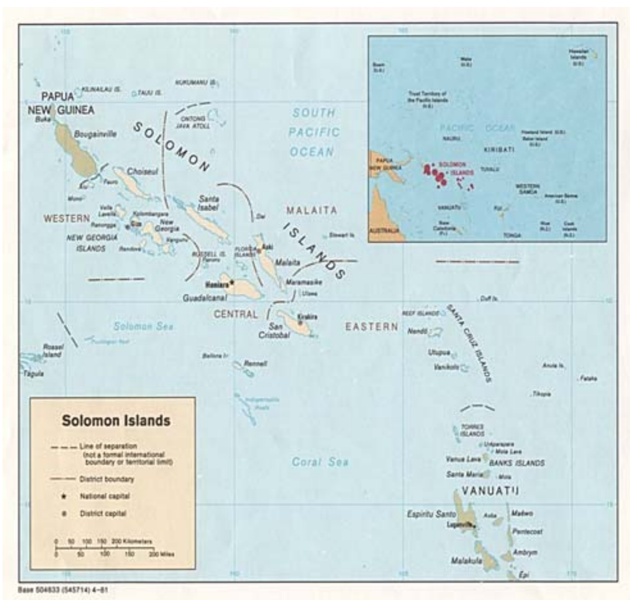

Figure 1. The Solomon Islands Nation.

The New Georgia Group, in the Western Province, is made up of 9 main islands that extend for approximately 270 kilometers. The largest island, New Georgia, is fringed by Roviana Lagoon to the southwest and Marovo lagoon to the northeast. The majority of this research was conducted in Roviana Lagoon, and studies were also carried out at the uninhabited island of Tetapare (Figure 2). The reason I focused on these two areas is that they provide an interesting insight into the ecological impacts of human subsistence and artisanal fishing systems. Roviana Lagoon represents a heavily fished area, while the uninhabited island of Tetapare represents a lightly fished area.

Roviana Lagoon where I was based, consists of a string of raised coral islands stretching for approximately 40km down the southwest coast of New Georgia Island. Between the outer islands and the mainland of New Georgia lies a shallow coastal lagoon of approximately two to three kilometers width (Sheppard *et al.* 2000). The lagoon system supports a high degree of biodiversity, through a wide range of habitats, such as: mangroves, coral atolls, barrier reefs, passages, marine lakes and sea grass beds. Scattered throughout the lagoon are a dozen small subsistence villages, whose inhabitants rely on the lagoon resources as a means of survival. The town of Munda is located at the western end of Roviana Lagoon, and is the only developed area in this region.

Topa (B. muricatum)

The topa, *Bolbometopon muricatum*, is the largest of all parrotfish, reaching over 50 kilograms and living to an age of at least 40. It is an herbivorous fish that feeds on corals. It forms mixed sized schools during the day and is extremely vulnerable to overfishing. Recent work by Dulvy and Polunin on this species' abundance in the Lau Islands in Fiji suggests that "the Bumphead parrotfish is highly vulnerable to exploitation and already extinct at some locations" (Dulvy and Polunin in revision).

Dulvy and Polunin attribute these local extinctions in the Lau group to overfishing by nighttime spearfishers, and reports that; "some young fishers (<25yr) had never seen an individual of this species and the last recorded captures varied from the 1980s to as long ago as the 1960s" (Dulvy and Polunin in revision). Topa is a highly prized food fish in Roviana Lagoon, and this is reflected both through the detailed ecological knowledge base of this species and the existing folk taxonomy for this fish. In the Roviana language, the Bumphead parrotfish is referred to as lendeke, kitakita, topa and topa kakara, where each respective name refers to an increasing size range of this fish.

Traditional ecological knowledge of topa

Previous research in the Roviana region has shown that TEK contained within Roviana Customary Marine Tenure systems is extremely detailed and precise (Aswani 1997, Hamilton 1999). The TEK of Roviana communities is directed towards identifying environmental and behavioral patterns that maximize capture success.

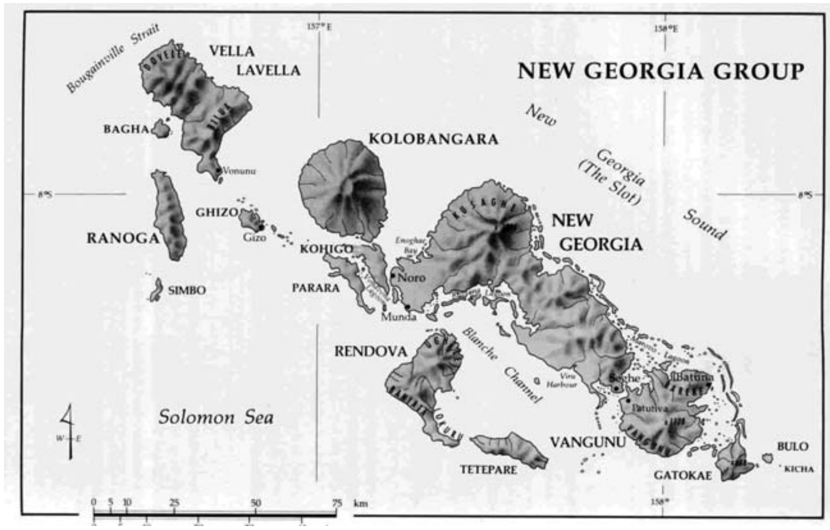

Figure 2. The New Georgia Group, with Roviana Lagoon to the North of Rendova Island, and Tetapare Island to the South East of Rendova Island.

Such knowledge requires an understanding of the influence that daily tides, tidal seasons, lunar stage and annual seasonality have on fish behaviour. This TEK is built up over generations and is cemented in Roviana culture through folk taxonomy, folklore and local place names. Roviana fishers draw upon this body of knowledge to decide when and where they will focus their fishing efforts (Aswani 1997, Hamilton and Walter1999, Johannes *et al.* 2000). The indigenous knowledge on the behaviour and ecology of topa is one such example. It includes knowledge on; diet, feeding times, schooling behaviour, juvenile nursery areas, spawning, the influence of the lunar stage on nocturnal behaviour, predation by sharks, nocturnal aggregations, individual color changes at night, spatial and temporal distributions, population changes over time and fleeing behaviour. A full description of Roviana TEK of topa is beyond the scope of this paper, but three aspects of this knowledge need mention, as they relate directly to the nighttime capture of this fish.

The most pivotal component of this knowledge, is the recognition that topa, which are a wary fish that are almost impossible to approach during the day, are easily approachable at night, when they are asleep up against coral structures. It is also well known that the spatial distribution of sleeping topa is not random. Topa fishermen understand that there are specific sleeping zones such as sheltered bays and certain passage areas where topa sleep.

Secondly, the lunar cycle is recognised as playing a very important role in topa behaviour. As in many parts of the Pacific, Roviana inhabitants have a traditional lunar calendar and many predictable fish behaviours are pinpointed using this (Aswani 1997, Hamilton 1999). Roviana fishermen know that several days immediately following new moon, and once the new moon had set, topa will be fast asleep up against coral, and thus easily approached and speared. Roviana fishermen also understand that if the moon is up, topa will not sleep properly. Instead they will be moving slowly about and are easily disturbed.

Finally, it is well known that topa do not normally sleep in solitude, but rather, a group of topa will sleep in the same small area. Roviana fishermen knew that the largest nighttime aggregations occurred during the new moon period, and that it is at this time that many of the topa sleep in very shallow water.

Traditional fishing methods

The traditional method of fishing for topa, hopere pana bongi, took place during tada sindara, the new moon period. Fishermen would paddle a wooden canoe to a shallow reef area where topa where known to aggregate to sleep. Once reaching their destination, fishermen would light one of many plaited dried coconut fronds that they had previously made and stored in the bottom of the canoe, and use the light to search for topa (Figure 3). This method needed at least two fishermen, one at the front of the canoe to hold the hand spear and burning coconut fronds and search for topa, while the

fishermen at the rear of the canoe would paddle. Once a sleeping topa was seen, the paddler would position the canoe above the sleeping topa and the fisherman at the front of the canoe would throw his spear at the topa, attempting to strike it in the head.

Figure 3. The traditional method of fishing for topa.

This fishing method, which had been used explicitly for capturing topa for generations, harvested topa well below the maximum sustainable yield. Evidence of this is apparent from the fact that this fishing method stayed culturally stable over time and that the same aggregation sites were continually fished with no noticeable effect. One of the old topa fishermen that I interviewed said to me:

> *"In the old days, when we used traditional methods, no matter how many years we fished in the same places, there was always an abundance of topa there"*

(pers. comm., Ezara, Nusabanga village, December 2000. Translated from Solomon island Pidgin by the author). Of six older topa fishermen interviewed, all agreed that this method would capture less than ten topa in a night.

Changes in technology and markets

The first changes to this traditional method occurred following World War II. The Second World War left a big impact on Roviana Lagoon, with thousands of American soldiers and their war machines moving in and developing the area as an air force base in their fight for control over the South Pacific. When the war ended, most of the heavy machinery and ammunition was left behind or dumped in the sea. As well as leaving behind bombs and barges, the Americans also discarded large amounts of diesel. Hopere pana bongi fishermen quickly saw the potential of this diesel as a source of light, and discarded burning coconut fronds in favour of a piece of reinforcing steel that had an old copra sack wrapped around one end of it. Fishermen would soak the copra sack in diesel, and then set the diesel alight. Flames from the burning diesel were used as a light source to search for sleeping topa.

Fishing methods similar to this continued to be used up until 1970, when electric flashlights became readily available. These were not waterproof, but fishers found it easier to simply stand in the canoe with a flashlight and a spear, and search for topa in this manner.

The means for over-exploitation arrived with the introduction of underwater flashlights to Roviana Lagoon in the mid 1970s. Nighttime spearfishing quickly took off. Fishers interviewed reported discovering they could easily spear 50-70 topa a night around the new moon period with just a handheld spear, a pair of goggles and an underwater flashlight. The huge catches produced by this method effectively spelled the end of the traditional method of spearing topa at night from a canoe.

It is important to note that from the mid 1970s-right up until the end of the 1980s there were no cash markets for topa, so although a spearfishing party could take 50-70 topa in a night they rarely did, as this was far more fish than the village could possibly eat. Large catches of 50-70 topa where normally only ever made for special occasions such as weddings and funerals.
The slow but steady move of rural Solomon island communities towards a cash based society, and the provinces' desires for greater financial development, saw the opening up of a small, EEC-funded community based fishing centre in Munda in 1988. Although this development failed after several years due to financial problems, it set the way for numerous future fisheries projects in Munda and Roviana Lagoon. Pressure on stocks increased as tops became the most sought after fish in Munda. By the mid 1990's, topa fillets were being bought at a higher price than any other fish.

MATERIALS AND METHODS

Ethnographic data

The field component of the research was carried out from early August 2000 until late July 2001. During this period the author resided at Nusabanga village, where he participated in the daily life of the village and worked regularly with the local fishers, to gain as wide an understanding as possible of the topa fishing system. Formal interviews were conducted with 21 nighttime spear fishermen from the villages of Dunde, Nusa Roviana, Nusabanga, Sasavalle, Baraulu, Bula lavata and Nusahope in Roviana Lagoon. These fishermen were selected according to their recognized status of nighttime spearfishing experts within their respective villagers. When possible, the interviewer sought out older spearfishing experts that had lived in their respective villages for their entire life and remained active in nighttime spearfishing over a long period of time. These older individuals had some of the richest TEK bases on topa ecology and most importantly, older fishers were able to give detailed information on the changes that have occurred in this fishery over the last 30 years. The interviewer covered a set number of questions that pertained to the history of the subsistence topa fishery in Roviana Lagoon, fishermen's knowledge of the ecology and behaviour of this fish and changes in this fishery over time. All interviews were conducted in Solomon Island Pidgin. During this research period the author actively participated in over 50 nighttime spearfishing trips with fishermen from numerous Roviana villages.

Scientific data

Catch Per Unit Effort survey:

A CPUE survey of Roviana nighttime spearfishing trips was carried out from August 2000 to July 2001 in order to establish the importance of topa in the catch and the size distribution of the topa being captured. 82 nighttime spearfishing trips were recorded in Roviana Lagoon. Fish speared were sorted to family level and species level where possible and weighed to the nearest 10 grams. For all topa caught in the CPUE survey, fork length and total weight measurements were recorded, sex was noted, and gonads were weighed. In most instances otolith and gonad samples were also collected. A CPUE survey of nighttime catches was also carried out at Tetapare Island. The author recorded catches from four nighttime spearfishing trips at Tetapare island in 2001.

Size of female maturity in topa

To determine the size of female maturity, female gonad weight in grams was plotted against fork length for 169 female topa sampled in this study. A plot of gonad weight on size reveals an exponential curve. The point of inflection on this graph indicates the size at which maturity is achieved. (Howard Choat, pers. comm.). The size at maturity is to be checked through histological analysis.

RESULTS

Ethnographic data

All 21 spearfishermen that the author interviewed from throughout Roviana Lagoon reported major declines in topa catches in the past 10 years. Out of 15 current spearfishermen interviewed, all reported that the most topa they had ever caught in one night in the past 2 years was between 5-16, and that the average number of topa they caught on a topa spearfishing trip was around 2-8. This contrasts with the mid 1970s and early 1980s when spearfishermen sometimes took as many as 70 topa in a night. Furthermore, all fishermen mentioned a very marked decline in the abundance of topa kakara, the large terminal phase males in recent years.

Finally, several of the 15 current spearfishermen that were interviewed, reported that they have increased their spearfishing efforts in the inner lagoon, exclusively targeting juvenile topa that sleep in these inner lagoon areas. These inner lagoon areas were rarely fished in the past, and are being more heavily exploited now due to the marked drop in catches at traditional outer reef and passage areas.

Scientific data

Size of female maturity in topa

Female gonad weight (g) was plotted against fork length (mm) for 169 female topa (Figure 4). It is clear from Figure 4 that some individuals as small as 610mm have significant gonad development, and by 620mm, at least 50% of the population have gonads of a significant weight. Thus, the size of maturity for female topa in Roviana Lagoon can be taken to be 62cm.

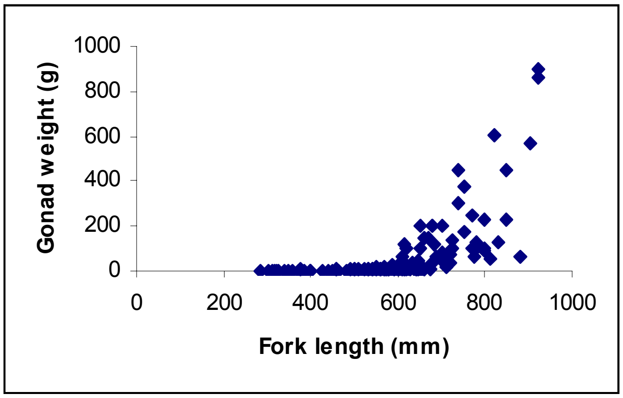

Figure 4. Fork length versus gonad weight for 169 female topa

Results of CPUE survey in Roviana Lagoon

The species that made up the most of the catch by weight was topa, accounting for 36.6 % of the total catch (Table 1). The size distribution of 239 topa recorded in the Roviana CPUE survey is shown in Figure 5. The mean size of topa speared in this survey was 63.2cm. Analysis of gonad data reveals that the size at which female topa mature is around 62cm, thus, 56% of all topa recorded in this survey can be considered juveniles.

What is also obvious from Figure 5 is that very few topa captured in this survey were over 100cm. Only 3% of the catch was made up of topa 100cm or more, a size range referred to as topa kakara in the Roviana language. In Roviana, the average number of topa shot on a nighttime spearfishing trip was 2.9. Figure 6 shows a good night's catch in Roviana Lagoon in June 2001. This particular fishing trip was organized to collect fish for a funeral, and it involved four spearfishermen who were diving for four hours. Most of the catch is topa and these topa are almost all juveniles, being between 50-60cm in length.

Results of CPUE survey at Tetapare

The species that made up the most of the catch by weight was topa, accounting for 86% of the total catch (Table 2). The size distribution of 65 topa recorded in the Tetapare CPUE survey is shown in Figure 7. The mean size of topa speared in this survey was 89.5cm. 5% of the Tetapare catch were juveniles and 35% of the catch were topa kakara, being 100cm or over. Topa 110cm or over where recorded at Tetapare 6% of the time. At Tetapare, the average number of topa shot on a nighttime spearfishing trip was 16.3. Figure 8 is a good night's catch at Tetapare in April 2001. This particular fishing trip was organized to collect fish for later sale at Munda town. The topa shown here were speared by four spearfishermen over a two hour period. In this short timeframe, almost 400 kilograms of topa were collected. This entire topa catch is made up of mature adult fish.

Table 1. Species that made up 1% or more of the Roviana CPUE survey.

Species	Percentage of catch
B. muricatum	36.6%
P. areolatus	10.9%
Naso lituratus	3.5%
A. nigricauda	3.3%
green turtle	2.6%
Painted crayfish	2.2%
C. undulatus	1.8%
hawkesbill turtle	1.5%
A. lineatus	1.4%

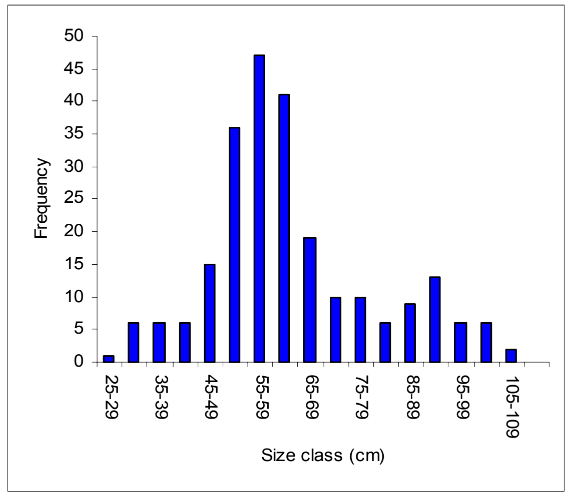

Figure 5. The size distribution of 239 topa recorded in the Roviana CPUE nighttime survey.

Figure 5. A good night's catch in Roviana Lagoon

Table 2. Species that made up 1% or more of the total catch at Tetapare Island

Species	Percentage of total catch
B. muricatum	86
Green turtle	3
C. undulatus	1.8

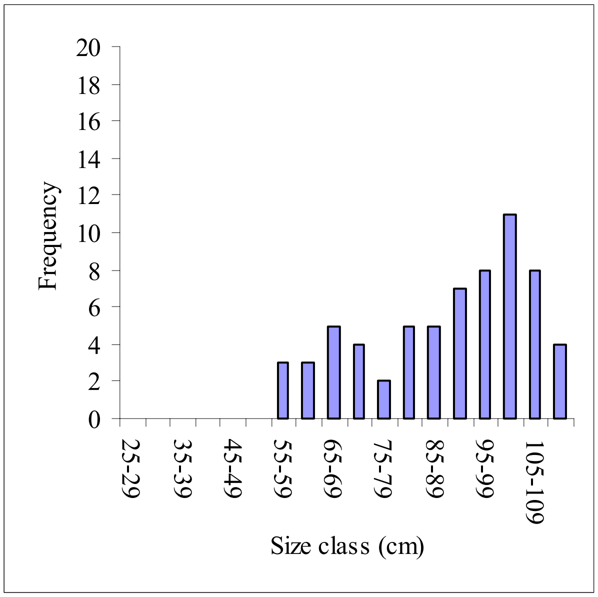

Figure 7. The size distribution of 65 topa captured at Tetapare Island.

Figure 7. A good nights catch at Tetapare Island.

DISCUSSION

The ecological impacts of new technologies and changing markets on topa populations in Roviana Lagoon have been profound. Roviana spearfishermen interviewed in this study unanimously agree that catch rates have declined strikingly in the last two decades, and topa kakara (large terminal phase males) which were once the dominant component of the night catch, are rarely captured these days. These changes have all occurred in only three decades, and coincide with the introduction of the underwater flashlight and the commencement of nighttime spearfishing in Roviana Lagoon. Scientific support for these anecdotal claims comes by comparing the heavily spear fished region of Roviana Lagoon with the only recently spear fished island of Tetapare.

In Roviana Lagoon, the mean number of topa caught on a spearfishing trip was 2.9, the majority of topa captured were juveniles (56%), the mean size of all captured fish was 63.2cm, only 3% of the catch was over 100cm and no topa in the 110-114cm size class were ever captured. In comparison, at the lightly fished island of Tetapare, the mean number of topa caught on a spearfishing trip was 16.3, only 5% of the catch were juveniles, the mean size was 89.5cm, 35% of the catch were topa kakara, being 100cm or over, and the size class of 110-114 cm was well represented, making up 6% of the total catch.

Large reductions in CPUE, a high number of juveniles in the catch, relatively few mature females and males in the catch and an absence of the largest size class, are all classical signs of an overexploited fish stock that is under stress. In short, all ethnographic and scientific data collected in this study points overwhelmingly at a fishery that is in need of management. In this study it was possible to evaluate the impact of nighttime spearfishing on Roviana Lagoon by comparing CPUE data from Roviana Lagoon with CPUE data from the lightly fished area of Tetapare. However, there are few places in the world where such a comparison are still possible. As more and more remote maritime locations become exploited, it will become increasingly important to draw on older fishers oral accounts as "sources of information on the histories of their fisheries, often the only link with marine environments and populations of times past" (Johannes *et al.* 2000).

The Roviana and Tetapare data presented in this paper supports research on topa in Fiji that shows that the abundance of topa is negatively related to fishing pressure, and that this is a species that is highly susceptible to overfishing (Dulvy and Polunin). Clearly, Roviana fishers possess a great deal of practical knowledge on topa, much of which is unknown to science,

however this TEK of topa is used in order to maximize capture rates, and there is no evidence of a conservation ethic among Roviana spear-fishermen.

Although all fishermen interviewed raised concerns and disappointment over the status of the topa fishery since the commencement of nighttime spearfishing, many did not comprehend that overfishing could be a reason for the decline. The few fishermen who did attribute declines in catches to increased fishing pressure were among the youngest of the fishermen interviewed. They also stated that the financial incentives provided by night diving outweighed any environmental concerns.

The possibility that globalisation and changing market demands have suppressed a conservation ethic that once existed in Roviana fishermen cannot be ruled out, but I believe the answer is simply that Roviana people never developed a conservation ethic for their reef fisheries because they never needed one. Johannes (1981) defines a conservation ethic as an awareness that one can deplete or otherwise damage one's natural resources, coupled with a commitment to reduce or eliminate the problem. He points out that in the South Pacific, it is in areas where resources are scarce, and have been for some time, that conservation ethics and resource controls are most developed. "Some islanders, however, were fortunate enough to live in areas where marine resources greatly exceeded their needs; they literally could not deplete them. They were thus unaware that natural limits on the yield of their marine resources even existed" (Johannes in press).

Roviana Lagoon inhabitants have always had access to a large marine resource base as well as utilising large areas of New Georgia mainland for shifting horticulture practices. The current population of Roviana Lagoon and the nearby Vonavona Lagoon is 12,235 people (Government census 1999), with these communities having access to over 300 square kilometres of reef. The population numbers in Roviana Lagoon may have fluctuated considerably in the past (Aswani pers. comm.). However, given the limited efficiency of traditional fishing methods, and the absence of western markets, it is unlikely that Roviana fishers ever over-exploited their topa prior to the commencement of nighttime spearfishing. Thus, before the advent of nighttime spear-fishing, topa stocks appeared unlimited in the minds of Roviana inhabitants, and the need to practice conservation measures never arose.

The situation today in Roviana Lagoon represents a crossroad between the old and the new. The good old days when reef fishery resources were seemingly limitless and conservation measures was not required, are being replaced with the modern realities of one of the highest population growths in the world and the ecological costs of conforming to ever encroaching westernization. There is an increasing desire among Roviana communities to exploit marine resources for cash, so that they can pay their children's school fees, buy petrol for their outboard engines and access the wide range of western consumer goods now available to them. Interestingly, the scene appears set for the development and solidification of a conservation ethic in Roviana culture. In the case study here presented, the ecological changes in response to simple new technologies and market demands have been so dramatic and negative, that many Roviana fishermen have witnessed a magnitude of decline in this fishery in their adult life time. Negative impacts of Live Reef Fish Trade operations on spawning aggregations of grouper have been as dramatic and even more recent in this region (Hamilton 1999). Today there is an across the board awareness in Roviana Lagoon that marine resources are not nearly as abundant as they used to be, a growing realization (especially among the educated youth) that is over fishing that has caused this.

There have been several encouraging signs that Roviana communities are ready to practice more sustainable measures. The recent establishment of seasonal marine invertebrate refugia in Roviana Lagoon provides one such example (Aswani 2000). Another sign of changing times and changing perceptions is the efforts of the Dunde council of elders to place a complete nighttime ban of nighttime spearfishing around the Munda bar region in June 2001 (pers. comm.). Although the motivations for these conservation attempts may more accurately reflect power struggles between different entitlement groups then a conservation ethic *per se* (Aswani pers. comm.), it is the growing perception of limited resources that has brought these power struggles and their resulting conservation efforts about. On a broader scale, positive signs are also coming out of other parts of the Pacific, such as Vanuatu (Hickey, 2001), Torres Strait Islands (Mulrennan, 2001) and Samoa (Fa'asili, and Kelokolo, 1999), where traditional reef owners are implementing new management strategies in order to make their marine resources more sustainable.

CONCLUSION

Indigenous fisheries in Melanesia are based on a sophisticated traditional ecological knowledge system that has built up over thousands of years. Over time, these fisheries may have reached a point of equilibrium with the local environments. But it would be a mistake to assume that indigenous fisheries systems are inherently conservation oriented by design. It is frequently the case that customary practices result in conservation of resources, but as this study demonstrates, the concept of maximisation of returns is also an important factor in indigenous fishing systems. In Roviana the indigenous topa fishery was sustainable within the context of the economies and technologies that existed prior to 1945. But globalisation brought new technologies and new markets. The indigenous topa fishing system was so acutely tuned to the subtleties of topa behaviour and ecology that when the Roviana fishers continued the practice of maximising returns, including the expansion of the fishery to previously unfished areas, such as inner lagoon areas and Tetapare, this had an adverse effect on local ecologies.

To ensure the future sustainability of coastal resources in the Solomon Islands, there is a need for resource owners to develop management plans that take local fishing patterns, Customary Marine Tenure, local environmental knowledge and scientific expertise into account. The scope for developing fisheries management plans in this region is increasing, as Roviana fishers come to the realisation that their marine resources are limited. From a western fisheries management viewpoint, TEK provides an excellent source of basic data on ecology and the status of the fishery, parameters essential in the design of sound management strategies. But these systems must be understood within the context of contemporary economic realities, which include not only those parts of the economy that articulate with the west, but also the indigenous economic and kinship networks. The existence of CMT and TEK systems within Melanesian fishing communities should not be taken to imply sound management.

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REFERENCES

Aswani, S. (1997). Customary sea tenure and artisanal fishing in the Roviana and Vonavona Lagoons, Solomon Islands: The evolutionary ecology of marine resource utilization. Ph.D. dissertation, University of Hawaii, Hawaii.

Aswani S. (2000). Women, rural development and community-based resource management in the Roviana Lagoon, Solomon Islands: establishing marine invertebrate refugia. SPC Traditional Marine Resource Management and Knowledge Information Bulletin, 12, 11-22.

Christie P. and White A.T. (1997). Trends in development in coastal area management in tropical countries: from central to community orientation. Coastal Management, 25: 155-181.

Dulvy N.K. and Polunin N.V.C. In revision. Detecting declines and extinctions of vulnerable exploited reef fishes. Journal of Applied Ecology.

Fa'asili, U. and L. Kelokolo. (l999). The use of village by-laws in marine conservation and fisheries management. SPC Traditional Marine Resource Management and Knowledge Bulletin. 11: 7-10.

Foale S and Day R. (1997). Stock assessment of trochus (Trochus niloticus) (Gastropoda: Trochidae) fisheries at West Nggela, Solomon Islands. Fisheries Research, 33: 1-16.

Foale, S. (1998). Assessment and management of the Trochus fishery at West Nggela, Solomon Islands: an interdisciplinary approach. Ocean and Coastal Management, 40: 187-205.

Foster, K. and J. Poggie. 1993. Customary marine tenure and mariculture management in outlying communities of Pohnpie State, Federated States of Micronesia. *Ocean and Coastal Management* 20: 1-21.

Hamilton, R.J. (1999). Tidal movements and lunar aggregating behaviours of Carangidae in Roviana Lagoon, Western Province, Solomon Islands. MSc dissertation, University of Otago, Dunedin, 142 pp.

Hamilton, R.J. & R. Walter. (1999). Indigenous ecological knowledge and its role in fisheries research design: A case study from Roviana Lagoon, Western Province, Solomon Islands. Traditional Marine Resource Management and Knowledge Bulletin 11: 13-25.

Hickey, F.R. (2001). Traditional marine resource management in Vanuatu: sacred and Profane. Putting Fishers' Knowledge to Work Conference Proceedings. UBC Fisheries Center.

Hviding, E. 1991. Traditional Institutions and their role in the contemporary coastal resource management in the Pacific Islands. NAGA Vol. 14:3-6.

Hviding, E. (1996). Guardians of Marovo Lagoon. practice, place, and politics in maritime Melanesia, University of Hawaii Press, Honolulu.

Jackson J.B.C. (1997). Reefs since Columbus. Coral Reefs, 16: S23-S32.

Jackson J.B.C., Kirby M.X., Berger W.H., Bjorndal K.A., Botsford L.W., Bourque B.J., Bradbury R.H., Cooke R., Erlandson J., Estes J.A., Hughes T.P., Kidwell S., Lange C.B., Lenihan H.S., Pandolfi J.M., Peterson C.H., Steneck

R.S., Tegner M.J and Warner R.R. (2001). Historical overfishing and the recent collapse of coastal ecosystems. Science, 293:629-638.

Johannes, R.E. (1981). Words of the Lagoon: Fishing and Marine Lore in the Palau District of Micronesia. Berkeley, University of California Press.

Johannes, R.E. 1988. Spawning Aggregation of the Grouper, *Plectropomus Areolatus* (Ruppel) in the Solomon Islands. Proceeding of the 6th International Coral Reef Symposium, Australia. Vol. 2: 751-755.

Johannes, R.E., K. Ruddle. and E. Hviding. 1993. The value today of traditional management and knowledge of coastal marine resources in Oceania. Workshop: People, Society, and Pacific Islands Fisheries Development and Management (Noumea, New Caledonia). 1-7.

Johannes R.E., Freeman M.M.R. and Hamilton R.J. (2000). Ignore fishers knowledge and miss the boat. Fish and Fisheries, 1: 257-271.

Johannes, R.E. (in press) Use and misuse of traditional ecological knowledge and management practices: Pacific island examples. In: D. Dallmeyer (ed.) Values at Sea: Ethics for the Marine Environment, University of Georgia Press.

Lalonde, A. and Akhtar, S. (1994). Traditional knowledge research for sustainable development. Nature and Resources, 30(2): 22-28.

Mulrennan M.E. (2001). Who's listening? Islander knowledge in fisheries management in the Torres Strait, Northern Australia. Putting Fishers' Knowledge to Work Conference Proceedings. UBC Fisheries Center.

Ruddle, K., E. Hviding. and R.E. Johannes. (1992). Marine resources management in the context of customary tenure. Marine Resource Economics Vol. 7: 249-273.

Suzuki D. and Dressel H. (1999). From naked ape to superspecies. A personal perspective on humanity and the global eco-crisis. Stoddart, Toronto.

Sheppard P.J., Walter R. and Nagaoka T. (2000). The archaeology of head hunting in Roviana Lagoon, New Georgia. JPS. The Journal of the Polynesian Society. Special Issue: Essays on head-hunting in the Western Solomon Islands 109: 9-37.

Wing S.R. and Wing E.S. (2001). Prehistoric fisheries in the Caribbean. Coral Reefs, 20: 1-8

QUESTIONS

Bob Johannes: Was there ever a population on Robiana Island large enough to put a stress on the marine resources? Was the fishery in enough trouble for them to develop a conservation ethic?

Richard Hamilton: I don't think so. They have a conservation ethic, but they were not at the point where they really stressed the fishery.

USING FISHERS' KNOWLEDGE GOES BEYOND FILLING GAPS IN SCIENTIFIC KNOWLEDGE – ANALYSIS OF AUSTRALIAN EXPERIENCES

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ABSTRACT

Most studies describing the nature of fishers' knowledge, and its value for fisheries research and management, have been concerned with small-scale fisheries in developing countries, for which conventional assessment and management techniques are usually not applicable. In industrial fisheries, accessing and using fishers' knowledge present new challenges. Fishers' interaction with scientists is influenced not only by economic imperatives and political lobbying, but also by the important changes that are currently affecting research and management practices.

In Australia, fisheries systems are increasingly based on a partnership approach, where fishers share responsibilities and costs for research and management through co-management and cost recovery mechanisms. Like many fisheries worldwide, Australian fisheries are facing serious challenges from community and government demands for greater protection of the environment. Traditional fisheries assessment and management methods are now seen as inappropriate and more holistic ecosystem-based precautionary approaches are being explored.

Three examples in Australia are examined to illustrate these changes and to show how, as a consequence, fishers' role also changes and expands (or should be allowed to expand) from simply filling gaps in scientific knowledge to providing expert advice on fisheries research and management. The partnership approach used in Australia is reviewed and difficulties in integrating fishers' and scientists' types of knowledge are discussed. Particular attention is given to the socio-cultural factors behind scientists' limited enthusiasm in using fishers' knowledge. In a partnership framework, both fishers and scientists have to realise that to acknowledge each other's knowledge and effectively cooperate is a necessity, not an option.

INTRODUCTION

There is a growing perception, worldwide, that conventional fisheries management is failing. Fish stocks are declining and some fisheries have already collapsed. Major problems include overfishing, by-catches and environmental degradation. To help improve the management of fisheries, there is an increasing recognition that more attention should be paid to fishers' knowledge and to the factors that affect fishing behaviour (Hilborn 1985, 1992, Hilborn and Walters 1992, Dorn 1998, Neis *et al.* 1999a, 1999b, Salmi *et al.* 1999, Neis and Felt 2000 and references therein).

Fishers' knowledge, and its communication to scientists, is influenced by the biological, socio-economic and cultural contexts in which fishers operate. Its value and usefulness is most often understood and studied in data-poor fisheries where conventional fisheries research and management methods are not applicable, such as small-scale indigenous fisheries in the tropics (e.g. Johannes 1998). Management philosophies and problems in these fisheries differ significantly from those in industrial fisheries. Indigenous peoples tend to have long standing association with a particular area and environment. In more recently developed industrial fisheries, fishers' association with the environment is more transient and is mediated by their tighter integration into technologically, socially, and economically capitalist societies (Neis and Felt 2000). Also, in industrial fisheries, formal procedures for the assessment and management of fish resources have been in place for some time and usually rely on scientific analysis of fisheries and biological data. This paper is concerned with fishers' role, and the use of their knowledge in Australian industrial fisheries.

Most Australian fisheries are under tight management controls, increasingly based on co-management, partnership and cost-recovery approaches and on allocating fishing rights to individual fishers. Fishers are now more involved in the scientific assessment and management of their fisheries, for which they pay a significant share, or even the entirety, of costs. However, in a context where fisheries assessment and management are dominated by science, what is the role and value of fishers' knowledge? What are the implications of the co-management, participatory approach for scientists and fishers?

Over the past decade, fisheries research and management have undergone significant changes, partly as a result of the inadequacy of traditional methods to respond to community demands for greater environmental protection. There are developing trends toward ecosystem-based and precautionary approaches to resource use and protection, along with greater and more open recognition of the uncertainty inherent in scientific results (Hilborn 1992). Both fisheries scientists and fishers have to review and adapt their philosophical beliefs and professional practices to these new approaches. In this paper, the implications of these changes for the role of fishers, and of their knowledge, in fisheries assessment and management are analysed using three examples from Australia.

EXAMPLE 1: FISHERS AS INFORMATION PROVIDERS

This example relates to a survey of the Australian south-east trawl fishery (SETF), which was carried out to collect information on, among others, changes in fishing gear and fishing practices. The SETF is a demersal, multi-species fishery in which catches of the most important species have been controlled by Individual Transferable Quotas (ITQs) since 1992. Trawl fishers' contribution to fisheries assessment and management formally began in 1986 when they started recording catch statistics in compulsory fishing logbooks[1]. Scientific stock assessments are done on a single species basis and rely for most species on catch-per-unit (CPUE) analysis using catch and fishing effort data recorded in logbooks. Both fishers and scientists have long questioned the validity of data recorded in logbooks, either because of potential mis-reporting by some fishers (especially since the implementation of the ITQ management system), or because of the influence of changes in fishing gear and fishing practices. Also, the single-species approach to stock assessment in this typically multi-species fishery, and scientists' reliance on CPUE as an index of fish abundance, have become a longstanding contention between fishers and scientists. It is well known that using CPUE as an index of fish abundance can lead to misleading results if changes in fishing gear and practices are not taken into account (Megrey 1989, Hilborn and Walters 1992, Tilzey 1999). Over the years, fishers' lack of confidence in scientific methods and advice grew, as they repeatedly demanded that scientists integrate changes in fishing technology and the influence of quota management and market demands on fishing practices into their analyses.

Eventually, in 1997, an industry survey was funded to collect this type of information. A questionnaire designed to collect a combination of quantitative information, e.g. vessel and gear description, and qualitative information, e.g. relating to fishing practice preferences[2] was used during face-to-face interviews with fishers, (see Baelde 1998, 2001 for more details). Much care was taken to keep the interviews flexible, extending the discussion beyond purely scientific conceptions (Johannes *et al.* 2000). Besides specific and practical questions, open questions were included to give fishers the opportunity to expand on their answers. The aim of the survey was to provide scientists with information that would help them improve their analysis of logbook data. Various validity and reliability checks, coding and ranking mechanisms were built into the survey questionnaire to assist scientists in quantifying and analyse the information collected.

The survey was a great success with fishers, all but two of the 47[3] fishers (skippers) approached agreed to be interviewed. Fishers provided a large and diversified amount of information including technical details of fishing equipment and description of how environmental, economic and management factors influenced fishing practices. Their perceptions and beliefs about the status of the fishery and the effectiveness of management were also recorded.

Qualitative analyses of the information collected identified significant changes in fishing practices following the implementation of ITQs (Baelde 1998, 2001). In summary, these changes included a general shift from maximising catch volumes to maximising quota holdings; catching smaller 'mixed-bags' of several species to satisfy market demand and quota restrictions. As part of their effort to diversify catches, fishers have modified the design of their trawl nets and are also fishing closer to harder, but more productive, grounds. In another developing practice, they tend to 'run away' from high

[1] Fishers also have a long, ongoing, but unappreciated and unacknowledged history of contributing to research and co-operating with scientists, often on a voluntary basis. For example, they regularly help with data collection during scientific surveys, take scientific observers onboard their vessels for routine catch monitoring studies, discarding studies, tagging experiments, and for fishing gear trials.

[2] Information on changes in environmental conditions (e.g. water temperature, winds, etc.) was also collected as fishers saw them as having a major influence on catches. Results are not presented here.

[3] This represented more than half of the skippers actively engaged in the fishery at the time.

concentrations of fish (also referred to as 'dodging the fish') to avoid over-catching their quota, or creating a fall in market prices (fishers described this as a very frustrating necessity). Such fishing practices have the potential to selectively drive down the CPUE of some species, with no relation to changes in their abundance (Baelde 2001). Communication between fishers has generally increased and, as observed in other fisheries (Allen and McGlade 1986), this influences fishing strategies and the dynamics of the fishing fleet. The survey also showed that assumptions about the direct relationship between technological improvement (e.g. access to global positioning systems) and increase in catches are not always justified (Baelde 2001). Similar observations were made by Maurstad (2000a) in Norway.

Despite the success of the survey, both in terms of fishers' willingness to participate and volunteer information and in terms of the wealth of information collected, things did not progress much further. Changes in electronic equipment and net design (the details of which scientists are mostly unaware), and quota- and market-driven changes in fishing practices have not been investigated further by scientists. These changes are not yet taken into account in stock assessments, despite their potential to seriously undermine the validity of these assessments. In fact, after initially welcoming the results of the survey, scientists then appeared to quickly lose interest. It became clear that they had unrealistic expectations and generally lacked an understanding of the quality and contents of fishers' knowledge. They failed to appreciate the need for dedicated and specialised work to turn this knowledge into a useful form for science. Institutional inertia quickly overcame their initial interest in favor of established fisheries science practices. Thus, single-species stock assessments and reliance on CPUE remain today a source of contention between fishers and scientists.

Example 2: Fishers as Active Collaborators

Example 1 described a direct interaction, albeit of limited success in this case, between fishers' information and conventional stock assessments. In Example 2, about the blue eye trevalla (*Hyperoglyphe antarctica,* Centrolophidae) fishery, quantitative stock assessment methods are not possible because of the limited data available and complex fleet and stock behaviour (Baelde 1995, 1996, 1999). However, there are important management issues, involving quota transferability and conflicts between several fishing sectors. These issues need urgent resolution and so another approach is to be taken shortly in an attempt to provide the best possible advice to management (a working group made of scientists, fishers and managers has been created and the process is about to begin).

The chosen approach for blue eye trevalla is partly based on the more holistic harvest and management strategy models that are currently developing in Australia and elsewhere (Smith *et al.* 1999, Punt *et al.* 2001). Broadly speaking, simulation-based operating models are to be built from hypotheses, or 'what if' scenarios. These scenarios will be identified using available data and expert opinion from scientists, various fisher groups and managers. In building the models, harvest strategies, stock assessment methods, performance indicators and research programmes are simulated and compared (Punt *et al.* 2001).

This approach to fisheries research and management presents three major challenges. The first will be to get members of the working group to accept and support the simulation approach and the concept of operating models. As Smith *et al.* (1999) pointed out, this type of approach is unfamiliar, complex and still experimental. To go from the principles and concepts of stock assessment methods to a simulation approach is difficult for everyone involved.

The second challenge will be to get the group members to commit themselves to the process. The success of this approach depends on genuine participation and input from, and collaboration between, scientists, fishers and managers. It is important that expertise and interests from all participants are taken into account in developing harvest and management hypotheses. Members must not only share their expertise and interests, but also be able to handle sensitive and/or controversial information in a transparent manner. Participants will also have to deal with the uncertainty inherent in their own knowledge.

The third challenge will be to get members to agree on how to use the results of simulations. Without quantitative stock assessments, operating models cannot answer questions regarding the size or current status of fish stocks and therefore cannot be used to set quota levels. This represents a major difficulty for managers. The operating models will test the performance of, and risks associated with, various management strategies. For example, 'what if' scenarios could involve proportional splitting of

the Total Allowable Catch between fishing methods, or closing particular fishing grounds (both scenarios are already quite controversial). The group members will then have to work out, and agree upon, a set of decision-rules that trigger management actions based on these tests.

In this second example, the fishers' role is not simply to fill gaps in scientific knowledge (as in Example 1), but to cooperate with scientists and managers in assessing and managing the fishery. It will also be important that scientists and managers cooperate effectively. To develop meaningful simulation models requires effective industry participation and, as noted by Smith *et al.* (1999), these new trends in research and management fit better with the co-management approach adopted in Australia. However, as a note of caution, Punt *et al.* (2001) highlighted that hypothesis-based modelling approaches may not resolve contentious issues, but simply move them from being about the validity of data and assumptions in stock assessment methods, to being about the plausibility of hypotheses.

EXAMPLE 3: FISHERS' ROLE IN THE DEVELOPMENT OF MARINE PROTECTED AREAS

In the face of growing perceptions that traditional fisheries management methods are failing, more and more attention is being paid, worldwide, to the establishment of Marine Protected Areas (MPAs) to assist fisheries (Attwood *et al.* 1997, Lauck *et al.* 1998, Parrish *et al.* 2000, Walter 1998, 2000, Pitcher 2001, Ward *et al.* 2001). Many fisheries problems are attributed to the lack of a precautionary approach by management and the implementation of MPAs, and of no-take areas in particular, is promoted as the most effective precautionary approach to protect both fisheries resources and biodiversity (Roberts and Hawkins 2000, Ward *et al.* 2001). In this fairly recent development in fisheries management philosophy, MPAs are not seen as substitutes for traditional fisheries management methods but as complements to them.

In Australia, the release of the Oceans Policy in 1998 included accelerated implementation of national and regional networks of multiple-use MPAs. This is currently being met with strong resistance from commercial fishers who are directly impacted by the establishment of no-take zones within these MPAs. Environmentalists often perceive fishers' opposition as resistance to changes and lack of care for the environment. However, in Australia, it is the lack of integration of MPA development with fisheries management which most contributes to fishers' resistance (Baelde *et al.* 2001). In this country, MPAs are specifically used for biodiversity conservation and not for fisheries management (ANZECC TFMPA 1998). They tend to be selected almost regardless of existing fisheries management systems and with very limited input from commercial fishers. Moreover, fisheries and conservation agencies show little willingness to cooperate on MPA issues or to accommodate their differing philosophical beliefs and legislative responsibilities.

In many Australian fisheries, management is evolving from a system of input-based controls (e.g. gear control, spatial management) to output-based controls (e.g. quota). As mentioned earlier, this is supported by the implementation of other mechanisms, such as co-management and partnership approaches, allocation of fishing rights, management and research cost recovery and, in some fisheries, collection of scientific data by industry. The granting of fishing rights is viewed as a means of providing fishers (and their financial institutions) with greater security of access to resources, thus promoting financial investment and development and long-term stewardship of the resources. By relying primarily on spatial management, the development of MPAs tends to conflict with these current trends in fisheries management. Whilst it is not the purpose of this paper to discuss the appropriateness, or otherwise, of Australian fisheries management systems or the value of MPAs, the point here is to highlight the uncertainty caused to fishers by the lack of congruence between the objectives of conservation and of fisheries management.

Governments' MPA policies fail to acknowledge, and properly assess, the potentially negative impacts of MPAs on commercial fisheries (Baelde *et al.* 2001). Mechanisms to address these impacts (e.g. more flexibility in designing MPAs, compensation to fishers[4], fisheries re-structuring, etc.) are not properly investigated.

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[4] Australian governments are generally reluctant to pay compensation to fishers for loss of access to fishing grounds (and loss of fishing rights). Fishers now tend to use the compensation issue as a bargaining tool in negotiating with governments. However, government agencies and MPA advocates fail to recognise that for most fishers, compensation is a last option. Fishers would rather see more compromise between biodiversity conservation needs and use of fish resources in designing MPAs. The currently poor integration of conservation and fisheries management, as well as lack of consideration of socio-economic issues, means that the opportunity of MPAs being used as tools for re-structuring fisheries (i.e. to reduce fishing effort) is being missed (Baelde *et al.* 2001).

Fishers have to be content with unsubstantiated blanket claims that MPAs may benefit their fisheries and provide protection against stock collapse (Robert and Hawkins 2000)[5].

Another important consequence of the poor integration of fisheries and biodiversity conservation needs is that conservation agencies also fail to recognise and promote the role that fishers could play in the protection of the marine environment. A recent review of Australian governments' MPA policies and planning processes (Baelde *et al.* 2001) showed that fishers have little real say in the selection and design of MPAs and that their concerns and needs are generally overlooked or poorly addressed. This too is in conflict with current trends in fisheries co-management and partnership approaches. Whether MPAs are used solely for biodiversity conservation, fisheries management, or a combination of both, has major implications for their selection and design (size, location, level of protection) and expected benefits and costs for fisheries. This in turn influences fishers' share of MPA management costs (monitoring, compliance and enforcement) and their potential involvement in MPA processes (Baelde *et al.* 2001).

It is well documented that to achieve effective natural resource management and conservation with minimal conflict and long-term community support requires the involvement of those directly affected by management measures (Fiskes 1992, Crosby 1997, Neis 1995, Well and White 1995, Beaumont 1997, Johnson and Walker 2000). However, in Australia, as observed elsewhere (Beaumont 1997), while government policies and legislation on resource management never fail to mention the importance of stakeholders' participation, they rarely provide practical details and critical accounts of approaches taken (Baelde *et al.* 2001)[6]. There are generally limited resources and expertise, and sometimes limited willingness, within government agencies to design and engage in effective consultation with the commercial fishing industry.

Recent events in the state of Victoria, Australia, are a good, if disappointing, illustration of the situation (see Baelde *et al.* 2001 for details). On May 17, 2001, after a nine-year investigation, the State Minister for Environment and Conservation proposed to declare twelve MPAs in Victoria's waters (all MPAs were to be highly protected no-take areas where all fishing was to be banned) and tabled a bill in Parliament for their establishment. The hastily drafted bill instantly generated strong opposition from the fishing industry and various political parties because it included a controversial constitutional change. Fishers would have lost their right to seek compensation through the court for loss of property rights, whether or not this loss was related to the creation of no-take areas (the Victorian Government later claimed that this was a drafting error). On 13 June 2001, about one month after tabling the MPA bill, and after stormy street demonstrations, the Victorian Government withdrew the bill from parliament.

The Victorian Government's refusal to pay compensation to fishers has been said to be the major cause of the (temporary) rejection of the MPA bill. However, it more directly reflected a very poor handling of socio-economic issues in the design of MPAs and a lack of proper consultation with the fishing industry (see footnote 4). Better protocols to ensure effective fishers' input in the design of MPAs would have helped find a compromise and help mediate their impacts on fisheries.

In the Australian south-east trawl fishery examined in Example 1, fishers are now contributing to spatial management (Williams and Bax, this volume) by providing information on fishing distribution, type of habitats that exist on fishing grounds, and fishers' operational and socio-economic dependency on these grounds. This is precisely the type of information that was missing in this Example 3. It is hoped that this cooperative work between scientists and fishers will help avoid the difficulties experienced in Victoria.

Discussion and Conclusion

There is an increasing number of studies that describe the detailed knowledge that fishers have of fish stocks, their environment and their exploitation patterns. Most of these studies highlight the usefulness of fishers' knowledge in

[5] Ward *et al.* (2001) have clearly shown that the fisheries benefits from MPAs occur in quite specific circumstances (i.e. in the case of overfished and/or unregulated fisheries). Claims of such benefits in the Australian context appear largely unsubstantiated and therefore unnecessarily undermine the validity of the conservation message (Baelde *et al.* 2001).

[6] Moreover, government policies tend to expect more and more from consulting with fishers. Consultation is expected to resolve many different issues: e.g. provide expert environmental knowledge, provide socio-economic information and assist integrated management by reducing conflict between users. While the stated scope of consultation with fishers continues to expand, there is no dedicated research to design protocols that would lead to effective consultation and integration of fishers' interests and expertise.

filling gaps in scientific knowledge. However, as noted by McGoodwin *et al.* (2000), the integration of scientists' and fishers' types of knowledge remains difficult in practice. By comparison to scientific knowledge, fishers' knowledge is mostly of a qualitative and narrative nature, holistic rather than sectoral, and subjective rather than objective. It reflects not only the biological and the socio-economic contexts within which fishers operate, but also fishers' personal beliefs and values (Baelde 1998, Neis and Felt 2000, Maurstad this volume). Various techniques to check the validity and reliability of fishers' knowledge have also been described (e.g. Neis *et al.* 1999a, Purps *et al.* 2000).

Studies on fishers' knowledge have generally been concerned with small-scale artisanal fisheries in developing countries. In industrial fisheries, the competitive pursuit of profit and political lobbying partly drive fishers' behaviour and their interaction with scientists and managers (Finlayson 1994, McGoodwin *et al.* 2000). This does not mean that fishers' knowledge in industrial fisheries is less useful, but it creates new challenges in accessing and validating it. Also, fishers' knowledge and input are often sought only when fisheries management is perceived to be ineffective, that is when fisheries are already in difficulties. By that time, fishers themselves are under pressure from increasing regulations, and may face the ultimate prospect of a ban on fishing (as seen in Example 3). Crisis situations do not facilitate cooperation as scientists' and fishers' information can become political issues in times of conflict over management (Finlayson 1994, Maurstad and Sundet 1998).

In Australian fisheries, the partnership framework established by management agencies usually includes the formation of expertise-based (by opposition to representative) scientific and management advisory committees (for example, see Smith *et al.* (1999) for an analysis of the partnership approach in the case of federally managed fisheries). Membership on these two types of committees comprises scientists, fishers, managers and environmentalists. This framework is, without doubt, a significant step toward promoting fishers' involvement in fisheries assessment and management and facilitating collaboration between scientists, managers and fishers (see Smith *et al.* 1999). However, it is only partly effective. Problems are often attributed to fishers' vested interests 'capturing' the process, but Smith *et al.* (1999) question these perceptions.

Other problems are created by the fact that, on the one hand, the partnership framework gives fishers greater access to the assessment and management process, and thus greater opportunity to scrutinise and challenge scientific knowledge with their own knowledge and expertise. But, on the other hand the partnership framework has not been designed to facilitate the use of the knowledge and expertise that fishers bring into the process. In many fisheries, the scientific assessment process relies largely on conventional quantitative, single-species methods and is not adequately adapted to incorporate fishers' type of knowledge (as seen in Example 1). Scientists tend to believe that the usefulness of fishers' knowledge is limited because of the difficulties inherent in quantifying it. Whereas, fishers express growing frustration at scientists' inability to make direct use of industry information and views (Baelde 1998, 2001, Smith *et al.* 1999). Fishers' frustration during scientific meetings sometimes turns into confrontation with scientists. Also, the partnership framework does not facilitate access and use of broad-based industry knowledge. The communication of information between members of advisory committees and the wider fishing community is not effective and this generates some tension within the industry[7]. Additional structures that are better adapted to the specific nature of fishers' knowledge must be developed[8].

Possibly the greatest difficulty with the partnership approach is overcoming existing socio-cultural barriers that hamper communication and collaboration between fishers and scientists/managers. There is a great

[7] McCay (1999) stated that current partnership practices based on advisory committees tend to create a new type of community, an interest-based community as compared to place-based community. These 'virtual' communities are defined by their management regimes (by species, area, gear type, etc.) and develop new social ties and identities. She suggests that such communities may be the only real hope for a participatory management that encompasses a wide diversity of interest groups. However, experience in Australia shows that they also tend to alienate non-member fishers and may create further divisions within an already divided fishing industry.

[8] In the case of the Australian south-east fishery, the management agency also funds a team of scientists and managers to conduct annual visits to major fishing ports. The aim is to give grass-root fishers an opportunity to interact with scientists and managers and raise issues about the fishery. However, it is obvious from the low attendance of fishers that this is not working satisfactorily. Individual fishers tend to be wary of public meetings (especially when there are conflicts about management issues) and one-day-a-year visits to their ports fail to attract their interest: they go fishing instead.

socio-cultural divide between the moral authority of science (collectively accepted by society and legitimised through rigorous objectivity rules) on the one hand, and the suspicion attached to fishers' information (subjective, non-tested and perceived as biased by vested interests) on the other hand. The lack of curiosity and interest that scientists showed in the wealth of information that was collected from fishers in Example 1 was surprising at first. However, it quickly became obvious that scientists' attitudes toward fishers' knowledge were influenced by the socio-cultural barriers so often described by social scientists (e.g. Finlayson 1994, MacCay 1999, Neis and Felt 2000 and references therein; Wilson, this vol). In a co-management situation, scientists have learned to respect fishers' political power, but they have remained sceptical of the validity of their knowledge. In his analysis of the northern cod fishery, Finlayson (1994) showed that scientists made a clear distinction between fishers' involvement in the scientific process and the incorporation of their knowledge in that process. Even the most sympathetic fisheries scientists are too perplexed by the structure, form, and scale of fishers' knowledge and prefer retreating into the security and familiarity of established scientific practices (McGoodwin *et al.* 2000).

Scientists tend to see themselves as possessors of universal knowledge and custodians of the sea (McGoodwin *et al.* 2000), as defenders of natural resources against an irresponsible fishing industry and an inefficient, or ambivalent, management (Finlayson 1994). When asking fishers to share their knowledge, scientists assume that they accept the purpose and methods of science, and that their role is to fill gaps in scientific knowledge. However, this science-driven approach fails to recognise fishers' own values, expectations and methods of gathering knowledge. Besides scientific understanding, other knowledge frameworks and value systems are gaining recognition as products of social, cultural and ecological contexts (McGoodwin *et al.* 2000). This increasingly challenges the central position of science. We need to explore and test fishers' own understanding and theories about biological processes and market or management-driven fishing behaviour (Maurstad and Sundet 1998, Baelde 2001).

By focussing on the technical difficulties of integrating fishers' knowledge into scientific methods, scientists maintain a narrow and prescriptive view of the nature and value of fishers' knowledge (Baelde 1998, Maurstad 2000b). McGoodwin *et al.* (2000) stressed that it is not longer enough to hire fishers as data-collecting technicians, or even to systematically collect their knowledge in a form that fits with the requirements of existing science. The type of fishers' input that is needed today for assessing and managing industrial fisheries is expanding well beyond simply filling gaps in scientific knowledge. This is because the principles and practices of fisheries research and management are also dramatically and rapidly changing. The three examples described illustrate these changes, from deterministic quantitative single-species stock assessment (Example 1), to exploratory, hypothesis-based simulation models (Example 2) to holistic ecosystem approach (Example 3). As a consequence, the role of fishers, and their input, also diversifies, from providing technical knowledge to providing advice and opinions on current and future harvest and management needs.

While the partnership approach is being increasingly adopted and promoted as a tool leading to better resource management, the social and cultural implications and constraints of such an approach are not well understood and appreciated by scientists. They fail to recognise that a truly effective partnership with fishers relies first of all on acknowledging the legitimacy of fishers' knowledge and actively developing ways of overcoming existing technical and socio-cultural difficulties[9]. This would require dedicated research, crossing the boundaries of fisheries and social sciences.

The sweeping changes that are taking place in fisheries assessment and management are partly in recognition of the limitations and uncertainty of traditional fisheries science. As public scrutiny of fisheries issues intensifies, community views and values on the use of common resources play an increasingly important role in fisheries assessment and management. Fisheries management and environmental protection are becoming matters of social debate and negotiations. A balance has to be found between environmental, social and economic values and this cannot be resolved on biological and technical grounds alone. Fishers are (or should be) active players in these social negotiations, contributing not only their knowledge but also their perceptions and values.

[9] Jentoft *et al.* (1998) also noted that, while income is important, the dignity and esteem that come from the occupation of fishing matter a great deal to fishers. Fishers' accumulated knowledge contributes to their pride.

Jentoft *et al*. (1998) point out that co-management is a process of social creation through which knowledge is gained, values articulated, culture expressed and community created. Scientists' reluctance to acknowledge, or at least test, the value of fishers' knowledge is anachronistic in today's circumstances. Like fishers, they are running the risk of being accused of resisting changes in order to protect their own entrenched professional interests.

This paper was concerned with scientists' responsibilities in ensuring effective partnership and effective use of fishers' knowledge. However, fishers do have responsibilities too toward the community, both as users of common resources and as food providers. They too must realise the extent of societal change with regard to the conservation of common resources and the consequences for their industry. They cannot operate with the same independence they once did and they must work on developing a more unified and credible voice. The well known divided nature of the fishing industry is an important factor limiting the use of fishers' knowledge. In the same way as too many scientists tend to retreat behind the comfort and familiarity of established science, too many fishers also tend to retreat behind the belief that resource protection and management is, ultimately, a government responsibility. This too is an anachronistic position, untenable in today's co-management approach.

Fisheries are in crisis and both fishers and scientists are under pressure to protect marine resources. Their ability to collaborate and find acceptable and workable solutions to fisheries problems partly depends on their ability to shift from their defensive positions to positions of leadership. Both fishers and scientists must now re-think their cultural and professional beliefs in order to accommodate each other's complementary knowledge and expertise and put them to best use.

REFERENCES

Allen, P., M., and McGlade, J., M. (1986). Dynamics of discovery and exploitation: the case of the Scotian Shelf Groundfish Fisheries. *Canadian Journal of Fisheries and Aquatic Sciences* 43, 1187- 1200.

ANZECC TFMPA (1998). Guidelines for Establishing the National Representative System of Marine Protected Areas. Australian and New Zealand Environment and Conservation Council Task Force on Marine Protected Areas, Environment Australia, Canberra, 15pp.

Attwood, C. G., Harris, J. M. and Williams, A. J. (1997). International experience of marine protected areas and their relevance to South Africa. *S. Afr. J. mar. Sci.* 18: 311-332.

Baelde, P. (1995). Analysis of the blue eye trevalla (*Hyperoglyphe antarctica*) fishery off Tasmania, Australia. *In*: Assessment of the Blue Eye Trevalla Fishery and Analysis of the Impact of Mid-water Trawling, Final FRDC Report (Project No. 91/20).

Baelde, P. (1996). Biology and dynamics of the reproduction of blue-eye trevalla, *Hyperoglyphe antarctica* (Centrolophidae), off Tasmania, southern Australia. Fish. Bull. 94:199-211.

Baelde, P. (1998). Synthesis of industry information on fishing practices and their effects on catch rate analysis (bottom trawl sector). *In*: Synthesis of industry information on fishing patterns, technological changes and the influence of oceanographic effects on SEF fish stocks, Prince J., P. Baelde and G. Wright (eds). FRDC Project No 97/114, Canberra, Australia, 70po.

Baelde, P. (1999). Blue eye trevalla – Stock assessment report compiled for the South East Fishery Assessment Group, Australian Fisheries management Authority, Canberra, Australia, 16pp.

Baelde, P. (2001). Fishers' description of changes in fishing gear and fishing practices in the Australian South East Trawl Fishery. *Marine and Freshwater Research* 52(4): 411-417.

Baelde, P., R. Kearney and D. McPhee. (2001). A coordinated commercial fishing industry approach to the use of Marine Protected Areas. Final FRDC Report (Project No. 99/163), 190pp.

Barber, W. E. and Taylor J. N. (1990). The Importance of Goals, Objectives, and values in the Fisheries Management Process and Organisation: A Review. *North American Journal of Fisheries Management* 10 (4): 365-373.

Beaumont, J. (1997). Community participation in the establishment and management of marine protected areas: a review of selected international experience. *S. Afr. J. mar. Sci.* 18: 333-340.

Crosby, M. P. (1997). Moving towards a new paradigm: Interactions among Scientists, Managers and the Public in the Management of Marine and Coastal Protected Areas. *In*: Crosby M. P., K. Geenen, D. Laffoley, C. Mondor and G. O'Sullivan (eds), Proceedings of the 2nd International Symposium and Workshop on Marine and Coastal Protected Areas: Integrating Science and Management, 1995, NOAA, Silver Spring, MD.

Dorn, M. W. (1998). Fine-scale fishing strategies of factory trawlers in a midwater trawl fishery for Pacific hake (*Merlucius productus*). *Canadian Journal of Fisheries and Aquatic Sciences* 55, 180-198.

Finlayson, A. C. (1994). Fishing for Truth: a Sociological Analysis of Northern Cod Stock Assessments from 1977-1990. St. John's: ISER Books.

Fiske, S. J. (1992). Sociocultural aspects of establishing marine protected areas. *Ocean and Coastal Management* 18: 25-46.

Hilborn, R. (1985). Fleet dynamics and individual variation: why some fishers catch more than others. *Canadian Journal of Fisheries and Aquatic Sciences* 42, 2-13.

Hilborn, R. (1992). Current and future trends in fisheries stock assessment and management. *South African Journal of Marine Sciences* 12, 975-988.

Hilborn, R., and Walters, C. J. (1992). Quantitative fisheries stock assessment: choice, dynamics and uncertainty. Chapman & Hall: New York.

Jentoft S., McCay B. J. and Wilson, D.C. (1998). Social theory and fisheries co-management. *Marine Policy* 22 (4-5): 423-436.

Johannes, R. E. (1998). The case for data-less marine resource management: examples from tropical nearshore fisheries. *Trends in Ecology and Evolution* 13: 243-246.

Johannes, R. E., Freeman, M.M.R., and Hamilton, H.J. (2000). Marine biologists miss the boat by ignoring fishers' knowledge. *Fish and Fisheries* 1:257-271.

Johnson, A. and Walker, D. (2000). Science, Communication and Stakeholder Participation for Integrated Natural Resource Management. *Australian Journal of Environmental Management* 7: 82-90.

Lauck, T., Clark, C. W., Mangel, M. and G. R. Munro (1998). Implementing the precautionary principle in fisheries management through marine reserves. *Ecological Applications*, 8(1) Supplement: S72-S78.

Maurstad, A. (2000a). To Fish or not to Fish: Small-Scale Fishing and Changing Regulations of the Cod Fishery in Northern Norway. *Human Organisation* 59(1): 37-47.

Maurstad, A. (2000b). Trapped in Biology – An Interdisciplinary Attempt to Integrate Fish Harvesters' Knowledge into Norwegian Fisheries Management. *In* : Neis, B. and Felt L. (eds) (2000). Finding our sea legs – Linking Fisheries People and Their Knowledge with Science and Management. ISER Books, Newfoundlands.

Maurstad, A. and J. H. Sundet. (1998). The invisible cod – Fishermen's and scientists' knowledge. *In*: Commons in a Cold Climate – Coastal Fisheries and Reindeer Pastoralism in North Norway: The Co-Management Approach, S. Jentoft (ed.), Man and the Biosphere Series, Volume 22, page: 167-184.

Maurstad, A. (this volume). Fishing in murky waters – Ethics and politics of research on fisher knowledge.

McCay, B. J. (1999). Community-based approaches to the 'Fishermen's Problem'. Paper presented at the 1999 FishRights Conference, Fremantle, Australia.

McGoodwin, J. R., Neis, B., and Felt, L. (2000). Integrating Fishery People and Their Knowledge into Fisheries Science and Management- Issues, Prospects, and Problems. *In* : Neis, B. and Felt L. (eds) (2000). Finding our sea legs – Linking Fisheries People and Their Knowledge with Science and Management. ISER Books, Newfoundlands.

Megrey, B. A. (1989). Review and Comparison of Age-Structured Stock Assessment Models from Theoretical and Applied Points of View. *American Fisheries Society Symposium* 6: 8-48.

Neis, B. (1995). Fishers' ecological knowledge and marine protected areas. *In*: Proceedings of the Symposium on Marine Protected Areas and Sustainable Fisheries conducted at the Second International Conference on Science and the Management of Protected Areas, N. L. Shakell & J. H. Martin Willison (eds), pp 265-72. Halifax, Canada: Dalhousie University.

Neis, B. and Felt L. (eds) (2000). Finding our sea legs – Linking Fisheries People and Their Knowledge with Science and Management. ISER Books, Newfoundlands.

Neis, B., Felt L., Haedrich R. L., and Schneider D. C. (1999a). An interdisciplinary methodology for collecting and integrating fishers' ecological knowledge into resource management. *In*: Newell, D. and R. Ommer (eds), Fishing Places, Fishing People: issues and traditions in Canadian small-scale fisheries, University of Toronto Press, Toronto, 217-238.

Neis, B., Schneider, D. C., Felt, L., Haedrich R. L., Fisher J., and Hutchings J. A. (1999b). Fisheries assessment: what can be learned from interviewing resource users? *Can. J. Fish. Aquat. Sci.* 56: 1949-1963.

Parrish R. Seger, J. and Yoklavich. M. (2000). Marine Reserves to Supplement Management of West Coast Groundfish Resources – Phase1 Technical Analysis. Pacific Fishery Management Council. Available on http://www.pcouncil.org.

Pitcher, T. J. (2001). Fisheries managed to rebuild ecosystems? Reconstructing the past to salvage the future. *Ecological Applications* 11 (2): 601-617.

Punt, A. E., Smith, A. D. M and Cui G. (2001). Review of progress in the introduction of management strategy evaluation (MSE) approaches in Australia' s South East Fishery. *Marine and Freshwater Research* 52(4): 719-726.

Purps, M., Damm, U. and Neudecker, T. (2000). Checking the Plausibility of data Derived from Fishing People of the German Wadden Sea. *In*: Neis, B. and Felt L. (eds) (2000). Finding our sea legs – Linking Fisheries People and Their Knowledge with Science and Management. ISER Books, Newfoundlands.

Roberts, C. M. and Hawkins, J. P. (2000). Fully-protected marine reserves: a guide. WWF Endangered Seas campaign, Washington, DC, USA and Environment Department, University of York, York, UK, 131pp.

Salmi, P., Salmi, J. and Moilanen, P. (1999). Strategies and flexibility in Finnish commercial fisheries. *Boreal Environment Research* 3: 347-359.

Smith, A. D., Sainsbury, K. J., and Stevens, R., A. (1999). Implementing effective fisheries management systems – an Australian partnership approach. *ICES Journal of Marine Research* 56, 967-979.

Tilzey, R. D. J. (1999). The South East Fishery 1998. Fishery Assessment Report compiled by the South East Fishery Assessment Group, Australian Fisheries Management Authority, Canberra.

Walters, C. J. (1998). Designing fisheries management systems that do not depend on accurate stock assessment. *In*: Reinventing fisheries management, T. J. Pitcher, P. J. B. Hart and D. Pauly (eds), Chapman and Hall, London.

Walters, C. J. (2000). Impacts of dispersal, ecological interactions, and fishing effort dynamics on efficacy of marine protected areas: how large should protected areas be? *Bull. Mar. Sci.* 66 (3): 745-757.

Ward, T.J., Heinemann, D. and N. Evans. (2001). The role of marine reserves as fisheries management tools: A review of concepts, evidence and international experience. Bureau of Rural Sciences, 184 pp.

Well S. and A. T. White (1995). Involving the community. *In*: Marine Protected Areas – Principles and Techniques for management. Gubbay S. (ed), Conservation Biology Series, Chapman and Hall, London.

William, A. (this volume). Integrating fishers' knowledge with survey data to understand the structure, ecology and use of a seascape off southeastern Australia.

Questions

Melita Samoilys: Why weren't marine parks used for fisheries management?

Pascale Baelde: It was a legislative decision. I will challenge that.

Bruce Burrows: How do you define a marine park?

Pascale Baelde: A marine park is defined by use; it includes no-take areas.

LOCAL ECOLOGICAL KNOWLEDGE AND SMALL-SCALE FRESHWATER FISHERIES MANAGEMENT IN THE MEKONG RIVER IN SOUTHERN LAOS

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ABSTRACT

Small-scale fishers possess a vast amount of local ecological knowledge (LEK) about the fish and fisheries of the Mekong River and tributaries in southern Laos. Between 1993 and 1999, a community-based co-management programme was implemented for the conservation and sustainable management of living aquatic resources in the Siphandone (4000 islands) Wetlands area of the Mekong River in Khong District, Champasak Province, southern Laos. In total, 63 villages established regulations related to living aquatic resources during the project, and local government has since officially recognised these regulations as constituting "village law". Independent evaluations conducted regarding the fisheries co-management system established in Khong report that local people believe that aquatic resources have benefited from the varied regulations adopted in individual villages, and it seems likely that the system will continue to function into the future, although the effectiveness of local management varies from community to community. The aquatic resource co-management measures established in Khong have been largely based on LEK, and LEK has played an important role in community fisheries monitoring activities, and in adapting management regulations to meet local conditions. This paper describes how LEK can be practically applied, disseminated, and strengthened for improving freshwater fisheries management in rural communities in Laos and other countries in mainland Southeast Asia. Particular techniques for utilising LEK in assessing fish diversity, and for addressing important fisheries management issues are also described.

INTRODUCTION

Small-scale fishers in many parts of the world have a vast amount of local ecological knowledge (LEK) about the fish and fisheries that they depend upon for their livelihoods (Johannes 2001; Poulsen and Joergensen 2000; Baird 1999b; IIRR, 1996; Johannes, 1981). While it is now generally recognised within the scientific community that fishers have a large amount of LEK, there has been little research specifically documenting the way local people use their LEK for fisheries management purposes, or how LEK can be adapted in order to improve the management of wild capture fisheries (Johannes 2001).

The purpose of this paper is to report on a community-based fisheries co-management programme of the communities living near the mainstream Mekong River in Khong District, Champasak Province, southern Lao People's Democratic Republic (Lao PDR or Laos), and the ways in which LEK has been utilised, disseminated and strengthened to improve the management of wild capture freshwater fisheries. A number of tools for improving fisheries management based on LEK are discussed, and methods for conducting fish diversity and behaviour studies using LEK are presented.

BACKGROUND

The Mekong River, with a length of approximately 4,400 km, is the 10th longest river in the world, and the 14th largest in terms of total annual discharge. However, the Mekong is third (after the Amazon and the Brahmaputra) when it comes to maximal flows (Baran *et al.* 2001). The diverse habitats of Mekong River Basin support one of the richest fish faunas in the world, and more fish species than any other river basin in Asia. Approximately 1,200 species are believed to occur in the Mekong Basin, although many have not yet been taxonomically described (Van Zalinge *et al.* 2000; Rainboth 1996). Many species seasonally migrate long distances up the Mekong River to Laos and Thailand from as far away as the Great Lake in Cambodia and the South China Sea in Viet Nam (Baird *et al.* 2001a; Van Zalinge *et al.* 2000; Baird *et al.* 2000; Baird *et al.* 1999a; Warren *et al.* 1998; Lieng *et al.* 1995; Roberts and Baird 1995a). Other species are relatively sedentary or only locally migratory (Baird *et al.* 1999a; Baird 2000; Baird *et al.* 2001b).

Laos is a land-locked country in mainland Southeast Asia, sharing long borders with Viet Nam to the east and Thailand to the west, and shorter borders with China and Burma to the north, and Cambodia in the south. With a multi-ethnic population of approximately 5.5 million, most people in Laos are semi-subsistence rural-based farmers and fishers. The country, which is about the size of Great Britain, is considered one of the poorest in the world. The Mekong River is the hydrological life-blood of Laos, flowing for some 1,860 km

through the country. Roughly 25 percent of the Mekong River Basin is located in Laos, which contributes 35 percent of the Mekong's total flow (FAO 1999).

The Mekong River and her tributaries are the main source of wild fish for local people, and fish constitute the most important source of both protein and cash income for the bulk of the population in Laos (Baird 1999b; Hubbel 1999; Baird *et al.* 1998b). There is a large variety of fisheries, each dependent on harvesting methods used, the particular habitats and seasons involved, and the ethnicity and socio-economic conditions of the fishers. The fishing methods used are also dependent on the species of fishes or groups of fishes being targeted, and the fishers' knowledge of the biology and behaviour of the fish (Claridge *et al.* 1997; Baird *et al.* 1998b). Certainly, the LEK of fishers contributes greatly to their ability to feed themselves and their families, and to generate income. In fact, fish resources and LEK are the basis for livelihoods (Baird *et al.* 1999a & b; Baird and Flaherty 1999). Yet, as human populations have grown, fishing implements have been modernised, markets have become more accessible, and development projects of various types have had a negative impact on fish populations (Baird 1999a & b; IRN 1999; Roberts and Baird 1995a; Roberts 1993a & b). Although there are few official data available on fisheries, there are increasing numbers of reports that individual fishers are experiencing significant declines in their catches (Baran *et al.* 2001; Baird *et al.* 2001a & b; Hogan 1997; Roberts and Baird 1995a; Lieng *et al.* 1995; Roberts and Warren 1994; Roberts 1993c).

The Siphandone (4000 islands) Wetland area, situated in the extreme south of Laos, is one of the most complex ecosystems found in the mainstream Mekong River. It is made up of large and small inhabited and uninhabited islands, channels, seasonally inundated forests, deep-water pools, rapids and waterfalls (CESVI 1998; Altobelli *et al.* 1998; Claridge 1996). The Siphandone Wetlands are largely situated in Khong District, which is in the southern-most part of Champasak Province (see Figure 1). The aquatic environment of the area is characterised by high biodiversity and productivity (Baird 2000; Baird *et al.* 1999a). So far, 201 fish species have been recorded from fish catches from the mainstream Mekong River just below the Khone Falls in Khong District, of which about 165 can be considered economically significant to fishers in the Khone Falls area (Baird 2000).

Figure 1 Lower Mekong basin

As of 1995, there were 65,212 people living in Khong, the vast majority being ethnic Lao rural subsistence-oriented peoples. For the most part, they are semi-subsistence wet rice farmers and fishers, and have a long history of inhabiting the area. The wild-capture fisheries of Khong may be more important to local people than in any other district in Laos. Of the 136 villages in Khong, 86 are situated on islands, and most of the rest are established along the eastern bank of the Mekong River (Baird *et al.* 1998b). Approximately 94 percent of families in the district participate in artisanal fisheries at a subsistence level or as a way of generating income. In 1996/1997, it was estimated that four million kg of wild fish were caught in Khong District, and that over US$ one million worth of wild fish and fish products originating from Khong were sold on the market. The average person caught 62 kg of fish (Baird *et al.* 1998b).

Fisheries Management in the Mekong River Basin

In the Mekong River Basin, including the mainstream river, wild capture fisheries management is faced with various obstacles and challenges. Scientifically documented information about the resource is very limited and fragmented (Baran *et al.* 2001; Kottelat and Whitten 1996; Roberts and Warren 1994; Hill and Hill 1994; Roberts 1993c). There are very serious gaps in understanding the many fisheries operating throughout the Mekong countries (Baird *et al.* 2001a; Ahmed *et al.* 1998; Hill and Hill, 1994; Roberts and Warren, 1994; Roberts 1993c). Furthermore, the Mekong system is characterised by having a large number of fisheries, some large and most small, each operating in different ways, adding to the complexity of management (Ahmed *et al.* 1998; Baird *et al.* 1998b; Claridge *et al.* 1997; Hill and Hill 1994). Many of these fisheries are located in relatively remote areas, making the possibility of government management extremely difficult and costly, and generally unrealistic (Cunningham 1998). The large number of highly migratory fish species in the Mekong basin that move between two or more countries also makes it difficult to manage many species at only a local level (Baird *et al.* 2001a; Warren *et al.* 1998; Roberts and Baird 1995a; Roberts 1993b).

Project development impacts

There are various development projects in the planning or implementation stage that have the potential to seriously impact natural aquatic resources. These projects are associated with a number of sectors, including hydro-electricity production, irrigation development and industrial expansion, to name but a few of the development sectors that have the potential to cause fish habitat degradation across international borders (Baird 2001; IRN 1999; Hubbel 1999; Roberts 1993b). For example, it has recently been documented that the Yali Falls dam in the Central Highlands in Viet Nam has caused major downstream impacts in neighbouring parts of northeast Cambodia (Fisheries Office and NTFP 2000).

Community-based Fisheries Co-Management

Centrally imposed natural resource management systems typically increase the monitoring and regulatory responsibilities of governments. Unfortunately, the fisheries departments in non-industrialised nations are typically understaffed and underfunded (Baird 1999b; Johannes 1998; Cunningham 1998; Kottelat and Whitten 1996; Cowx 1991). Given the pressing need for improved natural resource management, alternative decentralised management models, including "co-management" (CM) and "community-based natural resource management" (CBNRM), are being increasingly proposed in Southeast Asia and other parts of the world (Hirsch and Noraseng 1999; Masae *et al.* 1999; Johannes, 1998; Johnson, 1998; Pomeroy, 1998; Pomeroy and Carlos, 1997; Hogan, 1997; McCay and Jentoft 1996; Ali 1996; Clay and McGoodwin 1995; Kuperan and Abdullah 1994; Berkes and Kislalioglu 1993; Christy 1993; Berkes *et al.* 1991; Ghee 1990).

Natural resource co-management has been defined as, *"the collaborative and participatory process of regulatory decision-making among representatives of user-groups, government agencies and research institutes"* (Jentoft *et al.* 1998: 423). The term co-management (CM) is useful for demonstrating that fisheries management is often a joint effort between resource users and governments. However, some CM programmes remain strongly government dominated, with little real decision-making powers being given over to resource users (Simonitsch and Glaesel 2001; Glaese and Simonitsch, this vol). Because of the uncertainty of who controls management decisions when it comes to CM, some scholars and practitioners prefer to use the term community-based natural resource management (CBNRM), as it emphasises that the communities are the centre of management structures. However, the term CBNRM is limited because it does not imply the involvement or recognition of the government in management systems. Nor does it specify whether there are any partnerships or agreements between governments and users. In reality, most fishing communities require and desire some level of government support in order to be able to effectively defend community resource areas covered under local management regulations (Baird 1999b). Therefore, it seems preferable to use the term "community-based co-management" (CBC). This term is intended to convey the message that management systems and decision-making structures are centred in communities, with users having considerable management powers. However, the term also shows that the government is nevertheless participating in the process, and recognises the validity of the community-based management systems, and user tenure over resources. Essentially, the systems in Khong fit

into the class of CBC. This type of management regime holds considerable promise for furthering local fisheries management in the Mekong Basin.

Community-based Fisheries Co-Management in the Khong District

Between 1993 and 1999 63 villages in Khong District, Champasak Province, southern Laos established CBC regulations to sustainably manage and conserve inland living aquatic resources, including fish, in the Mekong River, streams, backwater wetlands and rice paddy fields (Baird 1999b). The "community-based fisheries co-management" (CBFC) systems in Khong have been supported by two non-governmental organisation (NGO) supported projects, the Lao Community Fisheries and Dolphin Protection Project (LCFDPP), which was implemented between 1993 and 1997, and the follow-up Environmental Protection and Community Development in Siphandone Wetland Project (EPCDSWP), which was in operation between 1997 and 1999 (Baird 1999b).

Villages have been permitted to initiate the CBFC process, and choose what regulations to adopt based on local conditions and community consensus, but local government has endorsed the process, and the regulations of each village, with minimal interference. Moreover, communities are empowered to implement and enforce regulations, and they can alter them in response to changing circumstances. Recognised as "village law", the regulations established in each of the villages are different. Nevertheless, many communities have adopted similar regulations, with slight variations (Baird 1999b). The most commonly adopted regulations relate to:

1) The establishment of Fish Conservation Zones (FCZs) in deep-water (10 to 50 m deep) parts of the Mekong River. These areas are essentially "no take areas", for either all or part of the year. They are especially important as low-water fish refuges for protecting large brood stock in the dry season. In total, 69 FCZs have been set in Khong, with some FCZs being jointly managed by two or three villages, while some villages have established up to three FCZs under their management (Baird 1999b; Baird *et al.* 1998a; Baird and Flaherty 1999).

2) The banning of the blocking of streams with fish traps at the beginning of the rainy season in order to prevent the harvesting of fish making short spawning migrations into inundated rice fields and other wetlands. Locals want to encourage spawning before catching brood stock (Baird 1999b).

3) The banning of "water banging" fishing, where a long wooden pole with a metal piece at the end of it is used to bang the surface of the water in order to chase small cyprinid fishes like *Henicorhynchus* spp. *(pa soi* in Lao*)* and *Paralaubuca typus (pa tep* in Lao*)* into small-meshed gillnets. This ban has been implemented because it is believed that the method results in fish leaving local areas, leading to lower catches for those fishers who set stationary gill nets without chasing fish into them (Baird 1999b).

4) The banning of spear fishing with lights at night. This ban has been implemented because it is seen as being too effective a fishing method, catching large amounts of large brood fish. It is also unpopular because people who use this method sometimes steal fish from peoples' nets and traps at night when they encounter them, and have also been known to steal chickens and other things from villagers (Baird 1999b).

5) The banning of catching juvenile snakeheads (*Channa striata*) *(pa kho* in Lao*),* especially when they are less than about two weeks old and are still traveling in schools. These juveniles are very vulnerable to scoop-net fishing, but the amount of fish harvested is very small due to the small size of the fish. Villagers believe that it makes more sense to allow the fish to grow before harvesting them, thus increasing total production (Baird 1999b).

6) The banning of frog (*Rana* spp.) catching at the beginning of rainy season, when they spawn, and in some cases, at other times of year. The banning of frog harvesting during the spawning season is especially important, because frogs croak loudly at that time, making them very vulnerable to harvesting. Moreover, if frogs are harvested before they can spawn, recruitment may be reduced, leading to population declines. The banning of certain harvesting methods such as frog traps, frog hooks and lights at night is also mandated by many villagers due to the belief that frog harvesting for commercial sale is too intense, leading to population declines. Local farmers see frogs as important for controlling insect attacks on their rice crops (Baird 1999b).

7) The banning of tadpole (*Rana* spp.) catching at the beginning of the rainy season after spawning takes place. The principle of

protecting these small juveniles is the same as for protecting juvenile snakeheads, as explained in point #5 (Baird 1999b).

8) The protection of inundated forest habitat by encouraging villagers not to cut down wetland trees and bushes in the mainstream Mekong River (Baird 1999b).

While not all the villages have been equally successful in their aquatic resource management efforts, due to biological, geographical and social reasons, most villagers have widely reported increased stocks of certain aquatic animals, as well as increased fish catches, since the adoption of CBFC regulations. Some rare and endangered species of fish have also made comebacks due to the regulations, thus benefiting biodiversity. Improved solidarity and coordination within and between rural fishing and farming villages and the government, has also been observed. The costs to government of managing fisheries are minimal, since local people do most of the work. Therefore, the local government advocates the system, and hopes to expand the work to other villages in the future, although not all villages have opted to join the system, and some do not have appropriate habitat near their village for establishing FCZs. In any case, the initiative can be seen as being relatively successful to date, since both local people and the environment are benefiting (Baird *et al.* 2001b; Chomchanta *et al.* 2001; Baird and Flaherty 1999; Baird 1999b; Baird *et al.* 1999b; Cunningham 1998; Baird *et al.* 1998b; AIT 1997). In addition, two independent evaluations regarding the fisheries co-management system in Khong have both confirmed the above conclusions, especially in relation to the apparent success of FCZs (Chomchanta *et al.* 2001; AIT 1997).

Putting LEK to Work in Fisheries Management

LEK related to fish and other living aquatic resources in Khong is widespread, and most of the people in the district either live on islands or on the banks of the Mekong River, and spend a considerable amount of time on the water. Most people in the area have lived all their lives near the Mekong. Their lives are highly influenced by changing hydrological conditions in the Mekong River. Moreover, fishing traditions are strong. Fishing begins very early in life for many children, and especially young boys, and most are seasoned fishers by the time they are teenagers (Baird 1999b).

Local people in Khong have a highly developed folk taxonomy for fishes, and all medium and large sized species have specific local names, even when there are only small differences in outward appearances. These names are widely known within the general population, and discussions in communities are often centred on fishing activities. The average fisher is familiar with well over 100 local names, which are used to describe the approximately 165 species of fish that are economically significant to local people (see also Freire and Pauly; and Wiener, both this vol).

Photographs of fish found in Khong shown to children as young as five or six years old elicit many local names, indicating that many children of that age already have a vocabulary of 50 or more local names for fish. However, at such young ages, young children are not as easily able to match local names with fish photographs, compared to teenagers or adults.

As a testament to the accuracy of their folk taxonomy, when a foreign ichthyologist visited one village in Khong in 1993, he heard of three local names for fish in the genus *Micronema* (the names were *pa nang khao, pa nang ngeun* and *pa sa-ngoua* in Lao). At the time, the ichthyologist believed that these names indicated an over-differentiation of local names for describing the two species he believed actually occurred there (Roberts 1993c). However, it has since been confirmed that the villagers were right in that there are actually three species of *Micronema* in Khong, each species corresponding with a single local name (Baird *et al.* 1999a).

Local people in Khong possess a considerable amount of LEK about fish behaviour, including migration and feeding patterns (see for example, Baird *et al.* 1999a & b; Baird and Phylavanh 1999). However, in the past most people interested in LEK have been more concerned with documenting it than strengthening and disseminating it to make it more practically useful for local fisheries management by local people.

LEK has been of critical importance in the development of regulations as part of the community-based fisheries co-management program in Khong. In fact, it has been the basis for the establishment of all regulations, and the government and supporting NGO projects have provided additional scientific information to local fishers to augment their LEK.

Although the passing on of ecological information from the old to the young, and from generation to generation is a vitally important component of its development, LEK does not represent a stagnant state of knowledge. Importantly, LEK is also developed through the actual experiences of individual fishers, and therefore, LEK is not uniform within the population of fishers. Those who spend more time on the water may know more than others, but it also depends on the powers of observation of individuals, and the dispositions for learning of individuals, which may differ considerably. Differences in LEK are also certainly based on the particular habitats, species, and fishing methods utilised by different fishers. For example, some fishers who mainly only use fish hooks may have a considerable amount of LEK about those fish species that they target, but they may know much less about species that are not caught on hooks. However, most fishers in Khong use a wide variety of fishing gears and methods, based mainly on seasonal appropriateness and habitat diversity, and therefore have a considerable amount of LEK about a broad range of species and habitats. The diversity of fisheries that individual fishers engage in certainly helps ensure a generally high level of LEK amongst individual fishers.

Local fishers, even ones with vast amounts of LEK, are generally very eager to learn more, and are quite receptive to integrating new information into their LEK, provided that the source of new information is credible, and the information makes sense in the context of the LEK already in the possession of the fishers. In fact, often the fishers with the most LEK are the ones the most interested in learning more. That is how they got to know so much: by being inquisitive. Therefore, it is possible for scientists, government officials and NGO workers to contribute to and help build on LEK so that fishers responsible for managing fisheries can make better decisions. This is not to say that many fishers are not already making good decisions, but management is rarely perfect. The most enduring management systems are ones that can adapt to changing environmental, political and social conditions. Since LEK is often very locally relevant, while lacking a broad and regional perspective, it is often useful for outsiders to provide information of this nature to local fishers, as a way of helping to improve local fisheries management decisions. In this way, the LCFDPP and later the EPCDSWP have helped to support the CBFC programme in Khong. However, it is important to remember that fishers are unlikely to accept information from outsiders unless they respect the outsiders. Outsiders should make strong effort to learn from the fishers, so that they know what the fishers know, how they make use of their knowledge, and how they communicate LEK between themselves. This helps them to know what new information can be communicated in context with already accepted LEK (Baird *et al.* 1999b).

Another important way in which the LCFDPP and the EPCDSWP have helped to strengthen LEK and thus local fisheries management in Khong, has been by facilitating the exchange of LEK both within and between communities. Since fishers do not always know the same things, this type of activity has proven very useful, and it is usually very easy for fishers to accept information provided by other fishers who are in similar socio-economic and cultural situations, and speak the same language. In Khong, many of the regulations chosen by communities were adopted after other communities first implemented them. This can be clearly seen, as villages that entered the CBFC programme in Khong early on generally have much fewer regulations than those that entered later. The relative homogeneity of communities in Khong makes this process of information exchange relatively easy. Thus, the programme has evolved based on the dissemination and strengthening of LEK (Baird 1999b; Baird *et al.* 1999b).

"Peer review" is an aspect of the CBFC programme in Khong that relates to LEK, and it is of critical importance to ensuring the relevance of regulations. Since almost all villagers in Khong are also fishers (Baird *et al.* 1998b), LEK about fisheries is widespread in the villages in Khong. Therefore, during community consultations about regulations, it is difficult for anyone in the community to suggest regulations that do not make ecological sense, because others in the community are likely to quickly realise the deficiencies of such regulations based on their LEK, and object. Peer review is not just for academics, and the peer review process in the communities in Khong has helped to ensure high quality regulations (Baird 1999b; Baird *et al.* 1999b).

It is significant that most of the government officials responsible for fisheries management in Khong are of the same ethnic group as the fishers themselves, and most originate from rural villages in Khong. Therefore, the officials and the fishers have similar backgrounds, and hold the same LEK about fisheries. This is

important, as it is generally easy for the fishers and local officials to understand each other, and officials can easily relate to the regulations that communities adopt (Baird 1999b).

One of the important reasons why CBFC has been successful in Khong is because the villagers have a strong sense of belonging to their communities, and a strong sense that their children and grandchildren will be living in the same villages in the future. This has helped to encourage a conservation ethic, and to ensure that many locals manage resources for the long-term and not just for the moment. A long-term sense of belonging often leads to good community-based resource management (Baird 1999b; Pomeroy 1998; Ostrom 1990).

ADAPTIVE MANAGEMENT AND LEK

Adaptive management is critical for successful natural resource management, especially over the long-term (Walters 1986). When fishers are involved in making management decisions, as they are in Khong, strengthening LEK is a critical part of supporting the adaptive management process. Adaptive management requires making management decisions; implementing them; monitoring and analysing the results of implementation; and then altering management decisions based on the results, gradually improving and adjusting them over time. This is commonly done by locals involved in the management of all kinds of natural resources, and is common in relation to fisheries management in Khong (Baird 1999b).

With regard to FCZs, it is been found that fishers monitor the success of FCZs in various ways, some of which are based on specific observations of natural processes. While observations regarding changes in fish species and quantities of fish caught are certainly very important, other tools for understanding FCZ success are more difficult for outsiders to understand. For example, fishers monitor the populations of some algae eating fish species like *Mekongina erythrospila (pa sa-i* in Lao*)*, *Morulius* spp. *(pa phia* in Lao*)*, and *Labeo erythopterus (pa va souang* in Lao*)* by observing shallow rocky areas adjacent to FCZs. If the rocks are covered with algae, they know that there are few algae eating fish in the adjacent FCZ. On the other hand, when the fish graze on the algae on the rocks, they can see what species have fed there, since the width of the grazing lines differ according to the species involved, and the sizes of individual fish. This method of observing fish populations is unknown within the scientific community (Baird *et al.* 1999b).

Another innovative and little known method of monitoring fish in FCZs by Khong people relates to fish rising to the surface of the water for oxygen, or other purposes. This is especially common during the height of the hot season, when water levels are at their lowest, and fish tend to concentrate the most in deep-water areas. Villagers have a considerable amount of LEK about what fish species rise up to the surface at what times of the day, and where, although this LEK is not understand by scientists. Villagers also exhibit a considerable amount of skill regarding their abilities to recognise those fish that rise to the surface, even though the non-experienced eye is unlikely to be able to identify them (Baird *et al.* 1999b).

Local people also monitor populations of the smallscale croaker *Boesemania microlepis (pa kouang* in Lao), which are important beneficiaries of certain deep-water FCZs in Khong. During their spawning season in the dry season, they make a loud croaking sound that is audible even out of the water. Local people gauge the amount of croaking that occurs each year, and in that way they have a sense whether populations are increasing or declining (Baird *et al.* 2001b; Baird *et al.* 1999b).

In Khong the EPCDSWP has helped to develop a more formalised data collection programme to monitor the results of management decisions related to the establishment of FCZs. This has been done to help communities improve their management strategies, but also to provide government agencies with quantitative data useful for assessing the value of FCZs (Baird *et al.* 1999b; Baird 1999b).

Initially, eight villages in Khong participated in the programme. In each village, locals themselves developed hypotheses regarding what fish species had already benefited from FCZs based on past observations. Once it had been determined what species locals believed had benefited from specific FCZs, each of which protects different micro-habitats of importance to different species, the communities determined what fisheries should be monitored to illustrate whether those species had really benefited or not. Then between five and twenty fishers were selected by the villagers to collect data regarding their daily fish catches in the selected fisheries, and the data were recorded in basic note books. After months of data collection, the data from different individuals

was pooled and statistically analysed. Although not all the data was correctly recorded, most of the data were useable in the analysis. The data were then returned to the villagers to be reviewed and verified. It was found that the villagers were able to add a considerable amount of context and depth to the data, and the data were often altered due to this verification process. The data verification process acted as an important tool for helping the fishers to understand how effective management strategies have been for specific fish species, although there is still much more to learn (Baird *et al.* 1999b; Baird 1999b).

The data were also used to test the knowledge of the fishers regarding their understanding of the catch structure of particular fisheries. It was found that in Khong, most fishers were able to list the top ten species of fish caught in fisheries based on total weight quite reliably, thus showing their deep understanding of the fisheries (Baird *et al.* 1999b; Baird 1999b).

The process of adaptive management in Khong has also been strengthened through various other activities at the community level, the most important being periodic village meetings to review regulations informally amongst community members and discuss ways to improve regulations and their implementation (Baird 1999b; Baird *et al.* 1999b).

CONCLUSION

In cases where fishers are given a high level of authority over making management decisions, as is the case in Khong District, it is important to make maximum use of LEK to improve fisheries management, and in this context, it is often useful to disseminate and strengthen LEK in various ways.

However, the situation may not always be as straightforward as it may appear to be in Khong, especially when one is dealing with less ethnically and socially homogenous communities. But, even when less homogenous communities are the focus, CBFM may be the most viable option for improving management, especially when one considers small-scale fisheries with few scientific data situated in remote areas. The critical importance of LEK should be recognised, and has considerable potential for strengthening the local management of living aquatic resources.

REFERENCES

AIT Aqua Outreach - Lao PDR [AIT] 1997. Participatory evaluation workshop of the LCFDPP, Unpublished report, Savannakhet, Lao PDR, 7 pp.

Ali, A.B. 1996. Community-based management in inland fisheries: case studies from two Malaysian fishing communities, In: Cowx, I.G (ed.), Stock Assessment in Inland Fisheries, pp. 482-493, Fishing News Books, London.

Altobelli, A, G. Daconto, E. Feoli, J.F. Maxwell, C. Milesi and E. Rui 1998. Environmental Assessment of Siphandone Wetland. Unpublished interim report prepared for the Environmental Protection and Community Development in Siphandone Wetland Project, CESVI, Pakse, Lao PDR, 43 pp.+

Ahmed, M., H. Navy, L. Vuthy and M. Tiongco 1998. Socioeconomic Assessment of Freshwater Capture Fisheries in Cambodia: Report on a Household Survey. Mekong River Commission, Phnom Penh, Cambodia, 186 pp.

Baird I.G. 1994. Preliminary Investigations of the Nam Mang, Nam Leuk and Nam Gnang Aquatic Ecosystems in and around the Phou Khao Khouay Protected Area; and a Review of Downstream Impacts of the Nam Leuk Hydropower Development Project and the Nam Mang No. 3 Multipurpose Project in Bolikhamsay Province, Lao PDR. Unpublished report to CPAWM, Department of Forestry, Vientiane, Lao PDR.

Baird I.G. 1995a. Investigations of the Xe Kaman and Xe Xou Rivers, with special reference to freshwater fish and river ecology; and a review of the potential social and environmental impacts of large dam projects being considered for these two rivers in Attapeu Province, southern Lao PDR. Unpublished report to CPAWM, Department of Forestry, Vientiane, Lao PDR.

Baird I.G. 1995b. A rapid study of fish and fisheries; and livelihoods and natural resources along the Sesan River, Ratanakiri, Cambodia. Livelihoods and Natural Resource Study, Oxfam (UK and Ireland) and Novib, Ratanakiri, 54 pp.

Baird I.G. 1997. A Preliminary Assessment of the Aquatic Resources of the Xe Piane National Biodiversity Conservation Area, Southern Lao PDR, BIORAP report submitted to the World Wide Fund for Nature (WWF) Thailand Project Office, Pakse, Lao PDR, 37 pp.

Baird I.G. 1998a. A Preliminary Assessment of Aquatic Resources, including Fish and Fisheries, in Dong Phou Vieng National Biodiversity Conservation Area and its Expansion Area, Savannakhet Province, Lao PDR. BIORAP report submitted to the World Wide Fund for Nature (WWF) Thailand Project Office, Pakse, Lao PDR.

Baird I.G. 1998b. A Preliminary Assessment of Aquatic Resources, with a Special Emphasis on Fish and Fisheries, in and adjacent to the Khammouane Limestone National Biodiversity Conservation Area, Khammouane Province, Lao PDR. BIORAP report submitted to the World Wide Fund for Nature (WWF) Thailand Project Office, Pakse, Lao PDR, 34 pp.

Baird I.G. 1999a. Fishing for sustainability in the Mekong Basin. Watershed. 4(3): 54-56.

Baird I.G. 1999b. The Co-Management of Mekong River Inland Aquatic Resources in Southern Lao PDR. Paper presented at the International Workshop on Co-Management, 23-28 August 1999, Penang, Malaysia, 43 pp.

Baird I.G. 2000. Aquatic Biodiversity in the Siphandone Wetlands. Technical Report. Environmental Protection and Community Development in Siphandone Wetland Project, CESVI, Pakse, Lao PDR, 24 pp.

Baird I.G. 2001. A Catchment Approach to Small-Scale Irrigation Schemes in Lao PDR. Watershed, 6(3): 36-41.

Baird I.G. and M.S. Flaherty 1999. Fish Conservation Zones and Indigenous Ecological Knowledge in Southern Laos: A First Step in Monitoring and Assessing Effectiveness.

Technical Report. Environmental Protection and Community Development in Siphandone Wetland Project, CESVI Cooperation and Development, Pakse, Lao PDR.

Baird I.G. and B. Phylavanh 1998. A Preliminary Survey of Aquatic Resources, with a special emphasis on Freshwater Fish and Fisheries, in the Xe Lampho River Basin (Dong Kanthoung proposed NBCA) in Mounlapamok District, Champasak Province, Southern Lao PDR. Technical Report. Environmental Protection and Community Development in Siphandone Wetland Project, CESVI, Pakse, Lao PDR.

Baird I.G. and B. Phylavanh 1999. Fishes and Forests: Fish foods and the Importance of Seasonally Flooded Riverine Habitats for Mekong River Fish. Technical Report. Environmental Protection and Community Development in Siphandone Wetland Project, CESVI Cooperation and Development, Pakse, Lao PDR, 46 pp.

Baird I.G. and V. Sok 2001 (In Press). A Rapid Survey of the Fish and Fisheries of Veal Veng and Adjacent Rivers. Fauna and Flora International, Phnom Penh, Cambodia.

Baird I.G., P. Kisouvannalath, V. Inthaphaisy, and B. Phylavanh 1998a. The Potential for Ecological Classification as a Tool for Establishing and Monitoring Fish Conservation Zones in the Mekong River. Technical Report. Environmental Protection and Community Development in Siphandone Wetland Project, CESVI Cooperation and Development, Pakse, Lao PDR, 28 pp.

Baird I.G., V. Inthaphaisy, B. Phylaivanh and P. Kisouvannalat 1998b. A Rapid Fisheries Survey in Khong District, Champasak Province, Southern Lao PDR. Technical Report. Environmental Protection and Community Development in Siphandone Wetland Project, CESVI, Pakse, Lao PDR, 31 pp.

Baird I.G., V. Inthaphaisy, P. Kisouvannalath, B. Phylavanh and B. Mounsouphom 1999a. The Fishes of Southern Lao (In Lao). Lao Community Fisheries and Dolphin Protection Project, Ministry of Agriculture and Forestry, Pakse, Lao PDR, 162 pp.

Baird I.G., V. Inthaphaisy, P. Kisouvannalth, B. Vongsenesouk and B. Phylavanh, 1999b. The Setting Up and the Initial Results of a Villager Based System for Monitoring Fish Conservation Zones in the Mekong River, Khong District, Champasak Province, Southern Lao PDR. Technical Report. Environmental Protection and Community Development in Siphandone Wetland Project, CESVI Cooperation and Development, Pakse, Lao PDR, 39 pp.+

Baird I.G., M.S. Flaherty and B. Phylavanh 2000. Rhythms of the River: Lunar Phases and Small Cyprinids Migrations in the Mekong River. Technical Report. Environmental Protection and Community Development in Siphandone Wetland Project, CESVI, Pakse, Lao PDR, 23 pp +.

Baird I.G., Z. Hogan, B. Phylaivanh and P. Moyle 2001a. A Communal Fishery for Migratory Catfish *Pangasius macronema* in the Mekong River. Asian Fisheries Science, 14 (2001): 25-41.

Baird I.G., B. Phylavanh, B. Vongsenesouk and K. Xaiyamanivong 2001b (In Press). The Ecology and Conservation of the Smallscale Croaker *Boesemania microlepis* (Bleeker 1858-59) in the Mainstream Mekong River, Southern Laos. Natural History of the Natural History Bulletin.

Baran, E., N. van Zalinge and Ngor Peng Bun 2001. Floods, floodplains and fish production in the Mekong basin: present and past trends. Contribution to the Asian Wetlands Symposium 2001, 27-30 August 2001, Penang, Malaysia.

Berkes, F. and M. Kislalioglu 1993. Community-based management and sustainable development. In: FAO/Japan Expert Consultation on the Development of Community-Based Coastal Fishery Management Systems for Asia and the Pacific, pp.619-624, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

Berkes, F., P. George and R. Preston. 1991. Co-management: The evolution in the theory and practice of the joint administration of living resources. Alternatives. 18 (2).

Beverton, R.J.H. 1992. Fish Resources: threats and protection. Netherlands Journal of Zoology. 42: 139-175.

CESVI 1998. First Year Term Report, Environmental Protection and Community Development in Siphandone Wetland Project. Agriculture and Forestry Division of Champasak Province, Pakse, Lao PDR.

Chomchanta, P., P. Vongphasouk, S. Chanrya, C. Soulignavong, BV. Saadsy and T.J. Warren 2000. A preliminary assessment of Mekong Fishery Conservation Zones in the Siphandone area of Southern Lao PDR, and recommendations for further evaluation and monitoring. Final Report. Unpublished report prepared for The Living Aquatic Resources and Research Centre (LARReC), Vientiane, Lao PDR, 32 pp.

Christy, F. 1993. A Re-evaluation of approaches to fisheries development: The special characteristics of fisheries and the need for management. In: FAO/Japan Expert Consultation on the Development of Community-Based Coastal Fishery Management Systems for Asia and the Pacific, pp.597-608, Food and Agriculture Organisation of the United Nations (FAO), Rome, Italy.

Claridge, G. (compiler) 1996. An Inventory of Wetlands of the Lao PDR. Wetlands Programme, IUCN – the World Conservation Union, Vientiane, Lao PDR.

Claridge, G.F., T. Sorangkhoun, and I.G. Baird 1997. Community Fisheries in Lao PDR: A Survey of Techniques and Issues. IUCN - The World Conservation Union, Vientiane, Lao PDR.

Clay, P. and McGoodwin, J. 1995. Utilizing social sciences in fisheries management. Aquatic Living Resources. 8 (3): 203-207.

Cowx, I. 1991. Catch effort sampling strategies: conclusions and recommendations for management. In: Cowx, I.G. (ed.), Catch Effort Sampling Strategies: Their Application in Freshwater Fisheries Management, pp. 404-413, Fishing New Books, London.

Cunningham, P. 1998. Extending a Co-management Network to Save the Mekong's Giants. Mekong Fish Catch and Culture. 3(3): 6-7.

Fisheries Office, Ratanakiri Province and the Non-Timber Forest Products (NTFP) Project, Ratanakiri Province 2000. A Study of the Downstream Impacts of the Yali Falls Dam in Ratanakiri Province, Northeast Cambodia. Ban Lung, Ratanakiri, Cambodia, 43 pp. +

Food and Agriculture Organisation of the United Nations (FAO). 1999. Fishery Country Profiles. FAO, Rome, Italy.

Ghee, L. 1990. Conflict over natural resources in Malaysia: The struggle of small-scale fishermen. In: Ghee, L. and M. Valencia (eds.), Conflict Over Natural Resources in South-East Asia and the Pacific, pp. 145-181, Oxford University Press, Singapore.

Hill, M.T. and S.A. Hill 1994. Fisheries ecology and hydropower in the Mekong River: An evaluation of run-of-the-river projects, Mekong Secretariat, Bangkok, 106 pp.

Hirsch, P. and P. Noraseng 1999. Co-management of fisheries in diverse aqua-ecosystems of southern Laos. Paper presented at the International Workshop of Fisheries Co-Management, Penang, Malaysia, 23-28 August 1999, Pakse, Lao PDR, 30 pp.

Hogan, Z. 1997. Aquatic conservation zones: Community management of rivers and fisheries. Watershed. 3(2): 29-33.

Hubbel, D. 1999. Food for the people: Natural fisheries of the Mekong River. Watershed. 4 (3): 22-36.

International Rivers Network [IRN] 1999. Power Struggle. The Impacts of Hydro-Development in Laos. Berkeley, CA, 68 pp.

IIRR. 1996. Recording and using indigenous knowledge: A manual. International Institute of Rural Reconstruction, Silang, Cavite, Philippines.

Jentoft, S., B.J. McCay and D.C. Wilson 1998. Social theory and fisheries co-management, Marine Policy. 22(4-5): 423-436.
Johannes, R. E. 1981. Words of the Lagoon: Fishing and Marine Lore in the Palau District of Micronesia. University of California Press, CA.
Johannes, R.E. 1998. Dataless Management. Trends in Ecology and Evolution. 13(6): 243-246.
Johannes, R.E. 2001. The Need for a Centre for the Study of Indigenous Fishers Knowledge. Contribution to Wise Coastal Practices for Sustainable Human Development.
Johnson, C. 1998. Beyond community rights: Small-scale fisheries and community-based management in southern Thailand. TDRI Quarterly Review. 13(2): 25-31.
Kottelat, M. and T. Whitten 1996. Freshwater biodiversity in Asia with special reference to fish. World Bank Technical Paper. No. 343, The World Bank, Washington D.C., 59 pp.
Kuperan, K. and N.M.R. Abdullah 1994. Small-scale coastal fisheries co-management, Marine Policy. 18(4): 306-313.
Lieng, S., C. Yim and N.P. van Zalinge 1995. Fisheries of the Tonlesap River Cambodia, I: The Bagnet (Dai) Fishery. Asian Fisheries Science. 8(1995): 258-265.
Masae, A., A. Nissapa, and S. Boromthanarat 1999. An Analysis of Co-Management Arrangements: A Case of Fishing Community in Southern Thailand. Paper presented at the International Workshop on Fisheries Co-Management, Penang, Malaysia, 23-28 August 1999, CORIN and ICLARM, Songkhla, Thailand, 84 pp.
McCay, B.J. and S. Jentoft 1996. From the Bottom Up: Participatory Issues in Fisheries Management. Society & Natural Resources.
Ostrom, E. 1990. Governing the Commons: The evolution of institutions for collective action. Cambridge University Press, Cambridge, U.K.
Pomeroy, R.S. 1998. Fisheries Co-Management and Community-Based Management: Lessons Drawn from Asian Experiences, Paper presented at Crossing Boundaries, Seventh Conference of the International Association for the Study of Common Property, 10-14 June 1998, Burnaby, Canada.
Pomeroy, R.S. and M.B. Carlos 1997. Community-based coastal resource management in the Philippines: a review and evaluation of programs and projects, 1984-1994. Marine Policy. 21(5): 445-464.
Poulsen, A.F. and J.V. Joergensen (editors) 2000. Fish Migrations and spawning habits in the Mekong Mainstream – a survey using local knowledge. AMFC Technical Report. Mekong River Commission.
Rainboth, W.J. 1996. Field Guide to the Fishes of the Cambodian Mekong. Food and Agriculture Organisation of the United Nations, Rome, 1-265 + plates.
Roberts, T.R. 1993a. Environmental impact assessment: the EIA on EIA. Asian Soc. Environ. Prot. Newsl. 9(3): 1-3, 10.
Roberts, T.R 1993b. Just Another Dammed River? Negative Impacts of Pak Mun dam on Fishes of the Mekong Basin. Natural History Bulletin of the Siam Society. 41: 105-133.
Roberts, T.R. 1993c. Artisinal fisheries and fish ecology below the great waterfalls of the Mekong River in Southern Laos. Natural History Bulletin of the Siam Society. 41(1): 31-62.
Roberts, T.R. and Baird I.G 1995a. Traditional fisheries and fish ecology on the Mekong river at Khone waterfalls in southern Laos. Natural History Bulletin of the Siam Society. 43: 219-262.
Roberts, T.R. and I.G. Baird 1995b. Rapid Assessment of Fish and Fisheries for the Xe Nam Noy-Xe Pian Hydroscheme in Southern Lao PDR. Unpublished report for the Wildlife Conservation Society, Vientiane, Lao PDR.
Roberts, T. and Warren, T. 1994. Observations on fishes and fisheries in southern Laos and northeastern Cambodia, October 1993-February 1994. Natural Historical Bulletin of the Siam Society. 42: 87-115.
Simonitsch, M. and H. Glaesel 2001. Increasing Authentic Participation in Marine Fisheries Problem Solving. Paper presented at the conference, Putting Fishers' Knowledge to Work, 27-30 August 2001, UBC Fisheries Centre, University of British Columbia, Vancouver, Canada.
Van Zalinge, N.P., T. Nao, T.S. Touch, and L. Deap 2000. Where there is water, there is fish? Cambodian fisheries issues in a Mekong River Basin perspective. Common Property in the Mekong: Issues of Sustainability and Subsistence. ICLARM Studies and Reviews. 26: 37-48.
Walters, C. 1986. Adaptive Management of Renewable Resources. MacMillan Publishing Company, New York, USA.
Warren, T.J., G.C. Chapman and D. Singhanouvong 1998. The Upstream Dry-Season Migrations of Some Important Fish Species in the Lower Mekong River in Laos. Asian Fisheries Science. 11(1998): 239-251.

Questions

Eduardo Espinoza: Do you have any idea of the level of immigration in the fishers' communities?

Ian Baird: There are issues of upstream and downstream development that affect the Mekong. It may not be sustainable forever, but it's a good start.

Paul Fanning: In your talk, you left out two things namely how they identify their goals, and how they enforce or sanction the community when rules are broken.

Ian Baird: In the past, the fisheries had already declined quite a bit, so the people were already quite concerned about future decline. The big issue was increasing the amount of fish, bringing back fish that had disappeared, and resolving some conflict with other communities. In answer to your second question, the government had power over local people in Laos. People didn't have much management to begin with so they didn't have much to lose. Here in BC, so much is invested in the bureaucracy that no one wanted to lose it, so change is more difficult.

Paul Fanning: But what are the local sanctions?

Ian Baird: There are lots of meetings and discussions. We started the project by getting the locals to have meetings by themselves for two or three months, then we came in to talk to them and gave them questions to answer. Their agenda was already set before we arrived. Outside communities were consulted regarding any policy changes and if no one objected, it became village law. The village had power to confiscate gear, keep people out of there, and to manage the area. If it gets too much for them to handle, they can call in the municipal government for assistance.

APPENDIX 1

SOME COMMENTS ON CONDUCTING RAPID ASSESSMENTS OF FISH AND FISHERIES BASED ON LOCAL ECOLOGICAL KNOWLEDGE

As indicated in the main text above, local people living in the Mekong River Basin in southern Laos clearly hold a large amount of LEK about living aquatic resources, including finfish. At the same time, scientific information related to fish and fisheries is generally very limited. Therefore, it makes perfect sense to try to tap the rich LEK of fishers to improve the management of natural aquatic resources.

However, methodologies for collecting and analysing information based on LEK need to be developed and improved, as poor quality data have sometimes been generated in the region, along with good quality data. Essentially, the quality of data has generally been inconsistent.

Neither social nor natural scientists have all the answers. On the one hand, social scientists often lack sufficient understanding about biology and ecology related issues. However, natural scientists often lack knowledge about good interviewing methods or participatory approaches for working with local people. In reality, the skills of both social and natural scientists are necessary for getting good quality data, and for supporting the management of natural resources (Johannes 2001; Allut *et al.* this vol).

Interviewers need to have at least a basic understanding of the habitats, species and harvesting methods that they discuss with local people, and preferably much more than that (Johannes 1981). To illustrate this point, imagine that you are an electrical engineer with detailed understanding of various technical processes. Then imagine being interviewed by someone who knows nothing about electrical engineering. How would you, as an electrical engineer, respond to general questions about electrical engineering from a person who obviously does not understand electrical engineering? You would probably give simple and non-technical answers. You would certainly not provide many details, as you would know that details would go right over the interviewers' head. You might not even be that concerned with the exact technical accuracy of your responses, since you would know that the interviewer would not know enough to see any faults in the answer anyway. It certainly would not be worth your time to put much thought into your responses. And, if you decided to provide some technical details, your interviewer would be at great risk of either misinterpreting the details, or incorrectly recording them, since they would not really understand the context of the information they were receiving.

The above scenario is not so different than the situations researchers who interview local fishers are often faced with, although they are often burdened with additional cultural and language obstacles to good communication as well. Should anyone be surprised that the data collected on the LEK of fishers are often incomplete and incorrect? However, more often than not, researchers with inadequate interview methods blame locals for data that are later found to be inaccurate, rather than viewing their own deficiencies in collecting the data.

It is important for interviewers not only to understand the resources that they are interviewing local people about, but also to ensure that those being interviewed are aware of the knowledge that the interviewers possess. It is often best to try to let the interviewees know about the interviewers' knowledge during informal discussions before beginning structured interviews, but this may not always be possible for various reasons. Early on in interviews, it may, therefore, sometimes be necessary for interviewers to point out obviously inaccurate statements made by overly eager or unthinking interviewees who may be too quick to respond to questions, due to their lack of confidence in the abilities of the researchers, or because they do not think that the interview is important. Pointing out inaccuracies may embarrass interviewees, but if the mistakes are pointed out politely, and are recognised by fishers as mistakes once pointed out, it should make interviewees more serious about ensuring that their responses are well thought out and reasoned, and it will help the fishers to respect the researchers more. The author has used this technique successfully in Laos, but using it too much, or in an impolite or arrogant way is unlikely to be useful. It is generally only good to use this technique once at the beginning of some interviews, and only to make the point that the interviews should be taken seriously.

In recent years, the author has conducted a number of rapid fish and fisheries assessments, including biodiversity assessments, in central and southern Laos, and parts of Cambodia (see, for example, Baird 1994; Baird 1995a & b; Roberts and Baird 1995b; Baird 1997; Baird 1998a & b; Baird and Phylavanh, 1998; Baird *et al.* 1998b; Baird *et al.* 1999a; Baird and Sok, 2001). Various techniques and tools were employed for conducting these surveys, as it certainly makes sense to take advantage of all the useful tools available to researchers, especially in areas where little is known about biodiversity, and the learning curve is high. It is important not to be overly reliant in any one tool for conducting fieldwork of this nature.

The use of various methods to help verify the validity of data collected is called "triangulation", and the methodology that is used by the author is highly oriented in this way. When conducting field studies, five main tools are used, each being complementary to the others. They fall into both the natural and the social sciences, and involve both quantitative and qualitative methods. They include:

1) Conducting a background literature review in advance of fieldwork, looking into both peer reviewed and "gray literature". It is obviously important to know what has already been

documented about the biodiversity of an area before it is surveyed, in order to avoid having to "re-invent the wheel," as well as to know what information is still lacking, and so as to be able to concentrate one's efforts on poorly documented species or areas.

2) Using colour photographs of fish thought to either occur in the area, or occur in nearby areas, is important during interviews with local fishers. There has been considerable debate recently in Mekong countries regarding the usefulness of using photographs of wildlife, including fish, as a tool for identifying species or groups of species while conducting rapid biodiversity assessments. The answer is, "yes", it is worth using photographs, but photographs by themselves are not nearly enough to ensure good and reliable results. Fishers in Laos and other countries in Southeast Asia are often quite capable of identifying colour photos of fish, even if they are from remote areas where photos of fish have never been seen. However, there are also sometimes problems with fishers identifying fish from photos due to limitations related to changes in the scale and colour of fish, and of course, photos are only two dimensional, and do not reflect the context in which the fishes are obtained or viewed. Moreover, some groups of fish are more difficult to identify than others, and locally relevant identifying characteristics may not all be shown in photographs. Rare species that are not often seen will certainly be more difficult to identify than more commonly encountered species, and people often do not care much about the smallest species (Freire and Pauly this vol). The experience of the investigator is critical in helping to provide clues as to the types of errors that are likely to be common and investigators should be mindful of.

3) Using local names for fish identified in photographs is useful in order to provide an indication of whether fish identified in photos are in fact those that the fishers believe that they have identified. While local names often vary from place to place in Laos, even amongst members of the same ethnic groups, there are patterns of name use that can, nevertheless, help to indicate the accuracy of photograph identification. Again, the experience of the investigator is critical in helping to identify and pick up on common errors. Over time, as local names are recorded in the literature, and the local use of names becomes better understood, the pool of information will make local names increasingly useful for identifying species in particular areas. However, like photographs, names are not enough by themselves. In any case, it is critical to know local names for species, to enable the communication of useful management information to local people and government officials responsible for management, who generally do not know Latin names, especially of rare and unusual species. Many good reports about wildlife have remained unused by local managers due to confusion regarding what local names should be applied for species identified in technical reports without local names.

4) Using species-specific fish behaviour indicators for questioning interviewees, in order to help ensure that fish have been correctly identified, is another important tool for identifying fish, and especially for learning about the behaviours of different species. Combined with photographs and local names, this method can help improve the chances of accurate identification, but if the interviewer / interviewee does not understand the resource well, he or she will not be able to use this tool very effectively. This is because the researcher may not know the species well enough to ask specific questions about their behaviour, or understand the relevance of responses.

5) Finally, specimen collection remains a useful method for verifying fish species identified during interviews. The first four steps outlined above can help lay the groundwork for this, helping researchers target species worthy of particular attention. Specimen collection is done either by asking local people to help catch fish, or by the researcher collecting fish specimens, either alone or with colleagues. Specimens are generally photographed, and some are preserved in formalin and water solution for more detailed taxonomic investigations. This more standard research activity is important to confirm identifications, but again, it is not enough by itself for understanding the resource, as it does not provide contextual information about the species' behaviour, use or management by local people. Specimens also do not provide social information related to fisheries, or historical perspectives important for understanding changes in population structure and local utilisation patterns.

Hundreds of interviews with Lao fishers in various parts of the country over the years have helped indicate what fish species locals can generally easily identify, and what species they cannot. For example, it is virtually impossible to get reliable identification, local names and behavioural information about the smallest fish species, such as loaches in the genus *Schistura*. Therefore, the author rarely spends much time trying to collect such information during interviews. All the limitations must be recognised, and interview methods should only be used when there is a reasonable chance of getting useful information. Otherwise, one is simply collecting suspect data. One major problem is that many researchers are not aware of the limitations of interviews, or of other methods, or if they are aware, they may simply "throw out the baby with the bathwater". Extreme positions for or against interview methods are equally dangerous.

When conducting interviews with local people, the author prefers to interview between three and five fishers in small groups, instead of conducting individual interviews or large group interviews. Small groups help to ensure that there is "peer review" amongst the fishers before any information is provided, but avoids problems related to too many respondents during large group interviews. However, it is important for the interviewer to facilitate small group interviews well, in order to ensure that single individuals within the group do not dominate other members of the group. Fishers between 40 and 55

years old are generally the best to interview, because they have considerable experience by that age, yet are still active as fishers, thus avoiding having to test the more distant memories of older fishers who have largely stopped fishing.

Unfortunately, the validation of data in cooperation with local fishers is rarely done in the region, sometimes leading to the use of poor quality data. Data collected by local people should be brought back to local people for verification before its publication whenever possible. For example, before publishing the book on the Fishes of Southern Laos, Baird *et al.* (1999a) brought the data collected back to some local people for verification. However, full local data validation may not always be possible for various reasons.

Finally, it is emphasised that conducting surveys using the above tools is only fully possible when one has a reasonable command of the local language, as the author does in terms of the Lao language. One's ability to speak the language of those interviewed is critical for ensuring good communication with fishers.

Sciaenid Aggregations in Northern Australia: an Example of Successful Outcomes Through Collaborative Research.

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Abstract

Aggregations of the Sciaenid, Black Jewfish (*Protonibea diacanthus*), off Muttee Head in far northern Cape York Peninsula (CYP), have been exploited by Indigenous subsistence fishers for over fifty years. The apparent recent increase in effort targeting *P. diacanthus* in CYP's Northern Peninsula Area (NPA), has prompted concerns for the Injinoo Aboriginal Community, which has custodial responsibilities for that stock, and for the Queensland Fisheries Service, who must provide for managing fisheries in Queensland on a sustainable basis.

The tendency of *P. diacanthus* to aggregate annually in large numbers at well defined times and locations appears to facilitate the harvest of the species. In 1999, 96% of the recorded catch of this fish in the NPA (3.91 tonnes) occurred between April and August, the period in which historical accounts suggest they aggregate in the area. In 2000, 89% of the recorded catch (4.46 tonnes) occurred between May and September. Catches in 1999 and 2000 commonly exceeded 50 *P. diacanthus* per boat, with CPUE peaking at 224.5 kg boat h^{-1}. The relative ease of catching Black Jewfish when aggregating may render them susceptible to over-exploitation.

Based on length-age keys of Bibby and McPherson (1998), the predominant size and age represented in catches from Muttee Head during the aggregation period fell from three year old stock in 1999 to two year old stock in 2000. Historical records reveal that specimens close to the maximum size (>1500 mm TL) were being caught up until 1994. These data support the notion of a rapid change in the NPA Sciaenid resource, and justify concern for the state of the resource given that the fishery was previously based on adult stock.

Sexually mature *P. diacanthus* comprised only a small component (12 fish out of 270 = 4.4%) of the NPA catch examined in a sampling program that was biased towards the largest individuals available. The present study observed a minimum size at first maturity of 790 mm TL for female *P. diacanthus*. This represents a significant departure from the previous observed first length at maturity in Queensland waters of 920 mm TL, reported by McPherson (1997). A mark and release program, analysis of the diet, and examination of the genetic population structure contributed to the findings.

In response to the research findings of the present project, the Injinoo Land Trust (representing the Traditional Land Owner Groups of the Anggamuthi, Atambaya, Gudang and Yadhaykenu Aboriginal people), in cooperation with the Injinoo Community Council, have self-imposed a two-year ban on the taking of Black Jewfish. The area of closure incorporates the inshore waters of the NPA north of the southern boundaries of Crab Island (on the West Coast) and Albany Island (on the East Coast). The aim of the two-year ban is to allow local Black Jewfish stocks to reach a mature size so that prospects for the replenishment of stocks are improved.

With much consultation, this imitative has developed into a regional agreement with comprehensive support across the NPA. Representing each of the communities of the NPA, the Community Councils of Umagico, Bamaga, New Mapoon and Seisia, have undertaken to participate in the two-year ban on the take of *P. diacanthus*. In order to gain legislative backing for this species-specific ban, each of the Indigenous communities have expressed a willingness to forfeit their statutory exemption from the relevant catch restrictions. The implementation of the two-year closure presents new opportunities and obligations for research and management agencies alike to meet highly developed public expectations.

Introduction

Australian fisheries have a history of being managed and monitored in cooperation with commercial and recreational fishing groups, a process which has, until recently, neglected the values intrinsic to indigenous subsistence fishers. The expanding realm of cooperative arrangements is starting to ensure that contemporary environmental management includes cultural values. Although the value of a holistic approach to resource management is increasingly being recognised (see reviews by Alter 1996, White *et al.* 1994), the value of collaborative partnerships in fisheries research has often been ignored.

Collaborative research is based on the inclusion of the users of the fishery, i.e. the fishers themselves, in the process of the study. Such an approach facilitates the incorporation of their knowledge and experiences, and allows a broader assessment of the fishery i.e. integration of cultural and socio-economic values in parallel with environmental factors. As the people who spend the greatest amount of time interacting with marine ecosystems, fishers possess untold knowledge of the environment and its use.

Participative approaches to research not only lead to the more efficient production of results, but may also serve to increase the fishers' ownership of the process and its outcomes. Inclusive programs should increase the resource users' understanding and commitment at all stages, extending from the project's design through to development of management outcomes. This case study provides an example in which both indigenous fishers and scientific researchers have benefited from working together.

The research described in this case study gained tremendously from its participative approach and clearly demonstrates the benefits that may result from collaborative partnerships. Additionally, it is the belief of all project partners that the strong management outcomes which resulted from this research would not have been achieved without this interaction. This paper aims to present an example of the successful outcomes that can be achieved through collaborative research.

Background

This case study focuses on a research project that concluded in 2001 after 2.5 years of close involvement with the Injinoo Aboriginal Community. Injinoo is situated 40 km from the northern-most point of the Australian continent (see Figure 1). The community lies over 1,000 km from the nearest city (Cairns), though there is a number of small indigenous communities nearby. The indigenous communities of Umagico, New Mapoon, Bamaga and Seisia are also located within the Northern Peninsula Area (NPA) of Cape York (north of the twelfth parallel).

The community was founded in the early 1900s, when the remnants of the clans whose customary lands occupy the NPA came together of their own accord to settle on the banks of Cowal Creek (Sharp 1992). The establishment of the community brought together five traditional owner groups: the Atambaya, Wuthathi, Yadhaigana, Gudang, and Anggamuthi. The population of Injinoo is presently less than 400 people (typically less than ten people of which being of non-indigenous descent), while the greater population of the region of the NPA is approaching 2,600.

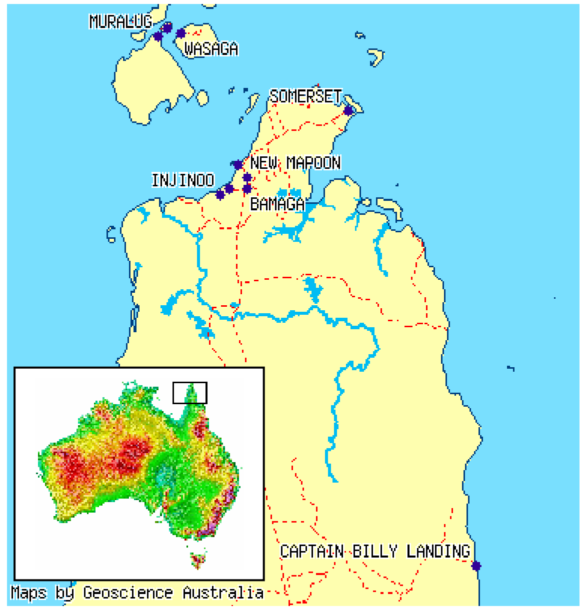

Figure 1: Map of the Northern Peninsula Area (north of the 12th parallel) of Cape York Peninsula, and the adjacent Torres Strait Islands.

The research focused on the biology and harvest of the aggregations of Australia's largest tropical Sciaenid, *Protonibea diacanthus* (see Figure 2). *P. diacanthus* may reach sizes greater than 150 cm in length and can exceed 45 kg in weight (Grant 1999). Aggregations of the fish form annually in the inshore waters of the NPA, and have also been reported at a number of northern Australia locations extending from Central Queensland (Bowtell 1995) to northern Western Australia (Newman 1995).

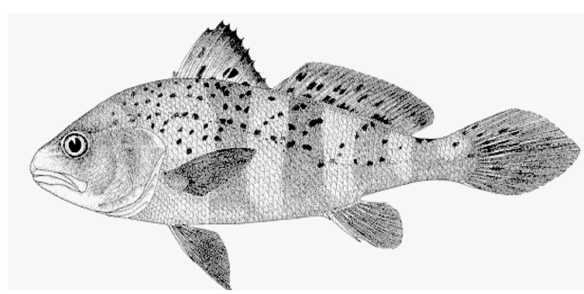

Figure 2. Juvenile *P. diacanthus*. (Source: FOA Fishbase.). Adult specimens do not show the distinct bands and spots on their scales.

Aggregations of fish, be they formed for the purpose of feeding, spawning or migrations, are renowned as vulnerable fishery targets (Johannes *et al.* 1999, Turnbill and Samoilys 1997). The

largest member of the family Sciaenidae, *Totoaba macdonaldi*, is a relevant example. *T. macdonaldi* is considered to be critically endangered and is now listed on the IUCN Red List of Threatened Animals; a consequence of overfishing annual spawning aggregations (True *et al.* 1997).

Finfish of the Family Sciaenidae are widely distributed in tropical and subtropical waters (Sasiska 1996, Trewavas 1977). They commonly dominate epibenthic fish assemblages of near-shore waters of both regions (Rhodes 1998, Blaber *et al.* 1990), and often form the basis of commercial and recreational fisheries throughout the world (Gray and McDonnall 1993).

Catches of *P. diacanthus* form an important component of commercial, recreational and subsistence fisheries in several countries, including Australia (Williams 1997, DeBruin *et al.* 1994, Apparao *et al.* 1992, Mohan 1991). *P. diacanthus* is currently exploited in the NPA by local recreational fishers, and by domestic and international tourist anglers.

Need

One third of Australia's indigenous people currently live within 20 km of the coastline (Australian Bureau of Statistics 2001) (Figure 3). Many of the coastal clans of Australia's Aboriginal nations identify themselves as 'saltwater people', and their traditional estates typically extend beyond the coastal zone into the sea. In general, these coastal people view the sea as a cultural landscape, an extension of, but no different from, land, with similar inherent responsibilities (Tanna 1996).

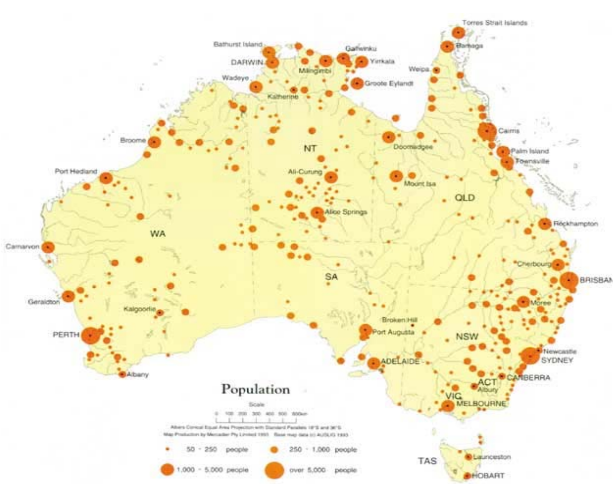

Figure 3. Distribution of Australia's indigenous population. Source: Australian Bureau of Statistics

In Australia, recognition of the importance of 'land' to Aboriginal cultures is a relatively new concept. It is still less than a decade since the Australian High Court decision (*Mabo -v- Queensland, 1992*), which acknowledged the native title rights of indigenous Australians. The legal validity of Aboriginal 'sea estates' is even more recent, having been recognised only in last two years (*Mary Yarmirr & Others -v- the Northern Territory of Australia and Others, 1999*).

Following these High Court decisions, the inherent rights and responsibilities of indigenous people under customary law are now recognised under Australian common law (Crisp and Talbot 1999). As a consequence, the rights of indigenous peoples to their traditional marine resources, and their role in the management of their customary estates, is of increasing relevance to coastal and marine resource administration in Australia.

In all there are about 100 coastal communities, mostly in northern Australia, occupying land under some form of Aboriginal or Islander leasehold or title (Smyth 1993). Indigenous members of these northern communities are largely exempt from Commonwealth and State legislation with regard to the utilisation of marine resources when they are harvested for traditional or subsistence use. However, there is presently a deficiency of datasets on the importance of the contribution of indigenous fish catch to the total annual catch (Tropical Finfish Management Advisory Committee 1998).

While indigenous people currently comprise less than two per cent of Australia's population, this figure is nonetheless growing rapidly. Since 1991 there has been a 45% increase in the number of people who identify themselves as indigenous Australian (Australian Bureau of Statistics 2001). The Aboriginal and Torres Strait Islander population has a much younger age profile than the non-indigenous population (see Figure 4), a reflection in part of higher fertility rates. For example, at Injinoo 49% of the population is less than eighteen years old.

It follows then that in the immediate future there is the potential for a rapid increase in fishing pressure place upon local resources. This appears more evident when one also couples in the improving economic situation among many of Australia's indigenous communities. At Injinoo, for example, there were five powered vessels in the community in 1990, ten years later the number had increased to 42 (at the same time there were 48 houses in the community).

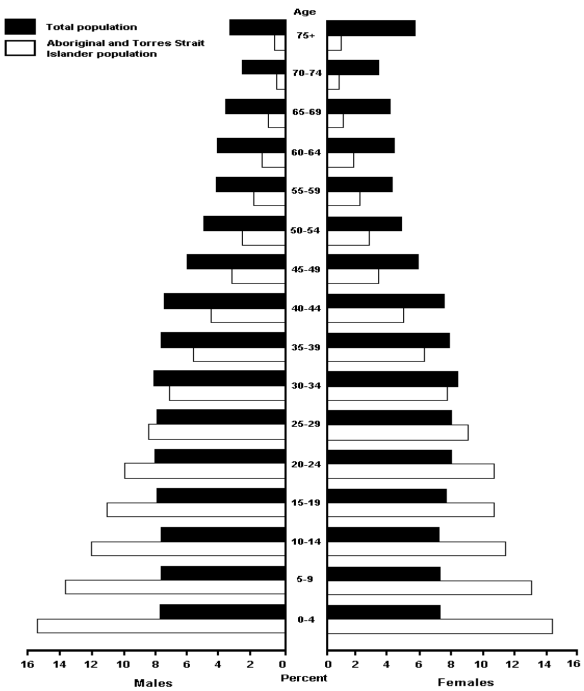

Figure 4. The age structure of Australia's indigenous population and the total population. Source: Australian Bureau of Statistics.

The research project was initiated due to concerns among the area's traditional owners of the impact of the perceived increase in fishing activity targeting aggregations of *P. diacanthus*. Aggregations of *P. diacanthus* that form off Muttee Head (~15 km south-west of Injinoo) have been linefished by indigenous subsistence fishers for over fifty years. The concerns of the traditional owners stem from an apparent rise over the last decade in fishing pressure sustained by the aggregations.

There is an extensive body of evidence derived from fish stocks around the globe that indicates target fishing of aggregations can rapidly undermine fishery production. Chronic effects of aggregation fishing include the truncation of size and age structure (e.g. Beets and Friedlander 1992), deterioration of the stock's reproductive capacity (e.g. Elkland *et al.* 2000), and altered genetic composition (e.g. Smith *et al.* 1991). Acute effects include the total loss of aggregations (e.g. Sadovy 1994).

As an example of the vulnerability of *P. diacanthus*, the once flourishing commercial fishery along the north-west coast of India has become 'non-existent' (James 1992). Anecdotal evidence suggests intensive fishing has also severely impacted several annual aggregations of *P. diacanthus* along the east coast of Queensland (Bowtell 1998, Bowtell 1994). Yet despite this there has remained a dearth of information on the species and the demands made upon those stocks by the various fishery sectors. In particular, the biological purpose and importance of these aggregations has yet to be demonstrated.

Methods

Increasing awareness of the concerns held by the traditional owners led to presentations to the Queensland Department of Primary Industry (the state fisheries research agency) by Balkanu Cape York Development Corporation (an indigenous organisation representing the people of Cape York). Together they successfully sourced funding from the Fisheries Research Development Corporation (the principal fisheries research funding organisation in Australia). It is notable that this was the first time that this Corporation had funded research principally devoted to examining an indigenous fishery.

As far as possible, community members were involved in the design and implementation of the project, as well as the interpretation of results. The act of working together on all aspects of the project greatly enhanced the communities' trust, and hence their willingness to participate (See Rudd, this vol; Kwan, This vol). At all stages the project adhered to the protocols established by Balkanu for conducting research in indigenous environments. These were designed to allow individual communities to participate in scientific research in a manner that community members deemed culturally appropriate.

The continued involvement of local fishers was integral to the success of the project. Not only did they provide critical information on the spatial and temporal scale of the fishery, they also assisted greatly in providing biological samples. Limited employment opportunities were provided by the project, but the vast majority of their contribution was voluntary. It was the common goal of ensuring the sustainability of the resource, which provided for this demonstration of the feasibility of collaboration between indigenous fishers and scientific researchers.

Prior to the commencement of sampling, project staff had made a substantial commitment in time meeting the community residents and promoting the objectives of the project. A key challenge to persuading fishers of the importance of research is that fishers may perceive that the advancement of such knowledge may 'backfire' and ultimately diminish their rights. From feedback generated at later stages, this initial consultation was deemed critical to the success of the project. Although seemingly unproductive in terms of annotated

results, this period was essential to gaining the understanding of community members. Initiatives undertaken to raise the profile of the project within the community included:

- the personal introduction of the project biologist to members of the community by a Balkanu staff member who had previously resided in the community;
- organisation of a drawing competition to create awareness of the project with the younger members of the community; and
- the introduction of the project's objectives and methods in an interview broadcast on the local community radio service, in a public meeting held in the community hall, and with posters displayed throughout the NPA.

There is no doubt at all that the project benefited greatly from the decision for the project biologist to reside in the community during most of the project. Like many other Australian indigenous communities, Injinoo is the focus of numerous studies each year. Researchers in almost all these studies 'fly-in and fly-out', and the community gains little understanding of the study and its findings. However, for the project biologist to reside in the community for such an extended period of time, considerable support was needed from the community, given the limited resources such as accommodation and office facilities.

By residing within the community, the biologist was able to achieve a stronger personal and working relationship with its residents, over time this generated a much greater understanding. This was not only from the perspective of the community's understanding of the research and results, but also of the researcher's understanding of the community. Adopting this method serves to bridge the skills held by biologists and those necessary to understand the ethnobiological information which Johannes (1981) advocates as critical for the integration of contemporary and traditional practices.

From the onset it was immediately clear that the indigenous fishers were not familiar with the methods and tools of western science. For example, while fish tags are very familiar items among recreational and commercial fishers in Australia, the indigenous people of Injinoo had never been exposed to such methods. This increased the importance of community awareness programs and called for slight alterations to some of the methods. The fish tags for example, were simply printed with a prompt alongside the normal contact details, which reminded the fisher to 'record tag number, date, place, and fish length'.

As there was no existing catch data on the fishery, oral accounts of traditional owners and long-term residents were collated in order to develop an historical profile. It is in such circumstances, when access to data is otherwise not available, that oral history proves an invaluable tool in establishing a retrospective analysis of resource use. Nonetheless, the acquisition of such information necessitated the same critical scrutiny that is applied to any other data set. In this investigation, only data verified by more than one source was adopted.

In order to maintain the high level of community ownership of the project, the community was consulted throughout all stages, with the results released as soon as they become final. The project staff liased directly with the community's Council Clerk, who also represented the interests of the community by serving on the project's steering committee. The steering committee was comprised of elected representatives of each of the stakeholder groups linked to the fishery, and guided the progress and direction of the project. The committee also ensured the transmission of the results to all stakeholder groups.

RESULTS

Oral accounts collected during the project provided a record of the fishery since its inception, and presented evidence of changes in the demographics of the fishery, the harvest levels, and stock condition. Very detailed information was available from members of the community, for example, elders were able to recall the very person and year in which *P. diacanthus* were first caught by the traditional owners. The indigenous fishers held a fine understanding of the spatial and temporal attributes of the aggregating behaviour of the fish stock. The seasonal, lunar and tidal patterns had long been common knowledge among fishers, but had never been scientifically documented.

Knowledge of the aggregating behaviour of the fish appears to facilitate the increased harvest of the species. Most of the recorded catch in 1999 (3.9 tonnes) and 2000 (4.5 tonnes) occurred during the aggregation season described by fishers (April to August) (see Figures 5 and 6). In contrast to their normal behaviour, *P. diacanthus* are exceptionally easy to harvest when aggregating. Catches of *P. diacanthus* typically exceeded 50 fish per boat, and catches of over 100 fish are not uncommon. Recorded CPUE ranged up to 250 kg per hour/boat.

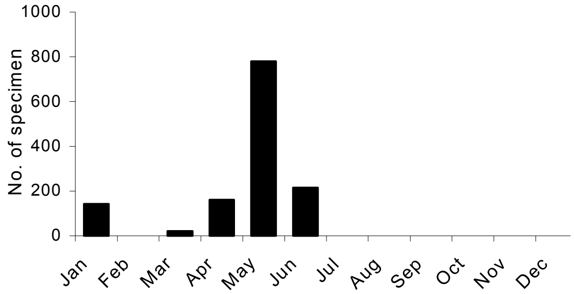

Figure 5. Number of *P. diacanthus* harvested each month of 1999 from the coastal waters and tributaries of the Northern Peninsula Area.

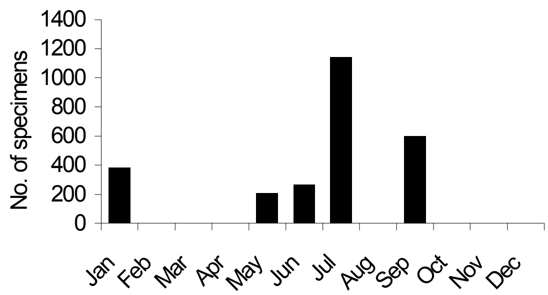

Figure 6. Number of *P. diacanthus* harvested each month of 2000 from the coastal waters and tributaries of the Northern Peninsula Area.

Data from the 4,000 plus fish observed in the catch revealed a decline in average size within the two years of monitoring. Catch records revealed that in 1999 the fishery was dominated by fish in the size range 75-80 cm (believed to be three year old fish), and in 2000, the dominant size class had decreased to 60-65 cm (believed to two year old fish) (see Figures 7, 8 and 9). Oral records reveal that specimens close to their maximum size (>150 cm) were caught up until 1994. These data support the notion of a rapid change within the fish stock, and warrant concern

Sexually mature fish comprised less than 1% of the catch examined in a sampling program biased towards the largest individuals available. This is a serious concern, given that estimates of the critical stock threshold for tropical fish range between 20% and 40% (Turnbill and Samoilys 1997). Among the fish showing evidence of sexual maturity, the development of their gonads coincided with the aggregation season. However, no hydrated or spent gonads were observed, so the exact timing and location of spawning could not be determined. Yet, the indigenous people of the Injinoo do eat the eggs of many marine species and state that ripe eggs were readily available during previous aggregations.
Another concern is a decrease in the age when first maturity was observed among females. From

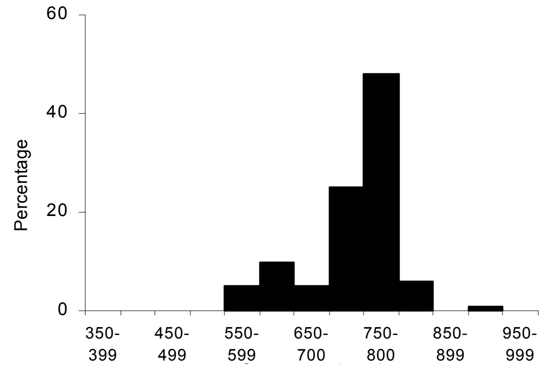

Figure 7. Composition of the size classes of *P. diacanthus* harvested off Muttee Head in 1999.

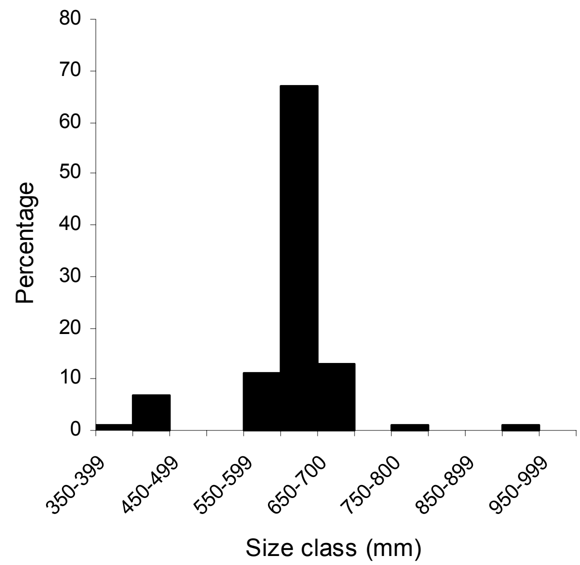

Figure 8. Composition of the size classes of *P. diacanthus* harvested off Muttee Head in 2000.

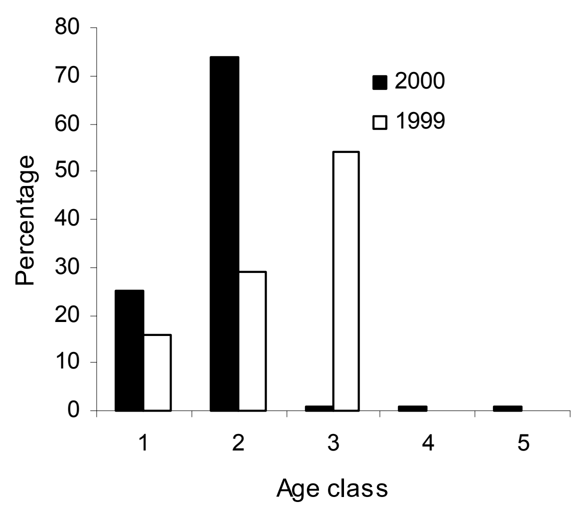

Figure 9. Composition of the age classes of *P. diacanthus* harvested the Northern Peninsula Area in 1999 and 2000.

the adjacent Gulf of Carpentaria waters, first maturity in females occurs at four years of age (McPherson 1997). Four year old fish were not present in the 1999 catch, and amongst the three year olds, no evidence of sexual development was observed in that year. However, in the following year, even though the three year old stock was greatly reduced, some of these displayed evidence of sexual maturity. Whether this was an artefact of increased sampling, or a direct consequence of the sustained fishing pressure, is currently the subject of further investigation.

Food items observed in the analysis of the diet of the fish included a variety of teleosts and invertebrates. The range of animal taxa represented in the prey items support the description of an 'opportunistic predator' attributed to the species by Rao (1963). The limited data gained in this project presented no evidence to support the notion that the seasonal migration of *P. diacanthus* was related to the increased availability of prey items in the inshore waters, as is suggested by Thomas and Kunja (1981). The occurrence and contents of stomach items observed between April and July did not contrast with that observed in the period outside which the aggregations form.

The tag and release component of the present project provided limited data on the movement patterns of *P. diacanthus* in the NPA waters. Tag returns prove that some of the fish remain at, or return to, the aggregation site at least into the following day. The recaptures also revealed the movement of an individual fish between two distinct aggregation sites. This was supported by DNA fingerprinting using the novel Amplified Fragment Length Polymorphisms (AFLP) technique. No significant genetic variation was found between fish sampled from the adjacent aggregation sites. As both sites are fished, their participation in multiple aggregations may increase their susceptibility to capture.

Resultant management outcomes

In response to the research findings, the Injinoo Land Trust (representing the traditional land owner groups of the Anggamuthi, Atambaya, Gudang and Yadhaykenu Aboriginal people), in cooperation with the Injinoo Community Council, have self-imposed a two year ban on the taking of *P. diacanthus*. The area of closure incorporates the inshore waters of the NPA north of the southern boundaries of Crab Island on the west coast and Albany Island on the east coast (see Figure 10). The aim of the two year ban is to allow local stocks of *P. diacanthus* to reach a mature size, thereby improving the reproductive capacity.

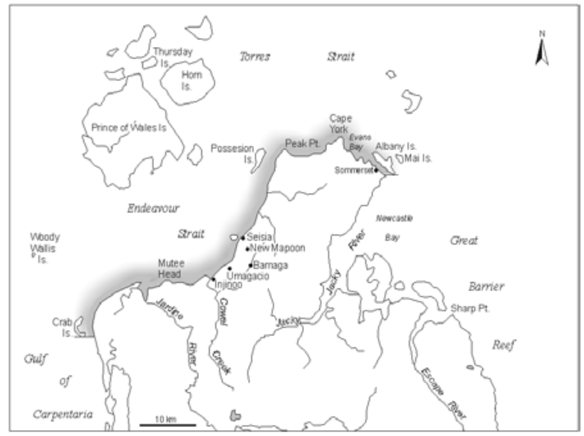

Figure 10. Location of the area within the Northern Peninsula Area that is closed to the harvest of *P. diacanthus* under the regional agreement.

Following extensive consultation, this community initiative developed into a regional agreement with comprehensive support across the NPA. Representing each of the communities of the NPA, the Community Councils of Umagico, Bamaga, New Mapoon and Seisia, have undertaken to participate in the two year prohibition on the take of *P. diacanthus*. Furthermore, Torres Shire and the Kaurareg Nation of the adjacent Torres Strait region are also signatories to the ban. Proprietors and operators of all tourist accommodation and fishing charter boats operating in the NPA region have also pledged their full cooperation with the initiative.

Adding to the uniqueness of this self-imposed management arrangement, the elected Chairmen of these indigenous communities have asked for legislative support for this species-specific ban. Each of the indigenous communities has expressed a willingness to forfeit their statutory exemption from the relevant catch restrictions. The relevant government institutions whose role is to provide for the management needs of the state's fisheries have been presented with a clear obligation to respond to these highly developed public expectations. As such the users of the resource have become empowered to assert responsibility for management.

Parties to the regional agreement of the NPA each recognise that the two-year closure may not provide adequate time for the complete recovery of the proportion of the adult fish in the population. All parties have requested continued investigation on local stocks, so that decision-makers will have sufficient information to review management needs at the conclusion of the two

year period. The species-specific area closure that developed as a result of the research findings presents many unique opportunities and obligations for research and management agencies alike. Further funding will be sought to continue stock assessments, so that the appropriate persons can be informed of the stock's condition prior to the end of the management outcome.

CONCLUSION

Aggregation is one of the most widespread behavioural mechanisms used by marine fish to reduce natural predation (Die and Ellis 1999). Yet it is this behaviour that often promotes increased fishing effort and higher catches, as concentrations of fish are both easier to detect and more efficient to harvest (Turnbill and Samoilys 1997). This research has indicated that widespread knowledge of the spatial and temporal attributes of the fish's aggregating behaviour, has facilitated the increased catch of this species.

While the geographical setting of the project was within Queensland, the results should have widespread application to fisheries for *P. diacanthus* and other aggregating fish species. The arguments for collaborative research have been advocated as they apply in Australia, yet they are predominantly universal to indigenous fisheries in developed nations and may also apply to other fishery sectors. Undoubtably, the ongoing cooperation of indigenous fishers in the project greatly enhanced the outcomes.

The fine scale of fishers' knowledge of the aggregating behaviour of the fish stock proved very useful in developing monitoring and sampling programs. This type of assistance is particularly useful in remote waters that are frequently used by local fishers but rarely visited by researchers. The assistance of fishers in also providing specimens and samples allowed the more efficient use of project resources. The voluntary nature of much of this work demonstrates the willingness of fishers to contribute to scientific research where tangible benefits of the research have been demonstrated.

The guiding principles adopted in the project follow those explained in detail by other speakers of this conference. In brief, these principles provide recognition of the value of fishers' knowledge and allow for their greater participation at all stages. The process adopted in this project was to:

- Identify the issues of concern so as to ensure the relevance of the research outcomes;
- Ensure the transmission of clear and salient objectives so that the direction of the project is clear to all;
- Involve interested parties as far as possible in all aspects of the project;
- Provide recognition of the relevant cultural and social values held by the various groups, to, among other reasons, ensure the adoption of appropriate methodology;
- Liase with all of the stakeholders at all stages to ensure a politically neutral and open process;
- Ensure results are made available in a transparent manner acceptable to the various groups; and,
- Provide a forum for the input of users and stakeholders in development of management outcomes that may be necessary as a result of the research findings.

The comprehensive consultation process conducted throughout the lifetime of the project ensured the implications of the research have been recognised by both management authorities and the communities of the NPA. The implementation of the community-developed two year closure exceeded all expectations and sets a precedent for similar works. It is believed that this outcome was a product of the communities' understanding, participation and commitment to the research process.

The outcomes are unique among Australian fisheries, being the only example we know of in the modern context in which indigenous communities have initiated a long-term ban on the harvest of a fish species. This outcome serves to demonstrate that, provided with the appropriate opportunities and information, mutually beneficial relationships may be developed between indigenous communities and scientific researchers. This partnership between government institutions and resource users may serve to further enhance prospects of achieving the sustainable use of resources.

REFERENCES

Alder J. 1996. Have tropical marine protected areas worked? An initial analysis of their success. Coastal Management. 24: 97-114.

Apparao T., Lal Mohan R.S., Chakraborty S.K., Sriramachandra Murty V., Somasekharan Nair K.V., Vivekanandan E. and Raje S.G. 1992. Stock assessment of sciaenid resources of India. Indian Journal of Fisheries Resources. 39: 85-103.

Beets J. and Friedlander A. 1992. Stock analysis and management strategies for red hind, *Epinephelus striatus* in U.S. Virgin Islands. Proceedings of the Gulf Carribean Fisheries Institute. 42: 66-80.

Blaber S.J.M., Brewer D.T., Salini J.P. and Kerr J. 1990. Biomasses, catch rates and abundances of demersal fishes, particularly predators of prawns, in a tropical bay in the

Gulf of Carpentaria, Australia. Marine Biology. 107: 397-408.
Bowtell B. 1998. Huge schools of black jew about. Fish and Boat. July.
Bowtell B. 1995. Heed jewfish warnings. Fish and Boat. July.
Crisp R. and Talbot L. 1999. Indigenous social profile report for SEQ RFA. Final report for FAIRA Aboriginal Corporation, Gurnag Land Council Aboriginal Corporation, and Goolburri Aboriginal Corporation Land Council.
De Bruin G.H.P., Russell B.C. and Bogusch A. 1994. The marine fishery resources of Sri Lanka. Food and Agriculture Organisation of the United Nations.
Die D.J. and Ellis N. 1999. Aggregation dynamics in penaeid prawn fisheries: banana prawns (*Penaeus merguiensis*) in the Australian northern prawn fishery. Marine and Freshwater Research. 50: 667-675.
Eklund A., McClellan D.B. and Harper D.E. 2000. Black grouper aggregations in relation to protected areas within the Florida Keys National Marine Sanctuary. Bulletin of Marine Science. 66: 721-728.
Grant E.M. 1999. Grant's guide to fish. E.M. Grant PTY Limited, Redcliff.
Gray C.A. and McDonall V.C. 1993. Distribution and growth of juvenile mulloway, *Argyosomus hololepidotus* (Pisces: Sciaenidae), in the Hawkesbury River, South Australia. Australian Journal of Marine and Freshwater Research. 44: 401-409.
James P.S.B.R. 1992. Endangered, vulnerable and rare marine fishes and animals. In: Dehadrai P.V., Das P. and Verma S.R. (eds). Threatened fishes of India. Proceedings of the National Seminar on Endangered Fishes of India, National Bureay of Fish Genetic Resources, Allahabad. April. pp. 271-295.
Johannes R.E. 1981. Words of the lagoon: fishing and marine lore in the Palau district of Micronesia. University of California Press, Berkeley.
Johannes R.E., Squire L., Granam T., Sadovy Y. and Renguul H. 1999. Spawning aggregations of groupers (Serranidae) in Palau. Marine Conservation Research Series Publication 1.The Nature Conservation Agency.
McPherson G.R. 1997. Reproductive biology of five target fish species in the Gulf of Carpentaria inshore gillnet fishery. In Garret R.N. (ed). Biology and harvest of tropical fishes in the Queensland Gulf of Carpentaria gillnet fishery. Department of Primary Industries, Cairns. pp. 87-103.
Mohan L.R.S. 1991. A review of the sciaenid fishery resources of the Indian Ocean. Journal of the Marine Biology. Association of India. 33: 134-45.
Sadovy Y. 1994. Grouper stocks of the Western Central Atlantic: The need for management and management needs. Proceedings of the 43rd Gulf and Carribean Fisheries Institute. pp. 43-63.
Sharp N. 1992. Footprints along the Cape York sandbeaches. Aboriginal Studies Press. Canberra.
Smith P.J., Francis R.I.C.C. and McVeagh M. 1991. Loss of genetic diversity due to fishing pressure. Fisheries Research. 10: 309-316
Smyth D. 1993. A voice in all places; Aboriginal and Torres Strait Islander interests in Australia's Coastal Zone. Report for Resource Assessment Commission. Coastal Zone Inquiry.
Tropical Finfish Management Advisory Committee. 1998. Queensland Gulf of Carpentaria inshore finfish fishery. draft management plan and regulatory impact statement. Report to the Queensland Fisheries Management Authority.
Newman J. 1995. Kimberly chaos. Fishing World. June.
Rao K.V. 1963. Some aspects on the biology of 'ghol', *Pseudosciaena diacanthus*. Indian Journal of Fisheries. 10: 413-459.
Rhodes K.L. 1998. Seasonal trends in epi-benthic fish assemblages in the near-shore waters of the Western Yellow Sea, Qingdao, People's Republic of China. Estuarine, Coastal and Shelf Science. 46: 629-643.
Tanna A. 1996. Traditional Priorities for traditional country. Aboriginal perspective's in the Cape York country. Proceedings of the Australian Coastal Management Conference, Glenelg, South Australia. pp. 50-56.
Thomas P.A. and Kunja M.M. 1981. On the unusual catch of ghol Pseudosciaena diacanthus off Goa. Indian Journal of Fisheries. 25: 266-268.
Trewavas E. 1977. The sciaenid fishes (Croaker and Drums) of the Indo-West-Pacific. Transactions of the Zoological Society of London. Vol. 33, Part 4.
True C. D., Loera A. S. and Castro N. C. 1997. Acquisition of broodstock of *Totoaba macdonaldi*: Field handling, decompression, and prophylaxis of an endangered species. The Progressive Fish-Culturist. 59: 246-248.
Turnbill C.T. and Samoilys M.A. 1997. Effectiveness of the spawning closures in managing the line fishery on the Great Barrier Reef. Report to the Reef Fish Management Advisory Committee of the Queensland Fisheries Management Authority.
White A.T., Hale L.Z., Renard V. and Cortesi L. 1994. The need for community-based coral reefs management. In: White A.T., Hale L.Z., Renard V. and Cortesi L (eds). The need for Collaborative and community-based management of coral reefs. Lessons from experience. Kumarian Press. Connecticut.
Williams L.E. 1997. Gulf set net fishery - monitoring and assessment. In: Garret R.N. (ed). Biology and harvest of tropical fishes in the Queensland Gulf of Carpentaria gillnet fishery. Department of Primary Industries, Cairns. pp. 5-28.

Questions

Bob Johannes: How do you do a stock assessment during the ban?

Michael Phelan: It's still possible to continue what we did before. We know the size of fish at maturity, so basically if we measure the fish, we can determine the age structure of the population. Two years may not be long enough to get the fish back. We'll have to wait and see.

Bob Johannes: So it's a catch, measure and release study?

Michael Phelan: Yes.

Melita Samoilys: What about the commercial and other recreational fisheries?

Michael Phelan: The commercial fishing operations are still relatively young so the fisheries never expanded to that area. It is a relatively unproductive area anyway.

Tony Pitcher: Your talk and project are sensitive to the feelings and aspirations of the aboriginal people, which is laudable. This is why I'm surprised that the name of the fish that you use is gratuitously insulting to humans. The American Fisheries Society recently decided not to use that word or squawfish. Perhaps it is not a big issue in Australia, but in an international forum, you may wish to use another name.

Michael Phelan: This is common in Australia. The name comes from the tendency of the fish scales to blacken upon death.

STATUS OF RESEARCH ON TRADITIONAL FISHERS' KNOWLEDGE IN AUSTRALIA AND BRAZIL

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ABSTRACT

This paper examines the status of research on indigenous Australian and Brazilian fishers' knowledge. In Australia, research involving indigenous ecological knowledge has been done mainly in terrestrial environments. The marine environment has gradually increased its profile and share of this research over the last 15 years, following research and management issues associated with indigenous use of marine resources, particularly in the Torres Strait and Northeast Australia. The development of such research is related to indigenous participation in marine resource management. The focus has been on threatened species – specifically dugong (*Dugong dugong*, Sirennia) and sea turtles rather than fish – and has now expanded beyond the domain of marine protected areas. Indigenous communities in Australia are increasingly valuing and protecting their knowledge as intellectual property. This involves strict controls of access and use, and adherence to culturally appropriate research ethics and methods. In Brazil, research involving ecological knowledge of artisanal fishers has been done mostly over the past ten years, focusing on marine and freshwater fish. Studies have been completed at the Southeastern and Northeastern coasts, and at the Southeastern and Amazonian rivers. Research findings show that fishers have a nomenclature system for fish species, usually classifying useful species in a detailed way. The classification of fish is influenced by their ecology and behaviour. Fishers apply their ecological knowledge while fishing and this knowledge is consistent with the relevant biological science observations. Despite its potential usefulness, application of this knowledge in a fisheries management context is yet to occur in either country. Environmental and socio-cultural factors threaten the maintenance of this alternate information base, and serve to highlight the need for increased research efforts to record this knowledge and realize its potential contribution to fisheries management.

INTRODUCTION

Human communities that rely directly on their natural resources for subsistence usually have a detailed environmental knowledge (Berlin 1992; Gadgil *et al.* 1993; Berkes 1999). There are several terms used to describe this type of knowledge, such as 'local', 'traditional' or 'indigenous', depending on the characteristics of the holders of that knowledge (Berkes 1999). Difficulties regarding this terminology have been addressed in the human ecology and ethnoscience literature (for example Berkes 1999). Ruddle (1994) argued that the term 'local' is less problematic, and thus a more practical description or identifier of the relevant people and their knowledge. Ultimately there may be no single terminology that is applicable to all circumstances. Australia and Brazil are indicative of this situation. Both countries have diverse Indigenous peoples and culture that have endured European colonization for generations. The immediate and prolonged effects of this are as diverse as the Indigenous cultures and the respective circumstances of their histories of colonisation. This diversity is linked to the range of terminology used to describe these communities today. The use of 'local', 'traditional' or 'indigenous' to describe a community and its knowledge often depends on the community's history and experience of colonisation. While acknowledging these differences, the knowledge held and applied by these communities in both countries has the common elements of being a part of their respective traditions or cultures, founded in practical experience and application. Therefore the term traditional knowledge is consistent in both an Indigenous Australian and Brazilian artisanal or local context. For the purposes of this paper the definition offered by Berkes (1999) is appropriate, with an additional note emphasising the fishery-related context of the discussion. Thus traditional fishers' knowledge (TFK) refers to the fishery-related component of the 'cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment (Berkes 1999:8). The terminology 'TFK' is used consistently throughout the text.

In the context of this paper, TFK research is ethnobiological research with Indigenous peoples, devoted to investigating, identifying and

recording their fish, fisheries and related knowledge. This research is carried out in a variety of contexts and in a variety of ways. It ranges from the more direct ethno-ichthyological approaches where TFK is the main focus of the research, to more indirect approaches where a particular species or habitat, or its use, is the research focus and TFK has been incorporated as a result of Indigenous involvement.

This paper reviews Indigenous Australian and Brazilian TFK research. The main characteristics of the research are identified and results summarised. The paper concludes with some discussion of future TFK research effort and associated issues.

AUSTRALIA

In Australia, research involving TFK has been carried almost exclusively in the northern half of the continent and the Torres Strait Islands (TSI). Nietschmann and Nietschmann (1977) and Nietschmann (1985) detailed the complex classification system applied to dugong and, to a lesser extent, sea turtles by TSI fishers (see also Kwan, this vol). The system described was based on the parameters of age, sex, location, type, size and quality of fat and meat. A detailed environmental knowledge was also identified among those fishers. This included tide and sea conditions, such as identification of tidal cycle, moon phase, wind direction, island or reef exposure and time of season; and generic and specific names for large and small underwater features such as reefs, passages, channels, sandbanks, feeding grounds, shallow- and deep-water places, coral heads and various zones on reefs (Nietschmann 1977). Anderson and Heinsohn (1978) surveyed by questionnaire Indigenous perceptions of dugong abundance, population trends, behaviours and ecology across northern Australia and the TSI. This knowledge was found to be compatible with the then current hypothesis of year round dugong breeding. A specific purpose of this research was also to assist in future planning of dugong field studies. Collaborative research with Indigenous communities has occurred on sea turtles in Northern Australia (Kennett *et al.* 1997-a, -b; Bradley 1997; Yunupingu 1997, Munungurritj 1997) and has been planned for dugongs in northeast Queensland (Oliver & Berkelmans 1999). Some of this research has incorporated traditional knowledge of sea turtle populations at specific times of the year and nesting sites (Bradley 1997).

Literature on marine resource use by Indigenous communities in northern Australia, particularly in the northeast and the TSI also documents TFK to various extents (Smith 1985, 1987; Gray and Zann 1988; Johannes and MacFarlane 1991). Smith (1987-a, -b) completed an ethnobiological study of marine resource use in northeast Queensland. Aspects of TFK of fish, turtles and particularly dugong were documented.

Gray and Zann (1988) edited the proceedings of a workshop examining traditional knowledge of the northern Australian marine environment. This included accounts by Indigenous Australians from northwest to northeast Australia and the TSI of the type of traditional knowledge of the marine environment held within their respective communities. Also included were papers on Indigenous marine resource use, some which included TK. Bradley (1988) documented TK in the Gulf of Carpentaria including a glossary of terminology for dugong and sea turtle anatomy, hunting methods and associated environmental conditions. Davis (1988) contributed a revised version of earlier research (Davis 1984, 1985) which included ethnobiological information of seasonal use and associated TK of the littoral zone in northern Arnhem Land. Baker (1993) documented TEK in southwestern Gulf of Carpentaria. Classification of seasons, climatic conditions, environmental units from terrestrial to open sea, and animal and plant food calendars that incorporated fisheries and related information were outlined.

Johannes and MacFarlane (1991) described the traditional fishing in the TSI, including quantitative catch data, hunting and fishing areas including Customary Marine Tenure (CMT) and TFK. This included a substantial glossary of fisheries terminology employed by TSI fishers. The TFK documented varied in detail geographically throughout the TSI, and also included contributions by Poiner and Harris (1991) and Fuari (1991). The contribution by Fuari (1991) is indicative of the TFK included throughout the work of Johannes and MacFarlane (1991), and included TFK relevant to fish, turtle, environmental and seasonal indicators or environmental cues for fish species, and medicinal knowledge.

Peterson and Rigsby (1998) edited a volume on CMT in Australia. TFK of climatic, tidal and seasonal conditions, marine environments and associated classifications for parts of northern Australia is included (Sullivan 1998; Memmott and Trigger 1998; Bradley 1998; Palmer 1998 and Southen *et al.* 1998).

Aspects of southeast Queensland TFK have been documented (Ross *et al.* 1996; Ross and Pickering, in press). This research has been collaborative in nature with Indigenous communities, and has documented shellfish resources and their role in Indigenous culture and heritage, and the relevance of TFK to heritage and resource management.

BRAZIL

In Brazil the small scale artisanal and commercial fisheries are important sources of food and income both in freshwater (Petrere, 1989; Bailey and Petrere, 1989; Kalikoski and Vasconcellos, this vol) and marine (Dieques, 1999) environments. This importance and the number and diversity of fishing communities is reflected in the volume of research focusing on fisheries resource use. These studies have mainly addressed the fishing strategies and technologies, catch composition and use of fishing resources by communities from the southeastern coast (Begossi 1996; Hanazaki *et al.* 1996, Nehrer and Begossi 2000; Seixas and Begossi 2000), South and Southeastern rivers and reservoirs (Castro and Begossi 1995; Okada *et al.* 1996; Vera *et al.* 1997; Silvano and Begossi 1998, 2001), Amazonian rivers (Goulding 1979; Petrere 1978, 1986, 1990; Setz 1989; Ribeiro and Petrere 1990; Begossi *et al.* 1999) and Northeastern coast (Cordell 1978). Among the studies of use of fishery resources other than fish, Rebêlo and Pezzuti (2000) verified the use and consumption of freshwater turtles by Amazonian riverine people, while Nordi (1997) studied the energy allocation related to mangrove crab gathering at the Northeast coast.

LFK research in Brazil is almost exclusively ichthyological in content. Classification of fishes has been documented in communities from the southeast coast (Begossi and Figueiredo 1995; Paz and Begossi 1996; Seixas and Begossi 2001), south coast (Fernandes-Pinto 2001) the Amazonian Tocantins River (Begossi and Garavello 1990), and the northeast coast (Costa-Neto and Marques, 2000-a; Mourão, 2000; Freire and Pauly, this vol). Other studies focussed on the TFK of fish from the Mundaú-Manguaba estuary (Marques 1991) and the São Francisco River (Marques 1995) in the northeast, as well as by other communities from the northeast coast (Costa-Neto and Marques 2000-b, c), and the Piracicaba River, in southeast Brazil (Silvano 1997; Silvano and Begossi in press).

The literature illustrates the significance and value of TFK in Brazil. For example Marques (1991) conducted biological research about the diet of an estuarine fish (*Arius herzbergii*, Ariidae). The results corroborated the TFK of communities from the Mundaú-Manguaba estuary in the northeast, and included the identification of a trophic relationship in that particular environment unknown to western biological or ecological science. Another example is the TFK of migratory behaviour unknown by western fisheries scientists, of an important commercial fish species (*Prochilodus lineatus*, Prochilodontidae) in the impounded Piracicaba River (Silvano and Begossi, in press).

Collectively the literature indicates the existence of well developed TFK in Brazil, which includes details of fish ecology and behaviour. TFK has proven consistent with western biological scientific observations (Marques 1991, 1995; Silvano 1997, 2001; Silvano and Begossi in press). TFK about target fish species probably influences fishing tactics and fishery yields (Cordell 1974; Marques 1991; Silvano and Begossi, in press; Silvano 2001). Research findings also show that communities have classification systems for fishes, sometimes classifying useful species in a more detailed way (Begossi and Garavello 1990; Begossi and Figueiredo 1995), although other criteria besides utility may also influence classification (Seixas and Begossi 2001). These systems may be hierarchical, similar to that used by western biology or based on other criteria such as fish growth cycle, ecological and behavioural characteristics, and meat colour or flavour (Marques 1991, 1995; Paz and Begossi 1996; Costa-Neto and Marques 2000-a; Mourão, 2000).

DISCUSSION

The Australian and Brazilian research differs in a number of ways. Australian TFK research is dominated by a marine focus. TFK of non-fish species, most notably dugong and sea turtle is prevalent throughout the research. TFK research in Brazil is almost exclusively focussed on fish, and has included studies in freshwater regions comparable to those completed in marine areas. Another feature of some of the Brazilian research has been an assessment of the usefulness or validity of TFK as an additional source of ecological information based on its consistency with western biological and ecological scientific information.

There are significant geographical gaps in the research coverage for each country. In Brazil it is the great Amazonian rivers and the southern coast. However the gaps in the Australian

research coverage are arguably more significant. With the exception of a pilot study planned for northern New South Wales (NSW), very little or no TFK research has taken place in the southern states of NSW, Victoria, Tasmania, South Australia or in Western Australia south of the Kimberley region.

The difference in research focus is attributable to the circumstances of each country. The coverage of northern Australia and TSI is, in part, a consequence of the dugong and sea turtle research focus, this being the geographic range of these species. It also reflects the importance of these species to Indigenous communities and marine resource managers in these regions. Research documenting TFK relevant to fish is also concentrated in these regions, a reflection of the relative importance of Indigenous communities in terms of fishery resource use. The southern, and especially the southeastern, states of Australia are more densely populated and Indigenous communities are a demographic minority. In these regions fishery resources are of continuing importance to indigenous communities despite the lack of research.

The Brazilian circumstances reflect the importance of fish as a food resource and the significance of small-scale fisheries in terms of food provision. Fishing for high conservation value species like sea turtles is strongly prohibited in Brazil by national environmental legislation. This limits detailed studies on TFK about such species, as fishers are unlikely to divulge information associated with illegal activities (but see Bird *et al.* this volume).

There is scope to broaden the TFK research effort geographically, especially in Australia, and in terms of the fishery and aquatic bio-resources in both countries. Studies addressing the TFK over broad geographical scales are also needed (Ruddle 1996), with few having been conducted with a simultaneous focus on different countries and fishing communities (Johannes *et al*., 2000; Healey and Hunn 1993). Silvano (2001) conducted a comparative study addressing the TFK of Indigenous Australians from southeast Queensland and artisanal Brazilian fishers regarding the fishery and natural history of the Atlantic Bluefish *Pomatomus saltatrix*, (Pomatomidae), an important marine food fish species in both countries. Despite environmental and cultural differences, similar information about the diet and migratory behaviour of *P. saltatrix* was documented from both countries, suggesting the occurrence of some global patterns to the biology of this widespread fish species (Silvano 2001). Such patterns are consistent with observations from the ichthyological literature (Juanes *et al.* 1996), thus reinforcing the potential of TFK to provide additional insights and expertise to western fisheries science and management.

Consideration of the Australian situation also illustrates some other important issues associated with this type of research. Australian fisheries are dominated by well-developed, large scale commercial and recreational sectors (Baelde, this vol; Williams and Bax, this vol). Notwithstanding current and future commercial interests and opportunities (Tsamenyi and Mfodwo 2000), Indigenous Australian fisheries are founded in Indigenous cultural practise with subsistence a consistent feature. The priority that Indigenous fisheries have within the resource use, management, policy and research framework varies across Australia. In general this priority appears to diminish from north to south, and this is reflected in the concentrated research coverage for north Australia and the TSI. For Indigenous Australian communities, desired research outcomes include improved recognition of their human rights, increased participation in marine resource management and control, and recognition and protection of their knowledge as intellectual property.

Progress toward such outcomes is evolving through Indigenous participation in dugong and sea turtle management and conservation in north Queensland and the Northern Territory. Where such outcomes are difficult to achieve, TFK research may not be possible (Faulkner, 2000). The status of Indigenous Australian peoples that are a part of TFK and related research has and continues to develop, as evidenced by the gradual increase in collaborative research (Kennett *et al.*1997a, 1997b; Ross *et al.* 1996; Ross and Pickering, in press). The protection and Indigenous control of their intellectual property is now a major ethical consideration in Australian TFK research. The nature and measures of protection of Indigenous intellectual property and TFK have been widely discussed in an Australian context (Williams 1998; Janke, 1998; Dodson 1996; Fourmile 1996). One interpretation of the Australian experience may be that the most effective way to protect Indigenous intellectual property is for Indigenous communities to participate as partners in collaborative research.

There is now an established international recognition of the need for research on traditional biodiversity related knowledge, of

which TFK is a part. This recognition is founded in the acknowledgment that such knowledge represents a substantial body of information and expertise that has contributed to, and is needed to continue, the protection and maintenance of the world's biological diversity. It is articulated in the Convention on Biological Diversity, and progressed by the Ad-hoc Working Group on Article 8j. To date a work plan has been developed that identifies the actions necessary to advance not only research, inclusive of TFK, but for its survival and continued application. Key elements focus on protecting the cultural practices from which the knowledge has evolved, intellectual property rights and equitable sharing of benefits accruing from the use of such knowledge to respective communities. The developments in Australia toward collaborations between TFK researchers and Indigenous communities are consistent not only with the established international objectives and standards for TFK research, but also with the domestic articulation contained in the *National Strategy for the Conservation of Australia's Biological Diversity* (Anon 1996).

References

Anderson, P.K. & Heinsohn, G.E. 1978. The status of the Dugong, and Dugong Hunting in Australian Waters: a survey of local perceptions. *Biological Conservation* 13(1): 13-26.

Anon. (1996) *The National Strategy for the Conservation of Australia's Biological Diversity.* Commonwealth Department of the Environment, Sport and Territories, Canberra.

Baker, R. 1993. Traditional Aboriginal land use in the Borroloola Region. In: N.M. Williams & G. Baines, (eds.) *Traditional Ecological Knowledge – Wisdom for Sustainable Development*. CRES, Australian National University, Canberra.

Bayley, P.B., Petrere Jr., M., 1989. Amazon fisheries: assessment methods, current status and management options. *Can. Spec. Publ. Fish. Aquatic Sci.* 106: 385-398.

Begossi, A. 1998. Cultural and ecological resilience among caicaras of the Atlantic Forest coast and caboclos of the Amazon. In: F. Berkes e C. Folke (eds.) *Linking Social and Ecological Systems for Resilience and Sustainability.* The Beijer International Institute of Ecological Economics.

Begossi, A., 1996. Fishing activies and strategies at Búzios Island (Brasil). In: Meyer, R.M., Zhang, C., Windsor, M.L., McCay, B.J., Hushak, L.J., Muth, R.M. (eds.) *Proceedings of the World Fisheries Congress, Theme 2***.** Oxford & IBH Publishing CO. PVT. LTD., Calcuta, India.

Begossi, A. and Figueiredo, J.L. 1995. Ethnoichthyology of southern coastal fishermen: cases from Búzios Island and Sepetiba Bay (Brazil). *Bull. Mar. Sci.* 56: 710-717.

Begossi, A. and Garavello, J. C. 1990. Notes on the ethnoicthyology of fishermen from the Tocantins River (Brazil). *Acta Amazonica* 20: 341-351.

Begossi, A., Silvano, R.A.M., Amaral, B.D. and Oyakawa, O.T., 1999. Use of local resources by fishers and hunters in an extractive reserve (Upper Juruá, Acre, Brazil). *Env. Develop. Sust.* 1: 73-93.

Berkes, F. 1999. *Sacred Ecology – Traditional Ecological Knowledge and Resource Management*. Taylor & Francis, Philadelphia.

Berlin, B. 1992. *Ethnobiological Classification. Principles of Categorization of Plants and Animals in Tradicional Societes.* Princeton University Press.

Bradley, J. 1998. 'We Always Look North': Yanyuwa identity and the marine environment. In: N. Peterson and B. Rigsby (eds.) *Customary Marine Tenure in Australia.* Oceania Monograph No.8, University of Sydney, Sydney.

Bradley, J. 1997. 'How can a Whitefella know it all?' Indigenous science – Western science and marine turtles. In: R. Kennett, A. Webb, G. Duff, M. Guinea & G. Hill (eds.) *Marine Turtle Conservation and Management in Northern Australia.* Centre for Indigenous Natural and Cultural Resource Management & Centre for Tropical Wetlands Management, NTU, Darwin.

Bradley, J.J. 1988 The concurrentce of knowledge and tradition in the hunting of dugongs and sea turtles in the Sir Edward Pellow Islands. In: F. Gray & L. Zann (eds.) *Traditional Knowledge of the Marine Environment in Northern Australia.* Workshop Series No.8. Great Barrier Reef Marine Park Authority, Townsville.

Castro, F. and Begossi, A., 1995. Ecology of fishing at Rio Grande (Brazil): technology and territorial rights. *Fish. Res.* 23: 361-373.

Cordell, J. 1974. The lunar-tide fishing cycle in Northeast Brazil. *Ethnology* 13: 379-392.

Cordell, J., 1978. Carrying capacity analysis of fixed - territorial fishing. *Ethnology* 17: 1-24.

Costa-Neto, E.M. and Marques, J.G.W. 2000-a. A etnotaxonomia de recursos ictiofaunísticos pelos pescadores da comunidade de Siribinha, Norte do Estado da Bahia, Brasil. *Biociências*, *Porto Alegre* 8: 61-76.

Costa-Neto, E.M. and Marques, J.G.W. 2000-b. Etnoictiologia dos pescadores artesanais de Siribinha, município de Conde (Bahia): aspectos relacionados com a etologia dos peixes. *Acta Scientiarum 22*: 553-560.

Costa-Neto, E.M. and Marques, J.G.W. 2000-c. Conhecimento ictiológico tradicional e a distribuição temporal e espacial de recursos pesqueiros pelos pescadores de conde, Estado da Bahia, Brasil. *Etnoecológica*, IV (6): 56-68.

Davis, S. 1988. Aboriginal tenure of the sea in northern Arnhem Land. In: F. Gray & L. Zann (eds.) *Traditional Knowledge of the Marine Environment in Northern Australia.* Workshop Series No.8. Great Barrier Reef Marine Park Authority, Townsville.

Davis, S. 1985. Traditional management in the littoral zone among the Yolngu of North Australia. In: K. Ruddle and R. E. Johannes (eds.) *The Traditional Knowledge and Management of Coastal Systems in Asia and the Pacific.* UNESCO-ROSTSEA, Jakarta.

Davis, S. 1984. Aboriginal knowledge and use of the coast and sea in northern Arnhem Land. In: K.N. Bardsley, J.D.S. Davie & C.D. Woodroffe (eds.), *Coasts and Tidal Wetlands of the Australian Monsoon Region.* ANU, NARU Mangrove Monograph No.1. Darwin.

Diegues, A.C. 1999. Human populations and coastal wetlands: conservation and management in Brazil. *Ocean & Coastal Management* 42: 187-210.

Dodson, M. 1996. Indigenous Peoples and Intellectual Property Rights. *Ecopolitics IX: Perspectives on Indigenous Peoples Management of Environment Resources.* Conference papers and resolutions. Northern Land Council, Casuarina.

Faulkner, A. 2000. Aboriginal fisheries in New South Wales, Australia. *Indigenous Knowledge and Development Monitor.* 8(1): 27-8.

Fernandes-Pinto, E. 2001. *Etnoictiologia dos pescadores da Barra do Superagüi, Guaraqueçaba/ PR: aspectos etnotaxonômicos, etnoecológicos e utilitários.* Msc Thesis, Universidade Federal de São Carlos, São Carlos (SP).

Fourmile, H. 1996. Protecting indigenous intellectual Property Rights in Biodiversity. *Ecopolitics IX: Perspectives on Indigenous Peoples Management of*

Environment Resources. Conference papers and resolutions. Northern Land Council, Casuarina.
Fuari, M. 1991. Fishing and its Social Significance on Yam Island. In: R.E. Johannes and J.W. MacFarlane. *Traditional Fishing in the Torres Strait Islands*. CSIRO Division of Fisheries, Hobart.
Gadgil, M.; Berkes, F. and Folke, C. 1993. Indigenous knowledge for biodiversity conservation. *Ambio* 22: 151-156.
Goulding, M. 1979. Ecologia da pesca no rio Madeira. Instituto Nacional de Pesquisas da Amazônia, Manaus, Amazonas, Brazil.
Gray, F. & Zann, L. (eds.) 1988. *Traditional Knowledge of the Marine Environment in Northern Australia*. Workshop Series No.8. Great Barrier Reef Marine Park Authority, Townsville.
Hanazaki N., Leitão-Filho, H.F and Begossi, A. 1996. Uso de recursos na Mata Atlântica: o caso da ponta do Almada (Ubatuba, Brasil). *Interciência,* 21: 268-276.
Healey, C. and Hunn, E. 1993. The current status of TEK: Papua New Guinea and North America. Pp. 27-30, In: Williams, N.M. e Baines, G (eds.). *Traditional Ecological Knowledge – Wisdow for Sustainable Development*. Australian National University, Camberra.
Janke, T. 1998. *Our Culture: Our Future. Report on Australian Indigenous Cultural and Intellectual Property Rights*. Prepared for AIATSIS & ATSIC. Michael Frankel & Co., Sydney.
Johannes, R.E. & MacFarlane, J.W. 1991. *Traditional Fishing in the Torres Strait Islands*. CSIRO Division of Fisheries, Hobart.
Johannes, R.E., Freeman, M.M.R. & Hamilton, R.J. 2000. Ignore fishers' knowledge and miss the boat. *Fish and Fisheries* 1: 257-271.
Juanes, F.; J.A. Hare and A.G. Miskiewicz. 1996. Comparing early life history strategies of *Pomatomus saltatrix*: a global approach. *Mar. Freshwater Res*. 47: 365 – 379.
Kennett, R., Mununguritj, N. & Yunupingu, D. 1997-a. The Dhimurru Miyapunu Project. In: R. Kennett, A. Webb, G. Duff, M. Guinea & G. Hill (eds.) *Marine Turtle Conservation and Management in Northern Australia*. Centre for Indigenous Natural and Cultural Resource Management & Centre for Tropical Wetlands Management, NTU, Darwin.
Kennett, R., Yunupingu, D., Yunupingu, D., Wunungmurra, B., Mununguritj, N. & Marika, R. 1997-b. Nhaltjan Nguli Miwatj Yolngu Djaka Miyapunuwu: Sea Turtle conservation and the Yolngu People of North East Arnhem Land, Australia. In: G.K. Meffe & C.R. Carroll (eds.) *Principles of Conservation Biology, Second Edition*. Sinauer Assoc. Inc., Massachusettss.
Marques, J.G.W. 1995. *Pescando Pescadores: Etnoecologia Abrangente no baixo São Francisco Alagoano*. Nupaub-USP, São Paulo.
Marques, J.G.W. 1991. *Aspectos ecológicos na ecologia dos pescadores do complexo estuarino-lagunar de Mundaú-Manguaba, Alagoas*. PHD Thesis, Instituto de Biologia, UNICAMP, Campinas (SP), Brazil.
Memmott, P. and Trigger, D. 1998. Marine tenure in the Wellesley Islands region, Gulf of Carpentaria. In: N. Peterson and B. Rigsby (eds.) *Customary Marine Tenure in Australia*. Oceania Monograph No.8, University of Sydney, Sydney.
Mourão, J.S. 2000. *Classificação e ecologia de peixes estuarinos por pescadores do estuário do Rio Mamanguape – PB*. P.h.d. Thesis, Universidade Federal de São Carlos, São Carlos (SP).
Mununguritj, N.1997. Sea Turtle conservation and the Yolngu People of East Arnhem Land. In: R. Kennett, A. Webb, G. Duff, M. Guinea & G. Hill (eds.) *Marine Turtle Conservation and Management in Northern Australia*. Centre for Indigenous Natural and Cultural Resource Management & Centre for Tropical Wetlands Management, NTU, Darwin.
Nehrer, R. and Begossi, A. 2000. Fishing at Copacabana (Rio de Janeiro): local strategies in a global city. *Ciência e Cultura, Journal of the Brazilian Association for the Advancement of Science* 52: 26-30.
Nietschmann, B. 1985 *Hunting and Ecology of Dugongs and Green Turtles, Torres Strait, Australia*. National Geographic Society Research Report 17: 625-652.
Nietschmann, B. & Nietschmann, J. 1977. *Eight Decades on an Island: Social and Ecological Relationships in the Torres Strait*. Final Research Report. Department of Human Geography, Research School of Pacific Studies, Australian National University, Canberra.
Nordi, N. 1997. The allocation and energy expenditure related to crab gathering activity. Ciência e Cultura, Journal of the Brazilian Association for the Advancement of Science 49: 136-139.
Okada, E.K., Agostinho, A.A. and Petrere Jr, M., 1996. Catch and effort data and the management of the commercial fisheries of Itaipu reservoir in the upper Paraná river, Brazil. In: Cowx, I.G. (ed.), Stock Assessment in Inland Fisheries. Fishing News Books, London.
Oliver, J. & Berkelmans, R. 1999. *A Dugong research strategy for the Great Barrier Reef World Heritage Area and Harvey Bay*. Research publication No.58. Great Barrier Reef Marine Park Authroity, Townsville.
Palmer, K. 1998. Customary marine tenure at Groote Eylandt. In N. Peterson and B. Rigsby (eds.) *Customary Marine Tenure in Australia*. Oceania Monograph No.8, University of Sydney, Sydney.
Paz, V.A. and Begossi, A. 1996. Ethnoichthyology of Gamboa fishers (Sepetiba Bay, Brazil). *Journal of Ethnobiology* 16: 157-168.
Peterson, N. & Rigsby, B. (eds.) 1998. *Customary Marine Tenure in Austraia*. Oceania Monograph No.8, University of Sydney, Sydney.
Petrere Jr., M. 1990. Nota sobre a pesca dos índios Kayapó da aldeia de Gorotire, Rio Fresco, Pará. Boletim do Museu Paraense Emílio Goeldi, Série Antropológica (Belem) 6:6-17.
Petrere Jr., M., 1989. River fisheries in Brazil: a review. *Reg. River. Res. and Manag*. 4: 1-16.
Petrere Jr, M.,1986. Amazon fisheries II - Variations in the relative abundance of tucunaré (*Cichla ocellaris, C. temensis*) based on catch and effort data of the trident fisheries. Amazoniana X (1): 1-14.
Petrere Jr, M., 1978. Pesca e esforço de pesca no Estado do Amazonas. II- Locais, aparelhos de captura e estatísticas de desembarque. Acta Amazonica 8, Sup. 2.
Poiner, I. R. and Harris, A. N. 1991. The Fisheries of Yorke Island. In: R.E. Johannes and J.W. MacFarlane. *Traditional Fishing in the Torres Strait Islands*. CSIRO Division of Fisheries, Hobart.
Rebelo, G. And Pezzuti, J. 2000. Percepções sobre o consumo de quelônios na Amazônia. Sustentabilidade e alternativas ao manejo atual. Ambiente e Sociedade, Campinas, Brazil, 6/7: 85-104.
Ribeiro, M.C.L.B., Petrere Jr., M., 1990. Fisheries ecology and management of the Jaraqui (*Semaprochilodus taeniurus, S. insignis*) in Central Amazonia. *Regul. Rivers Res. Manag*. 5: 195-215.
Ross, A. & members of the Quandamooka Aboriginal Land Council 1996. Aboriginal approaches to cultural heritage management: a Quandamooka case study. In: S. Ulm, I. Lilley & A. Ross (eds.) *Australian Archaeology '95, Tempus Vol.6*. University of Queensland.
Ross, A. & Pickering, K. (in press) The politics of reintegrating Australian Aboriginal and American Indian indigenous knowledge into resource management: the dynamics of resource appropriation and cultural revival. *Human Ecology*.
Ruddle, K. 1996. Geography and human ecology of reef fisheries. In: Polunin, N.V.C. and Roberts, C.M. (eds.). *Reef Fisheries*. Chapman & Hall, London.

Ruddle, K. 1994. Local knowledge in the folk management of fisheries and coastal marine environments. In: Dyer, C. L. and McGoodwin, J. R. (eds.) *Folk Management in the World's Fisheries*. University Press of Colorado, Niwot, Colorado.

Seixas, C.S. and Begossi, A. 2001. Ethnozoology of fishing communities from Ilha Grande (Atlantic Forest Coast, Brazil). *Journal of Ethnobiology* 21: 107 – 135.

Seixas, C.S. and Begossi, A. 2000. Central place optimal foraging theory: population and individual analyses of fishing strategies at Aventureiro (Ilha Grande, Brazil). *Ciência e Cultura, Journal of the Brazilian Association for the Advancement of Science* 52: 85-92.

Setz, E.Z.F., 1989. Estratégias de forrageio em populações indígenas de florestas neotropicais. In: Neves, W.A. (ed.), Biologia e Ecologia Humana na Amazônia. Museu Paraense Emílio Goeldi, Coleção Eduardo Galvão, Belém, Brazil.

Silvano, R.A.M. 2001. Etnoecologia e História Natural de Peixes no Atlântico (Ilha Dos Búzios, Brasil) e Pacífico (Moreton Bay, Austrália). P.h.d. Thesis, Instituto de Biologia, UNICAMP, Campinas (SP).

Silvano, R.A.M. 1997. *Ecologia das Comunidades de Pescadores do Rio Piracicaba (SP).* Msc. Thesis, Instituto de Biologia, UNICAMP, Campinas (SP).

Silvano, R.A.M. and Begossi, A. 2001. Seasonal dynamics of fishery at the Piracicaba River (Brazil). *Fish. Res.* 51**:** 69-86.

Silvano, R.A.M. and Begossi, A., 1998. The artisanal fishery of Piracicaba River (São Paulo, Brazil): fish landing composition and environmental alterations. *Ital. J. Zool.* 65: 527-531.

Silvano, R.A.M. and Begossi, A. In press. Ethnoichthyology and fish conservation in the Piracicaba River (Brazil). *Journal of Ethnobiology,*

Smith, A. 1987-a. An Ethnobiological study of the usage of marine resource use by two Aboriginal communities on the east coast of Cape York Peninsula, Australia. Unpublished PhD thesis, James Cook University.

Smith, A. 1987-b. *Usage of Marine Resources by Aboriginal Communities on the East Coast of Cape York Peninsula.* Great Barrier Reef Marine Park Authority, Townsville.

Southen, M. and the Kaurareg Tribal Elders. 1998. The Sea of Waubin: the Kaurereg and their marine environment. In: N. Peterson and B. Rigsby (eds.) *Customary Marine Tenure in Australia.* Oceania Monograph No.8, University of Sydney, Sydney.

Sullivan, P. 1998. Salt water, Fresh water and Yawaru social organisation. In: N. Peterson and B. Rigsby (eds.) *Customary Marine Tenure in Australia.* Oceania Monograph No.8, University of Sydney, Sydney.

Tsamenyi, M. & Mfodwo, K. 2000. *Towards greater Indigenous participation in Australian Commercial Fisheries: some policy issues.* ATSIC, Canberra.

Vera, C.V.M., Camargo, S.A., Bubel, A.P.M. and Petrere Jr., M., 1997. Artisanal fisheries in a urban reservoir: Billings case (metropolitan region of São Paulo). *Brazilian Journal of Ecology* 1: 143- 147.

Williams, N.M. 1998 Intellectual property and Aboriginal Environmental Knowledge. CINCRM Discussion paper No.1. Centre for Indigenous Natural & Cultural Resource Management, Northern Territory University, Darwin.

Yunupingu, D. 1997. Sea turtle conservation and the Yolngu People of East Arnhem Land. In: R. Kennett, A. Webb, G. Duff, M. Guinea & G. Hill (Eds.) *Marine Turtle Conservation and Management in Northern Australia.* Centre for Indigenous Natural and Cultural Resource Management & Centre for Tropical Wetlands Management, NTU, Darwin.

TRADITIONAL MARINE RESOURCE MANAGEMENT IN VANUATU : WORLD VIEWS IN TRANSFORMATION; SACRED & PROFANE [1]

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ABSTRACT

Much of the marine related traditional knowledge held by fishers in Vanuatu is concerned with enhancing their catch more than directly conserving the resources. However, the management of marine resources equates with the long-term survival of the community and thus a cosmology evolved over time to sustain these resources and hence the communities which depend on them. This system, enshrined in local custom, follows natural cycles of abundance for the various resources available and depends upon the respect for the rules of custom devised by their forefathers and passed down to the present generation. In addition, it is often the rules associated with the fabrication and deployment of traditional fishing gear and techniques that serves to manage the resources. The fabrication of these fishing devices also requires an extensive knowledge of the forest resources found far from the sea. A number of other customs, seemingly unrelated to marine resource management, also serve to directly conserve the marine resources.

Events associated with the arrival of Europeans and introduction of Christianity has initiated a process of transformation of these traditional cosmologies and practices related to marine resource use and management. More recently the forces of development and globalization have emerged to continue this transformation. The trend from a primarily culturally motivated regime of marine resource management is consequently being transformed into a commercially motivated system, that is from the sacred to the profane, in response to these external forces.

INTRODUCTION

Vanuatu is a Y- shaped archipelago roughly 1,000 km long located in the western South Pacific between 12 and 22 degrees South latitude (see Figure 1). Vanuatu means "Our Land" and was an appropriate name taken at Independence from the joint colonial rule of England and France in 1980. There are a total of 82 islands, mostly volcanic in origin, 70 of which are inhabited. Most of the islands are surrounded by narrow fringing reefs of limited size due to the steep nature of volcanic islands. There is only a limited number of areas with highly productive ecosystems such as mangroves, estuaries and lagoons. The reef areas, although limited, are non-the-less highly productive and support a high diversity of fish and invertebrates.

The population of 187,000 (as of 1999) is predominantly Melanesian. Approximately 79% of the population today lives in rural areas following a predominantly subsistence and traditional lifestyle. The term traditional used here is meant to refer to practices used prior to the arrival of Europeans in significant numbers starting in the mid-1800s. Root crops such as yam, taro, kumala and manioc are staples along with banana, pawpaw, plantain, breadfruit and numerous other fruits as well as various types of nuts. Wild birds, giant fruit bats, freshwater

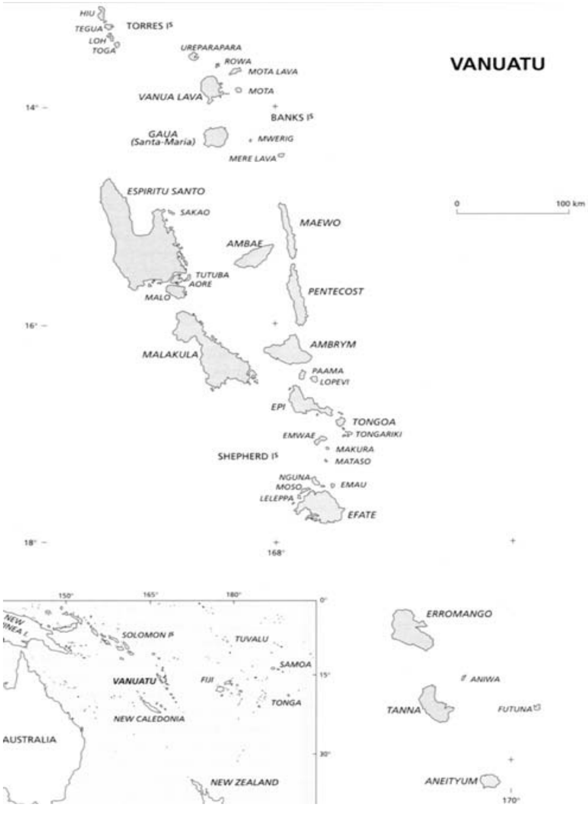

Figure 1. Map of Vanuatu

prawn, fish and eels as well as domestic pigs and chickens introduced by the early colonists were traditional sources of animal protein in addition to various types of seafood. These include turtles, dugongs, numerous types of fish and shellfish, crabs including the large terrestrial coconut crab, as well as octopus, spiny and slipper lobsters, urchins, giant clams and many other marine invertebrates.

[1] The title and theme of this paper was inspired by the book 'The Sacred & the Profane, The Nature of Religion' by Mircea Eliade.

A number of factors affect food security on the islands. There are about 5 active volcanoes today in Vanuatu that may cover gardens and villages with ash and acid rains as well as molten lava on occasion. Cyclones are liable to occur from November till April damaging gardens, fruit and nut trees as well as impacting coral reefs. Tsunamis and earthquakes, floods and droughts are also a regular part of life in these islands. A number of systems was developed to provide food security in light of these threats in addition to keeping pigs and chickens, such as storing fermented fruits and sourcing a number of other foods not normally eaten except in times of need. The sea is also a source of much needed protein after a natural disaster has destroyed your food crops, provided it wasn't already over harvested. The regularity of these natural events impacting food security was perhaps also significant motivation to keep the reefs bountiful much like the idea behind 'saving for a rainy day'.

In addition, the practice of 'giant clam gardens' was also utilized in many coastal areas. This practice consisted of families gathering a number of giant clams into a small area in front of the village on the inside of the reef for their exclusive use in times of need. This practice is also considered to increase reproductive success by maintaining close proximity of the breeding population that depends on external fertilization. Thus, it may also be considered a management strategy.

There is great linguistic/cultural diversity found amongst these lush tropical high islands with currently 113 different Austronesian languages now spoken (Tryon, 1996). There were in fact more languages spoken in the past, but massive depopulation associated with European contact primarily through the introduction of diseases reduced this number. There are also numerous Polynesian Outliers, including the islands of Futuna, Aniwa, Mele, Ifira as well as three villages on Emae Island. Many other islands also exhibit varying degrees of Polynesian influences.

Each of the 113 language groups currently found in Vanuatu represents a people with different oral histories, cosmologies, customs and traditions. Based on these differences, each of the 113 linguistic groups represents a distinct cultural group within Vanuatu. With its relatively small population Vanuatu thus has the highest cultural diversity per capita in the world, and this often makes it difficult to generalize about the customs, including the various marine resource management traditions found throughout Vanuatu.

A new language, called Bislama, was invented during colonial times to help overcome the difficulties in communication with the first Europeans and amongst the different islands. It is a unique form of Melanesian Pidgin based mainly on English, but also incorporating French and some of the vernacular languages. Its name stems from its association with early contact with European traders, notably the Beche-de-mer (dried sea cucumber) traders. Bislama, one of the three official 'national languages' is the most commonly spoken language in the country's mixed urban centres, along with some English and French.

The use of the word 'custom' perhaps requires some clarification. In this context, it is used to denote the contemporary expression of the ancient traditions which of course are not static, but are in constant flux with the flow of new ideas and circumstances demanding adaptation of inherited traditions. The continuous flow and migration of people and ideas in Vanuatu throughout its history cannot be over-emphasized. Rather than leading to a homogenization of customs in Vanuatu it has probably been more responsible for its startling diversity through the admixture of various ideas, peoples, customs and traditions. '*Kastom*' is the Bislama term commonly used by ni-Vanuatu (people of Vanuatu) to collectively denote their inherited traditions and customs. The term is often used to contrast with recently introduced Christian beliefs.

Christianity was introduced slowly some 150 years ago, primarily via the Presbyterian, Anglican and Catholic faiths initially. Most islands in Vanuatu did not quickly embrace these new religions and many missionaries and Polynesian catechists employed in the missionization of Vanuatu met their demise in cooking ovens at the hands of islanders. Peter Dillion, an early 'man of enterprise' in the South Seas remarked on his visit to Erromango (also known as Martyrs Isle) in search of sandalwood in 1825 that "their general disposition indicates a more permanent attachment to barbarous feeling and habits than has hitherto been found in any part of the South Sea"(Davidson, 1956:103).

His comment indicates how deeply rooted the island *kastoms* were and foreshadows how their world view was not about to change so quickly for the benefit of a few trade items. More recently, numerous other more obscure Christian denominations (Assemblies of God, Seven Day Adventists, Holiness Fellowship) have become increasingly popular. In some areas, the two belief systems, *kastom* and Christian, are in open conflict with each other, in other areas they have managed to harmonize,

as it is often said by those who speak of it, peace. In some areas people have only been converted in the last 30 years or less; in a few areas people have completely rejected converting to Christianity and choose to maintain only their *kastom* beliefs.

These recently introduced Christian beliefs overlie the much stronger *kastom* belief systems to varying degrees on the different islands. In virtually every community of Vanuatu and even in the urban areas, various aspects of *kastom* remain strong and are significant forces in people's lives. For example, the nature of people's relationships with others is still dictated largely by kastom protocol and the firm belief in sorcery, and the intervention of the spirit world is still very much alive and continues to influence peoples behavior.

One must consider that Christianity has only been received relatively recently, whereas *kastom* has been around for some thousands of years. Perhaps a useful metaphor is that *kastom* is like a deep ocean swell, powerful- almost immutable- and originating a long way off, a long time ago, while Christianity is like the small wind-driven waves or ripples found on the swell's surface. One is deeply rooted while the other is superficial. It takes a long, long time of blowing for a new wind direction to finally alter an ocean swell.

The traditional fishing methods of the islands varied somewhat amongst cultural groups. Most of the harvesting, however, was focused on the nearshore reefs. Reef gleaning for various fish and shellfish, octopus, giant clams, sea urchins, spiny lobsters and numerous other invertebrates provided a significant portion of the catch. Other methods including fish poisons, spearing and shooting fish with bow and arrow from the reef edge, as well as fish traps, leaf-sweeps, hook and line, nets and weirs, were all commonly practiced in different areas. However, it should be noted that the use of hook and line was apparently not known everywhere in former times.

There were also fisheries for turtles, and in some areas for dugongs, as well as the annual harvesting of the Palalo seaworm. In some areas offshore fisheries also occurred for deepwater snappers, bream and groupers, as well as for flying fish, tuna and tuna-like species, although the latter was mainly in areas of Polynesian influence. All of the various fishing methods were based on a significant corpus of traditional environmental knowledge (TEK) associated with these various resources to enhance the catches realized from their efforts. And all of these methods were embraced by a significant corpus of *kastom* as part of a group's oral histories.

The specialized TEK associated with the fabrication of the various fishing devices like traps, poisons, spears, bows and arrows, hook and line and canoes, etc. often took the fisherman far up into the islands interior where preferred plants were only found to grow. Its method of preparation and fabrication followed specific methodologies to isolate, strengthen, harden or preserve the materials. These methodologies were passed on via a group's oral traditions (with their own cultural-linguistic nuances) and were often encoded in *kastom* stories for the benefit of future generations.

Most of these various fisheries continue to be practiced today to varying degrees, however, the traditional nets and hook and lines have generally been replaced by their modern, introduced counterparts. Other introduced gear such as spearguns and underwater torches have also become increasingly common in the last few years, as has accessibility to outboard powered skiffs, now fairly commonly used for fishing and transport on most islands. The outrigger canoe still dominates in most coastal villages, however, and continues to serve local fishing and transport needs well. The use of dynamite to stun fish has stopped since the end of colonial times when dynamite was more readily accessible.

A number of small scale, village-based commercial fisheries was introduced with European contact, primarily for trochus (*Trochus niloticus*) green snail (*Turbo marmoratus*) and for dried sea cucumbers (Holothuroidea), locally known as beche-de-mer. These fisheries have provided access to early trade items of European manufacture to remote villages, and continue to provide access to cash for rural communities. In some areas they remain very important sources of income for rural areas, particularly trochus.

Johannes (1998a) notes that the tropical small-scale, multi-species fisheries practiced by the rural people today in areas like Vanuatu are prohibitively expensive and notoriously difficult to manage, except for a few high-value benthic species, using western models that require extensive data-collection. Johannes (1998b) suggested that the unrealistic emphasis on quantitative management ideals like optimum or maximum sustainable yields for tropical small-scale, multi-species fisheries could justifiably give way to a new paradigm, what he called 'data-less marine resource management', emphasizing that it is not management in the absence of information. The use of local knowledge (TEK) concerning the resources and

their environment were invaluable to achieve the realistic management objectives of preventing serious over-fishing, ensure reasonably satisfactory allocation of resources and to minimize conflict.

The Vanuatu Fisheries Department emphasizes the fundamental role of traditional management practices in managing nearshore reefs but has also introduced some regulations, for example size limits for some commercialized invertebrates, the protection of turtle nests, prohibition of harvesting berried spiny lobsters, etc. However, the monitoring and enforcement of these regulations remains extremely difficult and virtually cost prohibitive in an archipelago such as Vanuatu. The main value of such regulations is to assist in controlling the export of commercial fisheries products like trochus and green snail and the flow of other resources with regulations such as lobsters and coconut crabs in and from the urban centres.

The main strategy employed today for managing the nearshore reefs is based on the ancient system of Custom Marine Tenure (CMT) and the following of traditional cosmologies or '*kastoms*' which impose additional restrictions on people's behavior towards the harvesting and consumption of marine resources. The fundamental principle underlying CMT is the ability of clans, chiefs and/or communities to claim exclusive rights to fishing areas and to exclude outsiders from these areas. The benefits of their restraint on the fishing grounds may therefore be realized by themselves at a later date and thus provides the motivation to do so in contrast to the 'tragedy of the commons' observed in areas with open access.

Under CMT, chiefs now commonly put certain resources, fishing areas or fishing methods under taboo for varying periods of time. These taboos are locally monitored and enforced by the chief and communities themselves. This system effectively de-centralizes management under custom tenure to the chiefs, community or even clan level, i.e. to those most intimately knowledgeable of the resource and the most motivated to manage well as they, and their descendants, will directly benefit, or suffer, from any management decisions.

The traditional cosmologies or *kastoms* that contribute to the conservation of resources evolved in these islands are driven by a need to protect their finite natural resources, and in so doing, to ensure the survival of the communities that depended on these resources. A prime example of one of these cosmologies is the belief in many areas of Vanuatu that if you eat turtles or turtle eggs and go to the yam garden then your yams' growth will be stunted. Since yams are a primary source of nutrition and are considered to have great *kastom* significance in Vanuatu, the consumption of turtle and turtle eggs during the yam growing season is highly reduced.

As the yam growing season coincides with the time turtles come ashore to lay their eggs, this *kastom* therefore assists to conserve their numbers during their most vulnerable period. This example, and others of cosmological beliefs or *kastoms* that contribute to resource management, will be elaborated on further below.

While many of these *kastoms* are not ostensibly concerned with management, their conservation value is apparent. This would suggest that they evolved in the remote past to fulfil a conservation purpose, thereby contributing to the food security and survival of the island peoples. One could postulate that at some point in the remote past, such customs arose over time under the guidance of the chiefs and high priests, (Melanesian 'Big Men'), that is, those most responsible for *kastom*. This would have been necessary once they had determined that resources were finite and that they had the ability to deplete them. This would not have taken too long once their numbers had grown sufficiently to populate these relatively small tropical islands.

Spriggs (1997:85), who has done considerable archaeological work in Vanuatu, notes "a 'pioneering' pattern of initial settlement followed by serious erosion of the local landscape, abandonment of an area for sometimes many hundreds of years, and a later more conservation-oriented reuse with continuing occupation." Archaeological data for Vanuatu and most other parts of Oceania show a similar trend in marine resource harvesting patterns after initial colonization. It would thus seem reasonable to propose that the introduction of conservation strategies would follow the same pattern with marine resources; once the impact of over-harvesting marine resources was observed then conservation measures would be introduced as a matter of self-preservation. It is after all the same pattern that is now being repeated on continents relatively recently colonized by Europeans and industrialized like North America, Australia and New Zealand - and even globally; that of severe resource depletion followed by the introduction of substantial conservation strategies.

Johannes (2002) argues that it would have been much easier to impact on and deplete many terrestrial-based resources on remote islands due to the occurrence of many species of

flightless birds (due to the absence of large mammalian predators) which were vulnerable to over-exploitation due to being ecologically 'naïve' and also having very small clutch sizes. Additionally, the detrimental environmental and habitat impacts of the early effects of fire and land clearance by man would have introduced significant changes to island environments, including increased sedimentation. Finally, the introduction of the dog, pig and rat would have had a significant impact on island ecology, particularly on the nests and young of ground-nesting bird species.

Johannes also points out that the ability to deplete marine resources would not have been so great. There was no marine equivalent to the introduction of fire and land clearing, nor any known introduction of exotic marine fauna that could adversely affect the marine ecology. Also, the reproductive strategy of most marine fish and invertebrates involves the planktonic dispersal of thousands or millions of eggs and larvae from anywhere from a few days to a month. Larval dispersal is thus widespread and assists to replenish stocks that may be locally over-harvested, provided they are given some protection from further over-harvesting. It is thus reasonable to assume that it would take much longer to extirpate marine fauna than terrestrial, and thus people would have more time to recognize a decline and introduce measures to conserve them.

Indeed, archaeological excavations of Matenkupum, New Ireland, Papua New Guinea, have revealed fish bones and mollusc remains from 32,000 B.P. (before present). Allen et al, (1989) cite this area as being the world's longest continuously exploited reef and lagoon fishery and is the earliest evidence in the world for the human capture of fish. Midden excavations revealed the density of mollusc shells was greatest for the strata between 32,000 and 20,000 BP and that the shells deposited in the earliest strata were mainly large individuals from large species while the uppermost strata had the fewest large species and the smallest mean sizes of species. Gorsden and Robertson (cited in Allen et al) deduce that this indicates low levels of human predation on largely pristine mollusc populations and that some form of rotational harvesting of shellfish was practiced.

In a review of the archaeological record of anthropogenic effects on Pacific coastal fisheries, Dalzell (1998) concludes that mollusc resources were of prime importance for early Pacific island populations and that in some cases long-term exploitation can markedly reduce the average size and diversity of mollusc populations. Also, in some instances a decline in mollusc resources forced early human populations to turn towards other marine resources as well as to rely increasingly on agriculture. He also concluded that the archaeological record for subsistence fin-fisheries of reefs and lagoons indicated no strong evidence to suggest long-term effects on their populations.

However, we know of at least one sessile marine species extirpated in the past from Vanuatu waters, that of the largest of the giant clams (*Tridacna gigas*). We know this because their shells are now commonly found up above today's sea levels where they were transported through coastal uplifting. There has not been a confirmed sighting of a live *T. gigas* for many generations in Vanuatu. It has never been established when the extirpation occurred. One could speculate that they were heavily targeted by earlier residents due to their extremely large size and therefore the large amount of meat available from them for communal feasts. Just north of Vanuatu, however, in the Solomon Islands *T. gigas* can still be found.

One could hypothesize that these rules for conserving the resources necessary for the survival of ancient communities were thus initiated, encoded and enshrined into *kastom*, to be followed by the people as part of their cosmology. Melanesian society is characterized by numerous secret and Big Man societies that conceals the sacred knowledge associated with these elite groups from the uninitiated. Only through progressing through the rigorous prescribed stages of initiation is this knowledge slowly revealed to those deemed worthy. There is also an extensive use of metaphor and symbolism, understandable at its deepest level only by those initiated in the rich oral traditions associated with these societies and recording the island's histories.

Knowledge of the islands' histories is power, because it records who has primary rights to the land and sea and their resources. It is thus primarily held by the priestly and chieftain classes. The integration and obfuscation of resource management practices into the rules of *kastom* initiated by the ancients, to be then followed by rote by the general public is in keeping with this fundamental characteristic of Melanesian culture. This is why, if you ask an islander today, they follow certain rules associated with the fabrication of, for example, a fish trap, he will often simply respond that it is our custom to do so.

A Cosmology Evolved to Sustain Resources and Communities

The Lapita People

The first people known to have populated the islands of Vanuatu are now known as the Lapita people. They originated from somewhere in SE Asia (Kirch 1997). According to archaeological evidence, the earliest appearance of this people in Vanuatu was approximately 3,000 years ago (Spriggs 1997). By 2,800 years ago, the Lapita people had progressed through Vanuatu to New Caledonia, over to Fiji and on to Tonga and Samoa (Kirch 1997). This was a rather explosive expansion across a large area of the Pacific within a very short time period, when one considers that there were people who had progressed down through the large islands of the Solomon Islands as far south as San Christobal some 28,000 years ago. These much earlier coastal peoples have come to be known as Melanesians.

It should be noted that from mainland southeast Asia down to the southern Solomons there is a "voyaging corridor"; one can always see another island - but not when looking south from the southern Solomons. The success of the Lapita people in colonizing these pristine islands beyond the Solomons is attributed to their development of a superior seafaring tradition to that which had been previously known in this region, including more seaworthy canoes and navigation techniques (Irwin 1992). The cultural complexity of the Lapita people also included a well-developed repertoire of fish hooks, including trolling lures, and evidence for the use of a wide array of techniques including spearing, poisoning and netting fish as well as relying on the extensive shellfish beds. (Kirch 1997).

This rapid expansion of the Lapita people has been likened to a freight train that passed through the islands. It seems that these first colonists were not so interested in settling, but moving on once they had exhausted the large and often ecologically 'naïve' turtles, fish and land birds (many of which were flightless). Of course, without the initial benefit of crops (although these early settlers brought with them the plants and animals of their traditional economy), the Lapita people would have been almost entirely dependant initially on marine resources, especially the pristine shellfish beds and what could be hunted and gathered from the forests, primarily birds and fruit bats. There were also the domestic pigs and chickens that these early colonists brought with them. However, some 'boxcars' of this Lapita freight train remained and settled permanently in some areas.

The archaeological data available for these Remote Oceanic islands indicate a repeating pattern of marine (particularly turtle and shellfish) and avian resource extraction upon first contact, and in some cases numerous avian species extirpations and extinctions associated with these first colonists (Spriggs 1997; Kirch 1997). Although the archaeological data for Vanuatu remain relatively sparse, Bedford (2000:243) indicates there are "hints of a 'blitzkrieg-like' scenario on initial arrival" which will require further excavations for confirmation. He confirms the heavy exploitation of turtles and fruit bats and the extinction of some birds and a small, endemic land-based crocodile during the initial settlement phase. He also reports the dramatic reduction in size of some shellfish at some sites and an indication that some species may have been locally extirpated from particular areas on different islands. He also notes that "inshore and reef species of fish were targeted from initial arrival and continued to be so throughout the sequence, with no evidence for any change in preference or procurement strategies."

Arriving in what would have been a pristine 'paradise', these early arrivals tended towards a 'pillage and pull-out' strategy, in many cases needing only to move on to the next pristine bay around the corner to repeat the process. It appears that if the Lapita people had any sort of conservation ethic as part of their customs, it was apparently suspended while surrounded by such plentiful resources. This seems to be a common theme when resources appear to be infinite and seemingly inexhaustible. Europeans did the same thing when they viewed the endless expanse of rainforests and salmon on the coast of western Canada. Now, some 200 years later, both of these resources are severely threatened.

It was a different story, however, for the 'boxcars' whose people remained. The people who chose to remain in the islands of Vanuatu (and including the numerous subsequent waves of colonists from the north that arrived once the route was opened) would have been faced with the challenge of equilibrating with the finite space and delicate ecology of small tropical islands. One can imagine how the survival of these communities would depend upon the later inhabitants reaching equilibrium with their environment – or face the demise of their own people through a lack of resources to maintain a population. Indeed, the story of Rapa Nui (Easter Island) indicates that some Pacific peoples pushed their island environment to the brink of destruction which in turn led to the collapse of the islands culture and population. However, that this happened on one isolated island does not imply that the entire Pacific

lacked a system of self-preservation, including a system of marine resource management.

One of the efforts to maintain equilibrium would have been the establishment and protection of a territory which a clan or group of clans would have control over. In Vanuatu, and throughout Melanesia, these territories included the nearshore reefs as a natural extension to the land. These territories provided the necessary resources for people – access to marine resources and gardening areas, fruits and nuts, wild birds, pigs and fruit bats. Also to natural materials for house and canoe construction, for fabricating fishing gear, weaving materials for mats and baskets, traditional medicines and the myriad of other materials used in island technology that are utilized to help sustain life on the islands. The management of these resources, once the population pressure became sufficient to threaten them, would be a natural progression for any group of people intent on survival.

Through thousands of years of observation, experimentation and close association with their environment, a body of traditional ecological knowledge (TEK) became part of a clan's heritage. This knowledge was continually built upon, refined, added to and modified through subsequent generations. Today we still find in Vanuatu a rich corpus of TEK associated with both land and sea.

These systems of CMT and TEK both served to enhance a clan's chances of survival in an otherwise uncertain environment where hurricanes, volcanoes, tsunamis, earthquakes, floods, droughts and warfare were a part of the annual cycle and human drama of these islands. These ancient systems of land and reef tenure, as well as environmental knowledge, continue to assist in the management and resource use and ultimately to enhance survival for people who still live a predominantly traditional lifestyle on the islands of Vanuatu today.

Ancient Traditional Marine Management Measures in Vanuatu – Ritualized and Sanctified

Background

A fundamental consideration in examining the ways in which marine resources were managed in pre-contact Vanuatu is to consider the context in which these measures, as well as the harvesting methods, were practiced. That is, within the framework of the traditional cosmology or belief system practiced in ancient times. Life in those days had an inherent sanctity that was maintained through a high degree of ritualization and based on the premise held true still today in Vanuatu that all things have a spirit. For most of us today it is difficult to imagine the degree of sanctity and ritualization of earlier times as well as the spiritual connection people felt with their environs. However, we must try to imagine if we are to approach an understanding of how things may have worked in ancient times.

For one thing, marine resource management was not an isolated body of knowledge neatly compartmentalized into one clearly definable element of early island cultures. Instead the rules of custom which contributed to the conservation of resources touched all facets of life (See also Purnomo, this vol) and formed a multi-dimensional web of support for resource management. This point will be elaborated upon further below. Also, much of the harvesting of fin-fish, particularly by people not directly living on the coast, was done before not by independent individuals looking for dinner, as is often the case today, but was more often done communally at seasonally prescribed times of the year and through the use of '*kastom*'. That is, it was often highly ritualized and involved the "spirit of *kastom*" or the intervention of the spirit world.

The communal nature of these fin-fisheries is evident in the main methods used to harvest fin-fish like coconut leaf-sweeps, fish drives and the use of fishing weirs, which at least today are owned by clans, not individuals. The harvesting of shellfish beds and other reef gleaning activities were more likely to be practiced on a regular basis, and would include small amounts of fish, but would still be controlled by local cosmological and seasonal restrictions (see below).

The spirits, including ancestral spirits, were omnipresent and could be used to people's advantage if done correctly. There were shamans capable of enacting the correct rituals to ensure a bountiful communal harvest. A taboo would be placed on the area to be fished for up to a year or so, which prohibited anyone from swimming or even walking by on the beach. This would serve to decrease the wariness of fish from entering that area as well as allowing for an increase in fish size. The timing of the communal harvest would then be divined by the shaman, who studied the tides. The villagers would facilitate the catch with a communal harvesting method such as a leaf sweep (a long net made from coconut fronds and used as a barrier) or a similar method using people with poles acting as a human barrier (fish drive).

These fish would then be shared amongst all clan members and perhaps traded to inland villages in return for resources from the island's interior. These practices would only be done on

certain occasions according to the local *kastoms*, which appear to be timed to coincide with seasonal abundance or enhanced access of the target species, such as the season of extremely low tides. (see section below on 'Seasonal Considerations in MRM').

Traditional Marine Resource Management Measures: Taboos and Kastom Beliefs

There was formerly a number of different traditional marine resource management measures (MRM) practiced in Vanuatu. These practices varied between the numerous different cultural groups found throughout the islands, and reflect this cultural diversity. Some of these practices are still found today; others have survived only through oral history. Others have no doubt been lost.

Some of the traditional MRM measures resulted in fishing area closures, as outlined below. Other cosmological beliefs that manifested as rules associated with *kastom* contributed to the management of marine resources in less obvious ways. For example, the numerous rules associated with the fabrication and deployment of traditional fishing gear and techniques often contribute to the management of marine resources.

The most widely known example of this is the taboo against engaging in fishing after indulging in sex. One is given a choice - you may indulge, but if you do, it is taboo to go fishing for the next day or two, the actual duration varying with the area. Given that a certain proportion of the village population will indulge on any one night, it is easy to see how this taboo would contribute to reducing fishing pressure on the reefs the following day or two. It is easy to see that these rules also had something to do with birth control, in that devoted fishermen would not make love to their wives so as to be able to go out fishing the following day. Sexual abstinence is also required for those involved in the fabrication of fishing traps, weirs, canoes and most other fishing devices. This would further limit fishing pressure given that not all men would choose abstinence.

Other examples of cosmological beliefs or *kastoms* that effectively limited fishing pressure were that when you went on a fishing trip, you cannot be seen departing by others, or at least they must not be aware that you are joining a fishing expedition. Once seen by others as you prepare to depart for fishing brings nothing but 'bad luck' and so the trip is aborted. Another example is that any man with a pregnant wife is automatically excluded from any fishing activities. Both of these taboos relate to the belief in the negative intervention of the spirit world on fishing activity if these taboos are not followed.

It is also taboo to eat certain foods and to go to certain places when one is constructing fishing devices. If a fisherman is unable to respect these taboos, he must excuse himself from the fishing group, as he will ruin the fishing for all concerned. In most areas, there are ways to find out who has not followed the rules. This will put the offender to great shame within his clan, and so is to be avoided.

As noted above, in some areas it was taboo to eat turtle or turtle eggs if you planned to go to your yam garden. In some areas this was also the case with octopus, lobsters, certain fish and other foods including certain fruits. In some areas, it was taboo to go to the garden if your leg had so much as made contact with the sea. Thus, if there was work to be done in the garden (and there often was), one could not be involved in fishing, or in the consumption of certain seafood. Given the high priority to the production of food through agriculture in Vanuatu, it is apparent that these numerous rules of *kastom* also served to reduce fishing pressure.

During the season of preparing the new yam gardens there is much labour involved in planting and caring for the yams, necessitating frequent trips to the garden. Also, the production of yams was a central aspect of food production and in the *kastom* of most areas of Vanuatu and was thus treated as a serious endeavor. There were also numerous other taboos in addition to drawing upon the power of the spirit world to be followed to ensure a good crop.

Many other *kastoms* resulted in the direct conservation of marine, and other, resources. An example of this is the tabooing of a favorite food of a deceased clan member such that the family shows respect to the memory of the deceased by not eating that type of food for a specified time. For example a certain type of fish, spiny lobsters, octopus or a type of shellfish or a fruit may be tabooed in honor of a deceased clan member for a year or more. The time period is generally commensurate with the sorrow of the loss. This would take fishing pressure off that resource within the clan's area for that time period.

Another example is the practice of people not eating their ancestral or family totems for essentially spiritual reasons. This may be a certain type of fish, turtles, giant clams, or any other number of totems used. Again, this significantly reduces the fishing pressure on a given resource within a given area.

In fact, there were numerous rules of custom governing much of the activities and behavior not only of fishermen, but of all clan members engaged in any of the traditional arts of life from weaving baskets or making ceremonial carvings or headdresses to the preparation of traditional medicines. These numerous and various rules of *kastom*, which permeated all aspects of island life, combine to form a multi-dimensional lattice or web that provides a blueprint to life on the islands - including the management of resources - as well as all other aspects of life. These blueprints, encoded and enshrined in *kastom*, were often derived from the ancient gods and cultural heroes and thereafter sanctioned by the ancestors as 'The Way', and passed on to the next generation through the oral traditions and *kastoms* of a cultural group.

In all areas of Vanuatu there were also numerous secretly guarded customs associated with using spiritual powers, mediated through shamans, to ensure an ample supply of all resources. This was also a critical part of any taboo used to close an area to fishing, to use the power of the spirit world to increase resources. Reef taboos were never just set and left 'static', but were always accompanied by ancient rituals sometimes recited in languages long lost that drew upon the 'spirit of *kastom*' to proactively increase the resources.

These activities reflect a fundamental belief held by ni-Vanuatu in the spiritual connections between themselves and the rest of the natural world. This belief extends to the ability of people, through the power of *kastom,* to influence the natural world around them. This was frequently employed in all aspects of life, from agrarian and fishing practices to the cutting of a canoe, or in the preparation of natural medicines. These practices served to acknowledge, support and harmonize with the spirits and sanctity of the island world.

Examples of some of the cultural practices found throughout different areas of Vanuatu that resulted in a taboo being placed on a reef that allowed reef resources to rest and recover for varying lengths of time are outlined below. In most cases, taboo leaves specific to the cultural group are erected to indicate clearly the area covered by the taboo.

Death of a "Big Man"

In some areas, the death of a Big Man (or High Priest) meant that his memory would be honoured by the putting of taboo on his area of reef. This total closure to the harvesting of reef resources may last for many years, depending on the degree of respect held for the Big Man. This taboo is associated with the enactment of many rituals including the killing of pig(s), dancing, kava drinking and communal feasting. Upon the opening of the reef, a final communal feast is held to honour the deceased, using the fish and other marine resources harvested from the closed area.

Death of any Clan Member

In other areas, the death of any individual of the clan - man, woman or child - may mean that their clan's area of reef will be put under taboo, or closed to all harvesting for a year or so – this taboo is also associated with customary practices following ritualistic protocols.

Figure 2: A taboo indicator showing the fishing area closed as a memorial to a deceased clan member on Epi Island.

Grade Taking of a "Big Man"

In some areas, the practice of grade taking as part of ascending a social and spiritual hierarchy is accompanied by taboo being put on terrestrial, freshwater or reef resources for anywhere from 1-4 years. This is also associated with very strong custom practices like multiple pig killings, kava drinking, dances, songs, feasting and other rituals.

Yam Season

In many areas, the reef is annually closed to harvesting of all or some resources during the summer months at around the time of yam planting, and opened for New Yam Celebrations

approximately 6 months later. See discussion below on 'Seasonal Considerations in MRM'.

Circumcision

Circumcision rituals were also associated with putting taboo on an area of the sea; this was generally for a short duration, as short as 1 month.

Taboo Areas

In virtually every area of Vanuatu there were formerly numerous coastal taboo places of spiritual significance for which people had the greatest reverence and would respectfully avoid the area and not go fishing or collecting there. These taboo places were also found in the bush and in freshwater areas and were often areas associated with high biodiversity.

"To Allow Resources to Regenerate"

In some areas it is said that in the old days, there were taboos placed on the reefs to allow some specific species, such as a preferred type of shellfish or octopus to recover. However, these taboos were never 'static', but were accompanied by the use of ritual and *kastom* to draw upon the spirit world to ensure the resources would increase.

In Preparation for Specific Feasts or Other Customs

In many areas there were specific feasts or other customs arising, such as the harvest and exchange of fish or other marine resources to inland villages, which were preceded by a taboo being placed on the reef. During this time, the shaman would perform elaborate rituals invoking the power of the spirit world to make the fish plentiful and thus ensure a good catch.

The common theme to all of these closures was that they were highly ritualized and intertwined with the spirit world. It was this spiritual context that primarily ensured compliance by the people with these taboos. Punishment for breaking these taboos included retribution from the spirit world as well as the Chief imposing fines of pigs, kava, woven mats and other culturally significant articles or even death as an additional deterrent.

It can be seen from the number of *kastom* related area closures listed above that there would have been quite a few areas closed at any one time. When travelling through north Pentecost in central Vanuatu a few years ago, the author was informed of a total of eleven marine closures associated with grade taking ceremonies. These closures formed a mosaic of spatial-temporal refugia across the top end of this island that protected various types of marine habitats.

Given that there were always people taking new grades this mosaic of refugia and thus their management value would continually be perpetuated, varying in space and time. The same would be true for all other areas of Vanuatu that practiced the other culturally related taboos given above. Perhaps this was the traditional counterpart methodology to achieve the modern scientific concept of optimum sustainable yield through controlled harvesting rates in that through this system all areas would be fished but also be periodically closed in order to recover.

Seasonal Considerations in Marine Resource Management

In most areas of Vanuatu, much of the nearshore marine resources harvested came from reef gleaning or other fishing activities on low tides. Therefore an important environmental constraint regarding the harvesting of intertidal resources is the seasonal variation of the tides. The tides in Vanuatu occur twice daily (i.e. are semi-diurnal - two lows and two highs) while the height difference between the two highs and lows is markedly different. The overall maximum range of the tides is roughly 1.5-m.

The tides in Vanuatu reach their annual lows during the southern winter months and are at their highest during the summer months. The spring low tides of the winter months, peaking in June/July, are generally down to zero in height, or are negative tides, and this low occurs at midday. The tides never get as low as they do at the spring tides of the winter months at any other time of the year, either by day or night.

The reefs are therefore exposed optimally for gleaning purposes during daylight hours in the winter months. Thus, the environmentally determined season for reef gleaning is during the winter months, starting in April/May and finishing in September. These annual lows are also the optimal time for employing communal fish harvesting methods using the traditional leaf sweep, fish drives and use of fish poisons as these techniques also depend upon good low tides.

These annual winter daytime tidal lows are also coincident with the months of the ripening and harvest of Vanuatu's most esteemed root crop, the yams. The ripening of the first yams are celebrated annually in New Yam Ceremonies, (which are analogous to the European New Year celebrations) and are still a significant part of the annual cycle of island customs. The annual New Yam Ceremonies serves to ritually open the yams to harvesting, which will then continue throughout the winter months. A

preferred method to prepare the yams for these communal Celebrations is to make traditional puddings by grating the yams and baking them in the earth oven, often sweetening them with coconut crème. Included in these puddings are delicacies such as octopus, giant clams and other shellfish, lobster or fish, depending on the area, gleaned from the reefs with the annual return of the low tides.

The coincident timing of the lowest annual tides and the maturation of the yams led many areas of Vanuatu to have the custom of closing their reefs, or at least most of its resources, at the time of planting yams (September/October) until the harvesting of the new yams in April or so. The actual time of closure varies from area to area from clearing the yam gardens in preparation for planting, to planting time, to when the planted yam first shoots. This annual half-year closure is a management strategy to ensure a good harvest from the reefs for the New Yam Celebrations and for use in preparing yam puddings during the subsequent months of harvesting later maturing yams through until September.

This annual half-year closure of the nearshore reefs also coincides with the hot summer months, the time at which it is believed most of the fish and invertebrates targeted for subsistence from the reefs are at their spawning peaks. This annual closure thus has obvious and highly significant management value for the marine resources.

Some areas would then turn to the wild birds and fruit bats found on the islands as a source of meat during these hot months when the reef was closed. Also, during the hot season while the nearshore reefs were inaccessible for reef gleaning, flying fish would come inshore and thereby become more accessible. There are a number of methods used to catch these pelagic fish, from hooks and gorges in the Banks Islands down through the islands of Pentecost, Ambae, Maewo to traditional lights (burning coconut fronds) and small dip nets on the southern island of Futuna. Some of the southern islands would also target the other pelagic fish, the tunas that followed the flying fish inshore during the hot season. These pelagic fish offered an alternative source of fish protein during this time when much of the nearshore reef was closed.

On other islands there was no blanket taboo, *per se*, on the reefs during the hot season, but as the tides were not low enough for effective reef gleaning, very little if any was done, thus taking the pressure off the reefs during this season. Besides, this was the season to focus on the all-important production of yams and other garden staples. The hot season is also the rainy season and therefore the time when everything in these tropical islands, including garden crops, grows prolifically. The hot rainy months when the tides weren't very low were thus the time to focus on food production from the gardens.

An important factor which also contributes to this seasonal management strategy is the aforementioned taboo to eat if you intend to go to the yam garden, including certain types of fish, octopus, spiny lobster, turtle and turtle eggs.

Another consideration in this annual closure is that many areas of Vanuatu note an increase in ciguatera reef fish poisoning (caused by a proliferation of the epiphytic dinoflagellate *Gambierdiscus toxicus*) during the hot summer months. Serious cases of fish poisoning are highly debilitating, and as the toxin accumulates in an individual over their lifetime, people become more and more sensitive to it. This consideration may well be part of the reason it was prudent to avoid eating fish from the nearshore reefs during the hot summer months and may have contributed to the initiation of an annual taboo on nearshore reefs during this time.

Also, the occasional unexplained occurrence of ciguatoxicity in reef fish not normally affected remains enigmatic in many areas. Outbreaks may occasionally occur and affect not only the usual species known to be affected (generally the larger carnivores of particular species) but smaller herbivores as well. Some areas have had inexplicable ciguatoxicity affecting almost all reef fish and lasting for many years. This situation ultimately results in a forced closure or a 'natural taboo' on harvesting reef fish in the area until the ciguatera event is known to have passed. It thus imposes a severe restriction on fishing pressure during these events resulting in the conservation of fish resources.

In some islands, for example on Tanna, it is said today that people were 'vegetarians' and that they only ate meat ritually on special occasions. They consider that to eat too much meat regularly is unhealthy and results in a shorter life. This sounds much like the modern medical advice that we hear today. Deacon (1934:16), an early ethnographer comments on what he observed on Malekula, "The principal occupation of the people is gardening, for their diet is predominantly a vegetarian one, yams being the staple food-stuff. In the coastal villages, however, fish are caught and shell-fish and crabs are collected, while everywhere wild pig is hunted; but the products of these

activities are regarded as tasty extras to the usual vegetable dish, never as a basis of a meal."

FACTORS AFFECTING COMPLIANCE WITH TRADITIONAL TABOOS.

Ritualized Sanctification of Traditional Closures

One of the striking features of these ancient *kastom* taboos is that there is a high level of respect for them. The main reason for this level of respect is the strong cultural context of these taboos including the deeply rooted belief that the breaking of a taboo will result in the supernatural intervention of the omniscient ancestral spirits resulting in the demise of the transgressor, or of someone close to them. It is as if the ancestors remain in spirit form to ensure that the '*kastoms*', (and therefore the conservation of resources) are maintained by the following generation; the ancestors remain as a sort of conscience for subsequent generations. These beliefs are still part of the island consciousness in many areas of Vanuatu, despite over 100 years of Christian influence.

While the traditional cosmologies continue to shape much of Vanuatu's cultural landscape, there has been some erosion of many of these *kastom* beliefs and practices in most areas. This has consequently had a detrimental effect on the management of resources. Comments by Elkington (1907:181) who traveled through Vanuatu around the turn of the last century illustrates this process underway at that time regarding northeast Malekula "Turtle fishing is not gone in for much, as the natives are superstitious about the turtle, and civilization has not yet been able to dispel their fears. One of the chief ones is that the eggs are sacred and may not be eaten. But one by one their superstitions are going, for they see how the white man prospers in spite of scorning all their sacred ideas, and that now and then makes them courageous enough to break through the barrier and when once a superstition has been found untrue, they are not slow in testing another, if by challenging it they can see any gain for themselves." This process of the gradual erosion of traditional beliefs is still underway today in Vanuatu but is far from complete. The ocean swell of *kastom* still runs deep in most areas of Vanuatu.

The initiation of these ancient closures or taboos are accompanied by elaborate custom rituals, including pig killings, kava drinking, dancing to traditional drum rhythms and songs, and the erection of taboo leaves, all of which have a deeply rooted and heavy cultural significance for island people. These rituals all serve to invoke the power and the blessing of the ancestral spirits in their participation in these taboos. These taboos are thus in the realm of the sacred, as they involve the power of the spirit world.

In fact, the word 'taboo' is a vernacular term from Oceania and is translated locally into English as 'sacred' or 'holy'. (The OED defines Sacred as 'consecrated or held dear to a deity....made holy by religious association, hallowed...sacrosanct'.) These consecrations, through the enactment of elaborate rituals and invocation of the power of the ancestral spirits to initiate and oversee these taboos effectively consecrate the taboo, (make it holy, sacrosanct)., and are no doubt responsible for the high level of compliance found for these taboos still today.

Historical Impacts Which Affect Traditional Management Practices

In many areas, some of the ancient customs associated with the initiation of marine taboos have been lost or severely eroded, primarily due to the impacts of European contact. There are a number of historical factors which have contributed to this erosion since European contact and are outlined briefly below. Although they may be broken down into separate categories many of them were occurring simultaneously and thus were all closely interrelated with potentially synergistic effects in undermining ancient traditional ways.

Massive Depopulation

Massive depopulation of Vanuatu occurred as a direct result of the arrival of Europeans. Coastal people were generally the first to encounter the Europeans, (the whalers and Sandalwooders who arrived by ships starting in the early 1800's) and thus were the first to be exposed to the new diseases (smallpox, diptheria, whooping cough, influenza) that they had no immunity to. The 'Blackbirders' (labor traders) also targeted coastal areas starting in the 1860's to recruit labor for the cane fields of Queensland and other places like Fiji, Hawai'i and New Caledonia and thus contributed further to depopulation.

Those that returned from Queensland were often Christianized and spoke Pidgin or a bit of English. By the 1920's, the population of Vanuatu had dropped from an estimated pre-contact figure ranging from 500,000 to 1,000,000 inhabitants to only 40,000 due to the combined effects of European contact. This massive depopulation had an enormous cultural impact due to the loss of entire settlements (and cultural groups) in many areas as well as well as having a severe impact on the normal process of transmission of *kastom* knowledge between generations.

This dramatic drop in population starting in the early 1800's would have consequently resulted in a significant overall decrease in pressure on resources, including marine. The last two to three generations would have known relative times of plenty due to this prolonged reduced population pressure on resources. The old people of today all speak of the remarkable abundance of marine life in their youth, and the ease with which one could fill a canoe with fish and other seafood including turtles, giant clams and other shellfish. It is often under their guidance in their communities today that is highlighting the need for tighter management controls (taboos) so that future generations will also know what rich and diverse reefs are like. It is this older generation that has seen the abundance of the past and sparseness that is the future, if steps are not taken now.

Missionization and Christianity

Most of the early Christian missionaries, particularly the Presbyterians were highly intolerant of *kastom* and banned kava, numerous *kastom* ceremonies, dancing, and all other activities relating to *kastom* (Paton, 1911). The *kastom* use of the spirit world, which is a fundamental part of the taboo system as well as everything else in ancient times was labeled as the 'work of the devil' and outlawed by these early evangelists. Many forms of cultural expression were thus diminished and eroded in areas of strong Presbyterian influence. Anglican and Catholic, the other two main early denominations were often more tolerant of many traditional practices and the level of erosion was reduced in areas dominated by them. However, as noted previously, many of the underlying cosmological beliefs associated with *kastom* were not entirely eradicated, but their outward cultural expression often was. After all, the missionaries may have had great influence over what one did, but not over what one thought.

Traditional grade taking rituals, for example, a practice formerly central to the cosmology of much of northern-central and northern Vanuatu has been lost in many areas, with the exception of the islands of Ambrym, Pentecost, Ambae, Maewo and parts of Malekula where there has been an active revitalization of these practices since Independence in 1980. Big Men, who acted as High Priests in traditional society were sanctified and achieved their high status through very elaborate pig killing grade taking ceremonies, and as outlined above, the tabooing of marine (or freshwater or terrestrial) areas was in some areas a part of these rituals.

Also, it was these High Priests who had the right in most areas (in that they were sanctified) to set the taboos for all of the resources, including freshwater and terrestrial. With the loss of this Priestly class system and of grade taking ceremonies in many areas (which resulted in taboos being initiated in some areas) there was thus a void created in the setting of taboo and therefore the management of resources (as well as in numerous other aspects of traditional life).

Today in some areas, as observed on Gaua in the Banks Islands, the actual practice of raising tusked boars has dwindled to the point where the lack of pigs is the limiting factor in enacting the traditional setting of the reef taboos, as they were often an integral part of the initiation ceremony and/or the removal of the taboo. This lack of available pigs would indicate the general erosion of traditional practices, as the raising of tusked boars was a highly significant cultural practice for most areas of northern-central and northern Vanuatu in the past. It also means that the ancient traditional rituals, for example those required to properly initiate or remove, according to the rules of *kastom,* a marine taboo can no longer be performed.

Massive Migration

The introduced and mysterious diseases introduced by Europeans that rapidly decimated the population were interpreted by the people in context of the local cosmologies and thus believed to be the work of sorcery. The remnant populations of villages were then induced to consolidate to coastal missions where they were promised they would be safe from further sorcery and would have access to European medicines to combat disease.

Consequently, almost all of the coastal villages found today in Vanuatu are composites of remnant populations of numerous different *nasaras* or clans, which formerly lived in widely dispersed settlements consisting of extended families on their own ancestral lands. By formerly maintaining such a decentralized pattern of settlement, clans lived close to optimum gardening areas within their traditional territories, where they also had exclusive access to various terrestrial and freshwater resources.

This pattern of settlement would have significantly dispersed the pressure on terrestrial, freshwater and marine resources over the entire area of an island. However, by the majority of the island's residents of the interior areas migrating to the coast, the demand on resources was, and remains, significantly concentrated in relatively small coastal areas. These modern, translocated, composite villages now often share common access to waters considered communal in the immediate vicinity of the village while the lands

and reefs surrounding the village are under the tenure of the *kastom* owners. The interior of most of the islands, the exception being Tanna, remains virtually uninhabited today. In some areas today, people have begun moving back to their ancestral homelands in the interior of the islands to avoid this coastal crowding and the attendant competition for good gardening areas and land disputes.

These changes in demographics also had serious impacts on the *kastoms* of these translocated villages. The numerous *nasara* which were grouped together as a result of this migration did not always share the same dialects, languages, customs or leaders. The homogenization of these composite villages often results today in a lack of cooperation and conflicts involving land and resource access as well as over leadership within these communities that in turn affect the respect for taboos and the management of resources.

Changes to chiefly lineages

In many areas, the chiefs of an area were replaced with a new chief appointed by the early missionaries. As the early missionaries often sought to undermine and destroy the traditional chiefly and priestly classes, (as it was often them whom opposed the missionaries and strove to uphold *kastom*), they found it expedient to replace them with one more to their liking. They would typically choose someone who had embraced the newly introduced Church as the new chief, as he was someone they wished to elevate in status. Those whom knew a bit of Pidgin or English and had adopted some Christian ways such as those returning from the Queensland sugarcane fields were sometimes chosen.

This new chiefly system often became hereditary and is a source of conflict in numerous villages today, where the new chiefly line appointed by early missionaries is being disputed by the original chiefly lineage. These internal community disputes often result in the taboos set by them today not being well respected (Hickey and Johannes, 2002).

Colonial Land Alienation

Starting in the 1870's numerous copra traders and planters, both English (from Australia) and French, (often from the nearby French possession of New Caledonia) arrived to purchase land, often for a couple of axes, some stick tobacco and some calico (cotton cloth). The individual who put an X beside his name on the contract may have had some *kastom* rights to the land in question but it is not likely they would have understood a European's concept of land alienation. Some French interests including the Government of France bought up vast tracts of land trying to tip France's claim to the island group in their favor. By 1905, this group had highly questionable claims to over 55 % of the islands (Van Trease 1984). The subsequent sub-division and sale of these lands to new French settlers led to numerous land disputes with these opportunistic interlopers, with more than a few of these settlers being killed.

In part due to the increase in violence relating to land disputes, also on the rise between European settlers, a Convention was signed in 1906 by the two colonial powers to jointly administer the islands. In 1914, this was amended to establish a Joint Court, also called the Condominium, primarily to deal with the land disputes including the registration of European land claims. This system of registration favored and legitimized the often dubious claims of the Europeans (Von Trease, 1984).

As these settlers favored the flat coastal plains for their plantations in addition to safe harbors for exporting their copra, cacao and coffee it was primarily the flat coastal areas which were initially alienated. These areas were often the areas of greatest fringing reef development, as opposed to the steep volcanic slopes that supported very limited nearshore reef development. Although they did not legally have control over the reefs (they in fact had dubious legal claims over the land) many of them apparently asserted their authority over them effectively alienating many reef areas. This large-scale alienation of land and extensive clearing for coconut plantations (for the production of copra) would have also had a significant impact on the reefs and freshwater systems themselves through erosion and sedimentation as well as on the traditional use patterns and *kastoms* associated with the management of them.

Many of these plantations also ran their own small ships around the islands to recruit labor for their plantations, as labor from other islands could not so easily return to their own land when they tired of plantation work. This helped the plantation owners overcome local labor shortages for labor intensive copra production. This presence of migrant workers in turn created additional problems as these people had different *kastoms*, yet would also look toward the reefs for subsistence needs. A number of the larger islands in Vanuatu today still have large remnant populations of the descendants of plantation workers from other islands from this period. These 'migrant populations' are sometimes a continuing source of conflict regarding the access and management of reefs

and other resources on islands, lands and reefs not their own.

It was these ongoing and escalating conflicts over land, particularly when the European colonists eventually began to clear the islands interiors for plantations that led to the Independence of the New Hebrides and the creation of Vanuatu, which translates as “Our Land”. The land and reefs were at that time returned to the indigenous custom owners and their descendants as well as provisions made for them to lease their land to non-custom owners (other ni-Vanuatu or foreigners) for development or other purposes. There is to this day no freehold title of land in Vanuatu.

The western concept of an individual owning land thus remains in the legal framework of the Republic as the legally binding leasing of land requires **a** ‘custom owner’ to sign over the land to whoever is leasing it. This western notion of individual ownership conflicts with the customary practice of clan custodianship of a territory and its resources with an inherent responsabilty to look after it for ones descendants. This results in considerable conflict and division amongst families within a clan as to who has the right to lease the land and thereby receive the economic benefits. As leases are normally from 50 to 75 years, these leases may also affect subsequent unborn generations.

CONTEMPORARY TRANSFORMATIONS OF THE ANCIENT MARINE MANAGEMENT & TABOOS

The contemporary transformation in historical times of the management of marine (and other) resources including the use of taboos has been an ongoing process of adaptation since the historical impacts documented above began and continues into this more recent period of the Republic of Vanuatu’s nation-building. It is truly a testament to the adaptability, resilience and capacity of this ancient system of resource management to have continually been transformed throughout the process of upheaval associated with the arrival of Europeans and on into today’s pressures of development and even globalization.

These transformations emerged in response to massive demographic shifts which occurred while many aspects of traditional cosmologies were being eroded and displaced by Christian beliefs and traditional economies of barter and exchange were gradually displaced with the cash economy ushered in by the arrival of the Europeans. Consequently, these taboos have gradually become increasingly associated with the quest to earn money from the commercial harvest of reef resources. This represents a marked shift from the original predominantly cultural context use to manage reefs, a context that was found to significantly enhance compliance.

Some of the earliest transformations of taboos were associated with the management of the islands first commercially exported commodities of dried sea cucumber (beche-de-mer), trochus and green snail when European, American and Asian traders entered the region and initiated the era of commercial fishing for overseas export. Beche-de-mer, never a popular food item in Vanuatu or other parts of the Pacific was purchased in the region for export since the early 1800’s. Trochus on the other hand, has been targeted for subsistence purposes since the Lapita people’s arrival some 3000 years ago and at some later point became popular as well for making decorative armbands with cultural significance. It began to be targeted commercially for export sometime in the early 1900’s. Today, it is the single most commercially significant reef mollusc sold in Vanuatu by villages for export; it now sells for around 300 vt/kg (about CDN 4.50/kg). Green snail, a larger marine gastropod used for inlay in Asia, until recently fetched 2000 vt/kg (about CDN 30.00/kg); one good-sized green snail can weigh a kilogram. With the recent Asian economic decline this price has dropped off significantly as has its demand.

The motivation to manage these resources well in order to generate revenue in the rural areas is thus quite high. It is not quite clear how these resources were managed in the late 1800’s, early 1900’s, but older men in areas where these resources have been fished for many generations relate how taboos were used to help them recover after continuous harvesting left the stocks depleted. Today these taboos for commercial purposes are no longer accompanied by any pig killings or other rituals of cultural significance, except in some areas the posting of a taboo leaf indicator, typically a *namele* (a cycad frond) used in the central and northern islands to indicate a taboo. In some areas the *namele* will be placed with a trochus shell on it to indicate that it is trochus being banned. In many areas today the use of the *namele* is no longer used for trochus closures but the reef is left unmarked after a verbal declaration.

In areas of Vanuatu where the ancient traditional taboos are still practiced today, people state that they have observed their conservation value over time. That is, that when an area was closed to harvesting during a traditional taboo, resources, including trochus, beche-de-mer and green snail were later observed to become larger and more abundant,

as well as fin-fish being more easily caught as they were "less wild". That is, that the fish tend to lose their wariness of fishermen during periods when the reef is under taboo and therefore not being fished. When the fishermen return, the fish are much more easily caught.

For island people intimately associated with their environment, it is not too surprising that the effect of these taboos would be clearly observed and recognizable. In fact, it would be surprising if they did not notice the effect. They then took that knowledge and applied it to the conservation of commercial resources such as sea cucumbers, trochus and green snail that were being harvested and exported starting in colonial times.

Thus, the ancient system of putting a taboo as a customary practice rather than expressly a conservation one, was transformed into a modern management method to expressly protect particular marine resources in the quest to earn some cash. The context had changed from a cultural one to a commercial one. The way the taboo was initiated and implemented was also gradually transformed. Less emphasis was placed on the ritual formerly associated with the ancient custom taboos (such as pig killings) and the fines for breaking these taboos became mainly monetary, not items with cultural significance such as woven mats, kava or pigs as with the *kastom* taboos.

Essentially, a new custom was being invented through the transformation of an ancient one, one deeply rooted in peoples' cosmologies, to adapt to the social and economic changes that resulted from the arrival of European influences. Unfortunately, the respect for these more profane taboos, now normally referred to as 'bans' in many areas to denote this transition, has also significantly declined.

This also is a point made by older chiefs knowledgeable in *kastom*, that the system to protect commercial resources used today is like 'playing' with the power of *kastom*, i.e., the proper ritualization and spirit of a taboo. These chiefs are concerned because these contemporary taboos or bans are being so regularly broken compared to the ancient ones, that they serve to undermine the true power and respect of *kastom*. These *kastom* purists no doubt fear the eventual loss of respect for the ancient taboos as well, as a consequence of this gradual process of transformation from the sacred to the profane.

Since Independence in 1980 there has been a significant increase in the use of taboos to restrict harvesting of commercial products like trochus and in the use of introduced fishing gear to manage the reef resources in Vanuatu. This in part was due to the land and reefs going back to the indigenous landowners at Independence and this being enshrined in the new Constitution. In fact, as discussed above, the main issue behind the independence movement was land alienation. The increase in population and the consequent increase in competition for resources has also provided the impetus to gradually increase management efforts.

Newly independent Vanuatu was also a period when people were again proud to revive and transform some of their ancient customs and to openly express them, once the shackles of colonial rule and oppression had been cast off. One must remember that there was very little, if any, appreciation of the value and merits by Europeans of traditional knowledge and practices during colonial times. Even most 'New Hebrides natives' at that time had been convinced that the European ways were superior in all regards, and that their *kastoms* were part of their heathen past, a time still referred today as "the time of darkness", a term obviously imposed by missionaries.

Cooperative management initiatives

In the early 1990s the practice of putting taboos or reef bans received a significant boost when the Vanuatu Fisheries Department endorsed them in order to enhance the level of community management of trochus. In part, this was to protect transplanted juvenile trochus on select reefs as part of the Department's trochus hatchery program. The research section of the Department initiated a program of cooperative management for trochus whereby they would provide biologically relevant information such as growth rates, lifecycle information and size at sexual maturity to villagers (Amos, 1993).

This information was made available to local communities such that they could draw upon it to improve the timing and duration of their trochus taboos while, at the same time, appreciate why the Department had introduced minimum size limits. Understanding the rationale behind the size limits was found to greatly enhance compliance with them, once villagers understood that respecting the size limit allowed their trochus to spawn for many months before being harvested.

This cooperative management approach rapidly expanded to cover green snail and beche-de-mer to assist villagers with the management of their other most commonly commercialized nearshore resources. Following Johannes' (1998a) recommendations, the Department's Extension Services were used to broaden the

scope and delivery of these cooperative management efforts. The Vanuatu Environment Unit, Cultural Centre and some NGOs also became actively involved in promoting the use of traditional and 'contemporary' taboos (i.e., those used for the protection of commercial resources) and in furthering cooperative management efforts to reach more remote communities. Through this process, because it was based on *kastom* and *because it works*, the use of taboos on fishing gear and areas to manage virtually all resources of the nearshore reefs, including those used in subsistence, has become very common, very popular and generally very successful in managing nearshore marine resources in virtually all areas of Vanuatu.

The success of this form of community-based management may be attributed to the fact that; a) resources **will** recover as part of a natural process if left undisturbed for a sufficient period (provided they haven't been completely decimated and the environment remains stable; b) CMT is formally recognized by the Government so communities have the legal right and autonomy to make their own management and enforcement decisions based on their local knowledge of the resources and environment; c) under CMT, the benefits of sound management decisions and restraint on the fishing grounds are realized by the resource owners themselves thus providing the incentive to manage well; d) respect for *kastom* and traditional authority upon which this system of management is based although it is showing signs of stress, is still relatively high in most areas of Vanuatu; e) the well directed assistance of government and ngo's in furthering cooperative management; ie, providing access to biological information relevant to management for villagers to draw upon and integrate with their local knowledge; f) the village and their chiefs decide in the end what the management regime will be taking into account their own unique kastoms, marine resources and socio-economic needs and they monitor and enforce it themselves; this system must represent the ultimate in decentralized management;

A survey of the villages originally surveyed by Johannes in 1993 and surveyed again in 2001 by Hickey and Johannes (2002) indicated that the number of village-based marine resource management measures (taboos) more than doubled in the 8 years between surveys. And the trend is continuing. Of concern however is that an increasing number of these taboos no longer have much or any *kastom* association or ritualization to anchor them in the deeply rooted traditions of the past. As mentioned, many islanders now refer to them simply as 'bans' to make this distinction.

In fact, this trend has more recently taken yet another step away from the protection of resources with the inclusion of *kastom* as its cornerstone. The concept of a MPA is well known to most whom have spent time in an industrialized society. These are generally 'no-take zones' designed to compensate for often extreme over-fishing and environmental degradation which now characterizes most if not all industrialized country's waterways. Locking up a bit of nature in a museum-like no-touch area is meant to maintain a bit of real nature in the form of Marine Parks or MPA's while the rest can often be degraded and over-fished.

A large regional environmental organization now sponsors workshops in Melanesia, and other parts of the Pacific to promote MPA's as if they are oblivious to the context of thousands of years of marine resource management in the Pacific. Even the term CMT, which was closer to describing the reality of marine resource management in Melanesia, as described above for Vanuatu, and a popular term only a few years ago has been left behind for the new and very foreign concept of a MPA.

More recently in Vanuatu, well-meaning overseas volunteers have arrived and attempt to set up MPA's as well as terrestrial protected areas. The idea of simply reviving and supporting traditional practices relating to resource management seems to be sometimes overlooked, and instead inappropriate models from industrialized countries are sometimes imported and supported by overseas donor agencies more comfortable and familiar with these models. Truly, from the sacred to the profane.

Consequently, chiefs are facing new challenges in the maintenance of respect for their leadership and for the taboos used to protect the resources. These challenges are greater in areas where internal community disputes remain unresolved. In fact most of these disputes stem from the colonial impacts outlined above. In summary, they are most often related to;

Land Disputes - relating to the massive depopulation
and migration of peoples to the coastal settlements or missions many generations ago means actual territory borders are not always apparent today; also when it comes to leasing land, conflicts arise from the gap between customary law and western law, namely one individual signs the lease (and gets the benefits)

from land customarily held by an extended family of larger group;

Leadership Disputes – relating to missionaries changing the chiefly lines many generations ago that are no being challenged in many areas wishing to re-instate their ancient chiefly line; as well the translocation of many different nasara's (clan based settlements) into composite coastal villages during the missionization process often manifests in internal rivalries over chieftainship;

Religious and Other Divisions - many communities are divided amongst different Christian faiths, particularly with the recent advent of numerous new faiths, many of which openly scorn *kastom*; some communities are also internally divided due to different political affiliations; some communities also have internal divisions relating to predominantly Anglophone or Francophone alliances as vestiges of the condominium colonial rule by France and England;

'Independence' Disputes - when the land and reefs were given back to the customary owners at Independence some families took this to heart and interpreted this to mean that the chief no longer could make any management decisions regarding their land or reefs including the placement of taboos, as was done in the past; in fact there is an additional article also enacted at Independence that states " The rules of custom shall form the basis of ownership and use of land....".; this would still 'legally' keep the chiefs in the management loop in areas where this was the *kastom*;

The peri-urban areas of Vanuatu face perhaps the most serious challenges for maintaining respect for resource management related taboos in that they are generally more exposed to the cash economy and western education; two additional factors cited in undermining this respect. The Fisheries Department has thus seen a dramatic increase in the number of requests for assistance from chiefs in enforcing their taboos in the last 5-6 years.

The need to back up the rulings of the chiefs in Vanuatu is not isolated to the use of conservation taboos. Numerous other issues affected by the erosion of traditional leadership and cultural practices have begun to affect other areas of life, especially in the urban areas. The Government is thus contemplating introducing some sort of legislation to formalize support for the chiefs' rulings from their traditional village courts, but a clear path for Government to follow has not yet emerged.

One approach the Fisheries Department is considering is the passing of a "Closed Area Act". This would, upon a community's request, allow the Director of Fisheries to enact a legally enforceable closure for conservation purposes. The Department feels that this will serve the function of backing up the chiefs and their peoples' wishes to maintain a closure or taboo in areas where it is not enforceable through traditional means. The Environment Unit has included a 'Community Conservation Area' in a new Environment Act recently passed (but not gazetted) to also provide formal state support to community's wishing to protect areas but are not able to do so soley through customary means.

The increasing gap between the ancient taboos with a strong cultural context that clearly correlates with greater respect for compliance and the contemporary transformations or modern 'bans' (particularly the imported concepts with no cultural context) and an increasing trend in non-compliance reveals a clear trend from the sacred to the profane. This has resulted in some areas initiating a counter-trend back towards *kastom* in an effort to maintain respect for taboos.

These communities have undertaken to revitalize, transform and invent rituals associated with the placing of reef taboos, and thereby keep them in the realm of the sacred and rooted in the beliefs of their ancestors and thus ultimately more respected. This is done by re-enacting some of the elaborate rituals upon the initiation of these taboos, including the killing of pigs for a communal feast and placement of the taboo leaves associated with the cultural area.

Such a taboo initiation would be presided over by all of the local chiefs and witnessed by all of the villagers in the area. A custom fine for breaking the taboo is also specified at the outset; this would consist of pigs, mats, kava, shell money or other articles of custom significance. This is in contrast with the cash fine normally levied for many of the commercial taboos. However, if pigs are killed at the initiation, then following most areas customs, pigs will also be part of the fine. Fining people for breaking a taboo in articles of custom significance is obviously much more profound than people being fined in cash.

Another modern transformation seen is the use of Christian blessings on a taboo. Often there will be a combination of both custom and Christianity involved. This will help to appeal to all, no matter which belief system individuals in a community may lean towards. It also facilitates the inclusion of both powers, making

it more powerful, whilst endeavouring to satisfy all community members. Some areas also integrate modern administrative protocols to help formalize and ritualize the initiation of a taboo.

For example, on southern Malekula, a Memo of Understanding between all nearby clans was used to help ritualize the initiation of a long term reef closure, and as a means to maintain cooperation and respect from the clan members the MOU included, "That all marine wildlife in the Sanctuary belongs to God" and further, "That the Sanctuary is like a church, to maintain the Christian faith in the creator and everyone should value what it stands for."

The initiation of this Sanctuary also included blessings from a church elder and a pig killing ceremony, kava drinking and involved the placing of traditional *namele* leaves to indicate and oversee the taboo. The initiation of this long-term tabu was indeed a grand fusion of *kastom*, christianity and administrative protocols. Respect and compliance for this Sanctuary has remained high, as have the management and fishing benefits, after many years of operation.

The emergent trend is that there now appears to be four ways of empowering taboos in Vanuatu. The method used depends on how much respect for custom and/or the Church there is in the area. These four methods of empowerment / enforcement include the *kastom* way, the use of both *kastom* and Christianity, the use of just Christianity (rare) and the emerging use of the state to enforce the taboos. There is also the potential synergy of using all three incentives, *kastom*, Christian and state to empower taboos. The inclusion of the state may assist in compliance, but decreases the degree of decentralization and autonomy communities have enjoyed for centuries in managing their own affairs, including resource management. It also incurs significant financial burdens to the state, which it previously never had.

The use of the state has already begun unofficially, with the police often lending a hand to persuade repeating transgressors of the taboos to pay more respect to them. This is most commonly occurring in the peri-urban areas where custom has been the most seriously eroded and there are police available to take this sort of action. Most rural communities have no police readily available nearby; in fact most islands have no police on them at all, a tribute to the chiefs and the capacity of their customary laws in regulating the island societies, as they have done for thousands of years.

Vanuatu today is increasingly facing a crossroads in trying to reconcile both traditional values and the ancient rhythms of life and its emergence into the economic development expected of modern statehood in a rapidly changing global arena. For example, structural adjustments were recently introduced starting in 1997 funded through 'soft-loans' by the Asian Development Bank to reform Government policies and attempt to usher Vanuatu into the realms of globalization. At the same time there is enormous external pressure for accession to the WTO.

The pressure to 'develop' and join the cash economy under the banner of globalization is finally being felt even in rural Vanuatu; an area of the world that had been close to self-sufficient for 1000's of years. Now even island people living off the land are expected to compete on even terms with the industrialized nations of the world as governed by the WTO. These factors are sure to increase the pressure on the limited resources and fragile environment of these small tropical islands as well as putting further pressure on the traditional systems of management that have served so well for so long.

Whatever fork in the road Vanuatu decides to take, it seems clear that if the customs and values associated with the ancient traditions can be supported and maintained by some means through this process of westernization and globalization, that the management of resources and therefore the people of Vanuatu will be that much better off, as will their descendents. If Vanuatu can manage to maintain its relatively pristine islands, vibrant cultural diversity and smiling, genuinely happy people into the future, the people of the wealthy industrialized nations will no doubt pay handsomely to come and visit one of the few remaining places on the planet where this is so.

Parallels in Canada – from Sacred to Profane

By way of comparison, there would seem to be a parallel with what has happened in Canada where the resources of this country were formerly managed by the First Nations. They too seemed to follow a natural rhythm of harvesting and consumption based on their cosmologies, which also embraced a conservation ethic based on respect and on the limits of nature, and which are also in the realm of the sacred. This contrasts starkly with the profane approach undertaken by the Canadian Government which apparently relies primarily on scientific models of management and often seems to ignore much of the richness and usefulness of the TEK held by the First Nations regarding their resources. It would seem that

the conservation of resources in Canada could benefit significantly by the adoption of a cooperative management approach, as seen in Vanuatu. This involves the integration and application of both scientific and traditional knowledge like the rich corpus of TEK available to the cooperative conservation of resources. It also involves the devolution of much of the decision making and data collection to the communities residing in the area, and thereby to the ones most intimately associated with and dependant upon the resources. It seems rather wasteful to ignore the thousands of years of knowledge acquired by the First Nation peoples about the resources that could be put to work to conserve them.

The advantages of this synthesis of traditional and cooperative management approach found today in Vanuatu can be summarized in the seven C's.

The Seven C's

Communities - This system of traditional management is community based. Those most intimately associated and knowledgeable and dependent on the resources have autonomy over management decisions. This is common sense!

Conservation - Most island people of the Pacific have been successfully managing the limited fragile resources of small tropical islands for thousands of years. Their conservation methods have proven themselves through the test of time. Europeans living on large continents have only discovered the limits of the resources and the need for conservation in the last 40 years or so. Science, while a powerful tool, is only beginning to get a handle on the environmental impacts of human activities and is still struggling to find workable methods to conserve resources. The cooperative management approach helps traditional conservation methods to adapt to contemporary issues like modern gear, changing social conditions and the commercialization of resources.

Counterparts - In fact, all of the traditional methods have their counterparts in the modern western approach. Closed seasons, gear restrictions, closed areas and limited access were all traditional methods. Europeans have just started to learn to use these relative to Pacific Islanders.

Capacity - It is clear that the traditional system has the capacity to manage and conserve the marine resources while reducing conflict amongst resource users and ensuring a reasonably equitable distribution of benefits. This is clear from the relatively pristine nature of the reefs still found in most areas today after three thousand years of use.

Cooperation - This system is based on the collective cooperation of the community members, fishers and resource owners for a common goal. Also, in cooperative management there is good cooperation between the rural communities and the Fisheries Department. This has been achieved through the development of respect and trust over time. This then allows for the two to work together to refine the traditional system and to adapt it to the modern reality of commercial exploitation, social changes and the introduction of modern fishing gear.

It's Cool - because it's by the people for the people, and it's free. It costs the government very little in terms of monitoring and enforcement as the communities do this.

Canada Seems to Lack the Last Two

Cooperation seems to be replaced by *Conflict* in Canada for the most part. The recent news item 'Burnt Church in New Brunswick' over lobster fishing rights would highlight this. A police boat literally drove over a small First Nations boat forcing the occupants to jump into the cold waters in fear for their lives.

That's Cowboy…

After some hundreds of years we really have not progressed much beyond the old Cowboys and Indians mentality. It's time for the Canadian Government to reassess its management approach, and to initiate the necessary steps to build trust and respect with First Nations communities and get it back to cool and cooperative. We would all benefit, and so would the resources.

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REFERENCES

Allen, J., Gosden, C., White, J.P. 1989 Human Pleistocene adaptations in the tropical island Pacific: recent evidence from New Ireland, a Greater Australlian outlier. Antiquity 63:548-561.

Amos, M 1993. Traditionally based management systems in Vanuatu. SPC Traditional Marine Resource Management and Knowledge Information Bulletin 2:14-17

Bedford, S.H. 2000. Pieces of the Vanuatu Puzzle:

archaeology of the North, south and centre, Volume I: Doctoral Thesis, Department of Archaeology and Natural History, Research School of Pacific and Asian Studies, Australian National University, Canberra ACT

Dalzell, Paul 1998 The role of archaeological and cultural-historical records in long-range coastal fisheries resources management strategies and policies in the Pacific Islands. Ocean & Coastal Management 40: 237-252

Davidson J. 1956 Peter Dillion and the discovery of sandalwood in the New Hebrides. Journal de la Societe des Oceanistes 12:99-105

Deacon B., 1934 Malekula: A Vanishing People in the New Hebrides. London, Routledge and Sons.

Eliade, Mircea 1957. The Sacred & the Profane, The Nature of Religion. Harcourt Brace & Company. NY & London.

Hickey, F.R. and Johannes, R.E. 2002. Recent evolution of village-based marine resource management in Vanuatu. SPC Traditional Marine Resource Management and Knowledge Information Bulletin.14: 8-21

Irwin, Geoffrey,1992. The Prehistoric Exploration and Colonisation of the Pacific. Cambridge University Press

Elkington, E. Way, 1907. A & C Black, Soho Square, London

Johannes, R. E. 1998a. Government supported, village-based management of marine resources in Vanuatu. Ocean and Coastal Management Journal 40: 165-186.

Johannes, R. E. 1998b The case for data-less marine resources management: examples from tropical nearshore fisheries. Trends in Ecology and Evolution. 13(6): 243-246

Kirch, Patrick Vinton 1997. The Lapita Peoples - Ancestors of the Oceanic World. Blackwell Publishers Inc.

Paton, J. 1911 Missionary to the New Hebrides. Hodder and Stoughton, London

Spriggs, Matthew 1997. The Island Melanesians, Blackwell Publishers Inc.

Tryon, Darrell, 1996. Dialect Chaining and the Use of Geographical Space. In Bonnemaison, J., Kaufmann, C., Huffman, K., and Tryon, D., editors, Arts of Vanuatu, pp 170-181, Bathhurst, Australia. Crawford House Publishing

Von Trease, Howard 1984 The History of Land Alienation *in* Land Tenure in Vanuatu edited by Peter Lamour, Institute of Pacific Studies, University of the South Pacific

ACCOUNTING FOR THE IMPACTS OF FISHERS' KNOWLEDGE AND NORMS ON ECONOMIC EFFICIENCY

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ABSTRACT
Developing the theoretical links between the knowledge of fishers and socieconomic outcomes of its use is important if fishers' knowledge it to be taken seriously by policy makers. Having a theoretical basis that accounts for fishers' knowledge allows for rigorous approaches to marine ecosystem-based policy development that incorporates both social and ecological variables in management experiments. Social interactions that facilitate the development and communication of fishers' knowledge can improve aggregate economic performance by increasing productivity, reducing the risk of 'free-riders' engaging in opportunistic behavior, and encouraging the development of norms that support mutually beneficial collective action. The combination of (1) the social structures and protocols that facilitate predictable cooperative behavior and (2) the values that individuals hold, which predispose them to cooperate with each other, is known as *social capital*. Social capital theory is useful for addressing pragmatic questions about how to target and strengthen social structural variables that most increase the likelihood of successful collective action. When considered as a variable affecting fishery sustainability, social capital can also be used for comparative policy assessments and help address questions of how to devolve governance to comanagement systems that maximize efficiency.

INTRODUCTION
The use of fishers' knowledge has been hypothesized to facilitate effective fisheries management by utilizing context-specific information not readily available to external fisheries managers (e.g. Johannes *et al.* 2000) and increasing the legitimacy of, and compliance with, fishery management rules (e.g. Costanza *et al.* 1998). The need to incorporate fishers' knowledge seems to be especially important in tropical reef fisheries where our knowledge of ecological systems is relatively rudimentary (Jennings and Kaiser 1998; Johannes 1998) and where management organizations are perennially short of resources and expertise (e.g. Chakallal *et al.* 1998; World Bank 2000).

To be taken seriously in fisheries policy decisions, there needs to be a solid theoretical construct that explicitly links fishers' knowledge to social and ecological benefits that arise as a result of its use. In particular, it is important to link the use of fishers' knowledge to economic performance, because of the emphasis of economic performance in public policy decisions. A theory relating fishers' knowledge to economic outcomes would allow the development of testable research hypotheses and further the possibility for taking an experimental approach to fisheries policy development. Thus, an economic theory incorporating fishers' knowledge would facilitate the use of adaptive management approaches which are so important to marine ecosystem-based management (Walters 1997).

Social capital theory has been developed and refined by social scientists in a variety of disciplines to account for the effects of social context on economic performance (Putnam 1993; Woolcock 1998; Ostrom 1999; Rudd 2000; Woolcock and Narayan 2000). Increasing levels of social interaction tend to lead to: (1) increased knowledge about the world (which can reduce the costs of transforming ecological services into commodities for which humans hold economic value – food, recreational amenities, ecosystem resilience, etc.); and (2) increased knowledge about other people (which can increase trust or identify untrustworthy 'trading partners'), thus helping constrain individual opportunism. A variety of recent research has demonstrated the empirical effects of social networks and interaction on economic outcomes (Knack and Keefer 1997; Narayan and Pritchart 1999; Burt 2000; Uphoff and Wijayaratna 2000; Krishna 2001). Social capital theory offers a potential link between fishers' individual and collective knowledge and experience, and economic performance via social structure.

Knowledge about the world and the behavior of others affects economic outcomes by different paths, but both ultimately depend on fishers' knowledge. The importance of fishers' local ecological knowledge (LEK) has been increasingly recognized by fisheries scientists and managers (Johannes *et al.* 2000; Neis *et al.* this volume) for fisheries planning and management. While there is recognition that the

active engagement of local fishers can increase the legitimacy of management rules, and hence compliance (e.g. Costanza *et al.* 1998; Russ and Alcala 1999; Mascia 2000), the importance of the role of fishers' knowledge in the behavior of others is probably not fully recognized by most fisheries ecologists or managers. Knowledge about the behavior of others increases the likelihood of successful collective action needed to solve social dilemmas such as the 'Tragedy of the Commons' (Ostrom 1999; Rudd 2000), potentially reducing the transaction costs of fishery management and making community-based and comanagement governance systems economically more efficient than 'top-down' State management.

The purposes of this paper are twofold; firstly to provide an overview of social capital theory, emphasizing how social capital links fishers' knowledge to economic and ecological outcomes, and secondly to briefly examine how social capital theory can be applied to tropical inshore fishery policy analyses and research. My main conclusion is that social capital provides a theoretical foundation for accounting for the impacts of fishers' knowledge and norms on economic efficiency. As such, fishers' knowledge, and the social structures and institutions that facilitate building and communicating that knowledge, should become a much more important focus of policy research.

Social Capital – Background and Foundations

Social Dilemmas and Collective Action

Social dilemmas occur when it is in the short-term self-interest of individuals to behave in ways that result in sub-optimal benefits at the aggregate social level. There are incentives for individuals within society, for example, to 'free-ride' by consuming public goods and maximizing short-term self-interest at the expense of longer-term social interests. This problem often arises in fisheries. While it would be in society's best interest to maintain environmental quality – a public good – that provides a long-term flow of valuable ecosystem services such as reef fish production, collective action is needed to counter short-run incentives for individuals to overfish or engage in destructive fishing practices. Where collective action cannot be achieved, the results are often the devastation of the fishery and, in the worst cases, the destruction of the environmental base that could sustain future fishery productivity (e.g. McClanahan *et al.* 1997; World Bank 2000).

Public goods have two important characteristics: (1) society does not produce enough public goods because it is not in any individual's short-term best interest to do so; and (2) society as a whole would be better off if more of the public good were produced. Solving social dilemmas and conserving important ecosystem goods and services requires individuals to comply with formal or informal behavioral rules, incurring some short-run individual costs for long-run societal gain. Compliance with these rules by individuals can be viewed in terms of internal cost-benefit calculations that are influenced by the physical environment, market prices for products, formal rules and enforcement mechanisms, and social norms (Crawford and Ostrom 1995; Ostrom 1999). Institutions – systems of formal management rules and informal social norms (North 1990; Ostrom 1990) within which resource users function – influence incentives and, thus, compliance with fishery management policies.

The idea that social context matters for socio-economic performance is not new (see Portes 1998), but there has been a recent surge of research in the field, much of it with very important policy implications. Much of the interest, and controversy, can be traced back to a study of regional economic development in Italy by Putnam (1993). Putnam claimed that there were positive economic externalities – spillover effects – from mundane social interactions such as participation in choirs. Putnam argued that choir members tended to have increased levels of 'general trust' (i.e. trust for people who are not personally known) as a result of their social interactions within their choirs. Having trust for strangers can make it easier to engage in transactions with them and, in aggregate, can even enhance the economic performance of regions or countries, so the argument goes.

While the nature of causality linking social interactions, trust and economic performance have been a source of debate (see Woolcock 1998; Rudd 2000), there is widespread recognition within the social sciences that social networks and institutions have an important impact on economic performance (North 1990; Nee 1998; Ostrom 1999; Burt 2000; Woolcock and Narayan 2000). Engaging in social transactions and trade is ultimately a matter of trust because agreements can never be made to cover all possible contingencies. There is always some risk that a trading partner will cheat on an agreement and engage in short-term opportunistic behavior. Institutions based on trust and reputation can help constrain

opportunism, solve social dilemmas and, hence, increase the economic efficiency of producing public goods.

Social Capital – A Fisheries Example

Tropical reef fish stocks are a type of public good known as a common pool resource. They are subtractable – capture of fish means that there are less available for capture or consumption by others – and non-excludable – it is very difficult to prevent a person from using the resource (see Ostrom 1990). Tropical inshore fisheries are particularly complicated to manage because of the multiple species, myriad fishing technologies, and the difficulties inherent in monitoring and enforcing regulations (e.g. Dalzell *et al.* 1996; Chakallal *et al.* 1998; Johannes 1998). Maintaining environmental quality and the productivity of reefs that supply humans with a variety of ecosystem goods and services is a public good transaction and is, therefore, vulnerable to free-riding and individual opportunism. In tropical developing countries, where formal institutions may be relatively weak, social networks remain important for controlling opportunism and solving social dilemmas in the inshore fisheries (e.g. Sutherland 1986; King 1997; Cooke *et al.* 2000; Mascia 2000; World Bank 2000).

Consider the well-known case of Apo Island, Philippines (Russ and Alcala 1999), where a small community was able to implement a successful marine protected area (MPA). A community-based management initiative was developed in 1982 with technical support from Silliman University and, by 1985, the Apo community had endorsed an MPA for the entire reef. A Marine Management Committee, comprised of local community members, developed a management plan and met regularly. Between 1989 and 1990, a community education center was built with assistance from Silliman University and an Earthwatch expedition. Russ and Alcala (1999) note that "the planning, construction and frequent use of this building have been critical factors in maintaining the enthusiasm of the residents for the [MPA] concept. It has provided the community with a useful venue for meetings…" (p. 312). The MPA has enjoyed long-term, strong local support and compliance, and has met virtually all of the original objectives set forth by the community members.

Biologically, the result was an increase in fish density and biomass within the MPA and, according to local fishers, improved fishing adjacent to the MPA. There have also been tourism benefits for the local community, as Apo has developed into a popular dive destination. One can argue that the Apo community solved a social dilemma by establishing their MPA. The ecological services the MPA provides has resulted in a long-term stream of economic benefits to local residents that they would not have otherwise enjoyed. Without social capital – the rules and social norms that prevented opportunism on Apo – it is virtually certain that all economic rents would have been dissipated under open access conditions.

At nearby Sumilon Island, Russ and Alcala (1999) document the experience of developing and managing another MPA. The Sumilon MPA, which was established in 1974, experienced alternating phases of compliance and management breakdown over 25 years. The densities of large predatory reef fish decreased during the management breakdowns and any long-term benefits of the MPA have been virtually eliminated. The breakdowns in management – caused in part by a lack of trust between the community and outsiders (Silliman University and the Philippine national government), and in part by local politicians engaging in opportunism – led to depletion of fish stocks and the dissipation of resource rents that might have been collected through ongoing cooperation. Unlike Apo Island, the Sumilon MPA never gained genuine community-level involvement and support. Local rules and social norms were unable to prevent free-riding (in the form of destructive overfishing) and long-run economic performance has suffered as a result.

Social Capital Theory – Linking Fishers' Knowledge to Economic Performance

A number of disciplinary perspectives on social capital have emerged within the social sciences. Sociologists tend to hold a narrow view of social capital and concentrate on how one can use social networks for personal economic advantage by drawing on resources within the network (Nee 1998; Burt 2000). The emphasis is on narrow trust, prudence based on personal experience or on the basis of another person's reputation within a social network. Political scientists tend to emphasize civil society and how it can enhance the level of general trust in a society. Having trust for strangers can make it easier to engage in transactions with them and, in aggregate, can enhance regional economic performance (e.g. Putnam 1993). Economists tend to think of social capital in even broader terms, as the institutional infrastructure that facilitates trade with strangers whom one might not trust at all. Property rights, money and

banking, insurance, and the legal system reduce our reliance on personal trust, thus reducing the transaction costs of trading (Williamson 1985; North 1990).

Investments in social capital entail an opportunity cost but permit people to become more productive in fulfilling human aspirations. As Uphoff and Wijayaratna (2000) emphasize, social capital is associated with *mutually beneficial collective action*. Social and kin networks (e.g. organized crime, gangs) can be close knit, but the overall societal results of their actions can be negative because these social networks benefit one group at the expense of society as a whole. Such networks should not be considered social capital. For example, at the beginning of lobster fishing season in the Turks and Caicos Islands (TCI) a local phenomenon known as the 'Big Grab' occurs (Béné and Tewfik 2001; Rudd *et al.* in press). Many people take leave from their regular employment in other regions and come to South Caicos, the center of the local fishing industry, to go lobster fishing. These fishers, who are usually not skilled divers, target undersized lobster in shallow areas. As many as 95% of lobsters landed in some fishing grounds are under legal size limits. Constraint on the part of visiting fishers would allow more lobsters to reach a larger size, benefiting the resident fishers and TCI society as a whole. Tight kin networks, in this case, actually facilitate the plunder of the lobster resource because relatives are given access to accommodation, supplies and access to boats that are needed for fishing. Clearly, the social relationships used in this situation lead to personal gain (fishers can earn hundreds to thousands of dollars per day during the Big Grab), but do not lead to mutually beneficial collective action and should not, therefore, be considered social capital.

Uphoff and Wijayaratna (2000) define two types of social capital. Structural social capital consists of the rules, procedures, and protocols that make it easier for people to work together to achieve mutually beneficial collective action. Cognitive social capital consists of the norms and values that people hold, which predispose them to cooperate with each other and work for mutually beneficial collective action. Veitayaki (1998: 52) provides an illustration of how structural and cognitive social capital coexist in traditional Fijian fishery management:

> *"Traditional management arrangements are enforced through traditional authority, which means that there are protocols to be followed. The social structure and close-knit units in Fijian communities demand that people strictly follow tradition and respect each other. Decisions made by the group are often conveyed through the social channels of communication, which ensures that all those involved are made aware of the group's decisions. Consequently, the traditional system of retribution is an effective way of ensuring compliance. Nonconformists are treated harshly, and this is an effective deterrent to others..."*

How does social capital work? First consider reef fish as an economic commodity such that output $V = v(L, K)$, where L is labor input and K is capital input (e.g. boat and motor). Increasing L and K will, initially, lead to an increase in output. As inputs increase further, reef fish landings typically exhibit decreasing returns and, eventually, total dissipation of economic rent under open access. If social interactions can constrain opportunism and help society avoid the open access equilibrium, then investments that encourage social interaction will increase societal economic returns.

At Apo Island, for instance, there was a relatively small financial investment in a Community Education Center. The process of developing a management plan and vision for the Apo community, and the general exchange of fishers' knowledge (which undoubtedly led to positive non-fishery spin-off benefits) were facilitated by the financial investment in the Center. If fishery output is now viewed as $V = v(SI, L, K)$, where the additional input (SI) is the social interaction needed to maintain community enthusiasm and compliance, then the value of the social interaction is the net return once the costs of the other inputs (i.e. Center construction) are met. The long-run returns to the fishing community would not have been possible without the durable effects of social interaction and the overall returns have certainly exceeded the modest financial investment in the Center.

Flows of information, whether formal or informal, have three possible effects. First, increased knowledge of the behavior of others reduces the risk of free riders, hence reducing costs imposed by cheaters depleting the resource (e.g. 'known thieves' in the Belizean lobster fishery are closely monitored and socially marginalized – King 1997). Second, increased knowledge about the non-behavioral environment improves productivity and reduces both risks and transaction costs (e.g. productivity increases as a result of some fishers engaging in innovative behavior, with others

learning by example). Finally, collective action and coordination increase overall social benefits by helping to maintain compliance with social norms or formal rules.

Rudd (2000) summarizes by noting that informal or formal social interactions help solve social dilemmas by reducing transaction costs and increasing knowledge about both the world and the trustworthiness of other individuals. Economic performance can be enhanced by quantity-increasing measures (increased knowledge about the world and the transformation processes involved in production), cost-reducing measures (a reduction in production and transaction costs) and/or revenue enhancing measures (via gains from trade or increased knowledge about other trading partners). Social capital is a function of social interactions and social structural variables that may, on the surface, serve no explicit instrumental economic function.

When fishers imitate the innovations of another fisher or pool information about fishing conditions on the local dock at the end of the day, they are engaging in a type of social interaction, which increases knowledge about the world and has durable effects. Fishers who gain knowledge about the behavior of others through personal experience or reputation are in a better position to assess trustworthiness. If fishers trust other fishers, they may be able to exchange favors that help reduce fishing costs. On a broader scale, if there is trust between fishers and government, there may be more informal cooperation in developing fishing regulations and less need for costly enforcement or litigation.

Functions of social capital

Social capital can function on two levels, as an asset that can be used for either 'bonding' or for 'bridging' (Woolcock and Narayan 2000). Bonding occurs when strong intracommunity ties give kin and communities a sense of identity and common purpose. Bonding social capital is especially important for the rural poor because it serves as a substitute for the State when citizens are deprived of basic services. Bridging occurs when communities are endowed with diverse intercommunity ties, and as such are in a stronger position to confront problems and take advantage of economic opportunities.

For example, the Fijian government plays a relatively limited role in the management of inshore reef fisheries in many parts of Fiji due to their limited resources and inter-governmental jurisdictional conflicts (Cooke *et al.* 2000). Many communities in Fiji are left more or less on their own; even though they possess high levels of social capital (e.g. Veitayaki 1998; World Bank 2000), this asset is used for bonding purposes, helping communities to cope and manage local Customary Fishing Rights Areas without strong government support. In Samoa, on the other hand, the government worked closely with village councils to develop national legislation that supports local fisheries management (Zann 1999), and provided the services of extension officers to assist village councils in developing local management plans (King and Fa'asili 1999). The rapid adoption of village management plans and the implementation of a surprisingly high number of village MPAs is indicative of bridging social capital. Ideas and knowledge have flowed rapidly between villages. All villages that are part of the network benefit, increasing their capacity for solving local social dilemmas by accessing fishers' knowledge from other regions regarding successful MPA design experiences and how to effectively monitor and enforce village rules.

Community and Institutional Capacity

Fishers' knowledge plays a key role in the development of community-level social capital and solving local social dilemmas. The transaction of interest in inshore tropical fisheries management is the maintenance of environmental quality, a public good. The economic goal is to capture long run benefits, the ecological goods and services that flow in perpetuity from a healthy reef ecosystem, for human well-being. This is a transaction that normally has a high degree of specificity; that is, local knowledge is very important for understanding the unique aspects of the system. Broader cultural, institutional and ecological contexts all influence the degree to which LEK is transferable beyond the local level (Ostrom 1990; Ostrom *et al.* 1993). While local social capital may serve a useful bonding function, it should be clear that achieving broader scale sustainability for reef fisheries also depends on the institutional capacity of national or regional governance organizations. Community-level social capital alone will not be enough to solve all social dilemmas; the institutional infrastructure that the 'New Institutional Economics' emphasizes (Williamson 1985, 1994; North 1990) also has a role to play.

If communities don't have legally entrenched management rights, for example, they may not be able to exclude outsiders from fishing in their local grounds and depleting stocks (e.g. World

Bank, 2000). Evidence suggests that social capital can sometimes act as a substitute for government, but that social dilemmas are most effectively solved when strong governance organizations are present in combination with vibrant, capable communities (Uphoff and Wijayaratna 2000; Woolcock and Narayan 2000; Krishna 2001). Institutional capacity depends on factors like the strength of the legal system, property rights, the degree of government corruption, research and extension capacity, and the awareness of fisheries problems of bureaucrats and elected officials. There is certainly an ongoing need to account for fishers' knowledge in the education and government decision-makers.

Applying Social Capital Theory to Fisheries

Using social capital theory in a fisheries management context permits policy research that would be difficult or impossible using standard economic approaches. Three areas of particular importance are outlined below: (1) identification of key social structural variables in which investments can be made to build social capital; (2) comparative policy analyses that account for various combinations of community and institutional capacity; and (3) analysis of efficiency-maximizing co-management systems for maintaining environmental quality and long-run fishery production in inshore reef systems.

Social Structural Variables

Linking fishers' knowledge and economic outcomes using social capital theory makes it possible to hypothesize about the effects that specific social structural variables might have on the flow of fishers' knowledge, the development of trust and cooperation, and the transaction costs of producing public goods. Substantial guidance on the effects of various structural variables affecting cooperation and collective action is available in the common property literature (see Ostrom 1990, 1998, 1999). Ostrom (1998) outlined a theory of behavioral rational choice where a self-reinforcing 'core relationship' between trust, reputation and norms of reciprocity leads to increased levels of cooperation and, hence, net benefits. For any particular situation there might be a mix of salient structural variables, some of which could be used to build social capital via their enduring structure (e.g. the availability of meeting places for community members as in Apo Island) and some of which could build social capital via their enduring effect (e.g. the availability of transparent information about the past actions of community members).

From a policy perspective, the State faces a number of choices for managing fisheries, each of which has costs. Top-down management by the State ('command-and-control') has generally proven ineffective for tropical artisanal fisheries management (Johannes 1998). The question arises as to whether government might be best spending scarce resources on other non-traditional policy options rather than trying to enforce rules that are essentially unenforceable. Social capital theory suggests that fisheries management might be improved far more by targeted spending on specific social structural variables. For example, the construction of meeting halls, sponsoring visits of fishers to other communities, or the provision of facilitators and extension agents for community management planning are relatively modest investments may have substantial impact on long-run tropical inshore fisheries sustainability.

One insight of particular importance has emerged from social capital research. That is, that the process of working together on projects can be more important than achieving 'successful' results. O'Brien et al. (1998) found that the horizontal social linkages characteristic of successful communities led to benefits even if the specific project that volunteers worked on was a failure. The process of local people working together is more important than the accomplishment of a specific project objective. An implication of this is that the process of developing a community fisheries management vision can be seen as a key social structural variable affecting social capital. The vision-building process of identifying alternative policy options and deliberating about their relative merits builds social capital, helping to create shared understanding and generalized trust that has positive spin-off effects in other aspects of community life (Rudd 2000).

Comparative Policy Analysis

It is now widely recognized that any single policy goal can be achieved using a variety of tools (e.g. Ostrom *et al.* 1993). Transaction costs (i.e. gathering information, reaching agreements regarding the harvest and allocation of resource flows, and monitoring and enforcing those agreements) will vary according to the level of social capital that a community or region possesses and according to ecological, cultural and institutional context. The costs of different policies that might achieve a given end can, in fact, vary greatly.

When community level and state level capacity are considered jointly, a number of situations might be encountered. In northern Belize, relatively high social capital exists in combination with relatively high institutional capacity (Sutherland 1986; King 1997; Mascia 2000). Fishers have a history of collective action going back to the 1960 formation of the Northern fishery cooperative. Government is quite strong by Caribbean standards and is supportive of cooperatives. Local fishers, as a result, have been able to collect substantial economic rents from fishing over the past 40 years. Coastal Belize is not pristine, but compared with much of the Caribbean, is relatively ecologically intact despite export-oriented commercial fisheries.

This is in contrast to the situation in the Turks and Caicos Islands, where a centralized government department manages fisheries using conventional tools (e.g. total allowable catch, size limits, seasonal closures, etc.). Community capacity in the islands is low. There are strong kin ties, but 'The Big Grab' demonstrates that there is little mutually beneficial collective action (Béné and Tewfik 2001; Rudd *et al.* in press). In general, community apathy is high, and effective enforcement of top-down rules is limited by limited government resources and low compliance.

In Fiji, some strong traditional fisheries management systems are still intact. The government, while generally supportive of the traditional management system, can be somewhat irrelevant for local communities (Veitayaki 1998; Cooke *et al.* 2000; World Bank 2000). Local community management capacity is high, but there is limited input or support from government. Poaching is a major concern for local people except in areas where communities highly dependent on local marine resources have adopted strong (perhaps illegal) independent enforcement mechanisms.

Finally, consider situations where both community and institutional capacity are lacking. While there are remnants of traditional fisheries management systems in Kenya, population pressure, widespread adoption of destructive fishing practices, and cultural changes have eroded community capacity in many areas and have led to severe overfishing (McClanahan *et al.* 1997). The Kenyan government has limited resources and has encountered major challenges in dealing with fishers who don't trust them. Conflict, rent dissipation and ecological degradation are widespread as a result.

Why does social capital matter in comparative policy analysis? Consider the example of MPAs as a policy option for sustainable tropical reef fishery management. MPAs are widely advocated as an important policy tool for implementing adaptive marine ecosystem management at the community level (Costanza *et al.* 1998). The argument made by community-based MPA advocates usually revolves around three transaction costs: information costs are lower for MPAs compared to traditional management; the costs of monitoring fisher compliance are lower because it is simple to see, yes or no, whether someone is fishing inside MPA boundaries; and enforcement costs are lower when MPAs are locally implemented. Compliance is more likely when the community has a vested interest in the resource. In addition, cheaters can be punished immediately and internally rather than waiting for the more lengthy and costly process of court litigation.

When considered in light of social capital theory, it becomes clear that the conclusions above will only hold under a certain set of assumptions about community and institutional capacity. When there is a high level of local social capital and an institutional backstop that provides legally binding sanctions when necessary, the arguments in favour of MPAs are likely valid. So, perhaps MPAs would be a preferred policy tool in Belize, but what about the Turks and Caicos, where community capacity is weak, or Fiji, where institutional capacity is limited? Where there is community apathy, as in the Turks and Caicos, an MPA is likely to revert to open access due to low compliance (i.e. social norms are not sufficiently strong to prevent widespread individual opportunism). When institutional capacity is low, as in Fiji, local leaders may feel powerless trying to use traditional sanctions on fishers from outside their own community. The only general policy conclusion that can be drawn is that there will be no simple blanket policy prescriptions from country to country, or even from fishing ground to fishing ground in some cases. Understanding social capital will be crucial for choosing policy instruments that can increase the likelihood of ecological and economic sustainability. This requires that we understand and account for fishers' knowledge about the world and the behavior of other resource users.

Co-management and the Proper Scope of Governance

Social capital also plays an important role when considering government decentralization (transfer of authority to local government agents) and the devolution of fisheries management authority to local communities. The key question is how management authority can be decentralized or devolved so that overall fisheries transaction costs are minimized. Answering this question is contingent on the level of social capital in the region.

Determining the proper scope of governance is a major new research focus in the New Institutional Economics (e.g. Williamson, 1999; Knight 2001). A strong argument can be made that pure market approaches are unsuitable for tropical artisanal fisheries (they are subject to market failure because of the public good nature of the ecological base that supplies valuable ecological services). Thus the question becomes one of determining an efficient co-management balance between the 'State' and the 'Community'.

The discriminating alignment hypothesis (Williamson 1985) postulates that transactions have certain attributes and that governance systems have certain competencies. Minimizing societal transaction costs requires that these two factors be aligned. In tropical inshore fisheries, the transaction of interest is the maintenance of reef environmental quality and productive capacity. One attribute of this transaction is the high degree of uncertainty it entails, as our understanding of fishing impacts on complex reef ecosystems is limited (Jennings and Kaiser 1998; Johannes 1998). Aligning governance systems when there is uncertainty in artisanal fisheries depends on the degree of predictability of fish in time and space. Management by the collective action sector is usually more appropriate when resource users work in a predictable local environment, have higher levels of social capital and exhibit a high degree of dependence on the resource. Decentralized State governance may be more appropriate, however, if local management input is required for the resource but the collective action sector is weak. If regional management is important (e.g. there is widespread downstream dispersal of larvae important for fisheries recruitment in other regions), then co-management tipped in balance towards the State will be more suitable.

CONCLUSION

To be taken seriously in fisheries policy, there needs to be a solid theoretical construct that explicitly links fishers' knowledge to the economic benefits arising from collective action. This can be accomplished using social capital theory.

From a policy perspective, there are also important pragmatic issues. If the use of local knowledge increases resource sustainability, how can policy interventions target key social structural variables that build and share local knowledge? In many cases in tropical developing countries, it is likely that the most economically efficient policies are those that build community and institutional capacity for extended periods before even dealing with fisheries management *per se*. The success of devolution depends on local participation and the ability of the collective action sector to overcome individual opportunism. The likelihood of success increases as fishers' knowledge is increasingly taken into account. Social capital is, therefore, an appropriate indicator of the extent to which State and Community can work together to manage fishery resources.

Caution must be exercised, however, to ensure that the concept of social capital is not applied simplistically in cursory policy analyses. While there are strong theoretical reasons as to why fishers' knowledge and community capacity will have an impact on economic outcomes, there are equally strong reasons why social capital alone cannot solve all tropical inshore fisheries management problems. Effective conservation and fisheries management policies must consider ecological and cultural realities to minimize fisheries management transaction costs. In some cases, when fish stocks are highly mobile or inherently unpredictable, or when local communities have low internal capacity to solve social dilemmas, there may still be an important role for State involvement in fisheries management. Even in these cases, however, accounting for fishers' knowledge will be important, as effective State management will also depend upon context-dependent knowledge until local capacity for co-management is increased.

REFERENCES

Béné, C. and Tewfik, A. (2001). Fishing effort allocation and fishermen's decision making process in a multi-species small-scale fishery: analysis of the conch and lobster fishery in Turks and Caicos Islands. *Human Ecology* **29**: 157-186.

Burt, R.S. (2000). The network structure of social capital. *Research in Organizational Behavior* **22**: 345-423.

Chakalall, B., Mahon, R. and McConney, P. (1998). Current issues in fisheries governance in the Caribbean Community (CARICOM). *Marine Policy* **22**: 29-44.

Cooke, A.J., Polunin, N.V.C. and Moce, K. (2000). Comparative assessment of stakeholder management in traditional Fijian fishing-grounds. *Environmental Conservation* **27**: 291-299.

Costanza, R., Andrade, F., Antunes, P., van den Belt, M., Boersma, D., Coesch, D.F., Catarino, F., Hanna, S., Limburg, K., Low, B.S., Molitor, M., Pereira, J.G., Rayner, S., Santos, R., Wilson, J.A. and Young, M. (1998). Principles of sustainable governance of the oceans. *Science* **281**: 198-199.

Crawford, S.E.S., and Ostrom, E. (1995). A grammar of institutions. *American Political Science Review* **89**: 582-600.

Dalzell, P., Adams, T.J.H. and Polunin, N.V.C. (1996). Coastal fisheries in the Pacific Islands. *Oceanography and Marine Biology: An Annual Review* **34**: 395-531.

Jennings, S., and Kaiser, M.J. (1998). The effects of fishing on marine ecosystems. *Advances in Marine Biology* **34**: 201-352.

Johannes, R.E. (1998). The case for data-less marine resource management: examples from tropical nearshore finfisheries. *Trends in Ecology and Evolution* **13**: 243-246.

Johannes, R.E., Freeman, M.M.R. and Hamilton, R.J. (2000). Ignore fisher's knowledge and miss the boat. *Fish and Fisheries* **1**: 257-271.

King, M. and Fa'asili, U. (1999). A network of small, community-owned Village Fish Reserves in Samoa. *SPC Traditional Marine Resource Management and Knowledge Information Bulletin* **11**: 2-6.

King, T.D. (1997). Folk management among Belizean lobster fishermen: success and resilience or decline and depletion. *Human Organization* **56**: 418-426.

Knack, S. and Keefer, P. (1997). Does social capital have an economic payoff? A cross-country investigation. *Quarterly Journal of Economics* **112**: 1251-1288.

Knight, J. (2001). A pragmatist approach to the proper scope of government. *Journal of Institutional and Theoretical Economics* **157**: 28-48.

Krishna, A. (2001). Moving from the stock of social capital to the flow of benefits: the role of agency. *World Development* **29**: 925-943.

Mascia, M.B. (2000). *Institutional Emergence, Evolution, and Performance in Complex Resource Systems: Marine Protected Areas in the Wider Caribbean*. Ph.D. Dissertation, Department of the Environment, Duke University, Beaufort, NC. 388 pp.

McClanahan, T.R., Glaesel, H., Rubens, J. and Kiambo, R. (1997). The effects of traditional fisheries management on fisheries yields and the coral-reef ecosystems of southern Kenya. *Environmental Conservation* **24**: 105-120.

Narayan, D. and Pritchart, L. (1999). Cents and sociability: household income and social capital in rural Tanzania. *Journal of Economic Development and Cultural Change* **47**: 871-897.

Nee, V. (1998). Sources of the New Institutionalism. Pages 1-16 in M.C. Brinton and V. Nee (editors), *The New Institutionalism in Sociology*. New York: Russell Sage Foundation.

Neis, B., Pitcher T. and Johannes, R., editors. *Putting Fishers' Knowledge to Work*. Oxford: Blackwell Science.

North, D.C. (1990). *Institutions, Institutional Change and Economic Performance*. Cambridge, UK: Cambridge University Press. 152 pp.

O'Brien, D.J., Raedeke, A. and Hassinger, E.W. (1998). The social networks of leaders in more or less viable communities six years later: a research note. *Rural Sociology* **63**: 109-127.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Collective Action*. Cambridge: Cambridge University Press. 280 pp.

Ostrom, E. (1998). A behavioural approach to the rational choice theory of collective action. *American Political Science Review* **92**: 1-22.

Ostrom, E. (1999). Coping with Tragedies of the Commons. *Annual Review of Political Science* **2**: 493-535.

Ostrom, E., Schroeder, L. and Wynne, S. (1993). *Institutional Incentives and Sustainable Development: Infrastructure Policies in Perspective*. Boulder, Colorado: Westview Press. 266 pp.

Portes, A. (1998). Social capital: its origin and applications in modern sociology. *Annual Review of Sociology* **24**: 1-24.

Putnam, R.D. (1993). *Making Democracy Work*. Princeton, New Jersey: Princeton University Press.

Rudd, M.A. (2000). Live long and prosper: collective action, social capital and social vision. *Ecological Economics* **34**: 131-144.

Rudd, M.A., Danylchuk, A.J., Gore, S.A. and Tupper, M.H. (in press). Are marine protected areas in the Turks and Caicos Islands ecologically or economically valuable? In J. Alder and U.R. Sumaila (editors), *Economics of Marine Protected Areas - Conference Proceedings*. Fisheries Centre Research Report 9(8). Vancouver: UBC Fisheries Centre.

Russ, G.R. and Alcala, A.C. (1999). Management histories of Sumilon and Apo Marine Reserves, Philippines, and their influence on national marine resource policy. *Coral Reefs* **18**: 307-319.

Sutherland, A. (1986). *Caye Caulker: Economic Success in a Belizean Fishing Village*. Boulder, Colorado: Westview Press. 153 pp.

Uphoff, N. and Wijayaratna, C.M. (2000). Demonstrated benefits from social capital: the productivity of farmer organizations in Gal Oya, Sri Lanka. *World Development* **28**: 1875-1890.

Veitayaki, J. (1998). Traditional and community-based marine resources management system in Fiji: an evolving integrated process. *Coastal Management* **26**: 47-60.

Walters, C. (1997). Challenges in adaptive management of riparian and coastal ecosystems. *Conservation Ecology* **1**(2):1 [online at www.consecol.org/vol1/iss2/art1].

Williamson, O.E. (1985). *The Economic Institutions of Capitalism*. New York: The Free Press. 450 pp.

Williamson, O.E. (1994). Transaction cost economics and organization theory. Pages 77-107 in N.J. Smelser and R. Swedberg (editors), *The Handbook of Economic Sociology*. Princeton, New Jersey: Princeton University Press and the Russell Sage Foundation.

Williamson, O.E. (1999). Public and private bureaucracies: a transaction cost economics perspective. *Journal of Law, Economics and Organization* **15**: 306-341.

Woolcock, M. (1998). Social capital and economic development: toward a theoretical synthesis and policy framework. *Theory and Society* **27**: 151-208.

Woolcock, M. and Narayan, D. (2000). Social capital: implications for development theory, research and policy. *The World Bank Research Observer* **15**: 225-249.

World Bank. (2000). *Voices from the Village: A Comparative Study of Coastal Resource Management in the Pacific Islands*. Washington, DC: World Bank. 87 pp.

Zann, L.P. (1999). A new (old) approach to inshore resources management in Samoa. *Ocean and Coastal Management* **42**: 569-590.

QUESTIONS

Maria Mangahas: How exactly do you measure social capital? Isn't it something individuals possess?

Murray Rudd: In an ideal situation, you go into a community and do surveys. The World Bank has been very active in this. There are a number of very general questions that you can ask.

Maria Mangahas: My understanding of social capital is that if I have more relatives and friends than others do, then I have more social capital.

Murray Rudd: We look at the social capital held by the local community and not by individuals. In studies on farms in Tanzania for example, they are looking at differences in economic performances based on their values, norms and social context.

Maria Mangahas : Are you proposing to measure a community's social capital?

Murray Rudd : We are taking things from there. We are also using World Bank data.

THE USE OF FISHERS' KNOWLEDGE IN THE MANAGEMENT OF FISH RESOURCES IN MALAWI

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ABSTRACT
Until recently the management of fisheries in Malawi has been based on the policies and development objectives of Government alone. This took effect from the early stages of the colonial era and was formalized with the setting up of the Fisheries Department in 1971 as well as enacting of specific fisheries legislation in 1973. Unfortunately Government fisheries initiatives, in the form of management and development programmes, were not always successful. Among the many factors for the failure of the Government policies, was the 'sidelining' of the fishers in the planning and implementation of the fisheries programmes. Ironically, fishers were supposed to be one of the main beneficiaries of the Government's fisheries activities. Despite not being fully involved in the official programmes, the fishers, particularly from the artisanal sector, which is by far the major component of the country's fisheries, continued to rely mostly on their traditional knowledge for their fishing businesses. The fishers' knowledge can be categorized into a number of areas. Some still use traditional fishing methods and gears, others have established fishing seasons or control measures based on their local beliefs, long before Government started to get involved in the country's fisheries. The fishers also have a keen understanding, via their indigenous technical knowledge, of the resources they catch; and they accurately decipher the geo-climatic patterns in the areas that they work in. Co-management initiatives in the fisheries sector, introduced and formalized by Government in the mid 1990s, are starting to strengthen the importance of fishers' knowledge in the effective management of the fisheries in Malawi. Even technical areas such as monitoring of the fisheries can benefit from traditional practices and knowledge.

INTRODUCTION
The fish resources in Malawi have been exploited since people first settled areas adjacent to lakes, rivers and other water bodies and applied traditional methods. Government attention to fisheries as an important natural resource sector however, started with the advent of the colonial era: 1891-1963, the legacy of which lingers in present-day Malawi. Government regulation of natural resources began with the institution of the Protectorate of Nyasaland by the British in 1891. Research or recording of fisheries started in 1938 (Lowe 1948). Fisheries activities were carried out more systematically as a Section in the Department of Game, Fish and Tsetse Control from 1947. A fully-fledged Fisheries Department (FD) was established by an Act of Parliament in 1971 to manage fisheries in the country. In spite of the long Government involvement, the majority of the fishers, who are artisanal, continued to be guided by traditional knowledge. This covered all steps of fish resource production including harvesting, processing, marketing or distribution and consumption. The influence or impact of the Government policies on fisheries development has been somewhat limited (GOM 1989; ICLARM/GTZ 1991; Hara 1993; Chirwa 1996; Banda and Tomasson 1997; Dawson 1997; Scholz et al. 1998).

From an historical perspective, the situation is complicated by the difficulty of evaluating models of progress practiced by the local societies (Chanock 1972). Further, a general colonial Government approach of legislating agricultural and natural resource development (Lamport-Stokes 1970), largely disfranchised the people (Derman and Ferguson 1995; Chirwa 1996; Murombedzi 1999), as opposed to demonstrating preferred practices (Chilibvumbo 1969). For the southern African countries in similar arrangements, Katarere (1997) notes that

> *"...colonialism brought with it complex legal and administrative systems to regulate and control the use of natural resources by local communities. This significantly altered relationships communities had traditionally had with their environment..."*

SADC (1997) also presents the repercussions of the situation graphically by stating that

> *"...Africans for millennia managed their resources responsibly, and that it was only with the advent of colonialism that things deteriorated. Access and ownership were withdrawn, alienating the people from traditional means of sustenance. In response, they exploited resources ruthlessly and opportunistically. However, rationality prevails...inherent to their way of life..."*

Despite the survival of indigenous ways, disastrous encounters resulting from promotion of progress continue in rural Africa, even though many forms of impacts through foreign influence on local inhabitants have been documented

(Mitchell 1951; Chilibvumbo 1969; Krishnamurthy 1972; Phiri 1977; Robertson 1984; Dichter 1989; Hulme and Turner 1990; Ferguson et al. 1993). However, it is now abundantly clear (and understood) in development circles that rural people have a lot of knowledge on many subjects that affect or are associated with their way of life, particularly of their local environs (Berlin 1992; Chambers 1993, 1994; Matowanyika 1994). Chambers (1993) further notes that "...The apparent ignorance of rural people is an artificial product of 'outsiders' ignorance of how to enable them to express, share and extend their knowledge". Rapport through appropriate attitudes and behaviour, as a result of this recognition, is achievable.

Currently, the FD implements fisheries policy through six divisions: research, extension and development, training, fish farming, management and administration, and the coordination of inland fisheries[1] in the Southern African Development Community (SADC) area (Ngwira et al. 1996). The FD has many offices and field stations near or along the major water bodies in the country in addition to its headquarters in the capital city, Lilongwe. The policy objectives of the sector are to maximize the yield from fish stocks in national waters. They include improving efficiency of exploitation, processing and marketing; and exploiting all opportunities to expand existing, and develop new aquatic resources. However, care is taken to protect endemic fish fauna as scientific and educational assets; and because fish represent a particularly vulnerable major economic resource (GOM 1989; Ngwira et al. 1996; Scholz et al. 1998)[2]. The sector also complements the national development policy in its objectives of (i) poverty alleviation - through providing employment and thus financial income (GOM/UN 1992; Scholz et al. 1998); (ii) reduction of disease or improved health - the sector provides 70 % of the protein intake from animals and 40 % of protein intake from all sources (GOM 1989; ICLARM/GTZ 1991); and (iii) income re-distribution - through involvement in both direct and indirect fisheries services.

As a responsibility of FD, legislation for fisheries as a sector on its own was first enacted in 1973. The regulations are contained in the Fisheries Act in the Laws of Malawi, Chapter 66:05 1974 and amended or supplemented in 1976, 1977, 1979, 1984, 1996 and 1997. Regulations include: licensing; closed seasons; prohibited methods of fishing; prohibited fishing gear and dimensions; and minimum size or length of fish (Ngwira et al. 1996; Scholz et al. 1998; Mapila 1998; Nsiku 1999). Although these are viewed to be adequate measures for the management of fisheries in the country if appropriately applied, they have been largely ineffective in Malawi due to various factors (Scholz et al. 1998). The situation exemplifies crises in Government-controlled fisheries that prompt some form of stakeholder involvement or fisheries failures seen all over the world (Pitcher and Hart 1982; McGoodwin 1990; Sen and Nielsen 1996; Tailor and Alden 1998).

There were some negative experiences in the early stages where community involvement had been actively pursued (Hara 1998; Scholz et al. 1998). There is now, however, a big shift by Government towards encouraging involvement of user communities in management and conservation of natural resources. The Government has amended its fisheries legislation to recognize the roles of and empower fishing communities in the decision making process (GOM 1989; Turner 1995; Ngwira et al. 1996; Scholz et al. 1998; Mapila 1998). There is some apprehension as to its effectiveness but it is a commendable starting point (Dobson 1996). This sets the stage on which fishers' knowledge can be harnessed to enhance the conservation of the fish resources.

This paper sets out to describe indigenous fishers' technical knowledge of both fish resources and geo-climatic conditions in the localities in which they operate. Secondly, possible ways will be explored in which the knowledge may be used in fish resource management and in which it may be applied to the development of new community involvement processes in order to enhance fisheries resource conservation.

CATEGORIES AND EXAMPLES OF INDIGENOUS TECHNICAL KNOWLEDGE BY MALAWI FISHERS

Traditional techniques are still prevalent despite gradual changes in fisheries practices during the history of Malawi, (GOM 1989; ICLARM/GTZ 1991; Chirwa 1996; Banda and Tomasson 1997). Fishers' knowledge is seen in all steps of fish production, harvesting, handling or processing, marketing and consumption. Central to this is the learning system. Folklore, which serves as one of the channels along which knowledge can flow to future generations, is rich in beliefs, customs and practices, in many communities such as the

[1] This arrangement of implementation of the SADC's programmes of actions is being phased out and the SADC Secretariat in Gaborone, Botswana will carry out all the plans and activities of SADC (SADC 2001).

[2] The sector's policy objectives were being reviewed in 1996 to closely reflect the national priority policy of food security and poverty alleviation. The sectral policy goal is thus "to sustain the contribution of the national fish resources to the upliftment of life in Malawi by conserving the resources for the benefit of the future generations (Matiya 1997).

Chewa (Kalipeni 1996). Information is usually transferred orally in stories and song related to experiences of daily life. Fishing is thus learnt informally, as is common with the livelihoods of rural communities, and passed on to subsequent generations through practice (Berlin 1992; Matowanyika 1994; Dawson 1997). In shoreline communities, fishing has strong links to transition into adulthood. Hoole (1955) describes one such form of instruction for the Tonga people of Nkhata Bay District along the northwestern shore of Lake Malawi:

> *"...The male Tonga is wedded to the lake almost from the day he is born...learns to tumble in it, to swim like a fish, to exult his skill on it, and love it in all its moods. His main ambition in life then becomes to own his own net, and paddle his own canoe. In the hot season the boys of the village build themselves 'mphara', roofless shelters of reeds on the shore and at all times they are assisting their elders, and learning from them the many details of the fisherman's craft. In the kindergarten stage they become adept at catching small fish with a matete reed for a rod..."*

Local fishers, therefore, have detailed knowledge of fish types in their area, fishing methods and gears, as well as how to interpret climate and other factors such as wind, rain, clouds, temperature, vegetation and animal life to determine suitable times and places to fish. Similarities or large differences in fish are appropriately distinguished through assigning names to individual or group(s) of species (FM Nyirenda, *pers. comm.*). Other factors that fishers use to predict whether or not fishing will be successful include fish movements or migrations, feeding areas and times, breeding seasons and colours, and predator-prey relationships. Fish ecology is thus learned, although not in a scientific sense or methodology (Matowanyika 1994). Fish utilization tended to correspond to the level of prevailing techniques of fishing. Until recently, local fishers focussed on meeting their subsistence needs and those of their community. Banda and Tomasson (1997) report 1938-42 observations by Ricardo Bertram and others on operations of indigenous fishers:

"...The fish caught was mainly used to provide food for the owner of the gear and his dependants...". Some trading also took place. Earlier, fish, especially fresh products, would certainly have been bartered and distributed near fishing communities or stations. Fish handling or processing to reach distant areas was limited to sun-drying for small species, boiling or roasting and drying, and splitting and then smoking on open fires for the large species (Hara 1993; ICLARM/GTZ 1991).

In the past, fish resource management has not been a matter of daily concern for fishing communities. Traditional fishing operations were sustainable for a number of reasons, notably gear limitations and low population in many areas. On fishing gear, Chirwa (1996) notes that there are "some positive elements and some weaknesses in traditional fishing methods" and further observes that:

> *"...It was the adoption of new, and especially imported fishing technology such as nylon gill-nets, trawling nets, and narrow-meshed beach seine nets, which put fish stocks at risk...".*

Examples also abound, particularly in the terrestrial zone, that indigenous production processes tended to have "balanced use of ecosystems" so that the actions were "...deliberate natural resources management systems which mimic the natural cycles in local ecosystem" (Matowanyika 1994). Specific to Malawi fisheries, Munthali (1997) contends that:

> *"...legislation does not recognize the importance of traditional controls in promoting sustainable exploitation of the fish resources. Prior to the colonial era, the fish resources in Malawi were governed by traditional controls, through chiefs and village headmen who regulated all fishing pitches within their territorial units. Also ritual prohibition of fishing certain areas, magic and taboos relating to certain fish species regulated the number of fishers in each ground. Besides these traditional controls, there were technical inadequacies in the fishing gear used, and human population was small. Thus the fish resources resiliently absorbed the fishing pressure exerted by the local communities."*

Customs, beliefs and practices also have a big role. GOM/UN (1992) states that "...For the majority of rural based Malawians, traditional value systems still influence and guide their day to day life..." For the management of natural resources, the current situation is very different. Conservation of fish resources, for instance, has become important to local fishers and other players in the fisheries industry (Sen and Nielsen 1996; Scholz et al. 1998). It would thus be prudent to look critically at the folklore and related practices to encourage positive aspects

while leaving out the outdated ones (GOM/UN 1992). The fish ecology and geo-climatic and other resource knowledge of fishers, which has been accumulated through traditional practices over centuries (Hoole 1955; Msiska 1991; Berlin 1992; Matowanyika 1994), has to be used in ways that are cognizant of current realities of life and protect fish resources from depletion. Some specific details of fishers' knowledge of fishing methods, gears and craft, closed seasons and areas, fish ecology and geo-climatic conditions are as follows.

Fishing Methods

There are many traditional fishing methods in Malawi. Most fall into five categories, namely netting, trapping, line fishing (hooking), simple manual techniques and using fish stupefacients or piscicidal plants. Some methods are further improved in their effectiveness to attract, encircle or congregate fish by use of baits, dams, barriers or weirs, light and other aids (Hoole 1955; Mzumara 1967; Mills 1980; Ojda 1990; Tweddle et al. 1994; Brummett and Noble 1995). Additional information on methods appears in the next section on gears and craft. The way some gears are used may vary within or between water bodies. ICLARM/GTZ (1991) notes that:

> *"...There is considerable variation throughout Malawi in the fishing methods traditionally employed, as there has been in the rate and type of technological modernization accepted by fishing communities. Without exception, however, all techniques traditionally employed have been closely adapted to the local details of fishing grounds as well as the behavioral patterns of the species present..."*

There are also very specialized fishing methods or techniques that occur only in some specific fisheries in the country. Magalaji (translated as "garages") is a technique used by fishers on Lake Chilwa usually employing line fishing methods and targeting catfish *Clarias* spp. (mlamba) so that they remain alive for many days. Mzumara (1967) describes it as follows:

> *"...the fish caught...are kept in floating baskets suspended in the water near to the [gear used]. The 'mlamba' remain in the basket up to a week or even longer depending on the degree of success of the [fisher]. They are fed on maize meal or small 'matemba' (barbs, Barbus spp.) during their captivity before being taken ashore and offered for sale..."*

Lake Chilwa fishers use zimbowela (floating islands) in their fisheries. This is a direct result of adapting to ecological and climatic conditions existing in the lake region. Some parts of the lake are fringed by an extensive and dense growth of macrophytes, particularly majedza (bullrush *Typha capensis*), extending up to 15 km from fishing villages to access the open water area. There is a problem of floating weeds being "cut off from the marsh areas by strong winds which clogs beaches, landing points, jetties and fishing grounds, sometimes for long periods" (Landes and Otte 1983). Fishers of Lake Chilwa use floating manjedza to make a platform on which they build a temporary hut. These structures, called 'zimbowela', can be built as a deliberately planned fishing camp or temporary shelter when stranded in a windstorm. A small number of fishers in Nkhata Bay specialize in utilization of vuu (precarious stands on rocky ledges on falls or rapids), in association with Khombe, a specialized scoop net used at falls or rapids to target anadromous fish species, sanjika (lake trout *Opsaridium microcephalus*) and mpasa (lake salmon *Opsaridium microlepis*), particularly during their upstream migration to spawn from Lake Malawi. Khombe was especially used at Chiwandama falls on Luweya River in Nkhata Bay District, but is not common nowadays. Hoole (1955) has the following narration of vuu:

> *"...The rapids are formed by a band of hard black rock cutting across the softer rock of the country above, and it is on ledges no more than a few square inches in extent that the jealously guarded vuu are situated..."*

and khombe operation:

> *"...It is a narrow scoop net, somewhat like those used by 'elver' fishers and is fixed to a narrow frame to which is attached a long pole...Notwithstanding the wild rush of water downstream, the bulge of the nets on poles point upstream...The fishers stand on somewhat precarious footholds on ledges projecting over the main falls, and dip their nets into the eddies and pools at the foot of the rocky ledges..."*

Virundu (sing. chirundu) are rocky prominences, pinnacles or 'reefs' that occur in some fishing grounds, protruding from the lakebed. They are usually rich with stocks of species such as utaka ('happy', *Copadichromis* spp.). The Chilimila, an open water seine, was developed to target such habitats. ICLARM/GTZ (1991), based on a final report in 1983 for a fisheries development project

in the north, provides the following:

> *"...Utaka shoal above a chirundu and orient themselves toward the current, which concentrates their planktonic food around the rocks. The regime of these currents fluctuates, both annually and diurnally. Hence a thorough knowledge of the current pattern and bottom topography is essential to successfully use the open water seine...Over smooth, shallow bottoms ,...chilimila ...functions as a diver-operated lift net..."*

Fishing gears and craft

Net fishing gears used by fishers in Malawi include gillnet (machera, ndangala, chilepa); open water seine (chilimila, nkacha); shore seine (mkwau, [n]khoka, ukonde); scoop/dip net (chiu); and cast net (chabvi). Machine-made nylon netting materials started to appear probably long after the First World War on Lake Malawi and in the late 1950s and early 1960s in other water bodies such as Lake Chilwa and Lower Shire River. Before this, all nets were made from fibres of different shrubs and barks of trees, and creepers (Mzumara 1967; Mills 1980; Ojda 1990; ICLARM/GTZ 1991)[3]. The most popular source was a cultivated evergreen shrub *Pouzolzia hypoleuca* (variously known as mulusa, muluza, t(h)ingo, lu(i)chopwa, lukayo, (b)wazi, gavi, khonje). Preparation of the fibre is described in Hoole (1955):

> *"...The outer back is scraped off, and then they [net fibre shrubs] are dried in the sun. Later they are soaked in water and then partially dried, which allows the white inner bark fibre to be peeled off easily. From this inner fibre when dried out, the string is made by rolling out strips of it with palm of the hand on the thigh. The various lengths are then spliced and rolled together into one long skein of string. This string is made in many variations from fine to thick, according to the purpose for which it is required..."*

Most of the net gears have an active mode of operation. The gillnet falls into both passive and active modes. Fishers in Lake Chiuta and sometimes in the Lower Shire Valley dye their gillnets brown or reddish brown with bark or root preparation (usually boiled in water) from local trees or herbs such as chan(i)lama (*Newtonia* sp.), chanima (*Elephantorrhiza goetzei*), chirima (*Acacia macrothyrsa*), and chilusa/chirusa (*Lannea stuhlmanni; Lannea* sp.; *Commiphora* sp.; *Fagaropsis* sp.).

Traps are the second most common fishing gear after gillnets (ICLARM/GTZ 1991; MFD 1996). The main types are basket trap (mono, chisako) and fence trap (psyailo, beyu). Mono is made from split bamboo canes, reed stems or thin branches (twigs, wicker) held together by twisted palm leaves (milaza), bwazi/khonje fibres or creepers, and then tied to hoops of staves or lengths of supple branches (nthepa) as frames to give mono its shape and full size. It may be tapered with a valve placed on the larger front end to allow fish in but not escape. The back end is closed when the trap is set and opened when removing the catch. Mono may be used either singly or in association with weirs. Weirs are constructed using poles or other vegetation materials to close a section of a river or other water body. Basket traps are set in gaps left within the weir. Singly set traps are usually baited with other smaller fish or meal remains. In Lake Malawi, the mono is weighted to enable it to be set at the bottom while attached by a rope of a tree creeper held to a buoy or large float (sila) that has a stick fixed to it and serves as a marker called 'bingo' in Tonga (Hoole 1955). Psyailo or beyu is an encircling fish fence made of bangu/o (*Phragmites mauritianus*), nsenjere (*Pennisetum purpureum*) or other reeds and grasses such as manjedza (*T. capensis*), and stakes or poles. The materials are bound together by milaza -leaves of ngwalangwa (*Hyphaene crinita*) palm, or stems of chilambe (*Helichrysum chrysophorum*), a common creeper. Each is operated by six to eight people in shallow water of about a metre (ICLARM/GTZ 1991; Brummett and Noble 1995). Mills (1980) observes that:

> *"... the method requires a team of eight or more men. Essentially, a long sectional fence made of closely fitting reeds set vertically and about five feet high is set up on supporting stakes set into the shallow water areas of the marsh. The fence is normally set early in the afternoon in the form of a square or oblong with one end left open...to take up the most productive parts of that particular spot. Later in the day the men drive* the fish in the area into the fence

[3] Local plant materials for construction of traditional fishing gears include bango/matete reed grass *Phragmites mauritianus*; (n)duvi/nsanje/ (m)sali Hippo grass *Vossia cuspidata*; mulusa/t(h)ingo/ lu(i)chopwa/lukayo/wazi evergreen shrub *Pouzolzia hypoleuca*; lulisi climber *Tinospora caffrara*; (naka)bwazi/chosi/chiguluka/njefu/muluka/mu-uruak tree violet *Seciridaca longendunculata*; mbibu/msololikoko/nkoloso chashew nut *Anacardium occidentale*; chiumbu/sidyatungu livelong *Lannea discolor*; msaula/malandalala creeper *Ipoma pes caprae*; and mlambe baobab *Adansonia digitata* (ICLARM/GTZ 1991; Nsiku 1999).

> *by beating the water and then rapidly closing the opening with further lengths of fencing. Early next day the sides of the fence are moved inwards so as to form a dumb-bell shape, one end being larger than the other. Finally the smaller end is collapsed inwards completely driving the contained fish towards the other from whence they are scooped out..."*

Another form of fish encircling is used at Bangula Lagoon and Ndinde Marsh in the southern part of the country. It involves making banks of aquatic weed *Ceratophyllum* sp. and mud scooped out to form an enclosure. Traps are set in the gaps left in vegetative walls and fish escaping from the 'fishpond' is thus caught (ICLARM/GTZ 1991).

Hook fishing (kuwedza, kuweja) is in three forms; long line (khuleya), single line (chomanga) and pole-and-line (mbedza). Khuleya is a long main rope with 50 to 800 short sidelines, each with its own hook (Mzumara 1967). A khuleya line is held in place by poles fixed in the water at each end. A few staves (zichili) are sometimes included at distances between the two ends. Anchored floats or weights set at the bottom and tied to a float by a string are used in some areas used instead of the poles. Chomanga is a single hook on a short length of line attached to an anchored float or fixed stake. A chomanga fisher may set several of these on the fishing ground. Pole-and-line is also a single hook set on a hand held rod of about a metre and a string twice as long. A small float is usually attached so that the bait is around 30 cm below the surface. Pole-and-line is also used as a partial harvesting technique for fish ponds (Brummett and Noble 1995). Baits are used in all hook-fishing techniques. Baits vary according to the species targeted and water conditions, and include small fish such as usipa (*Engraulicypris sardella),* matemba (*Barbus* spp.), worms, insects, frogs or other amphibia, pieces of meat, and remains of the local meal (nsima). On Lake Chilwa, pieces of tablet soap are reported among the baits for mlamba (Mzumara 1967). Simple manual fishing techniques include plunge basket, spear (mkondo), and bow (uta) and arrow (mubvi). Plunge basket is constructed like a mono but it does not have a valve and is conical in shape with an opening on the side of its apex. It is mainly found in the Lower Shire Valley. It is operated in shallow water by driving or plunging it downward at random, over an observed fish or disturbance in the water. Spears, and bow and arrows are common in the marshes and flood plains of Shire River (for both) and Lakes Chilwa and Chiuta (for the former). A spear is a hard metal blade, usually sharpened that is fixed to a thin but strong stake about a metre and a half in length. The blade may, in rare instances, be winged or have barbs at the tip. The gears are used in very shallow water mainly for subsistence fishing during the dry season as well as wet season when it is flooding and mlamba, the main target species, is on spawning migration. Spear fishing may be conducted during both day and night (Mzumara 1967; Mills 1980; Ojda 1990; ICLARM/GTZ 1991).

Lastly, fishing by using stupefacients and piscicidal plants or fish poisons has been utilized mainly along seasonal rivers with pools that dry late, small and isolated swamps and marshes. This fishing practice was banned during the colonial administration. Hoole (1955) notes "...The use of poisons for catching fish is prohibited under the Game Ordinance, but it is still occasionally used surreptitiously..." This was in 1934, long before the Fisheries Ordinance was formulated or enacted in 1949 (ICLARM/GTZ 1991; Matiya 1997). Instances of excess use of stupefacients and poisons were associated with certain ceremonial occasions, particularly during the dry season. The large fish kills were to provide fish for whole communities. The method is still outlawed, but occasional cases come to the attention of the Fisheries, which intensifies its campaign against the technique during the dry season. There are many plants common in the country used for this purpose (ICLARM 1991; Nsiku 1999), some of which are indeed very potent[4]. Brummett and Noble (1995) report on recent research on piscicidal plants or fish poisons by three professors at the University of Malawi:

> *"...Fifty potential candidates were investigated by Chiotha et al. (1991). Of these, 14 (Agave sisalana, Aloe swynnertonii, Bridelia micrantha, Breonadia microcephala, Ensete, livingstonianum, Erythrophleum suaveolens, Euphorbia (unidentified species), Neorautenenia mitis, Opuntia vulgaris, Phytolacca dodecandra, Sesbania macrantha, Swartizia madagascariensis, Tephrosia vogelii, Xeromphis obovata) were found to kill 95-100 % of Tilapia rendalli and Oreochromis shiranus within*

[4] The potency of some of the plants was observed first hand by the author in 1992. Unscrupulous individual(s) poured a mixture of plant fish poison in a pool with slow moving water on one of the rivers stocked with trout on Zomba Plateau in the southern part of Malawi. Fish were stunned in a very short period of time and began to die soon after. A few tens were lost on the occasion. Luckily the river was flowing and flushed the site of application with no further disasters reported down stream.

> *24 hours at a concentration of 100 mg·l^{-1}. The potential risks to humans of eating fish killed in this manner have yet to be determined...".*

At least four species, in ICLARM/GTZ (1991) where stupefacient plant materials used to kill fish in Malawi are detailed, appear in the above list. The local communities in which these plants grow naturally have long known of the potency of these plants, and may even be aware of the effect on people of eating the dead fish.

Fisheries in Malawi have made some progress since the inception of modern fishing - a modest number of two European operators on Lake Malawi in 1938, and introduction of the plank boat as well as promotion of use of gillnet in 1951. Traditional craft, canoe (wato, bwato, ngalawa), have prevailed as the main fishing vessels, despite predictions they would long ago be replaced by other types of craft (Emtage 1967). The canoe commanded a proportional mean of 78.3 % for all traditional fisheries craft in the country between 1985 and 1995 (Nsiku 1999). On Lake Malawi, the proportion of canoes in 1994 was 81 % (Banda and Tomasson 1997). The simplicity in design and limited investment cost seemed to bolster the canoe's resilience despite declines in life span and size due to the unavailability of tree species most suitable for making canoes (ICLARM/GTZ 1991). Emtage (1967) describes one of the so-called technical designs of a canoe:

> *"...It is these in-curved lips of the hull that make the well-made dugout virtually impossible to turn over. To the uninitiated it may seem the most unsuitable craft; especially if one tries to sit facing straight forward, with the backside perched on both lips of the hull, spanning the central opening. The fact remains that a dugout can roll through 90^{o} to lie on its side and recover, without shipping water. A slight lift to stem and stern acts as a stop to rolling, and greatly helps recovery..."*

Besides the two square projecting knobs at the prow (mushyio) and stern (chisiuka, matambi), the only other essentials are paddles (nkhafi), a pole (mchonjolo), and a baler (lupu) depending on the water body the craft is to be used on. Lupu used to be wooden, but a tin can or pail is now common. A special feature which can be added to a canoe, and used to transport a fisher's catch, is a ziwo. This is a compartment created by compressed and tied bundles of grass or creepers to form the required size so that the fish or other items are confined in one place and not stepped upon (Hoole 1955). The best hardwoods for canoe making include chonya, mung'ona (*Adina microcephala)*, Mlombwa (*Pterocarpus angolensis*), mbawa (*Khaya nyasica*), mvunguti (*Kigelia* sp.), mkuru (*Pterocarpus stolzii*), muawanga (*Afrormosia* sp.), nsangu (*Acacia albida*), mtondo (*Cordyla africana*) and ntondo-oko (*Sclerocarya caffra*). These were favorites because they have long life spans and relatively high oil content. Mills (1980) notes of Mulanje cedar (*Widdringtonia whytei*), the now most popular wood in Malawi for boat construction: *"...a particularly oily and long-lasting wood requiring little protective maintenance..."* Canoe makers now resort to using inferior trees such as softwoods, acacia and blue gum; palm tree; and even mango fruit tree among others.

Closed seasons

Although not very well known in recent times or accounted for by Government fisheries authorities, closed seasons were and still are common in smaller water bodies such as lagoons, dambos[5] and other wet lands. Rural communities generally regard the areas as common property (Brummett and Noble 1995). Closures usually coincide with seasonal changes in agricultural activities. Areas may therefore be closed to fishing, watering animals, or swimming during the planting season, the ban being lifted when crops have been harvested. The seasonal closure of areas used as reserves by individuals or the community, particularly those used for cultivation of crops, is very common (Chipeta 1971; Chirwa 1998). There is a proposal to promote community fish stocking and management of one such area in the Lower Shire Valley which has two extensive marshes, Elephant and Ndinde, and several lagoons including Gumbwa, Kanjedza, Makhuthu, Chitimbe and Nyazuluko (K. Katambalika *pers. comm.*). This will probably be extended to many other similar water bodies. The best known example of a locally instituted closed season in Malawi is that of Mbenji Island located in the central part of Lake Malawi in Sub-Chief Msosa's jurisdiction within Salima District. The season is marked by elaborate ceremonies for its closing and opening which include offering nsembe, sacrifice to the ancestral spirits. Of the closed period Scholz et al. (1998) write:

> *"...mainly comprises of a closed season from December to March to allow stocks to recover. During the closed season no one is permitted to remain on the island or to fish in the surrounding waters..."*

[5] These are 'pocket' wetlands; marshy channels that drain surrounding higher ground (ICLARM/GTZ 1991; Brummett and Noble 1995).

Closed areas

There are many examples of marine and terrestrial closed areas. Unlike the latter areas, the basis for establishing the former ones are usually not clearly defined (Matowanyika 1994). They do, however, seem to revolve mainly around tenure or usage rights, similar to those of Japanese village fisheries, as presented in Ruddle (1989), as well as the Pacific Basin (Ruddle 1988). In Malawi there are some closed areas based on belief and the magico-religious systems of the communities. One such place is Phiri la Mtsatsi (hill of castor oil), one of three small islands on Lake Chiuta. There is no fishing or any other activity on the island and its surrounding area, due to the myth that spirits, probably of the land, live there. Compliance is total because of the strongly held belief that anyone who trespasses simply vanishes, and there is no one who has ever returned to say otherwise (Donda 1998). A similar situation exists near the western shoreline of northern Lake Malawi, where fishers avoid a very small island, sometimes just referred to locally as Mizimu ('spirits'). It is believed that an overabundance of monkeys sometimes seen from a distance is a disguise for the mizimu. It is however permitted to shelter there from bad weather. On these occasions no monkey has ever been seen anywhere (F.M. Nyirenda *pers. comm.*). Yet another place is Chileka, a very tiny island connected to Chisi, the largest and most densely populated island on Lake Chilwa. It is not used as a fish landing point, and resources such as firewood, poles, small game, thatch grass, soil and stones are also not used. The place was and probably still is, believed to be a landing site for witches. The place named 'Chileka', after Malawi's ever first international airport in Blantyre, probably as a joke about the witches' flying spot on the island[6].

Other closed areas not based on belief and magico-religious systems are found along Dwambazi, Luweya and Upper Shire Rivers. The right to set biyo, a fish fence fitted with basket traps on the Dwambazi is restricted to the traditional rulers, from Chiefs to village headmen. Two village headmen, Mkoma and Mpute have that right. On Luweya, vuu (noted in fishing methods section), for setting khombe to catch anadromous species at Chiwandama falls - is the preserve of the traditional leaders as well. Vuu associated with pools known as Mkwache and Chinteche at the falls belong to Headman Mambo and Chief Ngombo respectively. These two, however, allow two other people to fish to a limited extent. Those given the opportunity are another Headman Kahinja and an individual, probably an influential figure in the community, Mateyu Nkunkha (Hoole 1955). Chirwa (1998) points to the existence of a controlled area on the Upper Shire River, although this is no longer operative due to commercialization of fishing, when he notes:

> *"...there is historical evidence of chiefly control over fishing activities at certain times of the year...in parts of the river/lake traditionally used by the families in the area for domestic purposes..."*

Ecology and geo-climatic conditions

While traditional fishers in Malawi may have extensive ecological knowledge of the fisheries and areas they work in (as noted above) it is almost impossible for them to share it in systems of international science (Chambers 1993, 1994; Matowanyika 1994). There are nevertheless many broad areas that can be pointed out. They know the many different species they see or catch, and give them names. Of the more than 700 fish species identified and described in Malawi waters (Nsiku 1999), the majority have been given local names by the fishers, or at least a label for the group to which the species is perceived to belong (Berlin 1992). Some fish groups such as chambo (*Oreochromis* sp.) and utaka (*Copadichromis* sp.) have actually been accurately distinguished to the species level, including stages of growth judging from the names assigned (Msiska 1991; Smith 1998). It can also be safely said that local fishers are far better at identifying fish species than Government fisheries personnel, as there are so far only a few people with any form of training in formal ichthyology in Malawi. The fishers are aware of some species' breeding seasons, colours and sites (F.M. Nyirenda *pers. comm.*). Lake Malawi fishers have long observed chambo and other mouth brooders, although their understanding may be faulty. Lowe (1948) describes a case in point when she says:

> *"...In spite of the belief among many African fishermen that the young are born through the mouth, the eggs are probably always laid and fertilised in a sand scrape 'nest' and then picked up by the female..."*

Fish migrations (feeding, spawning, etc.) are known to cause corresponding movements of fishers (ICLARM/GTZ 1991; Munthali 1997). Fishers know the bycatch species of their fishing gears; influence of lunar cycles on their catch; qualitative stock status (i.e. when they are experiencing declines or increases in general);

[6] This is from accounts of the locals during the author's visits to Chisi Island, between 1987 and 1995.

and feeding relationships at least of their target species' predators (Munthali 1997; Smith 1998; F. M. Nyirenda, *pers. comm.*). Specialized feeding relationships between some species such as *Corematodus shiranus* and chambo *(Oreochromis squamipinnis)*, in which the former feeds on tail fins of the latter (biting small pieces), are keenly observed by local fishers. Since the *C. shiranus* follow the other species it is aptly named kapitawo, supervisor of chambo (Lowe 1948). The fisherfolk from the northern region of Lake Malawi know a lot about anadromous species, which spawn with the first rains, particularly those that migrate to upstream tributaries, such as sanjika (*Opsaridium microcephalus)*, mpasa (*O. microlepis)*, chimwe/ngumbo (*Barbus johnstonii)* and kadyakolo/kuyu *(B. eurystomus)* (Hoole 1955; F. M. Nyirenda, *pers. comm.*).

As with other aspects of indigenous knowledge discussed above, fishers in Malawi have acquired the ability to interpret geo-climatic signs and thereby enhance the effectiveness of their fishing operations over time. Some of the specific skill areas are as follows. In N. Lake Malawi, the combination of rising clouds and winds from the western mountains that follows a period of chimphungu (absolute calmness) is a sure sign of an impending heavy downpour or windstorm. Mupungu refers to evening (between 5 and 8 pm), and early morning (from around sunrise until 10 AM) rains brought by easterly (east to west) winds starting from the Mozambican shore of the lake. The winds may be short-lived; blowing for an hour or less. Winds that blow in the direction of home are studied carefully. If they are not too fierce, the fishers continue their work and 'ride on the winds' as they paddle home exerting little or no effort. If the winds are strong or blow away from home, the fishers rush for safety. Rising water level in swamps or water level in wells, particularly in areas of clay soils, which usually crack during the dry season, indicates the onset of 'm(u)wera' (southerly trade winds) which can bring rains for several weeks (F. M. Nyirenda, *pers. comm.*).

Other fisheries related traditional beliefs and practices

In some areas in Malawi certain fish species are not preferred, or are forbidden based on taste, looks or colour, because of traditional taboos or religion. Taboos and religious beliefs that prohibit people from eating certain fishes are also common in West Africa (ICLARM/GTZ 1991). In the case of taste, most people from the shores of Lake Malawi do not eat fish from rivers and ponds, particularly those that are layered with mud at the bottom. The people have such an acute sense of taste that they differentiate fish from the lake and other places with ease (F.M Nyirenda *pers. comm.*). Looks impact the utilization of nkunga (eel, *Anguilla nebulosa*) and dowe (lungfish, *Protopterus annectens brieni*) in some parts of Malawi. Many people do not consume nkunga because it looks like a snake. Dowe is not liked by others, particularly in the Lower Shire Valley, simply because its features and colouring are horrible. In certain areas it is believed to be a bad omen if fishers find snakes, dead frogs or other small animals, and fish species such as nkunga in their fishing gears. In those areas such animals are, in most cases, taboo to catch. A related dislike or taboo is for nyesi (electric catfish, *Malapterurus electricus*). Its skin in particular, is believed to have mangolomela, magical properties against opponents in duels when a dried piece is tied to the body or a powdery preparation from a charred piece is administered to one's skin[7].

An example of the influence of religion is the forbidding of mlamba (*Clarias* spp.), bombe (*Bathyclarias* spp.), kampango (*Bagrus meridionalis*) and related species (nkunga again falls in this group). This belief is strong in communities of Judeo-Christian background, particularly those of Zion and Apostolic Faith congregations. This is based on one of the Bible Laws in the Old Testament, which forbids eating fish with do not possess scales[8] (Carroll and Pricket 1997). ICLARM/GTZ (1991) quotes Grove and others on the case of mlamba being prohibited by taboo in West Africa. The role of religion in Africa is "all pervasive". Matowanyika (1994) makes the point clear when he writes:

> *"...African religion is founded on all aspects of people's livelihoods and has been very much responsible for shaping their character and culture. Religion is embedded in local languages and is transmitted orally...IKS [indigenous knowledge systems] also depends on this process.*

[7] This was a common belief in the Lower Shire Valley during the author's childhood.

[8] From Leviticus 11: 9-12 which states "These shall ye eat of all that are in the waters: whatsoever hath fins and scales in the waters, in the seas, and in the rivers them shall ye eat. And all that have not fins and scales in the seas, and in the rivers, of all that move in the waters, and of any living thing which is in the waters, they shall be an abomination unto you: They shall be even an abomination unto you; ye shall not eat of their flesh, but ye shall have their carcases in abomination. Whatsoever hath no fins nor scales in the waters, that shall be an abomination unto you"; and Deuteronomy 14: 9-10 reads "These shall ye eat of all that are in the waters: all that have fins and scales shall ye eat: And whatsoever hath not fins and scales ye may not eat; it is unclean unto you."

> *Religion reinforces the transmission process..."*

The types of relationship between people and the environment, often seen in the "animistic beliefs" of African peoples (ICLARM/GTZ 1991), come out of the cosmological (myths, legends and other forms of folklore) aspect of religion. Changing the pattern of resource use does not sit well with these beliefs, and taboos are instituted which affect the timing and means of resource extraction (Matowanyika 1994). Similar beliefs also seem to influence people's attitudes in Malawi on whether they may eat fish from ponds or small swamps or other water bodies that have been fertilized by manure from chicken, cattle, pigs or humans (Brummett and Noble 1995). A non-fish magico-religious practice involves the making of a dugout among the Tonga of north Malawi. Hoole (1955) describes such a ritual:

> *"...When a man who is searching for a canoe finds a suitable tree, he then approaches the "owner" of the land for permission to cut it. A price is agreed upon, and a small sum in addition...so that he may address the spirits of his ancestors to ensure that all may go well in the making of the canoe, and that it may be free from cracks, and other faults. The tree is then felled, and before the adzing of the canoe commences the "owner" of the land comes again, kills a chicken, and sprinkles the tree with blood. When the adzing of the canoe is completed and before it is hauled away, the "owner" of the land again addresses the spirits of his ancestors that all may be well with it on its journey to the lake."*

This is not common nowadays probably due to depletion of suitable canoe-making trees and forestry legislation that regulates use of trees.

Application of the Knowledge in Fisheries Management or Conservation

The Indigenous knowledge of fishers and their communities is not yet used in a systematic way for the management or conservation of fisheries in Malawi. There are, however, some examples of fishing communities taking action with respect to fisheries practices taking place in their areas. The actions or reactions in most cases seem to be based on the knowledge or belief system strongly held in those fishing communities. The measures can also be categorized into the knowledge areas discussed in the above section, i.e., fishing methods, gears, closed seasons and areas, and fish ecology and geo-climatic conditions.

Control of the fishing methods

In the lakeshore District of Nkhotakota along Lake Malawi, some chiefs (traditional authorities) prohibit the chiombela, although FD researchers have not found any evidence that the method is solely responsible for depleting the fish stocks in their areas (Msiska 1991; M. Hara *pers. comm.*). In the chiombela method, fishers drive fish into nets or other gear by beating the water surface with poles or paddles to make noise (Ojda 1990). The chambo fishery, which is the most lucrative in the country, collapsed in Lake Malombe at the start of 1990s. Through co-management initiatives launched in 1994, traditional leaders and fishers of the lake propose to restrict 'kauni', a fishing method that uses light as an attracting device, among many other measures (Chirwa 1998). The unintentional consequences of using the canoe, which is the most common fishing vessel in the country (ICLARM/GTZ 1991; Banda and Tomasson 1997), is its inability to access the offshore regions of large lakes, particularly Lake Malawi. This has the advantage of restricting offshore fishing. Although the inshore areas may be heavily impacted, the overall effect in the lake may be minimized.

Prohibition of certain fishing gears

Chief Kawinga, Sub-Chief Ngokwe, village headmen and the fishers of Lake Chiuta, where the main gears of the fishery are traps, gillnets and longlines, now prohibit use of nkacha (open water operated seine) and other small meshed seines on the lake (Donda 1998; Scholz et al. 1998).

Establishment of fishing seasons based on the local traditional beliefs

There is an effective closed season on Mbenji Island under Sub-Chief Msosa. As a result there is a thriving fishery of utaka (*Copadichromis* sp.) and the stocks are generally healthy. Other prohibitions include beer drinking, gambling, and chamba (marijuana). Women are also not allowed to visit the island, particularly during the fishing season. Penalties for flouting the rules are stiff, including expulsion from the area under the Sub-Chief's jurisdiction (Donda 1998; Scholz et al. 1998).

Establishment of closed areas based on the local traditional beliefs

The magico-religious systems of the areas surrounding Lake Chiuta forbid fishers from exploiting fish and other resources found at Phiri la Mtsatsi Island (Donda 1998). This enables the island to act as a natural fish sanctuary in the

lake.

Use of fishers' ecological knowledge of fish resources and geo-climatic conditions of the local areas to enhance conservation

Based on their knowledge of the mpasa fish including its upstream spawning migrations, its role in their communities as well as experience of declines in catches of the fish in recent years, some local leaders are taking measures to protect the species. Msiska (1991) reports that:

> *"...Some traditional chiefs are reported to have been policing against fishing for mpasa during its breeding migration into rivers...Conservationists should be encouraged to tap this traditional knowledge for regulating the fishery..."*

Fishers try to select for size and protect young fish (it is mainly young children that eat these when caught). They look for flavour, eggs in certain species, and large table size fish. Flavour is an issue in target species such as ntuwa/nchila (African carp, *Labeo* spp.), nkholokolo (squeaker, *Synodontis njassae*), and mbumbu/bombe (large catfish, *Bathyclarias* spp.) which is especially targeted for its eggs. The species are sometimes found in the lake and connecting rivers. When fish traps are set at the river mouths, they face in the lake direction to catch only upstream going fish. For fishers mwanga, the period after spawning, is not good for fishing, the fish (including masanga *Oreochromis karongae*, mgong'u other cichlids, mpherere/sanjika *O. microcephalus* and mpasa *O. microlepis*) are thin and not tasty. The fish are however very easy to catch because they are usually hungry and are taken by hook and line. For lakeshore people, even mwanga fish offer a better alternative in meals that have only mphangwe/masamba (vegetable) relish. Changes in seasons bring in factors that fishers learn to take into account. Rain or flooding is sometimes followed by an increase in fish food (algal or plankton blooms), which may in turn be followed by an increase in the presence of crocodiles, which restrict fishing grounds in some areas (F.M Nyirenda *pers. comm.*). Chirwa (1996) provides the following conservation aspects of some traditional fishing methods:

> *"...weirs and traps could only be used in shallow waters, and especially during the dry season. In the rainy season when the rivers, marshes and lagoons flooded, the traps were removed for fear that they might be washed away. They were also constructed in such a way that fish fry could easily pass through. Fish poison could only be used in still or slow moving waters and its effectiveness was limited to a short period of time. The amount, depth, and flow of water could easily reduce its strength. As for the traditional nets, they were designed to catch specific fish species in their habitat."*

Gear maintenance is an important activity. Apart from repairing them, fishing nets are kept in dry places with good air circulation. Khumbi huts (small round thatched shelters with no walls) are sometimes constructed for this purpose (Hoole 1955). As a result of their knowledge of fish, weather and climate in their local areas, fishers tend to devise specific and sometimes elaborate tools, and ways to conserve as well as catch the fish for both their own use and sale.

THE WAY FORWARD

There are many facets of indigenous knowledge systems (IKS). Matowanyika (1994) notes one of the problematic aspects that: "...IKS are often differentially distributed within groups". Apart from knowledge, there are also other differences ,such as relationships and influences, that exist within communities (Robertson 1984; Murphree 1993). Advocates of progress or agents of developmental change need to be aware of the issues even in the context of promoting IKS. When it comes to effective management of fish resources, full involvement of all stakeholders has to be at the forefront. Experience and advice e.g. for example, FAO (1986), Ruddle (1986), Mills (1990), Chambers (1993, 1994), Matowanyika (1994), Taylor and Alden (1998), Pinkerton (1999) and many others on the participation of different stakeholders of fisheries and other natural resources are important. The bringing on board of the rural poor, like most of Malawi's fishers, who have a lot of indigenous knowledge, will have dividends, although it may be slow at the start. Through this process, transformative learning (Pinkerton 1999) will be created for the target groups or stakeholders as well as change agents. There is thus potential to use the indigenous knowledge of fishers in Malawi more effectively. Two areas where the knowledge can be applied are in strengthening user involvement in the decision-making process for the management and development of fish resources, and the setting up of a monitoring scheme that is both less expensive and robust.

Co-management

It is widely realized now that management of resources, especially fisheries, must include all users. Fisheries management thus requires a

mutually agreed system of controls with appropriate forms of enforcement to ensure responsible use of the resource (FAO 1986; Tailor and Alden 1998). Co-management initiatives in Malawi began in 1994. Dialogues between fishers, and Government and other interested parties are on-going for Lakes Malombe and Chiuta (Dawson 1997; Chirwa 1998; Donda 1998; Hara 1998; Scholz 1998). For the rest of the water bodies in the country, the dialogue process is in the early stages. To show willingness to proceed with the co-management initiatives, Government has enacted new legislation that calls other stakeholders of the resources to take part in decision-making (Mapila 1998; Scholz et al. 1998). There is also support from external agencies, playing a role in sensitizing the local fishers who also have to accept and acquire transformative learning (Pinkerton 1999) as noted above, like the rest of the stakeholders. It is hoped that the experiences at Lakes Malombe and Chiuta will serve to catalyze crucial aspects of the process in the rest of the country's water bodies. Regional CBNRM (community based natural resource management) experiences like those of CAMPFIRE in Zimbabwe and ADMADE in Zambia (SADC 1996) are also important to learn from. When sustained dialogues are in place and functional co-management developed, IKS issues discussed in above sections will have an appropriate base and be used effectively.

Monitoring

The FD's major monitoring tool for traditional fisheries is annual frame surveys and monthly data collection organized in ten management zones associated with the fisheries of Lower Shire Valley, Lake Chilwa, Lake Chiuta, and Lake Malombe together with Upper Shire. The remaining six zones relate to fisheries of Lake Malawi. For the allocation and management of commercial fisheries, which only occur in Lake Malawi, the lake is also organized in fishing areas. There are nine areas where entry is regulated, at least in principle (ICLARM/GTZ 1991; Tweddle et al. 1994). The tenth zone is mainly inshore, available to traditional fishing operations, and is open access. Two systems of data collection, Catch Assessment Survey (CAS) and Malawi Traditional Fisheries (MTF), are currently in place. The MTF is applied in the Mangochi area, the most fished part of Lake Malawi, while CAS is used in the rest of the country. These systems entail elaborate recording and relatively huge costs, which unfortunately sometimes result in under-funding of FC in Government budget allocations. Designing and implementing an alternative data collection system along the lines of that proposed by Smith (1998), i.e., determining species composition from surveying drying racks and identifying fish found by using their local names (known to fishers), would bridge gaps that are inevitable in some other methods. Fishers' knowledge of fish species, bycatch, processing practices, and other aspects of the fisheries will therefore play an important future role in their management. In any case, fishers already help to identify species in their catches in the CAS and MTF data recording systems. The involvement of fishers in providing information for an alternative monitoring scheme can only strengthen their role in the appropriate management of fish resources, and the development of co-management practices.

References

Banda, M. C. and T. Tomasson.1997. Demersal fish stocks in southern Lake Malawi: Stock assessment and exploitation, Government of Malawi, Fisheries Department, Fisheries Bulletin No. 35. 39 p.

Berlin, B. 1992. Ethnobiological classification: Principles of categorization of plants and animals in traditional societies. Princeton University Press, Princeton. 335 p.

Brummett, R.E. and R. Noble. 1995. Aquaculture for African smallholders. Manila, Philippines. ICLARM Tech. Rep. 46. 69 p.

Carroll, R. and S. Pricket 1997 (eds). The Bible: Authorized King James Version. Oxford University Press. Oxford. 445 p.

Chambers, R. 1993. Participatory rural appraisals: Past, present and future. UPPSALA: Forests, trees and people newsletter 15/16: 4-8.

Chambers, R. 1994. The origins and practice of participatory rural appraisals. World Development. Vol. 22(7): 953-969.

Chanock, M.L. 1972. Development and change in the history of Malawi. p. 429-446. *In* B. Pachai (editor). The early history of Malawi. Longman, Bristol.

Chilibvumbo, A. 1969. The response to planned change: A study of the rice scheme in Chief Mwambo's area, Lake Chilwa, Zomba, Malawi. The Society of Malawi Journal. Vol. 22(2): 38-56.

Chipeta, W. 1971. Land tenure and problems in Malawi. The Society of Malawi Journal, Vol. 24(1): 25-34.

Chirwa, W. C. 1996. Fishing rights, ecology and conservation along southern Lake Malawi, 1920-1964. African Affairs 95: 351-377.

Chirwa, W. C. 1998. Lake Malombe and Upper Shire River fisheries co-management programme: An assessment, p.61-77. In A.K. Norman, J.R. Neilsen and S. Sverdrup-Jensen (eds.) Fisheries co-management in Africa. Fish. Co-mgmt. Res. Project, Res. Rpt. 12.

Chiotha, S.S., J.H. Seyani and E.C. Fabiano. 1991. Mulluscidal and piscicidal properties of indigenous plants (abstract), p. 22. In B.A Costa-Pierce, C. Lightfoot, K. Ruddle and R.S.V. Pullin (eds.). Aquaculture research and development in rural Africa. ICLARM Conf. Proc. 27, 52 p.

Dawson, K.A. 1997. Applying cooperative management in small-scale fisheries: The cases of Lakes Malombe and Chiuta, Malawi. MSc thesis. Michigan State University. Michigan. 53 p.

Derman, B. and A. Ferguson. 1995. Human rights, environment and development: The dispossession of fishing communities on Lake Malawi. Human Ecology Vol. 23 (2): 125-142.

Dichter, T. W. 1989. The enterprise concept: a comment on innovations in participatory approaches to development, p.131-137. *In* W. P. Lineberry (editor) Assessing participatory development: rhetoric versus reality. Westview Press/IFAD, Boulder, Colorado.

Dobson, T.A. 1996. Community participation and natural

resources legislation in Malawi: A report to the Director of Fisheries on behalf of the Malawi-German fisheries and aquaculture development project (MAGFAD). Michigan State University. Michigan. 21 p.

Donda, S. 1998. Fisheries co-management in Malawi: Case study of Lake Chiuta fisheries, p.21-39. *In* A.K. Norman, J.R. Neilsen and S. Sverdrup-Jensen (eds.) Fisheries co-management in Africa. Fish. Co-mgmt. Res. Project, Res. Rpt. 12.

Emtage, J.E.R. 1967. The making of a dug-out canoe. The Society of Malawi Journal, Vol. 20(2): 23-25.

FAO. 1986. Strategy for fisheries management. FAO, Rome, 1986. 26 p.

FAO. 1993. Fisheries management in the southeast arm of Lake Malawi, the Upper Shire River and Lake Malombe, with particular reference to the fisheries on chambo (*Oreochromis* spp.). CIFA Technical Paper. No. 21. Rome, FAO. 113 p.

Ferguson, A.E., B. Derman and R.M. Mkandawire. 1993. 'The new development rhetoric and Lake Malawi'. Africa (London) 63(1): 1-15.

Government of Malawi (GOM). 1989. Statement of development policies, 1987-1996. Government Printer, Zomba, Malawi. 198 p.

Government of Malawi and United Nations in Malawi (GOM/UN). 1992. The situation analysis of poverty in Malawi (Draft). UNICEF. Lilongwe. 202 p.

Hara, M. 1993. Fish marketing in Malawi, p. 63-83. *In* E. J. Reynolds (ed.) Marketing and consumption of fish in eastern and southern Africa (selected country studies). FAO Fisheries Tech. Report No. 332.

Hara, M. 1998. Problems of introducing community participation in fisheries management: lessons from Lake Malombe and Upper Shire River (Malawi) Participatory Fisheries Management Programme. p.41-60. *In* A.K. Norman, J.R. Neilsen and S. Sverdrup-Jensen (eds.) Fisheries co-management in Africa. Fish. Co-mgmt. Res. Project, Res. Rpt. 12. Hardin, G. 1968. The tragedy of the commons. Science Vol. 162: 1243-248.

Hoole, M.C. 1955. Notes on fishing and allied industries as practised among the Tonga of the West Nyasa District.The Nyasaland Journal, Vol. 8(1): 25-38.

Hulme, D. and M.M. Turner. 1990. Sociology and development: Theories, policies and practices. Harvester Wheatsheaf, Hertfordshire. 251 p.

ICLARM/GTZ. 1991. The context of small-scale integrated agriculture-aquaculture in Africa: a case study of Malawi. ICLARM Stud. Rev. 18. 302 p.

Kalipeni, E. 1996. Chewa. Worldmark Encyclopedia of Cultures and Daily Life. Vol. 1 (Africa): 98-102.

Katerere, Y. 1997. Partnerships, profit and power. Resource Africa (SADC NRMP Newsletter) 1(2): 9.

Krishnamurthy, B.S. 1972. Economic policy, land and labour in Nyasaland, 1890-1914, p. 384-404. *In* B. Pachai (editor). The early history of Malawi. Longman, Bristol.

Lamport-Stokes, H.J. 1970. Land tenure in Malawi. The Society of Malawi Journal. Vol. 23(2): 59-88.

Landes, A. and G. V. Otte. 1983. Fisheries development in the Lake Chilwa and Lake Chiuta region in Malawi: Report prepared for the German Agency for Technical Cooperation (GTZ). MAGFAD/GTZ, Zomba. 35 p.

Lowe, R.H. 1948. Notes on the ecology of Lake Nyasa fish. The Nyasaland Journal, Vol. 1(1): 39-50.

Malawi Fisheries Department (MFD). 1996. Fisheries statistics (unpublished). 12 p.

Mapila, S.A. 1998. Fisheries, Chapter 5. I*n* Malawi Government. State of the Environment Report (1998), Malawi 15 p (accessible from website http://www.sdnp.org.mw).

Matiya, G. 1997. Towards sustainable fisheries management: Paper presented to [Malawi] Vision 2020 as a contribution of the Fisheries Department. Lilongwe, Malawi (MS). 13 p.

Matowanyika, J.J.Z. 1994. Lecture on indigenous resource management: Six-week course in human and social perspectives in natural resources management: 6 February - 18 March, 1994, Harare, Zimbabwe (9 February 1994). 17 p.

McGoodwin. J.R. 1990. The tragicomedy of the commons, p. 89-96. *In* J.R. McGoodwin. Crisis in the world's fisheries: People, problems, and policies. Stanford University Press. Stanford. 235 p.

Mills, G.G. 1990. Active assisted diffusion: Roles for community activists in extension programmes. MAGFAD, Zomba. 2 p.

Mills, M.L. 1980. CIFA visit to the Lower Shire Valley, 12th December, 1980. Malawi Fisheries Department Reports (unpublished). 9 p.

Mitchell, J.C. 1951. An outline of the social structure of Malemia area. The Nyasaland Journal, Vol. 4(2): 15-47.

Msiska, O. V. 1991. Sustainability of the fish supply in Malawi. Paper presented at the "International Conference on Collaborative Research and Development", 2-4 September, 1991 Club Makokola, Mangochi, [Malawi]. 13 p.

Munthali, S.M. 1997. Dwindling food-fish species and fishers' preference: problems of conserving Lake Malawi's biodiversity. Biodiversity and Conservation 6: 253-261.

Murombedzi, J. 1999. Land expropriation, communal tenure and common property resource management in Southern Africa. IASCP 50 (Quarterly): 1-3.

Murphree, M.W. 1993. Communities as Resource Management Institutions. IIED (London). SA36: 1-15.

Mzumara, A.J.P. 1967. The Lake Chilwa fisheries. The Society of Malawi Journal, Vol. 20(1): 58-68.

Ngwira, N., E. Ng'ombe and E. Nsiku. 1996. SADC country reports on the inland fisheries sector: Malawi; for preparation of SADC inland fisheries sector policy and strategy. SADC Inland Fisheries Technical Coordination Unit, Department of Fisheries, Ministry of Natural Resources, Malawi (unpublished). 64 p.

Nsiku, E. 1999. Changes in the fisheries of Lake Malawi, 1976-1996: Ecosystem-based analysis. M.Sc. thesis. University of British Columbia, Vancouver, Canada. 217 p.

Ojda, L. 1990. Lake Chiuta study. Report for Malawi-German Fisheries and Aquaculture Development Project (MAGFAD) in Zomba, Malawi, Humburg. 50 p.

Phiri, K.M. 1977. Cultural and politicalchange in the pre-colonial history of Malawi. The Society of Malawi Journal, Vol. 30(2): 6-10.

Pinkerton, E. 1999. Factors in overcoming barriers to implementing co-management in British Columbia salmon fisheries. Cons. Ecol. 3(2): 2 (accessible from website http://www.consecol.org.vol3/iss2/art2).

Pitcher, T.J. and P.J.B. Hart. 1982. Fisheries ecology, Groom Helm, London. 414 p.

Robertson, A.F. 1984. People and the state: An anthropology of planned development. Cambridge University Press. Cambridge. 332 p.

Ruddle, K. 1988. Social principles underlying traditional inshore fishery management systems in the Pacific Basin. Marine Resource Economics 5: 351-363.

Ruddle, K. 1989. Solving the common property dilemma: Village fisheries rights in Japanese coastal waters, p. 168-184. *In* F. Berkes (ed.) Common property resources: Ecology and community-based sustainable development. Belhaven Press. London.

SADC. 1996. Resource Africa (SADC NRMP Newsletter) 1(1): 1-8.

SADC. 1997. Spotlight: Playing by whose rules. Resource Africa (SADC NRMP Newsletter) 1(2): 12.

SADC. 2001. Southern African Development Community (SADC): Background (accessible from website http://www.sadc.int).

Scholz, U.F., F.J. Njaya, S. Chimatiro, M. Hummel, S. Donda and B.J. Mkoko. 1998. Status and prospects of participatory fisheries management programmes in Malawi. p.5-19. *In* A.K. Norman, J.R. Neilsen and S. Sverdrup-Jensen (eds.) Fisheries co-management in Africa. Fish. Co-mgmt. Res. Project, Res. Rpt. 12.

Sen, S. and J.R. Nielsen. 1996. Fisheries co-management: a comparative analysis. Marine Policy 20 (5): 405-418.

Smith, L. W. 1998. Use of traditional practices and knowledge in monitoring Lake Malawi artisanal fishery. J. Fish. Mgmt. 18: 982-988.

Taylor, L. and R. Alden. 1998. Co-management of Fisheries in Maine: What does it mean?. Summary Report based on J.A. Wilson, J. Acheson and W. Brennan. 1998. Draft Report prepared for the Department of Marine Resources (DRM). DRM, Maine, 8 p.

Turner, G. F. 1995. Management, conservation and species changes of exploited fish stocks in Lake Malawi, p. 335-395. *In* T.J. Pitcher and P.J.B. Hart (eds.) The impact of species changes in African Lakes. Chapman and Hall. Fish and Fisheries Series 18.

Tweddle, D, S.B. Alimoso and G. Sodzapanja. 1994. Analysis of catch and effort data for the fisheries of the South East Arm of Lake Malawi, 1976-1989 with a discussion on earlier data and inter-relationships with commercial fisheries. Malawi Fisheries Department, Fisheries Bulletin No. 13. 34 p.

QUESTIONS

Heidi Glaesel : There was an MPA set up in that area about fifteen years ago. How much community involvement is there in the management of that area?

Edward Nsiku: It is different in the Lake Malawi National Park where there is no co-management and it is more of a government initiative. In the Lake Malawi National Park there are a few villages left. All management is top-down instead of bottom-up. A committee on natural resources has recently been set up to cooperate with the locals.

Jim Enright: You mentioned that the funding agencies were promoting traditional knowledge. How much do the local people want to participate in a top-down system?

Edward Nsiku: With this understanding, and also in the case of co-management, they are really very sensitive. The first case was funded through GTZ, a German funding agency, which was promoting co-management in Lake Malawi. It started as a government initiative, but during the process they are trying to balance it by bringing in more participation from the locals. Another example is Lake Chuta. Here the initiative came from fishers themselves and they set up a committee. These are some of the examples. In localized, small places it is the community itself that takes the initiative through a local process. They use the island model and co-management.

Agus Heri-Purnom: How confident are you about implementing the TEK?

Edward Nsiku: There is that potential through the funding agency. The majority of the fisheries is small-scale and still uses the traditional gears. The government wants to incorporate these fishers in programs and policies. There is the potential that their knowledge will be incorporated in order to sustain the fisheries. It is not there yet.

Scott: You mentioned that some traditional practices involved closing the fishery. Was this closing an area or closing down fishing for a species? Is this traditional practice complimented by scientific knowledge?

Edward Nsiku: In the case of Embenji Island, the main species of fish is called *utaba* and the closures were effected for it.

Scott: Following up from the previous presentation, are there ways to punish people if they don't follow the rules?

Edward Nsiku: In the smaller lake, there were traditional beliefs which were in existence, and the people believe that the spirits will punish those who infringe the law. The lake is like a natural sanctuary. In the case of Ebenji Island, there is a local committee that works on the regulations. For example, there are regulations for joining the fisheries operations. There is also a rule that drinking is prohibited. Some regulations are set up from time to time depending on what they are paid for etc.

Sheila Heymans: Does the chief set up the rules?

Edward Nsiku: There is a sort of fishing committee and it is the committee that decides together with the chief. They try to inform everybody and the people in the village will follow the rules, otherwise they will be subject to the local sanctions and penalties.

Kerry Prosper: This is like a value system within a community. Is it passed down through the community through education, like a spiritual thing?

Edward Nsiku: Their knowledge system is learnt through daily life. It is passed on from the older fishers to the younger fishers.

Kerry Prosper: How do you tackle the world changing, for example young people wanting new things and new technology?

Edward Nsiku: It has been a problem. When government came in and set the objectives, they tended to concentrate on economic criteria. A number of these programs have had limited impacts and it is only now that the government

has realized it is not enough. Yes, certainly there is that conflict. The regulations of the bay have not focused on the values system. Co-management will try to balance that.

EXAMINING THE TWO CULTURES THEORY OF FISHERIES KNOWLEDGE: THE CASE OF THE NORTHWEST ATLANTIC BLUEFISH

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ABSTRACT

Many accounts have relied on a general contrast between fishers' knowledge and scientists' knowledge. This 'two cultures' theory suggests A) that both training and experience lead fishers and scientists to think in systematically different ways about fish and B) that breakdowns in communications caused by this difference in knowledge cultures is a primary reason for fisheries management failures. The case presented here qualifies both of these suggestions. The research combines a participant observation study of scientific decision making, with a discourse analysis of debates around the management of Atlantic bluefish (*Pomatomus saltatrix*) from 1996 through 1998. The paper traces seven disputes over bluefish science and argues that institutional factors, rather than differences in understanding, were more important influences in five of these seven disputes. Fishers and scientists did not think differently about most of the central facts in the debate over the condition of the bluefish stock. In fact, they were in broad agreement. The final outcomes of the debate, however, involved a wholesale and specific rejection by the scientists of the "anecdotal" information that the fishers considered important. This happened in spite of the fact that most of the scientists involved believed that the anecdotal data accurately reflected the condition of the stock. The reasons for this outcome, which satisfied no one, are to be found in institutional factors that constrained and distorted the scientific debate, rather than in differences in culture among the parties concerned.

INTRODUCTION

Discussions of the differences between local ecological knowledge (LEK) and research-based knowledge (RBK) often reflect, more or less consciously, a “two cultures” theory that emphasizes how and why scientists and fishery workers see the resource in different ways (Berkes 1993, Felt 1994, Pinkerton 1989, Smith 1990,1995). Berkes (1993) sees LEK as beliefs associated with indigenous societies that have been handed down through generations and suggests that these systems of knowledge share among themselves characteristics distinct from Western RBK (Berkes 1995). Others have made similar observations about people of European extraction. Finlayson (1994) in his book on fishers’ knowledge and the collapse of the Canadian cod argues that Department of Fisheries and Oceans scientists "willfully dismissed" the insights of the inshore fishermen because of dissimilar cognitive cultures. Because they used alien rules, norms, and language in the negotiation of validity, "Knowledge claims by members of each culture were literally heard as incoherent by the other” (p. 103). Smith (1995) also argues that both fishers and scientists see the other as violating "plain common sense.” For example, both Smith (1995) and Pálsson (1995) found the same reaction to transect surveys amongst fishing skippers in separate studies: the scientists don’t seem to realize that fish swim! Roepstorff (2000) suggests that fishers in Greenland "focus on fish as a living being" and think of them as “mass nouns” while scientists see the fish as a “count noun,” meaning that the individual fish is a representative of the stock in the sense that the stock is the arithmetic sum of the single fish.

While appreciating the importance of these insights, I believe that this “two cultures” approach to the differences between LEK and RBK needs qualification. One problem with contrasting LEK and RBK as two cultures is simply that there are many more than two knowledge cultures in both categories. As even a short review of the sociology of science makes clear, science is made up of many communities with different scientific cultures and standards of validity (Barnes *et al.* 1996). Different local communities also have their own knowledge cultures. Nor is it useful to hold a position, while conceding ‘of course, there are more than two knowledge cultures,’ that there are still enough essential differences between LEK and RBK that they are useful as ideal types. As Agrawal (1995) argues, this will likely stereotype LEK while idealizing RBK. Good cultural explanations of LEK and RBK within a particular management situation begin with an empirical approach to uncovering communities of common understanding among both professional scientists and fishery workers.

An institutional approach to social influences on fisheries knowledge may yield more useful insight and be more empirically accurate than a cultural one. Here a cultural explanation is one that focuses on how one group shares meanings

that another group does not share. When Finlayson (1994) makes the argument mentioned above about dissimilar cognitive cultures making fishers and scientists mutually incoherent, he is offering a cultural explanation. An institutional explanation focuses on the way in which interactions within and among groups are structured, and how institutional attributes block or distort arguments that would otherwise be mutually understood. These structures include formal laws, operational rules, fora for discussion and decision-making and social networks. When, elsewhere in his book ,Finlayson (1994) argues that the data produced by offshore fleets was privileged over data from inshore fleets, he is offering an institutional explanation.

Drawing a distinction between culture and institutions has some very artificial aspects. The best understandings of institutional maintenance draw heavily on the concepts of culture and cultural embeddedness, where shared understandings are institutional products (Jentoft *et al.* 1998). The reason for using the distinction here is that fisheries social scientists have overemphasized the idea that fishers and scientists see the world differently. Not only does this threaten a reification of the categories of "scientist / RBK" and "fishery worker /LEK ," it leads us to underestimate the degree to which the rules governing management and stakeholder interactions create these apparent gaps in how the world is seen.

I ground this argument through an examination of the roles and beliefs of various stakeholders and how they affected their determination of the "best available science" with respect to the management of Atlantic Bluefish (*Pomatomus saltator*, Linnaeus 1766) during the period from the fall of 1996 to the spring of 1998 in the United States. The case study begins with a description of the methods used and a brief background discussion about bluefish management. Then each of the seven disputes about bluefish science is described in turn.

Case Study Background Methods

The case study presented here is part of a larger study of the tensions between science and public participation in fisheries management. This study includes two other Northeast Region species case studies and two random sample surveys, one of marine fisheries scientists and the other of the general population of people active in fisheries management in the Northeast Region. Information for the case studies was gathered in a number of different ways. Formal key informant interviews were carried out with 24 scientists, 21 fishers (many of whom served on advisory panels), nine activists in, or active observers of, the fisheries management system, and four administrators. Approximately 200 management-related documents were reviewed, including ten complete transcripts of the Council and/or Commission meetings, of which four related directly to bluefish. We also observed a total of 43 meetings.

Background on Bluefish

In 1976, the US Congress redesigned federal fisheries management and created eight regional Fisheries Management Councils (see also Glaisel and Simonitsch, this vol). Representatives of the fishing industry sit on and hold voting rights on the councils, which have certain powers over the creation of fisheries management plans (FMPs) in federal waters. These councils are only one part of a complex "alphabet soup" of agencies and other institutions. Table 1 overleaf provides a guide to help the reader navigate this soup. The regional council responsible for bluefish is the Mid-Atlantic Fisheries Management Council (hereafter the Council). The Council works very closely, indeed regarding bluefish it usually meets around the same table, with the Atlantic States Marine Fisheries Commission (the Commission), which is responsible for bluefish management in state waters. The third major government actor in bluefish management, the National Marine Fisheries Service (NMFS, pronounced nymphs) implements FMPs in federal waters and must ensure that they meet certain national standards.

US marine fisheries management between 1976 and 1996 was generally not a success. The dominant explanation given by observers was that the council system, and a history of close NMFS - industry cooperation, has put the 'foxes in charge of the hen house' (Safina 1994). In 1996, changes in Federal Law addressed the 'foxes' problem by both strengthening NMFS's powers vis-a-vis the regional councils and by more precisely defining the 10 National Standards that all federal FMPs must meet. During 1997, NMFS developed guidelines for implementing the new laws. Some of the most important related to specifying "objective and measurable criteria" for overfishing. These guidelines allow an overfishing definition to contain either a maximum rate of fishing mortality or a minimum acceptable stock size. In practice, for many FMPs including bluefish, both of these components of the overfishing definition are required (MAFMC and ASMFC 1998). This language also makes the creation of an FMP for

Table 1: Bluefish Management Jurisdictions and Institutions

		State Waters	Abbreviation Used in Text	Federal Waters	Abbreviation Used in Text
Area		0-3 Miles		3-200 Miles	
Jurisdiction		Individual States		US Federal Government	
Ultimate Decision Maker		Individual state legislatures		The Secretary of Commerce	
Responsible for FMP design		The Atlantic States Marine Fisheries Commission Bluefish Board	The Commission	The Mid-Atlantic Fisheries Management Council	The Council
Available Scientific Staffs		Individual state fisheries agency scientists Commission scientists		Council Scientists Northeast Fisheries Science Center at Woods Hole, Massachusetts	 Woods Hole
Basic scientific work		Bluefish Technical Committee		Northeast Fisheries Science Center at Woods Hole, Massachusetts Stock Assessment Workshop	Woods Hole SAW
Peer review of basic scientific work		Commission Scientific and Statistical Committee	S&S Committee	Stock Assessment Review Committee	SARC
Monitoring and Enforcement	of FMP compliance with national standards	National Marine Fisheries Service	NMFS	National Marine Fisheries Service	NMFS
	of fishers compliance with FMPs	State Fisheries Management Agencies		National Marine Fisheries Service – United States Coast Guard	NMFS

an overfished stock a legal requirement and this FMP must rebuild the stock to the minimum acceptable stock size (or often to a somewhat higher target value) within ten years. The most critical difference between the pre-1996 and post-1996 fisheries management regime is that, if a Regional Council fails to produce an FMP acceptable to the Secretary of Commerce (meaning in practice to NMFS) NMFS now has the authority to impose its own FMP.

Figure 1 (overleaf) is a schematic representation of the scientific institutions involved in bluefish management. Above the black line is the picture of the natural world that these institutions construct, below the black line is the social context in which the institutions operate. The upper left hand box is the unknowable actual condition of the bluefish stock. The upper right hand box is the legal condition of the bluefish stock that will be used for management. The bottom half of Figure 1 depicts the major fisheries management groups and how they relate to each other. On the right hand side is the Federal system made up of NMFS and the Councils. The arrow from NMFS to the legal condition of the bluefish stock box represents the Secretary of Commerce's final acceptance of the FMP. Arrows between boxes represent influence and /or authority. It is notable that the main entry points to the process from the fishing public are through the state level administrators or through the industry representatives on the Council, who are appointed at the state level. The arrows from the agencies to the fishing public represent the combined influence on fishing behavior of the perceived legitimacy of fisheries management, and the available surveillance and enforcement powers. The arrow going up the far left hand side represents the fact that the fishing behavior of the public is the only link from all of this back to the actual condition of the bluefish stock.

The states and the Commission, the Council and NMFS all have scientific staff. Representatives of these staff groups come together regularly in various fora, come to know each other and each others' work very well, and form a concrete scientific community, in the sense used by Barnes *et al.* (1996). They share a culture that includes a sense of shared responsibility of fisheries management, understandings of leadership, and criteria for evaluation of scientific work. Meetings of the ASMFC Bluefish Technical Committee (BTC) were the most important fora where these scientists interacted in this particular case study. In spite of this shared culture around bluefish, important differences exist between scientific cultures at the state and federal levels. For example, state scientists work more directly with the fishing industry and tend to have a higher evaluation of LEK (Wilson 2000a, Wilson 2000b).

In Figure 1, the peer review process is placed on the intersection between the science boundary and the stock assessment model. Stock Assessment Workshops (SAW) are open meetings that take place at Woods Hole. The SAW's assessment is then peer reviewed by a Stock Assessment Review Committee (SARC), which is also an open meeting that includes a broader group of fisheries scientists. The findings of the SARC are then presented in Public Review Workshops, which are basically informational and the one observed here did not involve any modifications of the material. NMFS and other fisheries administrators view basing an FMP on the findings of a SARC as the strongest foundation for certifying that the legally required "best scientific information available" has been used.

NMFS pushed hard for severe restrictions on the recreational bluefish catch, negative public reaction was intense and the Amendment failed to pass the Council. Under the old system, NMFS could not force the issue by threatening to impose its own FMP. In the fall of 1996, SARC 23 (NEFSC 1997) started the second round in the creation of Amendment One with a new bluefish stock assessment. They found bluefish to be "over exploited," a term that now triggered a legal requirement for a plan to reduce fishing effort. This finding contradicted a previous finding by the BTC that the bluefish stock was "fully exploited." This stock assessment was greeted with widespread disbelief and anger. This was partly because changing the stock from fully to overexploited, especially with the legal ramifications of the change, was seen as high-handed. But there was also a strong sentiment

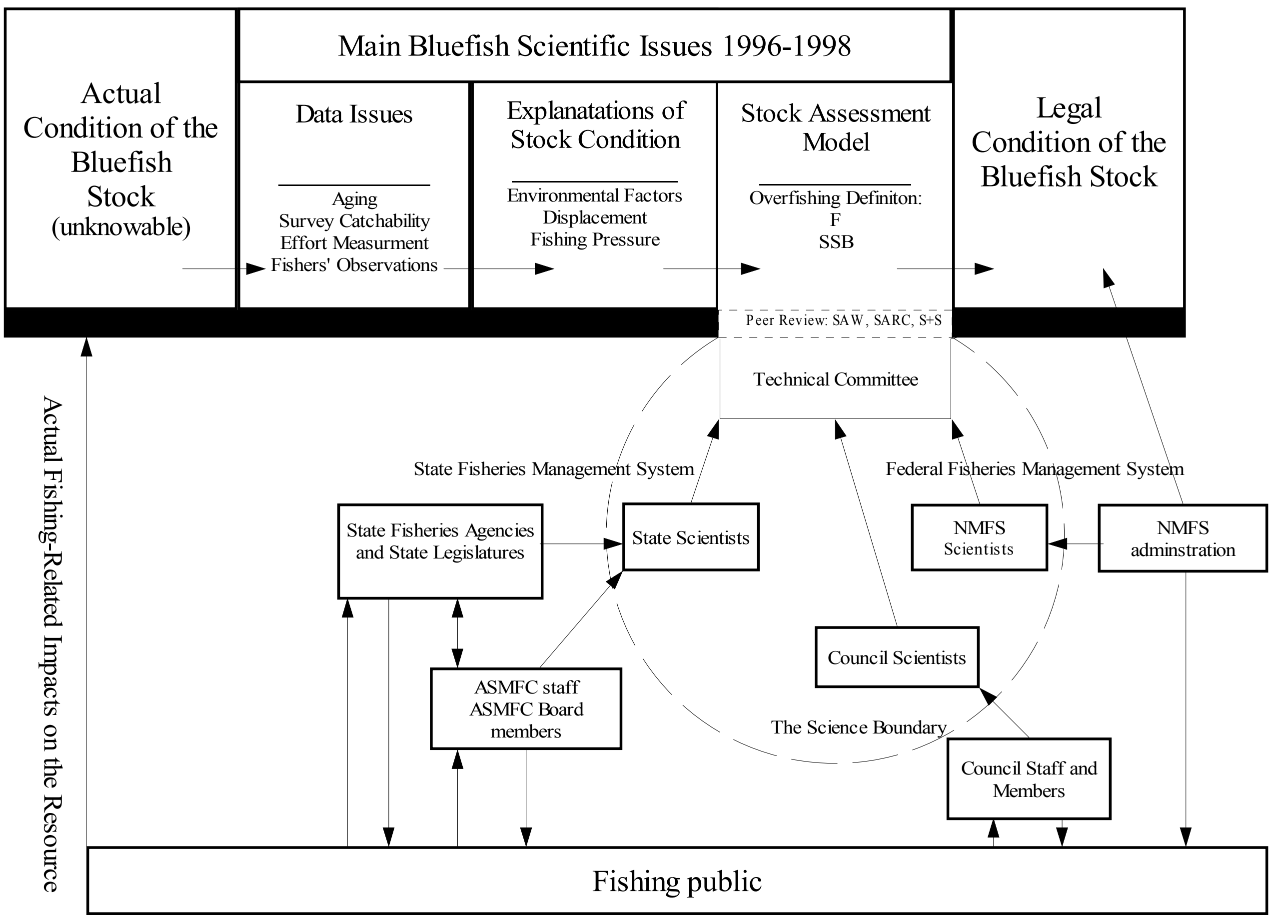

Figure 1: Schematic representation of the scientific institutions involved in bluefish management

The process of creating Amendment One of the bluefish FMP began in December 1994 (when SAW 18 found serious problems with the condition of the stock), and ended in the fall of 1998. The first two years of the Amendment One process, 1996, took place under pre-1996 rules.

that the SARC's decision was simply wrong and it had recommended drastic measures based on very shaky evidence. The case study traced seven major scientific disputes around bluefish science in the period from SARC 23 assessment to the official designation of the "best available"

scientific knowledge that would be the basis of Amendment One. Each of these disputes is presented in turn, and evaluated in terms of the degree to which cultural or institutional factors (as defined above) were the driving force in the course taken by the dispute. Table 2 lists the disputes according to the outcome of this evaluation.

Table 2: Important Scientific Disputes in Bluefish Management

Type of Dispute	Disputes Mainly Rooted in Cultural Differences	Disputes Mainly Rooted in Institutions
Data Issues	Aging of Bluefish	Usefulness of Survey Data
	Effort measurement	Usefulness of Fishers' Observations
Competing Explanations for Observations about Bluefish		Environmental Factors
		Fishing Pressure
		Offshore Displacement

DISPUTE #1: THE AGING OF BLUEFISH

The problem of aging bluefish is one that received relatively little attention among nonscientists concerned with bluefish, but which the scientists considered very important. Knowing the age of individual fish is critical because the more sophisticated ways of measuring fish populations are based on tracing year classes, which are cohorts of fish of the same age. It takes time to figure out how old a fish on a lab bench was when it died. It is done by looking at the fish's scales or its otoliths (hard formations found in fishes' inner ears) and counting the rings in them as you would do to age a tree trunk. Because aging fish takes so long, samples of fish are used to make "age-length keys" which give the probabilities of a fish being a particular age if it is a particular length.

SARC 23 (NEFSC 1997) used age-length keys for bluefish that came from the North Carolina Division of Marine Fisheries (NCDMF). In August 1997 the Mid-Atlantic Fisheries Management Council received a letter from the South Atlantic Fisheries Management Council. They were concerned that keys estimated from winter commercial catches in 1995 had not been used with information from recreational catches being used instead. Fish caught in the winter commercial fishery are twice as big as the summer, recreational fish. They also raised a new issue. The NC data was based on scales and not on otoliths, which their S&S Committee feared might lead to inaccuracies of as much as three years.

The NCDMF addressed this second concern with a study of bluefish aging techniques. They reported their findings at the Bluefish Technical Committee (BTC) meeting in February 1998. They had found that whole otoliths are not reliable for aging bluefish beyond age three. The reporter described aging a bluefish older than age six as a "crap shoot" and suggested that many ages in the past had been assigned by guess. They recommended that when analyzing the bluefish stock, fish over age six should be lumped together into a "six +" age category. The use of such 'plus' groups in these models is standard practice, but the question of the age at which to set them is an important one.

At the March 1998 BTC meeting, Woods Hole was represented by a scientist deeply involved in assessing bluefish. Almost immediately, as the minutes for the February meeting were being read, he began to object to the "unsubstantiated rumors that you can't age fish" based on the NC report. In a tense moment in the meeting, the state scientists reacted defensively that nothing in the minutes should be construed as an endorsement of the NC presentation. The federal scientist insisted that this be made clear because he "does not want to get blindsided by this stuff." Later, he presented two bluefish stock assessment models. One was based on the currently used 9+ as the oldest year class, the other on 6+. The 9+ gave an initial stock size in 1982 of 379,000 tones and a 1996 size of 158,000 tones. The 6+ model decreased the stock size by half in 1982 and by a factor of four in 1996. To understand the implications of this, remember that the new law required that a minimum stock size be established and that management measures must rebuild to that level, whatever it is, in ten years. The choice of the final model of the bluefish stock was strongly influenced by the desire of the scientists to avoid using unreliable aging data.

Government scientists were the only stakeholders involved in the dispute about bluefish aging. They were certainly not interested in publicizing this powerful ammunition for stakeholders who would like to delegitimize government science. The 10-year rebuilding requirements added particular urgency to the question as well. Therefore, there were institutional reasons why the dispute unfolded in the way it did. However, all of these

proceedings and associated documents were open to the public and more or less scrutinized by the interested parties. That other stakeholders did not make a major issue of the aging problems is most likely because they did not fully realize how bad and how crucial the scientists thought they were. This suggests that the progression of the aging dispute is better explained by cultural factors, i.e. a lack of fully shared understanding among some of the stakeholders, than by institutional factors. That these differences in understanding are related to statistical modeling is important, because that is true of almost all failures of mutual understanding found during the case study. Differences in understanding rooted in statistics exist among scientists as well as between scientists and other stakeholders.

Dispute # 2: Effort Measurement

Members of the bluefish fishing public are very concerned about how fishing effort is handled in assessments. The issue was raised in nearly every interview with fishers in which bluefish were discussed. Sitting in the recreational fishing communities, they have seen the degree to which anglers have shifted from catching bluefish in the 1980s to catching striped bass in the 1990s. They believe that this drop in effort is a major reason for the drop in catch and do not believe that this is adequately considered in the scientists' models.

Most of the scientists acknowledge some problems with effort measurement but feel that the models they are using handle it adequately. The model that SARC 23 used is based primarily on the relative number of fish caught in the various year classes, but a measure of catch per unit effort (CPUE) is used based on the Marine Recreational Fishery Statistics Survey (MRFSS). This survey includes both intercepts of anglers returning from fishing and a general population survey of coastal states that gathers information about catches. SARC 23 (NEFSC 1997) acknowledges that the intercept survey does not measure the lengths of an adequate sample of fish. As their measure of effort, SARC 23 uses the number of "trips that caught bluefish plus trips in which bluefish was the target species and in which some fish (of any species) were caught" (NFSFC 1997a p 156). At the Public Review Workshop for SARC 23 held in February of 1997 at a Council meeting the following exchange took place:

State scientist: The last issue I have deals with effort. There are no tables here dealing with fishing effort particularly on the recreational side, and I'm just curious if you considered trying to use that or use boat trips as some surrogate for fishing effort.

Federal scientist: Actually it doesn't show up in this one, but in the last assessment we went through what I would characterize as extensive discussions on effort. Looking at various ways to appropriately use the recreational data and the commercial data, we looked at that in a really hard way, there was no real modification done at this time .....we had done such extensive analyses in the last round, so we are sort of using that up to the present.

Council member associated with recreational fishing: Let me see if I understand what you are saying. In response to the question I asked earlier, you pointed out that it was something new that happened since the last SAW that helped you fine tune this assessment. Are you now saying that you did not take into consideration in that same time period anything that changed in the recreational fishing performance? We all know that that has changed significantly with respect to the targeting of bluefish and the lack thereof.

Federal Scientist: I just answered your question. We have taken into account the additional information, the additional years, the rec [recreational] index that we used again from the extensive analyses we did in the last assessment. We used that again, and added the new information to it.

Council member: Do you see a dramatic downturn in the participation in bluefish fishing recreationally? Any downturn? Do the lower catches, in fact, addressing [the state scientist's] point, in any way reflect less participation?

Federal Scientist: That's hard to say. We've looked at the effort data. I mean, I think probably, yes, that's true.... yes the recreational catch has declined. It's possibly due to less participation; we haven't quantified that to a great degree.

Council member: Okay, explain something to me, the extent to which you would use lower catches to help drive some of the conclusions about SSB, how then can you use that number if it isn't in some way fine tuned with effort? It suggests to me from what you are saying that the effort isn't as important in the calculation as the use of the number itself.

Federal scientist: I'm sorry if we got cross wired here. We're using an effort index to tune and we've incorporated the new information that is available up to the present through 1995, which is the terminal year of this assessment.

At first the Council member thought that the scientist was saying that they had not updated the effort data itself, when he had meant that they had not changed the way that data was modelled. This is perhaps because the Council member was focussed on the question of whether or not the change in effort was being considered. The federal scientist's need to double check the answer, implies that he was not aware before this interchange, of the degree to which the fishing public was concerned that changes in effort were being ignored. The opaque language he chose to use in his last remark suggests that he still may not have sensed the degree of concern.

In addition to the fear that changes in effort are being ignored, members of the fishing public frequently expressed three other criticisms of MRFSS as a measure of effort. The first is that the general telephone survey does not cover Pennsylvania, and a great many of the customers on party and charter boats come from the Philadelphia area. The second is that in the intercept survey, work is only done during the day, while a lot of bluefish fishing is done at night. They also believe, and I have heard a scientist express this belief as well, that the CPUE is higher at night than it is during the day. These things are seen to be correlated as night anglers are often from Philadelphia.

The third criticism is that the growing number of anglers who catch and release their bluefish rather than keeping them is not considered. As one sports fishing organization put it the "methodology becomes even less dependable when you consider that the recreational community has, in most recent years, been releasing the majority of its catch. This brings into question the use of recreational "landings" and recreational "catch" in the assessment. It almost appears the two are interchangeable in places when in actuality, the figures are different by orders of magnitude" (JCAA 1998). This criticism does not accurately apply to either the SARC 23 assessment (NEFSC 1997) nor the stock assessment adopted for Amendment One (Gibson and Lazar 1998). Both of these explicitly considered the release of fish and used figures that reflected the increasing trend toward catch and release. Recreational effort measurement was addressed by both the SARC and the BTC as a serious technical issue, especially once larger issues of model and raw data selection were becoming clarified.

Even more than the aging, effort measurement is a good example of how a lack of shared understanding between the recreational fishing community and the fisheries scientists can drive a fisheries science dispute. On the one hand, the anglers had difficulties understanding when and how the scientists were incorporating effort data into the models, while the scientists had a difficulty understanding the sources and degree of the fishers' concerns. On the other hand, the recreational people's knowledge of who fished and when led them to be much more critical of the ways effort was measured.

Dispute #3: The Status of Fishers' Observations

Fishers believe that they have considerable information to contribute to bluefish management. In interviews, fishers pointed to their knowledge about how different combinations of changes affect the bluefish stock, and particularly tracing the movements of the fish. Examples they gave of their knowledge of bluefish involved both what they were seeing and what they were hearing from different kinds of fishers around the coast. The observations they found important involved the behavior of both bluefish and species that the fishers associate with bluefish, e.g. striped bass, menhaden, and sand eels. These behaviors were most often seen as driven by environmental changes, particularly water temperature. What emerged from these discussions were not simply "anecdotal data," but "anecdotal hypotheses" (see also Stanley and Rice, this vol) about what is happening to the stock. None of the fisheries scientists interviewed, nor the fisheries scientist who accompanied us to some of these discussions with industry members, found these not yet systematically tested hypotheses, unreasonable. Anecdotal hypotheses for what was happening in the mid-1990s took various forms, but all suggested that the bluefish had moved offshore.

Fisheries scientists that we spoke with agree that using fishers' observations to improve stock assessment would be a good thing. At the state level in particular, there have been many instances of scientists working with fishers to address local research problems and to collaborate in research efforts that involved more than just using fishers' *ad hoc* observations. Both fishers and scientists learn in these small scale interactions.

The most critical problem, especially for NMFS, is one of scale. It includes both the logistical issue of processing detailed information from across the breadth of the Northeast Region, and the conceptual problem of translating local

observations into meaningful information at a larger scale. One attempt to use logbook information from party and charter boats was overwhelmed just by data entry demands. This led to loud resentment from the people who provided the data. Over the course of the case study, many presentations of LEK by fishers were made to scientists in public fora. A typical response to such presentations was "you're right and we looked at that question, and additional work is needed."

The use of fishers' observations in stock assessments is a charged issue. At one meeting, in response to a council member's raising the question of the degree to which fishers' observation did not jive with the SARC 23 assessment, the Regional Director (RD) of NMFS began by pointing out that anecdotal information is very difficult to use because fishers' observations in one place often don't agree with observations in other places. Then he said the following:

> 'Anecdotal is not a pejorative description, neither is analytical, although people are very happy to throw rocks at the analysis and are offended if people say 'that is anecdotal.' That seems to me to be silly. Nobody ignores anecdotal information .....Anecdotal information is used in the way that you can use anecdotal information, the same with analytical information. There is nothing pejorative about it.... I have never felt that it is not used in the assessment. It is used in the analysis when people are examining tuning indices and trying to explain why certain things occur in diagnostics. That is exactly what they used. It is used extensively.'

Two things are interesting in the RD's statement. The first is the defensiveness, he wanted people to understand that this is not some bias he or anyone else at NMFS has against the knowledge of fishers. The second is the assertion that fishers' observations are used as background information in putting together an assessment model. As will be clear, this case study suggests that this role as background information is a very problematic one.

The treatment by different stakeholders of fishers' observations, characterized by the use of the term "anecdotal data" by scientists, has important cultural elements. To some extent, different groups have different understandings of what makes a fact valid. Arguably these differences are more formal than substantive, by which I mean the "common sense" that lay people use to understand nature is often very similar in content to the method of the scientist. NMFS' basically positive response to using fishers' observations, and the real attempts they have made to do so, suggest that institutional problems run deeper here than cultural ones. We simply do not know how a government agency can make more than *ad hoc* use of fishers' observations, the response "you're right and we looked at that" is often the best they are able to do under the rules they have to operate under.

DISPUTE #4: SURVEY CATCHABILITY.

Two basic types of data are involved in stock assessment, information about the catches of fishers and "fisheries independent" data from surveys. Fisheries independent data is a critical source of information because the same gear is used in the same place year after year. Effort, i.e. the amount of time that the gear spends in the water, can be accurately measured, and the hauls are placed across the ocean according to a deliberate, mathematically designed plan. The Northeast Fisheries Science Center at Woods Hole does two surveys of the ocean between Canada and Cape Hatteras, which is approximately the mid-point of the US east coast. Because the most important commercial fish species are groundfish, the NEFSC surveys are done by pulling a trawl net along the bottom. Bluefish is a migratory, pelagic species that spends most of its life swimming quickly through the water high above the bottom. The catches of bluefish in the spring survey are so sporadic that it is not even considered in evaluating the stock. Data from the fall survey, however, is used in evaluating the stock.

Scientists point out that this poor catchability is not sufficient reason to dismiss the data. As long as the same gear is always used in the same way, the results are usable if the variance in the catch is not too high. Of course, 'too high' is a matter of judgement and an important one in the bluefish assessment. The fall survey is divided into geographical areas and there is an important distinction between the inshore and offshore areas. The inshore survey catches are of the order of fifty times as many fish as the offshore survey. This huge difference comes almost entirely from the number of young, age 0 and 1 fish that the inshore survey catches. In the offshore survey, the majority of hauls show either 0 or 1 fish, and so it becomes very difficult to arrive at statistically valid conclusions. The inshore and offshore contrast is very important in light of the dominant anecdotal hypothesis that the bluefish had moved offshore.

Much of the fishing public perceives these surveys as inadequate and many of them do so

for sophisticated reasons. All of the interested public, for example, seem to be aware of the problem of the bluefish being too high in the water column to be caught. In July 1997, leaders from recreational and commercial bluefish interests from one important bluefish state, including three Council members from the "industry representatives" category, met with scientists from their state to discuss how to respond to SARC 23. The content of the meeting was a review of the scientific arguments involved and a marshaling of counter arguments. Many were offered, including several related to survey catchability. One raised the point that the bluefish swim faster than the survey trawls move through the water. Another suggested that the surveys assume greater consistency in fish behavior than was justified. A council member argued that the survey moves north to south while the bluefish were moving south to north.

These issues were echoed in the meetings of the ASMFC Bluefish Technical Committee (BTC). As the federal scientist that attended the second meeting put it: "First of all, our trawl gear can't catch big bluefish unless it runs into them when we are hauling back because the damn things can outswim a trawl that is only this far [holds hand out] off the bottom and second, out on George's Bank or out on most of the shelf the trawl is down here and the bluefish are some 50 fathoms up there." His conclusion: "we need a bluefish survey, that is what we need."

At the conclusion of this BTC meeting two new stock assessment models were selected to be added to the one already created by SARC 23, and all three were sent to the Council Science and Statistical (S&S) Committee for a final determination. The first was an ASPIC[1] model. This model does not rely on aging, only on the number of fish caught, but accurate effort data is important. It cannot use the NEFSC offshore trawl because those were the only data that showed that the number of bluefish was increasing, and the model cannot accept data with contradictory trends. The validity of the ASPIC model depends on the assumption that the NEFSC inshore survey accurately reflects all of the bluefish available to the fishery. This fact is critical to understanding the present case study because it means that the ASPIC model relies on the assumption that the hypothesis that the bluefish had moved offshore was false. The other new model they considered was an *ad hoc* model created by a state scientist. He used both inshore and offshore data and melded several accepted approaches together. One of the justifications for the final selection of the ASPIC model as the "best scientific" characterization of the stock was that it did not use the less statistically tractable offshore data.

The dispute over the survey catchability was clearly driven by institutional factors. All stakeholder groups shared a common understanding of the problems with the survey. Therefore, it was institutional constraints, particularly driven by the expense of doing surveys and decisions about the allocation of fiscal resources, which lead to trying to assess all species with a single survey designed for the most commercially important species.

DISPUTE #5: THE EFFECT OF ENVIRONMENTAL FACTORS ON THE BLUEFISH STOCK

The issue of environmental factors such as habitat damage and predator - prey interactions played a relatively minor role compared to the offshore displacement and fishing pressure issues. The perceived need to manage fisheries as part of a broader ecosystem is intuitively appealing, especially to fishers. It resonates with their common argument to focus more on non-fishing related causes of declines in fish stocks. In interviews, several academic fisheries scientists were proponents of the ecosystem approach and no scientist denied its theoretical validity. There was skepticism about its practical relevance to management.

In April of 1996, the Subcommittee on Fisheries, Wildlife, and Oceans, of the House of Representatives Resources Committee, held a hearing on the decline in bluefish. At that hearing the NMFS representative attributed the decline in the stock to overfishing while other witnesses, including the Council, the Commission, and angler groups emphasized environmental factors (NOAA 1996), particularly a decline in bluefish prey species (JCAA 1996). Later the same year, NMFS produced a very short paper relating environmental variables to bluefish abundance (Terceiro 1996), which was later incorporated as a SAW 23 working paper. The paper found that many environmental variables do indeed correlate with bluefish abundance. The paper does not purport to test any theories; its main purpose seems to be to demonstrate the complexity of the question.

[1] ASPIC < www.fisheries.org/cus/library/cuslib39.htm> is a non-equilibrium implementation of the Schaefer stock-production model that can handle up to 10 simultaneous or sequential fisheries or indices of abundance for the same stock. The model can be fit conditional on the observed fishing effort or on the observed yield, and in the latter configuration, can handle missing values.

During the Public Review Workshop for SARC 23 the following statement was made by a fisher on the Council. It is representative of a common criticism of management.

> 'We're protecting all of the predators, fluke, striped bass are recovered, we're protecting the weakfish, we're protecting all of the predators, how about everything else? We're trying to protect the butterfish, the squid, everything in the ocean, but there has got to be a natural balance somewhere.'

A few minutes later:

Another council member: One of the things that we've discussed in the few years that I've been on Council, and in other meetings prior to being on Council, was a greater understanding of the migratory patterns and the relationships to ocean conditions and water temperatures and bait [fishers often refer to prey species as "bait"] availability for this species. Has there been any additional work done on that, because it could be a significant contributing factor to the presence in our waters?

To whom came the response:

NMFS Scientist: The other paper we looked at was one where we had a correlation matrix with about 25 environmental and biotic variables reviewed in that paper [note: this is the paper mentioned above] and, of course, the problem with a correlation analysis is that you don't know which ones are spurious.. the recommendation as a subcommittee... to do more work in that area.

Another comment made at the meeting:

Industry representative: That seems to be the approach sometimes, that we want an ocean full of bluefish and we want an ocean full of striped bass and those things may simply not happen. The problem is, in the process, what [The NMFS scientists] said is correct, the fishing pressure is the only thing that anybody can do anything about, but that makes the fishing industry the lowest common denominator in that attempt to maximize simultaneously or multiple variables. I disagree with the idea that fishing is the only thing that you can do anything about because certainly one of the greatest benefits to the bluefish resource might very well be to reestablish a greater commercial fishery on striped bass.

This statement shows another important aspect of the political complexities of considering species interactions, because the appropriate extent of the commercial fishery on striped bass was the most contested question in striped bass management. Many in the bluefish recreational community mirror this issue by arguing that a cause of the decline of bluefish is commercial fishing on prey species, particularly menhaden. The reduction or elimination of the menhaden fishery has been a priority of several recreational fishing groups.

As in other disputes, the dispute over the role of environmental factors reflects some cultural differences based mainly in scientific training. Scientists want to be able to model something before they start treating it as real. This is especially true when that treatment has a legal basis. The reason I have not classified this dispute as rooted mainly in culture, or even as rooted more or less equally in culture and institutional factors, is that all stakeholders basically agreed that environmental factors are important. The real differences were in possible responses to these factors, the law that NMFS in particular is mandated to carry out is designed to control the activities of fishers. The new laws do emphasize the importance of habitat, and require FMPs to identify areas of essential habitat for the species, but all NMFS is able to do with this information is to write letters to other agencies asking them to consider the protection of this habitat. To take into consideration all of the potential interactions may be academically appealing, but it is a poor fit with legal and political realities. This theme carries over into the next dispute.

DISPUTE # 6: THE EFFECT OF FISHING PRESSURE ON THE BLUEFISH STOCK

The second explanation given for the stock condition was that it was being overfished. SARC 23 concluded that fishing mortality has exceeded the appropriate biological reference since 1991. Critical reactions to these findings mainly took the form of highlighting the problems with the data discussed above. The varied reactions of other scientists to the model also focused on the data problems, particularly the aging issue.

During this year and a half period between SARC 23 and the creation of alternative findings by the BTC, NMFS put up a sprightly defense of the SARC findings and the need to take the management actions that they called for. Early on, NMFS cast the disagreements with the stock assessment as coming from "the sentiments" of people who were not willing to face reality. At the council meeting that followed the Public Review Workshop in February 1997 for SARC 23 the following exchange occurred:

Council Member (an academic): I believe that when this and these additional analyses go out to public hearing, there will be tremendous discussion, tremendous public concern on

what's occurring here, and perhaps once that public comment is completed, this Council may wish to take very careful note of that comment and reconsider some of the actions that it's taking.

NMFS Regional Director: This has come up a number of times now about the concerns that the public will have .Clearly, it will be controversial, but sometimes the need to do such things is controversial, the issue is what is needed to try to rebuild this stock. So, I think that regardless of the public outcry, sentiment and so on, it is important to be clear that that is what is apparently needed.

NMFS' application of the FAO Code of Conduct for Responsible Fisheries and the precautionary principle (FAO 1995) is at the heart of their vision of management and fishing pressure is what NMFS is best empowered to control in a precautionary way. NMFS scientists tend to conceptualize fisheries management as a technical problem and fishing pressure plays a key role in this conceptualization (Wilson and Degnbol 2001). During the initial presentation of SARC 23 at the Public Review Workshop, for example the NMFS scientists said

> 'So, again, I repeat that the focus of the SARC was more on, how do you get out of the current dilemma of, say, doing things that are within man's control, and the only thing you can do is really to lower catches.'

Other stakeholders are less comfortable with this assumption, as in this quote from an interview with an industry representative:

> 'Biologists are starting to acknowledge that there is less impact now, but they are saying "oh, maybe there's not but we still have to protect them and this is the only way we can do it, we can't deal with environmental factors, we can deal with you so we are going to screw you guys". I don't think it is going to have a great deal of impact biologically but ... It will destroy more human beings and small businesses who cannot survive this and who are not the cause of the problem.

The conflicting interests in fisheries management means that there can be no final, objective criteria that determine where the burden of proof lies. The issue in the final analysis is about the distribution of gains and losses from assuming or avoiding the risks of overexploitation. Those who are going to lose business now from a cutback, and who may or may not be the ones who enjoy its potential future benefits, are going to be much less sanguine about considering other causes of stock decline that cannot be responded to with changes in fishing pressure as irrelevant. While nearly everyone gives lip service to the precautionary principle, many people resist, and not always unreasonably, its stark demarcation of what the null hypothesis should be. As a council member put it at the special bluefish meeting:

> '[With all due respect for the precautionary principle] I think you will have a very hard time convincing people that it is wise to take actions that will put people out of business today because if we get squared away two years from now that we really didn't need to do that in the first place well now you can tell them to go back in business. Once they are gone they're gone.'

The dispute over fishing pressure clearly stems much more from institutional than cultural sources. All parties acknowledge that the size of a fish stock is a function of both environmental factors and fishing pressure. It is the law that requires that a target fishing mortality be identified, and the reason it does that is because that is what is most feasible to control legally. The dispute over the relative emphasis on fishing pressure versus environmental factors is driven by interests and by the rules that have been set up to adjudicate those interests. This is as much true for the government, which has a strong interest in emphasizing aspects of nature that are amenable to bureaucratic manipulation, as it is for the fishers.

DISPUTE # 7: THE DISPLACEMENT HYPOTHESIS

While there were many issues and problems with the bluefish assessment one disagreement stood out. Many people involved in the bluefish fishery, including scientists, believed that the observed decline in the bluefish stock was an illusion created by a large and sustained movement offshore of larger bluefish. The bluefish had moved away from where they had been caught in the past and the methods of catching them, both those of fishers and scientists doing surveys, had not followed them.

Among fishers the idea that the bluefish had moved offshore was close to a consensus. Longliners who targeted swordfish complained that bluefish were stealing their bait much more than in the past. Others told me that they had heard the same thing from tilefish and wreckfish fishers who fish in deep water canyons. This was the typical nature of the information. One fisher's observation was reinforced by that of another until a picture of the position of the resource was built up that was entirely coherent,

in the sense of being an internally consistent explanation, but not systematic. Thus a consensus emerged based on a great deal of information, but in a way in which information challenging that consensus could easily have been dismissed as not fitting the "common sense." A few typical statements are presented here. The first, from February 1997, is from a recreational fishing activist who served as chair of an advisory panel for another species and later became a member of the Commission:

Recreational Fishing Activist: I talk to offshore guys who see huge schools of large bluefish 60-100 miles offshore. The assessments we are getting are based on looking in the same places they always looked. These assessments say we are in deep trouble. I think we are but not to the degree that they are stating.

At the bluefish industry leaders' strategy meeting in July of 1997:

Council member: The 1996 year class was weak according to NMFS. Surveys are done in estuaries while the bluefish are offshore. Offshore the bluefish are giving fishermen a hard time but they are not seen inshore.

Another participant: They are not inshore down south.... Commercial Bluefish fisher: We are seeing half pound fish 10 miles offshore.

Council Member: Cold water runs down the coast along the beach to 12-13 miles off and bluefish don't like this.

The inshore water temperature theory was repeated by several fishers in different contexts. Water temperature figures frequently in fisher's observations. The importance of temperature is also reflected in the business of the Council member, who said the following at the Bluefish Monitoring Committee meeting in August 1997:

'To add a little anecdotal information onto the record...one of the businesses I am involved in provides satellite temperature chart service to recreational fishermen from New England through North Carolina. As part of that service people that receive our charts phone in fishing reports for their trips. They call them in to any one of six reporters who work exclusively for us. And that information is provided back in weekly reports to our customers up and down the coast. For the week of July 9th to July 15th I went back and read through the reports that were broken down by (50,000 reports) inside the 50 fathom curve areas and also by the canyons. What I found didn't surprise me but it might shed some light on the offshore distribution in these fish. I broke these down into canyon areas, and remember, keep in mind these are people who are not fishing for bluefish. They are fishing for yellowfin tuna...[tape is turned over]... There were bluefish harassing and believe me some of the reports said they could not get away from them. Bluefin tuna fishermen off Montauk, off Shinecock Inlet 45 miles, [the outer tip of Long Island] the sea buoy to the dip off Mariches [?] Inlet about 50 miles, the Texas Tower and Triple Wrecks area that's 50 -60 mile off NJ. The Slough Area, Little Italy, those areas are 16-28 miles off New Jersey, the Chicken Canyon, the Hambone and Sausage Lumps off of Delaware, the Fingers off Indian River, and 28 Mile Hill off of the Delaware-Maryland area. Those are all in one week period. That is a lot of bluefish covering a lot of area offshore.'

In spite of the number and coherence of the fishers' observations, some scientists did not find these arguments convincing. The response from one federal scientist when displacement was raised at the Public Review Workshop for SARC 23 was as follows:

'Actually in the subcommittee we did address some additional work that has been done in both of those areas [predator-prey and displacement]. We did look at a paper that suggested that perhaps there has been some movement of larger fish offshore, so that, in some way, addresses the availability thing you are talking about. It's weak evidence at this point, but we looked at it.'

The paper he referred to was written by a state scientist who was convinced that the displacement hypothesis had merit. The paper (Crecco 1996) is cited in SARC 23 as stating that "there is some evidence in the pattern of commercial landings and effort that adult bluefish have been displaced further offshore in recent years" (NEFSC 1997 p 161). That document did not use the word "weak" to describe the evidence. The paper argued that there had been a gradual shift, beginning in 1988 in commercial bluefish catches from state to federal waters, suggesting a shift in the stock.The federal scientist at the Public Review Workshop referred again to the displacement hypothesis a little while later in answer to another question about the "dome shaped partial recruitment vector," a statistical pattern showing that there were fewer older bluefish in the data than should be expected:

'In this case, since we have this funny fishing pattern, which we would characterize as a dome shape, where the older ages aren't recruited to the extent that the age ones are... The reason for using this pattern is because it

> has repeatedly shown up in the analysis that the Committee has done, it's not the usual one and in fact, most of the time you have a hard time justifying using this kind of relationship, but in this particular case we reviewed the evidence, both in terms of the analysis that you normally use to look at the fishing pattern. Also, as I mentioned before there is some, albeit weak evidence that larger fish are moving offshore and they may not be available, that would be a plausible mechanism why you would have a dome shaped curve.'

So while this scientist continues to characterize the evidence for the displacement hypotheses as weak, it is the only explanation he offers for why the "funny fishing pattern" keeps showing up in the data so often that they feel they have to go ahead and use it in the assessment in spite of the difficulty they have in justifying such a decision.

The displacement hypothesis became the central issue in the deliberations of the Bluefish Technical Committee. As described above, one of the models they were considering used the NEFSC off-shore trawl data and showed that bluefish was not overfished. Meanwhile, the other ASPIC model showed that the bluefish were overfished. The ASPIC model did not use the offshore data and its key assumption was the stock was fully available to the fishery. Bluefish is a recreational fishery which takes place near the shore; if the displacement hypothesis had any merit at all this assumption was not valid. Many, if not most, of the scientists that spoke at the meeting, however, believed that the displacement hypothesis had merit. One scientist, when accused of not believing it, responded that he had been catching bluefish far offshore just like other people (Wilson and Degnbol 2001).

The ASPIC model had a number of advantages, both scientific and institutional. It did not rely on aging fish. It yielded both a measure of standing stock biomass and fishing mortality, both of which are required by law if it is possible to obtain them. The management advice it triggered was not nearly as drastic as that from SARC 23, but was more conservative (more conservative = more restrictive of fishing) than the other model. Its being more conservative was definitely considered a plus by some, as a state scientist said,

> 'I don't know if we can spin it that way [chosen for being more conservative] but we should keep this in the back of our mind.'

Another scientist responded that one could call it conservative, or biased low. Finally, it was more scientifically standard than the alternative model, hence it would stand up to the kinds of peer review that are concerned with maintaining standards in science for public policy (Wilson and Degnbol 2001). The committee did not want to make a final decision. They decided to pass the final decision on to the Council's Scientific and Statistical Committee. They did this knowing that the ASPIC model would be chosen. As the presenter of the *ad hoc* model that accepted the displacement hypothesis said *'I don't think that my analysis will pass* [the Scientific and Statistical Committee] *as well as the ASPIC, I just think it is the right answer.'*

In May of 1998 the newsletter of the Atlantic States Marine Fisheries Commission announced their decision with the following comment:

> 'The S&S committee recognized the shortcomings of the assessment but concluded that it represents the "best scientific" characterization of the Atlantic bluefish stock given the currently available data. An important caveat is that the assessment does not consider the possibility that the sharp declines in landings and abundance indices may be due to migration of adult bluefish to offshore areas.'

The displacement hypothesis was the center and essence of the LEK about bluefish and supported by many scientists. Just as the RD had said, this "anecdotal data" was seriously considered by the scientists charged with making the stock assessment. That is was specifically rejected by the adoption of the ASPIC model as the *"best scientific characterisation of the Atlantic bluefish stock"* was even acknowledged in the announcement of that adoption. In spite of the scientists' awareness that the models key assumption of availability was questionable, valid scientific reasons, such as avoiding unreliable aging and survey data certainly contributed to the selection of the ASPIC model. But from the perspective of the social influences on the scientific process, cultural differences did not drive this dispute; the mutual understanding of the parties was nearly complete. It was the institutions of fisheries management, i.e. the legal requirements for specific types of answers, the administrative need for a peer review process that does not use "ad hoc" judgements, and the political need for an outcome which was precautionary but not too draconian, that made the ASPIC model the best science available.

Conclusion

The seven scientific disputes around the management of Atlantic bluefish in the mid 1990s are listed in Table 1 and evaluated in terms

of whether or not they are best explained as driven by culture, defined as the degree of shared understanding among the various stakeholder groups, or institutions, defined as the rules and practices governing management and stakeholder interactions. Most of these disputes contained both elements, but five of the seven seemed more clearly driven by institutional factors than by issues of mutual understanding.

These categorizations should not be overdrawn. As was conceded in the introduction, this strong distinction between what is "cultural" and what is "institutional" is an artificial analytical distinction made to drive home a specific point. Even as defined here, the distinction is hardly mutually exclusive as cultural and institutional factors can be found in all of the disputes. Nevertheless, the basic point is an important one: institutions have the power to "systematically distort communications" (Habermas 1987) involved the social construction of nature even in situations where the stakeholder groups understand each other well.

As do other social scientists involved in arenas of policy where science is important, fisheries social scientists face a difficult task as we try to understand social influences on the knowledge base used for fisheries management. We have recognized the importance of different worldviews in the process of building this knowledge base, and this case study suggests that we need to pay close attention to the distorting affects of rules and institutions as well. We can draw on tools to accomplish this from a number of areas. Many studies exist of the use of science in legal and regulatory areas (e.g. Jasanoff 1990, Salter 1988). A literature is emerging on the relationship between bureaucracy and quantification (e.g. Porter 1995). Various Habermasian concepts are also available to analyse the effects of social structures on human communications from a general perspective (Habermas 1987, Wilson *et al.* 1999). The application of these tools to fisheries management may well help us better understand how to develop a sound knowledge base for management within our disagreement-ridden policy arena.

References

Agrawal, Arun 1995 "Dismantling the Divide Between Indigenous and Scientific Knowledge" *Development and Change* 26: 413-439

Barnes, B., D. Bloor, and J. Henry 1996 Scientific Knowledge: A Sociological Analysis Chicago: University of Chicago Press

Berkes, F. 1993 "Traditional Ecological Knowledge in Perspective" Pp 1 - 9 in Inglis, J. T. (Ed) Traditional Ecological Knowledge: Concepts and Cases Ottawa: International Program on Traditional Ecological Knowledge, International Development Research Center.

Berkes, F. 1995 "Indigenous Knowledge and Resource Management Systems: A Native Canadian Case Study from James Bay" Pp 99-109 in Hanna, S. and M. Munasinghe (Eds) Property Rights in a Social and Ecological Context: Case Studies and Design Applications Stockholm: The Beijer Institute

Crecco, V. 1996 "Evidence of offshore displacement of Atlantic coast bluefish based on commercial landings and fishing effort. Report to the SAW Coastal/Pelagic Subcommittee. 24p

Felt, Lawrence,1994 "Two Tales of a Fish" in Dyer C. L. and J. R. McGoodwin (Eds) Folk Management of the World's Fisheries Boulder: University of Colorado Press.

Finlayson, A. C. 1994 Fishing for Truth: A Sociological Analysis of Northern Cod Stock Assessments from 1977 to 1990 Institute of Social and Economic Research, Memorial University of Newfoundland, Social and Economic Studies No. 52

Food and Agriculture Organization of the United Nations (FAO). 1995. Code of Conduct for Responsible Fisheries [online] http://www.fao.org/fi/agreem/codecond/codecon.asp

Gibson, M.R. and N. Lazar. 1998. "Assessment and Projection of the Atlantic Coast Bluefish Stock Using a Biomass Dynamic Model' A Report to the ASMFC Bluefish Technical Committee and the MAFMC Statistics and Science Committee

Habermas, J. 1987 The Theory of Communicative Action: Volume II Lifeworld and System: A Critique of Functionalist Reasoning Boston: Beacon Press

Jasanoff, S. 1990 The Fifth Branch: Science Advisors as Policy Makers Cambridge: Harvard University Press

Jersey Coast Angler's Association. 1996. "Fisheries Management and Legislative Report" JCAA News. May [online] www.jcaa.org

Jersey Coast Angler's Association. 1998 "JCAA & NJSFSC Comments on the Bluefish Management Plan - Amendment 1" [online] www.jcaa.org

Jentoft, S. , B. J. McCay and D. C. Wilson 1998 "Social Theory and Fisheries Co-management" *Marine Policy* 22(4-5): 423-436

MAFMC and ASMFC. 1998. Amendment 1 to the Bluefish Fishery Management Plan. A publication of the Mid-Atlantic Fishery Management Council pursuant to National Oceanic and Atmospheric Administration Award No. NA57FC0002

McCay, Bonnie J. and Svein Jentoft. 1996. "From the Bottom Up: Participatory Issues in Fisheries Management." *Society and Natural Resources* 9:237-250.

NOAA 1996. NOAA Legislative Informer. April 1996. [online] www.noaa.gov

Northeast Fisheries Science Center. 1997. Report of the 23rd Northeast Regional Stock Assessment Workshop (23rd SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. *Northeast Fish. Sci. Cent. Ref. Doc.* 97-05; 191p

Pálsson G. 1995 "Learning by Fishing: Practical Science and Scientific Practice" Pp 85-97 in Hanna, S. and M. Munasinghe (Eds) Property Rights in a Social and Ecological Context: Case Studies and Design Applications Stockholm: The Beijer Institute

Pinkerton, E. 1989 "Introduction: Attaining Better Fisheries Management through Co-Management - Prospects, Problems and Propositions" Pp. 3-36 in E. Pinkerton (Ed) Cooperative Management of Local Fisheries. Vancouver: University of British Columbia Press

Porter, T. 1995 Trust in Numbers Princeton NJ: Princeton University Press

Roepstorf, Andreas 2000 "The double interface of environmental knowledge" pp 165-188 in Neis, Barbara and Lawrence Felt (Eds) Finding our Sea Legs: Linking

Fishery People and their Knowledge with Science and Management St. John's, Newfoundland: ISER Books

Safina, C. 1994 “Where Have all the Fishes Gone?” *Issues in Science and Technology* 10:37-43

Salter, L. 1988 Mandated Science: Science and Scientists in the Making of Standards Dordrecht, Holland: Kluwer Academic Publisher

Smith, M.E. 1995 “Chaos, Consensus and Common Sense” *The Ecologist* (25):80-85.

Terceiro, M. 1996 “Data Snooping in Response to SAW TOR D for Bluefish: Identify Possible Causes for the Decline in Bluefish Abundance” Report to the SAW Coastal / Pelagic Subcommittee

Wilson, D.C., Medard, C.K. Harris, and. S. Wiley 1999 "The Implications for Participatory Fisheries Management of Intensified Commercialization on Lake Victoria" *Rural Sociology* 64(4):554-572

Wilson, D. C. 2000a. “Bluefish Science in the Northeast Region: A Case Study” Institute for Fisheries Management Research Publication No. 48

Wilson, D.C. 2000b “Fisheries Scientists and Fisheries Policy: Report of a Survey of Scientists” paper presented at Constituting the Commons, The Eighth Biennial Conference of the International Association for the Study of Common Property. Bloomington IN 31 May-4 June

Wilson, D.C. and P. Degnbol 2001 “The Effects of Legal Mandates on Fisheries Science Deliberations: The Case of Atlantic Bluefish in the United States” *Fisheries Research* in press

THE VALUE OF LOCAL KNOWLEDGE IN SEA TURTLE CONSERVATION: A CASE FROM BAJA CALIFORNIA, MEXICO

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ABSTRACT
The use of sea turtles by many coastal communities worldwide remains a part of their traditions and culture despite evidence of decreasing turtle numbers and strict laws prohibiting their harvest and use. There have been great advancements in our understanding of sea turtle biology and behavior, and the science of conservation is continually developing new tools. Unfortunately "science" does not always translate into "conservation" on the ground. As researchers become increasingly aware of the cultural motivations involved in sea turtle exploitation, it becomes critical to shift conservation efforts towards local communities, particularly to the fishers often in the position to make choices directly impacting the fate of turtles. While the ways that fishers have negatively impacted sea turtle populations have been documented, what is often overlooked is how these same individuals can contribute to their conservation. A major goal of community-based efforts in sea turtle conservation is to develop practices which will protect sea turtle populations and habitats that are also compatible with the socioeconomic system and cultural ecology of local resource-dependent communities. Within a conservation mosaic, the incorporation of both biological and social research methods and communication are critical. Analysis of a case study in sea turtle recovery efforts within Baja California, Mexico indicates that community-based research can result in locals actively participating in conservation and providing the knowledge and information necessary to create successful long-term conservation plans. Formation of partnerships through local education, informal conversations, and community meetings are shown to be a fundamental part of sea turtle conservation. By combining the knowledge gained through scientific investigations, with the insights of the local population, we stand a much better chance of succeeding in recovery efforts, particularly if adaptive management techniques designed through community-based research and action are advocated.

INTRODUCTION
Coastal communities worldwide continue to utilize sea turtles according to their traditions and culture despite evidence of decreasing turtle numbers and strict laws prohibiting turtle harvest and use (Frazier 1995; King 1995; Kowarsky 1995; Nietschmann 1995; Parsons 1962; Tambiah 1989; Tambiah 1995). In northwestern Mexico, and specifically the Baja California peninsula, turtle use originated as subsistence harvest, but over time this use broadened into a directed fishery (Clifton *et al.* 1995; Caldwell 1963). In addition to the food that turtle meat provided for an individual fisher's household, there were increasing economic benefits associated with the sale of turtle meat in the market, both regionally and internationally. Although legislation is now in place to protect Mexican sea turtles, enforcement is prohibitively expensive in such a vast area and fishers have devised elaborate methods of eluding existing enforcement. As such, laws and enforcement have not adequately abated harvest or declines in sea turtle populations, especially in rural areas like Magdalena Bay where laws have been misunderstood or disregarded. As Reichart (1999) suggests, marginalizing the participation of local stakeholders nearly always ensures the failure of such legislation.

Nichols describes the cultural significance of sea turtles in Baja California as having the food quality of filet mignon and the addictive quality of coffee, while possessing the traditional symbolism of Thanksgiving turkey (*SFS Center for Coastal Studies lecture* 2000). Whether you look at turtles from the perspective of cultural traditions, or as an economic or food resource, we believe that sea turtles are arguably among the most important species in northwest Mexican culture.

Of the five threatened or endangered sea turtle species known to inhabit the coastal waters of Pacific Mexico, two species most commonly frequent the waters within and adjacent to Magdalena Bay: the East Pacific green turtle -- or black turtle -- (*Chelonia mydas*), and the loggerhead turtle (*Caretta caretta*) (Clifton *et al.* 1995; Nichols 2001). These are also the species

that are most commonly caught by the fishers of Puerto San Carlos, Puerto Magdalena, and Lopez Mateos, the largest communities on the shores of Magdalena Bay (Gardner and Nichols *in press*). The coastal waters around the Baja California peninsula serve as critical feeding and developmental habitat for these and other sea turtles, after they migrate from as far as Michoacan (Nichols *et al.* 1998) and Japan (Nichols *et al.* 2000b).

Site Description

The Baja California peninsula, which extends into the Pacific Ocean south of the U.S. state of California, is comprised of two states: Baja California and Baja California Sur. The entire length of the peninsula is about 1000 miles (~1,600 km). Magdalena Bay, a large mangrove estuarine complex on the Pacific side of the peninsula, is one of the largest bays in all of Baja and is bordered by several barrier islands. Due to its location between the Pacific and California ocean currents, which allows for a mixture of both warm and cold water species, and the relative protection that the barrier islands provide, Magdalena Bay is a highly productive ecosystem which boasts enormous biodiversity. Mangroves present in this bay are at the northernmost limit of their range; their presence is a unique feature of the coastal ecology which contributes to the high productivity of a bay that has been called "the Chesapeake of the Pacific" (Dedina 2000).

Many of the towns on the shores of Magdalena Bay were settled by *rancheros* (ranchers) from the Santo Domingo valley and surrounding inland areas. While Magdalena bay was first discovered by *Conquistadores* (explorers) in the 14th Century, migration to this region did not commence until the 1920s when inland agricultural projects began to fail and new means of subsistence - shell and finfish - were sought (Dedina 2000). More permanent settlement began in the late 1950's when the cannery and deep-water port projects were initiated in Puerto San Carlos. Since that time, people have continually been migrating to the town. Though many who currently inhabit Puerto San Carlos have lived there for a number of years and consider themselves residents of the area, their roots may lie in other states in mainland Mexico (Bostrom *et al.* 1999). Today, migrant fishers continue to come from the mainland and other parts of the Baja California peninsula in order to exploit the seasonal resources.

Currently, numerous, mostly seasonal, fish camps are scattered along the coastline of Magdalena Bay. There are also a few permanent settlements, most notably the towns of Puerto Adolfo Lopez Mateos, Santo Domingo, Puerto Magdalena and Puerto San Carlos, which is the largest settlement on the bay. The population of Puerto San Carlos varies seasonally with the fisheries, and ranges between three and five thousand people. The people of Puerto San Carlos have been called "the people of the mangroves" - they form a resource-dependent community (Dedina, *pers. comm.*), relying on marine and coastal ecosystems for their livelihood and survival. While there is a cannery, port and large-scale commercial fisheries, as well as a thermoelectric plant in the area, the community and character of Puerto San Carlos rests on the shoulders of small-scale artisanal fishers and their families. These fishers may be members of a fishing cooperative or one of many *pescadores libres* (independent fishers) in the region.

The Conservation Mosaic

Frazier posed the question: "is increased scientific [knowledge] production conserving turtles?", stating that "we are learning more and more about what is becoming less and less" (Frazier, *in press*). There have been great advances in our understanding of sea turtle biology and behavior and the science of conservation is continually developing new tools. Unfortunately "science" does not always translate into "conservation" on the ground. As researchers become increasingly aware of the cultural motivations involved in sea turtle exploitation, it is critical to shift conservation efforts to *actively* include local communities, in particular the fishers who are making choices which directly impact the fate of turtles.

Despite inadequate population estimates and utilization assessments, throughout the world fishers have been blamed for declining sea turtle populations, (Caldwell 1963; Clifton *et al.* 1995; King 1995; Parson 1962; Tambiah 1995). As a result, local "science" has historically been excluded from the conservation process and the active participation by fishers in sea turtle conservation initiatives was rarely considered (Nader 1996). Within a *conservation mosaic* (Nichols 2001), the incorporation of both biological and social research methods and communication are critical. Placing value in the opinions, experiences, and knowledge of the fishers, and involving them directly in the project from the first step may form strong conservation alliances.

Over the past decade, local involvement in turtle conservation has been increasing, though generally as directed by an outside "expert" organizing and/or overseeing community work by providing guidance regarding appropriate conservation techniques. Community-based strategies are not new to sea turtle conservation: (see James and Martin; Faulkner *et al.* this vol) such approaches take a variety of forms including community monitoring of lighting practices on nesting beaches, community-based stranding networks and beach patrols, self-enforcement by fishing communities, formal sharing of traditional knowledge (Nabhan *et al.* 1999) and the systematic consideration of interviews with fishers (Tambiah 1999). While such practices are increasing, community-based efforts are still not widely accepted as valid conservation tools (Frazier 1999; Tambiah 2000).

A major goal of community-based sea turtle conservation efforts is to develop population and habitat protection practices that are also compatible with the socio-economics and cultural ecology of local resource-dependent communities (Bird and Nichols, *in press*; Tambiah 2000). In general, however, many of the "community-based conservation" cases documented in the literature have been those in which external researchers have initiated conservation projects and in the process have integrated local community *participation* (Govan 1998; Hackel 1999; Tambiah 1995). Few of these case studies have actually integrated local *science* into the project. In many places around the world, external researchers only have the time and resources to make a snapshot assessment. The typical approach of a research project is to "get in and get out" - gathering as much data as possible as efficiently as possible. Once the data are collected researchers may never return. They may enter the host community with complete autonomy, for instance with their own boat, equipment and food. Alternatively, a special connection can be made through a certain dependence on the host community - for food, equipment, labor and guidance - which fosters trust and builds partnerships. We suggest that such partnerships lay the foundation for long-term successes in conservation.

Research Approach and Methodology

Research objectives have been twofold: including both conservation research and active community involvement. Our research consists of socioeconomic studies of current and historic sea turtle utilization within Baja California Sur, particularly in the Magdalena Bay region, as well as ongoing biological monitoring and ecological studies (Brooks, *et al. in press*; Garcia-Martinez and Nichols 2000; Nichols *et al.* 2001). A variety of data have been collected, including mortality information, diet analyses (Gardner and Nichols, *in press*; Hilbert *et al. in press*), and tissue samples for genetic analysis. Radio and satellite transmitters have been deployed in order to monitor the distribution, movements and long-distance migratory patterns of sea turtles (Brooks *et al. in press*; Nichols *et al.* 1998; Nichols *et al.* 2000b). Local fishers from the community have been involved in all aspects of this data collection, identifying optimal locations and times to set nets, assisting in captures, measurements and marking, as well as informally monitoring turtle movements while fishing on the bay (Nichols *et al.* 2000a). Through their participation, the fishers have learned about the techniques used and the motivation behind our biological investigations. Their sharing of detailed knowledge about the ecology of the bay, including the seasonal movements of marine species and the daily movement of the currents, has contributed immensely to our work by improving the accuracy of the information collected and providing a more complete picture of the sea turtle's natural history.

The partnerships formed with individual fishers have been integral to other aspects of research in the area. Several fishers have helped in the collection of surveys and interviews within their communities. Furthermore, much has been learned about the community's needs and interests related to sea turtle exploitation and conservation in the region. Qualitative research conducted by Bostrom *et al.* (1999) at the SFS *Centro Para Estudios Costeros* (Center for Coastal Studies) in Puerto San Carlos also yielded some important primary data related to the cultural and socioeconomic factors that affect a fisher's decision to capture a turtle, or impact the choice of keeping or throwing back a turtle captured incidentally.

Our research approach seeks to utilize local knowledge and to foster partnerships, which facilitate the exchange of information and active community participation. The following stepwise approach outlining general research considerations for the integration of local science into conservation initiatives was used in this project:

1. The first step involved getting to know who we were working with while allowing them to

know us as more than just an outside researcher: We built trust through friendships and partnerships within the local community and showed respect in our interactions to all individuals.
2. After we made our introductions in the community, we learned about community issues, cultural norms and beliefs. Showing consideration towards personal, local, and regional politics, we worked within the existing socioeconomic framework.
3. While it was acceptable to share the knowledge we possessed with local fishers, (particularly when it was specifically requested), we didn't do all the talking: we spent an equal amount of time asking questions and engaging in participant observation. Both "outsiders" and "insiders" had something to share with and learn from each other.
4. We integrated the local knowledge and information contributed with 'outside' science into an action plan, and implemented the plan with the support, knowledge and *active* participation of the local population.
5. Lastly, we monitored progress and maintained flexibility, following adaptive management strategies.

OUTCOMES AND LESSONS LEARNED

Several meetings have been held within various communities in Baja California and Baja California Sur, the majority being concentrated in the Magdalena Bay area, in order to identify community issues and generate conservation strategies related to sea turtle recovery efforts. Through both formal meetings and impromptu discussions aboard *panga*s (small fishing boats) and in the back of pickup trucks, both local fishers and outside researchers have been engaged in participant observation, learning from each other and incorporating local and outside science into their daily activities (Bird and Nichols *in press*).

Over the past several years, interest in sea turtle conservation has been on the rise due to informal education and outreach initiatives, initially implemented by outside researchers from the United States and Mexico. More recently, we have witnessed some of the local fishers who have been involved in the biological research taking on their own educational pursuits within the region, leading discussions or simply setting examples by releasing turtles that were accidentally entangled in their nets.

Cross-regional communication is also extremely important in sharing knowledge of the implementation of conservation initiatives (Trono and Salm 1999). In August 2000, representatives from several of the fishing cooperatives in Magdalena Bay accompanied outside researchers to exchange knowledge and information with members of the very successful, organized fishing cooperative at Punta Abreojos, BCS. The fishers from Magdalena Bay wished to learn how the Punta Abreojos cooperative was successfully guarding the rich resources of their concession, including sea turtles in Estero Coyote, from outside poachers. Members of the Punta Abreojos cooperative were interested in learning about aquaculture, in which several individuals in Magdalena Bay had been actively involved. Over the course of a few days, sharing meals and going out on the water together, much knowledge was shared.

This interest in sharing information has also helped in the collection of data in the form of recovery of flipper tags placed on sea turtles locally and at distant locations. As word has spread and fishers have become increasingly aware of sea turtle conservation initiatives, flipper tag returns have also increased. Although many of these tag returns represent a dead turtle, it is still a positive sign of the trust and cooperation present within the community. Of particular importance was a tag return from Japan. Because the tag had been on this fisher's key chain for five years, predating any of the results from satellite telemetry and molecular genetic studies, this tag represented the first piece of concrete evidence of the loggerheads' trans-Pacific migrations to Baja California. Awareness of the importance of the information collected created a strong sense of pride within the community.

In recent months, an organized network of sea turtle conservation and monitoring spanning the Baja California peninsula from the Pacific coast to the Gulf of California, including both Baja California and Baja California Sur, has been created (Nichols *pers. comm.*). Through the annual meeting of the Sea Turtle Conservation Network of the Californias (STCNC), started in 1999 and held in Loreto (Baja California Sur, Mexico), several fishing communities have stepped up to say that they are interested in contributing more towards sea turtle conservation efforts through systematic monitoring (Nichols and Arcas 1999). In the past, fishers have known the general movements and distribution of the turtles, but have lacked

the support of numbers. Now, through the coordinated efforts of six dedicated communities, monthly monitoring will enable fishers to attach quantitative weight to their observations. The results of these studies will be shared between communities year round, with additional formal reports at the annual STCNC meetings in Loreto.

Concluding Remarks

An interdisciplinary approach allows for the utilization of many "sciences" and provides a more holistic view of how sea turtles fit into the grand picture. By avoiding a purely biological and "turtle-centric" approach, and instead investigating the overall turtle habitat, including the cultural and socioeconomic communities of which turtles are a part, our understanding may be greatly enhanced. The inclusion of local people in resource management can provide many benefits. Stronger conservation alliances based on the mutual sharing of knowledge, along with the combination of local science and structured monitoring, may produce the greatest conservation benefits. The objective behind "Western science" of external researchers is not too different from the "local science" of fishing communities. The integration of knowledge generated through quantitative approaches with the knowledge of local fishers may provide the most detailed information -- daily observations, leading to a 365 days/year account of turtle behaviors and movements. We need to contribute our knowledge and accept others'. Recognizing that outsiders and locals share the same goal of conserving sea turtles, we recognize that all involved have a right to be, and indeed, must be, part of the solution.

The foremost challenge remains in recognizing that "Western science" does not have all the answers, nor can it collect all the necessary information in order to make conservation plans materialize successfully (Nader 1996). By looking towards local communities to provide the "missing links" within the data, the time needed to develop the biological and social pieces of the *conservation mosaic* is tremendously reduced. Fishers and other members of local host communities will more readily share their intimate knowledge of their environment, including information on the daily movements and distribution of sea turtles, when friendship and trust are fostered through partnerships. Once the value of local fishers' knowledge is recognized, the next step is the active integration of that knowledge into marine conservation planning and management. In order for this to happen fishers must feel empowered to participate. In this way, the fishers are viewed, and view themselves, as an integral part of the conservation team contributing valuable knowledge and ideas, not just acting as boat drivers and guides for outside researchers within the host community.

Tambiah states that he would have to spend 365 days of the year living in a community for several years to derive even a fraction of the understanding and information that local people have shared with him in the 15 countries in which he has collaborated. Nichols often remarks that without the help and knowledge fishers have shared with him over his years of work in Baja California, he would have had a far more difficult time finding turtles and collecting information. Without the knowledge shared by local fishers, many attempts at long term marine conservation planning may have been met with minimal success.

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References

Bird, K.E. and W.J. Nichols. *In press*. Community-based research and its application to sea turtle conservation in Bahia Magdalena, BCS, Mexico. Proceedings of the 20th Annual Symposium on Sea Turtle Biology and Conservation. March 2000. NOAA Technical Memorandum.

Bostrom, L., E. Craig, E. Donlou, C. Fong, C. Forst, A. Garcia de Leon Ferrer, and A. Smith. 1999. Assessing the demand for sea turtles in Bahia Magdalena, Baja California Sur, Mexico. The School for Field Studies Center for Coastal Studies. Puerto San Carlos, BCS, Mexico. [Unpublished document].

Brooks, L.B., W.J. Nichols, V. Koch, and A. Hernandez. *In press.* Preliminary results on the distribution and movement of green turtles (Chelonia mydas) in Estero Banderitas, Baja California Sur, Mexico. Proceedings of the 21st Annual Symposium on Sea Turtle Biology and Conservation. February 2001. NOAA Technical Memorandum.

Caldwell, D.K. 1963. The sea turtle fishery of Baja California, Mexico. *California Fish and Game 49*:140-151.

Clifton, K., D.O. Conrejo, and R.S. Felger. 1995. Sea turtles of the Pacific coast of Mexico. Pp.199-209 *in* K.A. Bjorndal (editor). Biology and conservation of sea turtles - Revised edition. Smithsonian Institution Press: Washington.

Dedina, S. 2000. *Saving the gray whale: People, politics, and conservation in Baja California*. University of Arizona Press: Tucson.

Frazier, J.G. 1995. Subsistence hunting in the Indian Ocean. Pp.391-396 *in* K.A. Bjorndal (editor). Biology and conservation of sea turtles - Revised edition. Smithsonian Institution Press: Washington.

Frazier, J.G. 1999. Community-based conservation. Pp.15-18 *in* K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly (editors). Research and management techniques for the conservation of sea turtles. IUCN/SSC Marine Turtle Specialist Group Publication No.4.

Frazier, J.G. *In press*. Science, conservation, and sea turtles: What is the connection? Proceedings of the 21st Annual Symposium on Sea Turtle Biology and Conservation. February 2001. NOAA Technical Memorandum.

Garcia-Martinez, S. and W.J. Nichols. 2000. Sea turtles of Bahia Magdalena, Baja California Sur, Mexico: Demand and supply of an endangered species. Proceedings of the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade. Oregon State University, Corvallis.

Gardner, S. and W.J. Nichols. *In press*. Assessment of sea turtle mortality rates in the Bahía Magdalena Region, B.C.S., Mexico. *Chelonian Conservation and Biology*.

Govan, H. 1998. Community turtle conservation at Rio Oro on the Pacific coast of Costa Rica. *Marine Turtle Newsletter* 80:10-11.

Hackel, J.D. 1999. Community conservation and the future of Africa's wildlife. *Conservation Biology*. 13(4):726-734.

Hilbert, S.C., S. C. Gardner, R. Riosmena Rodriguez, and W.J. Nichols. *In press*. Diet composition of east pacific green turtles (Chelonia mydas) in Bahia Magdalena, Baja California Sur, Mexico. Proceedings of the 21st Annual Symposium on Sea Turtle Biology and Conservation. February 2001. NOAA Technical Memorandum.

King, F.W. 1995. Historical review of the decline of the green turtle and the hawksbill. Pp.183-188 *in* K.A. Bjorndal (editor). Biology and conservation of sea turtles - Revised edition. Smithsonian Institution Press: Washington.

Kowarsky, J. 1995. Subsistence hunting of turtles in Australia. Pp.305-313 *in* K.A. Bjorndal (editor). Biology and conservation of sea turtles - Revised edition. Smithsonian Institution Press: Washington.

Nabhan, G., H.Govan, S.A. Eckert, and J.A. Seminoff. 1999. Sea turtle workshop for the indigenous Seri tribe. *Marine Turtle Newsletter* 86:44.

Nader, L. (editor). 1996. Naked Science: Anthropological inquiry into boundaries, power and knowledge. Routlege Press: New York

Nichols, W.J. 2001. Biology and conservation of the sea turtles of the Baja California peninsula, Mexico. Ph.D. Dissertation. Dept. of Wildlife and Fisheries Science, University of Arizona, Tucson.

Nichols, W.J. and F. Arcas. 1999. First meeting of the Baja California Sea Turtle Group held in Loreto, Mexico. *Marine Turtle Newsletter* 85:19.

Nichols, W.J., K.E. Bird, and S. Garcia. 2000a. Community-based research and its application to sea turtle conservation in Bahia Magdalena, BCS, Mexico. *Marine turtle newsletter* 89:4-7.

Nichols, W. J., L. Brooks, M. Lopez, and J.A. Seminoff. 2001. Record of pelagic East Pacific Green Turtles associated with Macrocystis mats near Baja California Sur, Mexico. *Marine Turtle Newsletter* 93:10-11.

Nichols, W.J., A. Resendiz, J.A. Seminoff and B. Resendiz. 2000b. Transpacific migration of the loggerhead turtle monitored by satellite telemetry. *Bulletin of Marine Science*. July 2000.

Nichols, W.J., J.A. Seminoff, A. Resendiz, P.H. Dutton and A. Abreu. 1998. Using molecular genetics and biotelemetry to study life history and long distance movement: A tale of two turtles. *In:* S.P. Epperly and J. Braun (compilers). Proceedings of the 17th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-415.

Nietschmann, B. 1995. The cultural context of sea turtle subsistence hunting in the Caribbean and problems caused by commercial exploitation. Pp. 439-445 *in* K.A. Bjorndal (editor). Biology and conservation of sea turtles - Revised edition. Smithsonian Institution Press: Washington. .

Parsons, J. 1962. *The green turtle and man*. University of Florida Press: Gainesville.

Reichart, H.A. 1999. Grassroots stakeholders and national legislation. Pp. 221-223 *in* K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly (editors). Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group. Publication No. 4.

Tambiah, C. R. 1989. Status and conservation of sea turtles in Sri Lanka. In: K.L. Eckert *et al.* (compilers). Proceedings of the 9th Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFSC-232.

Tambiah, C. R. 1995. Integrated management of sea turtles among the indigenous people of Guyana: Planning beyond recovery and towards sustainability. Proceedings of the 12th Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFSC-361.

Tambiah, C. 1999. Interviews and market surveys. Pp. 156-161 *in* K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly, (editors). Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group. Publication No.4.

Tambiah, C. R. 2000. "Community participation" in sea turtle conservation: Moving beyond buzzwords to implementation. *In:* H. Kalb and T. Wibbels (compilers). Proceedings of the 19th Annual Symposium on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFSC-443.

Trono, R.B. and R.V. Salm. 1999. Regional Collaboration. Pp.224-227 *in* K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly (editors). Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group. Publication No. 4.

NOTE: For more information and on-going progress on sea turtle conservation activities discussed in this case study see web-site: www.wildcoast.net

PUTTING FISHERMEN'S KNOWLEDGE TO WORK: THE PROMISE AND PITFALLS

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ABSTRACT
Indigenous fishermen's knowledge often gets dismissed for being subjective, anecdotal, and of little value to today's fisheries and centralized management strategies. Yet, fishermen have spent much of their lives accumulating intimate, fine scale ecological information that is not otherwise available. Pitfalls encountered during efforts to access fishermen-based information during the mapping of historical Gulf of Maine spawning grounds of cod and haddock are reviewed and the strategies developed to overcome them are included. Current and future roles for fishermen's knowledge in managing coastal fisheries are examined. Various ways to integrate the local place-based information of fishermen into current management strategies and potential for introducing a new local management paradigm are explored.

INTRODUCTION
In New England, fishermen's knowledge has often been dismissed as subjective, anecdotal, and dealing only with local situations. It is usually further discredited by the argument that fishermen's reports are not only subjective, but they usually describe commercial stocks that were fished out decades ago and at best, are only historical footnotes describing a marine ecosystem that may no longer exist.

I tend to disagree. I have used fishermen's knowledge often in my life, not only in the traditional way of catching fish, but also as an important source of ecological information about a fishery. From this perspective, the accuracy and breadth of knowledge shared by fishermen is very impressive. Fishermen and their subjective, anecdotal descriptions have a pivotal role to play in the development and function of sustainable fisheries.

However, the question of whether fishermen's knowledge gets integrated into mainstream science to influence management ultimately depends on the ways it is used. Fishermen and their vessels for example, are currently being used to develop "real time" catch data for faster, ongoing stock assessments. Though useful in bolstering the status quo, this approach tends to employ fishing vessels rather than fishermen's knowledge, which deals with local populations and their seasonal habitats.

Fisheries science, involved as it is with the analysis of large population units, has not focused on local level phenomena, such as the changes in behavior and distribution of local populations associated with the collapse of a stock that are so often described by fishermen. The preoccupation of fisheries science with system-wide characteristics has left it without historical parameters that allow interpretation of fine-scale changes in stock distribution, behavior, or migration patterns over time. Consequently, management has lacked the ability to detect or interpret fine scale changes in abundance.

A New Role for Fishers' Knowledge
This lack of an historical perspective may have aggravated attempts to manage New England's commercial fisheries. We have all been so preoccupied by the depressed state of our fisheries that we may have missed some of the root causes of their depletion.

If we are to develop sustainable fisheries, we must, at the very least, understand how and why the stocks collapsed in the first place. While fishermen and scientists acknowledge that many stocks have declined because of high catch rates, the problem is far more complex than the simplistic rationale of "too many fishermen chasing too few fish". (National Academy of Science 1997) Declines in abundance have consistently been accompanied by local changes in distribution, migration patterns and species assemblages. Clues abound about the disruption of local interrelationships and changes associated with them. But fine-scale changes cannot be detected by today's system-wide fisheries assessments.

It is here that fishermen's knowledge can play an important and perhaps critical role. Fishermen are, in fact, the only available source of local, historical, place-based fisheries information. Just to survive, let alone succeed, each fisherman has become proficient at figuring out how local changes in a fish stock affect distribution and abundance. This creates a pool of people with unique experiences with local marine ecology.

Not only do they have special knowledge about what is presently there, but each generation of fishermen has developed its own particular fishing patterns that are attuned to the stock

migrations and behavior present during that period. With a little effort, information can be retrieved about such factors as distribution, behavior, species assemblages and abundance that are unique to the period.

Information collected from several generations of fishermen creates a series of historical windows into a fishery's local ecology that can be used to identify long-term processes in the fishery (Hutchings and Meyers 1995). Compiling an historical database forms a timeline that allows those processes to be studied. If a relatively short time span is used to capture changes occurring before, during, and after the depletion of a fishery, the sequential effects of its depletion on the marine ecosystem can be analyzed. Linking the intimate, place-based knowledge of fishermen with scientists would help in the study of how highly productive coastal ecosystems functioned when they were more robust. This would also provide historical perspective into the fine-scale details so lacking in fisheries today.

The value of fishermen's historical insights into fisheries ecology goes beyond its benefit to research. Fishermen's knowledge is most powerful when it is applied to fisheries management. Fisheries management, based on an understanding of local, long-term details of a fishery's ecology offers a whole new paradigm. Alternatives such as community-based strategies using local knowledge and local participation to maximize productivity within sustainable fisheries could maintain local populations and forage stocks while at the same time protecting spawning areas and nursery grounds.

The Gulf of Maine Cod Spawning Grounds Project

A good example of the use of traditional fishermen's information surfaced during efforts in New England to revitalize the collapsed inshore cod fishery. Two fishing associations, Maine Gillnetters Association and Maine Fisherman's Co-op successfully petitioned the Maine State Legislature to form a Groundfish Hatchery Commission to study the feasibility of establishing one or more groundfish hatcheries. Raising the groundfish license fee to commercial fishermen funded the hatcheries. The commission found large areas of groundfish habitat along the coast that used to be highly productive, but were now abandoned. They concluded that, if hatchery production could be used to increase the number of active spawning sites along the coast by reintroducing groundfish into these areas, the resulting spawning success would drastically reduce the time depleted stocks would need to recover. The commission recommended that young cod and haddock be released near once-productive spawning grounds and nursery areas in an attempt to jump-start the process. Releasing juveniles in the right habitats would be a critical step.

Unfortunately, most of the inshore grounds that were suitable for such a project had been fished out decades before and had long been abandoned and forgotten by fishermen. With collapsed cod and haddock stocks, scientists were unable to locate spawning areas by conventional methods.

In spite of the fact that the Gulf of Maine had maintained a directed cod fishery for more than three centuries, few spawning grounds were known. Most of the spawning areas suitable for such a project had been "fished out" decades earlier and had been abandoned and forgotten. Few current fishermen were even aware of their existence.

A study was funded to locate and interview the few remaining fishermen who had fished those areas to identify coastal spawning and nursery areas of cod and haddock. It became my privilege and great pleasure to interview these older fishermen and to draw the spawning ground maps based on their knowledge.

Prior to the fishermen-based spawning ground study, very few coastal spawning locations for cod and haddock were known, causing researchers to raise important questions about whether either species had actually been year-round coastal residents. Fishermen, however, indicated quite the opposite was true. As the interviews proceeded, the number of confirmed spawning sites mounted.

It soon became clear that both cod and haddock once had spawning areas along the whole length of the Gulf of Maine's coast. By the time the study was over, nearly 700,000 acres of spawning grounds for cod and haddock were identified (see Figure 1), and numerous questions had been raised about what actually caused coastal fisheries to collapse. Their contributions have provided new insights into the causes of the collapse of Atlantic cod in the study area. (Ames *et al.* 2000)

An accompanying study, using side-scan sonar, (Barnhardt *et al.* 1998) found the spawning locations given by fishermen, including their descriptions of substrates and depths were

exceptionally accurate. This reinforced general acceptance of the locations identified by fishermen as coastal New England's historical spawning grounds for Atlantic cod.

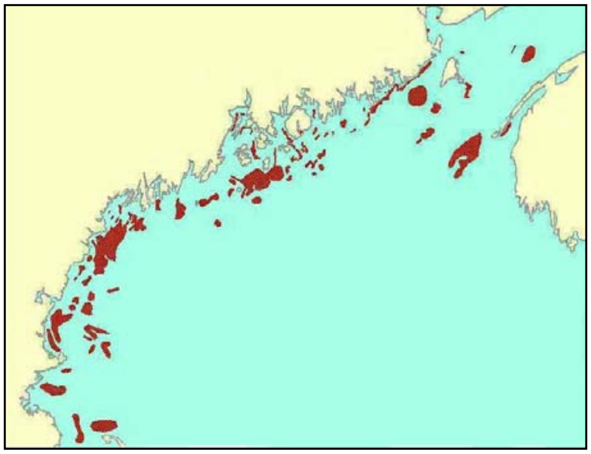

Figure 1. Map showing cod and haddock spawning grounds along the Gulf of Maine coast, identified in the study.

Pitfalls to Avoid When Interviewing Fishers

Collecting fisheries information about commercial stocks does not come without its own set of hurdles. Simply interviewing some fishermen and then cleaning up the data to make it presentable to the scientific community is only a small part of what has to be done to interview fishermen effectively. The process of figuring out who can best provide the information you seek can be formidable. The knowledge of a random fisherman may not be enough.

In addition, the majority of interviewers confirm that fishermen can be difficult to interview, their information is difficult to verify, and once verified, is very difficult to integrate into conventional fisheries information. A well-defined strategy for surmounting these hurdles is essential for good results.

Also be aware that different gear types may give quite different types of information. What is observed by one fishing technique alone can be very misleading. For example, an overview of coastal New England shows that hook fishermen caught cod in their feeding areas. Since fish do not feed when they are spawning, hook fishing may not provide good information about spawning locations. Otter trawlers and gillnetters caught fish whether or not they were feeding and so became a prime source for spawning ground information. Similar issues exist with each gear type.

A brief description of the problems that emerged during the spawning ground project, and the strategies used to resolve them, follows. Hopefully they will be of use to others:

1. When we started, we did not know the names or addresses of the fishermen who were part of the collapsed coastal fishery for cod and haddock. Most of them were retired and had not fished for decades.

We asked Maine's two coastal groundfish organizations to help us identify older fishermen to interview. Their members prepared a list of older fishermen for us who were well known locally and respected for their skill at catching cod and haddock in coastal waters.

2. Fishermen generally mistrust fisheries researchers and managers. To counter this, a local fisherman accompanied the interviewer, introduced him, and participated in the session. This proved to be an effective way to put everyone at ease.

3. In general, fishermen are not inclined to hand over hard-won knowledge that could threaten the livelihood of friends, family, and self by inviting competition or closures.

The project did not encounter this concern often because the fishermen being interviewed were older and were no longer groundfishing. They had little motivation to safeguard or falsify information about spawning areas.

In addition, the interviews focused on coastal spawning areas that had been fished out years ago, rendering their location relatively worthless.

4. Fishermen are often reluctant to answer questions if they perceive the interviewer to be collecting information simply for the sake of collecting it, or worse yet, collecting it for management purposes.

The survey addressed this concern by explaining that its purpose was to rebuild the fishery for the benefit of fishermen. The few remaining fishermen who had taken part in the fishery were the only ones who knew where the spawning grounds were located.

They were told that, if we could find them, funding would be available to support an effort to rebuild the stocks. In the end, fishermen themselves were to be the beneficiaries.

All recognized that restoration efforts were a long shot at best, but felt that it was worth talking with us anyway. And, if all went well, fishermen in their area would regain a fishery.

5. Fishermen feel especially threatened when asked to share information that may become public and often refuse to talk.

Interviewers should recognize the economic consequences fishermen face when their fishing secrets are revealed. Once made public, it becomes available to anyone, including competitors, fisheries managers, and anti-fishing interests. Facts so glibly asked for in an interview often form a key part of a fisherman's economic existence and they need to be reassured that they won't be misused.

The challenge to interviewers starts with thoughtful decisions about what to ask and how to handle the resultant information to minimize the detrimental consequences to those sharing it. Only then does it involve strategies for persuading fishermen to share their knowledge. These are not trivial issues.

PITFALLS TO AVOID WHEN PROCESSING FISHERS' INFORMATION

Traditionally, many fisheries scientists have brushed fishermen's information aside because it is so difficult to integrate into research's high-tech, statistics-based world. Even when fishermen's subjective observations can be confirmed, they will lack the reproducibility and precision of a carefully controlled experiment.

Given these concerns, controlling data quality becomes critical. Researchers who find ways to accommodate these limitations by developing ways to validate fishermen's knowledge, however, may find a treasuretrove of site-specific information about fisheries ecology.

Three different strategies for validating data were developed during the cod spawning ground project. The first came from recognizing that each spawning ground and its location had to be independently verified in some credible way before the results could be considered for peer review.

A protocol was developed to ensure that;
(a) each spawning site was identified independently by two or more fishermen,
(b) the presence of cod and haddock was established on-site during known spawning seasons, and
(c) the depth and substrate present at the site agreed with known species behavior.
This was adequate to validate the 30-60 year-old observations being described.

A second problem arose from our efforts to figure out exactly where fishermen said a given site was located. Some fishermen identified spawning grounds directly on nautical charts, but most preferred to simply name a fishing ground in an area, or gave marks and bearings leading to the bottom they had once fished.

With marked nautical charts, two independent reports confirmed the site, but the other cases required additional work. In addition to the criteria listed above, the location of grounds lacking bearings, but which had been named by two or more fishermen, had to be verified by additional fishermen or references.

Spawning areas identified by sets of landmarks required the marks to be found and then plotted by dead reckoning. Once the site was established, it then had to be correlated with the bottom types reported on a nautical chart. Finally, other fishermen had to be questioned to establish independent confirmation of the ground.

Of all parameters encountered in the study, timelines were perhaps the most difficult to establish. Fishing information collected during the spawning ground study was, by necessity, decades old. Even though fishermen were quite sure of the season or month they had caught ripe fish, they often could not recall the exact year when it happened. In these cases, supporting information occurring during the same period had to be identified and then used to determine the approximate year when the fish were caught.

NEW APPLICATIONS FOR FISHERS' KNOWLEDGE

The mapping project of cod and haddock spawning grounds displays only a fraction of the potential value found in fishermen's knowledge.

Two years ago it gave rise to my current work, a new project building a prototype database for Atlantic cod from fishermen's knowledge. The results of the spawning ground interviews became key components of the database. Combined with a 1920s data set of historical fishing information and basic habitat information, the database allowed closer examination of distribution and movements that was invaluable in untangling the historical stock structure of Gulf of Maine groundfish.

Fine-scale details of the distribution and behavior of Atlantic cod in the Gulf of Maine became obvious after placing the 1920s data set on GIS (Geographic Information System). Movement patterns to and from the historical cod spawning grounds linked them to historical fishing grounds identified from the reports and logs of fishermen from the same period.

Seasonal distribution patterns, migration corridors, and the fine-scale details of Atlantic cod stock structure were identified for the 1920s. Movement patterns associated with the spawning grounds identified several local populations of cod. Enough historical information was available on Atlantic cod in the Gulf of Maine to allow local, long-term behavior patterns to be compared with those found today.

A comparison that matched spawning grounds and winter fishing grounds of the 1920s (Ames, 1997) with recent distribution patterns of gadoid eggs (Berrien and Sibunka 1999), indicated that local populations of cod were still using the same spawning grounds. Another comparison relating recent tagging studies (Perkins *et al.* 1997) to historical movement patterns showed that the local population of cod inhabiting the area still followed the same routes.

Today's Gulf of Maine managers and fishermen alike are trapped by a system totally dependent on annual stock assessments, that cannot even detect local indicators of depletion, and must watch helplessly as one fishery after another is depleted to a fraction of its historical productivity.

Fishermen's knowledge can play a new and positive role in the restoration of commercial stocks. Their local, fine scale information offers a new paradigm based not solely on annual stock assessments, but on strategies that protect and enhance local spawning grounds, local nursery areas, and maintain local forage stocks and critical habitats. This provides an unparalleled opportunity to create an overarching historical framework that will allow assessment data to be linked to stock structures, abundance, migrations, distribution patterns, and a host of related ecological parameters.

Used in conjunction with historical references, fishermen's knowledge can provide valuable insights that may be pivotal to developing sustainable fisheries based on ecological principles.

Local, place-based historical information linking local populations, abundance, and critical habitats to stock assessment data can supplement, and perhaps even replace, management strategies based on today's stock assessments. Historical profiles of stocks and their seasonal habitats could even be used to guide the placement and character of Marine Protected Areas.

The linking of fishermen's knowledge to historical reports offers a new paradigm to fishermen, managers, and environmentalists in support of local and regional efforts to restore coastal fisheries. Similar studies should be initiated for other coastal stocks found today.

References

Ames, E.P., S. Watson, and J. Wilson (2000) Rethinking Overfishing: Insights from Oral Histories of Retired Ground-fishermen; pp153-164, in Finding Our Sea Legs", Barbara Neis and Larry Felt; ISER.

Ames, E.P. (1997) Cod and Haddock Spawning Grounds of the Gulf of Maine;NRAES 118, Ithaca,NY.

Barnhardt, W.A., J.T. Kelly, J.T., S.M. Dickson, and D.F. Belknap (1998) Mapping the Gulf of Maine with Side-scan Sonar: A New Bottom- type Classification for Complex Seafloors; J. Coastal Research, v. 14, pp 647-659.

Berrien, P. and J. Sibunka (1999) Distribution Patterns of Fish Eggs in the U.S. Northeast Continental Shelf Ecosystem, 1997-1987; NOAA Technical Report MNFS 145, U.S. Dept. Commerce.

Hutchings, J. A. and Myers, R. A.(1995) The Biological Collapse of Atlantic Cod off Newfoundland and Labrador, pp. 38-93, An Island Living Series vol. 3, Institute of Island Studies, Charlottetown, PEI.

Perkins, H. C., S. B. Chenoweth, and R. W. Langton (1997) The Gulf of Maine Atlantic Cod Complex, Patterns of Distribution and Movement of the Sheepscot Bay Substock; Bull. Natl. Res. Inst. Aquacult., Suppl. 3:101-107.

Questions

Omer Chouinard: What kind of gear was used?

Ted Ames: Trawling, handline, gillnet, and otter trawl. One of the things that is really neat is that in one of the studies I was doing, by isolating the hook fishery from other fisheries, I was able to get the feeding habitat.

Jennifer Graham: How do you set boundaries for your plotting areas?

Ted Ames: Massachusetts Bay fishermen have known for a long time that fish move in a different way there. Their migration didn't appear to go back into the Gulf of Maine proper. Their behavior is different in Cape Ann. They come up the shore and back. We arbitrarily decided the area was big enough. It was arbitrary with a little bit of practical fishermen knowledge.

USING EXPERT KNOWLEDGE TO IDENTIFY POSSIBLE GROUNDFISH 'ESSENTIAL FISH HABITATS'

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ABSTRACT

Despite over a century of exploitation of fish in European waters, scientists know surprisingly little about the precise distribution of the major commercially exploited fish species, and their habitat requirements. This is the first European study that aims to identify essential fish habitats of commercially important fish species (cod, haddock, whiting, plaice, sole, plaice, lemon sole) in the Irish Sea and the English Channel (UK). Areas of the seabed that harbour the highest densities of these species were identified and mapped using an existing database spanning 12 years' data from national stock assessments.

Demersal fishers observe samples from the sea floor every time they haul their nets, which far exceed the sampling schemes that scientists can afford or mobilise. Experienced fishers may have decades of observations to bring to bear and keep detailed records of exactly where and when they fish and how much they catch. Although the ultimate goal of fishing is to provide income from the catch, rather than to test scientific hypotheses, many fishers seek to understand the very questions about the seabed that motivate our study. Therefore, we decided to liase with the fishing industry to refine our broad scale fish maps for future survey. Information was gathered in a pilot study through questionnaires filled in at a fishing exhibition. Through a process of informal presentations and meetings, fishermen have helped us to refine our studies by pinpointing fishing grounds of importance for the fish species in question. The co-operation with fishers has not only added to the credibility of the study and any management decisions that may depend on its findings, but has also highlighted once more the vast amount of knowledge that can be gained from this declining species.

INTRODUCTION

Habitats used by marine fish are generally 'hidden' underwater, and may, therefore, have received less attention from scientists than more obvious and accessible terrestrial faunas (Koehn 1993). As with terrestrial species, fish may be dependent upon the availability of certain habitat types, and alterations to such areas may be partially responsible for the recently witnessed decline in the world fisheries (FAO 1995), and should therefore be addressed in fisheries science and management (Benaka 1999). Despite centuries of intensive commercial exploitation of fish in European waters, scientists know relatively little about the variation in the small-scale distribution of the major commercially exploited marine fish species, and their habitat requirements. Freshwater biologists, by contrast, have an extensive tradition of research that has focused on the habitat requirements for fish (e.g. Keast *et al.* 1978; Ebert and Filipek 1988; Koehn 1993). In recent years, the wider ecological effects of fishing have become a global environmental concern (*e.g.* Dayton *et al.* 1995; Jennings and Kaiser 1998; Collie *et al.* 2000). Consideration (and mitigation) of the effects of fishing on marine habitats that are critical for certain life-stages of commercially important fish species became a legal requirement in the United States with the reauthorisation of the Magnuson-Stevens Fisheries Conservation and Management Act (1996). These habitats have been termed 'Essential Fish Habitats' (EFH) and would include areas that are spawning and nursery grounds, provide specific feeding resources and shelter from predators, or form part of a migration route (Benaka 1999). This new emphasis on EFH has resulted in a number of studies in North America (see Banaka 1999; Coleman *et al.* 2000). The present study is the first in Europe that specifically aims to identify the EFH for cod (*Gadus morhua* L.), haddock (*Melanogrammus aeglefinus* (L.)) and whiting (*Merlangius merlangus* (L.)) in the Irish Sea.

Haddock, cod, whiting and plaice (*Pleuronectes platessa* L.) accounted for 52% of the demersal species landed by UK vessels in 2000 (DEFRA 2000). National landings of haddock and cod have generally decreased from *ca* 90,000t and 75,000t to 53,000t and 42,000t, respectively, between 1996 and 2000 while landings of whiting and plaice decreased between 1996 and 1998, but have remained constant between 1998 and 2000. Fishing effort remains very high, while spawning stocks have fallen below the precautionary level, and the numbers of young

fish have generally declined since 1990, raising concerns about the risk of stock collapse.

In general, the spawning grounds and nursery areas of many species of fishes are well known. In contrast, we know relatively little about the specific habitat requirements of fish during different parts of their lives. One component of essential fish habitats, which to date has received relatively little attention, would constitute those areas in which fish are able to feed effectively and reduce their risk of predation.

It is well known that certain fish species are associated with specific habitat features (*e.g.* reefs, sandbanks), a fact used by fishers to target particular species. Demersal fishers observe samples from the seabed each time they haul their nets, which far exceed the sampling schemes that scientists can sustain (Maynou and Sardà 2001). Furthermore, experienced fishers may have knowledge based on decades of observations, and that has been passed down from one generation to the next (Freire and García-Allut 1999; Sardà and Maynou 1998). In addition, they often keep detailed records of exactly where and when they fish and how much they catch. Present day ship-based electronic instruments permit fishers to see first-hand the link between different seabed types and textures. Although the ultimate goal of fishing is to provide income from the catch, rather than to test scientific hypotheses, many fishermen seek to understand the very questions about the seabed that motivate our study. Despite this obvious wealth of experience, and the fact that the Magnuson-Stevens Act requires the National Marine Fisheries Service (USA) to consult with fishers before submitting its advice, few studies, to our knowledge, have sought to consider or integrate fishers' views and knowledge on EFHs (but see Pederson and Hall-Arber 1999). The need to improve the collaboration between scientists and the fishing industry is widely recognised by scientists and fishers alike (*e.g.* Mackinson and Nøttestad 1998; Taylor 1998; Freire and García-Allut 1999; Baelde 2001; Maynou and Sardà 2001; Marrs *et al.*, in press). The involvement of the fishing industry in fisheries science might not only improve the credibility of fisheries science but also enhance the support for any regulations that may be based upon it.

In the present paper, two complementary approaches were adopted to identify possible EFHs. We used existing data from annual national groundfish surveys of fish abundance and biomass and compared them with fishing grounds outlined by fishers. Fishers marked grounds they considered to be important on nautical charts for a finer scale resolution of fish distribution (Taylor 1998). Information on habitat characteristics of target fish was also sought in a questionnaire format.

Materials and Methods

Identification of potential EFHs Using National GroundFish Surveys

Areas of seabed, which consistently harbour the highest densities of cod, haddock and whiting in the Irish Sea (ICES division VIIa), were identified using two databases spanning a decade of fishery-independent data from national groundfish surveys. The Centre for Environment, Fisheries and Aquaculture Science (CEFAS, Lowestoft) holds a complete data set from 1990 to 1998. Fish were sampled every autumn using a 4-m beam trawl at fixed stations (Ellis *et al.* 2000). The Department of Agriculture and Rural Development of Northern Ireland (DARDNI, Belfast) database spans a period from 1991-2000. Fish were caught by otter trawling at fixed stations every summer or autumn.

In our analysis, the abundance of each species for each station per year was ranked and a mean rank over time (per station) calculated to identify potential EFHs for further habitat survey (reported elsewhere). Plots of mean abundance or total abundance over a set time period were not considered useful to the identification of habitats that are used consistently from one year to the next. In addition, an exceedingly high abundance of fish in any one year could skew the results. We converted abundance to ranks within each year. Our rationale for using a rank score was that it is most relevant to know which habitat is consistently attractive to fish. These ranks were plotted using ArcVIEW GIS 3.2 software.

Using Expert Knowledge

We consulted with the fishing industry to refine our broad scale fish maps (from bottom trawl surveys) in terms of the seasonal and spatial distribution of fish. The project was first introduced to the fishing community through an article in 'Fishing News', the main national industry paper. It is often not practical to consult directly with individual fishers that spend most of their time at sea, often for more than a week at the time. Therefore, information was gathered in a pilot study through questionnaire-based interviews with maps (n=19) at an annual national fishing exhibition.

The interviews were designed to study fishers' perceptions of the relationship between fish and habitat features, perceived changes to habitats and to gain information about the location of potential EFH. Further information was gathered by sending out revised questionnaires with maps and more detailed information about the project to Sea Fisheries Committees and other relevant fisher's organizations with requests to circulate these among their members. Further interviews were conducted at a fish fayre in Lowestoft (English SE coast fishing port) (*n*=2) and a fishing exhibition in Newcastle (Northern Ireland) (*n*= 5). We collated a total of 39 questionnaires and 19 maps. These hand-drawn charts were digitized using ArcVIEW GIS and plotted in a chart format suitable for comparison with the charts generated from the scientific ground fish surveys.

The questionnaire (Figure 1) contained a total of 16 questions (following Pederson and Hall-Arber 1999), only six of which were analysed in this paper (see below). The responses were analysed by calculating the frequency of categories ticked and the frequency of statements made.

RESULTS

Fishing ground locations and distribution of mean ranks of fish abundance

Most fishers were very responsive and helpful during interviews. Following contacts with the Irish Sea Sea Fisheries Committees, the Fleetwood Fish Forum provided a high-resolution chart detailing the seasonal distribution of commercial fish species in the eastern Irish Sea (Fig. 2). Figure 2 represents the aggregated knowledge of 50 fishers that have outlined information gathered over a period of *ca* 50 years. More responses were obtained from contacts with Sea Fisheries Committees and Fisheries Producer Organizations but many of these 'mail shots' were answered by respondents that worked outside the Irish Sea or that targeted other species. Eighteen fishers out of 40 (excluding Fleetwood) plotted fishing ground locations on charts but only eight of these were located in the Irish Sea.

The geographical position of the fishing grounds outlined by fishers for cod, haddock and whiting were similar (Figs 3a-c). The main fishing grounds for these species appeared to be located between the north of the Isle of Man, southwest of Scotland and around the Solway Firth (NW England). It should be noted that several fishers highlighted areas in this region and north off the Welsh coast independently, which increases the confidence in these data. Some of these grounds are no longer visible in Figures 3a-c because they lie on top of each other. Further grounds are located off the Irish and Northern Irish coast and along the North Wales coast.

Similarly, fisheries survey data indicated that the highest mean ranks of cod from the two databases were situated off the Ribble Estuary (NW England), off Belfast Lough (Northern Ireland), off Colwyn Bay/Anglesey (N Wales), the Solway Firth (NW England) and in St George's Channel (Fig. 3a). The distribution of haddock mean ranks was similar to the distribution of fishing grounds (Fig. 3b). No

1. What do you regard as important ground features for your target species ? Please identify seabed structures (e.g. mud, gravel, boulders) or other characteristics of the grounds (e.g. sea weed, sponges) that you associate with your target species:
____

2. What do you regard as the most important factors that affect the grounds that you fish?
____

3. Do you think fishing gear has altered the grounds that you usually fish? ☐yes ☐no.
If 'yes' how has it affected the grounds? Please explain:
____

4. Have you noticed any changes over the time that you have been fishing?
☐target species ☐bottom animals and plants ☐habitat structure ☐fish health ☐bycatch ☐other changes.
Specify:____

5. Which of the following have you observed over time for the species that you target?
☐no change ☐increase ☐decrease ☐moved to other areas ☐replaced by another species ☐decrease in size
Please describe your observations:________________________

6. If you noticed a change to the grounds or species that you fish, please indicate what you think may be the cause(s): ☐climate☐pollution ☐changes in fishing gear ☐changes in prey abundance
☐habitat loss ☐overfishing ☐other
Please explain:____________ ________________________

Figure 1: Questionnaire format used in interviews and mail shots.

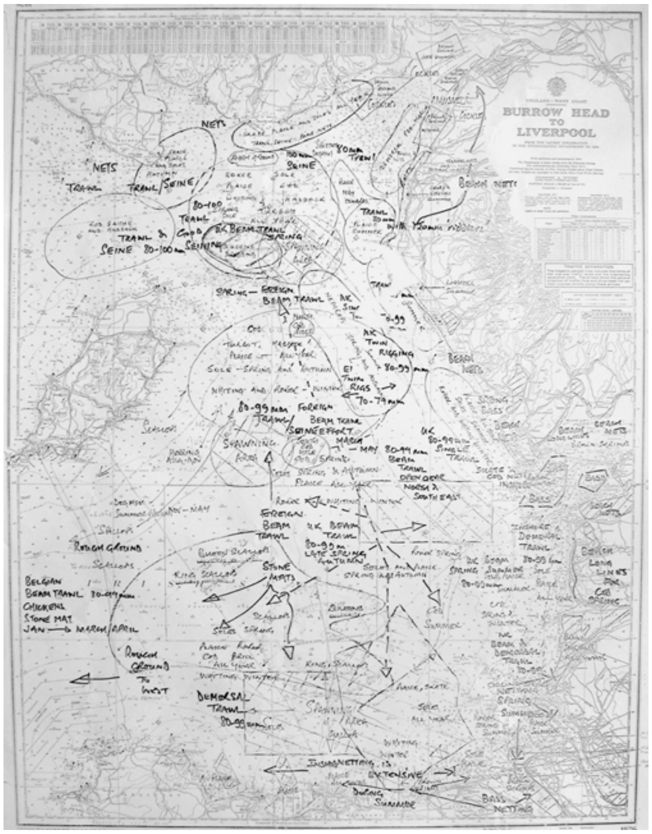
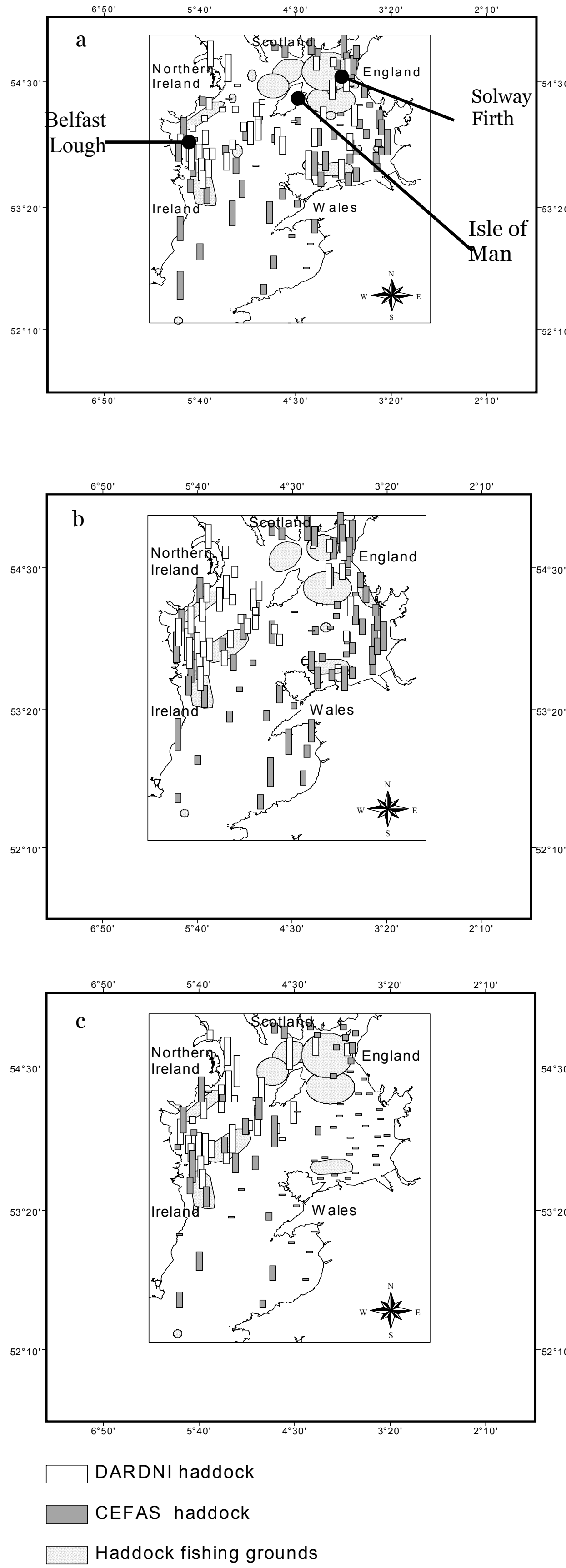


Figure 2. Chart with important fishing ground locations provided by the Fleetwood Fish Forum



Figures 3a-c. Distribution of mean ranks of fish abundance (bars) in the Irish Sea from 1990 to 2001 and fishing ground locations as outlined by fishers.

haddock fishing grounds were outlined at the low abundance stations off the English coast. There was less consistency between the whiting fishing ground locations and the distribution of the higher mean ranks of whiting (Fig. 3c). For example, no whiting fishing grounds were outlined off the Ribble Estuary, an area with high mean ranks of whiting but this may be explained by a low mean size of fish.

Questionnaires

Question 1. Cod, haddock and whiting were targeted by 16 out of 39 total respondents. The most important ground types stated for cod included sand (56%), mud (56%), 'hard' ground (comprises the categories boulders, cobble, rocks, stones, 'rough') (44%) and gravel/shingle (31%) (Fig. 4). For haddock the most frequently stated ground types were hard grounds (69%), sand (56%), mud (50%) and gravel/shingle (38%) while important grounds for whiting comprised mud (56%), sand (50%), hard grounds (31%) and gravel/shingle (31%) (Fig. 4).

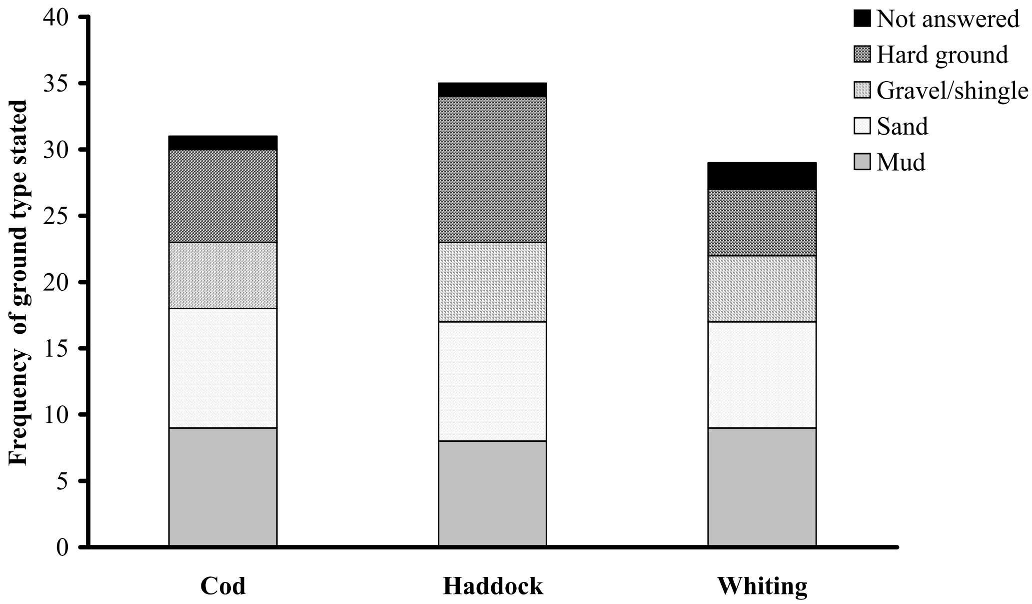


Figure 4: The most important ground types stated for cod included sand (56%), mud (56%), 'hard' ground (comprises the categories boulders, cobble, rocks, stones, 'rough') (44%) and gravel/shingle (31%)

The most frequent stated habitat features for cod were sand, feed (meaning the ground contained food for the fish), hard grounds (each 25%), wrecks, gravel (each 19%), mixed grounds and mussel beds (each 6%). Haddock habitat features included hard grounds (25%), brittlestar beds (19%), feed (19%), gravel, sand, mud (13%), seaweed (we interpret this to mean emergent growths of weed-like bryozoans such as *Flustra spp.*) and mixed grounds (6%). Sandeels (*Ammodytes spp.)* were perceived as important prey items of cod (67%) and haddock (80%), followed by 'small fish' (50% and 60%, respectively) shrimps (25% and 40%, respectively) and small crabs (38% and 20%, respectively). The most frequently stated habitat features for whiting were hard grounds (19%), mud, sand, gravel (13%), sea grass[1] and soft corals (*Alcyonium digitatum*) (6%). The response rate to this open-ended question was relatively low: 25% of the respondents did not comment on cod habitat features, haddock habitat (44%) or whiting habitat (69%).

Question 2. 21% of the respondents named heavy fishing gear such as beam trawls, scallop dredges and twin otter trawls as important factors that affect targeted habitats. Other factors stated included fishing (effort) (21%), feed (15%), weather (15%) and season (13%).

[1]Although the respondent used the term 'seagrass' we doubt that the angiosperm plant was meant. It seems more likely that he used this term for seaweed or weed-like bryozoans or hydroids.

Question 3. Fifty-six percent of the respondents thought that fishing gear had altered their grounds (96% response rate).

Questions 4.-6. A third of the respondents observed changes in their target species such as a decrease in numbers (74%) and size (35%), and only two percent stated that there was no change in their target species (Table 1). These changes were attributed to overfishing (56%), climate (38%) and pollution (36%), changes in fishing gear (28%) and prey abundance (23%).

Discussion

Fishing ground locations and distribution of mean ranks of fish abundance

Although many fishers volunteered to fill in questionnaires, fewer were willing to outline their fishing grounds on charts. This was largely for reasons of confidentiality and due to suspicion that such information might lead to negative management developments for fishers. For example, the information may inform the choice of potential areas for closure or the imposition of further limits on fishing practices (Pederson and Hall-Arber 1999). Furthermore, many respondents worked in areas other than the Irish Sea or targeted other species, which restricted the number of charts used in this paper to eight. The similarity of the fishing grounds outlined for the three different fish species reflects, to some extent, the fact that several fishers did not distinguish between which

Table 1: Results of three questions posed in questionnaires (n=39 unless stated otherwise; f= frequency of category checked; %= percentage of frequency)

Changes over time	f	%	Changes in your target species	f	%	Cause of change	f	%
Target species	12	31	No change	2	5	Climate	15	38
Bottom animals and plants	12	31	Increase	5	13	Pollution	14	36
Habitat structure	3	8	Decrease	29	74	Changes in fishing gear	11	28
Fish health	1	3	Moved to other areas	5	13	Changes in prey abundance	9	23
Bycatch	7	18	Replaced by another species	2	5	Habitat loss	3	8
No changes	5	13	Decrease in size (n=26)	9	35	Overfishing	22	56
Other changes	5	13	Other changes	1	3	Other causes	4	10
Not answered	9	23	Not answered	4	10	Not answered	7	18

species were targeted in the different areas outlined. In those cases, it was assumed that respondents fished for all of their target species in the area outlined although we recognize that it may have been a prime ground for one particular species.

At first sight, it would appear that areas of the highest fish densities obtained from databases do not always coincide with those given by fishers. For example, cod, haddock and whiting densities were generally high along the (Northern) Irish coastline according to the fisheries survey bases, whereas many fishers highlighted grounds off the Solway Firth (S Scottish and N English coast). This, however, may partly reflect a local bias in the port of origin of many of the respondents that attended the fishing exhibition in Scotland at which many of the interviews were undertaken. Owing to logistic problems, it was more difficult to reach (Northern) Irish fishers. It should be noted, however, that two Irish fishermen also outlined grounds off the Solway Firth. An attempt to interview more (Northern) Irish fishers at the Fisheries Co-operative meeting in Newcastle (Northern Ireland) yielded five questionnaires but no charts as many fishers targeted shellfish, or were unwilling to mark their fishing grounds. After closer inspection of Figures 3a-c, however, it is apparent that the highest mean ranks for haddock and cod coincided with fishing grounds off the Solway Firth (S Scotland and N England) and those off the N Welsh coast. A greater sample size, involving more fishers from (Northern) Ireland, would allow for a less biased comparison between the fishers' data and the groundfish survey data. It is possible that this spatial bias could be circumvented by restricting a spatial analysis of the ground fish survey data to subsets in the vicinity of respondents' ports.

The fishers' information has added to our confidence that high density sites indicated by the fisheries survey data are indicators of areas targeted by fishers, Several fishers highlighted the same grounds in the northern Irish Sea and off Ireland and off Wales. These areas presumably have features that consistently attract fish in sufficient numbers and quality to be of interest to fishers. Some of the discrepancies between the fishers' charts and the groundfish survey data may also lie in the fact that there were relatively few sampling stations located between the N Isle of Man, NW Scotland and NW England. This is probably due to differences in the gear historically used for the CEFAS ground fish survey, a beam trawl, the use of which would be restricted over the rough grounds around the Isle of Man. Recent studies from the NW Atlantic indicate that young cod and haddock prefer habitats of coarse sediment interspersed with rocks (Lough *et al.*,1989; Gotceitas *et al.* 1995; Gregory and Anderson 1997; Lindholm *et al.* 1999). On the other hand, the groundfish survey may include areas that fishers normally avoid because they would catch too much 'rubbish'[2] that may clog up their nets during the longer commercial tows.

Although it could be argued that no 'filter' was incorporated in our questionnaires to test if questions were answered truthfully (Johannes 1981; Maynou and Sardà 2001) we believe that most respondents answered the questions to the best of their knowledge. Maurstad (2000) highlighted that the publication of maps and other information given by fishers in a purely scientific context can put scientists into a dilemma in terms of intellectual property rights and confidentiality. Also the

[2] inert material and by-catch of non-target species

knowledge becomes separated from its sociological context. We decided to publish our results, however, as we feel that the quality of the charts presented here is not sufficiently accurate to pose a threat to any individual respondent's livelihood. Also, it is likely that the information volunteered is known by many fishers.

Questionnaires

Sand, mud and hard grounds were most frequently named as key ground types for all three fish species, although more respondents (69%) considered 'hard' grounds as important for haddock *vs* the other species. In a similar study in the US, fishers indicated that they preferably fished whiting on fine-grained sediments whereas other groundfish were targeted across all habitat categories (Pederson and Hall-Arber 1999). 'Feed' was named as one of the critical sea bed features for cod and haddock. Sandeels were reported to be important prey items of cod and haddock and many fishers were concerned about a decline in sandeels due to an increased effort in industrial fishing over recent years. Information on fish diet can be regarded as particularly valuable as fishers gut high numbers of fish and often observe their stomach contents. Pederson and Hall-Arber (1999) even suggested that trained fishers could sample and preserve stomach contents for scientific purposes.

Interestingly three fishers stated independently that 'wigs' (probably brittlestar beds) are an important habitat feature for haddock, especially after spawning. Although fishers suggested that haddock sought out brittlestar beds to 'clean themselves' after spawning it is known that haddock feed on brittlestars as a grinding substance in their stomachs (Mattson 1992). This emphasizes the potential value of apparently obscure observations made by fishers even though their conclusions may be partially inaccurate.

A few other fishers noted that weed (possibly hydroids or the wide-spread bryozoan, *Flustra spp*.) was often found in their haddock or plaice catches and one fisher also associated whiting with soft corals, *Alcyonium digitatum*. These habitat features may provide fish with shelter from predators or act as foci of prey species (*e.g.* pandalid shrimps). These features of fish habitats are currently the subject of further investigation (Freeman *et al*., unpublished data). Similar to the findings of Pederson and Hall-Arber (1999), few fishers commented on habitat features other than ground types (see above), and such features were given in interviews rather than in mail shot questionnaires. Fishers often do not know scientific names, especially those of non-target invertebrates, and seem unwilling to offer their own interpretation that may be proven incorrect (Mackinson 2001). It was easier to steer and expand questions during interviews through explanations and by showing images of marine animals that fishers would recognize. In a more comprehensive survey, the provision of a standard photo card showing common marine animals could help to increase the response rate and train fishers that are often keen to expand their knowledge of the marine environment.

More than 50% of the fishers believed that fishing gear has, in some way, altered their grounds. Many recent studies have shown that towed bottom fishing gears have altered the seabed (Jennings and Kaiser 1998). Fishers were also concerned about heavy mobile fishing gear such as scallop dredges, beam trawls and twin otter trawls. Similarly, Collie *et al.* (2000) showed that scallop dredging together with intertidal dredging has the greatest initial impact on benthic biota.

It should be noted that most fishers attributed habitat changes to gear types that were not used by them. Less than a third of the respondents polled in a study in the US believed that fishing gear had changed the grounds (Pederson and Hall-Arber 1999). This difference may be attributed to the fact that in Pederson and Hall-Arber's study fishers were asked if their own gear had altered the grounds. In the same study, more than 50% of the fishers identified mobile gear as the most important factor that affected habitats.

A third of the respondents observed changes in their target species such as a decrease in number and size, which reflect recent trends in the state of the fishery. Overfishing, climate change and pollution were perceived as the most important causes for declines in fish abundance. Again, many fishers complained about the decline of sandeels (due to industrial fishing) as an important food source for their target species, and an increase in seal populations that feed on their target species. The majority of fishers attributed changes to overfishing.

It should be noted that only a few fishers commented on habitat loss over time although many fishers stated that fishing gear smoothes seabed topography and 'damages the ground'. It is possible, that once stated, fishers thought it unnecessary to repeat the statement in

subsequent questions of the questionnaire. Also, fishers may have been unfamiliar and therefore uncomfortable with the term 'habitat', although the meaning was explained either verbally or on enclosed information leaflets and the word 'ground' was used instead in most questions.

Although more time-consuming, questionnaire based interviews on a one to one basis yielded the best data as it enabled the essential establishment of trust between the scientist and the fisher and allowed for elaboration of specific questions when technical terms were unclear. Our consultation with fishers has not only added to the credibility of the study and any future management decisions that may rely on its findings (Maurstad and Sundet 1994), but has also highlighted how our current knowledge can be expanded. Further insights may be gained by an analysis of statements made in questionnaires which are then integrated with biological data using fuzzy logic (Mackinson 2000). The integration of fishers' knowledge into science and management is a potentially invaluable tool that should not be overlooked (Pederson and Hall-Arber 1999).

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References
Baelde, P. 2001. Fishers' description of changes in fishing gear and fishing practices in the Australian South East Trawl Fishery. Marine and Freshwater Research, 52: 411-417.

Benaka, L. 1999. Fish habitat: essential fish habitat and rehabilitation. American Fisheries Society, Bethesda, Maryland. 459 pp.

Coleman, F., Travis, J. and Thistle, A.B. 2000. Essential Fish habitats and Marine Reserves. *In*: Bulletin of Marine Science, Sarasota, Florida.

Collie, J.S., Hall, S.J., Kaiser, M.J. and Poiner, I.R. 2000. A quantitative analysis of fishing impacts on shelf-sea benthos. Journal of Animal Ecology, 69: 785 - 798.

Dayton, P., Thrush, S.F., Agardy, M.T. and Hofman, R.J. 1995. Environmental effects of marine fishing. Aquatic Conservation: Marine and Freshwater Ecosystems, 5: 205-232.

DEFRA. 2000. United Kingdom sea fisheries statistics 1999 and 2000. The Stationery Office, London.

Ebert, D. and Filipek, S.P. 1988. Response of fish communities to habitat alternation in a small Ozark stream. Proceedings of Arkansas Academic Science, 42: 28-32.

Ellis, J.R., Rogers, S.I. and Freeman, S.M. 2000. Demersal Assemblages in the Irish Sea, St George's Channel and Bristol Channel. Estuarine, Coastal and Shelf Science, 51: 299-315.

FAO. 1995. The state of the world fisheries and aquaculture. Rome, Italy.

Freire, J. and García-Allut, A. 1999. Integration of fishers' ecological knowledge in fisheries biology and management. A proposal for the case of the artisanal coastal fisheries of Galicia (NW Spain). ICES Council Meeting Papers, ICES-CM-1999/S:7 17pp.

Gotceitas, V., Fraser, S. and Brown, J.A. 1995. Habitat use by juvenile Atlantic cod (*Gadus morhua*) in the presence of an actively foraging and non-foraging predator. Marine Biology *1*23: 421-430.

Gregory, R.S. and Anderson, J.T. 1997. Substrate selection and use of protective cover by juvenile Atlantic cod *Gadus morhua* in inshore waters of Newfoundland. Marine Ecology Progress Series *1*46: 9-20.

Jennings, S. and Kaiser, M.J. 1998. The effects of fishing on marine ecosystems. Advances in Marine Biology, 34: 201-352.

Johannes, R.E. 1981. Words of the lagoon: fishing and marine lore in the Palau District of Micronesia. University of California Press, Berkeley.

Keast, A., Harker, J. and Turnbull, D. 1978. Nearshore fish habitat utilization and species associations in Lake Opinicon (Ontario, Canada). Environmental Biology of Fish, 3: 173-184.

Koehn, J.D. 1993. Freshwater fish habitats: key factors and methods to determine them. *In*: Sustainable fisheries through sustaining fish habitat, Ed. by D. A. Hancock. Australian Government publishing services, Canberra (Australia). 77-83.

Lindholm, J.B., Auster, P.J. and Kaufman, L.S. 1999. Habitat-mediated survivorship of juvenile (0-year) Atlantic cod *Gadus morhua*. Marine Ecology Progress Series *1*80: 247-255.

Lough, R.G., Page, C.V., Potter, D.C., Auditore, P.J., Bolz, G.R., Neilson, J.D. and Perry, R.I. 1989. Ecology and distribution of juvenile cod and haddock in relation to sediment type and bottom currents on eastern Georges Bank. Marine Ecology Progress Series, 56: 1-12.

Mackinson, S. and Nøttestad, L. 1998. Combining local and scientific knowledge. Reviews in Fish Biology and Fisheries, 8: 481-490.

Mackinson, S. 2000. An adaptive fuzzy expert system for predicting structure, dynamics and distribution of herring shoals. Ecological Modelling *1*26: 155-178.

Mackinson, S. 2001. Integrating local and scientific knowledge: An example in fisheries science. Environmental Management *2*7: 533-545.

Marrs, S.J., Tuck, I.D., Atkinson, R.J.A., Stevenson, T.D.I. and Hall, C. in press. Position data loggers and logbooks as tools in fisheries management: results of a pilot study and some recommendations. Fisheries Research.

Mattson, S. 1992. Food and feeding habits of fish species over a soft sublittoral bottom in the northeast Atlantic. 3. Haddock (*Melanogrammus aeglefinus* (L.)) (Gadidae). Sarsia, 77: 33-45.

Maurstad, A. and Sundet, J. 1994. Improving the link between science and management: drawing upon local fishers' experience. ICES Council Meeting Papers, ICES-CM-1994/T:20: 7 pp.

Maurstad, A. 2000. Trapped in biology. *In*: Finding our sea legs - Linking fishery people and their knowledge with science and management, Ed. by B. Neis and L. Felt. ISER Books, St. John's, New Foundland. 135-152.

Maynou, F. and Sardà, F. 2001. Influence of environmental factors on commercial trawl catches of *Nephrops norvegicus* (L.). ICES Journal of Marine Science, 58: 1318-1325.

Pederson, J. and Hall-Arber, M. 1999. Fish habitat: a focus on New England fishermen's perspectives. *In*: Fish habitat: essential fish habitat and rehabilitation, pp. 188-211. Ed. by L. R. Benaka. American Fisheries Society, Hartford, Connecticut.

Sardà, F. and Maynou, F. 1998. Assessing perceptions: do Catalan fishermen catch more shrimp on Fridays? Fisheries Research, 36: 149-157.

Taylor, R. 1998. Another approach to scallop production, habitat concerns and biodiversity. *In*: Effect of fishing gear on the sea floor of New England, Ed. by E. M. Dorsey and J. Pederson. Conservation Law Foundation, Boston, Massachusetts. 111-114.

INTEGRATION OF FISHERS' KNOWLEDGE INTO RESEARCH ON A LARGE TROPICAL RIVER BASIN, THE MEKONG RIVER IN SOUTHEAST ASIA

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ABSTRACT

The Mekong River is home to an estimated 1,200 species of fish and supports one of the most important freshwater fisheries in the world, vital for food security and employment among the 60 million people in the Mekong Basin. Many of the fish migrate seasonally between flood-season feeding, spawning and rearing habitats, and dry-season refuge habitats. Only limited, fragmented, information on these movements is available for individual species. Much more information is urgently needed in order to include such information into future development plans for the river basin. In order to start filling this knowledge gap, a survey of local fishers' knowledge was carried out. More than 350 local fishers along the Mekong were interviewed about the migratory and reproductive habits of 50 important fish species and the distribution ranges for another 120 species. Interviews covered a stretch of almost 2,500 km extending through four countries.

By merging data from different areas, migration patterns for 50 species were produced. We were also able to divide the Mekong into three distinct, but inter-connected regions, based on the pooling of the migration data. Further to this, the research produced considerable information on certain important fish habitats. Interviews revealed, for example, the role of deep pools within the Mekong mainstream. These appear to be very important dry season habitats for many species. Although this was not included as a specific subject during the interviews, fishers volunteered more than 230 records on the importance of the deep pool habitat. Our research demonstrates how fishers' knowledge can provide information that is vital for management, and help develop hypotheses that focus future research.

INTRODUCTION

This conference is the latest evidence that local ecological knowledge has finally entered into the mainstream of fisheries research and management. We have now reached a point where it should no longer be needed to argue for the use of local knowledge but instead aim for its wider integration into research programmes and management strategies.

The diversity of presentations on offer at the conference also reflects the diversity of issues and scales at which local knowledge has a role to play. This diversity will likely increase in the future as more fisheries researchers and managers embrace local knowledge in their activities.

In this paper, I will focus on the role that local fishers' knowledge has recently played in a research programme in the context of a large river basin, the Mekong River, in Southeast Asia. During the past three years, ecological studies, with emphasis on fish migrations, have been carried out as a joint effort between the four countries of the lower Mekong Basin: Cambodia, Lao PDR, Thailand and Vietnam[1]. These studies were based entirely on the systematic compilation of local ecological knowledge throughout the lower part of the Basin.

I will use a few key results to demonstrate how local knowledge can provide information at several scales. Not only can it provide a wealth of detailed and site-specific information at local scale, but by merging data from different places, crucial information at the regional, and sometimes ecosystem, scale can also be obtained. For a large system like the Mekong Basin, where it is almost impossible to obtain relevant large-scale ecosystem information based on conventional ecological research, this is perhaps the most promising result of this study.

The Mekong River.

The Mekong is the largest river in Southeast Asia. From its source at the rim of the Tibetan plateau to its outflow in the South China Sea, it covers a distance of more than 4,200 km and drains an area of 783,000 km². During its course, the river flows through six countries: first through the Yunnan Province of China, then for a short distance along the northeast of Myanmar, along the border between Lao PDR and Thailand, cutting through Cambodia until, finally, reaching its delta and discharging into the South China Sea in southern Vietnam (see Figure 1).

[1] Under the auspices of the Mekong River Commission (MRC), an inter-governmental river management organisation established by the four countries, Cambodia, Lao PDR, Thailand and Vietnam in 1995.

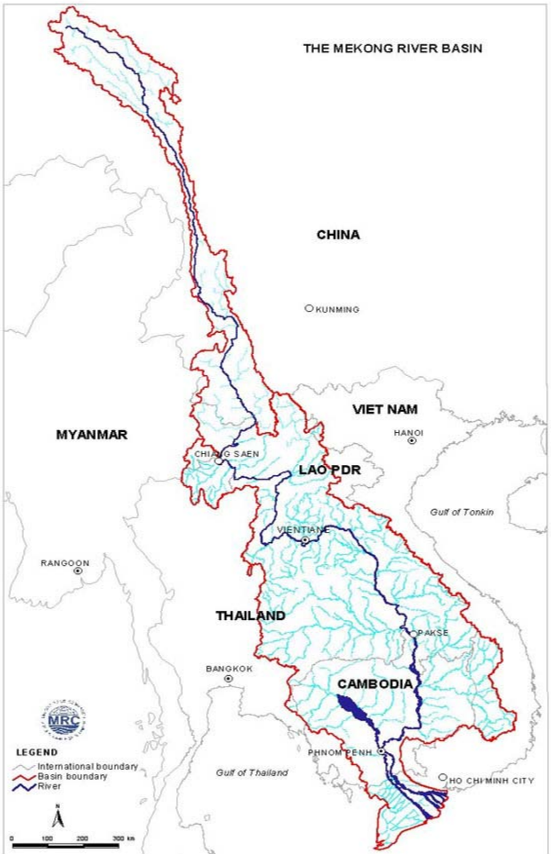

Figure 1. Map of the Mekong River Basin

The river basin contains a breath-taking biodiversity. It is home to an estimated 1,200 species of fish, which in turn represent the foundation for one of the largest and most important freshwater fisheries in the world. Conservative estimates suggest the total annual fisheries yield from the river basin to be 1 million tonnes (Jensen 1996). These fisheries are of critical importance for food security and income generation for the 60 million people living in the lower Mekong Basin (Ahmed *et al.* 1998; Sjørslev 2000).

The Mekong is a seasonal river, highly influenced by the monsoon climate of Southeast Asia. During the rainy season from May to September, a large amount of water is "injected" into the system as a result of both rain throughout the basin and snowmelt in the upper mountainous stretches. This flood-pulse inundates vast land-areas adjacent to the river. These seasonal floodplains are extremely productive fish habitats and they account for most of the fisheries production in the basin. Most fish species in the river have developed life cycles which are adapted to take full advantage of these seasonal habitats for feeding and rearing young. As a result, fish migrations between seasonal and perennial water-bodies are very common in the system. A large number of Mekong species are migratory, to a greater or lesser extent, and a large proportion of the fisheries activities target migrating fishes.

Fish migrations are a common feature in river systems (Barthem and Goulding 1997), and they have substantial management implications since they interconnect different parts of the whole system. Managing such resources thus requires management actions at both the local habitat scale and at the regional ecosystem scale. In some cases, the ecosystem encompasses almost the entire river basin (e.g. Barthem and Goulding 1997).

Through a long interdependence, fishers along the Mekong have become as intimately linked to the rise and fall of the Mekong waters as the fish. For example, migratory fishers follow the paths of migrating fishes during the year.

In order to be able to develop management strategies and development plans for the river basin, it is crucial to have more information about the extent of these fish migrations and their importance for the functioning of the ecology of the system.

The need for more and better ecological information about the Mekong basin led to the formulation of a basin-wide study of fish migrations, initiated in 1997 under the MRC fisheries programme[2]. The main objectives were to obtain information on migration patterns and spawning behaviour for a large number of important species, with a view to incorporating such information into future management strategies and development plans for the region.

Considering the size and ecological complexity of the Mekong River basin, this felt like a daunting task! Very early on in the planning process, it was recognised that the best, and possibly the only, way to achieve the objectives was to seek the assistance of local fishing communities, i.e. by compiling and merging their existing knowledge about fish migrations. These communities depend on the capture of migratory fishes passing through their area and have built up very detailed knowledge over a long period, which enables them to predict when they will

[2] The MRC fisheries programme is a sector programme under the Mekong River Commission, Its activities are implemented as a joint effort between the following line agencies in the riparian countries: Cambodia: Department of Fisheries; Lao PDR: Living Aquatic Resources Research Centre (LARReC); Thailand: Department of Fisheries, and Vietnam: Research Institute for Aquaculture No. 2 (RIA-2).

catch which species. They have a clear concept about fish migration and often liase with neighbouring villages upstream and downstream to send, or receive, the message that certain fish are on the move.

So, detailed knowledge about fish migrations in the Mekong River has existed for a long time, dispersed in local communities and in their fishing practices. The main issue then is to get access to that knowledge. The following section gives a brief overview of the process that was developed to access local knowledge about fish migrations in the Mekong River basin.

Overview of the Methods

The decision to carry out the survey through systematic compilation of local ecological knowledge was relatively easy to make. Given the objectives and the time available, we concluded that there were simply no alternatives. However, the next question was **how** to do it. Since hardly any previous experience was available to draw upon, at least not in the given context, we had to "start from scratch". At the initial planning stages, lots of brainstorming sessions were held in order to produce some rough outlines for a field method. From then on, we entered into a more formal process of methodological development, which included the involvement of all the future data collectors and interviewers from the four countries. The final outcome was a set of field guidelines, describing the process of defining the right people to talk with, creating the right conversational atmosphere, and designing a survey format for entering detailed ecological information emerging from the interviews.

The process and the method were described in detail by Poulsen and Valbo-Jørgensen (1999), and further discussed by Valbo-Jørgensen and Poulsen (2000). The following is a brief overview.

In each of the four countries, a team of 2 to 3 people carried out the survey. A number of workshops and meetings were held with the interview teams. During these workshops, the survey was designed through a process of field-testing, re-designing and testing again, before the final format was agreed upon. Other important objectives of the workshops were to ensure that the data obtained from different countries were compatible and, importantly, to gradually develop the skills and confidence of the interview teams, who in most cases had never before attempted this type of research.

The final survey format was quite rigid in its structure, reflecting the need to obtain specific data that could easily be merged between different interview teams in different countries. However, the need to "strike a balance" between rigidity and flexibility was strongly emphasised throughout the survey process. We tried to develop an atmosphere where the formal rigidity was kept on paper, whereas the interview process itself was carried out in an informal, conversational manner. Furthermore, we also tried to avoid a common danger of rigid survey questionnaires: they often miss crucial information that is not allowed for on survey forms (see for example, Johannes and Freeman 2000). As will be discussed later, crucial information was indeed obtained, which was not allowed for in the rigid structure of the survey format. Most fishers knew something, which did not have an entry field on the form. Such information was included as endnotes on the forms (i.e. "any other information").

For the target species, the following key data were obtained: 1) local name(s); 2) occurrence by month over the year; 3) sizes of fishes by month; 4) migration timing and direction (i.e. upstream or downstream) by month; 5) environmental indicators for migrations; 6) spawning (timing, behavior and habitat); 7) any other information.

Finally, I would like to emphasise a few important details. Firstly, as focal points of discussion during the interviews, photos of Mekong fishes were used in the form of a photo flipchart specially designed for the study. This tool proved invaluable, not only in order to minimize the chances of misunderstandings between interviewers and fishers, but also as an ice-breaker at the start of the interview. Secondly, the starting point for each interview session was a mapping exercise, where fishers were encouraged to draw a map of the fishing ground and include everything they believed was important. Apart from providing detailed habitat information for each site, this mapping process also helped fishers to focus on that particular fishing site in the subsequent interview session.

The survey was conducted at 51 sites along the Mekong mainstream during 1999 and more than 350 fishers were interviewed (Valbo-Jørgensen and Poulsen 2001). In 2000, the survey was extended into certain important tributary systems of the Mekong. The analysis of these data is not included in this paper. In the following section, I will discuss some of the key results that were obtained during the survey.

Key Results

Based on this survey, migration patterns for 50 important fish species from the lower Mekong Basin was described along a stretch covering almost 2,400 km (Valbo-Jørgensen and Poulsen 2001). In this paper, I will discuss three of those species in order to illustrate the nature of the information obtained. By pooling data, e.g. on all species and/or all sites it was also possible to reveal ecosystem patterns on a larger scale. This is perhaps the most significant outcome of the work. It demonstrates, for example, the degree to which the ecology of the system depends on the hydrology of the river basin, in particular the annual flood cycle. It further illustrates how the whole system is ecologically inter-connected by fish migration networks "criss-crossing" the basin. Finally, dry-season refuge habitats within the main river channel were identified as crucial habitats for many species and for the ecological integrity of the ecosystem at large.

Migration patterns for three species of river catfishes

The family of river catfishes (*Pangasiidae*) is important for fisheries in the Mekong basin. The family also includes some of the most "charismatic" species, such as the Mekong giant catfish (*Pangasianodon gigas*), and (*Pangasius sanitwongsei*). The family contains 21 species globally, of which 15 occur in the Mekong Basin (although the taxonomy of the family is currently being revised). In this paper, I will discuss the results for three members of the family: *P. krempfi*, *P. sanitwongsei* and *P. larnaudiei.*

The migration patterns for the three species are illustrated in Figures 2, 3 and 4, in Appendix 1 at the end of this paper. These migration maps are the result of data on the timing and direction of migration, combined from each station for each species. Black arrows indicate migration within the period October to February, white arrows indicate migration in the period May to September, and grey arrows indicate migration in the period March to May.

A comparison between the three migration patterns reveals both striking similarities and differences. Firstly, the only major waterfalls on the mainstream Mekong, the Khone Falls, influence the migrations of all three species. *P. sanitwongsei* does not appear to migrate over the falls and thus may consist of two separate populations, one above and one below the falls. On the other hand, *P. krempfi* and *P. larnaudiei* both migrate across the Falls during May to September. This observation is supported by several long-term sampling programmes near the Khone Falls (Baird 1998; Singanouvong *et al.* 1996). However, the Falls appear to separate two different migration patterns. For both species, fish migrate upstream above the Khone Falls during May-July, while at the same time below the Falls, fish of the same two species are migrating downstream. A look at the reported fish sizes reveals that juveniles mainly occur below the Falls, whereas large mature adults mainly occur above the Falls. For example, *P. larnaudiei* juveniles, ranging from 10 to 60 cm, are reported almost exclusively below the Falls, whereas adults ranging from 70 to 90 cm are reported from above the Falls. The two migration patterns may thus represent simultaneous but different life stages, i.e. upstream spawning migrations above the Falls, and downstream juvenile migrations below the Falls.

All three species appear to have a distinct migration pattern in the upper catchment, i.e. approximately from Vientiane and upstream. This may represent different populations of the same species from the middle and lower sections of the river.

Thus, in summary, there appear to be three distinct migration patterns for each species: 1) a lower Mekong migration pattern covering the stretch from the Khone Falls down to the Mekong Delta, and including the Tonle Sap Great Lake system of Cambodia; 2) a middle Mekong migration pattern covering the stretch from Khone Falls upstream to around the mouth of the Loei River tributary (approximately 100 km upstream from Vientiane); and 3) an upper Mekong migration pattern covering the stretch from Loei River to the border between Lao PDR and China (and probably further). These three migration systems emerge even more clearly when data for all the surveyed species are pooled (Valbo-Jørgensen and Poulsen 2001). Thus, by pooling local ecological knowledge from different sites along the river, ecosystem patterns on a much larger scale were revealed.

Hydrology and Fish Migrations

Fish species of the Mekong have evolved life cycles that are intimately adapted to the hydrological cycle of the river. Fishers know this very well and use hydrological indicators to make decisions about their fishing activities. For example, many fishers have learnt the sequence of fish species migrating in response to a hydrological event and are therefore able to adjust their fishing activities accordingly. Often, they use naturally occurring "hydrological gauges", such as rocks and trees in the river

channel, to decide when the time is right to start fishing for a certain species of fish. When asked about what triggers fish migration, there is broad agreement between fishers from all over the basin that rapid changes in water discharge is the main cause, either directly or indirectly. As a result, large-scale migrations peak twice per year, at the beginning of the rainy season (May-June) and at the end of the floods (October-November).

Deep Pools as dry season refuge habitats

One of the issues which we did not anticipate at the beginning of the survey, and therefore did not include as a "question" in the survey formats, was the issue of certain stretches of the river serving as important refuge habitats during the dry season. However, many fishers emphasised that in certain deep pools within the river channel near their villages, a large number of fish species congregate during the dry season. Many fishers volunteered more than 230 records about the key role of deep pools. Importantly, certain stretches emerged as "deep pool hot-spots", while others appeared of limited use as dry season refuge habitats. As we will discuss later, this information may have important management implications. Had our survey not been able to accommodate this "unexpected" information, we would have missed it, and thereby missed a crucial factor in relation to the ecological integrity of the river basin.

Ecosystem patterns

To summarize the findings, local knowledge made it possible for us to: 1) identify three migration patterns along the lower Mekong River (covering a stretch of more than 2,400 km); 2) determine that migrations are closely linked to the hydrological cycle of the river and peak twice per year during rapid changes in water discharge, and 3) the importance of deep pools as dry season habitats.

If we put all this information together, we may define the three migration systems that were identified more precisely. What signifies them as 'systems' is mainly the relative geographic position between dry-season refuge habitats and flood-season feeding and rearing habitats. Thus, the lower Mekong migration system constitutes a migration between dry-season pool habitats in the upper stretch and floodplain habitats in the lower stretch. The middle Mekong migration system constitutes a migration between refuge habitats in the Mekong mainstream and floodplain habitats along major tributaries. Finally, the upper Mekong migration system constitutes a longitudinal migration between downstream refuge habitats and upstream spawning habitats (i.e. in this section of the river, very little floodplain habitat exists).

Concluding remarks on the results

The preceding results only constitute a small fraction of the data that were compiled. I hope they have illustrated the nature of the obtained information and thereby demonstrated how local knowledge can be applied in the context of a large river basin. It is hard to imagine that all this information could have been generated based on conventional biological/ecological research tools, such as sampling or tagging, particularly considering available funds, time and human resources. This is not to say that they do not have a role to play. Based on large-scale local knowledge surveys, conventional scientific techniques may be applied in a more focussed manner to test specific hypotheses on a smaller scale. For example, as illustrated by the three species discussed in this paper, we generated several hypotheses about population structures for many species (Poulsen and Valbo-Jørgensen 1999). Advanced genetic tools may then be applied to test such hypotheses.

LOOKING TOWARDS THE FUTURE

Based on our experiences from the Mekong River, we believe that Local Ecological Knowledge will play an increasingly important role in future activities related to river fisheries research and management. We also believe that it will play a crucial role as an important element of Environmental Impact Assessment (EIA) procedures related to development plans for the river basin. For example, existing EIA procedures for large-scale water management schemes such as hydroelectric dams could be substantially improved by incorporating local knowledge. In the following, I will briefly discuss the prospects for local ecological knowledge within 1) fisheries research and management, and 2) EIA procedures.

Fisheries Research and Management

It can be argued that the survey described in this paper has been a "one-way" study, where local fishers provided information, which was then used to reveal migration patterns and other ecological features of the river basin. It is thus important to emphasise that this was the beginning, not the end, of a process of increasingly involving local fishers and fishing communities in research, management and monitoring of river fisheries. The next step is to take the results of the research back to the

fishers and discuss it with them, so that they are aware of, and accept, the use of the information that they provided. This process has already started, and some of the most motivated fishers from the survey are currently involved in a migration monitoring programme, where they monitor their catch daily over one whole annual cycle with a view to identifying any fish migration waves passing through their areas. Such a programme could, with a few modifications, be implemented for future monitoring purposes of targeted areas. For example, fishers living near deep pool hot-spots may be involved in monitoring these crucial dry-season habitats.

In a complex system such as the Mekong fisheries, research, management and monitoring should ideally be regarded as integrated parts of an *adaptive management* process. If such a process is to succeed in managing aquatic resources, local communities must play the central role throughout. The starting point should be to build upon the knowledge and practices that are already in place within local communities.

In the Mekong basin, traditional management systems are still common in many places (Sjorslev 2000). However, as has happened elsewhere around the world, traditional management systems have been abandoned in recent decades as globalisation slowly, but steadily, expands to every remote corner of the world. Since the globalisation process has happened relatively recent in the Mekong Basin, traditional management systems here can be "re-awakened". This has for instance been achieved with success in southern Laos where a large number of so-called fish conservation zones has been established within the river channels based on initiatives, which, although facilitated externally, largely originated from within communities (Baird, this vol). There is thus clearly a good foundation within the river basin on which to build future co-management strategies. Management systems which are locally rooted have a far better chance of success than externally imposed systems.

Migratory fish stocks pose a special management challenge in the Mekong River. Such stocks are shared between many local communities, in many cases even between communities in different countries. Thus, by nature, local management practices are not enough. Although management measures, in practice, are always implemented locally, higher levels of co-ordination are needed for migratory stocks. The nature of this co-ordination depends on the scale at which the resource is distributed. For transboundary stocks, for example (i.e. stocks which migrate across international borders), co-ordination is required at the level of national governments (for the Mekong region, this could potentially be through the Mekong River Commission). However, it could also happen at lower scales, e.g. between provincial or district authorities, or even between two or more villages, within a country. The details about how such a system could be established are beyond the scope of this paper. The main issue of relevance here is that, no matter how high up management co-ordination takes place; local communities should always be actively involved throughout the process. And, as we have seen, local knowledge **can** contribute significantly with information at even the largest of scales in the ecosystem.

Environmental Impact Assessment

Current EIA practices in the Mekong region are often based on external experts carrying out short-term field studies to establish species lists and site inventories for the particular area under assessment. The main shortcoming of this approach is that ecosystem dynamics are often disregarded. A particular site or stretch of river may inhabit few species at the time of the EIA field study, but may at other times act as an important habitat or migration corridor for many species. This is particularly true for large rivers with pronounced seasonal variations such as the Mekong and its seasonal hydrological cycle. Furthermore, most often only local impacts are considered. However, in rivers, upstream activities and events may have impacts that reach far downstream, either through changes in water quality or quantity, or timing of supply. Such impacts often extend beyond national borders. Thorough environmental impact assessments that take account of both seasonal variations and far-reaching impacts, can not possibly be based on field surveys covering only a few weeks of sampling in the vicinity of the project site. The incorporation of local knowledge into EIA procedures seems to be one of the few possible solutions to remedy this problem.

Johannes (1993) discussed the potential for incorporating local ecological knowledge into Environmental Impact Assessment (EIA) procedures. He suggested that one should focus on four essential frames of reference: 1) taxonomic, 2) spatial, 3) temporal and 4) social. 1) The taxonomic frame of reference should

establish local names of plants and animals and establish their local significance, i.e. as sources of food as well as other uses (including religious). 2) The spatial frame of reference should establish the spatial distribution of living and non-living resources by mapping. 3) The temporal frame of reference should establish timing of ecological events such as spawning and migration periods. 4) The social frame of reference includes the way local communities perceive, use and manage their natural resources. This in turn may influence the way they would react to any environmental impacts of a development project.

The study on which this paper is based covered the first three perspectives: taxonomic, spatial and temporal. I thus believe that the applied methodology can be incorporated into EIA procedures with few modifications. Since it was carried out at the basin-wide scale, the information generated may best fit into more strategic environmental assessments, i.e. under a basin development planning process, which is currently on-going within the framework of the MRC. Each specific EIA for smaller scale projects, for example hydroelectric dams, will require additional studies, which can use the same approach and methodologies as this study.

Conclusion and Final Remarks

Local ecological knowledge is ideal for revealing ecological events and life history information, such as migration routes and spawning habits. It is based on daily observations made over many years, often reaching beyond the lifetimes of individual people. I believe that in the context of a large and complex, multi-species ecosystem, such as the Mekong River, local knowledge is particularly appropriate since, as we have seen, it can provide information at different ecological scales, which include many species and cover long time horizons.

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References

Ahmed, M., H. Navy, L. Vuthy and M. Tingco (1998) *Socio-*Economic Assessment of Freshwater Capture Fisheries of Cambodia. Report on a Household Survey. Mekong River Commission, Phnom Penh, Cambodia. 186 pages.

Baird, I.G. (1998). Preliminary fishery stock assessment results from Ban Hang Khone, Khong District, Champasak Province, Southern Lao PDR. Technical Report, Environmental Protection and Community Development in the Siphandone Wetland, Champasak Province, Lao PDR. Funded by European Union, implemented by CESVI. 112 p.

Baird, I. G. and M. Flaherty (1999) Fish Conservation Zones and Indigenous Ecological Knowledge in Southern Laos: A first step in Monitoring and Assessing Effectiveness. Technical Report, Environmental Protection and Community Development in the Siphandone Wetland, Champasak Province, Lao PDR. Funded by European Union, implemented by CESVI.

Barthem, R. and M. Goulding (1997) The Catfish Connection – Ecology, Migration and Conservation of Amazon Predators. Columbia University Press, New York, USA.

Jensen, J. G. (1996) 1,000,000 tonnes of fish from the Mekong? Mekong Fish Catch and Culture, Mekong River Commission Secretariat, Phnom Penh, Cambodia

Johannes, R. E. (1993) Integrating Traditional Ecological Knowledge and Management with Environmental Impact Assessment. In: Traditional Ecological Knowledge – Concepts and Cases. J. T. Inglis (editor). International Programme on Traditional Ecological Knowledge. International Development Research Centre, Canada.

Johannes, R. E., M. R. Freeman and R. J. Hamilton (2000) Ignore Fishers' Knowledge and miss the Boat. In: Fish and Fisheries, 1: 257-271.

Lieng, S., C. Yim and N. P. van Zalinge (1995) Freshwater fisheries of Cambodia, I: The bagnet (dai) fishery in the Tonle Sap River. Asian Fisheries Science 8: 255-262

Roberts, T. R. (1993) Artisanal fisheries and fish ecology below the great waterfalls of the Mekong River in Southern Laos. Nat. Hist. Bull. Siam Soc. 41: 31-62.

Poulsen, A. F. and J. Valbo-Jørgensen (1999). Survey Manual – For the use of local fishers' knowledge in the study of Fish Migrations and Spawning in the Mekong River Basin (Basin-wide). AMFP Report # 1/99, Mekong River Commission. 23 p

Poulsen, A. F. and J. Valbo-Jørgensen (2000) Fish migrations and spawning habits in the Mekong mainstream – a survey using local knowledge. AMFC Technical Report. Mekong River Commission, Phnom Penh, Cambodia.

Singanouvong, D., C. Soulignavong, K. Vonghachak, B. Saadsy and T.J. Warren (1996a) The main dry-season fish migrations of the Mekong Mainstream at Hat Village, Muang Khong District, Hee Village, Muang Mouan (Sic) District and Ban Hatsalao Village, Paxse. IDRC Fisheries Ecology Technical Report No. 3. 131 p.

Singanouvong, D., C. Soulignavong, K. Vonghachak, B. Saadsy and T.J. Warren (1996b) The main wet-season migration through Hoo Som Yai, a steep-gradient channel at the great fault line on the Mekong River, Champassack Province, Southern Lao PDR. IDRC Fisheries Ecology Technical Report No. 4. 115 p.

Sjørslev, J. (ed.) (2001) A Fisheries Survey of Luang Prabang Province, Lao PDR. Living Aquatic Resources Research Center, Vientiane, Lao PDR.

Appendix 1

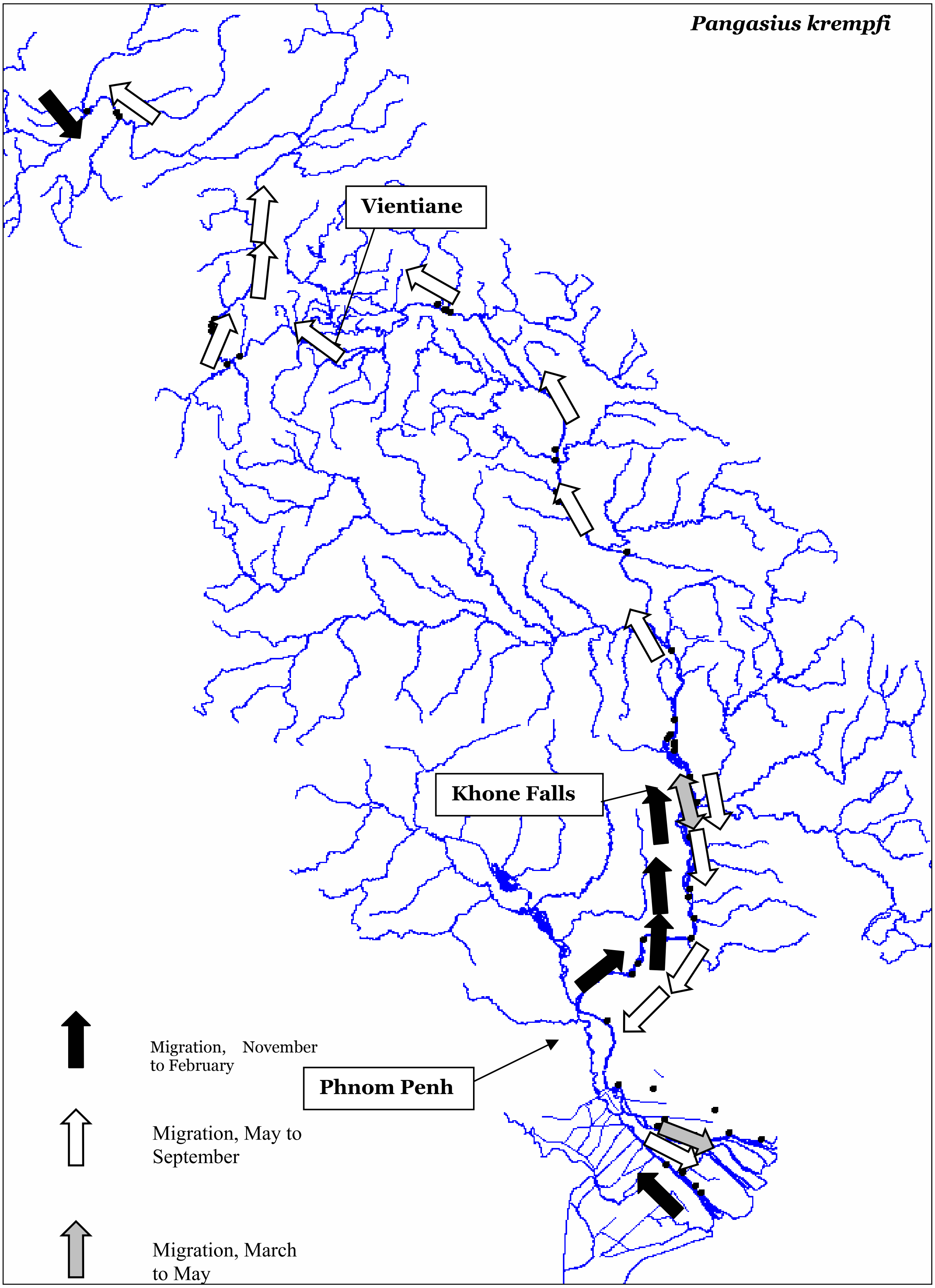

Figure 2: Migration data for *Pangasius krempfi*

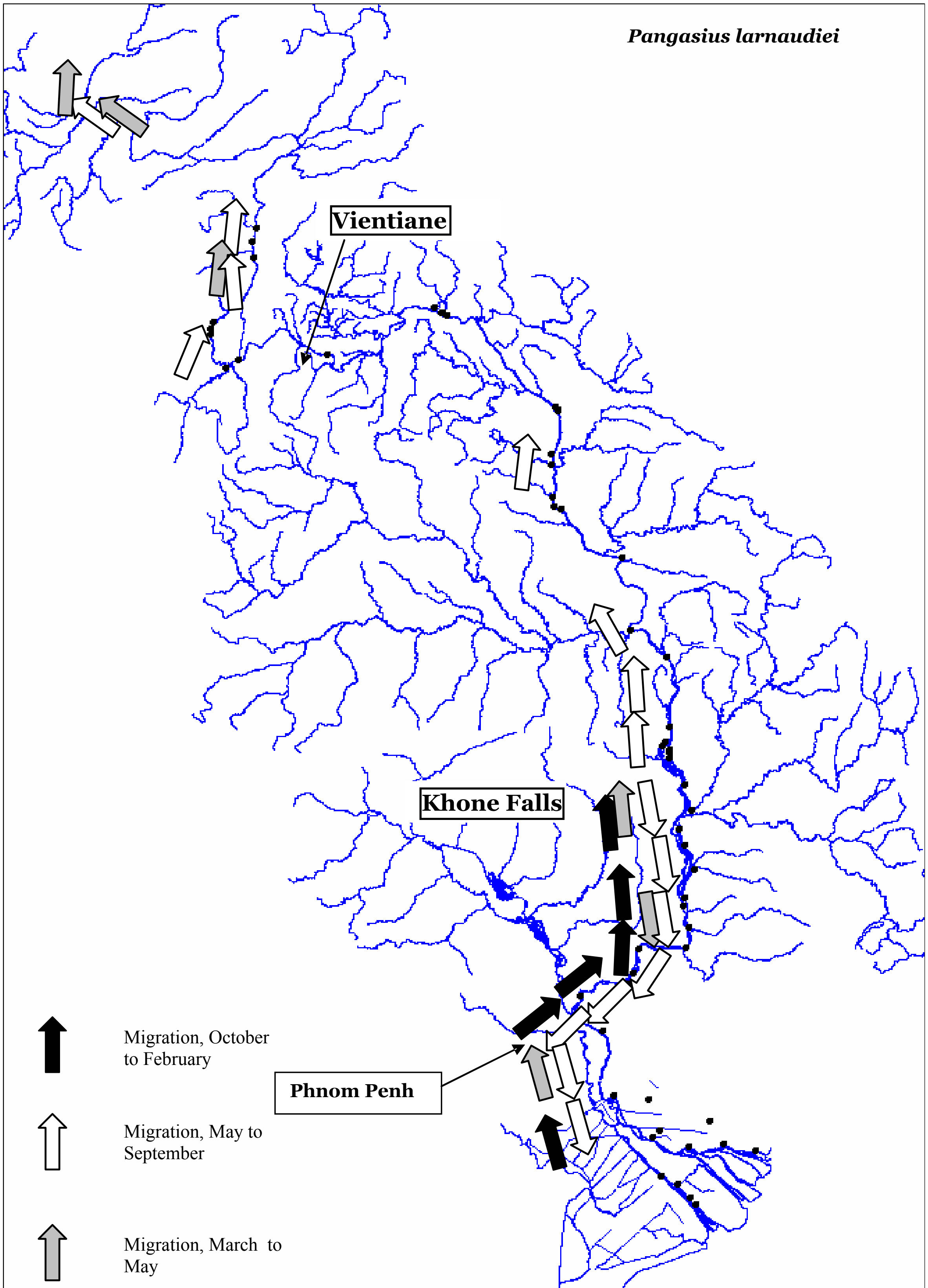

Figure 3: Migration data for *Pangasius larnaudiei*

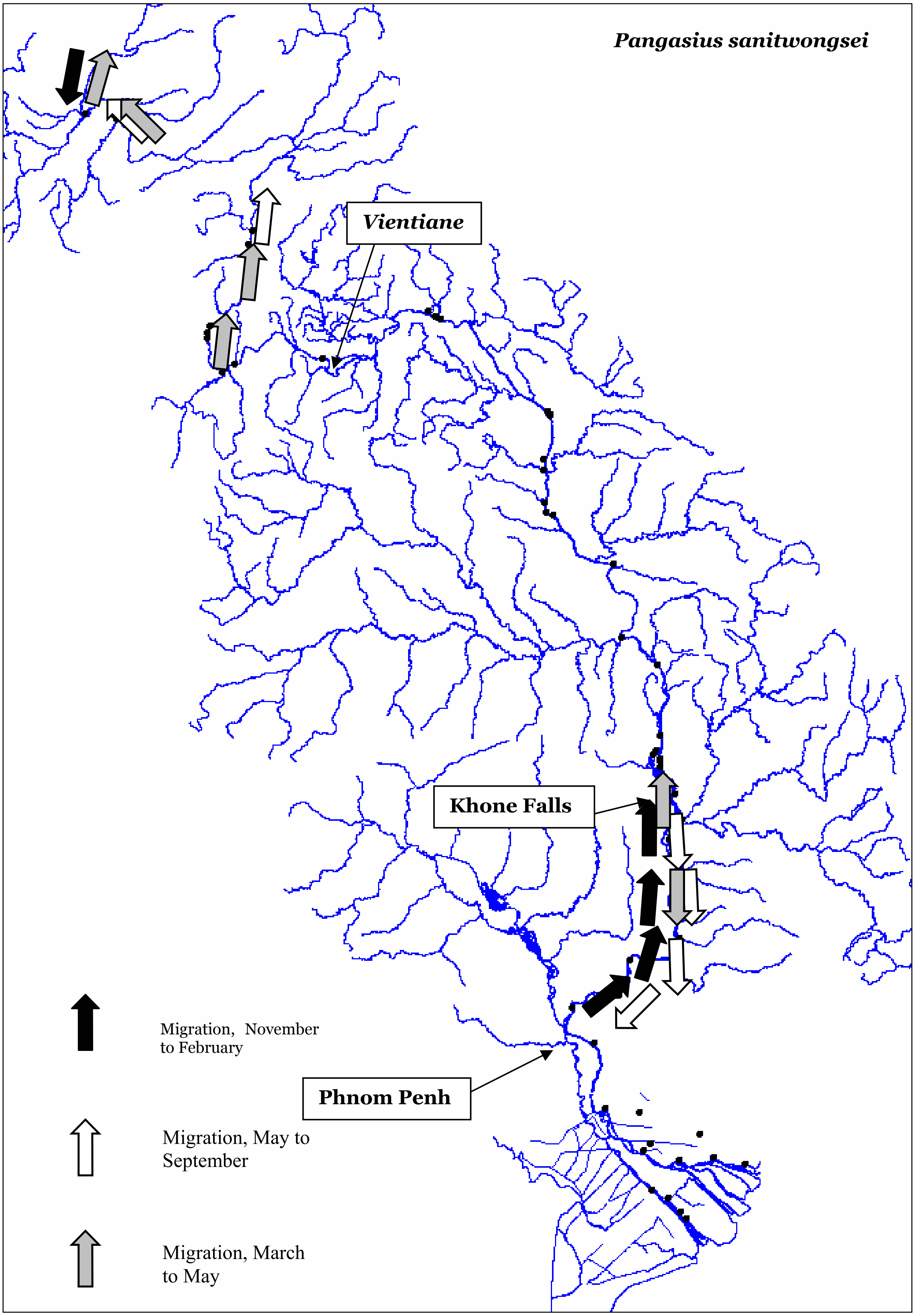

Figure 4: Migration data for Pangasius sanitwongsei

FISHERS' PERCEPTIONS ON THE SEAHORSE FISHERY IN CENTRAL PHILIPPINES: INTERACTIVE APPROACHES AND AN EVALUATION OF RESULTS

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ABSTRACT

We conducted a study in coastal communities in the central Philippines designed to involve seahorse fishers in research and conservation initiatives. The study comprised (i) an initial scoping survey to obtain data on the fishers and their fishery, including effort and habitat quality, and (ii) community meetings conducted as focus group discussions, in which results from the scoping study were fed back to the communities, questions were repeated, and information on fishers' knowledge and opinions with respect to the seahorse fishery, the state of their fishing grounds, and the condition of their livelihood were collected. Discussions on marine resource management were also held. Participatory methods using visual aids were designed to facilitate communication and discussion. The scoping survey collected information from 173 seahorse fishers in 19 communities on location and quality of fishing grounds, and fishing effort while the community meetings collected information from 117 fishers in 10 focal communities. Average effort was reported in the scoping survey and community meetings as 111 and 192 trips (nights) per fisher per year and 334 and 894 trips per fishing ground per year, respectively. Habitat quality of fishing grounds was generally assessed as good in the scoping survey and community meetings but live coral was not commonly perceived as the dominant habitat type. Responses differed markedly from independent ecological surveys of the same fishing grounds. A comparison of the answers provided by fishers in the scoping study and community meetings indicated that although absolute values differed, relative estimates of fishing effort per fishing ground and effort per fisher corresponded well across the two surveys. Fishers consistently described seahorse abundance, habitat quality and their livelihoods as in decline, and proposed a number of solutions. Through our participatory approach, seahorse fishers are playing a role in designing applied fisheries research, and in developing management plans for their fishery.

INTRODUCTION

Stakeholder involvement in the planning and implementation of conservation initiatives is considered fundamental to the achievement of resource management objectives (Akimichi 1978; Johannes 1981, 1982; Polunin 1983, 1984; Wright 1985; Zann 1985; Johannes 1989; Bailey and Zerner 1992; Ruddle *et. al.* 1992; Ruddle, 1994; Jennings and Polunin, 1996; Walters *et. al.* 1998; Neis *et. al.* 1999; White and Vogt 2000). Participatory approaches to resource management have a number of benefits: (1) stakeholders may have specialized knowledge relevant to resource management that is accessible only through collaborative approaches; (2) the process transfers knowledge and builds stakeholder management capacity; and (3) compliance with resource management decisions is more likely if stakeholders participated in their establishment. There are a number of examples of stakeholder involvement in the management of tropical marine ecosystems. Local knowledge of fish behaviour has been harnessed in the management of South Pacific fisheries (Johannes 1981, 1982; Jennings and Polunin 1996; Cooke *et. al.* 2000). Capacity building lies at the heart of community-based resource management initiatives in the Philippines (White 1988; Vincent and Pajaro 1997; Walters *et. al.* 1998; Alcala 1998, 1999; White and Vogt 2000; Alcala 2001). The integrity of community-based marine protected areas relies heavily on stakeholder compliance that in turn increases with understanding and agreement based on involvement in the process of establishing these areas (Johannes 1982, 1989; Gulayan *et. al.* 2000; Pajaro *et. al.* 2000; Alcala 2001).

Interest in participatory approaches in resource management in part reflects the failure of top-down, centralized approaches to manage natural resources alone (Murdoch and Clark 1994; Agrawal 1995; Maguire *et. al.*, 1995; McClanahan *et. al.* 1997; Sillitoe 1998; White and Vogt 2000). Bottom-up, community-based approaches (BOBP 1990; Walters *et. al.* 1998), involving stakeholders may be more appropriate where resource exploitation is diffuse as is typically the case with subsistence fisheries (Pauly 1997), and

where human and financial resources are limited (White and Vogt 2000).

As part of a seahorse conservation program (Project Seahorse, www.projectseahorse.org) we initiated a participatory research-focused fisheries project in 1999. Our study focused on the seahorse fishery of Danajon Bank, Bohol, central Philippines (Fig. 1, overleaf). Danajon Bank is a double barrier reef stretching approximately 145 km along the northwest coast of Bohol (Pichon 1977). The reef system is shallow (approximately $\leq$ 10m), silty, and composed of scattered and patchy coral reefs interspersed with *Sargassum* and seagrass (pers. obs.). Fishing is the primary source of income for communities located on islands in this system. Seahorse fishing began in the 1960s as part of a subsistence food / cash income fishery termed the lantern fishery. Fishers free dive at night on shallow (1-5m) fishing grounds, using a kerosene lantern strapped to the front of their small boat (4 m outrigger canoes called *bancas*) to illuminate prey items (see also Mangahas, this vol). They spear fish, catch crabs and hand pick seahorses and holothurians (sea cucumbers) that they find. This is the primary method used to collect seahorses in this region (Vincent and Pajaro 1997), though not all lantern fishers collect seahorses. Hookah divers also catch a limited number of seahorses incidentally.

We developed a participatory approach that involved the exchange of information about marine resources on Danajon Bank between lantern fishers and researchers, and among fishers. Stakeholder inclusion was incorporated in the fisheries research program to achieve three goals: (1) obtain information about habitat quality of fishing grounds and fishing effort to aid in the design of the research component of the program; (2) increase fisher awareness about marine conservation issues to build stakeholder resource management capacity; and (3) develop an understanding of what fishers believe to be key marine conservation concerns and appropriate strategies for resolving them. Our participatory approach was unusual in that it was also designed to allow assessment of the information collected on fishing grounds in order to evaluate its accuracy and consistency. We did this by comparing two interview methods and by comparing fishers' perceptions of fishing ground habitat quality with ecological measures from underwater transects (Samoilys *et. al.* 2001) conducted on a subset of the fishing grounds. This analysis evaluated the degree of correspondence between fishers' perceptions and ecological measures of habitat quality.

METHODS

The study consisted of two components: (i) an initial scoping survey; (ii) community meetings which involved a) sessions in which the results of the scoping survey were fed back to the fishers and the survey was repeated, and (b) marine resource management discussions to collect information on fishers' knowledge, opinions and actions in relation to their fishery resources. The scoping survey was done by one community organiser (CO), who was then replaced for the community meetings by a second CO (JE). Community organizers are trained social workers that focus on community level social issues as opposed to family or individual level issues. They are an integral part of many community-based resource management programmes in the Philippines (Third World Center 1990). The presence of a Filipino CO, who was fluent in the national language and supported by a local assistant fluent in the local language, was pivotal to the research methods.

1. Scoping survey

The scoping survey was conducted from March to May, 1999, and was designed to: (i) determine the number of fishers involved in the seahorse lantern fishery on Danajon Bank and their distribution among villages, (ii) identify the number of fishing grounds exploited in the seahorse lantern fishery, (iii) quantify fishing effort per fisher and per ground, and (iv) assess habitat quality on the fishing grounds. This information was subsequently used to identify 28 coralline fishing grounds for the ecological research project (Samoilys *et. al.* 2001).

The CO visited 19 seahorse fishing communities in the municipalities of Getafe, Talibon, Bien Unido, Carlos P. Garcia, Ubay, and Tubigon in northern Bohol, Central Philippines (Table 1, Fig 1). In each fishing community, the CO first contacted village leaders to explain the project and ask permission to work in the community. Lantern fishers in the community were then identified, frequently by village leaders, and interviews requested. All fishers asked to participate agreed to do the interview, a total of 199 fishers, 9.1 ± 7.7 (s.d.) fisher per village (Table 1, overleaf).

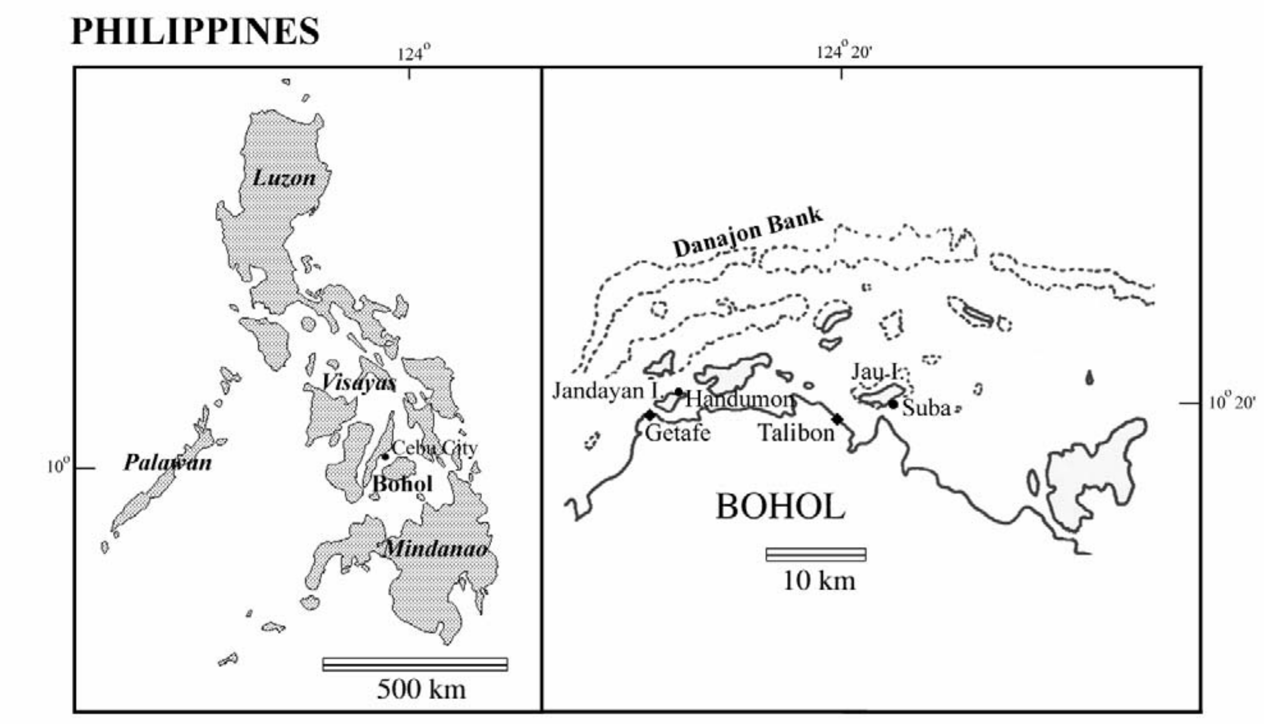


Fig. 1. Map of the Philippines showing the study area of Danajon Bank in northern Bohol, central Visayas.

Table 1. List of villages participating in the scoping and community meetings. Communities in bold participated in both components; others only in the scoping study. CPG = Carlos P. Garcia municipality.

Village	Municipality	Gears	#fishers interviewed	#lantern fishers	#fishing grounds/ village	#lantern fishing grounds/ village
Alumar	Getafe	lantern and hookah	8	6	11	11
Banacon	Getafe	lantern and hookah	6	5	7	7
Bansaan	Talibon	lantern only	8	8	19	19
Batasan	Tubigon	lantern and hookah	20	9	16	6
Calituban	Talibon	lantern and hookah	4	3	3	3
Cataban	Talibon	lantern only	15	15	7	7
Guindacpan	Talibon	lantern only	13	13	9	9
Handay-Norte	Getafe	lantern only	5	5	22	22
Handumon	Getafe	lantern only	33	33	46	46
Jagoliao	Getafe	lantern only	14	14	13	13
Nasingin	Getafe	lantern and hookah	9	3	21	18
Nocnocan	Talibon	hookah only	5	0	2	0
Paraiso	CPG	lantern only	11	11	7	7
Pinamgo	Bien Unido	lantern only	4	4	4	4
Sagasa	Bien Unido	lantern only	3	3	2	2
Sagisi	CPG	lantern only	4	4	5	5
Sinandingan	Ubay	lantern only	20	20	22	22
Suba	Talibon	lantern only	11	11	2	2
Lipata	CPG	lantern only	6	6	6	6
Total			199	173	11.79	11.00

Each interview consisted of a brief questionnaire administered verbally to fishers. Limited information on the fisher (name, number of children) and gear (lantern *vs*. hookah, and paddled *vs*. motored boat) was collected. Fishers were then asked to list all of the fishing grounds they visit. For each of these fishing grounds, they told us the number of hours spent fishing per trip, the number of trips per week, weeks per month, and months per year that they fished the ground. This information allowed the calculation of perceived annual total fishing effort (hours per year) for each fisher for each fishing ground. To indicate the total fishing pressure over time and current levels, fishers also indicated the year they began fishing each ground and the last year that they went there, if they no longer fished it. With respect to the habitat quality of these largely coralline fishing grounds, fishers were asked to: indicate whether the site was "good" (*ma'ayo*) or "bad" (*guba*), identify the major habitat types, and rank all of the sites they fished from best (=1) to worst (= number of sites identified). For each site, we then calculated the following fishing ground indices:

1. % good = the % of fishers that identified each fishing ground as "good";
2. % coral = the % of fishers that identified live coral as the dominant habitat component of a particular fishing ground;
3. fishers' relative rank (FRR) = the average of the rank each fisher gives the fishing ground. Each rank is relative to the total number of fishing grounds ranked by a fisher (e.g. 4^{th} of 10 sites gives a relative rank of 0.4).

All three indices range from 0 to 1, where 1 indicates a good site (e.g. all fishers think it is good, or all fishers identify live coral as the dominant habitat component or it ranks at the top of their lists), and 0 indicates a poor site (e.g. no fishers think it is good or no fishers identify live coral as the dominant habitat component or it ranks at the bottom of their lists).

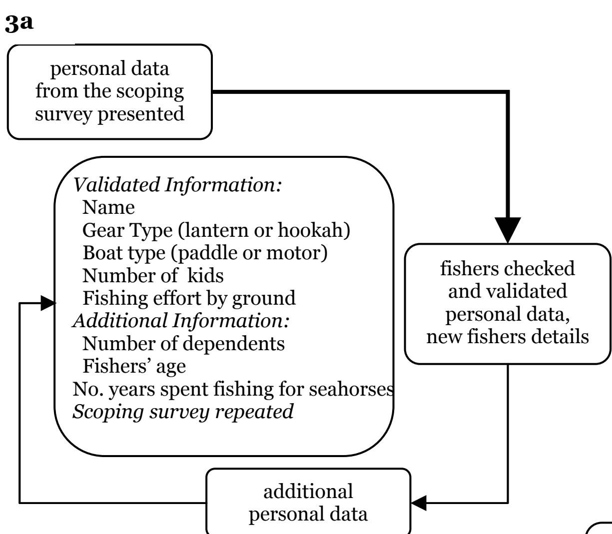
2a. Community-based meetings: feedback sessions

Community-based meetings were held from June to September 2000, except for one village (Alumar) which was visited in February 2001. Meetings were held with fishers in 10 target villages for the feedback sessions (Table 1) and 9 villages for the marine resource management discussions. These villages included those with the greatest number of lantern fishers (average of 12.6 fisher/village). The community meetings involved focus group discussions using highly visual but low cost methods developed by one of the authors (JE) based on the Reflect method of community interviews. Such methods were necessary given the low level of literacy among fishers and the need to engage their interest for 1-2 day periods. The approach also allowed open-ended questions, a key characteristic for areas in which the researchers had little existing information. The community-based meetings also encouraged fishers to express and formulate their ideas on marine conservation and fisheries management, and engaged fishers in the research process. The gathering of data used graphical symbols, such as cut-outs of seahorses and crabs of various sizes to indicate abundance. Fishers posted these symbols on large gridded sheets with columns for each fisher (Fig. 2). Throughout the meetings, fishers shared or validated information either individually using fishers' worksheets or through group activities using graphic symbols and large gridded sheets. In the group interactions, individual responses could still be tracked as graphic cards were uniquely numbered for each fisher.

The goals of the feedback sessions were to: (i) share and validate the data collected in the scoping survey; and (ii) repeat the scoping survey, gather additional data, and add fishers who were unable to participate in the scoping survey. The structure of the feedback sessions in each village is given in Fig. 3a. To repeat the questions in the scoping survey, a mixture of individual questionnaires and focus group discussions were used. The latter were used to solicit information on the lantern fishing grounds, in terms of habitat type (first identified in the scoping survey) and quality (Fig. 3b).

2b. Community-based meetings: marine resource management discussions

The goals of the marine resource management discussions were to collect the fishers' views on: (i) the relative importance of various marine resources; (ii) the status of marine resources in the past, present and future; and (iii) the causes of resource degradation and their relative importance. In this component of the meetings, fishers were asked to rank the six marine resources identified in the scoping survey in terms of their general economic importance to the fishers, both as a source of cash and food. These resources were grouped by fishers under widely differing taxonomic divisions, including order, family and genus: (i) crabs and other crustacea, (ii) fish, (iii) sea cucumbers, (iv) seahorses, (v) seaweed, and (vi) shells.



[1] Fishing effort calculated as # hours per trip x # trips per month x # months fisher per year

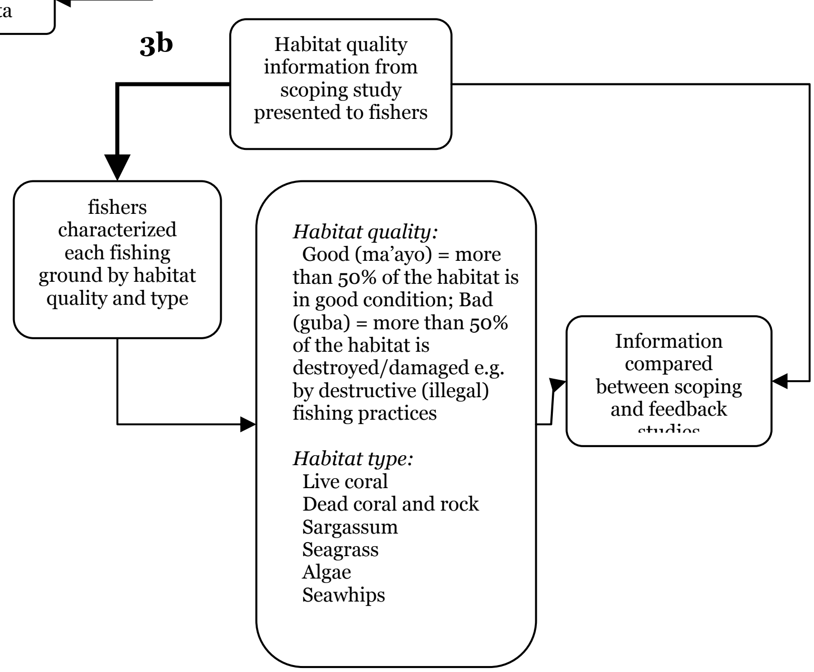


Fig. 2. Structure of a) feedback sessions to validate personal and fishing effort data and repeat scoping survey for catch and effort data, b) focus group discussions on fishing ground habitat type and quality.

Fishers were also asked to provide information for the past (1990), present (2000) and future (2010), on three main topics: the status of their livelihood as fishers, the seahorse fishery, and the fishing grounds. Fishers were asked to assign their answers into categories. Fishing grounds were described as Good (>50% of habitat is in good condition), Mixed (~ 50% of habitat is in good condition), or Bad (> 50% of habitat has been damaged or destroyed). Seahorse populations were described as many, average, or few. Fishers' livelihood was described as Good (income from fishing is sufficient to support the family - includes food, education and recreation), Bad (income from fishing is barely enough to support basic necessities such as food), Very Bad (income is not sufficient to support the basic necessities). Collective discussions were then held to ask fishers for possible reasons for the trends and possible solutions, and to rank both reasons and solutions. The marine resource discussions also consisted of several sessions covering a range of topics such as destructive fishing, particularly blast fishing, and how it affects their fishing grounds. Management options such as protected areas or sanctuaries were also discussed.

In most villages, the CO acted as facilitator for the entire group. However, for villages with more than 12 participants, fishers were subdivided into 2-3 groups with 5-6 members each and groups were assigned different topics. A local facilitator was used for each sub-group, with the CO overseeing all groups. At the end, each sub-group reported and discussed their results with the whole group of fishers.

Data Analysis

The feedback sessions provided an opportunity to evaluate the accuracy and consistency of answers provided by fishers in the scoping survey. The two surveys differed both in terms of the fishers participating and the number of fishing grounds they considered. We analysed similarities between the two surveys for: (i) all fishers and fishing grounds in the scoping survey (173 fishers and 67 fishing grounds, see fishing effort below) *vs*. 117 fishers and 25 fishing grounds in the feedback survey, and (ii) using only those fishers and fishing grounds common to both surveys. Seventy-one fishers and 25 fishing grounds were common to both the scoping and feedback surveys.

The fishers' ranking of fishing grounds by habitat quality was compared to ecological survey data from underwater transects (Samoilys *et. al.* 2001) conducted on a subset of these fishing grounds.

RESULTS

The ability to attract fishers was essential to the success of the community meetings. 117 fishers, 68% of all lantern fishers in 10 villages, participated in the feedback sessions. 114 lantern fishers in 9 villages participated in the marine resource management discussions. Feedback sessions were done in the morning with the resource management discussions in the afternoon, with 97 % attendance throughout the day's meeting. This high participation rate was attributed to the popular highly visual and graphic methods used by the CO.

Profile of Danajon Bank lantern fishers

Of the 199 fishers interviewed from 19 villages across the Danajon Bank region, 87% were exclusively lantern fishers (Table 1). In most villages, lantern gear was used exclusively, though hookah gear was also used. On average there were 9 lantern fishers per village, accessing 11 lantern fishing grounds per village (Table 1). Fishing grounds were common to several villages. Sixty percent of the lantern fishers in the scoping survey and 53% of fishers participating in the feedback sessions still used non-motorised paddle boats. The average number of children per fisher from the scoping survey was 4.1±2.4 (s.d.), and the average number of dependents from the feedback sessions was 5.2±3.0 (sd). On average, the number of children per fisher was 80.5%±35.4 (sd, n=70) of the total number of dependents. This relatively low number of children for the region probably reflects the relatively young age of the fishers: 33.6±10.8 (sd) years.

Fishers participating in the community meetings ranged from those who started fishing seahorses in 1961 to those who started in 2000. Nineteen of the fishers had stopped fishing seahorses between 1990 and 1999, the rest were still actively fishing.

Fishers gave names for 147 fishing grounds. However, reference to a map of the area indicated that these names represented 92 distinct fishing grounds, of which 73% were dominantly used by lantern fishers (>95% of the total effort per ground from lantern fishers), 16% were used by both lantern and hookah fishers, and 11% were exclusively used by hookah fishers. Nine fishing grounds were exploited in 1961, increasing to 67 in 1999 with the most rapid expansion occurring in the early 1970's (Fig. 4).

Only two grounds had been entirely abandoned in 1999. On average, fishing grounds had been exploited for 14.5 years ± 5.7 (s.d.) (range 3-39).

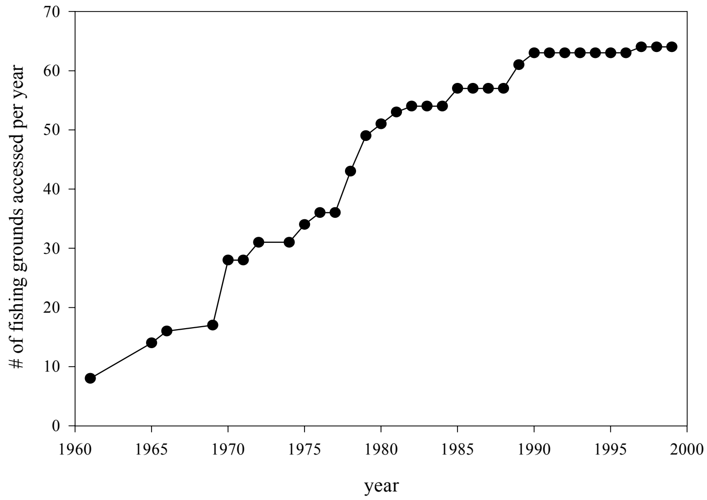


Fig. 4. The number of grounds fished per year on Danajon Bank, Bohol

Fishing Effort

Reported annual fishing effort per fisher and per fishing ground differed markedly between the scoping and feedback studies (Table 2). Considering the 67 grounds on which lantern fishing comprised at least 95% of total annual effort, fishers in the scoping survey reported they were spending around 30% of their nights fishing (111 fishing trips per year, Table 2). On average, each fishing ground was fished almost one trip per night for every night of the year (Table 2). In contrast, fishers in the feedback survey reported that they were spending up to 50% of their nights fishing on the 25 lantern fishing grounds considered (Table 2). Furthermore, these grounds were fished on average 2.5 trips per night for every night of the year.

Considering the subset of data for fishers and fishing grounds common to both studies, fishers in the feedback sessions reported total annual effort 2.6 times greater than that reported by the same fishers for the same grounds in the scoping study (45,665 hrs·yr^{-1} vs. 17,513 hrs·yr^{-1}, respectively). Annual effort per fisher within the overlapping group was significantly greater in the feedback group than in the scoping group (paired t-test, df=70, $p<0.0005$). Reported effort per fishing ground was also significantly greater in the feedback group than in the scoping group (paired t-test, df=21, $p=0.027$). Despite the absolute difference between the two groups, error estimates were relatively consistent, both by fisher (Fig 5a) and by ground (Fig 5b). Note that there was no correspondence between the estimates from fishers in Alumar and Bansaan villages, and these two outliers were therefore excluded from the analyses.

Fishing ground habitat quality

Habitat quality on the lantern fishing grounds was generally considered to be good by fishers in both the surveys. 78% of fishers (± 28% s.d., range 0-100%, n=67 sites) said the fishing grounds were in good condition in the scoping survey, and 75% of fishers (± 35% s.d., range 0-100%, n=25 sites) said the fishing grounds were in good condition in the feedback sessions. If the group of fishers and grounds common to both studies are considered, 77.3%±6.7% and 81.4±7.4% of the fishing grounds were described as "good" by fishers in the scoping and feedback groups, respectively. No significant differences could be detected and indeed, when considering the responses of each fisher for each fishing ground (n=128), 76% of the answers were consistent between the two studies.

Table 2. Annual lantern fishing effort on Danajon Bank as reported by fishers from the scoping and feedback surveys. Figures in parentheses are standard deviations. Fishing trip duration was not asked in the scoping survey: the value is an approximation. n refers to the number of fishers interviewed.

	Fishing trip duration	**Total fishing effort**		**Fishing effort per fisher**		**Fishing effort per ground**	
	Hours	**Trips**	**Hours**	**Trips**	**Hours**	**Trips**	**Hours**
Scoping survey (n=173)	~4	19,141	76,562	111 (82)	444	334 (539)	1,334
Feedback sessions (n=117)	3.5 (1.8)	21,653	75,114	192 (148)	671 (519)	894 (1,254)	3,129

The Fishers Relative Ranking allowed sites to be ranked from high (FRR near 0) to low quality (FRR near 1). Although fishers' assessments varied both qualitatively and as a function of the number of fishing grounds fished, there was sufficient consistency to allow fishing grounds to be distinguished (Fig. 6).

The assessment of habitat type was more problematic. In the scoping survey, on average, 45% of fishers (± 31% s.d., range 0-100%, n=67 sites) said that the fishing grounds were dominated by live coral, as opposed to 26% of fishers (± 31% s.d., range 0-100%, n=25 sites) in the feedback survey. Using the same group of fishers and fishing grounds common to both studies, 49.2±6.5% of fishers described fishing grounds as dominated by live coral in the scoping study, whereas only 22.1±6.8% of fishers described the same fishing grounds as dominated by live coral in the feedback sessions. This difference was significant (paired t-test, n=25, p=0.007). When considering the responses of each fisher for each fishing ground (n=128), only 20.9% of responses were consistent between the two studies.

Fishers' assessments of habitat quality generally did not correlate with any formal measurements of habitat composition (e.g. % live coral, % *Sargassum*, % dead coral etc.) as measured by a biologist (Samoilys *et. al.* 2001) using the line intercept method (English *et. al.* 1994). The only significant relationship was that between the % of fishers indicating that a fishing ground was "good" and % rubble cover (Fig. 7). The fishers' assessment of habitat quality was significantly negatively correlated with % rubble cover for both surveys.

Resource management discussions

Food fish were ranked as the most economically important resource (mean rank = 1.61 (±0.11s.e.) followed by sea cucumbers (2.81±0.11), seahorses (3.04±0.16), crabs (3.60±0.11), seaweed (4.28±0.13) and shells (5.24±0.10). Notably, one seahorse genus (*Hippocampus*), ranked third among orders and families of other organisms. The fishers' assessment of seahorse populations, fishing ground habitat quality and their livelihood indicates that these were largely healthy in the past (10 years ago), but conditions are felt to have deteriorated to the present with a poor outlook for the future (Fig. 8).

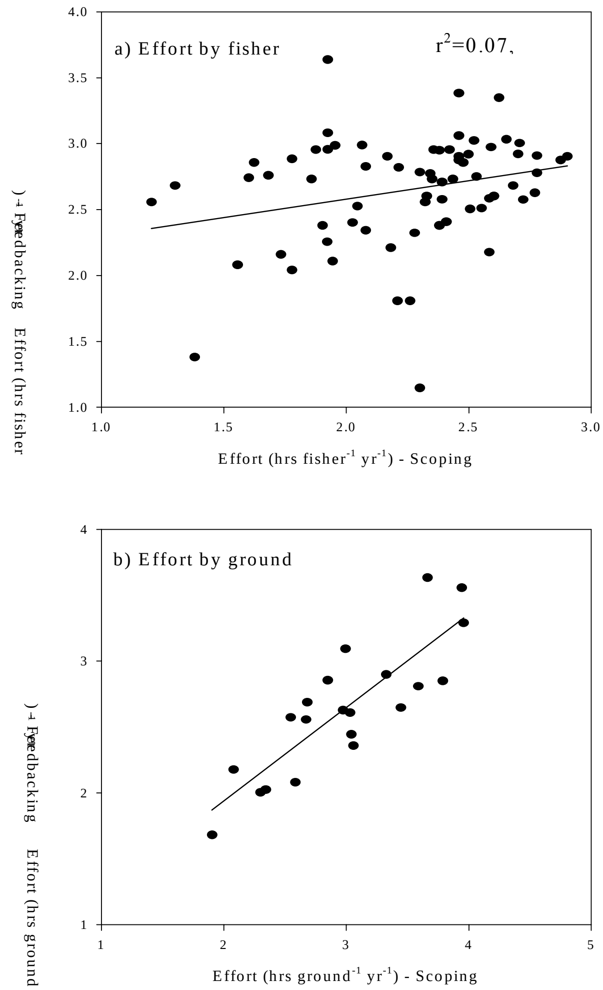


Figure 5. Correlations of effort by a) fisher and b) fishing ground in the group of overlapping fishers (n= 71) and grounds (n=25) for the Scoping (S) and Feedback (F) studies.

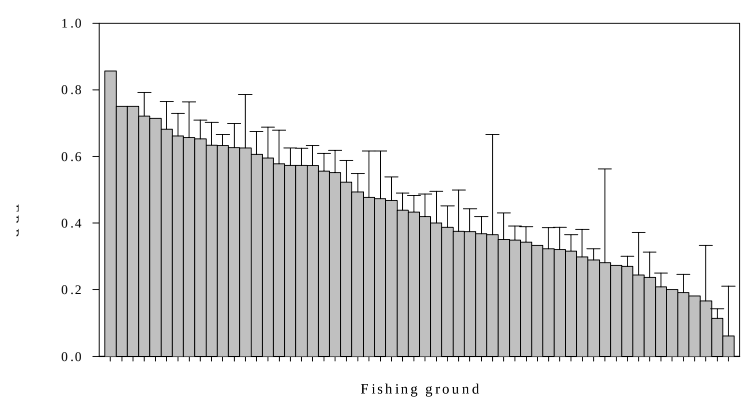


Figure. 6. Mean fisher's relative ranking (FRR) of habitat quality by fishing ground; error bars indicate standard errors.

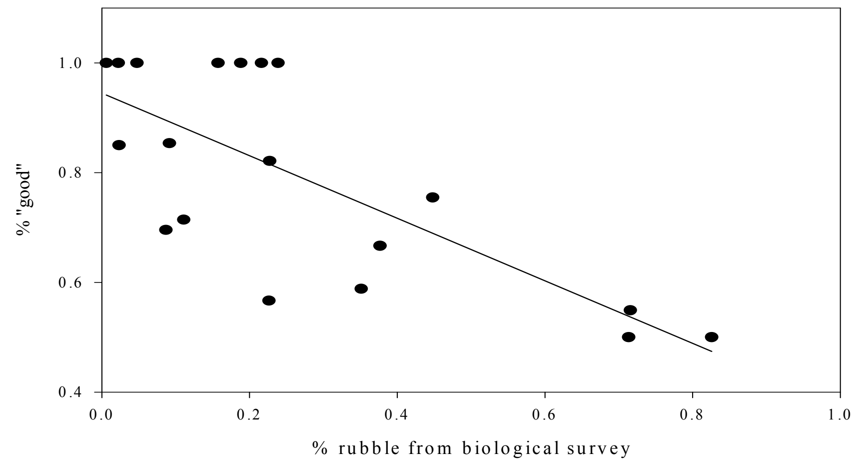


Fig. 7. Correlation between % of fishers indicating a site is "good" and % rubble cover measured on ecological surveys (points shown are from scoping survey)

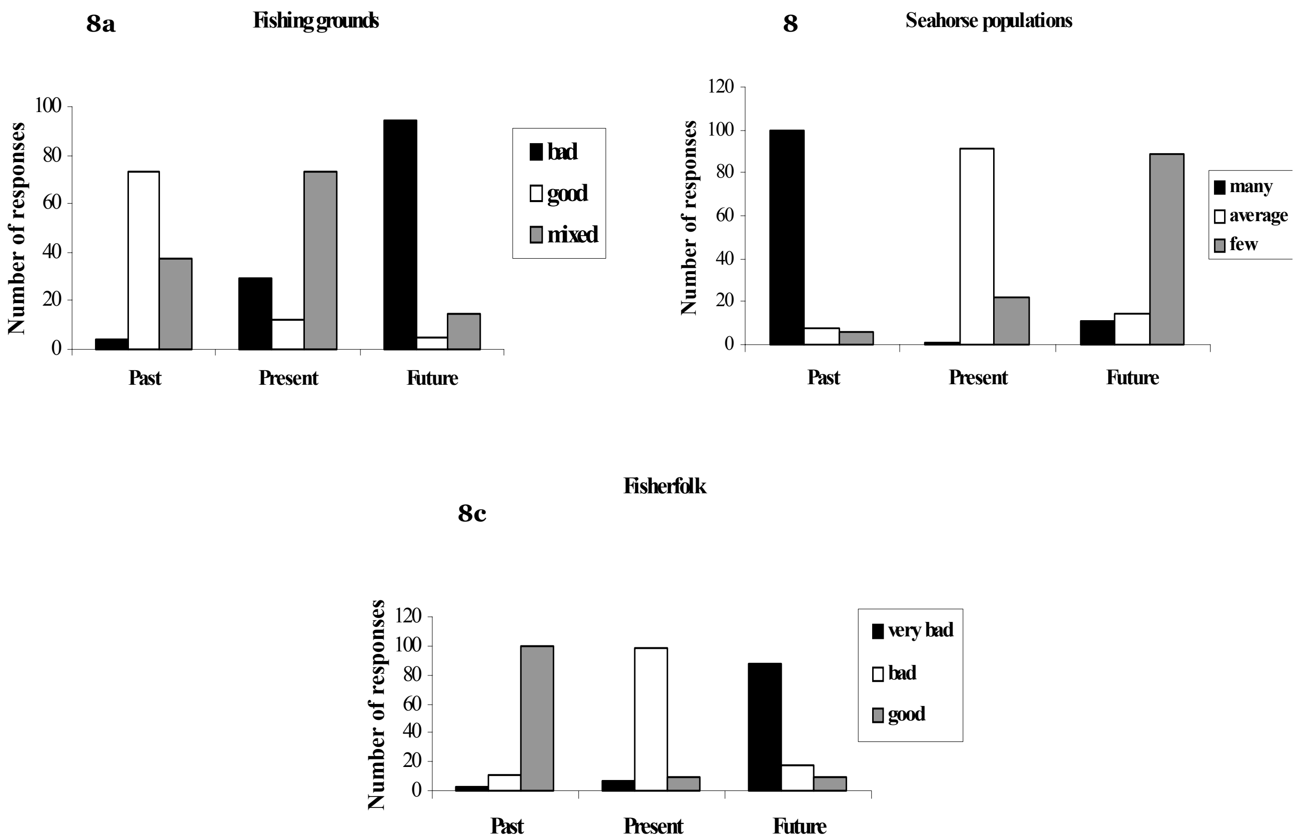


Fig. 8: Trends in status of a) fishing ground condition , b) seahorse populations and c) fishers' livelihood assessed by fishers from Past (1990), Present (2000) to Future (2010).

Reasons for the negative trends in fishing grounds, seahorse populations, and fishers' quality of life were proposed and ranked, and suggestions for improvements were given (Tables 3-5). Fishers in all villages listed destructive (generally illegal) fishing as the most important reason for the poor condition of the fishing grounds. Dynamite ("blast" fishing), cyanide and *tubli*, a local plant poison, were the major illegal gears used (Table 3).

Commercial fishing, primarily trawling and Danish seining (*liba liba*), was cited as the second most important reason for the degradation of fishing grounds. Both trawling and Danish seining are illegal within municipal waters. Fishers frequently used the terms commercial fishing and destructive fishing synonymously. Beach seining (*baling*), though legal in some municipal waters, was also cited as a destructive fishing method. Fishers stated strongly that the fishing grounds were likely to deteriorate further due primarily to continuing illegal and destructive fishing, and also increasing numbers of fishers and a lack of concern regarding protection of the seas from fishers and government (Table 3). Fishers in some villages stated that illegal fishing would continue because there was either no will on the part of government to enforce fishery laws, and/or that government officials were conniving with illegal fishers. Fishers in all villages listed the stopping of destructive and illegal fishing as the highest-ranking solution to the deterioration of their fishing grounds (Table 3). They suggested this should be done through strict and proper enforcement of fishery laws by local government units (village and municipal level), through involvement of non-government organisations (NGOs) in fishery law enforcement, and through appointing more fish wardens.

Reasons for perceived declines in seahorse populations were more variable (Table 4). Fishers perceived the taking of pregnant seahorses and habitat destruction as primary reasons for the decline. Increased effort was also listed and was ascribed to an increase in the number of fishers, partly due to fishers switching from other fishery resources (e.g. fin fish) that had declined. Fishers felt declines in seahorses are likely to continue due to insufficient numbers of adult seahorses, deteriorating habitat quality, and a lack of juveniles (Table 4). To halt declines in seahorse populations, fishers most frequently suggested stopping destructive fishing and protecting pregnant seahorses (Table 4).

Table 3: Results of marine resource discussions on the destruction of fishing grounds. The number of villages that ranked each reason or solution from most important (rank = 1) to least important (rank = 5) is indicated. Destructive fishing included both methods destructive to the habitat and illegal fishing such as trawling and seining in municipal waters. Total villages = total number of villages providing each reason/solution.

	Rank					Total Villages
	1	2	3	4	5	
Reasons for the destruction of fishing grounds						
Destructive (illegal) fishing	9					9
Commercial fishing		8				8
Typhoons			3			3
Coral collecting				1		1
Increasing # of fishers				1		1
Increasing # of outside fishers					1	1
Reasons destruction will continue in the future						
Continuing destructive fishing	7		1			8
Increasing # of fishers	1	5	2			8
Lack of concern in protecting the sea (fishers and/or government)	1	2				3
Increasing effort per fisher		1	1	1		3
Improved fishing methods				1		1
Solutions to arrest the destruction of fishing grounds						
Stop destructive and commercial fishing	9					9
Establish more MPAs		4	2			6
Stop buying destructively bought fish		1	1			2
Educate and inform fishers		1	1			2
Maintain own MPA		1				1
Alternative livelihoods for fishers			1			1
Stop outside fishers		1				1
Organize fishers			1			1

Table 4: Results of marine resource discussions on declines in seahorse populations. The number of villages that ranked each reason or solution from most important (rank = 1) to least important (rank = 7) is indicated. Total villages = total number of villages providing each reason/solution. MPA = marine protected area or sanctuary implemented and managed at the village level.

	Rank							Total Villages
	1	2	3	4	5	6	7	
Reasons for declines in seahorse populations								
Taking pregnant seahorses	3	3	1					7
Habitat destruction	3	2	1	1				7
Catching juveniles		2	2					4
Destructive fishing		1	2					3
Increased fishing effort	3		2	1				6
Weather		1	1	1	1			4
Indiscriminant catching				1				1
Catch during spawning season						1		1
Pollution							1	1
Reasons declines will continue in the future								
Few adults for reproduction	3	1						4
Continuing habitat destruction	3	1	1					5
Lack of good habitat (destroyed)	2	3	1					6
Few juveniles		2						2
Increasing effort	1	1	2					4
Catching pregnant seahorses		2						2
Solutions to arrest declines in seahorse populations								
Stop destructive fishing	4							4
Stop catching of pregnant seahorses	4	2						6
Caging of pregnant seahorses		2		1				3
Stop fishing juveniles	1	2	1					4
Establish sanctuaries		1	1					2
Moratorium on seahorse fishing		1	2					3
Regulation of trade and catch			2	1				3
MPA management			1					1
Protect habitat		1						1
Seasonal closures		1						1
Fishers to cooperate with LGU, NGO		1						1

Reasons for the poor condition of fishers' livelihood and why their situation would be very bad in the future were varied, and there was less consistency across villages (Table 5). Less income was cited as the main reason for the poor situation of fishers today, that is, less income derived from fishing which results in less disposable income for recreation. Secondarily, fishers cited an increase in the costs of living and fishing as significant factors. They also listed a lack of alternative livelihoods to fishing. The reasons for the continuing decline in quality of life were rooted in the status of the fishing grounds, with destructive fishing cited as the main reason, followed by less catch and more fishing effort. Alternative livelihoods were perceived as the most important tool to improve the fishers' situation with the need to stop destructive fishing as the second most important solution (Table 5).

Table 5: Results of marine resource discussions on the status of fishers' livelihoods. The number of villages that ranked each reason or solution from most important (rank = 1) to least important (rank = 6) is indicated. Total villages = total number of villages providing each reason/solution. MPA = marine protected area or sanctuary implemented and managed at the village level.

	Rank						Total Villages
	1	2	3	4	5	6	
Reasons for deterioration of fishers' livelihoods							
Less income	5	1			1		7
Increased price of commodities		2	3				5
Increased operating costs	1	1	1				3
No alternative livelihoods		1	1				2
Difficulty meeting basic food needs	1	1	1	3			6
Inability to improve gear technology			3		1		4
Difficulty funding kids' schooling		1		1			2
Bad weather	1	1					2
Travel further to fishing grounds				1			1
Reasons livelihood deterioration will continue							
Destructive fishing	6						6
Less catch	1	3	1	1			6
Increased # of fishers	1	1	2	1			5
Increased operating costs	1		1		1		3
Bad weather							0
Travel further to fish		1					1
No alternative livelihoods			1				1
Destroyed fishing grounds		1					1
Commercial fishing							0
Solutions to arrest the deterioration of fishers' livelihoods							
Alternative livelihood	5	3					8
Stop destructive fishing	3	1					4
Alternative income		2	1				3
Fishers' cooperative		2					2
Improve technology			3				3

DISCUSSION

The participatory approaches of the focus group discussions generated a lot of interest among the lantern fishers of Danajon Bank. The highly visual, graphical methods of conveying data were very effective in engaging the fishers and soliciting responses. The method is particularly well suited to fishers who are semi – literate. For example, only 11% complete elementary school in Handumon village (Buhat *et. al.* in prep.). High participation rates indicated this element of the program was successful.

One issue in the focus group discussion approach is the validity of the responses obtained from the group. Bias towards answers provided by dominating fishers which other fishers copy is likely. In the present study we were able to examine this by comparing reported fishing effort data obtained from the conventional questionnaire–based approach (the scoping survey) with the focus group discussions of the feedback survey. Although there were differences in the absolute values obtained, trends in fishing effort among fishing grounds were significantly correlated between the two surveys. Similarly, there were no significant differences in the description of the overall quality of the fishing grounds between the two methods.

Most of the fishing communities of Danajon Bank that we visited had not been involved in our conservation program and therefore this study served to integrate the CO into the communities and to engage the fishers in our research and management initiatives.

One objective of the study was to generate discussions on resource management, and though at times dominated by key members in the fisher communities, group discussions served as opportunities for sharing ideas particularly between the CO and the communities. This step of educating, informing and agitating fishers (called "conscientization", in Filipino CO terminology) is vital in the community organising process (Third World Studies Center 1990). It is also fundamental to stakeholder involvement in conservation and management

initiatives (Ruddle 1994; Walters *et. al.* 1998; Alcala 1999; Cooke *et. al.* 2000; White and Vogt 2000).

A much higher estimate of fishing effort was obtained from the feedback survey compared with the scoping survey. This may reflect bias from the group discussions or the difference in sample size. There were 67 fishing grounds included in the scoping survey and only 25 in the feedback survey. However, with a change in CO during the feedback survey, we found that not all fishers had responded to the questions of fishing effort during the scoping survey, and that estimates per village were in fact based on only around 2 fishers. Therefore it is likely that the feedback survey, which collected effort estimates from each fisher in each village (mean = 9 fishers per village), provides a more accurate estimate of fishing effort. An average of 2.5 fishing trips per night per lantern fishing ground throughout the year was recorded, which is high considering the fishing grounds were less than 1km^2 in size (Samoilys *et. al.* 2001) and fishing trips lasted for 3.5 hours.

Estimates of fishing effort from interviews with fishers are renowned for their inaccuracy in terms of absolute value (Rawlinson 1993, Die 1997). However they provide useful relative estimates, and can be used to plot trends over time. This is well demonstrated in the present study. Highly consistent relative estimates of fishing effort per fishing ground were obtained between the two surveys. Effort per fisher was less consistent, therefore presumably less reliable, but still significantly correlated between the two surveys.

We suggest that long term blast fishing and other destructive fishing methods in this region means that fishers' perceptions of a healthy fishing ground have changed and now differ markedly from ours. Fishers described their fishing grounds to be in good condition in the scoping and feedback surveys. In contrast, independent transect surveys revealed average % live coral cover of 15% and % rubble/dead coral cover (an indication of blast fishing damage) to be 37% for the same fishing grounds (Samoilys *et. al.* 2001), suggesting the fishing grounds are in poor condition. This discrepancy indicates fishers and ecologists are using different criteria to assess fishing ground habitat quality. There is a difference in threshold, or a shift in baseline (Pauly 1995 and 1996), for perception of a healthy habitat, with the fishers' threshold being substantially lower. Fishers may use the extent of rubble cover as an indication of habitat quality since the relationship between fishers' perceptions of good habitat was significantly negatively correlated with % rubble cover from independent surveys. A fishing ground was not considered to be in bad condition by fishers until rubble cover exceeded 50%, a value that would be considered very high by ecologists (Gomez *et. al.* 1994; Chou 2000).

Our results highlighted potential difficulties in composing suitable questions when interviewing fishers. Fishers may interpret questions quite differently from how they were intended by the interviewer, and results can be easily misinterpreted. This is a common problem when conducting interviews and focus group discussions with subsistence fishers (Baird, this vol). In our study the definition of habitat "quality" was poorly defined, and was open to many interpretations. This may explain why the fishers described their fishing grounds to be in poor condition when asked during the marine resource status discussions. Such questions need to be defined very specifically, so that fishers' knowledge can be accurately interpreted.

The marine resource discussions revealed that 20 year trends (1990-2010) in the status of the fishing grounds, seahorse populations and the fishers' livelihood as lantern fishers were all negative. In many cases there was strong consensus across villages for the reasons and for the solutions to these trends. For example, illegal fishing (primarily blast fishing) was cited as the primary cause of the poor state of the fishing grounds, with its corollary of stopping illegal fishing as the primary solution. In other cases there was less consensus amongst fishers. For example, fishers assessed their livelihood as being bad for a number of different reasons, though most of these did relate to an increasing need for cash which their livelihood could not provide. In all cases it was clear that fishers recognized their problems and had informed ideas on how to alleviate them, though perceived themselves to be largely powerless to effect change. It was overwhelmingly clear that stopping illegal fishing, especially blast fishing, and finding alternative livelihoods for the fishers were key solutions to the problems in the Danajon Bank lantern fishery. These results provide us with useful backing when directing our conservation efforts, though neither result is surprising. The prevalence and problem of blast fishing in the Philippines is well recognised (Alcala and Gomez 1987, Yap and Gomez 1988, Bryant *et. al.* 1998, Chou 2000). Furthermore, the lantern fishers of Danajon Bank are marginalized, comprising a relatively small proportion (nine fishers per village) of the total

village population, with the lowest average income in the region, living well below the national poverty level (Buhat *et. al.* in prep.). Considering the fact that they fish for up to 50% of their nights in arduous conditions, using paddle canoes and spending on average 3.5 hours in the water per night with no protection, it is not surprising that they would gladly welcome a supplemented livelihood.

The fishers' views are guiding us in our fishery management planning with various stakeholders (Martin-Smith *et. al.* In prep.), The fishers demonstrated a good understanding that gravid seahorses are important for population sustainability, citing the taking of pregnant seahorses as the primary cause of population depletion, and that the ensuing lack of adults and juveniles will contribute to further decline. It was not clear whether they knew that the pregnant seahorses were males (Vincent 1994), however the option of protecting pregnant seahorses through fishery regulations is clearly understood (Martin-Smith *et. al.* in prep.). Fishers also linked population decline directly to habitat destruction. Fishers from the village of Handumon, where Project Seahorse has been active since 1995 (Vincent and Pajaro 1997), provided the same range of reasons and solutions to their problems as other villages. One village, Guindacpan, consistently provided more answers and appeared more informed. The reasons for some of the differences between villages require further study.

Fishers' knowledge can guide conservation initiatives. We are acting on their knowledge and formalising it. The lantern fishers demonstrated that they are aware of conservation and management issues, are concerned about their marine resources and their livelihoods, recognise the negative trends, and know the reasons for their demise. However, they feel powerless to do anything about it, and see the government as being responsible but ineffective. These results have been instrumental in our initiatives to introduce supplementary livelihoods, and to facilitate the formation of a fishers' alliance across Danajon Bank to provide seahorse fishers with their own institution with which they can effect change.

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REFERENCES

Agrawal, A. 1995. Dismantling the divide between indigenous and scientific knowledge. *Development and Change*. 26: 413-439

Akimichi, T. 1978. The ecological aspect of Lau (Solomon Islands) ethno ichthyology. *Journal of the Polynesian Society*. 87: 310-326

Alcala, A.C. 2001. Marine Reserves in the Philippines: Historical Development, Effects and Influence on Marine Conservation Policy. Makati City, Bookmark. 115pp.

Alcala, A.C. 1999. The role of community in environmental management. p.529-537. In: Chua, T.E. and N. Bermas (eds) Challenges and opportunities in managing pollution in the East Asian Seas. MPP-EAS Conference Proceedings 12/PEMSEA Conference Proceedings 1:567.

Alcala, A.C. 1998. Community-based coastal resource management in the Philippines: a case study. *Ocean* and *Coastal Management* 38: 179-199.

Alcala, A.C., and Gomez, E.D. 1987. Dynamiting coral reefs for fish: a resource- destructive fishing method. p.51-60. *In*: Salvat, B. (ed.) *Human Impacts on Coral Reefs: Facts and Recommendations*. Antenne Museum E.P.H.E., French Polynesia.

Bailey, C. and Zerner, C. 1992. Community-based fisheries management institutions in Indonesia. *Maritime Anthropological Studies*. 5: 1-17

Baird, I. In press. Local ecological knowledge and small-scale fisheries management in the Mekong river in southern Laos. UBC abstracts, p.7.

Bay of Bengal Programme for Fisheries Development (BOBP). 1990. *Helping fisher folk to help themselves: a study of people's participation in fisheries development*. Affiliated East-West Press (P) Ltd. Madras.

Bryant, D., Burke, L., McManus, J., and Spalding, M. 1998. Reefs at Risk: A Map-Based Indicator of Threats to the World's Coral Reefs. World Resources Institute.

Buhat, D., Pajaro, M.G., Vincent, A.C.J. and Cruz-Trinidad, A. In prep. Socio-economics of a Philippines seahorse fishery.

Chou, L.M. 2000. Chapter 7. Southeast Asian Reefs - Status Update: Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. p. 117-129. *In*: C. Wilkinson (ed.) *Status of Coral Reefs of the World: 2000*. Australian Institute of Marine Science.

Cooke, A.J, Polunin, N.V.C., Moce, K. 2000. Comparative assessment of stakeholder management in traditional Fijian fishing-grounds. *Env. Cons.* 27:291-293

Die, B. 1997. Fishery (CPUE) Surveys. *In*: Samoilys, M.A. (ed.) *Manual for Assessing Fish Stocks on Pacific Coral Reefs*. ACIAR Fisheries Programme

Gomez, E.D, Alino, P.M. Yap, H.T., Licuanan, W.R.Y. 1994. A review of the status of Philippines reefs. *Mar. Pollut. Bull.* 29: 62-68.

Gulayan, S.J., Ancog, I. Pajaro, M.G. and Brunio, E.O. 2000. Management of marine sanctuaries in Bohol, central Philippines. Abstract. 9th International Coral Reef Symposium, Bali, Indonesia, October 2000.

Jennings, S and Polunin, N.V.C. 1996. Fishing, fishery development and socio-economic in traditionally managed Fijian fishing grounds. *Fisheries Management and Ecology*. 3: 101-113

Johannes , R.E. (eds). 1989. *Traditional ecological knowledge: a collection of essays*. IUCN, Gland, Switzerland and Cambridge, UK. 77pp.

Johannes, R.E., 1982. Traditional conservation methods and protected marine areas in Oceania. *Ambio*. 11(5): 258-261

Johannes, R.E. 1981. Working with fishermen to improve coastal tropical fisheries and resource management. *Bull. Mar. Sci.* 31: 673-680

Maguire, J.J., Neis, B. and Sinclair, P.R. 1995. What are we managing anyway? The need for an interdisciplinary approach to managing fisheries ecosystems. *The Dalhousie Law Journal*. 18(1): 141-153

Martin-Smith, K. *et. al.* In prep. Collaborative development of management options for an artisanal fishery: seahorses in the central Philippines.

McClanahan, T.R., Glaesel, H., Rubens, J. and Kiambo, R. 1997. The effects of traditional fisheries management on fisheries yields and the coral-reef ecosystems of southern Kenya. *Environmental Conservation*. 24(2): 105-120

Murdoch, J. and Clark, J. 1994. Sustainable knowledge. *Geoforum*. 25(2): 115-132

Neis, B., Schneider, D.C., Felt, L., Haedrich, R.L., Fischer, J. and Hutchings, J.A. 1999. Fisheries assessment: what can be learned from interviewing resource users? *Can. J. Fish. Aquat. Sci.* 56:1949-1963

Pajaro, M.G., Nozawa, C.M., Lavides, M. and Guitierrez, S. 2000. Status of marine protected areas in the Philippines: better management of coral reefs and the coastal areas in the tropics. Abstract. 9th International Coral Reef Symposium, Bali, Indonesia, October 2000.

Pauly D. 1997. Small-scale fisheries in the tropics: marginality, marginalization and some implications for fisheries management. *In*: Pikitch EK, Huppert, DD, Sissenwine, MP (eds) Global Trends: Fisheries Management. American Fisheries Society Symposium 20: 40-49. American Fisheries Society, Bethseda, Maryland.

Pauly, D. 1996. Biodiversity and the retrospective analysis of demersal trawl surveys: a programmatic approach. *In*: D. Pauly and P. Martosubroto, P (eds). *Baseline Studies of Biodiversity: The Fish Resources of Western Indonesia*. ICLARM, Manila (Philippines), 1996, pp. 16, ICLARM studies and reviews. Manila [ICLARM Stud. Rev.], no. 23

Pauly, D., 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology and Evolution 10(10): 430.

Pichon, M. 1977. Physiography, morphology and ecology of the double barrier reef of north Bohol (Philippines). pp. 261-267. Proceedings, Third International Coral Reef Symposium.

Polunin, N.V.C. 1984. Do traditional marine 'reserves' conserve? A view of the Indonesian and New Guinean evidence. *In*: K. Ruddle and T. Akimichi (eds). *Maritime Institutions in the Pacific*. Senri Ethnological Studies 17. Osaka, Japan: National Museum of Ethnology, pp. 267-284

Polunin, N.V.C. 1983. The marine resources of Indonesia. *Oceanography and Marine Biology Annual Review*. 211: 455-531

Rawlinson, N.J.F., Milton, D.A., Blaber, S.J.M., Sesewa, A. and Sharma, S.P. 1995. A survey of the subsistence and artisinal fisheries in rural areas of Viti Levu, Fiji. ACIAR Monograph No 35, 135 pp. Australia Centre for International Agricultural Research, Canberra.

Ruddle, K. 1994. *Traditional community-based marine resources management systems in the Asia-Pacific region: status and potential*. Manila, Philippines: ICLARM, 330p.

Ruddle, K., Hviding, E. and Johannes, R.E. 1992. Marine resource management in the context of customary marine tenure. *Marine Resource Economics*. 7:249-273

Samoilys, M.A., Meeuwig, J.J., Villongco, Z.A.D., and Hall, H. 2001. Seahorse fishing grounds of Danajon Bank, central Philippines: habitat quality and seahorse densities. Indo-Pacific Fish Conference, Durban South Africa, May 2001. Program Abstracts, p.51

Sillitoe, P. 1998. The development of indigenous knowledge: a new applied anthropology. *Current Anthropology*. 39(2): 223-252

Third World Studies Center 1990. *The Language of Organising: A Guidebook for Filipino Organizers*. University of the Philippines. 147 pp.

Vincent, A.C.J. 1994. Seahorses exhibit conventional sex roles in mating competition, despite male pregnancy. *Behaviour*. 128(12):135-151

Vincent, A.C.J., and Pajaro, M.G. 1997. Community-based management for a seahorse fishery. pp. 761-766. *In*: Hancock, D.A., Smith, D.C., Grant, A. and J.P. Beumer (eds.) Proc. World Fisheries Congress, Brisbane, 1996.

Walters, J.S., Maragos, J., Siar, S. and White, A.T. 1998. *Participatory Coastal Resource Assessment: A Handbook for Community Workers and Coastal Resource Managers*. Coastal Resource Management Project and Silliman University, Cebu City, Philippines, 113p.

White, A.T. 1988. The effect of community managed marine reserves in the Philippines on their associated coral reef fish populations. *Asian Fisheries Science* 2: 27-41.

White, A.T. and Vogt, H.P. 2000. Philippine coral reefs under threat: lessons learned after 25 years of community-based reef conservation. *Marine Pollution Bulletin*. 40(6): 537-550

Wright, A. 1985. Marine resource use in Papua New Guinea: can traditional concepts and contemporary development be integrated? pp. 79-100. *In*: K. Ruddle and R.E. Johannes (eds). *The Traditional Knowledge and Management of Coastal Systems in Asia and the Pacific*. Jakarta: UNESCO, Regional Office for Science and Technology in Southeast Asia,

Yap, H.T. and Gomez, E.D. 1988. Aspects of recruitment on a northern Philippine reef. Proc. 6th Int'l. Coral Reef Congress. Australia. Vol. 2, pp. 279-283.

Zann, L.P. 1985. Traditional management and conservation of fisheries in Kiribati. pp. 7-38. *In*: K. Ruddle and R.E. Johannes (eds). *The Traditional Knowledge and Management of Coastal Systems in Asia and the Pacific*. Jakarta: UNESCO, Regional Office for Science and Technology in Southeast Asia,

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QUESTIONS

Ian Baird: I have a comment regarding the apparent inconsistencies in the fishers' answers regarding the conditions of seahorse habitat. There can be explanations for these inconsistencies. For example, since you mentioned that there has been dynamite fishing for a long time, the habitat may have been in even worse condition than it is now, and people perceive it relative to the way it was before. They could also be comparing the habitat to adjacent places that are in even worse condition. It may not be as much of an inconsistency as it looks like initially. What you should do is go back to the fishers and tell them what you told us, and ask why there may be such inconsistencies.

Melita Samoilys: That's the next step in the project, to take our results back to the fishers and show them what we got and to ask fishers about the conditions of the fishing ground. They could be relating it to how it is doing compared to seahorses and not the habitat itself. We have to be careful.

Willard Sparrow: How do you deal with cultural understandings?

Melita Samoilys: We were fortunate in that Joel Erediano, who is in the project, is Filipino so he speaks the language. There's difficulty in translating it back to English, and it is hard for someone like myself to interpret the results.

Focusing and Testing Fisher Know-How to Solve Conservation Problems: A Common Sense Approach

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Abstract

Worldwide, the incidental capture or bycatch of marine organisms, especially mammals, turtles and seabirds, can pose serious threats to specific animal populations causing public outcry and regulatory attention. When such issues arise, especially in US fisheries, they can threaten fisheries and necessitate immediate solutions. Unfortunately, no standard mechanisms exist within stewardship and regulatory authorities to go beyond problem identification to crafting solutions. We have worked to devise solutions to seabird mortality in two fisheries: the Puget Sound drift gillnet fishery for sockeye salmon and the longline fisheries in Alaska for sablefish and Pacific cod. Although these fisheries are very different, the cooperative research model we have developed is the same and is proving successful in both. At the most basic level, this model includes communication and cooperation with all stakeholders, strict scientific protocols and development of effective and practical regulations. Although this model was developed with specific reference to seabird bycatch reductions, it is readily applicable to a wide range of conservation issues. There are three key elements: 1) Working with industry leaders through relevant industry associations to identify possible new technologies and/or operational practices that are practical and likely to solve the problem; 2) Testing the proposed solutions in a collaborative study on active fishing vessels using strict scientific protocols, and developing incentives for individual participants to: a) host scientists, who collect the necessary data, and b) adhere to a specific scientific protocol within their standard operation is key; 3) Crafting new regulations based on the results of the research program in cooperation with the industry, resource management agencies and conservation organizations. Our model results in proof at two levels. At the practical level, fisher's ideas are tested in the context of an active fishery. At the scientific level, peer review and publication certify results for the regulatory, academic, and conservation communities.

Introduction

Worldwide, the incidental capture or bycatch of marine organisms in fisheries has posed serious threats to specific animal populations as well as to specific fisheries. In particular, bycatch of mammals, turtles and seabirds has proven problematic because of the sensitivity of these species to even slight increases in adult mortality, and public opinion that these charismatic animals must be protected. When such conservation issues arise, especially in US fisheries, they necessitate immediate solutions to satisfy requirements of existing environmental law, the demands of the environmental community, and concerns of the public. Unfortunately, no standard mechanisms exist within stewardship and regulatory authorities to go beyond problem identification to the crafting of solutions.

Since 1994, we have developed cooperative research programs to devise solutions to seabird mortality of in two fisheries: the Puget Sound drift gillnet fishery for sockeye salmon (*Onchorynchus nerka)* and the Alaskan longline fisheries for sablefish (*Anoplopoma fimbria*) and Pacific cod (*Gadus macrocephalus*). The gillnet work was completed in 1996 (Melvin *et al*. 1999) and the longline work was completed in 2001 (Melvin *et al.* 2001). Although these fisheries are very different, the same cooperative research model proved successful in both. This essay outlines a cooperative research model that includes industry and agency input, cooperation at all levels, strict scientific protocols and clear direction towards effective and practical regulations.

Defining the Model

From the outset, it was realized that successful solutions must satisfy three basic criteria:

- reduce bycatch without reducing target catch or increasing the bycatch of other species;
- be acceptable and practicable for fishers; and,
- be scientifically acceptable to managers, conservation organizations and the public.

Although the cooperative research model was developed specifically to reduce seabird bycatch, it is readily applicable to a wide range of conservation issues. There are three key elements:

1. Working with industry leaders through relevant industry associations to identify new technologies and/or operational practices that are practicable and likely to solve the problem. Cooperation with

managers and agency scientists, academic scientists, and representatives of the conservation community is also essential.

2. Testing the proposed solutions in a collaborative study using strict scientific protocols under actual fishing conditions. Developing incentives for individual participants to:
   a) host scientists to collect necessary data;
   b) adhere to a specific scientific protocol within their standard operations.
3. Crafting new regulations based on the results of the research program in cooperation with the industry, resource management agencies and conservation organizations.

This model results in proof at two levels. Because practitioners within the industry have a primary role in developing potential solutions, and are involved in the actual research activity, they develop trust in the scientific process and are satisfied that technologies or methods tested are practical and actually work. Managers, scientists, and conservation groups are satisfied because mitigation techniques are rigorously tested, and results are scientifically defensible through peer review and ultimate publication in the scientific literature.

For this model to be effective, both industry and managers must be highly motivated, funding must be available, and a qualified and willing third party must be available to lead the effort. Unfortunately, these conditions rarely exist without a motivating crisis. Crises are important for at least two reasons:

1) Industry is not likely to respond to conservation issues unless the livelihood of its practitioners is threatened. Similarly, management agencies rarely respond to loss of non-commercial species unless they are threatened by litigation or requirements of environmental law, e.g. the Endangered Species Act (ESA), the Marine Mammal Protection Act, the Migratory Bird Treaty Act or Court injunction.
2) Funding for applied conservation research is not likely to be forthcoming unless there is a crisis. In the case histories below, the threat of litigation played a primary role in motivating funding for the research activities.

Finally, scientifically credible and independent third parties are important, because they do not come with an underlying political agenda, and are therefore in a better position to establish trust. Applying this model through agency scientists can be difficult because they represent institutions that are both regulatory and scientific. The agencies routinely find themselves in conflict with industry. Scientists associated with conservation organizations or environmental groups are often seen by industry as biased against harvesters of natural resources.

Case Study #1: Gillnets and Seabirds

Observer programs established that mortalities of marbled murrelets, listed as threatened under ESA in 1992, were in fact extremely rare in Puget Sound gillnet fisheries, but also established that these fisheries can entangle large numbers of other diving seabirds such as common murres (*Uria aalge*) and rhinoceros auklets (*Cerorhinca monocerata*). The fishery was faced with partial and full closure if research was not initiated to develop techniques that reduce the incidental mortality of diving seabirds. The Washington Department of Fish and Wildlife (WDFW) was threatened with litigation from a group representing sport fishers. Neither a research plan nor funding to carry out research was in place. After a Sea Grant pilot project in 1994, research was scaled up in 1995 and 1996 with funding from the Saltonstall Kennedy Program of National Marine Fisheries Service (NMFS S/K) the US Fish and Wildlife Service (USFWS), and the Washington Sea Grant Program (WSGP). Ultimately gear modifications (nets with visual barriers in the upper net), the elimination of dawn fishing, and ecosystem approaches were proposed for new regulations based on the research. Regulations were adopted with industry support, marking the first time solutions for seabird bycatch in gillnets were proven and implemented.

In this cooperative study, the Puget Sound Gillnetters' Association (PSGA) and (WDFW) played key roles. PSGA was the lead entity for the industry, promoting cooperation within the association, identifying individual cooperators, and establishing a forum to identify possible solutions. WDFW established the capability to use the proceeds from a test fishery to pay for vessel charters and fish outside scheduled openings, which in turn provided the incentive for individual fishers to participate in research. WDFW also played a lead role in organizing meetings of fishers, scientists and the conservation community.

Case Study #2: Alaska Longline Fisheries

Alaska longline fisheries for groundfish and halibut (*Hippoglossus stenolepis*) together yield about $300 million in ex-vessel revenue from approximately 2,200 vessels. These fisheries

have been estimated to catch between 10,000 and 20,000 seabirds per year including exceedingly rare catches of the internationally endangered short-tailed albatross (*Diomedea albatrus*). Under the Biological Opinion of the USFWS under the Endangered Species Act (ESA), bycatch exceeding four short-tail albatross every two years in the groundfish fishery and two short-tailed albatross every two years in the halibut fishery could close or curtail these otherwise healthy fisheries. The motivation to develop effective mitigation techniques was clear to industry, and research to develop bycatch deterrent strategies was required but not funded. Funding was obtained from USFWS, NMFS S/K Program and WSGP to conduct research over two seasons in the Gulf of Alaska sablefish and halibut fisheries and the Bering Sea Pacific cod fishery.

An *ad hoc* industry committee was established through the Fishing Vessels Owners Association and the North Pacific Longline Association with participation by NMFS and USFWS representatives. Deterrent techniques specific to each fishery were identified for testing through a series of meetings of the *ad hoc* group. In the case of sablefish, cooperating fishers received free NMFS-required observer coverage. In the case of Pacific cod, an exempted fishing permit from the North Pacific Fisheries Management Council allowed two vessels to fish under the research protocols for 25 days each prior to the open access season. The collaboration process concluded with meetings of the *ad hoc* industry group to share results of the research program and develop recommendations for new regulations to replace those borrowed from fisheries in the Southern Oceans. The goal was to develop new, practical regulations specific to Alaska fisheries with the support of industry, the resource management agencies and the conservation community. Those recommendations were included in the final technical report and were the basis for final regulations adopted by the North Pacific Fisheries Management Council in December 2001.

CONCLUSION

Cooperative research as described here has limitations. Field research is costly and entities willing to fund solutions are few. Organizing a collaborative process with a field program takes a great deal of effort and trust, and perhaps, some luck. Critical to both the programs described was a Principal Investigator (Melvin) associated with a neutral agency (Washington Sea Grant Program) dedicated almost full-time to the project. Most academics and agency scientists have neither the freedom nor the mandate to dedicate themselves to problem solving activities. Collaborations with academics within the School of Aquatic and Fishery Sciences at the University of Washington and with managers from state and federal agencies were also key components. Finally, we had the good fortune to work with fishing industry associations and fishers with vision and dedication, who understood the threat and the challenge to their industry. This model may not always appropriate, but when the circumstances and the people are right, it is a win-win formula. It is simply common sense.

RELATED LITERATURE

Melvin, Edward, and J.K. Parrish, K.S. Dietrich and O.S. Hamel. 2001. Solutions to Seabird Bycatch in Alaska's Demersal Longline Fisheries. Washington Sea Grant Program. WSG-AS 01-01. Available on line at http://www.wsg.washington.edu/pubs/seabirds/seabirdpaper.html

Melvin, Edward, and Julia Parrish (eds). 2001. Seabird Bycatch: Trends, Roadblocks and Solutions. University of Alaska Sea Grant College Program. AK-SG 01-01 (also available from Washington Sea Grant Program as WSG-DP 01-01)

Melvin, Edward. 2001. Streamer Lines for Reducing the Incidental Mortality of Seabirds in Longline Fisheries. Washington Sea Grant Program. WSG-AS 00-03

Melvin, E.F. and G. Robertson. 2000. Appendix 3. Seabird mitigation research in longline fisheries: status and priorities for future research and actions. In: Cooper, J. (Ed.). Albatross and Petrel Mortality from Longline Fishing International Workshop, Honolulu, Hawaii, USA, 11-12 May 2000. Report and presented papers. Marine Ornithology 28: 178-181

Melvin, Edward, Julia Parrish and Loveday Conquest. 1999. Novel tools to reduce seabird bycatch in coastal gillnet fisheries. Conservation Biology, 13:6, 1386-1397

Melvin, Edward, Loveday Conquest and Julia Parrish. 1997. Seabird bycatch reduction: new tools for Puget Sound drift gillnet salmon fisheries. Washington Sea Grant Program. WSG-AS 97-01

Melvin, Edward, and Loveday Conquest. 1996. Reduction of seabird bycatch in salmon drift gillnet fisheries: 1995 sockeye/pink salmon fishery final report. Washington Sea Grant Program. WSG-AS-96-01.

Melvin, Edward. 1995. Reduction of seabird entanglements in salmon drift gillnets through gear modification. Washington Sea Grant Program. WSG-AS 95-01.

QUESTIONS

Charlie Beliss: You're one of the first people I've seen looking at both fish management and bird management and bringing the two together.

Edward Melvin: That's probably true. It's so new that no one else has done it. I don't know if it is necessarily a good or a bad thing. It did come up because of the sequence of events. When I looked around to see who had done this kind of work I did not find much.

METHODOLOGY FOR INTEGRATION OF FISHERS' ECOLOGICAL KNOWLEDGE IN FISHERIES BIOLOGY AND MANAGEMENT USING KNOWLEDGE REPRESENTATION [ARTIFICIAL INTELLIGENCE]

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ABSTRACT

The fisheries crisis of the last decades and the overexploitation of a great number of stocks (FAO 1995) have been due mainly to the inadequacy of scientific knowledge, uncertainties in assessments and/or failures of the management systems. These problems are critical when the management of coastal ecosystems and artisanal fisheries is involved. These systems possess great complexity due to the high number of human factors that influence their functioning and the fishing activity. Small-scale coastal fisheries have a much greater social significance than offshore industrial fisheries, despite the larger economical importance of the latter (only in macro-economic terms).

The artisanal coastal fisheries in Galicia (NW Spain) are in a general state of overexploitation derived from the mismatch between management (derived implicitly from models designed for industrial finfisheries) and the biological and socioeconomic context. Freire & García-Allut (2000) proposed a new management policy (based on the establishment of territorial users' rights, the involvement of fishers in the assessment and management process in collaboration with the government agencies, and the use of protected areas and minimum landing sizes as key regulations) to solve the above problems. As well as a new management system, research should pay special attention to the design and use of inexpensive and rapid methodologies to get relevant scientific data, and introduce local or traditional ecological knowledge of the fishers to the assessment and management process.

In this paper, we analyze the values and characteristics of fishers' ecological knowledge (FEK). Using the artisanal coastal fisheries of Galicia as a case study, we present the objectives of the integration of FEK in fisheries biology and management and propose a methodology for that goal. The use of Artificial Intelligence (AI) as a tool for the analysis and integration of FEK is discussed, and the role of *Knowledge Representation,* a branch of AI, is described to show the epistemological and technological adequacy of the chosen languages and tools in a non-computer science forum.

INTRODUCTION

World fisheries are in crisis. According to the FAO (1995), 69% of the world's marine stocks are either fully to heavily exploited, overexploited or depleted, and are therefore in need of urgent conservation and management measures. The causes of the collapse of exploited marine populations have been the subject of wide debate, pitting those who believe that excessive fishing effort leads to over-exploitation, against those arguing that fluctuations in population dynamics are attributable to natural environmental changes. Myers and other researchers in (1996 and 1997) studied the collapse of the cod fishery in Newfoundland and concluded that the overexploitation hypothesis is backed by scientific evidence which is much stronger than other related to environmental changes. The collapse of stocks constitutes the final stage of overexploitation generated by an excessive fishing effort. This process may be attributed either to a lack of appropriate scientific information or, on occasion, where there *was* suitable assessment, to faulty management systems or failure to enforce the compliance of several fisheries.

In the case of artisanal fisheries in Galicia (NW Spain) there are also a number of indicators that reveal overfishing (Freire 1999; Freire 1000a): 1) the virtual depletion and collapse of several stocks (for example lobster, spiny lobster, sea bream) whose catches are irrelevant today but were important historically in the area, 2) the time series of catches that, despite problematic interpretation, show that there has been a decline in many cases from the 1940s-60s to the present time, e.g. crustaceans, and 3) specific assessments, such as on the spider crab in the Ría de Arousa (Freire 1000b) reveal exploitation rates greater than 90% per fishing session. As well as showing indicators of overfishing, the following differential characteristics of the

artisanal sector complicate the design of successful management systems:

1. From a biological standpoint, the species harvested by the artisanal coastal fleet of Galicia, and particularly the great majority of invertebrate species, present a number of characteristics which render useless the classical analytical models of finfish population dynamics used in the management of industrial fisheries. These species, sedentary benthic or mobile benthic/ demersal, have a strong and persistent spatial structure and are characterized by the following: 1) complex life cycles (planktonic dispersing larval stages and sedentary or low mobile benthic or demersal postlarval stages), 2) a spatial distribution characterized by the existence of aggregations which are evident on different scales, 3) a population structure that could be defined as meroplanktonic meta-populations in which the postlarval stages make up a chain of local populations along the coast with low migration and dispersal levels, interconnected by a planktonic larval stage, and 4) the aggregated stock-recruitment relationship is not applicable to a segment of a metapopulation.
2. In an industrial fishery, the relationships between the economic benefits obtained by the fishery and its biological and social complexity is high, which would make it possible to fund and develop intensive lines of research. In terms of the artisanal coastal fisheries of Galicia, the economic yield of each of the species harvested does not appear to be able to support specific lines of research which could complete our incomplete scientific knowledge.

Faced with these scenarios, some argue that finding ways to incorporate fishers' participation would improve our capacity to manage fisheries sustainable. Neis (1999) presents a methodology for collecting and integrating fishers' ecological knowledge into resource management, but the formal representation of this knowledge is not addressed. We believe that formal representation using AI (specifically *Knowledge Representation*) techniques could not only assist in the acquisition and refinement of this knowledge, but could also facilitate comparison with other knowledge systems (scientific knowledge), the observation of possible changes in these over time, and the impact of both knowledge systems on management initiatives. The aim of this paper is to a) show that *Description Logics* and *Terminological Systems* are good candidates for this task, b) describe the methodology designed to carry out this task, c) develop a case study implementing this and d) document the evaluation by biologists.

Also, following this line of work, it is worth mentioning a *fuzzy logic* expert system whose knowledge base incorporates fishers' knowledge in the form of heuristic rules (Mackinson and Nottestad 1998). Consequently our approach complements the work in (Neis 1999) and (Mackinson 1998) both in content and methodological aspects.

The remainder of the paper is organized as follows. The next section defines the concept of Fishers' Ecological Knowledge (FEK) which is rooted in ethnoscience and cultural ecology traditions. Section 3 argues that given the characteristics of FEK and what we want to do with it, *Description Logics* (DLs) are a good choice to represent FEK. In section 4 we describe our methodology. A visual terminological language which has been designed to facilitate knowledge input is described in section 5. The paper ends with some conclusions.

FISHERS' ECOLOGICAL KNOWLEDGE

FEK is a specialized branch of TEK (Traditional Ecological Knowledge). The concept of TEK appeared in the mid-1980s, and social scientists have argued that it represents at least a critical supplement to scientific understanding. Mailhot (1993) gave an explanatory definition of TEK:

> *"the sum of the data and ideas acquired by a human group on its environment as a result of the group's use and occupation of a region over many generations"*.

FEK (Neis 1999) typically includes not only categories of fishes, but also information on behavior, ecology, meteorology and oceanography, and references to time and space that can complement scientific knowledge. Moreover, FEK is an updated understanding that includes the latest changes occurring in the local marine environment. However, those who plan management policies are usually politicians who work unilaterally in collaboration with technicians from the administrations, and disregard entirely the knowledge of the fishers within their field of experience. Some examples that occurred in Galicia in recent years may serve as an illustration. Artisanal fishers used the traditional fish trap (cylindrical and closed) to fish velvet swimming crab and octopus. In order to regulate these resources, the administration required fishers to employ a more selective type of trap (square and open) designed by its technicians to fish exclusively octopus. The fishers bought these new traps and soon discovered that they were inefficient. They

required more work and produced less. The response of fishers was to replace the new traps with the traditional ones behind the back of the administration. This process went on for several years before the administration recognized its error which had resulted in an economical setback for the artisanal fisheries. The government, in opposition to an important sector of fishers, also opened the fishing season for velvet swimming crab at a critical time of its reproduction, thus putting the stock in danger. This latter situation example continued for several years.

Therefore, our main objective is to acquire new knowledge that can be applied to the sciences involved in designing management models for artisanal fisheries in Galicia. The generic scope of knowledge that we will need to achieve the above goals will be centred, in turn, on acquiring knowledge and information on coastal ecosystems, population dynamics, descriptions of habitats and bottom types, interactions and relationships between species, behavior and feeding habits, reproductive zones and seasons, climate (atmospheric and oceanic) influences on the species, stock assessment of fishes, crustaceans and molluscs, reconstruction of the history of marine ecosystems in relatively short periods, etc. After filtering, systemizing and formalizing fishers' ecological knowledge, it can contribute to broaden our understanding of many of these topics.

METHODOLOGICAL CHOICE: DESCRIPTION LOGICS

It has been recognized by Neis (1999) that the main hurdle associated with combining science and FEK is methodological: finding ways to combine these two knowledge systems. In (Neis 1999) and other works, methodologies and research techniques to acquire traditional knowledge are described. These include: analysis of discourse, selection of information, semi-guided open interviews, surveys on specific points of knowledge, analysis of the distribution maps of the resources and habitats drawn up by the fishers (Ames, this volume), and other documents of a functional nature that they may have, such as notebooks and graph interpretations (depth sounder, radar), etc. This work is being done almost exclusively by anthropologists and this knowledge circulates mostly through channels of dissemination of maritime anthropology. If this knowledge could be represented in a formal manner, it could be refined, reused, shared with others or integrated with biological knowledge in a principled way. Therefore *Knowledge Representation* (KR) plays an important role in improving the knowledge of biologists, technicians, anthropologists and fishers, with the ultimate goal of designing better fisheries policies.

Two main properties of FEK are that it is a very large body of knowledge and it is subject to continuous changes. Up to now, anthropologists have seen the work of formalizing FEK as part of their research area. This situation motivated us to seek a methodology where the anthropologist is not only an end-user of the resulting knowledge-based system, but he/she is involved in the knowledge engineering process from the beginning. Anthropologists can certainly break down the domain into its characteristic elements, even possibly express them in a computer language. However these tasks must be accomplished in the framework of a formal model, since the lack of a formal semantic foundation could lead to several problems such as inconsistencies or circular definitions. Therefore, to be successful the *Knowledge Representation Language* (KRL) must be carefully selected. Epistemological adequacy must derive from the nature of FEK. Note that one of the major components of FEK is the categorization used by fishers to classify components of the environment and the organization of these categories into a system of representation. From a technological perspective we need a language that is both expressive and easy to learn. Implementations of DLs seem to be the right choice.

From a logical and formal view, DLs integrate research done in semantic networks, frame systems and other object-oriented representations, and constitute the formal successor of the family of KL-ONE languages (Brachman 1985). During the last fifteen years the main issue of research in Description Logics has been the identification of the sources of intractability. The results of this research allow us to depart from a very basic language and to increase expressiveness while ensuring computational tractability.

The primary aim of DLs is to express knowledge about *concepts* and *hierarchies of concepts*. DLs have declarative tarskian semantics and can be identified as sublanguages of *First Order Logic* (FOL). A *concept expression* is a general description of a class of objects in the target domain. Concept expressions are formed using various *constructors*, some of them expressing relations with other concepts (roles). Relations expressed by means of roles, can be qualified in several ways (type restrictions, value

restrictions, number restrictions, etc.). Just by analyzing concept expressions, a taxonomy of concepts following generality-specificity criteria can be built. The efficient implementation of reasoning services is based on this hierarchical structure.

The basic blocks of the descriptive languages are atomic concepts and roles. Atomic concepts can be considered as unary predicates, and atomic roles can be considered as binary predicates. Atomic concepts and roles are combined to build complex concepts and roles. Semantics allows the interpretation of concepts as subsets of objects (here called individuals) of the domain and the interpretation of roles as binary relations between objects of the domain. Therefore the extension of a concept is a set of individuals, and the extension of a role is a binary relation between individuals. Also following the semantics of language constructors, the equivalent in FOL of any concept or role expression can be obtained.

Satisfiability and subsumption are the basic inferences in DLs. A concept is satisfiable if it can have a on-empty extension. A concept C is subsumed by a concept D if the extension of C is always a subset of the extension of D. Other inference tasks of great utility such as equivalence or classification can be reduced to satisfiability and subsumption. Reasoning about individuals is also provided with these logics. Since the seminal works in the field (Levesque 19 and 1987), reasoning in DLs and the tradeoff between expressiveness and tractability have been deeply studied, leading to important results - see Donini (1997) for a survey.

Terminological languages (also called concept languages) are implementations of DLs. *Classic* (Patel-Schneider 1991) and *Fact* (Horrocks 1998) are examples of well-known terminological languages. These languages allow us to define concepts and roles, to organize them by means of taxonomies, to define individuals and to make inferences on these elements and structures. Practical applications of description logics (terminological systems) using these and other terminological languages exist in a wide variety of domains: data and knowledge management systems (Borgida 1993 and 1995), global information systems (Levy 1995), clinical information systems (Rector 1997), software engineering (Devanbu 1991), etc.

In our project, we have chosen to use *Classic* for several reasons. The language is expressive enough to be useful and limited enough to assure tractable reasoning. The language is simple and small enough to be really usable because it can be learned by non-experts in computer science. Even a methodology for using *Classic* has been published (Brachman 1991). This knowledge engineering methodology has been elaborated, emphasizing the modeling choices that arise in the process of describing a domain and the key difficulties encountered by new users. The language has additional features that increase usability such as a limited forward-chaining rule system and the possibility of concept definitions written as test functions in a procedural programming language. However, these additional features are designed following the principle that user code cannot subvert the knowledge representation system, that is, these additional features have to be kept opaque and should not destroy the correspondence between the reasoning subsystem and the formal semantics - Lisp, C and C++ implementations of *Classic* exist, and an API (Application Programmer's Interface) is available. The distribution is now being handled by Bell Labs and licenses for research and commercial use can be obtained (ATT 1999).

Putting it into practice

This section shows our methodology from the following points of view: 1) interdisciplinarity, 2) description of the case study, 3) formulation of the case study and 4) evaluation of the results by a biologist.

Interdisciplinarity

The framework in which this research has been carried out is characterized by the convergence of anthropological and marine biological objectives for obtaining new knowledge about Galician coastal ecosystems. The final objective is to improve and increase biological knowledge of the coastal ecosystems and to apply it in the management of Galician artisanal fisheries. In summary, this process has been carried out in the following way:

- The original question (posed by the biologist) is related to the search for information (data) and knowledge about species of fishery interest;
- In the population-dynamics framework, a catalogue of themes to elicit is established in the fishers' communities under study;
- Using social science methodologies, a large corpus of knowledge relating to this field is obtained;
- The knowledge is systematized and methodologies of closed interviews, discussion groups, etc., are applied;

- Since the knowledge obtained from fishers is much extended, one specific topic, the microhabitats, was selected to be formalized.

Description of the case study.

When speaking about coastal ecosystems, fishers frequently mention elements and descriptive characteristics of the marine benthic habitats associated with the presence of different species. Also, in their descriptions, fishers include variables such as depth, tides, time, season, climatology, etc. This knowledge, once it has been systematized, allows the construction of a typology of bottom classes and their relationships with the species. Since both the knowledge and the information about this topic is extensive, we selected it as the topic of study.

Specifically, the relationship among different types of rocky bottoms (microhabitats) and a selection of species (involving crustaceans, molluscs and fishes) is described. Other species, such as seaweeds or echinoderms, were excluded to make the results easier to understand.

For rocky bottoms, fishers differentiate spatial and morphological categories according to the types of rocks and the species using the different microhabitats. The rocks are characterized using morphological factors such as form, size, rugosity, height, etc (BOLO, LAXA, PETON, PEDRA BRAVA, CHAN, LAXA, CABEZO, etc.). These categories are related to their location and extension over the bottom, constituting characteristic microhabitats: VEIRADAS, BOLEIRAS, OIADOS, RODAS, etc. Fishers use these microhabitats as the conceptual background to their daily fishing operations decision-making.

Definition of some of the concepts used by fishers:
"Bolos": smooth and round rocks.
"Boleiras": a zone of boulders of variable size extended randomly over a smooth rocky substrate.
“Laxa”: flat rock .
"Laxeado": area of flat rocks covering surfaces of up to 6000 m^2.
"Pedra brava": rock with strong rugosities.
"Chans": rocky bottoms without relief.
"Cabezo": a rock with a high relief but always underwater.
"Veiradas": transition between sandy and rocky bottoms.
"Oidados": areas with mixed rocky and sandy bottoms. Usually small areas, between 50 and 100s of m^2.
"Roda": small area of rocks inside a large sandy bottom.

Formalization of the case study

We must recall that our goal is not only to represent FEK; but also that the anthropologist become involved in this task. We distinguish three phases.

1. The anthropologist is trained in the basic concepts of terminological languages.
2. The domain must be broken down into its elements in accordance with the representation basics.
3. The result of the second phase must be transformed in *Classic* expressions.

Firstly, the anthropologist must acquire the basic concepts of descriptive languages: individuals, concepts, roles and taxonomies. This can be done in an informal but fair way without resorting to formal model-theoretic notions. DLs are particularly well suited to this process because their basic elements can be explained just using elementary set-theoretic and algebra concepts.

When developing a Knowledge Base (KB) in a terminological language, the second phase is a knowledge engineering process where the key is finding the way to break the domain into individuals, concepts and roles. In the case of *Classic* a methodology especially devised for beginners is available (Brachman 1991). Though this method may oversimplify some aspects of the knowledge representation process, it is ideal for our purpose of introducing the anthropologist to using Classic. The method consists of twelve basic steps exemplified with the *wine and meal* example: 1) enumerate object types, 2) distinguish concepts from roles, 3) develop concept taxonomy, 4) isolate individuals and for each individual try to determine all of the concepts that describe it, 5) determine properties and parts, 6) determine number restrictions, 7) determine value restrictions, 8) detail unrepresented value restrictions, 9) determine inter-role relationships, 10) distinguish essential and incidental properties, 11) distinguish primitive and defined concepts, 12) determine disjoint primitive concepts.

Background:

- The example analyzed here has not been the subject of specific scientific studies, at least in our area.
- There is a previous general knowledge of the habitat use of the species, basically using wide habitat categories defined by the type of substrate (sand / rock), which is not useful for management objectives.

```
(createRole shape true)
(createRole rugosity true)
(createRole fastening true)
(createTole size true)
(createrole surface-closeness true)
(createRole height true)
(createRole fishes)
(createRole bordering true)
 (createRole rocktype)
(createRole sand true)

(createConcept ROCK (and  (all rugosity (oneOf Smooth Rough))
                          (all shape (oneOf Rounded Flat))
                          (all fastening (oneOf Fastened Loose))
                          (all size (oneOf Small Medium Big))
                          (all surface-closeness (oneOf Near Far))
                          (all height (oneOf High Low))))

 (createIndividual Bolo (and ROCK (fills rugosity Smooth)
                          (fills shape Rounded)
                          (fills fastening Loose)
                          (fills size Small)))

(createIndividual Laxa (and ROCK (fills rugosity Smooth)
                          (fills shape Flat)))

 (createIndividual Peton (and ROCK (fills fastening Fastened)
                          (fills height High)))

 (createConcept FISH (oneOf Wrasse-female Wrasse-male Turbot
                          (Sea-bream Velvet-swimming-crab Octopus Conger-eel Bib))

(createConcept ENVIRONMENT (and (all bordering (oneOf Yes No))
                          (all rocktype ROCK)
                          (all sand (oneOf Yes No))
                          (all fishes FISH)))

 (createConcept OIADOS (and ENVIRONMENT (fills bordering No)
                          (fills rocktype Bolo)
                          (fills sand Yes)))

 (createConcept VEIRADAS (and ENVIRONMENT (fills bordering Yes)
                          (fills sand Yes)))

(createConcept RODAS (and ENVIRONMENT (fills bordering No)
                          (fills rocktype Peton)
                          (fills sand Yes)))

(createConcept BOLEIRAS (and ENVIRONMENT (fills bordering No)
                          (fills rocktype Bolo)
                          (fills sand No)))

(createRule one VEIRADAS (and   (fills fishes Wrasse-female)
                          (fills fishes Wrasse-male)
                          (fills fishes Turbot)
                          (fills fishes Sea-bream)
                          (fills fishes Velvet-swimming-crab)
                          (fills fishes Octopus)))

(createRule two OIADOS (and (fills fishes Conger-eel)
                          (fills fishes Wrasse-male)
                          (fills fishes Turbot)
                          (fills fishes Sea-bream)
                          (fills fishes Velvet-swimming-crab)
                          (fills fishes Wrasse-female)))

(createRule three RODAS (and   (fills fishes Bib) ))
            (createRule four BOLEIRAS (and  (fills fishes Conger-eel)
                          (fills fishes Octopus)
```

Figure 1. Terminological Knowledge Base written in Classic

Practice with this method is done through the use of real examples extracted from FEK. For instance, the anthropologist has useful knowledge about rocks (*laxa, bolo, petón*), clusters of rocks (*veiradas, oiados, boleiras, rodas*) and species associated with these *environments* or microhabitats. Following the method, this domain is decomposed into elements of the terminological language. The result of the second phase is an informal representation that in the third phase must be transformed into a *Classic* KB. To serve as an example, Fig. 1 shows the *Classic* KB with fishers' knowledge about microhabitats of some species of interest.

The following lines explain the meaning of the KB. The first ten terminological axioms define the set of roles of the KB using the function *createRole*. *Roles* are the entities that represent the properties of individuals. They map individuals to other individuals. The roles of an individual can be filled by individuals (the role fillers) or have their potential fillers restricted by concepts, or both. Each role definition includes the name of the new role and the boolean specifies whether the role is an attribute. An attribute is a role that has at most one filler. For instance, size is an *attribute* because we use this role to model a property for rocks and a rock is supposed to have a specific size. On the contrary, 'fishes' is not an attribute because this role models the relationship between an environment and the fishes within it. Clearly, within an environment different species can occur. The first six role axioms correspond to properties for rocks and the last four role axioms define environmental features. After creating the roles, we define the concept ROCK by means of the function *createConcept*. In this terminological axiom the symbol ROCK is the name of the concept being defined and the description is the concept definition. The 'and' concept constructor creates the conjunction of a number of descriptions. The 'all' restriction specifies that all the fillers of a particular role must be individuals described by a particular description, and 'one-Of' is a concept constructor which forms a concept enumerating its individuals. Therefore, the axiom defining ROCK includes a domain constraint for each one of the properties of a rock. In this case, the domain is constrained by specifying the set of individuals that can be fillers for each role. For instance, the 'rugosity' of a rock has to be either smooth or rough or the shape has to be either rounded or flat. Individuals are specific instances of concepts that are used to represent the real-world objects of the domain. Individuals are created by means of the function 'createIndividual'. In the function call, the first symbol is the name of the individual being created, and the description is the definition of the individual. The 'fills' concept constructor specifies that a particular role is filled by the individuals specified. Once a rock is defined, the individuals Bolo, Laxa and Peton are created. As an example, Laxa is an individual belonging to the concept ROCK whose rugosity is smooth and whose shape is flat. The definition of the concept FISH simply specifies the set of its individuals. The concept ENVIRONMENT models *environments* as sets of individuals whose rocktype property is constrained to be a ROCK (all rocktype ROCK) and where several types of fishes can occur (all fishes FISH).
Environments can have sand [all sand (oneOf Yes No)] and can border other elements [(all bordering (oneOf Yes No)]. The concepts VEIRADAS, OIADOS, RODAS and BOLEIRAS are subconcepts of ENVIRONMENT with specific fillers for the involved roles. Specific instances (individuals) of these concepts representing specific locations of these environments could be added to this knowledge base. The final lines of the KB define several *rules* via the function 'createRule'. A *rule* consists of an *antecedent*, which must be a *concept*, and a *consequent*, which is a *concept description*. As soon as an individual is known to belong to the antecedent concept, the rule is fired, and the individual is deduced to belong to the consequent description. The individual does not need to be described by the consequent in order to be classified under the antecedent. Once the rule is fired, the individual is further classified based on the new information provided by the rule. These rules allow us to infer automatically the set of species occurring in a given environment. For instance, from the third rule, each individual belonging to the concept RODAS has the species Bib (*Trysopterus luscus)* as one of its fillers for the role fishes. This way, when defining an environment we do not have to specify the set of fishes that occur, but the system infers them automatically. The use of rules permits to distinguish between definitional and incidental properties. The set of fishes living in a given environment is not a definitional aspect for the environment but the definitional aspects of an environment, i.e. shape, rocks, etc., are the elements that really determine the set of fishes which can live within those conditions.

Since we have to provide the biologist with the results obtained in an understandable and efficient format, we have drawn graphical representations e.g. Fig. 2. In these graphical

representations we use the notation of Gaines (1991). It is important to point out that, for the sake of clarity, we allow duplication of graphical nodes that are associated with a single knowledge representation element. Note also that the graphical syntax of Gaines (1991) allows only defined concepts as consequents in rules, but *Classic* allows any concept description in the consequent part of a rule and not just a defined concept. These unnamed concepts are simply represented in Fig. 2 as ovals without labels. We have recognized a multiple purpose of this graphical representation: 1) it reinforces the knowledge engineering methodology, 2) it has been used to explain FEK to biologists and technicians and 3) it has motivated us to implement a visual terminological language which facilitates the task of writing *Classic* KBs thus giving more weight to the role of the anthropologist in the knowledge engineering process and providing a tool to overcome the difficulties presented in the third phase.

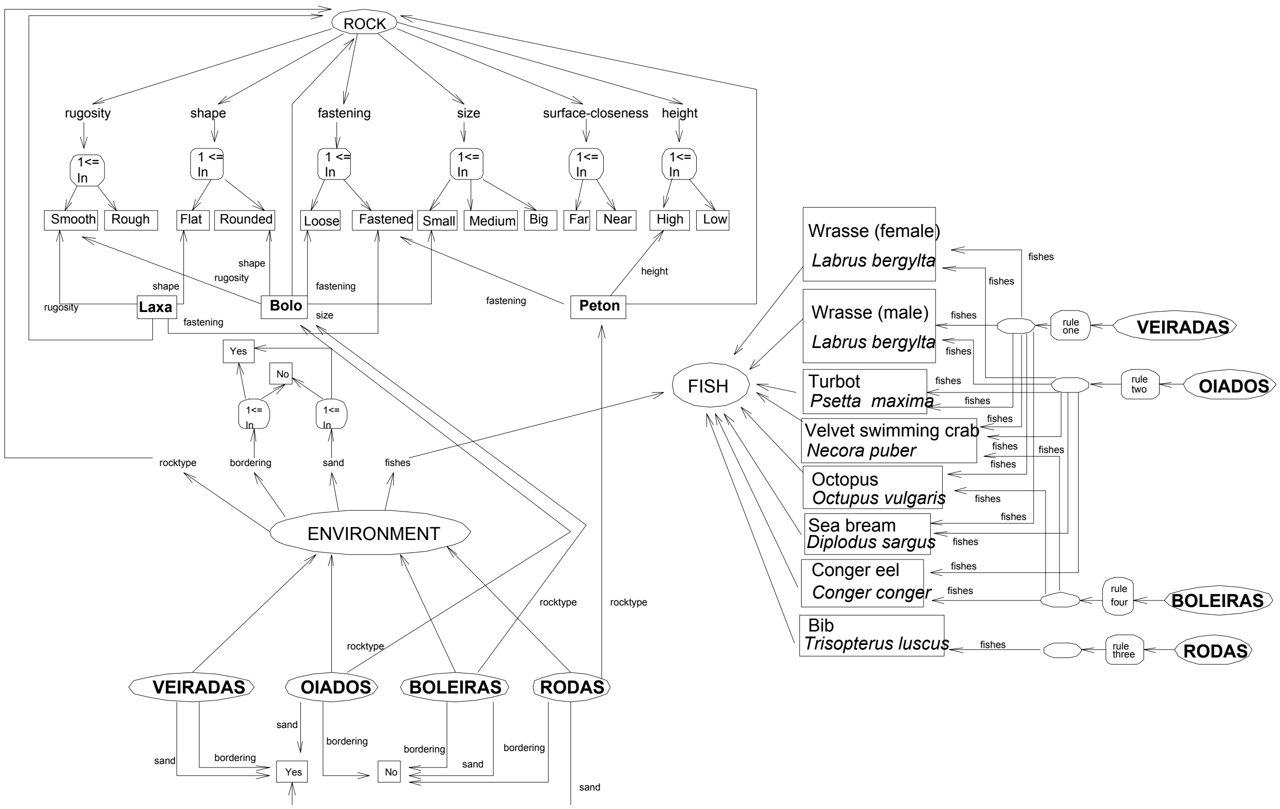

Figure 2. Graphical representation of the terminological knowledge base

EVALUATION OF THE RESULTS OBTAINED OF THE ANALYSIS OF THE FEK

Representation of the knowledge

Biologists are used to working with information in a tabular format where all variables of interest are explicit; this fact limits the usefulness of the raw verbal FEK. The representation of the knowledge base obtained *translates* the original FEK to a format operative for biological analysis. The diagram obtained clearly reflects these components and relationships and allows the biologists to use this semi-quantitative information in their hypotheses and models.

Biological knowledge obtained

The results obtained constitute new information about the problem analyzed. In brief:

- the basic components of the habitat (different kinds of rocks, defined by their morphology and size) are identified,
- the microhabitats are the result of the spatial configuration in the small-scale of these components,
- each species shows a different pattern of use of the microhabitats here identified.

The level of detail attained is very high in comparison with typical biological sampling or experimental studies, indicating the importance of some habitat features usually overlooked in scientific studies.

Potential uses of the results obtained

Two basic applications are identified in the biological and fisheries management contexts:

- **Fisheries management**. In coastal ecosystems exploited by artisanal fleets, management models are changing from direct effort regulations to systems based on regulation of the use of space. In this context, knowledge of the species-habitat relationships is fundamental to assess the value of different areas and to optimize their human uses. The results of the FEK analyses combined with maps of the distribution of the habitat components would allow rapid assessment of the value of different areas and the proposal of management strategies based in different uses of areas.

Visual terminological language
To facilitate the use and understanding of these methodologies to other potential users (fishery technicians, biologists, fishers, etc) we decided to use help tools for this task. For this reason we transformed these languages into visual languages to improve the usability. In this section we describe a visual terminological language for *Classic* and give a sketch of the implementation.

The visual language
For the sake of being concise, the visual syntax is illustrated with figures 3, 4 and 5.

Visual descriptions.
Fig. 3 shows the visual descriptions that can be built with concept constructors, and the corresponding *Classic* expressions. *Classic* has no role constructors, therefore the only role expressions are formed with atomic roles. For this reason there are no additional visual role descriptions.

Visual axioms and rules.
Concept descriptions and atomic roles and attributes are used in the axioms that define concepts, individuals and roles, and in the rules definition. The visual axioms and rules, and the corresponding Classic expressions are shown in Fig. 4.

Temporal definitions. The visual language provides temporal definitions for concepts, individuals and rules. These elements allow us to differentiate between what is being defined (temporal axioms and rules) and what is actually defined (real axioms and rules). Fig. 5 shows a temporal definition for the case of a defined concept.

Implementation
Visual descriptions, axioms, rules and temporal definitions are represented as Directed Acyclic Graphs (DAGs). Operations over these visual elements are implemented as operations over graphs. Fig. 6 shows the main window of the interface for this visual language. In the normal operation and using the buttons on the left, the user can define roles and attributes, build visual descriptions, attach them to concepts and individuals to create temporal definitions and eventually transform these temporal definitions into axioms and rules. The result is a visual knowledge base, i.e. a collection of visual axioms and rules subject to certain rules that facilitate the visual representation. For instance, note how in Fig. 6 the representation of the visual axioms for the definition of Bolo and ROCK avoid the duplication of the ROCK node, but for reasons of clarity in the visual representations, duplication of nodes corresponding to the same role rugosity is allowed. Also note that roles do not carry descriptions with them due to the absence of role constructors, this facilitates the graphical duplication of role nodes.

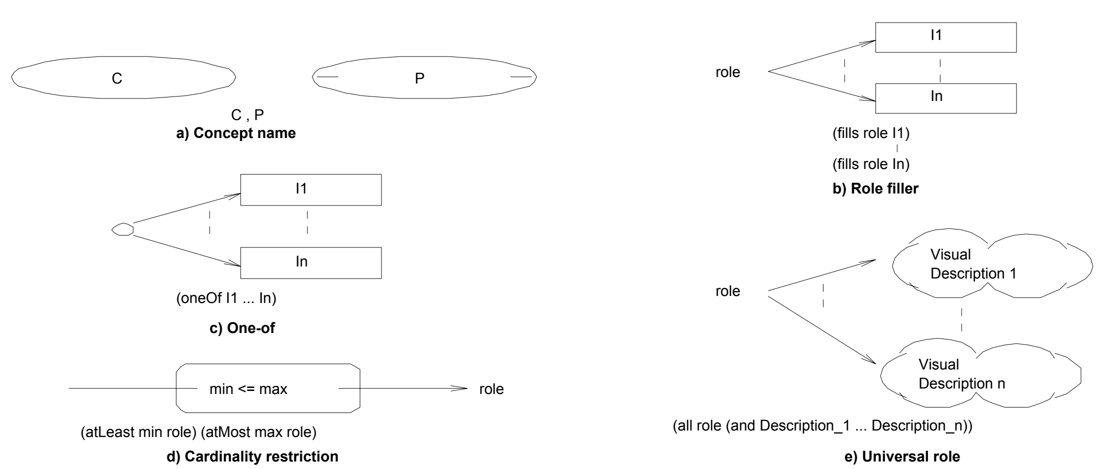

Figure 3. Visual descriptions

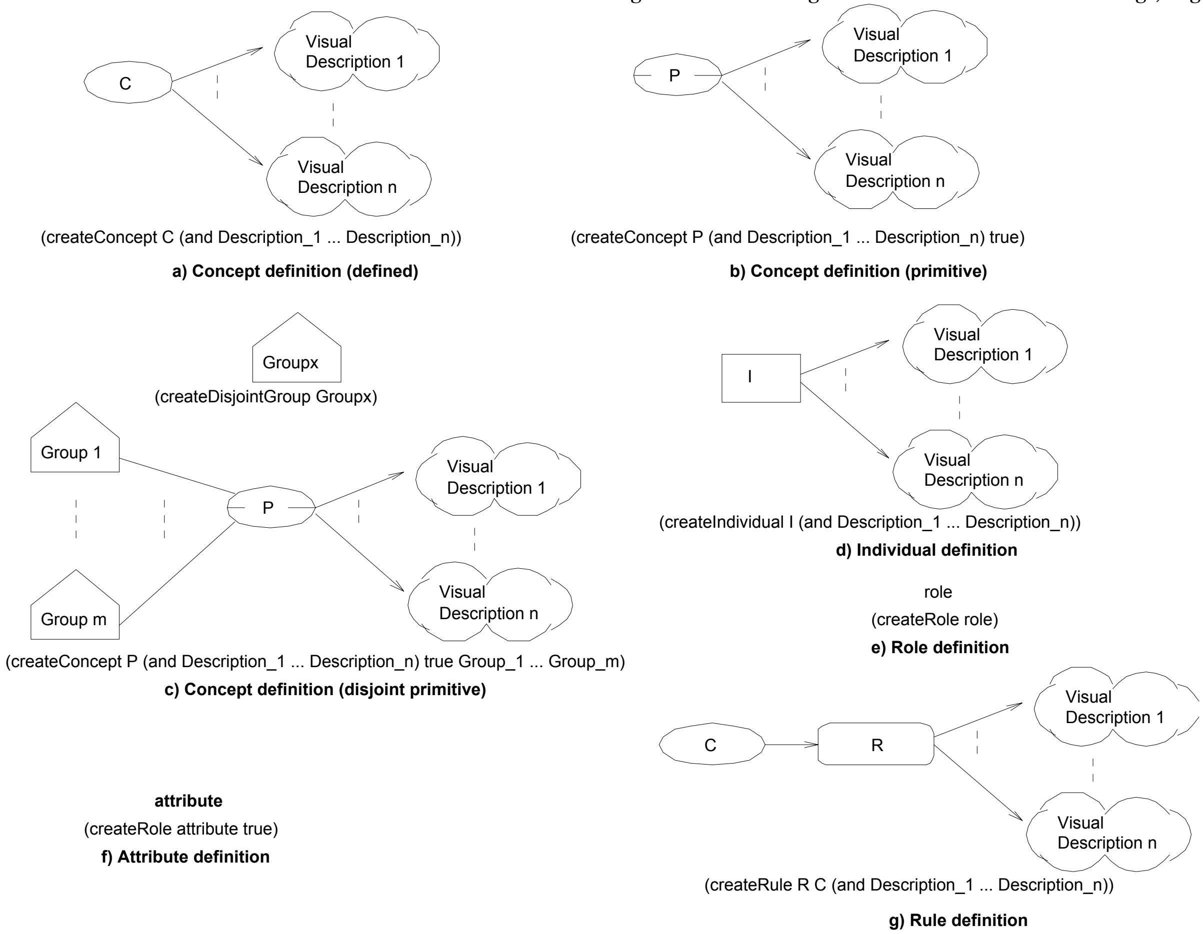

Figure 4. Visual axioms and rules

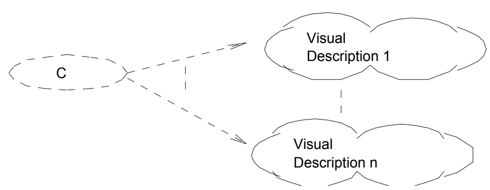

Figure 5. Temporal definition of a defined concept

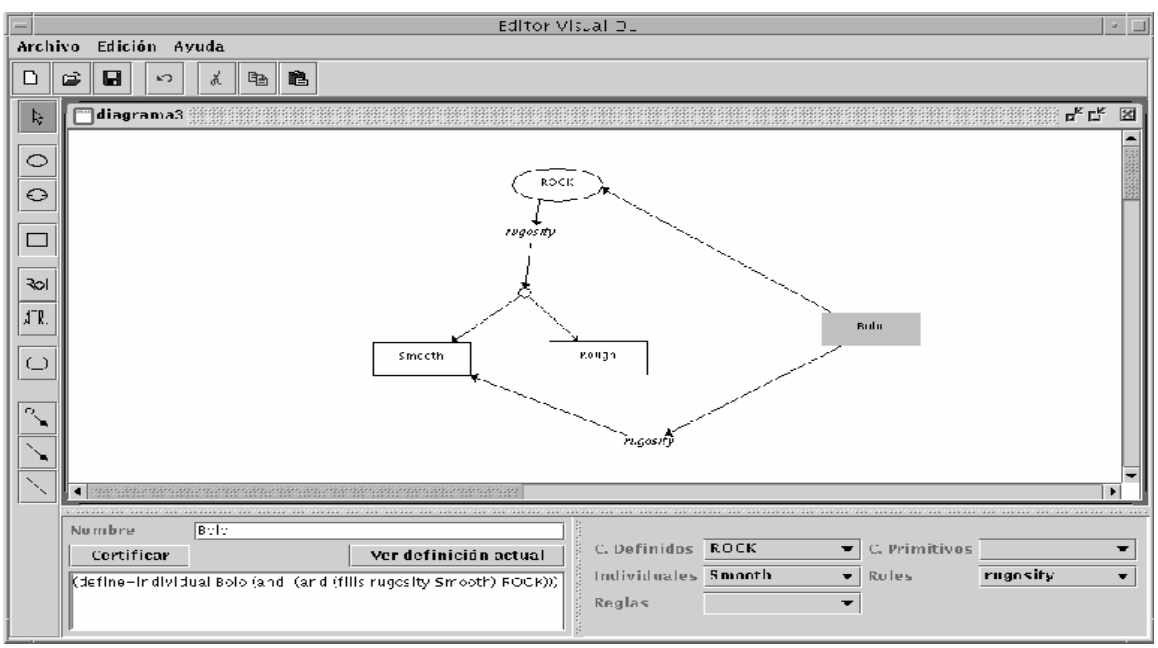

Figure 6. Interface for the visual language

CONCLUSIONS

We have presented a methodology to incorporate Fishers' Ecological Knowledge in the research of artisanal fisheries based on a knowledge representation formalisation and a knowledge engineering technique reinforced with the appropriate tools. An evaluation of this work in terms of usability, productivity and knowledge content is still to be done and in this task anthropologists, biologists and fishers themselves must be involved. But preliminary results are encouraged and we think that this approach can be considered in other domains where Traditional Ecological Knowledge can be incorporated into the management of natural resources.

ACKNOWLEDGEMENTS

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REFERENCES

AT&T (1999) The Classic Knowledge Representation System, www.research.att.com/sw/tools/classic, 1999.

Borgida A. (1995) Description Logics in data management, IEEE Trans. on Knowledge and Data Engineering, 7(5) (1995), 671-682.

Borgida A. and R.J. Brachman (1993) Loading data into description reasoners, in: Proceedings of the ACM SIGMOD Conference on Management of Data, Washington, DC, 1993, 217-226.

Brachman R.J., D.L. McGuinness, P.F. Patel-Schneider, L.A. Resnick and A. Borgida (1991) Living with Classic: when and how to use a KL-ONE knowledge representation system, in: Principles of Semantic Networks: Explorations in the Representation of Knowledge, J.F. Sowa, ed., Morgan Kaufmann, San Mateo, CA, 1991, 401-456.

Brachman, R.J. and J.G. Schmolze (1985) An overview of the KL-ONE knowledge representation system, Cognitive Science, 9(2) (1985), 171-216.

Devanbu, P, R.J. Brachman, P. Selfridge and B. Ballard (1991) LaSSIE: a knowledge-based software information system, Communications of the ACM, 34(5) (1991), 34-49.

Donini, F, M. Lenzerini, D. Nardi and W. Nutt (1997) The complexity of concept languages, Information and Computation, 134 (1) (1997), 1-58.

Freire, J and A. García-Allut (1999) Integration of fishers' ecological knowledge in fisheries biology and management. A proposal for the case of the artisanal coastal fisheries of Galicia (NW Spain), in: ICES CM S/07, 1999.

Freire, J, L. Fernández and E. González-Gurriarán 2000b) Interactions of the fishery of the spider crab *Maja squinado* with mating, reproductive biology and migrations ICES Journal of Marine Science, (2000), in press.

Freire, J. and A. García-Allut (2000a) Socioeconomical and biological causes of management failures in European artisanal fisheries, Marine Policy, 24(5) (2000), 375-384.

Gaines B.R. (1991) An interactive visual language for term subsumption languages, in: Proceedings of the Twelth International Conference on Artificial Intelligence (IJCAI'91), Sydney, Australia, 1991, 817-823.

Horrocks, I. (1998), Using an expressive description logic: FaCT or Fiction, in: Proceedings of the Sixth International Conference Principles of Knowledge Representation and Reasoning (KR'98), Trento, Italy, 1998, 636-647.

Levesque, H.J. and R.J. Brachman (1985) A fundamental tradeoff in knowledge representation and reasoning (revised version), in: Readings in Knowledge Representation, R.J. Brachman and H.J. Levesque, eds., Morgan Kaufmann, Los Altos, CA, 1985, 817 -823.

Levesque, H.J. and R.J. Brachman (1987) Expressiveness and tractability in knowledge representation and reasoning, Computational Intelligence Journal, 3 (1987), 78-93.

Levy, A.Y., D. Srivastava and T. Kirk (1995) Data model and query evaluation in global information systems, Journal of Intelligent Systems, Special Issue on Networked Information Discovery and Retrieval, 5(2) (1995), 1-23.

Mackinson, S. and L. Nottestad (1998) Combining local and scientific knowledge, Reviews in Fish Biology and Fisheries, 8 (1998), 481-490.

Mailhot, J. (1993) Traditional Ecological Knowledge: The Diversity of Knowledge Systems and their Study, The Great Whale Public Review Support Office, Montreal, 1993.

Myers, R.A., J.A. Hutchings and N.J. Barrowman (1996) Hypothesis for the decline of cod in the North Atlantic, Marine Ecology Progress Series, 138 (1996), 293-308.

Myers, R.A., J.A. Hutchings and N.J. Barrowman (1997) Why do fish stocks collapse? The example of cod in Atlantic Canada, Ecological Applications, 7 (1997), 91-106.

Neis, B, L.F. Felt, D.C. Haedrich and D.C. Schneider (1999) An interdisciplinary method for collecting and integrating fishers' knowledge into resource management, in: Fishing Places, Fishing People: Traditions and Issues in Canadian Small-Scale Fisheries, D. Newell and R.E. Ommer, eds., University of Toronto Press, Toronto, 1999, 217-238.

Patel-Schneider, P.F., D.L. McGuinness and A. Borgida (1991) The Classic knowledge representation system: guiding principles and implementation rationale, ACM SIGART Bulletin, 2(3) (1991), 108-113.

Rector, A., S. Bechhofer, C.A. Goble, I. Horrocks, W.A. Nowlan and W.D. Solomon (1997) The Grail concept modeling language for medical terminology, Artificial Intelligence in Medicine, 9(3) (1997), 139-171.

UN Food and Agricultural Organization (1995) The State of World Fisheries, United Nations, Rome, Italy, 1995.

INTEGRATING FISHERS' KNOWLEDGE WITH SURVEY DATA TO UNDERSTAND THE STRUCTURE, ECOLOGY AND USE OF A SEASCAPE OFF SOUTHEASTERN AUSTRALIA

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ABSTRACT

Australia involves fishers at all stages of the fishery assessment and management process. A key factor in the success of this approach is using fishers' information to supplement and interpret standard fisheries data. From 1994, we collected fishers' information on fishing grounds and habitats as part of a 5-year study of a continental shelf fishery. We met regularly with experienced fishers during port visits, commercial fishing operations at sea and in formal (management) meetings. This pattern of liaison enabled us to build relationships and a level of trust that facilitated a two-way sharing of knowledge. We integrated the ecological knowledge of fishers with scientific survey data to map and understand the seascape (seabed landscape) in a way that would not have been possible from scientific data alone. Fishers provided detailed information on the fishery, navigation, fishing effort distribution, individual species, fish behaviour, productivity, seabed biology, geology, and oceanography. A key result was an interpreted seascape map incorporating geomorphological features and biological facies at a variety of spatial scales of resolution from 10s to 100s of km. Supported by industry, we are now extending the mapping project to the entire shelf and slope of the South East Fishery region. Fishers believe that the project provides them with the opportunity to contribute to developing spatial management under Australia's 'Oceans Policy', and guarantees their involvement in a developing program of 'regional marine planning'. However, they also fear that their information will be used against them - especially for closing off valuable fishery areas. We discuss the importance of fishers' knowledge to interpreting scientific data, and the need for an ongoing dialogue between the fishing industry, scientists and managers. Only this ongoing dialogue will ensure that fishers' knowledge is used appropriately and, equally importantly, that fishers' concerns are addressed in developing management options for this area.

INTRODUCTION

Management of the world's oceans has typically been driven by single issues – for example, how many fish to catch, where to discard waste, where to mine, dredge, or drill for oil, and more recently which areas to protect (Allison *et al.* 1998; McNeill 1994). At its simplest, single-issue management can be achieved with specific and limited information and by ignoring many of the potential interactions with other issues or aspects of the marine environment. However, coincident with our increasing awareness of the ecosystem services provided by the marine environment (Norse 1993), is an increasing recognition of the limitations of single-issue management (Sainsbury *et al.* 1997), especially as our use of the oceans continues to increase.

It is no longer sufficient to manage a fishery solely on the basis of the number of fish removed; instead, where and how fishing occurs, and with what impacts, have become equally important questions. To answer these questions requires first that we define the management units we are dealing with (Langton *et al.* 1995). In particular, and as has been the case on land for centuries, spatial attributes of the marine environment have become increasingly important for effective management. This requires that we understand the ecological patterns at regional and local scales, and integrate over these scales to provide a 'seascape' perspective (Garcia-Charton and Perez-Ruzafa 1999).

Australia is developing integrated management of its marine resources through *Australia's Oceans Policy*, launched in December 1998. Principal drivers for the policy are: ecosystem-based management; integrated oceans planning and management for multiple use; promoting ecologically sustainable marine-based industries; and managing for uncertainty (Commonwealth of Australia 1998). It is recognized that real success of the plan will depend on all Australians gaining an appreciation and understanding of both the complexity of the ocean environment, and the interaction of humans within that environment (Sakell 2001).

The marine environment off southeast Australia is the test case for 'regional marine planning' in Australia as it forms the first of 13 'large marine domains' (LMDs) that will eventually be covered by management plans. While there are some spatial data relevant to fishery management available for this area, in general they are either of low resolution (e.g. the start and end positions of commercial fishing operations from fishery

logbook records), or lack ecological interpretation (e.g. bathymetric and geological maps from geoscience sampling). Until recently, little was known about the spatial organization of habitats (substrata, biota and adjacent water column) or the ways in which the seabed is used as fishing grounds. Seabed habitat in the South East Fishery (SEF) was mapped for the first time as part of a five-year study to interpret the ecological processes contributing to the productivity of the shelf fishery ecosystem – 'the ecosystem project' (Bax and Williams 1999). The SEF is a complex, multi-species, multi-sector fishery (Tilzey and Rowling 2001) that operates in a large fraction of the South East LMD adjacent to mainland Australia. The mapped area was ~24,000 sq km of the continental shelf (~25-200 m depths) adjacent to the coastline between Wilsons Promontory in eastern Victoria and Green Cape in southern NSW – the south-eastern point of the Australian continental margin where east and south coasts meet (Bax and Williams 2001: Fig. 1). In that study, survey data provided the means to determine the structure of the seabed and its association with biological communities and environmental factors at particular scales in space and time (Bax and Williams 2001; Williams and Bax 2001). The addition of fishers' ecological knowledge aided the interpretation of those associations, as well as enabling an understanding of the ways in which the seabed is used by the commercial fishing fleet. As it turned out, fishers' information was so useful that we developed a second study – 'the mapping project' – using fishers' information on habitat types and distribution (interpreted through scientific knowledge and ground-truthing) as the primary data source to develop fine-scale maps of the southeast Australian seascape.

In this paper, we first describe how fishers' knowledge contributed to the ecosystem project and explain why this provided a better understanding than a study based on scientific survey data alone. Second, we provide an overview of our methodology for collecting and integrating fishers' knowledge in the follow-up mapping project. Finally, we draw attention to the benefits of combining fishers' ecological knowledge with scientific survey data to provide a seascape perspective of the marine environment, and stress that this combination requires an ongoing dialogue between the fishing industry, scientists and managers. The direct benefit of combining our knowledge in this way is an improved understanding of the seascape. An indirect benefit is that it empowers fishers with the opportunity to be actively involved in developing management options for the marine environment that they are most familiar with.

The South East Fishery

The continental shelf and slope off south-eastern Australia is the area of greatest fishing effort within the South East Fishery (SEF) – Australia's largest scalefish fishery, and the most important source of scalefish for domestic markets. Trawling started in the early 1900s, and by 1999 the SEF fleet was made up of 89 operating otter-board trawlers (draggers) and 20 Danish seiners (the 'trawl sector') (Tilzey and Rowling 2001), as well as a smaller number of demersal longliners, dropliners, mesh-netters and trappers (the 'non-trawl sector'). More than 100 species form the commercial catch of the fishery, but 18 species or closely-related species-groups managed by a system of catch-quotas make up the bulk (> 80%). Annual total allowable catches of individual species range from a few hundred to a few thousand tonnes generating a total value for the fishery of about A$70 million.

Overview of the 'ecosystem' and 'mapping' projects

The ecosystem project was designed to consider the ways in which management intervention, beyond the established single-species fisheries management, could have a direct effect on the long-term productivity of this fishery ecosystem (Bax *et al.* 1999). Production was taken to mean both the production of fish and the factors that determine their availability to the fishery, while our concept of "ecosystem management" was tied strongly to the notion of needing to manage peoples' interactions with ecosystem components (Bax *et al.* 1999). Engagement with the fishing industry was desirable to understand how fishers viewed the ecosystem, how they interacted with it, and how to best target our limited survey time. Accordingly, we initiated a two-pronged industry liaison program when the project started. Depending on individual skills and experience, members of the project team became involved in formal fishery management and assessment meetings, and/ or spent time in the two big ports in our study area (Eden and Lakes Entrance) and did trips to sea on fishing boats (several trips in the first year, then only 1-2 per year). A particularly useful feature of our sampling program was using industry vessels for specialized fishing. Collectively, these interactions enabled us to establish contact with a range of industry personnel from the working skippers to the association executives. This gained us the support (and data) of individual operators and, in addition, the endorsement of the executive to further develop the project.

We maintained fairly regular contact with a core group of operators and were able to build up a level of trust and dialogue with this core group as the project developed. Our findings were reported back to individuals and the peak industry associations on an ad-hoc basis during the course of the project. So, in summary, our approach to industry involvement evolved naturally during the ecosystem project – importantly, it lacked systematic planning or protocols, and there were no obvious benefits for industry.

The contacts with industry members and associations that we developed during the ecosystem project proved crucial in garnishing support for the second project – the mapping project – that makes extensive use of industry information and has explicit benefits (and risks) for industry. In this partnership project, we are extending the seascape mapping to the entire continental shelf and upper slope (to ~ 1000 m depth) of the SEF region. In contrast to the ecosystem project, the mapping project has a planned methodology for collection, review and release of industry data. However, our approach is necessarily adaptive as the scale and detail of outputs are realized, and as industry responds to a rapidly evolving environmentally-focused fishery management regime. Key elements of the methodology are discussed in the final part of this paper.

Value of fishers' knowledge for navigating and mapping

When we started the ecosystem project our means of navigating around the fishery seabed was limited to what could be gleaned from third-party, coarse-scale bathymetry data and navigation charts – primarily point-source depth soundings, the approximate positions of key depth contours including the continental shelf edge at ~ 200 m, and the positions of some near-surface rocky banks identified as shipping hazards (Table 1). This information, in combination with some prior survey data and some rapid exploration by echosounding during survey, enabled us to fix a set of transects and sampling sites, stratified by depth and latitude (Bax and Williams 2001: Fig. 1). These were used for broad-scale coverage of the area during 4 seasonal trawl surveys – by definition on sediment substrata. But to meet the core aim of the project, which was to understand the importance of habitat to fisheries productivity, we needed to both survey a range of characteristic rocky reef habitats in the study area and understand the spatial context of habitats, e.g. patch sizes, boundary types and distributions.

This is where we really started to benefit from our dialogue with fishers – they told us where to look. At an early stage we were able to build a focused study of habitats into the field surveys to intensively sample at a relatively small number of sites (Bax and Williams 2001: Fig. 1). This enabled us to understand the ecological roles of particular features, and their often small spatial scales (100s of meters to a few kilometers), for example the use of prominent reef edges by commercially important semi-pelagic, feature-associated species. Fishers' knowledge (Table 1) enabled us to progressively build a spatial framework on which to interpret the range of information we were collecting during our surveys. For example, by providing information on the boundaries of rocky reefs we were able to produce thematic maps of underlying geology (Bax and Williams 2001: Fig. 3). Over the course of the project we collected sufficient spatial information from fishers to put together what we called our 'fishers map' (Bax and Williams 2001: Fig. 4). In many ways it is a coarse-scale map of habitats, although its units – fishing grounds – are actually a hybrid mix of geomorphological features, such as sediment plains and rocky banks, and biological facies or biotope types – patches of substratum dominated by one particular community or animal. In summary, fishers contributed unique mapping knowledge, such as ground types, boundaries and names, which enabled us to understand the make-up of the seascape at a variety of spatial scales – from small-scale features through to a regional overview.

Value of fishers' information for understanding species' ecology and their environment

Two fundamental differences between observations made by fishers during commercial fishing and by scientists during survey are related to the timing and frequency of sampling - the temporal and spatial resolution (Table 1). While time spent at sea by skippers varies considerably, some average over 200 days per year and sustain this for many years, building on the experience of their parents or other older skippers. In addition to learning where to fish, their mode of operation often includes searching and watching to enable precise target-fishing of fish "marks" seen on echosounders. For example, the first shot of the day is often delayed until the 'feed layer' (or acoustic scattering layer) descends to the bottom – around first light

Table 1 Sources and types of information used to describe the continental shelf seascape in the south-eastern South East Fishery during the 'ecosystem project'

	Project surveys	Fisher's knowledge
Navigation over seabed	Navigational charts, depth contours	Accumulated maps in charts and plotters; names for features
Fishery	Fish species and size composition (quantified seasonal catches– trawl, trap, mesh-net)	Fish species and size composition (unquantified daily catches– trawl, mesh-net)
Fish behaviour (use of grounds)	Seasonal, diel (at times of surveys)	Time scales from days to decades
Fishing effort distribution	Logbooks (aggregated start position data)	Detailed tracks and marks of individual vessels
Productivity	Detailed energy flows at set points in time	Dependability of fishing grounds over decades
Seabed biology	Fish and invertebrate communities (quantified, but few samples from nets, sleds, and photography); detailed species information	Dominant fish and invertebrate types (unquantified, but numerous net catches); local species-mixes or 'taxonomies'
Seabed geology	Rock type and geological history (dredge rocks); sediment classification (grab samples); depth contours (echo soundings from survey track lines)	'Ground-type' classification (gear damage/ wear, by-catch of rocks, mud etc.); depth contours (echo soundings accumulated over years of exploration)
Oceanography	Regional surface currents (SSTs; sea surface height) and local vertical structure (CTDs); bottom currents (sediment modification in photographs)	Local surface and bottom current direction and speed (gear/ vessel behaviour)

(Prince *et al.* 1998). In contrast, our survey samples (a combination of randomly directed and targeted) were fixed on the calendar, but essentially random in time as they took no account of the annual variability in seasonal progression (Bax *et al.* 2001) or of fine-scale patterns of fish movement. Sampling was only regulated (standardized) to either day or night, but not by season, or by considering a site-season interaction. Relative to the high number and frequency of commercial sampling, surveys represent very brief snapshots in time and space. In the year when we sampled most intensively (2 surveys in 1996) we completed less than 100 trawl tows on the continental shelf (< 250 m depth) while the trawl fleet completed over 10,000 – a two orders of magnitude difference in intensity spread widely across the fishery.

What differences in knowledge of species ecology and the fishery ecosystem resulted from these differences in sampling? One of many species examples is illustrated by the morwong (or sea bream), a mainstay quota species on the domestic market. Our survey sampling – including targeted sampling based on prior information from fishers – showed that morwong were associated with limestone reef and sediment substrata, and had high abundance on reef edges. It is primarily a benthic feeder, and presumably moves away from the shelter of reefs to forage on sediments plains. It had a generally higher abundance in the southern part of the study area (consistent with its broad temperate distribution) and was most abundant (in our seasonal trawl samples from sediment plains) in spring and autumn. Catch rates were higher during the day than at night in diel gillnet samples. Local trawl fishers report that movements of morwong are linked to season, depth, habitat type and time of day in a more complex way. Thus, in autumn, they catch this species in the south of the area, but catches are taken progressively shallower and northwards over a period of weeks, during which time it is caught only at night (i.e. it is not available to trawl during the day). Through winter and spring, with a peak in September, morwong move onto the elongate banks of limestone reef to the north where they are caught in what are called the "gutters" between reefs, but now *only during the day*.

Our scientific data show that this is not a spawning movement, and while oceanographic data indicate a general correlation between the horizontal movement of fish and opposing seasonal flows of warm and cool currents, the processes that drive the depth-related, substratum-associated and vertical patterns (the

latter inferred from variable availability to trawl) remain unexplained. Irrespective, the distinct patterns known to fishers would be very unlikely to be detected by a typical scientific survey or by analysis of logbook data, and this is just one of the many examples for individual species. Information at this fine spatial and temporal resolution, unless provided by fishers, is not available to survey design, for the interpretation of CPUE or other fishery statistics, nor to assist an understanding of individual species' ecology such as habitat utilization.

Although fishers tend not to talk about their knowledge of the fishery "ecosystem", it is the environment in which they conduct the business of catching fish. For example, successful fishers have considerable insights into structures and processes that affect production – the availability of particular species or species-groups, of the right size, and in commercial quantities. In our region, fishers know that production is concentrated at the shelf break and on the upper slope (~150-700 m) particularly around canyon heads. Successful fishing depends on knowing when and where the right combinations of depth, bottom types, currents and good feed marks occur together. There are hot-spots, but they are dynamic over periods of days, weeks or years – for example, with hydrodynamic climate being influenced by daily tide, episodes of upwelling, wind-driven currents, and the moon, as well as 'long-term' seasonal events. Fishers may not be aware of the movement of the eddies of the East Australian Current onto the shelf, but their observations of how fish catchability changes with 'clean' or 'dirty' water matches the movement of these eddies. The extent to which hot-spots can be detected or predicted is closely linked to the degree of success in fishing over time.

We were able to explain some of the patterns known to fishers by identifying food webs and sources of primary production from analysis of diets, stable isotopes and pigment breakdown products in survey data (Bax and Williams 1999; Bax *et al*. 2001). Oceanic production (food) is highly important whereas terrestrial or nearshore inputs are relatively trivial. Commercial shelf fishes– including many traditionally viewed as demersal or 'bottom dwelling'– prey heavily on the animals that form 'feed layers' in the oceanic water column (pelagic prey) as well as those in local sediments (benthic prey) (Bulman *et al*, 2001). As a consequence, the seabed at the shelf-break is productive because it is bathed with upwelled slope waters containing high levels of nutrients, particulate organic matter, oceanic pelagic prey, and particular elements of oceanic micronekton at their near-shore limit of distribution (e.g. lanternfishes) (Bax and Williams 1999). Fishing is especially productive in the first few hours of daylight, the time at which this feed layer intersects with the bottom. Thus, because fishers and scientists tend to observe the fishery ecosystem at different spatial and temporal scales, their observations are often complementary. Fishers' knowledge may permit scientific observing to be better targeted, and more insightful, while survey data can provide the detail that leads to a more rigorous interpretation of fishers' knowledge.

Role of fishers' information in understanding seascape use

The ways in which the seascape of this area is being used and impacted by fishing is the subject of developing interest by fishery mangers, environmental and conservation agencies, the general public, and by industry itself. Management of the seabed is being considered more actively, but whereas spatial management (or zoning) is universally accepted on land, it has only recently been considered as an option, or even necessary, in the ocean (Bohnsack 1996). Spatial management on the land has benefited from numerous datasets available from visual observation of the landscape – in person, from the air, or via satellite. Similar information is not available for the seascape because it cannot be observed directly (except at the shallowest depths). Increasingly, scientific surveys can be used to provide detailed 'pictures' of the seabed with single beam acoustics (Kloser *et al*., 2001a) or multibeam acoustics (Kloser *et al*. 2001b), but even the most modern techniques are very time consuming and therefore expensive, especially at shallower depths where the acoustic sampling footprint is comparatively small. Only large-scale undersea features such as upwellings of colder water driven by topographic features or sea level rises over submarine ridges can be observed from satellite. What is needed for spatial management, at anything less than the coarsest scale (bioregion and depth), is an information source of sufficient resolution to detect seabed features at the scale where management is possible (less than 1 km for fisheries where satellite transponders are fitted to vessels). Fishers operate below this level of resolution, and we suggest that their information has the potential to provide information on the seabed at a scale suitable for spatial management.

In the SEF, the distribution of trawl tows has been used as an index of disturbance (Larcombe

et al. 2001). However, interpretation of the resulting maps is limited because fishing is highly targeted at specific seabed features that occur at scales less than the typical 3-hour trawl tow. Even unaggregated trawl start (or end) positions are poor representations of tows that are, on average, three hours in duration and therefore up to ~10 nautical miles in length. Analysis based on shot mid-points provides a closer spatial approximation of effort by considering both end-points, but suffers from the introduction of unknown errors because trawl tows do not follow straight lines. They most often follow physical boundaries and may involve several directional changes, for example to navigate through 'broken-ground'; the ~12-nautical mile 'Snake Track' through the Howe-Gabo Reef complex is one aptly-named example. We conclude that logbook data (start and end positions) enable interpretation of effort distribution at the scale of fishing grounds (10s-100s of sq km), but provide limited insights into impacts of seabed use because most significant habitat features occur at a finer spatial scale (10s-1000s of sq m) (Bax and Williams 2001).

In the SEF, the vulnerability of seabed types to fishing impacts is highly variable. Fishers have shown us that when areas of low-relief limestone slabs are fished, benthic fauna and some of the actual substratum can be removed. On the other hand, high-relief and heavily cemented limestones will never be trawlable and these are regarded as 'natural refuges' by trawl fishers. However, these same 'natural refuges' are often the prime fishing grounds of the non-trawl sector that fishes with static gears such as gillnets, traps, and hook and line. This is a potential source of conflict between industry sectors when spatial management is introduced to the fishery. Habitat features at the scale at which the industry sectors operate will need to be considered if equitable management arrangements are to be introduced, although actual management regulations may operate at a coarser scale. The only feasible way to map the seascape at a resolution similar to that at which fishers operate, is to use the information collected by the fishers themselves. However, this information is sometimes highly confidential, being the commercial advantage that one fisher may have over another. In the following section we describe how we set about accessing this confidential information.

Integration of fishers' knowledge in the mapping project

"Integrating fishing industry knowledge of fishing grounds with scientific data on habitats for informed spatial management and ESD evaluation in the SEF" – the official title of the mapping project – has the explicit aim of incorporating fishers' knowledge of the seascape into strategic management planning. We have broad support from industry because the project is viewed as a mechanism to have industry information considered in decision-making processes for the fishery, and that *informed* decisions will result. However, support is not unanimous and this is due, in large part, to many fishers remaining skeptical that their information will not be used appropriately. Moreover, fishers are not a single cohesive group, and have different views of the system they fish, and short- or long-term approaches to sustainability – based, at least in part, on their level of tenure in the fishery. Some fishers are unwilling to share their commercially confidential information with us. Many fear that their information will be used against them, especially for closing off valuable fishery areas – they are well aware of the link between areas of high fishery productivity and areas of high biodiversity. Our approach to gathering, storing and releasing industry information needed to address these concerns to the extent possible; we needed to maximize our support from industry, whilst retaining the option to release aggregated industry knowledge to a broad audience in the form of map products.

We argued the benefits of the project aims to individuals and the peak bodies for several years (including through several failed proposals) before we gained support and funding. Our key argument was that the project would provide a tool to help industry respond to the raft of upcoming environmental legislation soon to affect the fishery. Legislation includes spatial management of all marine industries under Australia's Oceans Policy – a developing program of Regional Marine Planning that includes a National Representative System of Marine Protected Areas – as well as fishery specific "strategic environment impact assessments" that aim to support ecological sustainability. With their information systematically collected and rigorously evaluated, fishers would be positioned to critically evaluate proposed spatial management plans, such as the placement of MPAs, and require management agencies to have clearly defined and measurable aims for their proposed management options.

Interestingly, the peak industry bodies supported the project, at least in part, because they saw it as a mechanism for industry to be

actively engaged in the process of management planning, rather than just reacting to it. Our hope is that the project, by broadening industry understanding of the seascape they rely on, will encourage proactive thinking and actions from industry to enhance the sustainability of their fishery. In addition, the project provides industry with a tool for improving its public image. Presently, there is discontent and concern about what fishers see as poorly-informed and often misleading media and scientific reporting on interactions between fishing and the environment. This project will provide industry with some hard facts that they can use to demonstrate their real level of impact on the seascape – the trawl sector is particularly keen to be able to demonstrate that large areas of the fishery are untrawlable or untrawled.

The project is structured in a very transparent way to give fishers a high degree of control over the form in which information is released and the timing of various outputs. We have agreed that habitat maps of the area will be released following review by individual contributors and the relevant associations, and that these maps will include summary detail from commercially confidential information. Higher resolution maps of specific areas of interest, showing precisely the trawled and untrawled areas may also be released but these will require the approval of individual fishers.

The key processes and infrastructure of the project include:

- Project staff that are known and trusted by fishers - including consultants who have history and regular contact with the trawl and non-trawl sectors
- Data collection in ports and at sea
- Registration and strictly controlled storage of industry's information
- Rapid data acquisition and map-making by using raw track and mark data from fishing vessel trackplotters in conjuction with a GIS
- Collection of habitat attribute data (including terrain and bottom types, species mix and fishing patterns) using a questionnaire that was developed with industry help
- Verification and validation procedures to ensure data are scientifically rigorous
- Data management (spatial and attribute) and map production facilitated by a custom-designed spatial database
- A step-wise release of map products with clear arrangements for industry review and approval of maps prior to release
- A statement of arrangements and responsibilities of CSIRO and industry set out in a memorandum of understanding
- Field sampling from industry vessels - including photography with a high-tech camera system designed and built as part of the project
- Value adding with scientific survey data (geology/ oceanography/ video)
- Continued involvement of industry through the associations, and
- Involvement of a Steering Committee with cross-sector industry representation

Our approach is adaptive to a degree for two main reasons. First, it is difficult to determine what level of spatial scale and detail is acceptable for map outputs until data are collected and mapped. We have an explicit step-wise protocol for making, reviewing and releasing maps – but this has the flexibility to release maps at various resolutions depending on the specific needs and concerns of ourselves and industry. Secondly, the implementation of the new legislation for this fishery is evolving rapidly: the transition from conceptual to operational objectives may make demands on information that we have not anticipated. For that reason we have developed a comprehensive questionnaire, requiring the repeated involvement of active fishers. The resulting data will be available as new management approaches develop, thus allowing industry to have an input in their development, and managers to access information in a form that best addresses their specific management objectives.

Conclusions

Management for conservation, multiple-use or fishery goals will benefit from collaboration with the fishing industry because fishers know the seascape considerably better than other stakeholders, and they have a broad understanding of the processes that influence fishery productivity. As concisely stated by Neis (1995), "fishers deal regularly with a landscape that no one has seen". In addition, fishers potentially provide the means for cost-effective acquisition of mapping data over large areas, and they have an important stake in ensuring that any spatial management of the seabed is based on reliable information interpreted appropriately. Acquiring reliable data requires a structured, verifiable collection process, and methods to resolve conflicting information.

However, collaboration with industry is not limited to acquiring their data, but requires an ongoing dialogue if the data are to be interpreted

judiciously, and industry is to understand the value of any proposed management measures (Neis 1995). Developing maps of the seabed is one thing, but interpreting them to provide the basis for improved management of the fishery that accounts for the diversity and specialisation of fisher's daily activities is another. This is where the ongoing dialogue between the fishing industry and scientists really begins.

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REFERENCES

Allison, G.W., Lubchenco, J. and Carr, M.H. (1998). Marine reserves are necessary but not sufficient for marine conservation. Ecological Applications 8: S79-S92.

Bax, N. and Williams, A. (1999). Habitat and fisheries production in the South East Fishery. Final Report to the Fisheries Research and Development Corporation (FRDC) Project 94/040.

Bax, N., Williams, A., Davenport, S., and Bulman, C. (1999). Managing the Ecosystem by Leverage Points: a Model for a Multispecies Fishery. In 'Ecosystem Approaches for Fisheries Management'. Pp. 283-303. (Alaska Sea Grant College Program, AK-SG-99-01)

Bax, N.J., Burford, M., Clementson, L., and L., Davenport, S. (2001). Phytoplankton blooms and productivity on the south east Australian continental shelf. Marine and Freshwater Research, 52: 451-62.

Bax, N.J. and Williams, A. (2001). Seabed habitat on the southeast Australian continental shelf – context vulnerability and monitoring. Marine and Freshwater Research, 52: 491-512.

Bohnsack, J.A. (1996). Marine reserves, zoning, and the future of fishery management. Fisheries 21: 14-16.

Bulman, C.M., He, X., Bax, N.J. and Williams, A. (2001). Diets and trophic guilds of demersal fishes of the south-eastern Australian shelf. Marine and Freshwater Research, 52: 537-548.

Commonwealth of Australia. 1998. Australia's Oceans Policy, vols. 1 and 2. Canberra: Environment of Australia.

Garcia-Charton, J.A. and Perez-Ruzafa, A. (1999). Ecological heterogeneity and the evaluation of the effects of marine reserves. Fisheries Research 42, 1-20.

Kloser, R.J., Bax, N.J. Ryan, T., Williams, A., and Barker B.A. (2001a). Remote sensing of seabed types in the Australian South East Fishery – development and application of normal incident acoustic techniques and associated "ground truthing". Marine and Freshwater Research, 52: 473-489.

Kloser, R.K, Williams, A. and Butler, A.J. (2001b). Acoustic, biological and physical data seabed characterisation. Marine Biological and Resource Surveys of the South East Region, Progress Report 2 to the National Oceans Office.

Langton, R.W., Auster, P.J. and Schneider, D.C. (1995). A spatial and temporal perspective on research and management of groundfish in the northwest Atlantic. Reviews in Fisheries Science 3, 201-229.

Larcombe, J.W.P., McLoughlin, K.J. and Tilzey, R.D.J. (2001). Trawl operations in the South East Fishery, Australia: spatial distribution and intensity. Marine and Freshwater Research, 52: 419-430.

McNeill, S.E. (1994). The selection and design of marine protected areas: Australia as a case study. Biodiversity and Conservation 3: 586-605.

Norse, E.A. (1993). (Ed.) Global marine biodiversity: A strategy for building conservation into decision making. Island Press, Washington, DC.

Neis, B. (1995) Fisher's ecological knowledge and marine protected areas. In 'Marine Protected Areas and Sustainable Fisheries'. (Eds. N.L. Shackell and J.H.M. Willison). pp. 265-272 (Science and Management of Protected Areas Association, Novia Scotia, Canada.)

Prince, J., Baelde, P. and Wright. G. (1998). Synthesis of industry information on fishing patterns, technological change and the influence of oceanographic efdects on SEF fish stocks. Final Report to the Fisheries Research and Development Corporation (FRDC) Project 97/114.

Sainsbury, K., Haward, M., Kriwoken, L., Tsamenyi, M. and Ward T. (1997). Multiple Use Management in Australian Marine Environment: Principles, Definitions and Elements. Oceans Planning & Management; Issues Paper 1. Environment Australia, Canberra

Sakell, V. 2001. Australia's Oceans Policy: Moving forward. Paper presented to the Global Conference on Oceans and Coasts at Rio+10, December 3-7, 2001, UNESCO, Paris, France.

Tilzey, R.D.J. and Rowling, K.R. (2001). History of Australia's South East Fishery: a scientist's perspective. Marine and Freshwater Research, 52: 361-375.

Williams, A. and Bax, N. (2001). Delineating fish-habitat associations for spatially-based management: an example from the south-eastern Australian continental shelf. Marine and Freshwater Research, 52: 513-536.

Sustainability Vectors as Guides in Fisheries Management: with examples from net fisheries in the Philippines and Australia

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Abstract

Catch data provided by fishers, when transformed into 'sustainability vector' format, provide a broad picture of the status of fishery resources. These sustainability vectors were developed to evaluate the status of net fisheries at three fishing areas in central Visayas, Philippines and three fishing areas in north Queensland, Australia. Magnitude and direction were the two properties of a vector used. The annual catch was used as the magnitude. The length of each vector was expressed as mean annual catch per family in kg/yr. The direction of a vector was represented by the catch trend. This parameter was measured on a five-point Likert scale, from rapidly increasing to rapidly declining. The catch trends for the net fisheries were only increasing in lower Burdekin, Australia and Apo Island, Philippines. It is speculated that the fishers of Apo Island reported a high annual catch possibly due to a genuine increase in yield as a result of the established fish sanctuary. The increasing catch trend in the lower Burdekin may be due to relatively underexploited fishery resources and/or lesser competition with other fisher groups.

Sustainability vectors may be used as a handy guide for busy fisheries managers and administrators. In their present format, sustainability vectors provide the following information at the taxonomic family level: annual catch, catch trend, proportion relative to the total catch, and fishing gear used. The concept may be improved by incorporating other parameters, such as actual fishing effort, economic value of particular species and natural variations in fish population.

Introduction

One of the crucial problems in fisheries management in the tropics is the difficulty in evaluating whether or not a certain form of management is effective. For example, can it be stated that fisheries management in state X or village Y is successful? Such a question cannot be easily answered with a straightforward 'yes' or 'no'. In fact, the answer will vary if the question is posed to a fisheries manager, a practising fisher, or to an environmental lobbyist. All of these stakeholders have different perspectives of success. The evaluation of fisheries management is controversial, because it is enmeshed in the political process and affected by the subjectivity of the evaluators.

A major constraint in evaluation is the lack of valid or reliable indicators to measure either success or failure of a given fisheries management system (Smith 1996; Staples 1996b; Sainsbury *et al.* 1999). There have been attempts to construct more reliable sets of management indicators. The 1996 World Fisheries Congress (Hancock *et al.* 1996), the 1999 Australia-FAO Technical Consultation on Sustainability Indicators in Marine Capture Fisheries (FAO 1999), and the 1999 Workshop on Performance Indicators for the Great Barrier Reef (Dinesen 1999) were among the key attempts to identify indicators for a comprehensive evaluation of fisheries management programs. Unfortunately, these efforts have led to the proliferation of jargon associated with the term indicator. These included fisheries 'sustainability' indicators (Garcia 1996); 'reference points' for fisheries management (Caddy and Mahon 1995); 'barometer' of sustainability (IUCN 1997); and 'performance' indicators in the context of recreational fisheries (Kirkegaard and Gartside 1998). The significance of using reliable indicators for evaluating fisheries resource management systems is paramount as "the choice of indicator or focus will be critical to the social construction of the problem, maintaining diversity and resilience of ecosystems for sustainable fisheries" (Hammer 1995 p 147).

The critical state of fisheries management in the tropics cannot be understated (FAO 1994; ADB 1995) with overfishing an overriding issue (Pauly and Chua 1988). Wilkinson (1994) describes the worsening situation of the fisheries and other coastal resources in tropical Asia. Fisheries are crucial to the economies of both Australia (a developed country) and the Philippines (a developing country); however, there are contrasting details. There are about 10,000 commercial fishing vessels in Australia (Zann

1995), and 200 different types of fish and 60 species of crustaceans are harvested (Kailola *et al*. 1993). The "value of commercial fisheries production is estimated at A$1.8 billion per annum" (Commonwealth of Australia 1998, p 9) and the average seafood consumption is 12 kg/capita/year (Zann 1995). Fishing is comparatively economically more important in the Philippines because it is often the employer of last resort. The 1994 marine fisheries landings were 1.67 million tons (62% of total fisheries production from all sources) valued at US$1.65 billion, and the 172,000 tons exported were valued at US$578 million (BFAR 1995). Fish consumption is high at 28.5 kg/capita/year (Barut *et al*. 1997), more than twice the Australian average.

The governments of both countries are actively seeking the participation of fishers in management. This type of partnership between the government and the fishers is often called fisheries co-management and/or cooperative management (McGoodwin 1992; Pinkerton 1993; Pomeroy 1993; Sen and Nielsen 1996). It is argued that one advantage of a co-management system is that it effectively utilizes indigenous and non-expert knowledge (McCay 1993). Many governments in the tropics are now moving towards some form of co-management in the administration of their marine fisheries. Part of the institutional strengthening is the formation of Fisheries and Aquatic Management Councils (FARMCs) in the Philippines and the Management Advisory Committees (MACs) in Australia. A thrust of co-management is involving the fishers themselves, who may become partners for collecting and analysing data for the monitoring of fish stocks (World Bank 1993).

The information derived from fishers through social surveys, however, has been contentious in at least two aspects. The first is in terms of reliability. To what extent the information supplied by fishers can be relied upon has been the subject of intense debate between scientists. Many 'hard-nosed' fishery biologists would not accept the data from fishers because of statistical imprecision, or due to lack of a proper sampling design in data collection. On the other hand, many social scientists argue that the knowledge of fishers could be readily used for practical management. For example, Johannes (1981, 1998a) argues that the knowledge of fishers is even encyclopaedic in some areas; Starr and Fox (1996) report that commercial fishers' log book data on fish distribution and abundance are comparable to results from a research survey; Berkes (1994) contends that the local knowledge of fishers is useable because it has been accumulated from observation over many generations. The second aspect of the debate is how to present the information fishers provide in a way that could be useful to both researchers and policy makers. 'Sustainability' has become a byword in marine fisheries. Fishers are encouraged to become involved in achieving it. Yet there is a conspicuous lack of indicators that enable 'sustainability' to be assessed in practical fisheries management. Sustainability - which has over 100 definitions since popularised by the Brundtland Commission in 1987 - is a contentious issue because it is difficult to define in practical terms, and the expansion of the concept beyond fishing income and conservation of fish stocks is fairly recent. These indicators should be able to determine whether the fisheries are better or worse compared with some earlier point in time Pitcher (2001) argues that in depleted systems, 'sustainability' is the wrong goal – all we are doing compared to past abundance levels, is 'sustaining the present misery'. A measure of successful management is the fact that the natural resource (in this case fisheries) has not been squandered (Bromley 1992).

The objective of this paper is to compare the sustainability of net fisheries at selected study sites in the Philippines and Australia. The bases of evaluation are the reported annual catch and catch trends of fishers, through a social survey. These data sets are transformed into sustainability vectors. This study evaluates the comparability of data supplied by fishers, with the existing ecological and fishery literature, as well as view of experts. Any data collection scheme involving fisher groups should be designed in such a manner as to allow appropriate checks for verification.

METHODS

Sampling design

This study adopted a purposive (non-probability) sampling in the selection of fisher respondents. The social survey was limited to only three fisher groups in each country (see Fig.1). Hence, a total of six fisher groups was purposively selected. A census or 100% enumeration was attempted in each of the six fisher groups. Three criteria were used for selection of the fisher groups. First, the fishers were operating in marine areas under some form of marine protected area (MPA) status such as marine parks, marine reserves, fisheries habitat reserves, or fish sanctuaries. Secondly, the fishers were willing to participate by completing

the questionnaire form themselves, or through a guided interview. Thirdly, secondary information on fish catch was available to which the responses of the fishers could be compared.

In an experimental sense, the six study sites were nested: three within each country. The design, in the context of social research, was a 'retrospective panel design' (de Vaus 1993). As such, the fishers were asked about their beliefs or perceptions about the status of fisheries management across two time periods: past and present.

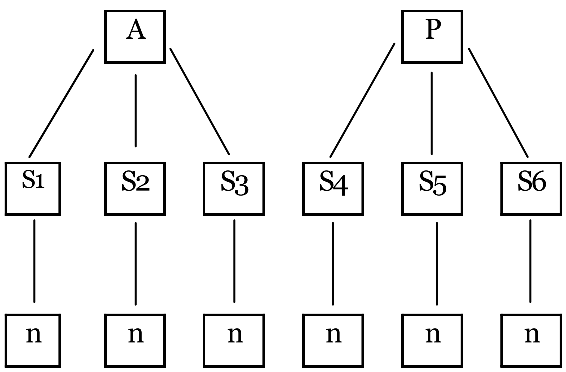

Fig. 1. Sampling design of the social survey respondents. (A = Australia; P = Philippines; S = study sites; n = number of respondents)

Respondents and study sites

A total of 351 occupational fishers participated in the social survey: 241 from the Philippines and 110 from Australia (Table 1). The number of active fishers, i.e., those currently fishing at the time of the study in 1997/98, served as the base figure for the population (N). The percent of samples was calculated by simply dividing the population size (N) by the sample size (n), and then multiplying by 100./.;

The three study sites selected in Australia were all part of north Queensland's Great Barrier Reef Marine Park (GBRMP) within the Great Barrier Reef region (Fig. 2). The GBRMP's inshore areas in the central section are adjacent to the Townsville/Whitsunday Marine Park, a Queensland state marine park. In effect, the study sites in Australia are mixtures of multiple use marine parks and fish sanctuaries because north Queensland's coast is under various forms of MPA status. These sites were selected based on their geographical proximity to the location of the Queensland Commercial Fishermen's Organisation (QCFO), a formal organization where all licensed commercial fishermen (those who earn a living through fishing) are required to become members. These sites are also called 'management areas,' adopting the term used for the Townsville/Whitsunday Marine Park (QNPWS 1987). It was assumed that most QCFO fishers operated near their place of residence. Site 1 (Hinchinbrook Management Area) included the adjacent Family and Palm Islands, as well as the inshore areas of Rockingham and Halifax bays. The QCFO Branch 6 is based in Lucinda. Site 2 was the Magnetic Island Management Area including Pallarenda and Cleveland bay. The QCFO Branch 7 is based in Townsville. Site 3 was Bowling Green Bay Management Area including the adjacent Cape Upstart. The QCFO Branch 8 is based in lower Burdekin.

The three study sites in the Philippines were all situated in the Central Visayan region (Fig. 3). Site 4 was Apo Island, a 74-ha volcanic island situated in the Mindanao Sea off the southeastern coast of Negros Island. A 1.5-km^2 reef area surrounds it. Apo Island was established as a marine reserve in 1986. Site 5 was Pamilacan Island, a coralline island with about 200 hectares of land area. It is about 10 km south of the town of Baclayon in the southern main island of Bohol. Its 1.80 km^2 fringing reef area is mostly flat and gradually sloping. Pamilacan Island was established as a marine reserve area in 1985. The first two sites were considered as inshore 'small' islands. Site Area 6 was Capinahan, a coastal village in the city of Bais in the eastern coast of the main island of Negros. The coastal region has a mixture of coral reefs, seagrass beds, mangroves, and soft-bottom communities. It was established as a marine protected area and fish sanctuary in 1992. The three Philippine sites are comparable to the Queensland sites in terms of proximity of small islands to the mainland coast, and are similar in some marine habitats such as mangroves and sea grass beds. However, Queensland and Filipino fishers differ significantly in socio-economic conditions, such as population pressure and the relative economic prosperity.

Data collection techniques

A questionnaire was used to collect the social survey data. The study was conducted between May 1997 and June 1998. The substantive content of the Filipino and Australian questionnaires was identical. The Australian questionnaire was written in English but the Filipino questionnaire was translated into Cebuano, the dialect of the central Philippines. This paper focuses on the responses of Australian and Filipino fishers regarding volume of catch and catch trend in net fisheries.

Close to two-thirds of the questionnaires were completed through guided interview while the rest were completed by the fishers themselves.

Table 1. Summary of fisher groups for social survey.

Country	Fishing area	No. Active Fishers (N)	Sample size (n)	Sample as % of all fishers (n/N)
Australia	Site 1: Hinchinbrook Management Area	49	31	63%
	Site 2: Magnetic Island Management Area	120	68	57%
	Site 3: Bowling Green Bay Management Area	16	11	69%
	Australian Sub-total=	***185***	***110***	***59%***
Philippines	Site 4: Apo Island Marine Reserve	90	73	81%
	Site 5: Pamilacan Marine Reserve Area	140	80	57%
	Site 6: Capinahan Fish Sanctuary	130	88	68%
	Philippine Sub-total=	***360***	***241***	***67%***

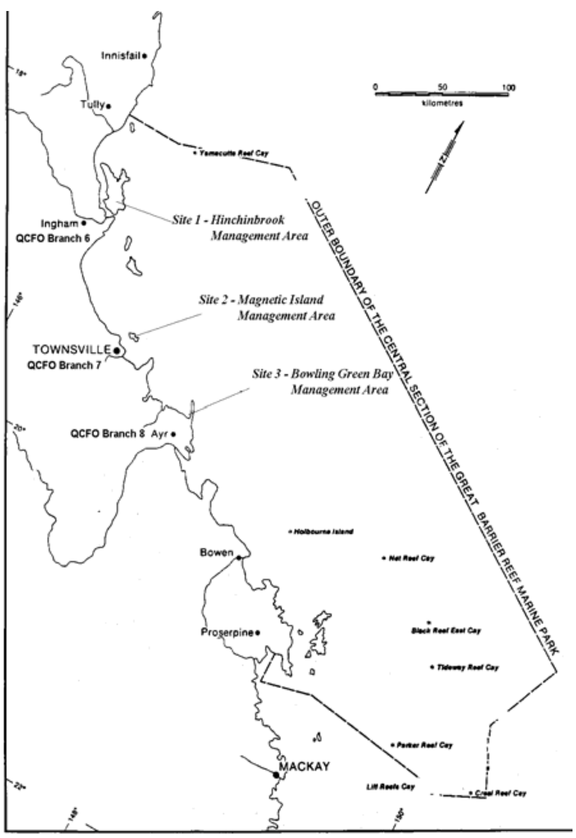

Fig. 2. Location of three study sites in the Great Barrier Region of North Queensland, Australia.

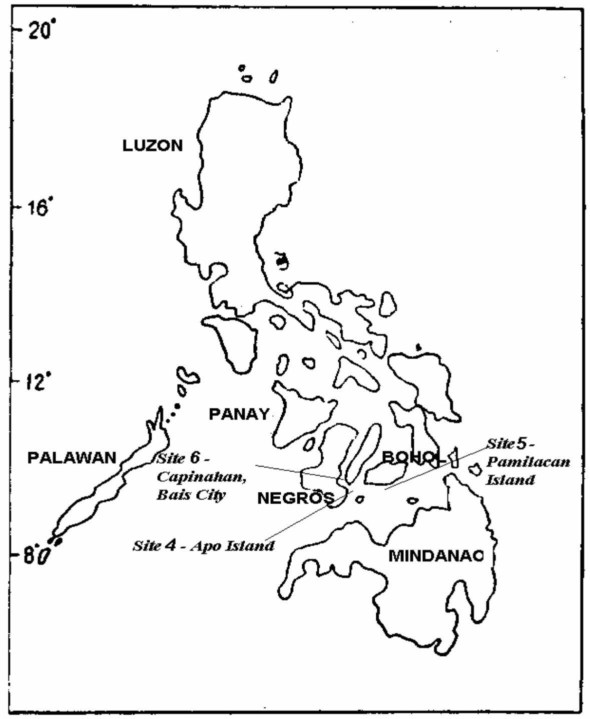

Fig. 3. Location of three study sites in central Visayan region, Philippines.

Data analysis

A series of data analyses was undertaken to compare the sustainability of net fisheries in the six study sites in terms of annual catch[1] and catch trends (measured on the five-point Likert Scale from rapidly increasing to rapidly declining). To compare the net catch per year per fisher differ between countries and between study sites, the data were organized in three ways. First, the types of fish caught using nets were classified in an upward taxonomic hierarchy, species, genus, and family. Second, the reported annual catch of each fisher by species was tabulated. Third, an ANOVA was performed to determine if the differences between countries and between sites were significant. The design was a Nested Two-factor ANOVA, with one factor nested inside the other with replicates. Hence, the six sites were nested, three sites within each country. The country was treated as a fixed factor while the site was treated as a random factor. The dependent variable was the annual catch (kg/yr) of fishers using nets.

To determine if there is a pattern in catch trend for net fisheries between the six study sites, the data were analyzed in three ways. First, the annual catch and catch trends for net were summarised at the species level. Second, this information was aggregated at the taxonomic level of a family. For example, narrow-barred Spanish mackerel (*Scomberomorus commerson*), school mackerel (*Scomberomorus queenslandicus*), and grey mackerel (*Scomberomorus munroi*) are three different species but they all belong to the family Scombridae. Third, the combined annual catch and catch trend data sets were presented in terms of sustainability 'vectors'.

A vector is an entity that has two properties: magnitude and direction. In this case, the annual catch was used as the magnitude. The length of each vector was expressed as the mean or average annual catch per family. This was measured on an interval scale, expressed as kg/yr. The information was aggregated at the family level to simplify the presentation. Some families are represented by a single species, such as barramundi (*Lates calcarifer*) for the family Centropomidae, while Lutjanidae is comprised of various species of snappers. As an example of the vector's magnitude (or length of the line), the net fishers at Hinchinbrook region (Site 1) reported a total annual catch of 31,559 kg for family Scombridae (mackerel). There was a total of 15 responses or entries for all species belonging to this family. Hence, the mean annual catch for Scombridae was 2,104 kg/yr, obtained by dividing 31,559 kg by 15 responses. The length of the vector was then represented by the mean value of 2,104 kg.

The direction of the vector was represented by the catch trend. Similar to annual catch, a catch trend was aggregated at the family level. Each species has distinct values for annual catch and catch trend. The original five categories of a catch trend in ordinal scale were given values as follows: 1 = rapidly declining; 2 = slowly declining; 3 = no change; 4 = slowly increasing; and 5 = rapidly increasing. This is graphically represented in Fig. 4. The zero value is the point of origin. A vector exactly along this zero point means the catch trend is constant or no change, i.e., a value of 3. Anything above this horizontal zero line means the catch trend is increasing, while all vectors below indicate a declining catch trend. This model assumes that the difference in fisher's perception about a catch trend between the ordinal categories is the same. Hence, the angles corresponded to the five ordinal scales as follows: 5 = 0 degree; 4 = 45 degrees; 3 = 90 degrees; 2 = 135 degrees; and 1 = 180 degrees. Therefore, the difference in angle from no change (= 3) to slowly increasing (= 4) is 45 degrees. Consequently, the difference in angle from no change (= 3) to slowly declining (= 2) is also equal to 45 degrees.

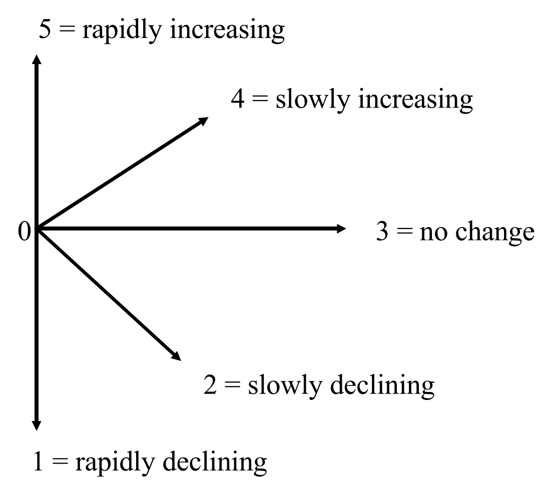

Fig. 4. Graphical representation of catch trend.

[1] Only the value for annual catch in terms of kg/yr was supplied by the fishers in the questionnaire. The Philippine fishers estimated this value for each species they caught by recalling their typical daily catch, and then multiplied by their total number of days fishing in a year. Queensland fishers, used the annual summary in their fishing log books. The kg/yr as a parameter says something about the value of the fish with respect to the fisher's annual income. It is acknowledged, however, that it is not a good measure of fish abundance without detailed information, such as number of hours and length of net, as indicators of actual fishing effort. As a social research project, this study simply aimed to look at general patterns of sustainability of the fisheries through reported annual catch and catch trends of fishers.

Fig. 5 presents a schematic of combined annual catch and catch trends for five families of fish. The length of the vector represents the mean annual catch, while the direction of the vector (from 0 to 180 degrees) signifies the catch trend. In this framework, the highest mean annual catch is for family Priacanthidae but its catch trend is constant or no change (= 3). The direction of the vector for Priacanthidae indicates either the catch trends for all species belonging to this family are all no change (= 3), or a combination of catch trends from 1 (rapidly declining) through 5 (rapidly increasing) but the average or mean value is equal to three. The lowest mean annual catch is for the family Scaridae; however, its catch trend is rapidly increasing (= 5). Although the family Pomacentridae has the worst catch trend (= 1), its mean annual catch or yield is still higher when compared with the families Scaridae and Siganidae. Going back to the Hinchinbrook example, the catch trend for the family Scombridae had a mean value of 2.79. Since this value is below 3 (no change), the overall catch trend for this family was declining. It implies that most fishers in this region perceived that their catches using net were declining for mackerel. Therefore, the direction of the vector for Scombridae (given its mean trend value of 2.79) is below Priacanthidae, which has a trend value of 3.

RESULTS

A summary of net fisheries between the six study sites is given in Table 2. Table 3 shows the reported catch of gill netters. There are more varieties of fish caught in the Philippines at all taxonomic levels across all sites. Overall, the mean annual catch in Australia was higher compared with the Philippines. An ANOVA was performed to determine if the differences between countries and between sites were significant. The ANOVA results show that the annual catch between gill netters differed significantly between sites. However, the difference between Australia and the Philippines was not significant. There was no difference between the two countries because the Apo Island fishers, one of the three Philippine sites, reported a similar annual catch to the three Australian fisher groups (Table 4). This was confirmed by post-hoc analysis, showing that the Philippine fisher groups from Capinahan and Pamilacan Island reported similar annual catches, which were significantly different from the Apo Island fishers and the three Australian fisher groups.

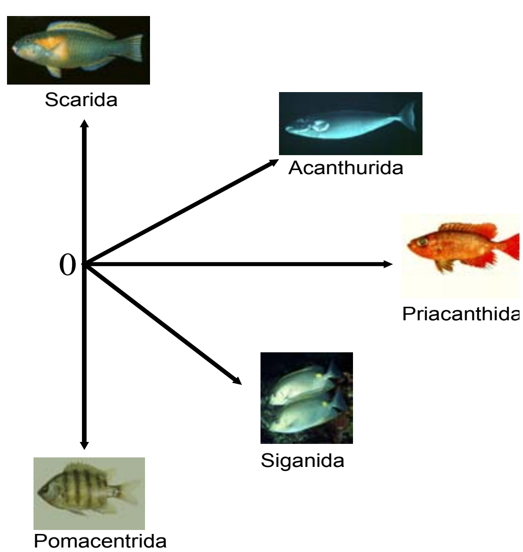

Fig. 5. Combined schematic of annual catch and catch trend.

Table 2: Comparative annual catch of gill netters at six study sites

Country	Site number and site name	Total annual catch (kg/yr)	Number of fishers	Mean annual catch/fisher (kg/yr)
Australia	1 - Hinchinbrook	93481	17	5499
	2 - Townsville	165770	13	12752
	3 - lower Burdekin	90563	9	10063
Philippines	4 - Apo Island	201682	29	6955
	5 - Pamilacan Island	44047	24	1835
	6 - Capinahan	66649	49	1360

Table 3: Count by taxonomic grouping of fish caught by net at six study sites

Country	Site number and site name	Family	Genus	Species
Australia	1 - Hinchinbrook	10	13	17
	2 - Townsville	9	11	15
	3 - lower Burdekin	12	14	16
Philippines	4 - Apo Island	14	21	28
	5 - Pamilacan Island	20	27	45
	6 - Capinahan	23	31	38

Table 4: ANOVA of annual catch (kg/yr) of net fishers between countries and sites.

Source of variation	Sum of squares	df	Mean square	F	Sig.
Country	10.598	1	10.598	4.032	.112
Site (Country)	13.214	4	3.303	13.003	.000
Error	34.298	135	.254		

Comparison of net catch trend

Sets of sustainability vectors[2] were constructed to determine if there was a pattern in catch trend for net fisheries between the six study sites" The vectors for the three Australian sites are given in Figs. 5 through 7. The results of catch trend for net fisheries in the three Queensland sites are contrasting. All families in Hinchinbrook and Townsville were declining, while most families in lower Burdekin were increasing. The vectors for the three Philippine sites are presented in Figs. 8 to 10. The results are mixed: the Apo Island fishers reported an increasing catch trend, while the fishers from the two other sites reported a declining catch trend.

Note: % of catch based on total of 93,481 kg.

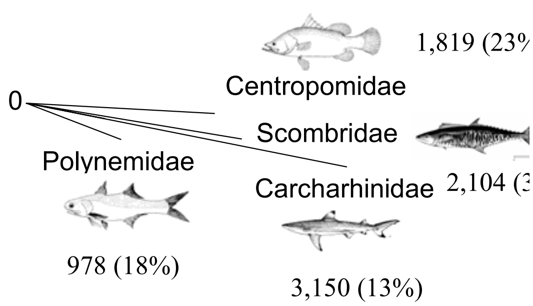

Figure 5. Sustainability vectors of major families caugh net fishers from Hinchinbrook, Australia.

Note: % of catch based on total of 165,770 kg.

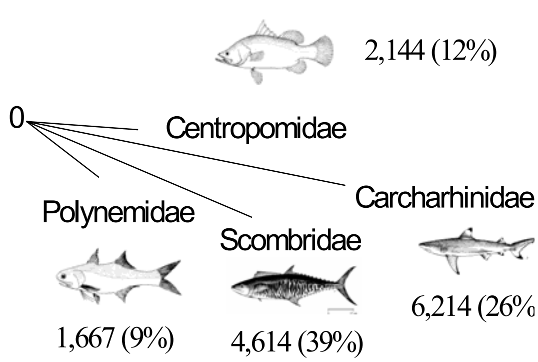

Figure 6. Sustainability vectors of major families cau net fishers from Townsville, Australia.

Note: % of catch based on total of 90,563 kg.

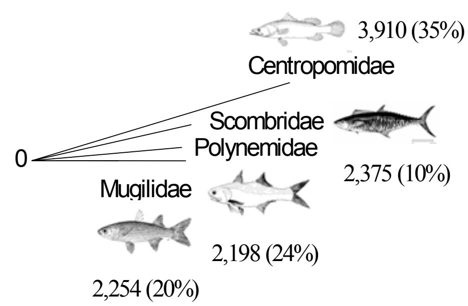

Figure 7. Sustainability vectors of major families caught by net fishers from lower Burdekin, Australia.

Note: % of catch based on total of 201,682 kg.

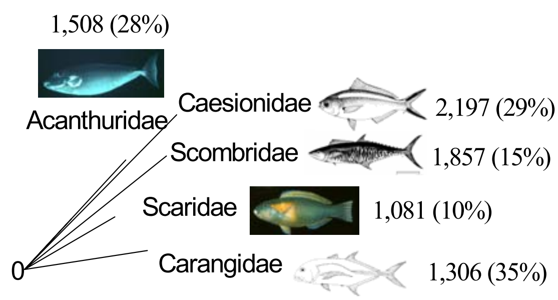

Figure 8: Sustainability vectors of major families caught by net fishers from Apo Island, Philippines.

Note: % of catch based on total of 44,047 kg.

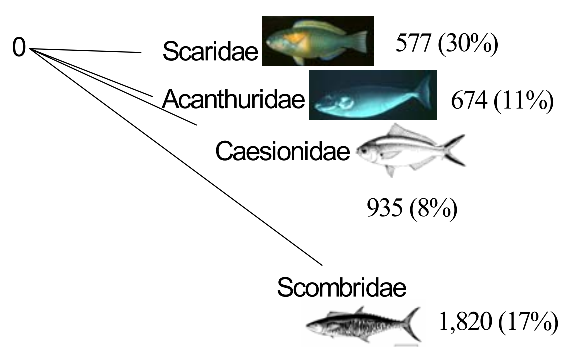

Figure 9. Sustainability vectors of major families caught by net fishers from Pamilacan Island, Philippines.

Note: % of catch based on total of 66,649 kg.

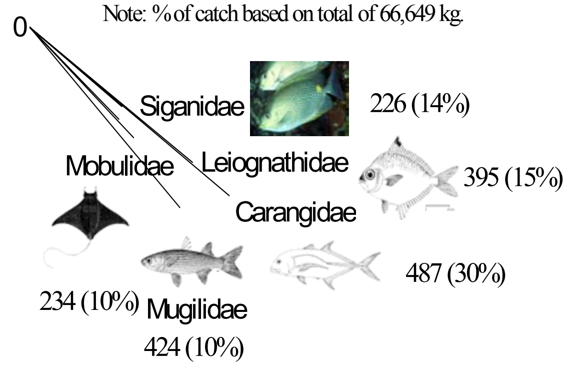

Figure 10. Sustainability vectors of major families caught by net fishers from Capinahan, Philippines.

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[2] The elements of the sustainability 'vectors' are recapitulated. The length of the vector is equivalent to the mean annual catch per family. As such, the magnitude of a vector is measured in kg/yr. The direction of a vector along horizontal zero line means the catch trend for that family of fish is constant or no change. If the direction is above the horizontal zero line, it indicates an increasing catch trend; if it is below the horizontal zero line, the interpretation is a declining catch trend. The percentage in bracket refers to the proportion of catch for that family in relation to the total catch for a particular fishing gear. The figure would not add up to 100% because only the major families are represented. There are 6 vectors in all to compare the catch trends: six for net fisheries (Figs. 5 through 10).

DISCUSSION

Comparison of annual catch using net

It is difficult to interpret, from the angle of coastal marine habitat, why there were more species of fish caught using nets in the Philippines than in Australia (Table 3). The gill netters operated in different marine habitats, hence, it is difficult to make a conjecture about species diversity between the two countries. The three Australian fisher groups operated in estuarine environments. In the Philippines, however, the fishers of Apo and Pamilacan Islands were netting in coral reef areas, while the fishers of Capinahan operated in mixed estuarine and coral reef environments. Netting is permitted in the Philippine reefs but not in Australian reefs. Therefore, the most logical reason for the difference is that there are few commercially exploited species for net fisheries in Australia. The major species that comprise the bulk of net catch are barramundi (Centropomidae), black tip shark (Carcharhinidae), sea and flat-tail mullets (Mugilidae), blue and king threadfins (Polynemidae), and grey and school mackerels (Scombridae). Other species caught in the net, which cannot be sold in the market, are thrown back to the sea as discards or trash fish. There may be more species 'caught', compared with those species of fish 'caught and kept' for commercial trading (M. Bishop pers comm).

In the Philippines, there is no discrimination in gear catch (FSP-PMO 1991). Everything caught in the net, which includes the juveniles and non-target species, is utilised. The catch that cannot be eaten is transformed into other economic uses such as animal feed. Although all the six fisher groups used nets, a between country and between site comparison is difficult due to the difference in target species, and the difference in habitats where the fishers operated.

The unexpected ANOVA results (Table 4) indicated that the annual catch (kg/yr) of gill netters differed significantly between sites but not between countries. Although different species of fish were involved, the mean annual catch for the three Australian sites was anticipated to be higher in comparison with the three Philippine sites. Hence, the predicted difference between the two countries would be significant. The expected higher annual catch in the three Queensland sites is due to the following reasons: there were fewer commercial fishers; they used motorised boats and sophisticated equipment such as fish finders; the estuarine marine habitats where they operated, such as mangrove and sea grass beds, were generally intact; the quality of marine waters overall was high; and the target species were not classified as over exploited. The post-hoc analysis revealed that the reported annual catch was not statistically significant between the two countries because of data sets provided by the Apo Island fishers. The mean annual catch (see Table 2) for an Apo Island netter was 6,955 kg/yr, even higher than their counterpart in Hinchinbrook who reported an average annual catch of 5,499 kg/yr. If the Apo Island netters had reported a mean annual catch comparable with the two other Filipino fisher groups (1,835 kg/yr in Pamilacan Island and 1,360 kg/yr in Capinahan), there would have been a significant difference between the two countries.

Several reasons may be suggested to explain why the fishers at Apo Island reported higher annual catch compared with the fishers at Pamilacan Island and Capinahan. First, there might have been a genuine increase in fish yield in their fishing grounds. In 1985, a fish sanctuary (no fishing zone) was established as a component of the Apo Island Marine Reserve. Before 1985, the reefs surrounding the island were subjected to destructive fishing practices, such as the use of dynamite and cyanide. With the establishment of the Marine Reserve, however, such destructive fishing techniques were totally stopped. The members of the local community were also able to keep the sanctuary free from fishing activities. There are empirical studies that support the increase in diversity and density of the species within the sanctuary (Alcala and Russ 1990; Russ and Alcala 1996a, 1996b, 1999). The adult fish populations from the sanctuary could have easily migrated (spillover effect) into the fishing zones. Given such increases in abundance of the target species, it is logical for the fishers to report an increase in their yield.

Secondly, the reef of Apo Island may have higher natural productivity compared with the two other reefs. Russ (1991) notes that the yields of fishes from actively growing coral reef vary from as low as 5.0 kg/yr/km^2 in Port Moresby, Papua New Guinea to as high as 36.9 kg/yr/km^2 in Sumilon Island, the Philippines. There are more genera of corals and fishes in Apo Island compared with Pamilacan Island (White and Savina 1987; White 1988b). Salm (1984) argues that the ecological boundaries for coral reef reserves should be properly delineated so that their contribution to the conservation of fisheries and other coastal resources can be properly evaluated. Thirdly, the fishers might have reported the upper range of their catch, ie, the days when they had good catch. Since their catch

per day was multiplied by the total number of days they fished in a year, their annual catch (kg/yr) could easily be overestimated. Bellwood (1988) reported that the sustainable yield of reef fishes in Apo Island was around 24,860 kg/yr/km². Since the extent of the reef is only about 1.5 km², the theoretical catch could only be around 37,290 kg/yr. If we calculate the yield using the productivity figure of 36.9 kg/yr/km² in Sumilon Island (Alcala 1981), the yield would be higher at about 55,350 kg/yr. The gill netters, however, recounted a total yield of 287,354 kg/yr using net. This figure is an overestimation when compared with the two other estimates from the literature. The fishers of Apo Island may have also overestimated their catch by recalling only the days when they had a good harvest. There could have been double or triple counting of catch. Most fishers undertake netting or line fishing in groups, ranging from 2-5 people in a boat. Hence, fisher Y could have also reported the catch reported by fisher X from the same boat.

Comparison of net catch trend

The results (Figs. 5 through 10) for the catch trends of major families of fish using net were mixed. Some results were supported by the literature while others were in contrast to logic. In theory, because the six fisher groups were fishing in areas with various forms of MPAs, it is anticipated that the catch trend for the major families would be at least stable. This assumption holds true for the lower Burdekin (Fig. 7), one of the three Queensland sites. The reported catch trend was stable for Mugilidae, and increasing for Centropomidae, Polynemidae, and Scombridae. The reported catch trends for major families for the Townsville (Fig.6) and Hinchinbrook (Fig. 5) regions, however, were all declining. The catch trend for some families in these two other sites were consistent with the findings of Ludescher (1997) about the decline of some fishery resources in north Queensland. Some of the species in decline are sharks (Carcharhinidae), blue salmon (Polynemidae), and grey mackerel (Scombridae). It is possible that the regional differences for catch trends between the three sites might be attributed to the smaller number of active fishers in the lower Burdekin (16 fishers) compared with 49 fishers in Hinchinbrook and 120 fishers in Townsville. There are also more recreational anglers in the Hinchinbrook and Townsville districts who compete with professional fishers for potential catch. Some ecological factors may also favour recruitment and growth in the lower Burdekin area.

It is difficult to evaluate the contribution of the GBRMP and State Marine Parks to the sustainability of fishery resources in the three Australian sites (Robertson 1997, p 397). These MPAs have 'green zones' (no fishing areas) scattered all over the coast of Queensland. In addition to these marine parks, there are several riverine and estuarine Declared Fish Habitat Areas (Mayer and Beumer 1993; Zeller and Beumer 1996). Except for the project on the 'Effects of Line Fishing on the Great Barrier Reef' (Mapstone *et al.* 1997), however, there is no other literature that provides a quantitative estimate on how these MPAs contribute to improved fisheries management by providing habitats to juveniles. Due to the wide geographical coverage of the three study sites, it is also difficult to assess if there are spillover effect or migrations of adult populations from the 'green zones' to the multiple use fishing zones. Tanzer *et al.* (1997 p 306) added that "whether this should be interpreted as the result of management interventions that have been in place or as a function of the large area of the Great Barrier Reef fisheries and the relatively low effort per unit area to date is a matter of conjecture and opinion."

In the Philippines, only the fishers of Apo Island (Fig. 8) reported increasing catch trends for major families. As described earlier, this perceived increasing catch trend might be attributed to a genuine increase in yield due to the establishment of the fish sanctuary. In the cases of Pamilacan Island (Fig. 9) and Capinahan (Fig. 10), catch trends have declined for the major species. It appears that while the MPAs may have eliminated destructive practices, such as dynamite and cyanide fishing, and have contributed to the conservation of the coastal habitats, the fishing effort outside the reserves remains uncontrolled. In Pamilacan Island, there are more young people entering the fisheries than adults moving out (C. Valeroso pers comm). Hence, whatever contribution the reserve provides in terms of spillover effects to the fishing zone is negated by the continuous increase in fishing effort. The fish sanctuary in Capinahan had only been established for five years at the time of the study. Hence, the sanctuary may not as yet have had an impact on the fisheries in terms of larval dispersal or migration of adult population.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

This study provides an avenue along which to reassess sustainability of fishery resources in terms of annual catch and catch trends. In a

comparative sense, Queensland has one of the best catch statistics datasets for commercial fisheries throughout the world. Yet Williams and Russ (1994) in their review of the catch information about commercial line fisheries in the GBR region acknowledged the difficulty in comparing databases collected through varying methodologies by different researchers. The problem of objective evaluation is further accentuated by data gaps at certain time periods. The database for commercial fishing (known as CFISH) officially started in 1998 when commercial fishers were required to enter a summary of their fishing activity by location, effort, and landed weight by species in their logbooks (Trainor 1991). Under this database system, Queensland waters were partitioned into bands of 30 nautical miles width. However, the annual catch information provided by fisher respondents in this study could not be readily compared with the CFISH database. Although the CFISH database provides information by species, gear, time, and geography, it does not organize the information in terms of fishing area. For example, the datasets on annual catch and catch trends were aggregated based on the geographic location of the QCFO branch. The net fishers from Hinchinbrook (QCFO Branch 6) reported a total net catch of 93,481 kg/yr. These netters, however, fished up to Tully in the north and down to Cape Upstart in the south. What is reflected in the CFISH data base are reported catches for the Hinchinbrook region by species, gear, and year, but not the identity of the fisher groups who reported the information. Some of these catch records, then, may have been reported by the Townsville fishers (QCFO Branch 7) or lower Burdekin fishers (QCFO Branch 8). This study illustrates the difficulty of assessing the sustainability of the fishery resources when variables such as time, location of fishing grounds, gear, species caught, and geographic mobility of the fishers groups are incorporated in the analysis.

Validation of the catch statistics provided by the Filipino fishers is even more difficult. Unlike Queensland, the Philippines has not yet established computerized records of CPUE in fisheries. Hence, the reported annual catch and catch trends could only be compared in two ways. The first is by comparison based on certain standards, e.g., established range of fish yield (kg/yr/km^2) from actively growing coral reefs. For instance, the reported annual catches of fishers from Apo and Pamilacan Islands were higher compared with the productivity of 36.9 kg/yr/km^2 in Sumilon Island (Alcala 1981), a similar small island in the region. The variation is difficult to quantify, however, because the fishers combined their catch in the reef with the non-reef catch such as small pelagics. The secondly is to seek the opinion of experts in the field to validate the data sets of fishers. The annual catch provided by net and line fishers in three Queensland sites were reasonable (M. Bishop pers comm). The situation is more complicated in the Philippines, particularly Capinahan (Site 6), because the fishers operated in a variety of marine habitats. Although their reported annual catch and catch trends were reasonable (G. Russ pers comm), it is difficult to correlate their yield with the productivity of the marine habitats where they operated. It is stressed that the data provided by fishers in terms of annual catch and catch trends were based on their perceptions. While this information is useful in providing a 'broad picture' of the sustainability of the fishery resources, it must be correlated with other relevant variables such as number of days fishing, length of net, natural variation in fish population and conditions of fish habitats.

This study recognizes the difficulty in understanding the sustainability of marine fisheries solely in terms of annual catch and catch trends. This information is difficult to collect, even for trained biologists. Such data should be collected systematically over a long period of time, in order to discern significant patterns of use. Research of this nature also requires robust sampling designs, to be able to establish generalizations or make unequivocal statements about cause-effect relationships. In this social study, the datasets obtained for annual catch and catch trend were derived solely from the perceptions of the fisher groups. Many of the results were supported by the literature or were theoretically plausible. On the other hand, the annual catch information supplied by the Apo Island fishers in particular was biologically improbable. Although there are studies which indicate that the perceptions of the fishers were either close to established knowledge (Johannes 1981), or consistent with information collected by the scientists, such as catch estimates for trawling (Starr and Fox 1996), this does not necessarily apply to this study, due to the mixed results. What may be concluded is that the data provided by fishers in terms of annual catch and catch trends were excellent 'starting points' for providing a general pattern of the sustainability of the fishery resources. This information will only become more useful, however, when correlated with other variables related to fishing effort. Sustainability should also be contextualized in terms of comparative

differences between the two countries, such as the density of fishers and the types of gear used.

The catch statistics supplied by fishers, when transformed into formats similar to sustainability vectors, may be used as a guide for fisheries managers and administrators. In its present format, a sustainability vector provides the following information at the taxonomic level of family: annual catch, catch trend, proportion relative to the total catch, and fishing gear used. It does not yet include other variables related to the actual fishing effort, such as number of days fishing, length of net, and number of boats. In addition to the incorporation of such variables, several recommendations are proposed to improve the present format of the vector. The first is to disaggregate each vector from the taxonomic level of family down to the level of genus or species. This will increase the level of detail. The length of the vector may also be expressed as total catch instead of mean catch. The second is to add the cost factor in terms of economic value of that particular species. For example, although the volume of coral trout caught is lower than mackerel, coral trout are more economically valuable because they command a higher price both in the domestic and export markets. Thirdly, appropriate spatial and temporal dimensions may be incorporated. For instance, the yearly fish yield of a given area of fish habitat, say 20 km² of coral reefs, may be assessed given the number of fishers harvesting the resource. Fourthly, a colour code should be provided that reflects the harvesting level of each species. Similar to a traffic light, a species coloured red is overfished and the effort has to be reduced; a species coloured yellow is approaching full biological exploitation and the effort has to be maintained at that level; a species coloured green is at a sustainable level or possibly still underexploited, effort may therefore be maintained or possibly even increased. The vector information is also relatively easy to collect from the fishers. This research area is suited to mathematicians and modellers. Reinterpreting the concept of sustainability in terms of 'vectors' is a simple way of presenting complex information about annual catch and catch trends. This is also a cost-effective method because the information can be easily derived from the fishers.

References

Alcala, A. C. 1981. Fish yield of the coral reefs of Sumilon Island, Central Philippines. Natural Resource Council Philippines Research Bulletin. 36:1-7.

Alcala, A. C. and G. R. Russ. 1990. A direct test of the effects of protective management on abundance and yield of tropical marine resources. J. Cons. Int. Explor. Mer. 46: 40 - 47.

Barut, N.C., M.D. Santos, and L.R. Garces. 1997. Overview of Philippine marine fisheries, p. 62-71. *In* G. Silvestre and D. Pauly (eds.) Status and management of tropical coastal fisheries in Asia. ICLARM Conf. Proc. 53, 208 p.

Bellwood, D.R. 1988. Seasonal changes in the size and composition of the fish yield from reefs around Apo Island, Central Philippines, with notes on methods of yield estimation. J. Fish Biol. 32:881-893.

Berkes, F. 1994. Co-management: bridging the two solitudes. Northern Perspective. 22(2-3): 18-20.

Bromley, D.W. 1992. The commons, property and common-property regimes, p. 3-15. *In* D.W. Bromley (ed.) Making the commons work: theory, practice and policy. Institute for Contemporary Studies, San Francisco.

Commonwealth of Australia. 1998. Australia's ocean policy. Oceans Policy Marine Group, Environment Australia, Canberra. 48 p.

de Vaus, D.A. 1993. Surveys in social research. University College London Press, London.

Dinesen, Z., Compiler. 1999. GBRMPA/CRC Reef joint 'scoping' workshop on performance indicators for management of the Great Barrier Reef World Heritage Area, Townsville, 3-4 June 1999.

FAO (Food and Agriculture Organisation). 1994. Review of the state of world marine fishery resources. FAO Fisheries Technical Paper 335, 136 p. Rome, Italy.

FAO (Food and Agriculture Organisation). 1999. The development and use of indicators for sustainable development of marine capture fisheries. FAO Technical Guidelines for Responsible Fisheries. No. 8. 68 p. Rome, Italy.

Garcia, S. M.. 1996. Indicators for sustainable development of fisheries. Paper presented at the Second World Fisheries Congress, 2 August 1996, Brisbane, Australia.

Hammer, M. 1995. Integrating ecological and socioeconomic feedbacks for sustainable fisheries, p.141-149. *In* S. Hanna and M. Munasinghe (eds.) Property rights in a social and ecological context: case studies and design applications. The Beijer International Institute of Ecological Economics and The World Bank, Washington, D.C.

Hancock, D.A., D.C. Smith, A. Grant and J.P. Beumer, Editors. 1996. Proceedings of the Second World Fisheries Congress. Commonwealth Scientific and Industrial Research Organisation. Collingwood, Australia.

IUCN (World Conservation Union). 1997. Barometer of sustainability: measuring and communicating wellbeing and sustainable development. Gland, Switzerland.

Johannes, R.E. 1981. Words of the lagoon: fishing and marine lore in the Palau District of Micronesia. University of California Press, Berkeley, California.

Johannes, R. E. 1998a. The case for data-less marine resource management: examples from tropical nearshore finfisheries. Trends in Ecology and Evolution. 13(6):243-246.

Kailola, P., Williams, M., Stewart, M., Reichelt, R.E., McNee, A. and Grieve, C. 1993. Australian fisheries resources. Bureau of Resource Sciences, and Fisheries Research and Development Corporation, Canberra.

Kirkegaard, I. R. and D. F. Gartside. 1998. Performance indicators for management of marine recreational fisheries. Marine Policy. 22(4-5):413-422.

Ludescher, C.M. 1997. Fisheries resources between Bowen and Tully – an inventory. Queensland Fisheries Management Authority, Brisbane, Australia. 136 p.

Mapstone, B. D., C. R. Davies and J. W. Robertson. 1997. The effects of line fishing on the Great Barrier Reef: available evidence and future directions, p. 178-192. In Proceedings of the Great Barrier Reef Science, Use and Management: A National Conference. Great Barrier Reef Marine Park Authority/CRC Reef Research Centre, Townsville, Queensland, Australia.

Mayer, D.R. and J.P. Beumer. 1993. Reserves protecting fisheries habitat. The Queensland Fisherman. 23-27.

McCay, B.J. 1993. Management regimes. Beijer Discussion Paper Series No. 38, 12 p. Stockholm, Sweden.
McGoodwin, J. 1992. The case for co-operative co-management. Australian Fisheries. 11-15.
Pinkerton, E. 1993. Local fisheries co-management: A review of international experiences and their implications for salmon management in British Columbia. A Discussion Paper, 21 p. School of Community and Regional Planning, University of British Columbia, Vancouver, Canada.
Pitcher, T.J. (2001) Fisheries managed to rebuild ecosystems: Reconstructing the Past to Salvage the Future. Ecological Applications 11(2): 601-617.
Pomeroy, R.S. 1993. Research framework for coastal fisheries co-management institutions. Naga, ICLARM Q. 16 (1):14-16.
QNPWS (Queensland National Parks and Wildlife Service). 1987. Townsville/Whitsunday Marine Park. Zoning Plan.
Robertson, J. 1997. The management of fisheries in the Great Barrier Reef Marine Park, p. 395-401. vol. 1. Proceedings of a national conference held at James Cook University of North Queensland, Townsville, Queensland, Australia, 25-29 November 1996. Volume 1 and 2. Great Barrier Reef Marine Park Authority, Townsville, Australia.
Russ, G.R. 1991. Coral reef fisheries: effects and yields, p. 601-635. *In* Sale, P.F. (ed) The Ecology of fishes on coral reefs. Academic Press, San Diego.
Russ, G. R. and A.C. Alcala. 1996a. Marine reserves: rates and patterns of recovery and decline of large predatory fish. Ecological Applications. 6(3): 947 - 961.
Russ, G. R., and A. C. Alcala. 1996b. Do marine reserves export adult fish biomass? Evidence from Apo Island, central Philippines. Marine Ecology Progress Series, 132: 1-9
Russ, G. R., and A. C. Alcala. 1999. Management histories of Sumilon and Apo marine reserves, Philippines, and their influence on national marine resource policy. Coral Reefs. 18(4):307-319.
Salm, R.V. 1984. Ecological boundaries for coral reef preserves: principles and guidelines. Environment. Cons. 11(3):209-215.
Sainsbury, K., A.D.M. Smith and H. Webb. 1999. Current use and recommendations for future development of sustainability indicators to measure performance of Australian fisheries against ESD objectives. Fisheries Research and Development Corporation. FRDC 98/168 Draft Report.
Sen, S. and J. Raakjaer-Nielsen. 1996. Fisheries co-management: a comparative analysis. Marine Policy. 20(5):405-416.
Smith, A.D.M. 1996. Quantification of objectives, strategies and performance criteria for fishery management plans – an Australian perspective p. 291-295. *In* D.A. Hancock, D.C. Smith, A. Grant and J.P. Beumer (eds.) Proceedings of the Second World Fisheries Congress. Commonwealth Scientific and Industrial Research Organisation, Collingwood, Australia.
Staples, D., Editor. 1996b. Indicators of sustainable development fisheries. Discussion paper developed by SCFA Management Committee. Bureau of Resources Sciences, Canberra.
Starr, R.M. and D.S. Fox. 1996. Can fishery catch data supplement research cruise data? A geographical comparison of research and commercial catch data. p. 190-197. *In* D.A. Hancock, D.C. Smith, A. Grant and J.P. Beumer (eds.) Proceedings of the Second World Fisheries Congress. Commonwealth Scientific and Industrial Research Organisation, Collingwood, Australia.
Tanzer, J.M., M.A. Elmer and T. Healy. 1997. Fisheries management in the Great Barrier Reef region, p. 298-306. vol. 1. Proceedings of a national conference held at James Cook University of North Queensland, Townsville, Queensland, Australia, 25-29 November 1996. Volume 1 and 2. Great Barrier Reef Marine Park Authority, Townsville, Australia.
Trainor, N. 1991. Commercial line fishing. Queensland Fisherman. 17-24.
White, A. T. and G.C. Savina. 1987. Reef fish yield and nonreef catch of Apo Island, Negros, Philippines. Asian Marine Biology. 4:67-76.
White, A.T. 1988b. The effect of community-managed marine reserves in the Philippines on their associated coral reef populations. Asian Fisheries Science. 2:27-41.
Williams, D.M. and G.R. Russ. 1994. Review of data on fishes of commercial and recreational fishing interest in the Great Barrier Reef. Research Publication No. 33, Volume 1, 103 p. Great Barrier Reef Marine Park. Great Barrier Reef Marine Park Authority, Townsville, Australia.
Wilkinson, C.R., Editor. 1994. Living coastal resources of southeast Asia: status and management. Australian Institute of Marine Science, Townsville.
World Bank. 1993. Fish for the future: summary report / Study of International Fisheries Research (SIFR). World Bank, United Nations Development Program, Commission of the European Communities, Food and Agriculture Organisation. Washington, D.C.
Zann, L.P., Compiler. 1995. Our sea, our future: major findings of the state of the marine environment report for Australia. Department of Environment, Sport and Territories, Canberra. 112 p.
Zeller, B. and J. Beumer, Compilers. 1996. Departmental procedures for permit applications assessment and approvals to perform works or related activity in a Declared Fish Habitat Area. Fish Habitat Management Operational Policy FHMOP 002, 88 p. QDPI, Brisbane.

Questions

Tony Pitcher: I can't help commenting that we have an ecosystem model of coral reefs to see the impact of MPAs. Under certain conditions, they can yield 200,000 tonnes. We thought it was just a mistake, but Michael just corroborated it!

Ian Baird: You talk about validating the information from fishers with science, but the other side of it is that a lot of scientific information needs to be validated by fishers. We need to go both ways on this. People can falsify information in science as well, and they can have incorrect methods. You also talk about the villagers fooling you, but the problem may lie in the way you collect data or other factors relating to how you asked for the information. Maybe you confused them with the questions, and they didn't deliberately set out to lie to you. Maybe it's your methodology. In Laos, we found that we were getting inaccurate information but it seemed that the problem was more with the people who were asking the questions.

Michael Pido: To answer your first point, yes, that's true. While scientists should evaluate the information given by fishers, the fishers can also evaluate the information given by scientists. It goes both ways. Regarding the second question, I think that the fishers get tired of being asked questions all the time. In Apo Island I think that the establishment of MPAs led to an increase of researchers and the fishers felt I am just one of

the many researchers, so they gave me what they thought I wanted to hear. The fishers think that they can't say that the yield is going down, so they say that it's going up.

Ian Baird: I'm not denying that's not a possible reason, but it might not be the only one. Maybe it says a bit about your methodology if the villagers lie to you; maybe they didn't trust you.

Michael Pido: I know some of the villagers personally and I used some people from the University but they gave me inflated figures. The other study areas gave reasonable estimates, so they act as good comparisons. However, I don't rule out that possibility.

FISHER AND FISHERY SCIENTIST: NO LONGER FOE, BUT NOT YET FRIEND

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ABSTRACT

It has often been assumed that, in natural resource issues, particularly ethical issues related to fisheries, fisheries scientists, fishers, and the general public differ in their opinions. Typically, these assumed differences are neither investigated nor quantified. This paper describes an approach to examine these assumed differences and demonstrates their implications in fisheries management. The method combines the Rapfish assessment of fisheries sustainability with the paired comparison method, in ranking fisheries sustainability using the nine ethical Rapfish attributes as criteria. A paired comparison questionnaire of these attributes was given to scientists, fishers and the general public. The resulting importance weighting of these attributes was applied to the normalised raw Rapfish scores for selected Canadian fisheries. We found no significant difference between respondent groups in the importance ranking of these attributes, thus no effect on the sustainability ranking of the examined fisheries when all attributes were considered. However, when sustainability was measured using only the three most important attributes, the rankings provided by fishers differed slightly from those by scientists and the general public.

INTRODUCTION

Never in the history of fishery management has there been a time more favourable to user-participation, community involvement and co-management than the past decade. Recent publications indicate the growing interest in user and community involvement. Jentoft and McCay (1995) listed eleven countries in Europe and North America as examples of various levels of user participation in fisheries management. Sen and Nielsen (1996) complemented this study by reviewing 22 case studies on fisheries co-management, with an expansion to developing countries in Africa, Asia, the Caribbean and the Pacific. Both studies observed similar difficulties in involving user groups in the management process, ranging from the choice of appropriate mechanism to encourage and enable participation, to the ability of user groups to participate fully, and the willingness of government officials to share their management authority.

The level of user participation and community involvement in resource management ranges from the minimum exchange of information between government and users, as in the 'instructive' type of co-management to the 'informative' type where government has delegated authority to the user groups and community (Sen and Nielsen 1996; see also Arnstein 1969 for a general discussion on citizen participation). In Canada, fisheries co-management initiatives tend to occur at the 'consultative' level, where government bodies consult with users, but retain the final decision-making power; some have shifted into the 'co-operative' type of participation, where government and users co-operate in the decision-making process, as in the case of some Atlantic fisheries (Jentoft and McCay 1995).

Frequent issues in the design of institutional co-management arrangements include the heterogeneity of user groups (Felt 1990), community representation (Jentoft *et al.* 1998), community support (Noble, 2000), and the genuine devolution of power (Sandersen and Koester 2000). Underlying these issues is the common belief that users, scientists and managers, and the general public typically hold different positions in resource management. Users are thought to be concerned only with their own personal welfare (thus, the 'Tragedy of the Commons'). Scientists and managers are assigned the role of managing the resources for the society as a whole, despite the fact that scientists are often accused of being unable to provide fishery managers with the information needed to make decisions. Community and user group involvement is commonly touted as a means to resolve these perceived conflicts. Such involvement may take the form of consultation processes, public meetings and workshops, and formation of resource management committees, comprised of representatives from various user groups, community groups, scientists and managers or policy makers.

In this paper, we propose an alternative viewpoint. Rather than assuming the existence of fundamental differences of opinions between scientists, users, and community members, we explored potential commonalities which may serve as a starting point in the design of fisheries

policy. Our approach is based on the work of Chuenpagdee *et al.* (2000), who reported that scientists, managers, resource users and communities did not differ significantly in their opinion about the importance of the resources and the impacts of different activities on the resources.

To test our thesis, we chose to explore perceptions of a potentially controversial topic, the ethical issues associated with fisheries. These include, *inter alia*, traditional access to fisheries, influences on fishers' values, unreported catches, as well as the inclusion of fishers in management decisions. Using a selection of fisheries from Canada's east and west coasts as case studies, we began with a Rapfish assessment of fisheries sustainability by researchers, fishers, and fishery scientists and managers, based on the nine ethical attributes described by Pitcher and Power (2000). Next, we used the paired comparison method to present these nine ethical attributes to scientists (including natural and social scientists, and researchers from other related disciplines), fishers, and the general public to determine the aggregate, ranked preferences of each group. The rankings of the importance of these attributes according to each of the three respondent groups were then tested for correlation before applying the resulting weighting to the ethical attributes for the selected fisheries. The detailed methodology and the results of the study are described below.

Appraisal of fisheries sustainability using 'Rapfish'

Rapfish is a relatively new technique for the rapid appraisal of fisheries. Initially designed to evaluate the health of fisheries on ecological, economic, social, and technological grounds (see Pitcher *et al.* 1998 for early development; see also Pitcher and Preikshot 2001 for subsequent applications), it has subsequently been extended to include ethical considerations (see Pitcher and Power 2000). Further developments have included criteria to evaluate fisheries with regard to the UN FAO Code of Conduct for Responsible Fisheries (Pitcher 1999).

In Rapfish, fisheries are evaluated in terms of sustainability or health as defined within each of five discrete 'fields' or disciplines: ecological, economic, ethical, social, and technological. Each filed is characterised by between nine and twelve criteria or 'attributes'. A simple scoring scheme is applied to each fishery for each attribute, representing the range of possible responses to each attribute. (See Table 1 in Appendix for the ethical attributes and the scoring scheme associated with those attributes.) A multidimensional scaling routine is then conducted for the single field for all fisheries in the evaluation.

The technique allows flexibility in the definition of 'fishery', hence, the evaluated fisheries may be aggregated or subdivided as needed (Pitcher and Preikshot 2001). For instance, fisheries may be defined on a scale ranging from a single boat through a whole fleet in a given region, or subdivided by, for instance, species, or gear type. A given fishery may also be tracked through time. Two 'constructed' or hypothetical fisheries are also included in the assessment: one comprised of the best possible scores for all attributes within the field, defining the fishery with highest or 'Good' level of sustainability; and the other with the worst possible scores, resulting in the fishery with lowest or 'Bad' level of sustainability. These two constructed fisheries constrain the results of the analysis and allow for arrangement of the actual assessed fisheries along a scale of sustainability from high to low. The results, therefore, demonstrate the overall sustainability of the assessed fishery within the field of evaluation, and may be expressed in a variety of ways including a percentage scale, wherein the constructed low sustainable fishery scores 0% and the constructed high sustainable fishery scores 100%, with the actual fisheries ranging along the percentage scale.

It must be noted that Rapfish is not a method for stock assessment (Pitcher and Preikshot 2001). Rather, it is a useful tool for evaluating the overall health of a fishery based upon a number of defined criteria. As fisheries may also be evaluated over time, trends in a specific fishery over time may be identified and assessed. Furthermore, fisheries can be compared against one another using the defined criteria, regardless of time period, scale, or geographic range.

Weighting of ethical attributes using paired-comparison method

Rapfish attributes have previously been applied with equal weighting. It has become apparent, however, that in the real world, the factors represented by each attribute may not contribute equally to the sustainability of a fishery. The approach taken in this paper is to use the paired comparison method to obtain an appropriate weighting for each attribute based on the aggregated preferences of respondents. The case study is limited to the nine ethical attributes first identified by Pitcher and Power (2000).

The paired-comparison method is normally used to elicit preferences and subjective judgements, such as in taste-testing or colour comparison (David 1988). The method involves the presentation of objects in pairs to a sample of respondents. Respondents are asked to simply choose, within each pair, the one object that they prefer or consider to be more important. This method is particularly useful when the number of objects to be judged is large or when the objects are complex or too similar, such that a direct ranking of preference is no longer a simple task. Moreover, because the resulting preference scale is interval, not ordinal, the distance between objects A and B is meaningful in comparison to that between objects B and C. Finally, it is possible to detect the intransitive responses that can occur due to the complexity of the objects for comparison, the high similarity between objects, and/or the lack of competence of respondents (David 1988). One common form of intransitivity is the circular triad, which refers to a situation where, in a paired comparison of three objects, x, y, and z, the results are such that x is preferred to y and y is preferred to z, but z is preferred to x. This information is particularly valuable when dealing with complicated issues such as ethical considerations in the management of fisheries.

The basic model employs all possible paired comparisons of n objects by k judges, with the total number of possible pairs for each judge equal to $n(n-1)/2$. In this study, the nine ethical attributes described in Table 1 were used to create a total of 36 pairs for comparison. Box 1 shows an example of one pair.

Box 1: An example of a paired comparison of ethical attributes

In your opinion, which one of these two factors should receive **GREATER** consideration by policy makers in designing fisheries policy? (Please choose only **A** or **B**, even if you feel they are equally important)

The distance to and the reliance on the fishery	The existence of alternative sources of livelihood
A	**B**

Earlier uses of paired comparisons in environmental management include the effort by Opaluch *et al.* (1993) to rank potential sites for noxious facilities, described in terms of acreages of various land uses, groundwater quality, wildlife habitat, and cost per household, and the Peterson and Brown (1998) study of the reliability and transitivity of paired comparison judgements involving a mix of public and private goods. The first study found that the choices made between alternative sites using the paired comparison approach were more natural than the responses to questions of willingness to pay to preserve specific attributes of such sites. The latter supported the use of the paired comparison method to yield highly reliable and transitive judgements, even with 155 pairs.

More recently, Chuenpagdee *et al.* (2001 a, b) conducted an empirical study of the importance of coastal resources in Thailand, with an emphasis on testing the differences between the judgements from experts, fishers and other interested groups in the coastal communities. They found that the paired comparison method provided consistent judgements from various groups of respondents. The study reported in this paper was modelled after their research.

Using stratified quota sampling, the study was structured such that the respondents included three groups, i.e. scientists, fishers, and general public. The questionnaire booklet contained pairs of ethical attributes randomised in their order and left-right position such that each booklet was unique. The questionnaire was distributed, either by mail or by personal delivery, to the pre-identified scientists, based on their recognized expertise in the topic area. The survey of the fishermen and the general pubic was conducted at fishing piers, fish markets, and at fishermen association meetings in British Columbia. A total of 22 scientists, 17 fishers and 19 other people responded to the survey. Note that the 'scientists' group included natural and social scientists as well as researchers in related fields.

The analysis of the paired comparison results followed the variance stable rank sum method of Dunn-Rankin (1983), which allowed the aggregation of individual preference scores and the normalization to a scale of 0 to 100 using a proportional procedure. In this study, an ethical attribute with 0 score reflects no importance, such that the attribute was never chosen as being more important than other attributes. On the other hand, the score of 100 indicates the highest importance of a particular attribute, as it was selected as being more important in every pair combination. We used the normalised, aggregated scores of all individuals in each respondent group to present the comparison of the resulting scale values, as in Figure 1 (in Appendix 1).

Further, we provided a ranking of these attributes based on their scale values, and used rank correlation analysis to test for significant

difference (Table 2, in Appendix 1). The results suggest that fishers considered inclusion of fishers in the management to be the most important factor in the design of fisheries policy. In comparison, the scientists and general public did not rank this attribute as being as important as the impacts of fishing and the human influences on fisheries ecosystems. While all groups agreed that the existence of alternative sources of livelihood was the least important consideration, they differed slightly in their opinion about the importance of the existence of traditional or historical fishing access, the level of utilisation of fish (or discarding), and the existence of social and political structures influencing fishers' value (Figure 1, Appendix 1). Despite these differences, the ranking of the nine attributes provided by each group of respondents was not significantly different from the other two groups at p = 0.05 (Table 2, Appendix 1). It was thus possible to aggregate further the preference scores across all three groups of respondents and represent them as a single set of aggregated scale values. This aggregated scale was used in subsequent stages of the study.

Reassessment of fisheries sustainability

To demonstrate how the application of different weightings to the Rapfish ethical attributes can complement the assessment of fisheries sustainability, we applied the scale values obtained from the paired comparison survey to the raw, normalised Rapfish scores of thirteen fisheries conducted on Canada's Atlantic and Pacific coasts. The procedure followed three steps. For each fishery, we first normalised the original raw Rapfish scores of each attribute to a scale of 0 to 100. Next, we multiplied each Rapfish scale value with the attribute scale value. Finally, we calculated the weighted average using equation (1), after Jongman *et al.* (1993):

$$WA = (Y_1U_1 + Y_2U_2 + \ldots + Y_mU_m) / (U1 + U2 + \ldots + Um) \qquad (1)$$

where Y is the Rapfish score and U is the attribute score.

We compared the original Rapfish scores with the weighted scores based on all respondents to demonstrate the varying importance of these attributes in the decision about fisheries policy (Table 3, Appendix 1). We found that the rankings of fisheries were not significantly different (with a rank correlation coefficient of 0.9761). A traditional west coast Aboriginal fishery, the herring spawn-on-kelp fishery, was considered to be most sustainable in both cases, while the British Columbia lingcod fishery was considered least sustainable. Except for the herring spawn-on-kelp fishery, the east coast fisheries were considered more sustainable than the west coast fisheries based on both scoring methods.

Further analysis was performed to test the impact of the ethical attributes on the sustainability ranking of the fisheries. Instead of using all nine attributes to weight the Rapfish scores, we first used only the three most important attributes according to all respondents, specifically, fishing impacts on the ecosystem, inclusion of fishers in management, and human impacts on fish habitats. In the next round of analysis, we used the top six attributes. These two sets of weighted scores were ranked and tested for correlation with the Rapfish scores weighted using all nine attributes, as shown in Table 4 (Appendix 1). While the rankings based on the three sets of scores were not significantly different, we observed that the correlation coefficient was lowest between the ranking of fisheries sustainability based on the top three ethical attributes compared with that based on all nine attributes. It should also be noted that, although the rankings were not significantly different, the scores and their range varied. When using only the top three attributes in the weighting average, west coast halibut and salmon fisheries were ranked higher than east coast lobster, cod, and mackerel fisheries. The opposite was found when the ranking used all attributes. The least sustainable fishery based on the top three attributes was the British Columbia trawl fishery, not the lingcod fishery as with all attributes. Adding three more attributes to the weighting gave the ranking a higher correlation coefficient to the overall attribute weighting. As with using only the top three attributes, we found that the ranking of mackerel, halibut and salmon varied slightly from that with the all attributes. Further, we observed that when using the top three attributes as criteria for sustainability, only herring spawn-on-kelp and snow crab fisheries scored higher than the 50% mid-point. As we added three more attributes, capelin scored higher than 50%, and when considering all attributes, the east coast herring fisheries also exceeded the mid-point. The other nine fisheries remained at the lower end of the sustainability scale in all considerations. Finally, the correlation between the rankings of fisheries sustainability obtained from the original Rapfish score and those based on top three attributes was lower than other pairs at 0.7874.

Implications for fisheries management

An awareness that fishers, communities, and scientists do not differ significantly in their opinions regarding the ethical issues that ought to

be considered in assessing fisheries sustainability can be quite helpful in both the design of fisheries policy and in co-management efforts. Priorities in management can be set using the general agreement between these groups and subsequent discussions can focus on issues where the groups may be at odds. As illustrated above, ethical considerations, such as the ecosystem impacts of fishing, inclusion of fishers in management, and the human impacts on fish habitat, provide clear distinction between fisheries in terms of sustainability when used as primary criteria to assess sustainability of fisheries. As well, the ranking of fisheries in terms of their sustainability shifts slightly when applying weighted attributes. This shift will more likely be significant if stakeholders differ in their opinion about the importance of attributes used in assessing fisheries sustainability. In such case, careful considerations must be taken when formulating fisheries policies.

The paired comparison survey conducted in the case study included a small sample size. Clearly, a more comprehensive survey should be conducted to assure proper representation of each stakeholder group. Once this is done, these inputs can assist policy makers in the design of fisheries policies that are in accord with the judgements of stakeholder groups. For example, the results suggest that fishers should be involved in designing policies that address fishing impacts on ecosystems, and human impacts on fish habitats. At the same time, it implies that the management of fisheries that are scored low on the sustainability scale should be evaluated and revised for improvement.

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REFERENCES

Arnstein, S. R. (1969). “A ladder of citizen participation.” *Journal of the American Institute of Planners*. 35(July): 216-224.

Chuenpagdee, R., Knetsch, J. L., and Brown, T. C. 2001a. Environmental damage schedules: community judgements of importance and assessments of losses. *Land Economics* 77:1-11.

Chuenpagdee, R., Knetsch, J. L., and Brown, T. C. 2001b. Using Public Judgements, Importance Scales, and Predetermined Schedule. *Coastal Management* 29(4):253 – 270.

David, H.A. 1988. *The paired comparison method*. London: Charles Griffin & Company.

Dunn-Rankin, P. 1983. *Scaling Methods*. Lawrence Erlbaum Associates. New Jersey.

Felt, L. 1990. Barriers to user participation in the management of the Canadian Atlantic salmon fishery: if wishes were fishes. Marine Policy July 1990:345-360.

Jentoft, S. and McCay, B. 1995. User participation in fisheries management: Lessons drawn from international experiences. *Marine Policy* 19(3):227-246.

Jentoft, S., McCay, B. J. and Wilson, D. C. 1998. Social theory and fisheries co-management. *Marine Policy* 22(4-5): 423-436.

Jongman, R. H., ter Braak, C. J. F., and van Tongeren, O. F. R. 1987. Data Analysis in Community and Landscape Ecology. Pudoc Wageningen, Weningen, The Netherlands.

Noble, B. F. 2000. Institutional criteria for co-management. *Marine Policy* 24:69-77.

Opaluch, J.E., Swallow, S. K., Weaver, T., Wessells, C. W. and Wichelns, D. 1993. Evaluating impacts from noxious facilities: including public preferences in current siting mechanisms. *Journal of Environmental Economics and Management* 24:41-59.

Peterson, G. L. and Brown, T. C. 1998. Economic valuation by the method of paired comparison, with emphasis on tests of the transitivity axiom. *Land Economics* 74(2):240-261.

Pitcher, T.J. (1999). "Rapfish, A Rapid Appraisal Technique for Fisheries, and its Application to the Code of Conduct for Responsible Fisheries". Rome, Food and Agriculture Organization of the United Nations**:** 47.

Pitcher, T.J., A. Bundy, D. Preikshot, T. Hutton and D. Pauly (1998). "Measuring the unmeasurable: a multivariate and interdisciplinary method for rapid appraisal of the health of fisheries". *Reinventing Fisheries Management*. T.J. Pitcher, P.J.B. Hart and D. Pauly. London, Kluwer Academic Publishers.

Pitcher, T. J. and Power, M.D. 2000. Fish Figures: Quantifying the Ethical Status of Canadian Fisheries, East and West. p. 225-253 *In*: Coward *et al.* (eds). Just Fish: Ethics and Canadian Marine Fisheries. Social and Economic Papers No. 23. Institute of Social and Economic Research, Memorial University of Newfoundland. St. John’s, Newfoundland. 304 p.

Pitcher, T.J. and D. Preikshot (2001). “Rapfish: A Rapid Appraisal Technique to Evaluate the Sustainability Status of Fisheries.” *Fisheries Research* (49): 255-270.

Sandersen, H.T. and Koester, S. 2000. Co-management of tropical coastal zones: the case of the Soufriere marine management area, St. Lucia, WI. Coastal Management 28:87-97.

Sen, S. and Nielsen J. R. 1996. Fisheries co-management: a comparative analysis. *Marine Policy* 20(5): 405-418.

QUESTIONS

Christina Soto: I didn’t follow how you score the fisheries. How did you do it?

Melanie Power: In the original raw data, which goes back 4 years now, each attribute has a range of scores that go from 0-1 to 0-5 in some cases. For example, for the distance to fishery and reliance on fishery attribute, the scores reflect whether the fishery has been around for hundreds of years or whether they’re very modern.

Christina Soto: The socio-political attributes are so hard to score. How did you do it?

Melanie Power: Yes, that’s problematic. Because it was used in the original raw data, it has to stay in this study. It’s part of my thesis, but I think I will excise it.

Ian Baird: It was an interesting presentation and I don't want to detract from it, but I have one small note. We talked about terminology a few times today, and I want to advise you to be careful about using the term "expert". That's implying that fishers know less than the others, which is not necessarily true. Maybe you can use "scientists" versus "fishers"?

Melanie Power: I agree, and I am chastened. I was using the shorthand; we usually use the phrase "formal expert", which refers to people who are trained in an institution. I hesitate to use the term "scientist", because I'm not one myself. It is hard to find a good phrase.

Saudiel Ramirez-Sanchez: What did you do when you had cases of complete triads?

Melanie Power: We were looking for inconsistencies. I didn't take the survey myself, but when I was looking through the book, I thought, "How could I choose between some of these choices?" When there are indecisions, you get some sense of where the grey areas are and how closely the choices are preferred.

Saudiel Ramirez-Sanchez: What is your explanation of the inconsistencies? What are the implications? Is it the method or is it the way people think?

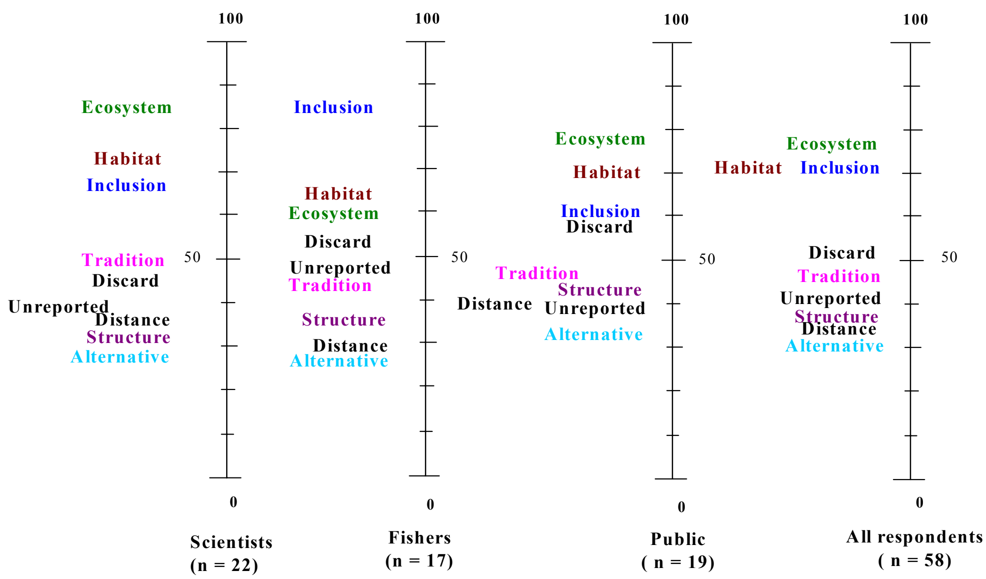
Melanie Power: It's the way people think. In my spreadsheet, I made a note of which ones were inconsistent, because I was expecting it. Out of 59 respondents, only 10 were consistent.

APPENDIX 1

Table 1 Rapfish Ethical attributes and scoring scheme.

Attribute*	Scoring Scheme	Best Possible Score	Worst Possible Score
The distance to and the reliance on the fishery.	0 to 3	3	0
The existence of alternative sources of livelihood.	0 to 2	2	0
The existence of traditional or historical fishing access.	0 to 2	2	0
The inclusion of fishers in the management of their fishery.	0 to 4	0	4
The existence of social/political structures influencing fishers' values.	0 to 4	4	0
The human influences on fish habitats.	0 to 4	4	0
The fishing impacts on the fisheries ecosystem.	0 to 4	4	0
The existence of fishing practices beyond regulations.	0 to 2	0	2
The level of utilisation of fish which are caught in a fishery.	0 to 2	0	2

* These attributes were first described and applied by Pitcher and Power (2000), and re-worded for simplicity and neutrality in the present study.



Notes:

Ecosystem	The fishing impacts on fisheries ecosystem
Habitat	The human influences on fish habitats
Inclusion	The inclusion of fishers in fishery management
Discard	The level of utilisation of fish which are caught in a fishery
Tradition	The existence of traditional or historical fishing access
Unreported	The existence of fishing practices beyond regulations
Distance	The distance to and the reliance on the fishery
Structure	The existence of social / political structures influencing fishers' values
Alternative	The existence of alternative sources of livelihood

Figure 1. Scale value reflecting the importance of nine ethical attributes as judged by scientists, fishers and the general public

Table 2 Scale value and ranking of the ethical attributes by scientists, fishers and the general public.

	Scientists		Fishers		Public	
Attributes	Score	Rank	Score	Rank	Score	Rank
Ecosystem	84.7	1	60.3	3	77.6	1
Habitat	73.9	2	65.4	2	69.1	2
Inclusion	66.5	3	83.8	1	60.5	3
Traditional	50.0	4	46.3	6	43.4	5
Discard	42.6	5	54.4	4	57.2	4
Unreported	35.8	6	48.5	5	40.1	7
Distance	35.2	7	29.4	8	38.2	8
Structure	33.0	8	35.3	7	42.8	6
Alternatives	28.4	9	26.5	9	33.6	9

Correlation table

	Scientists	Fishers	Public
Scientists	1		
Fishers	0.8667	1	
Public	0.9333	0.8833	1

Table 3 Rankings of fisheries sustainability based on direct Rapfish scores and on weighted averages obtained from paired comparison (E and W indicate east coast and west coast fisheries, respectively)

	Rapfish Average score		Weighted PC All groups (n = 58)	
	score	rank	score	rank
Herring Spawn-on-kelp (W)	66.7	1	72.3	1
Herring (E)	61.3	2	57.1	4
Snow crab (E)	60.2	3	58.3	2
Capelin (E)	60.2	3	59.4	3
Lobster (E)	51.6	5	47.5	6
Shrimp (E)	49.5	6	48.2	5
Northern cod (E)	49.3	7	46.0	7
Mackerel (E)	46.8	8	40.1	8
Halibut (W)	41.2	9	39.1	9
Groundfish trawl (W)	33.8	10	29.6	11
Salmon (W)	32.6	11	33.2	10
Herring (W)	30.1	12	29.2	12
Ling cod (W)	28.7	13	27.5	13

Table 4 Weighted scores and ranking of fisheries, based on three, six and all nine attributes

	Wt.Ave All Att.		Wt.Ave. Top 3		Wt. Ave. Top 6	
	score	rank	score	rank	score	rank
Herring Spawn-on-kelp (W)	72.3	1	100.0	1	70.7	1
Snow crab (E)	59.4	2	57.5	2	57.8	3
Capelin (E)	58.3	3	41.9	4	58.5	2
Herring (E)	57.1	4	47.8	3	49.1	4
Shrimp (E)	48.2	5	37.8	5	46.6	5
Lobster (E)	47.5	6	31.4	9	42.0	6
Northern cod (E)	46.0	7	31.5	8	40.5	7
Mackerel (E)	40.1	8	16.4	12	31.4	10
Halibut (W)	39.1	9	37.2	6	36.0	8
Salmon (W)	33.2	10	36.4	7	32.0	9
Groundfish trawl (W)	29.6	11	12.2	13	27.6	11
Herring (W)	29.2	12	29.1	10	27.5	12
Ling cod (W)	27.5	13	20.9	11	26.1	13

Rank Correlation Table (2)

	Wt. All	Wt. 3	Wt. 6
Wt. All	1		
Wt. 3	0.8407	1	
Wt. 6	0.9780	0.8901	1

HARVESTING AN INLAND SEA: FOLK HISTORY, TEK, AND THE CLAIMS OF LAKE MICHIGAN'S COMMERCIAL FISHERY

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ABSTRACT
In 1998, the Great Lakes Center for Maritime Studies began a two-year documentation project on the contested history of Lake Michigan's fisheries management and policy. After World War Two, the debate over Lake Michigan's fisheries became more acute as four stakeholder groups made highly vocal and strident claims to the fisheries resources of this ecologically sensitive freshwater basin. State governments sought to re-claim managerial control they had informally relinquished to the federal government. Sport fishers sought to create what they saw as a more economically and ecologically sustainable fishery. Native Americans began to re-claim treaty fishing rights in an act of cultural and economic revitalization. Commercial fishers simply sought to survive. Of all the groups documented, Lake Michigan's commercial fishers made traditional ecological knowledge a principal theme of their oral and folk histories. Specifically, they used the theme of TEK in their oral histories to explain, justify, and claim Lake Michigan's commercial fishery as their economic and cultural patrimony.

This paper will examine how these oral histories and their expression of traditional ecological knowledge illuminate the longstanding politics and culture of fisheries claims on Lake Michigan; in short, it will consider oral history not just as past accounts, but as continuously circulating narratives in an on-going historical debate. This was never more evident then during the re-negotiation of a Federal Consent Order in 2000 to settle historical claims among these groups. These oral histories profoundly delineate this fragmented legacy and clarify how divergent politics, cultures, and ethics of fisheries claims developed on Lake Michigan in the modern age. Not surprisingly, these oral histories corroborate the late 19th/early 20th century genesis of these debates, and verbally continue the endurance and revision of claims in the present. By interpreting the verbal expressions of the history and traditional ecological knowledge of Lake Michigan's commercial fisheries, this paper will reveal paradoxical considerations that will continue to inform the evaluation of fisheries history and the formulation of future fisheries policy and stakeholder relations.

INTRODUCTION
This essay uses Lake Michigan as a case study to explore the relevance of folk history and traditional ecological knowledge (TEK) in commercial fisher oral tradition. Specifically, this study considers a number of factors that have made TEK a prevalent theme in the oral histories of Lake Michigan's commercial fishers. This trend has been particularly noticeable over the past twenty years as Lake Michigan's commercial fishers have used TEK to justify the retention or expansion of their allocation of fisheries resources.[1] By invoking TEK in current policy debates, commercial fishers are, in Paul Thompson's words, "living the fishing," and are historically accounting and validating the acquired knowledge, rules, and working contexts that are their most traditional management framework.[2] Thus, the folk history of Lake Michigan's commercial fishers—their own accounts and interpretation of the events of their lives—are narratives whose meaning is rooted in each fisher's individual and collective experience of the basin's fisheries ecology. When these ecological insights and relationships take the form of oral history, they underline that "folk" or "vernacular" fisheries management is deeply entrenched in the regular work routines, social affairs, and political deliberations of fishing communities. Viewed from this perspective, oral history's role in contextualizing a commercial fishery's folk history reveals social and cultural dimensions of TEK that inform innumerable management or policy decisions on a daily basis. Unfortunately, most environmental policy historians have not evaluated these vernacular management schemes that are ecologically forged through work and orally expressed in an occupational culture that displays a high degree of historical consciousness. Nor have researchers adequately availed themselves of commercial fishing technology and material culture to elicit TEK when interpreting occupationally-specific resource use values and their ultimate relationship to "official," government-mandated policy (Figure 1).[3]

The historical narratives of this study of Lake Michigan's commercial fishers were shaped and collected during an era of changing occupation, when claims to fisheries resources were consistently challenged. Keeping in mind that an expansive definition of TEK is its relationship to

the social and cultural parameters of the commercial fishery's folk history, such insight was, and continues to be, the inhabitant's principal means of expressing and contextualizing its position in this half-century debate. Quite simply, TEK's standing in the oral historical tradition of Lake Michigan's commercial fishing community serves as a policy response that legitimates the group's claims to fisheries resources. While historical and cultural research in fishing communities shows TEK's longstanding function as an adaptive vernacular management system, its rhetorical use in confrontational fishing policy debate is less frequently recognized. This situation exists on Lake Michigan, where, over the past half century, commercial fishers have been severely restricted by state regulation and the ecological problems wrought by the non-indigenous species. Having worked in a socio-political and ecological context that has not been favorable to their economic interests, they have been less inclined to argue over abstract policy issues and instead narrate life histories that focus on TEK as a bulwark of their regulatory prerogatives and occupational survival. The thematic organization of TEK in these historical narratives reveals that Lake Michigan's commercial fishers consider the harvesting process to be not only a tangible factor in determining economic return, but, as an ecological index, a means of historically evaluating fish stocks, adaptive technologies, changes to the fisheries landscape, environmental conditions, and the quandaries of occupational endurance.

Figure 1-Ray Wakild of South Haven, Michigan used photographs of fish tugs to describe historical and ecological dimensions of Lake Michigan's commercial fisheries. (Photograph by Chiarappa)

At the close of the twentieth century, Lake Michigan's principal fish-using constituencies felt a heightened sense of historical identity. The dawn of a new millennium was coinciding with the end of a fifty-year time period in which Lake Michigan's fisheries had undergone significant change. Amidst this context, fish-using groups were taking serious retrospective views of the extreme political and ecological developments that had re-shaped the lake's fisheries. It was the conclusion of an era that had severely tested Lake Michigan's fisheries management and policy. Specifically, it was a time frame punctuated by the biological invasion of sea lamprey (*Petromyzon marinus*), alewife (*Alosa pseudoharengus*), and zebra mussel (*Dreissena polymorpha*), the decision of state government to prioritize sport fishing over commercial fishing, and the re-assertion of treaty-rights fishing by Native Americans. For years, these issues engendered intense debate around the shores of Lake Michigan; both the documentary record and oral testimony reveal the strident positions that commercial fishers, sport fishers, Native American fishers and government took regarding the allocation of fish or the manipulation of Lake Michigan's fisheries ecology.[4]

These events define the broad context of the contested relations that have existed between Lake Michigan's principal fish-using groups since the mid-twentieth century. The afflictions of this management and policy-making legacy were exacerbated by the inadequate consideration of historical and cultural factors that shaped each group's view on the use of fisheries resources. Many standard documentary sources did not go far in explaining the more in-depth historical basis for each constituency's emphatic claim to both use the resource and participate in the governance of its allocation. When information did exist or new sources were identified, their effective consideration was plagued by the polemical tone of Lake Michigan's fisheries debates. Extreme posturing by each constituency often meant that valuable management perspectives from each stakeholder group—historical and cultural views of fisheries resource use—were ignored, derided, or mishandled in deliberations that made Lake Michigan the most "political" of all the Great Lakes. In an effort to evaluate these oversights, faculty and students from Western Michigan University's Department of History conducted a two-year documentation project to better understand the history and culture that informed each group's fisheries management perspective.

Rather than just examine the traditional policy-making process, the project re-cast the issue with a more holistic perspective in mind and asked what historical factors shape the resource-use values that are the basis for each group's claim to the resource. This examination of a more expansive notion of fisheries management and policy required the use of written documents, fishing technology, and the cultural landscape as source material. But the traditions and decisions that guide the use or allocation of fisheries resources are also engulfed in daily deliberations, casual talk, and highly vocal debates—a social and cultural process that plays out on the streets, in homes, on the docks, in fishing boats, at community meetings, in government offices and legislatures, and in adjudicative bodies throughout the world. Within this oral culture circulates an extensive array of historical perspectives that either go undocumented or are not carefully interpreted in the process of fisheries policy debate. These circumstances made the collection and interpretation of oral history a focal point of this documentation project. As expected, these narratives conveyed the divided opinion of a fifty-year fisheries debate. However, of greater significance, these narratives showed the differences in how each group historically perceived and expressed what can variously be called their resource-use values or their policies or their management methods. While the content of these oral histories show that each group's resource-use priorities are shaped through a multi-faceted occupational and environmental experience, the longtime debates over the use of Lake Michigan's fish were consistently waged through a simplified dialogue of selected economic and allocation issues. Within this framework, each group's oral history was scarcely recognized or evaluated as expressing elements of an informal, occupationally-derived environmental position—traditional ecological knowledge—an ethnographic oversight in the policy-making process that failed to account for the diverse ways in which fish-using groups justify their claim to the resource.

Aware of these problems, this documentation effort got underway in 1999, just as a 1985 Federal Consent Order settling Native American fishing rights disputes in Michigan's Great Lakes waters was being re-negotiated. Once again, the clamorous voices of Lake Michigan's fishing constituencies were raised on all sides. Interviewees were asked to chronicle their lifetime involvement in Lake Michigan's fisheries and their group's fish management priorities and resource-use values. From these interviews, each group's custodial view of Lake Michigan's fish emerged as their own unique historical perspective—folk histories that justified their claim to the resource. Much of this material qualified as traditional ecological knowledge—an understanding of fish behavior and fishing grounds (Figures 2 and 3), the development of technology and shoreside facilities to pursue these species, and the evolution of local management systems.

Figure 2-This map shows the locations of pound net fisheries on Lake Michigan in 1885. While not all of these grounds are utilized today, they do shape the historical foundations of traditional ecological knowledge (TEK) among Lake Michigan's contemporary commercial fishers. (U.S. Commission of Fish and Fisheries-1887 Report)

Of all these major stakeholder groups, Lake Michigan's commercial fishers most consistently invoked TEK as the basis of their occupational history and as justification for the resource-use values and vernacular governance they presented and claimed in policy debates. In short, the wide-ranging ecological perspectives and ecological responses that Lake Michigan's commercial

fishers describe in their oral histories are their management positions; in practical terms, these historical and contemporary experiences are their contribution to the formulation of fisheries policy. Since Lake Michigan's commercial fishers contribute their multi-generational use patterns and observations through a traditional occupational prism, this project seeks to assist fisheries policy-making and fisheries management in documenting and interpreting the ethnographic shroud that covers these compelling ecological insights on the challenges of harvesting and processing fish. As vernacular or occupationally-derived policy statements, these oral histories begin to delineate the ethnographic logic that guides the integrated use of TEK and traditional occupational management in Lake Michigan's commercial fishery. For those outside of the commercial fishing community, TEK's thematic emphasis in oral history can be seen as a narrative pattern that functions rhetorically to present the occupation's environmental ethic and occupationally-based policy perspectives.

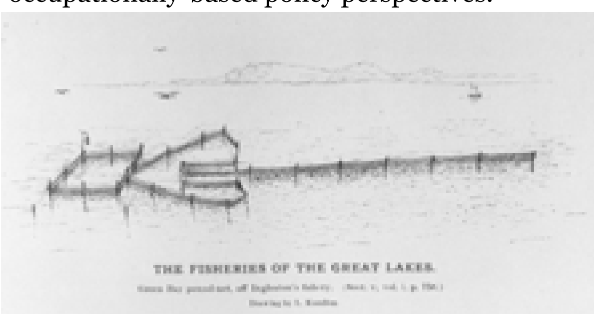

Figure 3-The typical configuration of a Lake Michigan pound net in the late19/early 20th century. (U.S. Commission of Fish and Fisheries-1887 Report)

Identifying the thematic patterns of these orally expressed occupational and ecological histories is the first step in applying them to more holistic management plans. The everyday utility of these oral histories emerges in thematic patterns that convey knowledge and use of fisheries resources as an ecological map. The content of this ecological map is historically shaped, but these antecedents provide a longstanding context that informs contemporary fisheries practice and its adaptation.

Life Histories in Fishing Locales: TEK, Geographic Sentiment, and Resource Claims

One's claim to use the knowledge that defines this ecological map arises in oral history that links family, ethnic, and community tradition with the work organization of each particular fishery and the sense of place that connects its participants to a fishing area. In short, these oral testimonies specify the human factors that function as compass points in each fisher's environmental experience. Daniel "Pete" LeClair of Two Rivers, Wisconsin describes the ecological basis of this relationship through the transitions he and his family have made from the pound net fishery to the gill net fishery to trawling and trap net fishing:

> *Our main fishing area is north of the harbor—about ten miles. If we went further, then we would get up near the nuclear plants and that's all big rocks. This is where my dad fished—in the Kidville area—that's all nice sand there. But you get closer to the nuclear plant and its all big rocks and you cannot fish there with pound nets, trap nets or gill nets or nothing—it's just unfishable…I know this little area here. Half of these grids are rocks and shipwrecks, so we can maybe only fish in half of it. We have fished straight out of here—five miles southeast of Two Rivers and ten miles north. So we're talking about a 15 mile area that is 4 to 5 miles wide.*[5]

He adds:

> *I have been in it since I was old enough to walk. Some of our pound nets were in 80 feet of water, but most of them were for lake herring (Coregonus artedi) and lake whitefish (Coregonus clupeaformis)in 40 feet of water. Around 1946-47, the lamprey got so thick and they killed all the lake trout (Salvelinus namaycush). That was the end of our pound net operation and then we had to go to gill net fishing for chubs (Coregonus hoyi-johanne-kiyi-nigripinnis-reighardi-zenithicus) and so forth…When the lamprey arrived, it was an awful mess. The dead lake trout were 2 feet thick on the bottom of the lake and when you would fish gill nets the lake trout would just rot and lay on the bottom. You could not pull your nets out of the dead, decaying lake trout on the bottom…So they (the state) encouraged us to start trawling for chubs, alewife, and smelt (Osmerus mordax)…there were too many…it takes a long, long time to get these captains experienced on the operation of the net, the equipment, where to fish, and so forth. Once you lose these guys, there is no way you're coming back…under the present management system they are not going to stay…it will*

> *never come back…they do not have the knowledge like the older people in developing this type of fishery.*[6]

William Carlson of Leland, Michigan has worked the fishing grounds around Michigan's Leelanau Peninsula his entire life, making transitions from gill nets to trap nets to purse seines. He invokes community-based knowledge of this habitat in chronicling his participation in fishery policy debate and occupational endurance over the past thirty years:

> *The native species that commercial fishermen pursued in the Great Lakes were lake trout and whitefish and lake sturgeon (Acipenser fulvescens) and chubs and yellow perch (Perca flavescens) and menominees (Menominee whitefish-Coregonus quadrilateralis), though lake trout and whitefish were the most valuable and that's what they concentrated on…A lot of the knowledge that we have was passed down. Species that are indigenous to this area of the Great Lakes, they're doing things for a reason—reasons we may not know—but they do not change very often. Exotic species, species that may have been introduced, those are the things the we've had to learn about—the salmon, for instance, what their habits are and why they react to things. But the information that's been passed down to us, traditional spawning grounds, traditional feeding areas, the ways fish move, that's information that somebody learned the hard way and we've learned the easy way…*
>
> *We're still doing a lot of research and learning things but when it comes right down to it, we're still going back to those traditional fishing grounds that have been passed on from generation to generation.*[7]

He continues:

> *But historically, we still have the advantage that my father and my grandfather and my great-grandfather passed onto us that gives us a lot of shortcuts. We know where the fish should be at certain times of the year. They were not as sophisticated in understanding water temperature. I do not think they knew why fish came up shoal. I do not think they knew why fish went deep or why they came off the bottom. We have a better feel for that. I do not even remember my father saying much about water temperature being a factor. He said he knew when the fish came up—if the pollen is on the water the whitefish will be shoal. Now whether he associated that with white—the pollen—with the whitefish coming shoal, I have no idea, but that's how he gauged when to move his nets into shoal water. If there was a lot of east wind, he would tell me: " well, we're going to have better fishing in shallow water." But the reason was that the wind blows the surface water away from this shore and brings colder water up from the bottom and the fish are temperature oriented. Whitefish like water that is in the 40's and low 50's. Lake trout like it a little bit warmer. Salmon like 55 degrees. We learned that because of advances made in technology. But most of it was observation—trial and error—putting those things together.*[8]

The U.S. Fish Commission's earliest economic surveys of Lake Michigan's fisheries account for these combined ethnic, family, and regional affiliations, a work structure that led to the development of frequently referenced "fishing centers" or "fish towns" and their recognized fishing grounds. From these locations, members of Lake Michigan's fishing communities developed TEK's geographic vocabulary and spatial sense of species behavior. For all its strengths and weaknesses, the ecological basis of this management tradition is long and vestiges survive among Lake Michigan's small commercial fishery.[9] While these forms of vernacular governance and vernacular ecological interpretation are easily romanticized, oral history reveals the manner in which these human geographic affiliations and occupational folk histories use TEK to socially and culturally validate the commercial fishing community's claims to the resource.

The Technological Interface: TEK's Relationship to Tradition and Change in Harvesting Methods

Commenting on the roots of inherited knowledge of Lake Michigan's fisheries ecology, commercial fishers describe the knowledge of lake bottom that was required to successfully use the pound net, gill nets, and set lines by prior generations. Mastery of this technology established the fisher's ecological relationship to the resource, knowledge that could easily be disrupted by biological invasions, overfishing, planting of non-indigenous species or lack of skill in using

harvesting technology. Commercial fishers' oral histories reveal that their technological proficiency not only determined economic success, but also determined the fisher's ability to evaluate the overall ecology of the fishery. Lake Michigan commercial fishers who made the transition between pound nets, gill nets, trap nets (Figures 4 and 5), and trawling, attest to this system of ecological learning.

Figure 4-The *Joy*, which works out of Leland, Michigan, is typical of the trap net boats that are used on Lake Michigan today. It long, open stern area allows for the safe and manageable retrieval of the trap net's pot section—the end of the net and the main entrapment device on this type of harvesting technology. The trap net is essentially a submerged version of a pound net. (Photograph by Chiarappa)

Figure 5-The Weborg family of Gills Rock, Wisconsin has fished Lake Michigan's waters for the past century. Having started as gill net fishers, they have translated their knowledge into a successful trap net fishery for lake whitefish (Coregonus clupeaformis). In this photograph, two members retrieve the pot of the trap net. (Photograph by Chiarappa)

For each generation that has fished Lake Michigan over the past half century, each harvesting technology and its environmental context has established relative ecological relationships, ethnoscience, and evaluative functions. Alan Priest of Leland, Michigan describes how his mentors instilled, and his owned working experience affirmed, TEK's synergistic dependence on technology and fishing environments:

> *Ross and Fred Lang taught me how to work. You cannot show up for work and jump on the boat and go out and catch chubs. It does not work that way. Right here in the shed is 90 percent of your fishing—working on nets. If you do not keep up your nets…your not going to produce anything. I'm not saying go out and rape the lake or take every fish that you can catch, no…they taught me how to work and be responsible. Well, you have to learn the banks. Certain spots produce better in the summer than they do in the fall. Over the years, you just learn which spots produce better at certain times of the year and at what depth of the water. You keep a logbook. I write the weather conditions. While we are lifting nets, I always have the sounder on so I can see where we are catching most of our fish. So, when you set back, you put most of your nets in that depth. But you do not concentrate on that depth. Say the fish are in 57 to 60 fathoms. Well, you might start out in 63 and go up to 49 and then go down to 57, 58, 59, 60 and set seven or eight boxes in that depth. You always have two or three that are up above or deeper because the chubs move up and down the bank.*[10]

Although a generation older than Alan Priest, "Pete" LeClair of Two Rivers, Wisconsin describes a similar situation when he converted his gill net tugs to trawlers to harvest chub, alewife, and smelt. LeClair described a significant adaptive process in learning how to achieve the proper spread with the otter trawl and in the need to install a hauling ramp on the fish tug to avoid being swamped by the weight of the full cod end. But LeClair's emphasizes, particularly in policy debate, the demands of acquiring new ecological knowledge to find and successfully harvest each species:

> *We started trawling here in the Two Rivers area in1962. We started with the old small Susie Q and I'll tell you, we did not have much money to buy a trawl net (Figure 6). At the time, trawl nets were*

$1500—I believe. We went out the first day and we lost her—our trawl net. Got a shipwreck and lost the whole works. Went out the next day, lost another one. I said this is not going to work so we had to go to our next plan. So then we got a hold of an old car ferry captain. He had been on the lake a long time and he had a map of all the lakes showing shipwrecks, explaining the lake bottoms, where the rocks were, where the reefs were, and where the clay balls were. We worked with him for several weeks and mapped out an area that had a good sand bottom where we had half of a chance of fishing. Fortunately, now with loran and shipwrecks charted, you know where you can go and where you cannot go. So, all this was part of the development of the fishery. We went from charts to sounders to color TV sounders to fish finders. The only way you do all this is through experience. You cannot take a guy off the street, throw him in the boat, and say your going fishing. We tried fishing up in Lake Superior a couple of times, but if you're not familiar with the grounds it is difficult. We took our trawlers up there and we tried to catch smelt on Lake Superior. But we were not familiar with the bottoms and we tore our nets and lost some nets. There are clay balls up there and we got clay balls in our nets and they destroyed the whole operation. It just did not work. You have to grow up in an area of the lakes and you have to know your lake bottom.[11]

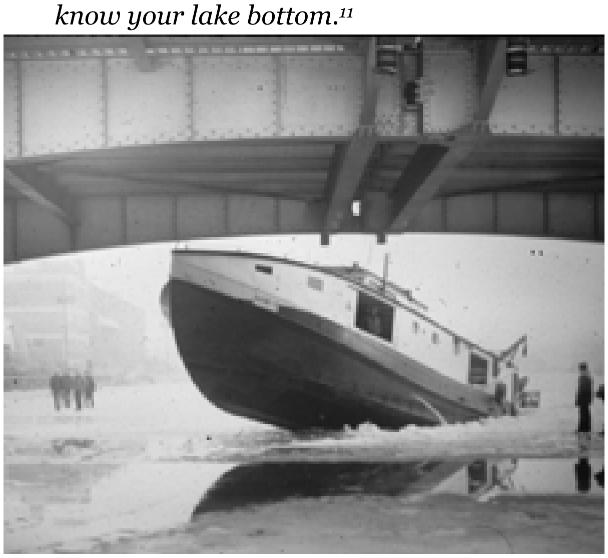

Figure 6-Daniel "Pete" LeClair's fish tug *Susie Q.* breaking ice at Two Rivers, Wisconsin. This boat was originally designed for gill net fishing and LeClair converted it to trawling—no small task considering the boat's low freeboard. The boat technologically adapted to the ecological factors of trawling for alewife, smelt, and chub. (Photograph courtesy of Daniel "Pete" LeClair)

Filling the inshore waters, these fishing grounds, harvesting technologies, and shoreside facilities (fish houses, shanties, reel yards, processing buildings), create an ecological synthesis that was tuned to the instinctive movements of various Great Lakes fish—most notably whitefish, lake herring, and lake trout—and the undulating seasonal rhythms and temperature of the freshwater sea's surface water. Both Pete LeClair and William Carlson note that their families earlier use of pound nets set the precedent for these localized management schemes, and their proximity to their shoreside facilities and created ecological relationships and knowledge that initially established each family's customary notion of its territorial or home fishing grounds. It was not just architecture and technology's economic function that engendered this sentiment, but the manner in which the integrated use of buildings, boats, and netting fostered each family's intimate understanding of their local fish habitat (Figure 7).

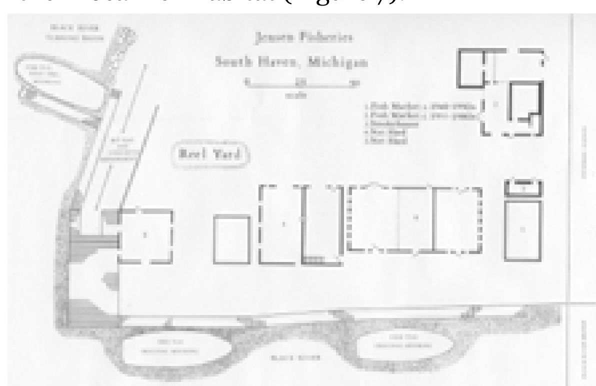

Figure 7-This site plan of the Jensen fishery in South Haven, Michigan is representative of the region's "fishing centers" or "fish towns." Such sites and their architecture provide territorial bearings and technological infrastructure that figures prominently in the formulation of TEK. (Drawing by Chiarappa)

Great Lakes commercial fishing struggled through the 1940s and 1950s. While this was partly attributable to the over-fishing of certain stocks, it was more shockingly revealed in the effects of non-Native species. In particular, the predacious, non-Native sea lamprey practically extinguished the lake trout population of the Great Lakes basin. These factors, combined with the events of World War II, instigated a series of logical, yet varied, adjustments in the interface between TEK and technology. In this regard, the technological and ecological versatility of the earlier fish tug design, which was used

exclusively for gill netting, found new expression in the larger, steel-hulled fish tugs (Figure 8) and trap net boats of the mid-twentieth century (used for gill netting, trap netting, and trawling). For reasons relating to its basic occupational function and geographic affiliation, these larger, more durable boats assumed distinct cultural value within the commercial fishing community—a sense of technological empowerment and new TEK that enabled them to face new problems that were confronting the industry.[12]

Figure 8-This advertisement shows how the design and use of Great Lakes fish tugs, and, by extension, TEK, was being influenced by wider technological developments. (Atlantic Fisherman)

Daniel "Pete" LeClair, Jack Cross of Charlevoix, and Charles Jensen of South Haven noted that new fish tug and trap boat designs, navigation equipment, and bottom reading technology responded to ecological and policy changes, but, in turn, fostered the creation of new TEK.[13] William Carlson describes the process as follows:

> *We've used other techniques in catching fish that helped us learn quite a bit. In the 1970s, we adapted the purse seine to the Great Lakes to catch whitefish. We built a boat, outfitted it, got equipment made for the particular areas we intended to fish in and the areas that we were limited to, had gear made to fit those conditions, and then we used the purse seine on the Great Lakes. It worked very, very well and we learned a lot about fishing doing that. We learned a lot about whitefish—what they did, what were their general movements, how they congregated or schooled and the strata of water that they would be located in. Because it was a new technique on the Great Lakes—we were pioneering it—we had to do a tremendous amount of research, a lot of trial and error. It's no longer used here, but that's because we cannot fish in the waters where we used it. They're Indian waters and they have exclusive rights to those areas. The purse seine had its limitations in that it had to be fished in good weather, and so we looked for bays and areas where we could get protected waters to fish it in, and those areas we can no longer fish in. So there's a lot of learning in a situation like that, but in the traditional gear like trap nets and pound nets, we're doing that on a historical level. We're learning a little bit, especially with trap nets, because we're fishing areas that were never fished with pound nets.*[14]

Through these changes, informants describe fishing vessels, harvesting technology, and processing buildings as maintaining the vital balance between old and new TEK as the commercial fishing community's negotiating position became increasingly marginalized making TEK a much needed hedge as the industry pursued new target species and adjusted to sport fishing policy and Native American treaty rights fishing. Technology and TEK are fused in the oral record as an archive of the commercial fishing community's effort to adapt its claims to fisheries resources amidst Lake Michigan's uncertain ecological and policy changes.

OF ICE AND MEN: TEK, TECHNOLOGICAL AFFINITY, AND THE GREAT LAKES FISH TUG

Over the course of the twentieth century, the Great Lakes fish tug occupied a central position in the region's commercial fishing ecology. These stout, durable boats—distinguished by their totally enclosed working areas—mediated their user's relationship with the Great Lakes. As Great Lakes fishermen pursued various target species in frequently rough and ice-ridden waters, the fish tug framed an experience that was at once technologically empowering and

environmentally humbling. These conditions prompted not only the technological necessity of the fish tug, but also the technological affinity that defined its ecological role and occupational status. As Lake Michigan's commercial fishing activity became more fragile due to diminishing stocks of target species and the biological invasion of non-indigenous species, the fish tug's role as an archive of collective memory and TEK became more acute. Why did this boat's ecological profile—as harvesting technology and visual icon--function so prominently as a memory device in personal histories, local historical events, descriptions of the environment, and accounts of work patterns (Figures 9, 10, 11-The evolution of twentieth century Great Lakes fish tug design. To mitigate weather conditions, facilitate the efficient retrieval of gill nets, and provide fish processing space, the fish tug went from being principally an open deck vessel to being fully enclosed).

Figure 9-The fish tug *Herbert* of St. Joseph, Michigan, c. 1910-1920. (Courtesy of Kathryn Chappel)

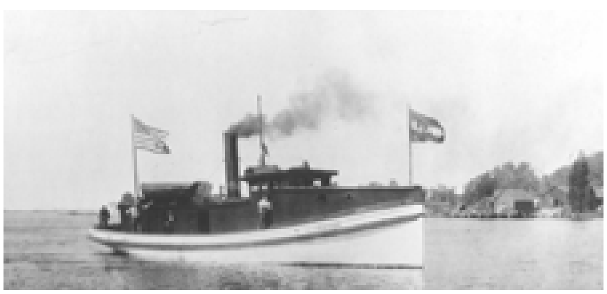

Figure 10-the fish tug *H.J. Dornbos* of Grand Haven, Michigan, c. 1930-1935. (Courtesy of Fern and Robert Ver Duin)

Figure 11-The fish tug *Butch LaFond* of South Haven, Michigan, c. 1940 (Courtesy of Michigan Maritime Museum)

Oral history, along with written and visual documentary sources, establishes the context and wider expression of a technological affinity or "technologically sublime" relationship between fish tug users, the vessels, and the fisheries ecology within which they are used.[15] Initially, the fish tug empowered the ecological perspective of Lake Michigan fishers by allowing them to travel greater distances and harvest greater volume of their two principal target species—lake trout, whitefish, and lake herring. Having been restricted by the limited range of the Mackinaw boat, the steam and diesel-powered fish tug made Lake Michigan fishers less bound to a single port of operation and could explore a wider range of off-shore fishing grounds. After World War II, when lake trout and whitefish declined in number, the fish tug enabled fishers to investigate new fishing grounds for previously underutilized stocks of perch, chub, and walleye. Both wood and steel fish tugs allowed Lake Michigan's fishers to be more mobile and able to understand the more diverse complexion of the basin's fisheries ecology. Oral history consistently sheds insight into how the fish tug continued to foster each fisher's local ecological consciousness and gradually facilitated a more holistic view of the spatial diversification that characterized the lake's fisheries ecology. In this role, fish tugs not only allowed fishermen to act on the ecological contingencies of the fishing enterprise, but also acted as a visible marker of the fisher's extra-territorial affiliations.[16]

When the Mollhagen family of St. Joseph, Michigan built the steam-powered fish tug *Herbert* in 1908—before the rise of the enclosed-deck fish tug—they did not hesitate to adorn their business stationery with a drawing of the boat and the by-line: "Great Lakes steel fish tug." The sentiment behind this label is most revealing and substantiates the fish tug's longtime technological tenure and the manner in which it engendered ecologically-specific relationships on Lake Michigan and the other Great Lakes. Oral testimony correlates the production of steel tugs in local Great Lakes boatyards with the vernacular re-definition and re-appraisal of Lake Michigan fisheries ecology.

The ecological contingencies of this learning process are emphasized in narratives that describe the region's cold water, highly capricious wave-action, and, most of all, arduous ice conditions. Alan Priest describes a typical situation:

> *In the wintertime we try to fish close to home. There's a place called the Northeast Channel bank and the channel bank which is right off the northeast corner of North Manitou Island. They're about an hour and ten minutes out. And that's because of the weather. It blows just about every day starting the end of October until the ice is out or spring. It's very rare, but we fished the last three winters all winter. It's very seldom that we get to do that. The harbor freezes up with ice every once in a while. Then we take the boat up and turn it around at the falls and get her pointed down the river and just give her the berries. We can go through lots of ice. What you do is you hit the ice with the bow and you feel it. Then you give her the throttle and the tug goes up and breaks the ice. Always make sure you have a clear spot behind the boat so you do not get stuck. You can turn around, but it will take time. But right here in the harbor, we can get through anything that will build up. It's just the drift. I call it snowballs. You will start with a snowflake and then it will freeze and roll. You can get some that are as big as these fish sheds. Then they pack in here. You get a southwest wind and it just packs in here. You have to be careful if you're out on the lake and you get ice drifting around—you have to get home.17*

Chuck Jensen of South Haven, Michigan cited similar circumstances regarding his lifetime experiences with fish tugs on Lake Michigan. He, along with other commercial fishers, acquired knowledge about various aspects of Lake Michigan's fisheries ecology through using a fish tug. But in extreme weather conditions, he hastened to note that the vessel's technological benefits hinged on the fisher's understanding of pre-existing ice conditions in port locations and his ability to read wind conditions that created large ice floes that Great Lakes fishers refer to as "ice windrows."[18] In both cases, Jensen and Priest evaluate the earlier ecological lessons that had been wrought from fish tug use. Steel tugs were never to be a reality for many of Lake Michigan's fishers, but they did reinforce a pervasive mindset within Lake Michigan's commercial fishing community that is evident in Priest's hyperbole: "I have more faith in these old fish tugs than I do a freighter or a sailboat or any kind of boat…I'm married to my fish tug, just like my wife."[19]

Conclusion: TEK, Occupational Struggle and the Coded Claims of Lake Michigan's Commercial Fishers

When Lake Michigan's commercial fishers narrate their participation in the management debates of the later twentieth century, their perspective is colored by their efforts to occupationally survive. This stance certainly elicits commentary on policy that has either facilitated or hindered their pursuit of fish. But for commercial fishers, fisheries management is a far more entrenched claim whose historical effect is only minimally gauged by the printed word of the policy making process. Not surprisingly, when asked to provide oral testimony on their view of the historic relationship between fisheries management and their economic livelihood, most of Lake Michigan's commercial fishers chose to do so through description of their fishing grounds, harvesting technologies, shoreside communities, and family affiliations.

In the oral histories of Lake Michigan's commercial fishers—in the themes emphasized, in the points made, in the resonating reflections—herein lies the critical nuance of TEK's capacity to measure a fishing community's past and present prospects. Oral history allows its narrators to explore the broader implications of TEK and offer it as counterpoint to "official" regulations, scientific reports, and evaluations of harvesting technology. In developing new co-management schemes, fisheries managers can use these narratives for their sheer content or they can ethnographically observe their use in various contexts within the commercial fishing community. In either case, our view of Lake Michigan fisheries management and policy will be revised and will embrace far greater criteria; in short, by mapping human sentiment, oral history reminds us that fisheries management and policy is the exercise and expression of values, needs, and ecological relationships. Much material can embody these intentions, but oral history clarifies how they are complexly synthesized as TEK.

Lake Michigan commercial fishers use oral history to invoke TEK's authority as a form of vernacular governance and enlist it in on-going historical claims over the right to use Lake Michigan's fish. As in many debates, there have been points of striking division and surprising agreement since Lake Michigan's commercial fishers first began asserting their competing claims among the basin's stakeholder groups. Pete LeClair's testimony is emblematic of the

sympathies and conflicts that consume the expression of TEK:

> *The fishery is so up and down it's almost impossible to manage it by sitting at your desk in Madison (Wisconsin)—saying we have to put quotas on them and we have to do this when they do not even know what's out in that lake or what the biomass really is. Fish and Wildlife go around once a year with their small net and their boat. It is just a waste of time because if you go one week earlier or one week later from when they go, or if you go in a different depth of water, the whole project would be turned right around. You can get a ton of smelt and you go out the next day you cannot find one and you're in the same depth of water and same area. So, the current, the water temperature—it all changes and you cannot do this by going around the lake 2 weeks out of the year and say this is what is out in the lake. That's false. It's very, very, very disturbing when you try to manage a lake off this kind of a data. You just cannot do it and we would like to be part of a research program where we could go and make test drags with our nets. We know the nets -- we know what the nets can catch because we proved it. We would like to be a good research team with the DNR* [Department of Natural Resources]*—take the DNR people out there and monitor our catches, study the classes, study the gross factors, study the sex ratios and really know what's going on out on that lake. If you have more forage fish, you have to plant more predator fish. If the forage fish is down you plant less predator fish. If you do this, you can maintain a perch fishery, maintain a sports fishery and maintain a commercial fishery that produces food for human consumption. This is what this is about.*[20]

But competing claims to natural resources are scarcely unique in broad historical perspective, and historians and anthropologists are just starting to take note of how the threshold or liminal nature of the maritime environment shapes these dynamics. During the late nineteenth century, the seeds of a complex array of claims or authority over Lake Michigan's fisheries began to take place. The major fishing constituencies on Lake Michigan began this self-referential (at times, polemical) claiming exercise by describing their administrative prerogative or natural heritage or economic livelihood or cultural birthright. For Lake Michigan's commercial fishers, oral testimony unifies these strands of TEK and places them at the center of the group's folk historical consciousness. The folk historical dimensions of TEK verbally corroborate the past and verbally continue the endurance and revision of fishing claims in the present. The utility of these perspectives in wider planning arrangements rests with oral and public history's ability to "share authority" with those groups who will continue to bear the burden of fisheries management and policy in the future.[21] In this way, the inextricable relationship between TEK and folk historical identity reveals paradoxical considerations that will inform the evaluations of fisheries history and the formulation of future fisheries policy and stakeholder relations.

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[1] For more on collection, interpretation, and application of traditional ecological knowledge see: Barbara Neis, Lawrence F. Felt, Richard L. Haedrich and David C. Schneider, "An Interdisciplinary Method for Collecting and Integrating Fishers' Ecological Knowledge into ResourceManagement," in Fishing Places, Fishing People: Traditions and Issues in Canadian Small-ScaleFisheries, eds. Dianne Newell and Rosemary E. Ommer (Toronto: University of Toronto Press, 1999), 217-238; Barbara Neis and Lawrence Felt, eds. Finding Our Sea Legs: Linking Fishery People and Their Knowledge with Science and Management (St. Johns, Newfoundland: Institute of Social and Economic Research, 2000).

[2] Paul Thompson, with Tony Wailey and Trevor Lummis, Living the Fishing (London: Routledge and Kegan Paul, 1983).

[3] A number of works present the intersection of folk history and oral history in fishing communities. See: Timothy C. Lloyd and Patrick B. Mullen, Lake Erie Fishermen: Work, Tradition, and Identity (Urbana: University of Illinois Press, 1990); Janet C. Gilmore, The World of the Oregon Fishboat: A Study in Maritime Folklife (Ann Arbor, MI: UMI Research Press, 1986); James Acheson,*The Lobster Gangs of Maine* (Hanover, NH: University Press of New England, 1988) For more on methodological and interpretive considerations surrounding oral history and folk history see: Rosemary E. Ommer, "Rosie's Cove: Settlement Morphology, History, Economy, and Culture in a Newfoundland Outport," in Fishing Places, Fishing People: Traditions and Issues in Canadian Small-Scale Fisheries (Toronto: University of Toronto Press, 1999), 17-31; Jean L. Manore and John J. Van West, "'The Water and the Life': Family , Work, and Trade in the Commercial Poundnet Fisheries of Grand Bend, Ontario, 1890-1955," in Fishing Places, Fishing People, 55-79; Henry Glassie, "The Practice and Purpose of History,"Journal of American History 81 (December 1994): 961-968; Passing the Time in Ballymenone: Culture and History of an Ulster Community (Philadelphia:University of Pennsylvania Press, 1982); Sam Schrager, "What is Social in Oral History,"International Journal of Oral History 4: 76-98; Charles L. Briggs, Learning How to Ask: A Sociolinguistic Appraisal of the Role of the Interview in Social Science Research (Cambridge:Cambridge University Press, 1986); Edward D. Ives, George Magoon and the Down East Game War (Urbana:University of Illinois Press, 1988); Robert Perks and Alistair Thomson, eds. The Oral History Reader

(London: Routledge, 1998); Stephen Caunce, Oral History and the Local Historian (London: Longman, 1994).

[4] The broad historical patterns of commercial fishing on the Great Lakes are presented in Margaret Beattie Bogue, Fishing the Great Lakes: An Environmental History, 1783-1933 (Madison: The University of Wisconsin Press, 2000) and A. B. McCullough, The Commercial Fishery of the Canadian Great Lakes (Ottawa, Canada: National Historic Parks and Sites/Canadian Parks Service/Environment Canada, 1989). The contested issues surrounding Great Lakes commercial fishing since the middle of the twentieth century are well-documented in: Robert Doherty, *Disputed Waters*: Native Americans and the Great Lakes Fishery (Lexington: The University Press of Kentucky, 1990); ; Tom Kuchenberg, Reflections in a Tarnished Mirror: The Use and Abuse of the Great Lakes (Sturgeon Bay, WI: Golden Glow Publishing, 1978).

[5] Daniel "Pete" LeClair, interview by author, tape recording, Two Rivers, WI, 11 December 1997.

[6] Daniel "Pete" LeClair interview.

[7] Lester William "Bill" Carlson, interview by author, tape recording, Leland, MI, 26 and 27 May 1999.

[8] Lester William "Bill" Carlson interview.

[9] Hugh M. Smith and Merwin-Marie Snell, "Review of the Fisheries of the Great Lakes in 1885," U.S. Commission of Fish and Fisheries, *Report of the Commissioner for 1887* (Washington, D.C.:GPO, 1891), 1-333.

[10] Alan Priest, interview by author, tape recording, Leland, MI, 29 May 1999.

[11] Daniel "Pete" LeClair interview.

[12] "Great Lakes Fish Tug Has Dual Engine Drive," *Atlantic Fisherman* (hereafter *AF*) 26 (October 1945), 27; "42 Ft. Steel Fishing Tug Has New Features," *AF* 26 (November 1945), 40; "Gill Netter 'Sir Knight' Added to Michigan Fleet," *AF* 26 (January 1946). The later twentieth century context, values, and temperament that shaped the Great Lakes fish tug are reflected in feature articles and photographs in *Atlantic Fisherman*. See *AF* 27 (May 1946), 33; *AF* 27 (June 1946), 31; *AF* 27 (December 1946), 25; *AF* 28 (March 1947), 24; *AF* 28 (August 1947), 26; *AF* 29 (April 1948), 20; *AF* 29 (July 1948), 25. See also: Frank E. Firth, " Fishing Gear and Fishing Methods, " in *Marine Products of Commerce* by Donald K. Tressler and James McW. Lemon (New York: Reinhold Publishing Corporation, 1951), 263-264; Shari L. Dann, *The Life of the Lakes: A Guide to the Great Lakes Fishery* (East Lansing, MI: Michigan Sea Grant Extension/Michigan State University, 1993), 30; "Fisheries of the Great Lakes Waters: Over Half of Nation's Fresh-Water Yield Comes from Eight Lakes States, Led by Michigan," in *AF* 31 (December 1950), 14, 35; *AF* 26 (September 1945), 34; *AF* 28 (April 1947), 26; *AF* 28 (June 1947), 18. See Robert C. Grunst, "Farsighted Designs: The Fish Tug *Johanna* and Trends in the Upper Great Lakes Fishery," *Inland Seas: Quarterly Journal of the Great Lakes Historical Society* 53 (Summer 1997), 97-108, for one of the few contextual studies of the Great Lakes fish tug.

[13] Daniel "Pete" LeClair, interview; Charles Jensen, interview; Jack Cross, interview, tape recording, Charlevoix, MI, 27 May 1999

[14] Lester William "Bill" Carlson interview.

[15] David Nye, *American Technological Sublime* (Cambridge, MA: MIT Press, 1994).

[16] Smith and Snell, "Fisheries of the Great Lakes," 185; HowardWeborg, interview by author, tape recording, Gills Rock, WI, 1 June 1999; Kenneth Peterson, interview by author, tape recording, Fairport, MI, 4 June 1999. Commercial fishing trade journals—*The Fishing Gazette, The Fisherman: The News Journal of the Great Lakes Fisheries, and Atlantic Fisherman*—contain frequent references to the geographical movement of Great Lakes fishermen during their occupational calendar year.

[17] Alan Priest, interview.

[18] Charles Jensen, interview.

[19] Alan Priest, interview.

[20] Daniel "Pete" LeClair, interview.

[21] Michael Frisch, A Shared Authority: Essays on the Craft and Meaning of Oral and Public History (Albany, NY: State University of New York Press, 1990).

Can Historical Names & Fishers' Knowledge Help to Reconstruct Lakes?

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Abstract
Reconstructing the historical distribution of local Brown trout populations is of great importance. Information of what has actually been lost and its causes is necessary for rebuilding natural lake ecosystems and recreational fisheries, as well as monitoring future changes. Older fishermen and local fishing right owners in 63 privately governed fishery management organizations (FMOs) in Northern Sweden were interviewed, focusing on current species distribution, stocking, introductions and extinctions in 1509 lakes. Names were collected for each lake from modern and historical maps. Historical archives concerning fish species distribution and stocking were also compiled. Brown trout lake candidates were surveyed with multimesh-sized gillnets or other methods. Observations of bottom substrate confirmed or ruled out existence of proper habitat conditions for spawning. Chemical, physical and biological anthropogenic impacts were assessed by archival data and limnological surveys over 20 years. Information gathered from a number of sources and methods allowed for comprehensive validation of lake name evidence and interviews. All data were temporally as well as geographically referenced and stored in a GIS-linked database. One third of all lakes with historical or present Brown trout populations had *Rö,* or other dialectal terms commonly used for brown trout, included in their names. By targeting *Rö*-lakes, there was a minimum of a 90% chance of finding an historically or currently present brown trout population, compared with 11% when lakes were randomly chosen. Lake names were shown to be strongly associated with details regarding the fish fauna as well as the habitat. This study is, to my knowledge, the first published attempt to employ lake-name evidence in investigating fish species distribution. The entire data supports the idea of long-term stable brown trout lake distribution under pre-industrial natural conditions. However, since the 1920's, 27% of *Rö*-lake populations were found to have suffered permanent extinction (extinction rate >3 % per decade) mainly associated with fish introductions. Historical names, fishers' knowledge and documentary evidence combined with limnological data proved powerful in revealing the past natural distribution, as well as initiating restoration of brown trout lakes in Northern Sweden.

Introduction
Most marine and freshwater ecosystems around the world are being degraded and fish species pushed towards extinction (Moyle & Leidy 1992; Maitland 1995; Pitcher 2001). European inland waters are subjected to chemical, physical and biological anthropogenic disturbances leading to extinction of local fish populations (Lelek 1987; Maitland & Lyle 1991; Bulger & Lien 1993; Crivelli & Maitland 1995). From this perspective, knowledge on the most basal questions like, which populations have survived? or, which populations have been lost? are fundamental to practical conservation and management. For example, anthropogenic impact is eradicating or reducing brown trout (*Salmo trutta* L.) populations all over the species range according to Laikre *et al.* (1999). They conclude that the valuable biological resources that local brown trout populations represent are being lost at an alarming rate. Consequently, reconstructing the historical distribution of local Brown trout populations is of great importance. Information of what has actually been lost is necessary for rebuilding natural lake ecosystems and recreational fisheries, as well as monitoring future changes. However, no scientific investigations appear to have addressed the problem of reconstructing either the historical distribution of local Brown trout populations in any country in Europe, what has actually been lost to date, or the extinction rate. Laikre *et al.* (1999) strongly recommended that such studies of local brown trout populations be carried out both on a national and international level. Thus, empirical studies that include the historical dimension are needed to provide insight into conservation and management on a wider landscape scale.

Spatial dimension
If the objective is to cover large areas and achieve a wider landscape scale study on fish species presence or absence, it can mean surveying thousands of lakes. Conventional scientific methods with multimesh-sized gillnets (Appelberg 2000) by skilled personnel can be too time consuming, labour intense and costly if every lake were to be sampled. Making use of fishers' knowledge gathered through interviews can enable larger scale studies with less effort producing valuable data if properly validated (Hesthagen *et al.* 1993).

Historical dimension

In the absence of paleontological methods, the sources of information on historical distribution of species are limited to interviews and rare, fragmented archival records, where they exist. With first hand interviews it might be possible in some cases, to extend our perspective 80 or so years back in time, and with some rare archival data, perhaps even longer. A few studies have also suggested that many hundreds of years old place-names from maps can be useful historical sources of information on different species occurrence and habitat. Place-name evidence for the former distribution of beaver, wolf, crane and pine-marten is put forward in three studies in Britain. (Aybes & Yalden 1995; Boisseau and Yalden 1998; Webster 2001). Examples of place names in maps as historical sources on the past occurrence of halibut, sturgeon and whale is mentioned in Wallace (1998). The feasibility of using place names as indicators of original landscapes is tested and verified in a recent study (Sousa & Garcia-Murillo 2001). Lake names with species terms could prove to be valuable historical records of fishers' knowledge. If so, it might be one of few pre-industrial sources on fish species information for many lakes. The present study aims to show that historical lake names from maps can be useful indicators of past and present fish distribution if properly validated. To my knowledge, this is the first published scientific attempt to employ lake names in investigating fish species distribution.

The main objective of this study is to demonstrate how fishers' knowledge from interviews and historical fishers' knowledge from maps and archives together with limnological surveys can be used to elucidate the past and present distribution of fish species. This is exemplified by discerning brown trout lakes among 1509 lakes in northern Sweden. The following hypothesis is tested: "historical brown trout term" lakes with/without brown trout populations are represented at the same frequency as other lakes with/without this species. Making use of fishers' knowledge, it is intended that results from this study will serve as a template for ecosystem reconstruction as well as help management with policies and action to avoid present populations going extinct.

MATERIAL AND METHODS

Study area

The present study focussed on one geographic region to enable high sensitivity in detecting local dialectal phenomena, in contrast to choosing a more scattered random sample with the same effort e.g. a national survey. The study area with its center situated near 63°32´N 18°12´E extended over roughly one third of northern Västernorrland and parts of Västerbotten in the northern boreal region of Sweden (Fig 1). This investigation included 1,509 lakes and was delimited within the lake watersheds covering over 700,000 hectares. This area consists of 20 entire adjoining watersheds, each of which drains into the Baltic Sea, plus 40 partial drainage basins. The lake district is a result of deglaciation from 7,600 B.C. and new lakes are continuously being formed by the isostatic uplift of the coastline at a rate of around 8mm/year (Anon. 2001). Lakes have an elevation range of 0.1 to 515m above sea level. They are mostly oligotrophic, located in hilly productive forest land or bogs although some eutrophic lakes are found in cultivated areas. The region is sparsely populated with 8 inhabitants per km², most of which are concentrated in a few population centres. A majority of lakes belong to 63 privately governed Fishery Management Organisations (FMOs). FMOs consist of associations of private and company landowners that sell licenses to the public and manage the waters, as well as provide information about the fisheries (Fig 2).

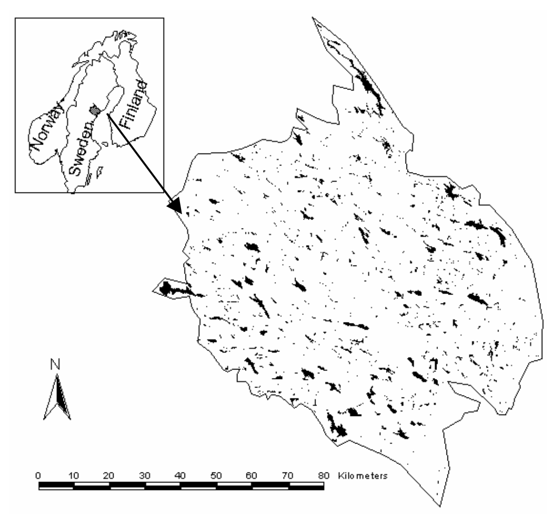

Fig 1. 1509 lakes within the study area.

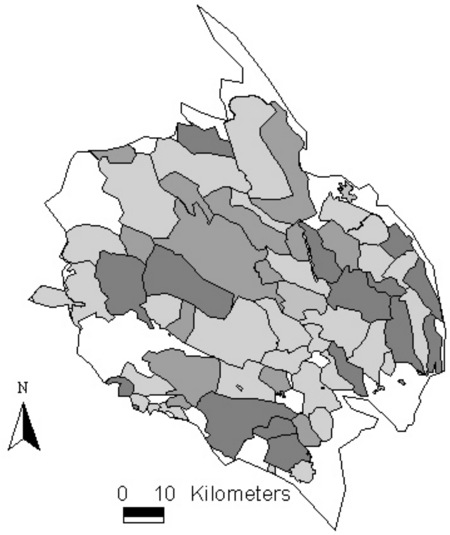

Fig 2. Coverage of 63 fishery management organizations (FMO:s) within the study area

Methods

Face to face in-depth interviews with older fishermen and 250 local fishing right owners in FMOs were held between 1985-2001, focusing on current species distribution, stocking, introductions and extinctions in all lakes. In addition, similar data was collected from local fishermen in remaining non-organized areas. Interviews generally commenced in a structured manner with specific questions concerning key issues e.g. brown trout distribution, spawning areas and stocking. This was gradually followed by in-depth interviews that gave an understanding of the informant's area of knowledge. Furthermore it provided additional contacts with other people knowledgeable on specific waters, fish species or historic events concerning the fisheries. In return, information on management and conservation was given which contributed to a comprehensive exchange of information concerning the waters of interest. Formal meetings were held indoors, often with the aid of maps for proper orientation and to avoid any mix up of lakes. Moreover, in most FMOs, additional field meetings were combined with observations of essential features of their waters. Relationships were built with most interviewees leading to several additional contacts over the years. Data were sought from at least two concordant primary sources when evaluating fish species presence-absence records from interviews. Discrete presence-absence data less prone to impacts of ordinary natural sweeping cyclic environmental change was collected in an effort to make data comparable with different methods and sources as well as avoiding subjective personal opinion. I also investigated archived audio recordings and written linguistic records of fishers born in the nineteenth century from the region of interest, dealing with fish species in local dialects. Scientific papers, encyclopaedias and archives with dialectology, onomastics and folklore research in Scandinavian languages were explored, focusing on lake names and historical brown trout names.

Historical documents concerning fish species distribution and stocking between 1872-2000 were collected from 3 major forest companies, county and municipality administrations, FMOs, the National Board of Fisheries and other sources. Approximately nine months were spent in archival research work, collecting hard-to-access fisheries related information concerning these waters of interest. Stocking data were evaluated in concert with other investigations to discriminate between native and introduced self-sustaining populations as well as non-reproducing populations. The majority of Brown trout lake candidates were inventory sampled with multi-mesh-sized gillnets according to Appelberg (2000) or with a somewhat modified stratification. A few were surveyed with other methods e.g. trapping, rod or single-pass electrofishing with a (LUGAB Inc.) backpack unit in the inlets and outlets. A population was considered extinct when sampling efforts of 0.5-2 multi mesh-sized gillnets per hectare/night plus electrofishing[1] in potential spawning areas did not generate any fish. Moreover, classification of each lake was tested for consistency with limnological survey data and interviews. Lake tributaries and outlets were classified as sufficient for brown trout spawning and early growth depending on the stream size, calculated from hydrological data and field studies. Visual qualitative observations of bottom substrate confirmed or ruled out the existence of proper habitat conditions for spawning of salmonids, determining the capability of lakes to hold self sustainable populations of brown trout. In the current study, waters were considered to lack spawning substrate suitable for brown trout if the bottom material totally consisted of sand or organic fine material (≤ 1 mm). Spawning substrate was confirmed if particle sizes in the range gravel, pebble or cobble (Bain and Stevenson 1999) could be found in patches of a minimum length depending on particle size. (See Witzel and MacCrimmon 1983 and Crisp 1996 for formulae on critical minimum sizes of spawning

[1] In pike-invaded lakes, extinction classification did not consistently include electrofishing.

substrate.) Natural fish migration barriers up and downstream from brown trout lakes were identified, thus determining the possibility of access to spawning-grounds as well as the progeny's ability to get back to the lake. A number of hydraulic, hydrologic and ecological factors were taken into consideration when classifying absolute barriers (Stuart 1962; Jones *et al.* 1974; Reiser & Peacock 1985; Powers & Orsborn 1985). Chemical, physical and biological anthropogenic impacts were assessed using archival data spanning 1925 to 2000, and limnological surveys spanning 1985 to 2001. Names were collected for each lake from 1:50,000 topographic maps (The Swedish National Land Survey 1961-1967). Additional names from county, parish, ordnance or village maps (The Swedish National Land Survey 1672-1908) were collected as well. The production date of each map provided a minimum age of every lake name. All data were temporally as well as geographically referenced and stored in a GIS-linked database. With modern tools like GIS systems and database software it was possible to store and access large amounts of information and achieve a wider grasp of both space and time. Having access to a number of sources and methods on species presence and absence, such as fishers' knowledge, archival data, historical names from maps and limnological surveys, allowed for validation of data concerning each lake. The hypothesis that "historic brown trout term" lakes with/without this species are represented in the same frequency as the number of brown trout populations if any lake is randomly chosen, was tested and rejected with Pearson Chi-square ($p<0.001$).

Feedback to FMOs on the preliminary results generated in this study was given in an effort to make use of the knowledge gained, to help management and in some cases initiate lake restoration.

Quality control of presence-absence

Face to face in-depth interviews, that gave an understanding of the informant's area of knowledge and allowed for collection of data that matched their expertise, were utilized to generate more reliable data. In *Rö*-named lakes, presence/absence data from interviews were validated with the combined data from test-fishing results, stocking records and other archival data as well as habitat surveys. In this respect, interviews succeeded in targeting all lakes with past and present self-sustaining brown trout populations, but within these lakes, two extinct populations were classified as still present. Archival data corresponded to these interview results except for two cases where non-brown trout lakes had been stocked with this species and a brown trout lake that was noted as a single species perch lake. Further validations were made to verify the informants' ability to target non-brown trout lakes. An additional 60 lakes pointed out through interviews as non-brown trout waters were confirmed brown trout free, by multi-mesh sized gillnet surveys. One possible brown trout-term lake was not classified as present or extinct in this study because of insufficiencies in data collected and so was excluded from all the results and evaluations.

RESULTS

Fishers' knowledge gathered from interviews and historical documents discerned several hundred brown trout lake candidates from the 1,509 lakes in the study area. Some lakes were sifted out when surveys found no suitable brown trout habitat e.g. lack of spawning substrate. Stocking data together with other investigations revealed a number of introduced, self-sustaining populations as well as non-reproducing populations totally dependant on hatcheries. These translocated brown trout populations were also excluded from further evaluation. Finally, multimesh-sized gillnets and other methods could verify that 161 lakes, i.e. the majority of remaining brown trout lake candidates, represented past or present self–sustaining local brown trout populations. Hence, if a lake was randomly chosen in this area, there was an 11% chance of targeting a brown trout lake (Fig 3). In addition to the *Rö*-named lakes treated herein, the entire set of lakes will be reported on by Spens (*in prep*) or elsewhere.

Interviews with an elderly fisherman revealed an old oral traditional term for Brown trout - *Rö,* which is not a recognized term for this species in modern language but a common prefix of lake names in modern and historical maps. Furthermore, several records relating to the name form *Röa* in local dialect were found in archives. The following excerpts are from part of the interviews made in Norrland around 40 years ago, freely translated: "Röding i.e. brown trout we call it rödingen" (Dahlstedt 1956). "*Röa* is a large kind of brown trout with red meat, not arctic charr" (Dahlstedt 1961). The term had also been dealt with in onomastic papers that referred to this geographic area e.g. "*Rö*-lake is characterized by its richness in *röa*, i.e. Brown trout" (Edlund 1975). However the linkage of the term *Rö* to brown trout was not known among fishers in the study area.

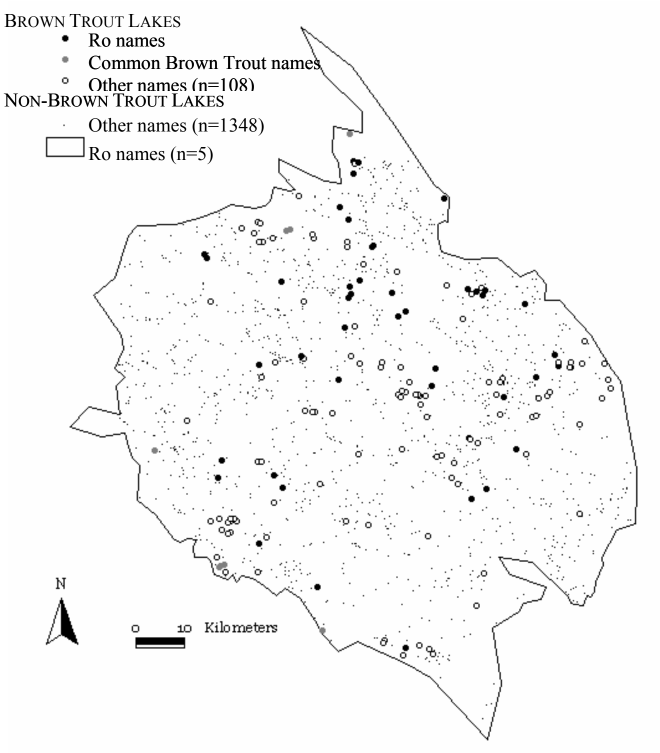

Fig 3 Brown trout and non-brown trout lakes in the study area.

Of all lakes with historically or currently present Brown trout populations, 28% had *Rö* as part of its name. An additional 5% of brown trout lakes in the outskirts of the study area had one of two other dialectal terms commonly used for brown trout (Fig 3). Hence, one third of all brown trout lakes in the study area had been named after brown trout. By targeting *Rö*-lakes, there was a minimum 90% chance of finding an historically or currently present brown trout population. The hypothesis that *Rö*- lakes with/without this species are represented in the same frequency as the number of brown trout populations if any lake is randomly chosen was rejected with Pearson Chi-square test ($\chi^2 = 341.5$; $p<0.001$). Accordingly, *Rö*-lakes were associated with historically and currently present self-sustaining brown trout populations. The *Rö*-name indicated that good natural habitat conditions for this species could be found in these lakes (Table 1):

1) 94% had outlet or inlet streams of sufficient size for brown trout spawning and early growth,
2) 94% had outlet or inlet streams with proper spawning substrate,
3) 94% lacked natural barriers to potential spawning areas,
4) 96% lacked an indigenous severe brown trout predator e.g. northern pike (*Esox lucius*).
5) 100% were isolated by natural barriers from several fish species downstream

Temporal perspective of methods

All types of lake names were found to be "evolutionarily" conservative and most were virtually unchanged through the centuries. A few *Rö*-lakes nevertheless, had been renamed with terms unrelated to brown trout. Many older fishermen used an elderly form of pronunciation not found in modern maps, thus providing evidence of names being passed on in a conservative oral tradition. Detailed maps over 100 years old were scarce as well as fragmented in the heart of the study region and generally drawn at too coarse a scale to illustrate the small lakes in this current study. Even so, 43 *Rö*-names were found dating back 100-330 years, many to pre-industrial times (Table 1 & Fig 4). However it was also assumed that the remaining 7 smaller *Rö*-lakes found on maps produced in the 1960s were initially named more than a hundred years ago. This was since the historical *Rö*-term almost vanished as a species word during the previous century. Moreover, the smaller size of these lakes explained why there was less chance of being marked on the coarse-scale and simple maps produced in this area more than 100 years ago. Archival sources referring to brown trout presence in lakes were found to date back 129 years. First-hand interviews had a maximum scope of 80 years back in time with a median of 61 years.

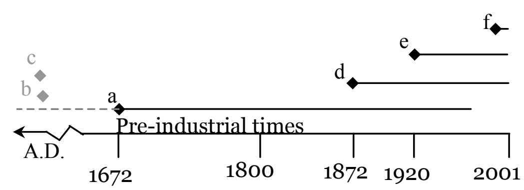

Fig 4. Temporal perspective of methods to reconstruct brown trout distribution in lakes within the study area in northern Sweden.
[a] Lakes names [b] Paleontology: Lack of fish fossil evidence makes reconstruction impossible for individual lakes. [c] Models are not yet developed for reconstruction of fish fauna. [d] Archival data
[e] First hand Interviews [f] Field Surveys

Anthropogenically induced permanent extinctions (1920's -1990's)

Interviews identified 10 of the *Rö*-lakes with brown trout as having lost their populations during the last 80 years (Fig 5). Archival data could verify that the majority of these were historic brown trout lakes. Two independent test-fishing results confirmed that the lakes no longer harboured this species. Two additional recently extinct populations were discovered by

Table 1. *Rö*- Named Lakes and Methods Elucidating Past and Present Brown Trout Populations.

[a] *=Modern maps list a different name. [b] P.ex.b. = Possibly extinct before decade or no population ever existed. [c] Yes = sufficient spawning stream size and substrate existed as well as no natural absolute migration barriers to spawning streams in lake outlet or inlets. [d] [R]=reproductive area called *Rö*-. [e] [N]=Written historical documentation does not mention brown trout [f] Fishers' earliest recollection of brown trout population (decade), [NE] = interviewees never observed Brown trout in lake during the time-span from listed decade until present. [2nd] =Interviews consist of several concordant second-hand sources [g] Self–sustainable local brown trout population sampled year (A.D.), [NO] = no brown trout observed when test-fishing, classified as extinct if evidence of past population exists.

Lake names[a]	Lat° Long° (WGS 84)	Self-sustaining Brown trout population[b]	Spawning substrate access[c]	Earliest records (A.D.)			Test-fishing[g]
				Rö-names[d]	Archive[e]	Inter views[f]	
Hattsjö-Röjdtjärnen	63°37´02´´N 18°59´15´´E	Present	Yes	1852	1961	1930	2001
Hemling.-Rödtjärnen	63°37´20´´N18°29´55´´E	Extinct 1930's	Yes	1766		1930[2nd]	1995[NO]
Inner-Rötjärnen	63°25´05´´N 18°40´13´´E	Never existed	No	1799		1940 [NE]	
Inre Rödingträsksjön	63°59´33´´N 18°12´14´´E	Present	Yes	1792		1980	1999
Lill-Rödtjärnen	63°42´55´´N 18°21´38´´E	Present	Yes	1837		1930	2000
Lill-Rödtjärnen	63°45´30´´N 18°38´29´´E	Present	Yes	1837		1920	1998
Lill-Rödtjärnen	63°14´46´´N 17°59´18´´E	Never existed	No	1824		1950[NE]	
Lill-Rödvattenssjön	63°50´15´´N 17°36´04´´E	Present	Yes	1758 [R]	1958	1930	2001
Lill-Rödvattnet	63°46´13´´N 18°10´10´´E	Present	Yes	1865	1955	1940	2000
Lill-Rötjern*	63°45´12´´N 18°40´23´´E	Present	Yes	1864		1920	2000
Lill-Rötjärnen	63°45´31´´N 18°41´50´´E	Present	Yes	1961		1920	2001
Norra Rötjärn*	63°54´40´´N 18°08´33´´E	Present	Yes	1837		1930	1998
Rödingtjärnen	63°55´14´´N 18°33´51´´E	Present	Yes	1856		1940	2001
Rödtjärnarna	63°50´21´´N 18°15´56´´E	Present	Yes	1961		1930	2000
Rödtjärnarna	63°50´34´´N 18°16´12´´E	Present	Yes	1961		1930	2000
Rödtjärnen	63°38´30´´N17°48´12´´E	Extinct 1930's	Yes	1968		1920	2000 [NO]
Rödtjärnen	63°39´16´´N 17°58´22´´E	Extinct 1920's	Yes	1961		1920[2nd]	2000 [NO]
Rödtjärnen	63°36´35´´N 18°06´54´´E	Present	Yes	1707	1930	1970	2001
Rödtjärnen	63°42´01´´N 18°08´39´´E	Present	Yes	1830		1950	1995
Rödtjärnen	63°35´33´´N 18°28´48´´E	Extinct 1990's	Yes	1766	1940	1930	2000 [NO]
Rödtjärnen	63°29´52´´N 18°37´15´´E	Present	Yes	1961		1950	1990
Rödtjärnen	63°26´27´´N 18°08´59´´E	Present	Yes	1961		1940	1999
Rödtjärnen	63°26´43´´N 17°51´09´´E	Present	Yes	1680	1958	1940	1990
Rödtjärnen	63°45´00´´N17°31´36´´E	Never existed	No	1820		1940[NE]	
Rödtjärnen	63°07´54´´N18°20´21´´E	Extinct 1950's	Yes	1762		1940[2nd]	2001 [NO]
Rödtjärnen	63°25´24´´N 17°53´08´´E	Present	Yes	1776		1920	1999
Rödtjärnen	63°45´25´´N 18°20´19´´E	Present	Yes	1837		1930	2000
Rödtjärnen	63°19´34´´N 17°46´58´´E	Extinct 1970's	Yes	1755	1961	1960	2000 [NO]
Rödtjärnen	63°58´16´´N 18°12´09´´E	Present	Yes	1886		1930	2001
Rödvattensjön	63°47´05´´N 17°54´22´´E	Extinct 1980's	Yes	1752	1967	1930	2000 [NO]
Rödvattnet	63°28´23´´N 17°38´47´´E	Extinct 1990's	Yes	1856	1943	1990	2000 [NO]
Röftierna*	63°28´30´´N 18°48´06´´E	Present	Yes	1711		1970	1998
Röjdtjärnen	63°35´58´´N 18°53´37´´E	Present	Yes	1774		1998	2000
Röjtjärnen	63°43´36´´N 18°51´50´´E	Present	Yes	1790		1990	1998
Rörsjötjärnen	63°45´07´´N 18°09´45´´E	Reintroduced	Yes	1825	1959	1940	2000
Rötenburstjerna*	63°23´24´´N 18°37´07´´E	Extinct 1950's	Yes	1676	1953	1940[2nd]	2001 [NO]
Rötjern*	63°44´50´´N 18°41´57´´E	Present	Yes	1864		1920	2000
Rötjärnen	63°26´39´´N 17°37´53´´E	Extinct 1950's	Yes	1804	1951	1950[2nd]	2001 [NO]
Rötjärnen	63°34´03´´N 18°45´53´´E	Present	Yes	1705		1940	1999
Rötjärnen	63°53´24´´N 18°10´42´´E	Present	Yes	1837		1930	2000
Rötjärnen	63°21´13´´N 19°04´57´´E	P.ex.b. 1930's	Yes	1902	1958[N]	1930[NE]	2000 [NO]
Stor-Rödtjärnen	63°43´22´´N 18°23´32´´E	Present	Yes	1844		1930	2001
Stor-Rödtjärnen	63°14´44´´N 18°00´22´´E	Present	Yes	1672	1958	1930[2nd]	2001
Stor-Rödvattenssjön	63°49´49´´N 17°36´42´´E	Present	Yes	1758 [R]	1937	1930	2000
Stor-Rödvattnet	63°46´54´´N 18°12´45´´E	Present	Yes	1865	1955	1940	2000
Stor-Röjdtjärnen	63°38´19´´N 18°58´28´´E	Extinct 1960's	Yes	1901	1940	1960	2000 [NO]
Stor-Rötjärnen	63°45´21´´N 18°42´40´´E	Present	Yes	1837	1960[N]	1920	1997
Västergiss.-Rötjärnen	63°33´35´´N 18°47´25´´E	P.ex.b. 1920's	Yes	1901		1920[NE]	1996 [NO]
Ytter-Rötjärnen	63°24´25´´N 18°40´53´´E	Present	Yes	1799		1940	1998
Yttre Rödingträsksjön	63°59´22´´N 18°13´36´´E	Present	Yes	1792		1980	1999

way of test fishing, making the total 12 (27% lost in eight decades). The average anthropogenic extinction rate during this time was estimated to exceed 3% per decade. Insight into possible explanations for eradications was gained by limnological surveys and archival data. All *Rö*-lakes, where brown trout populations were classified as extinct, had experienced major anthropogenic impact, in many cases decisive for the survival of populations (Table 2). Such anthropogenic impacts were not observed in any other *Rö*-lake with brown trout present (except for brook charr at a few spawning areas), strengthening the interview and archival data that affected lakes once possessed self-sustaining populations. The lakes (n=12) pointed out as having lost populations were more stricken by anthropogenic impact (n=33) than lakes where populations still existed: Fisher's exact test (total impact $p<0.001$), (brook charr in spawning areas $p<0.05$). Feedback to local fishing right owners on preliminary results generated in this study led to action by FMOs to restore *Rö*-lakes with self-sustaining populations.

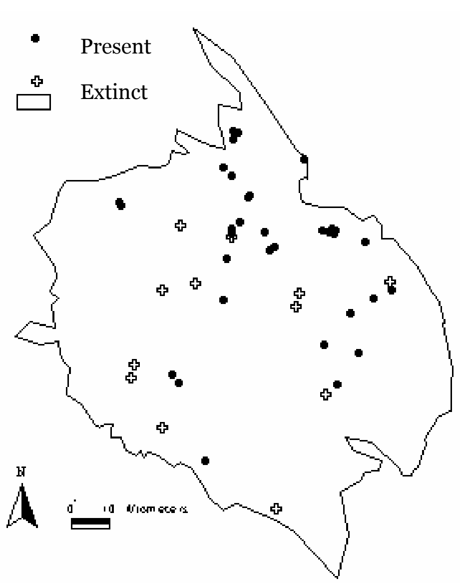

Figure 5. Rö-named lakes with brown trout populations

Table 2. Factors Associated With the Extinction of Brown Trout Populations in *Rö*-Named Lakes. [a] Number of lakes (n=12) affected by specific impact. [b] One lake was classified in two categories. [c] Permanently acidified pH=4,7 to 4,9. [d] Once impossible now recolonized by brown trout

Anthropogenic Impact		Brown trout habitat	L[a]
Bio	Brook charr	Spawn. area overtake	5 [b]
	Pike transloc.	Strong predation	3
Chem	Acidification	Impossible[c]	2
	Rotenone	Impossible[d]	1
Phys	Barrier	Impossible	2 [b]

Maximum natural or anthropogenic permanent extinctions (1672 – 1920)

A total of 45 out of 50 *Rö*-named lakes were confirmed to still have harboured self sustainable brown trout populations in the 20th century (Tables 1 & 3). Interviews with a maximum historical scope of 30-80 years back in time, asserted that five of the Rö-lakes never carried self-sustaining brown trout populations during this time. Habitat surveys in the same five lakes determined that reproducing brown trout populations could never have existed in three of these lakes. The remaining two lakes were found to have historically suitable habitat conditions for holding brown trout, although a man-made barrier prevented reproduction in one of these lakes. Test fishing confirmed interviews, that these lakes did not hold brown trout. Since all but these 2 out of 47 lakes with natural potential conditions for brown trout were confirmed brown trout waters, 2/47 was found to be the maximum potential fraction of lakes suffering permanent extinction before the scope of interviews and historical documents could detect this. If *Rö*-lakes represented a non-biased sample of all brown trout lakes in the study area, (there are no indications to the contrary), then between none and seven brown trout lakes out of 161-168 in the whole study area would have suffered permanent extinction prior to 1920. It was concluded that the pre-industrial distribution of brown trout was 11% of all lakes in the study area, and remained so until the 1930s.

Table 3. Estimating the maximum (E_{MAX}) of permanent extinctions occurring 1672-1920, from lake names (before the scope of possible detection by interviews and historical documents). [a]=Brown trout confirmed 1920-2001

Self-sustaining Brown trout populations	No. lakes
Present[a]	33
Extinct[a]	12
Possibly extinct or never existed [(P)]	2
Max. number of Rö- brown trout lakes [(M)]	47
Never existed (impossible habitat)	3
Total number of Rö-lakes	50
Non-Rö brown trout lakes [a]	116
Total number of brown trout lakes [a]	161
E_{MAX} (1672-1920) [(P/M)] (4.3%)	2/47
E_{MAX} (1672-1920) Number of pop.	7
Max. Brown trout lakes (1672-1920)	168

Possible misinterpretations of the Rö-term

Three *Rö*-term lakes were excluded from the current study when the earliest name forms in older maps clarified that these names were originally derived from *Ry*, meaning something other than brown trout. One explanation of the *Rö*-term in lake names, red water colour, was refuted at field visits since none of the waters were more reddish in colour compared to other lakes in general. Another possible mix-up of the *Rö*-term meaning was suggested to be arctic charr (Salvelinus alpinus L.), called röding in Swedish. The *Rö*-name was however not an indicator of suitable arctic charr habitat. The majority of *Rö*-lakes did not contain spawning grounds for arctic charr and could never have harboured self-sustaining charr populations. This species was only found in 3 out of 50 *Rö*-lakes and were too few in all lakes to gain any statistical evidence on an association with the name. Since repeated stocking of charr had been done in all three lakes, it could not be ruled out that these populations were non-native to these lakes. Nothing in the entire data set indicated that arctic charr could have had an historically wider distribution in *Rö*-lakes. Arctic char was an uncommon species in the whole study area and was only considered possibly indigenous to one additional lake out of 1509 lakes.

DISCUSSION

Historical names

The results allow some general conclusions to be drawn. For instance, lake names are just arbitrary, but reveal details regarding the fish fauna as well as the habitat. These historical records of fishers' knowledge in the form of lake names in maps can communicate valuable information on environmental history that can, in turn, have an impact on management and conservation. Danko (1998) recommends collecting ecological data from the regions studied to increase the reliability of fish-terms used as evidence of past occurrence. The present study uses a number of sources and methods allowing for comprehensive validation of lake name evidence. When lake names are verified to be positively (or negatively) associated with certain species, the spatial and temporal data linked to the name can then be used in a variety of ways. This study verifies that *Rö*-named lakes are associated with past or present self-sustaining brown trout populations. Thus, lakes with species-associated names can help identify habitats suitable for deeper investigations or restoration. Could landscape scale inventories of certain fish species benefit from selecting lakes from names in maps instead of performing a random survey? A fictional inventory in the present study area with knowledge of local dialect and the *Rö*-term deciphered would provide wide spatial coverage with less effort. A simple overview of local maps targets 1/3 of all brown trout populations among 1,509 lakes. To pick out the same amount of brown trout lakes by random sampling with multi-mesh sized gillnets (Appelberg 2000), would take approximately 5 years' full time fishing for two persons during the ice-free season. The gillnet inventory would, however, have missed all extinct populations and also be lacking the temporal perspective that lake-names provide.

Another useful feature of lake names is that historical anthropogenic impacts or past natural perturbations may be discovered and further investigated where lake names do not correspond to the species currently living in the lakes. The remaining two *Rö*-lakes (4.3%) that cannot be confirmed by interviews or archival data as brown trout waters in spite of historically suitable habitat might have harboured populations now lost both in nature and in local collective knowledge. In that case, the populations went extinct long before the scope of possible detection by interviews or archival data. However, it is predicted that one of these lakes will be colonized in the near future from a downstream population, once a man-made migration barrier discovered in this study is removed. Other essential ecological information such as details regarding habitats and fish communities is also associated with these lake names. Inlet or outlet streams of a specific minimum size with spawning gravel suitable for brown trout are found in 94% of *Rö*-lakes. Picking out *Rö*-lakes, we also find that 96% of the original fish communities are not exposed to large predators like pike, and that 100% of the lakes are isolated by natural barriers stopping the upward migration of several fish species downstream. *Rö*-lakes can thus be considered as refuges protected from severe predators.

Pike is represented in most lakes elsewhere in the study area and studies indicate that predation by pike limits brown trout distribution in slow flowing streams (Näslund *et al.* 1998) and in lakes (Went, A. E. J. 1957; Toner, E. D. 1959). Consequently, with the *Rö*-names, fishers from hundreds of years back in time are communicating to us and saying: - *This lake is characterized by its richness in brown trout. There are good habitat conditions for this species here*. The past distribution of fish populations in a given area can be estimated from the wide temporal and spatial data generated from historical lake names associated

with fish species, providing that associations are properly validated. This is demonstrated in the present paper by utilizing occurrences of lake-names fixed in time from historical maps. Most *Rö*-names are found to date back more than 160 years, revealing a pre-industrial perspective of brown trout distribution. All types of lake names in maps are found to be "evolutionarily" conservative and most meanings or core structures are virtually unchanged through the centuries. This is further supported in this study by findings that *Rö*-lake names are being passed on in a conservative oral tradition, even though the historical species name *Röa* has disappeared from the common language. For this reason, it is proposed here that there is little chance the core structure will change once a lake has been named. Edlund (1997) suggests that prehistoric fishermen and trappers developed a fixed onomastic system for lakes and rivers and gives examples together with C_{14}-dating of settlements and other data implying a genesis of a fisheries related name-complex in the heart of the study area 1,900 years ago. It is possible that *Rö*-lakes were named during this prehistoric period. Since all but 2 out of 47 *Rö*-lakes with possible brown trout populations are accounted for in interviews and archival data, it is highly unlikely that extensive permanent extinctions of brown trout took place prior to the 1920s. This is supported by limnological surveys of lakes in the area. The past distribution of brown trout was consequently 11 % of all lakes in the study area, and remained so until the 1930s when extinctions started to become evident.

Interviews

The use of fishers' knowledge obtained from interviews can also provide wide temporal and spatial insights into the past and present distribution of fish populations. This is demonstrated in the present paper by utilizing fishers' knowledge gathered from in-depth interviews and validated by a number of methods. Interviews result in a temporally and geographically more extensive picture of the fish fauna distribution than could ever be achieved through conventional scientific methods, with the same effort. To identify the brown trout lakes found in this survey among 1,509 lakes would take two persons a minimum of 15 years of full time fishing with multi-mesh sized gillnets (Appelberg 2000) during the ice-free season. The gillnet inventory would however miss all extinct populations and also be lacking the temporal perspective of up to 80 years at times, provided by interviews in the current study. The interviews reveal most of the distribution of brown trout in the study area within a temporal scope of 20 years, up to a maximum of 80 years in some cases. No populations "new" to the informants were discovered by test-fishing among the *Rö*-lakes. However, interviews are slightly over optimistic concerning the existence of self-sustaining populations.

Masking of abundance by stocking activities was discussed in Hesthagen *et al.* (1993) who reported that interviews concerning the status of fish-populations in Norwegian acid lakes were too optimistic. They also suggested that bias might result from a time-lag before anthropogenically-induced population damage becomes evident to fishermen. This might be the case for one *Rö*-lake where unawareness of a recent extinction was evident. Another *Rö*-lake was stocked annually, masking extinction of the original population.

Apart from these two examples, fishers' knowledge obtained from in-depth interviews regarding the *Rö*-lakes was totally reliable, matching the test-fishing results and consistent with habitat surveys. Discussing the future of fisheries science Mackinson and Nøttestad (1998) emphasize that it is imperative for scientists to use diverse data sources to their maximum potential, and advocate the increasing use of local fishers' knowledge. Face to face interviews are claimed to be most effective. This view is supported by the findings in this study. The accumulated interviews reveal that the lion's share of brown trout population extirpations has happened during the last eight decades. Archival data can validate that most of these extinct populations once existed, while their current absence is confirmed by a combination of test-fishing methods. More than a quarter of the populations are lost. Explanations for what is causing this wave of extinctions are needed if these lakes are to be restored. Limnological surveys demonstrate that all extinctions are associated with severe anthropogenic impact. Extinctions of brown trout populations caused by acidification of Scandinavian lakes during the 20th century are reported in several papers (Bergquist 1991, Bulger 1993, Lien 1996) as well as in this study. Local extinction of fish species caused by anthropogenic biological impacts is also reported (Nilsson 1985, Crivelli 1995, Lassuy 1995, Townsend 1996). Similarly, historical records and present data in this study demonstrate that a minimum of 95.7% of all brown trout populations survived until the 20th century when the successful colonization of introduced fish species in the lakes resulted in the extinction of the original trout populations. Many of these brown trout populations are now

long gone and forgotten, but the names of the lakes remain and, being deciphered, help to remind us of all that is lost. The entire data set supports the idea of long-term stable brown trout lake distribution under pre-industrial natural conditions. In part owing to the *Rö*-names, people are now motivated to restore *Rö*-lakes with self-sustaining local populations of brown trout. Before this study, the available methods to collect historical data on fish species distribution in northern lakes were limited to interviews and archival data. Integrating the use of historical names and historical fishers' knowledge into fisheries science will facilitate investigations to move from brief snapshots of local scale to the wider landscape context and historical dimension. In conclusion, historical names, fishers' knowledge and documentary evidence combined with limnological surveys have proven useful in revealing the past natural distribution, as well as initiating restoration of brown trout lakes in Northern Sweden.

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REFERENCES

Anon. (2001). Natural site datasheet on "the High coast of Sweden" in Unesco World Heritage List http://www.wcmc.org.uk/protected_areas/data/wh/high_coast.html Protected Areas Programme, UNEP World Conservation Monitoring Centre. 219 Huntingdon Road, Cambridge CB3 0DL United Kingdom.

Appelberg, M. (2000). Swedish standard methods for sampling freshwater fish with multi-mesh gillnets. Fiskeriverket information. Göteborg, 2000:1: 1-32.

Aybes, C. and D. W. Yalden (1995). "Place-name evidence for the former distribution and status of wolves and beavers in Britain." Mammal Review 25(4): 201-226.

Bain, M. B. and M. J. Stevenson (1999). "Aquatic habitat assessment: common methods." Bethesda, Maryland, American Fisheries Society.

Bergquist, B. C. (1991). "Extinction and natural recolonization of fish in acidified and limed lakes." Nord.J.Freshwat.Res.(66): 50-62.

Boisseau, S. and D. W. Yalden (1998). "The former status of the Crane Grus grus in Britain." Ibis 140(3): 482-500.

Bulger, A. J., Lien, L., Cosby, B. J. and Henriksen, A. (1993). "Brown trout (Salmo trutta) status and chemistry from the Norwegian Thousand Lake Survey: Statistical analysis." Can.J.Fish.Aquat.Sci. 50(3): 575-585.

Crisp, D. T. (1996). "Environmental requirements of common riverine European salmonid fish species in fresh water with particular reference to physical and chemical aspects." Hydrobiologia 323(3): 201-221.

Crivelli, A. J. and P. S. Maitland (1995). "Future prospects for the freshwater fish fauna of the north Mediterranean region." Biol.Conserv. 72(2): 335-337.

Crivelli, A. J. (1995). "Are fish introductions a threat to endemic freshwater fishes in the northern Mediterranean region?" Biol.Conserv. 72(2): 311-319.

Dahlstedt, K-H. (1956) Taped and written record number DAUM 3994 Tape 133, Department of Dialectology, Onomastics and Folklore Research: Box 4056 904 03 Umeå , Sweden. (In Swedish)

Dahlstedt, K-H. (1961) Written record number ULMA 25260 p.16, Institute for Dialectology, Onomastics and Folklore Research: Department of Onomastics Box 135, 751 04 Uppsala, Sweden. (In Swedish)

Danko, P. D. (1998). "Building a Reliable Database from a Native Oral Tradition Using Fish-Related Terms from the Saanich Language. "Fisheries Centre Research Reports. D. Pauly, T. J. Pitcher and D. Preikshot. Vancouver, Fisheries Centre, University of British Columbia. Vol.6: 29-33.

Edlund, L. E. (1975). "Namn på vattensamlingar i Trehörningsjö och Björna socknar, Ångermanland. Bildning med särskild hänsyn till efterlederna." Masters thesis. Department of the Nordic languages. Umeå university. (In Swedish)

Edlund, L. E. (1997). "Från Gene till Myckelgensjö - kring ett hydronymkomplex i norra Ångermanland. " Nomina Germanica. Ed: S. Strandberg. Uppsala, Uppsala university. 22: 85-106. (English summary)

Hesthagen, T., Rosseland, B. O., Berger, H. M. and Larsen, B. M. (1993). "Fish community status in Norwegian lakes in relation to acidification: A comparison between interviews and actual catches by test-fishing." Nord.J.Freshwat.Res. 68: 34-41.

Jones, D. R., Kiceniuk, J. W. and Bamford, O. S. (1974). "Evaluation of the swimming performance of several fish species from the Mackenzie river." J.Fish.Res.Board Can 31: 1641-1647.

Laikre, L., Antunes, A., Apostolidis, A. P., Berrebi, P., Duguid, A., Ferguson, A., Garcia-Marin, J. L., Guyomard, R., Hansen, M. M., Hindar, K., Koljonen, M. L., Largiader, C. R., Martinez, P., Nielsen, E. E., Palm, S., Ruzzante, D. E., Ryman, N. and Triantaphyllidis, C. (1999). "Conservation Genetic Management of Brown Trout (Salmo trutta) in Europe." EU FAIR

Report by the Concerted action on identification, management and exploitation of genetic resources in the brown trout (Salmo trutta). ("TROUTCONCERT"; EU FAIR CT97-3882).

Lassuy, D. R. (1995). "Introduced species as a factor in extinction and endangerment of native fish species. "American Fisheries Society Symposium, 15: 391-396.

Lelek, A. (1987). "The freshwater fishes of Europe." Wiesbaden, Aula-Verlag.

Lien, L., Raddum, G. G., Fjellheim, A. and Henriksen, A. (1996). "A critical limit for acid neutralizing capacity in Norwegian surface waters, based on new analyses of fish and invertebrate responses." Science of the Total Environment 177: 173-193.

Mackinson, S. and L. Nottestad (1998). "Points of View: Combining Local and Scientific Knowledge." Rev.Fish Biol.Fish. 8(4): 481-490.

Maitland, P. S. (1995). "The conservation of freshwater fish: Past and present experience." Biol.Conserv. 72(2): 259-270.

Maitland, P. S. and A. A. Lyle (1991). "Conservation of freshwater fish in the British Isles: The current status and biology of threatened species." Aquat.Conserv.: Mar.Freshwat.Ecosyst. 1(1): 25-54.

Moyle, P. B. and R. A. Leidy (1992). "Loss of biodiversity in aquatic ecosystems: Evidence from fish faunas." In *Conservation Biology. The Theory and Practice of Nature Conservation, Preservation, and Management*, ed. P. L. Fiedler & S. K. Jain. Chapman & Hall, New York pp.127-169.

Näslund, I., Degerman, E. and Nordwall, F. (1998). "Brown trout (Salmo trutta) habitat use and life history in Swedish streams: Possible effects of biotic interactions." Can.J.Fish.Aquat.Sci. 55(4): 1034-1042.

Nilsson, N. A. (1985). "The niche concept and the introduction of exotics." Rep. Inst. Freshwat. Res. Drottningholm, Sötvattenslaboratoriet. 62: 128-135.

Pitcher, T. J. (2001). "Fisheries managed to rebuild ecosystems? Reconstructing the past to salvage the future." Ecological Applications 11(2): 601-617.

Powers, P. D. and J. F. Orsborn (1985). "Analysis of barriers to upstream fish migration." BPA fisheries project. Portland, Oregon, USA, Bonneville Power Administration. Project 82-14, Final Report. Part 4.

Reiser, D. W. and R. T. Peacock (1985). "A technique for assessing upstream fish passage problems at small scale hydropower developments." American Fisheries Society Symposium: 423-432. Paper presented at the symposium on small scale hydropower and fisheries Bethesda, Maryland., Amer. Fish. Soc.

Sousa, A. and P. Garcia-Murillo (2001). "Can place names be used as indicators of landscape changes? Application to the Doñana Natural Park (Spain)." Landscape Ecology 16(5): 391-406.

Stuart, T. A. (1962). "The leaping behaviour of salmon and trout at falls and obstructions." Freshw.Salm.Fish.Res. 28: 1-46.

The Swedish National Land Survey (1961-1967) : The General Staffs' Topographic Maps of Sweden 1:50 000. Reconnaissanced 1961-1967. Generalstabens Topografiska karta 1:50 000 Rekognoserad 1961-1967

The Swedish National Land Survey (1672-1908) : The General Staffs' Maps of Sweden 1:100 000 & 1:200 000; county, parish, ordnance or village maps reconnaissanced 1672-1908. Generalstabens karta övfer Sverige 1:100 000 & 1:200 000; läns-, församlings-, stabs- & by-kartor rekognocerade 1672-1908.

Toner, E. D. (1959). "Predation by pike (Esox lucius) in three Irish lakes." Rep. Sea Inland Fish. Eire: 67-73.

Townsend, C. R. (1996). "Invasion biology and ecological impacts of brown trout Salmo trutta in New Zealand." Biol.Conserv. 78(1-2): 13-22.

Wallace, S. S. (1998). "Sources Of Information Used To Create Past And Present Ecosystem Models Of The Straits Of Georgia. "Fisheries Centre Research Reports. D. Pauly, T. J. Pitcher and D. Preikshot. Vancouver, Fisheries Centre, University of British Columbia. Vol.6: 19-21.

Webster, J. A. (2001). "A review of the historical evidence of the habitat of the Pine Marten in Cumbria." Mammal Review 31(1): 17-31.

Went, A. E. J. (1957). "The pike in Ireland." Irish Nat. J. 12: 177-182.

Witzel, L. D. and H. R. MacCrimmon (1983). "Embryo survival and alevin emergence of brook charr, Salvelinus fontinalis , and brown trout, Salmo trutta , relative to redd gravel composition." Can. J. Zool. 61(8): 1783-1792.

Questions

Bryan Pierce: Do the private fisheries and managers use local stocks for the replanting program or do they access fish stocks from elsewhere?

Johan Spens: They used local populations

Saudiel Ramirez-Sanchez: In the previous presentation, there was an emphasis on fisheries that have caused reduction in the abundances of fishes. In this presentation you have shown how other anthropogenic factors can influence fish abundance. If Ecopath and Ecosim assume that the most important factor affecting fish abundance is fishing without considering other factors, like logging, you put the entire blame on where it is not. There could be other factors that should be considered when reconstructing ecosystems.

Johan Spens: It is a complex problem and there are a lot of factors. We have multivariate VPA with hundreds of factors. It is safe to say that a lake environment differs a lot from marine environments- for example; lakes do not sustain many fisheries.

Nigel Haggan: In a recently published paper, Carl Walters said that habitat destruction accounts for 20% of salmon population depletion while overfishing accounts for about 80%. Fisheries are designed to kill fish and hence are a big factor in depletion.

Tony Pitcher: It is possible in Ecosim to partition the effect of fisheries from other environmental factors. I agree with Nigel - there have been a number of studies that show that most of the degradation is by fishing while other environmental factors are important but not as much, at least in the marine environment. The situation seems to be different in inland waters, such as these lakes in Sweden, where it seems that the introduction of an exotic species – the pike - has had a significant effect.

EXPLORING CULTURAL CONSTRUCTS: THE CASE OF SEA MULLET MANAGEMENT IN MORETON BAY, SOUTH EAST QUEENSLAND, AUSTRALIA

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ABSTRACT

Incorporating indigenous knowledge into fisheries management is becoming increasingly important in the derivation of alternative management solutions. It also satisfies the political demands of indigenous communities to exercise their rights and responsibilities to traditional resources and their management. Using a methodology that considers perceptions or constructs of the environment to be dependent on the social and cultural structures in which they operate, we compare indigenous and government management of sea mullet in Moreton Bay, Australia. Our investigation focuses specifically on the landscape and seascape constructs of the Queensland Fisheries Service (QFS) and the traditional Aboriginal community of Moreton Bay – the people of Quandamooka. Results from the case study indicate that while both management parties aspire to achieve ecologically sustainable development, a divergence between the constructs of the QFS and the Quandamooka community for sea mullet management is evident. Current QFS approaches reflect 'scientific truth' and economically-dominated strategies whilst the Quandamooka community approach represents constructivist and holistic ecosystems-based strategies. The research highlights the need for more collaborative and inclusive fisheries management approaches that move beyond viewing the Quandamooka community as just another stakeholder. We argue that the QFS needs to recognize the relationship between the Quandamooka community and the Bay in order to value indigenous knowledge of the Bay and its resources. Furthermore, it is critical for the QFS to move beyond economic and species-specific dominated strategies towards ecosystem and adaptive management strategies to include indigenous knowledge and to achieve ecologically sustainable development.

INTRODUCTION

Although government resource management agencies regularly dismiss indigenous knowledge for being anecdotal, untrustworthy and inferior (King 1997; Sillitoe 1998; Simpson 1999; Wolfley 1998), they recognize that alternative management practices are needed to achieve ecologically sustainable resource management. Indigenous knowledge is increasingly being sought to guide these alternatives (Salas *et al.* 1998). The inclusion of indigenous knowledge in its totality, as defined by Berkes (1999) for example, also serves to satisfy the political demands of indigenous communities to exercise their rights and responsibilities to resources and their management. However, one major obstacle to the inclusion of indigenous knowledge in mainstream environmental management is the failure of managers to understand and / or appreciate the different constructs that underpin their own as well as other management strategies (Pomeroy 1994). Gaining an appreciation of these underlying constructs would help to avoid the piecemeal inclusion of indigenous knowledge that has plagued more recent attempts to include traditional owners' views. In this article we provide a preliminary comparison of indigenous and government approaches to the management of the sea mullet spawning migration in Moreton Bay, southeast Queensland, Australia. The objective is to examine different knowledge constructs to see if they present barriers to the joint sharing and application of knowledge and management practices.

Case Study Background

Moreton Bay is situated in southeast Queensland, Australia (Figure 1) and covers an area of approximately 1490 km² (Dennison and Abal 1999). While numerous studies have defined the Bay differently depending on what aspects they have studied (QFMA 1996a) and from which cultural perspective they have come, Moreton Bay is commonly defined as stretching for 160 km from the northern tip of Bribie Island in the north to the southern tip of south Stradbroke Island in the south (Dennison and Abal 1999). The Bay encompasses 360 islands of varying sizes including three of the biggest islands in the Bay – Moreton, North Stradbroke and South Stradbroke Islands (Neil 1998).

[1and2] We would like to acknowledge and thank members of the Quandamooka community, especially Dale Ruska for their input.

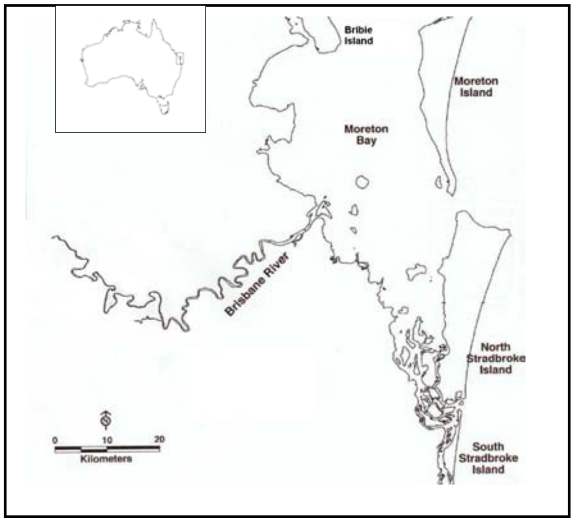

Figure 1. Map of Moreton Bay

Moreton Bay was chosen as the case study site for several reasons. Firstly, the Bay is of environmental significance as evidenced by the establishment of the Moreton Bay Marine Park in 1993 and its extension in 1997 to encompass nearly all tidal land and waters to three nautical miles off the east coast of the barrier islands (Dennison and Abal 1999). The park is also listed under Ramsar as a significant migratory bird habitat. It is an important fish breeding ground with recent scientific research having identified around four hundred different fish species within the Bay (Davie and Hooper 1998), and it is home to a significant population of dugongs and bottle-nose dolphins (EPA 1999). Secondly, Moreton Bay is of economic significance to the fishing, ports and tourism industries, amongst others which are dependent on the Bay (McDonald and Brown 1992; Perkins 1996).

While the environmental and economic importance of the Bay is well known and cited by many mainstream environmental managers and scientists, the cultural importance of the Bay is often neglected or relegated to a short introductory passage in historical descriptions (see, for example, BRMG 1997; Haysom 1999; Neil 1998). However Moreton Bay and its fisheries were and continue to be, sources of cultural importance to the Aboriginal communities who reside within and around the Bay. The key to Aboriginal cultural survival is the continuation of traditional cultural management practices that allow indigenous knowledge to evolve and adapt.

The Quandamooka Aboriginal community is a prominent indigenous community in the Bay. Many members still reside on North Stradbroke Island, the traditional country of two of the clans that make up the Quandamooka people. This community retains their traditional knowledge of the natural resources of the Bay and its islands, and desires to practice this knowledge as a component of mainstream land and sea management.

As well as the indigenous population, Moreton Bay provides the eastern extent of the urban expansion of Brisbane, the largest city and capital of Queensland. At present the Moreton Bay region contains more than two million people and is expanding at around 2.9% per annum (Skinner *et al.* 1998). With a projected increase of 430,000 to 650,000 people between 1996 and 2006 along the coastline of the Moreton region (Skinner *et al.* 1998), increased pressure is being placed on Moreton Bay to cater for this growth in human activity. Urbanization, agricultural production, industrial development, floodplain modification, and sand and water extraction among other factors have led to the degradation of habitats, increased sedimentation and decreased fishing productivity in the Bay (BRMG 1997; Dennison and Abal 1999; Williams 1992).

Approximately 400 licensed fishing vessels operate in and around Moreton Bay, and in addition an estimated 300,000 commercial and recreational fishers spend 1.5 million fishing days per year in the Bay (Williams 1992). This amount of fishing activity combined with development pressures, has led to concerns for the viability of fisheries, including the sea mullet fishery that is important to commercial, recreational and indigenous fishers.

Sea mullet is alternatively known as 'bully' or *Mugil cephalus* in the Western scientific sense (QFMA 1996b) or as *andacall* (Crowthers *et al.* 1997) or *nandacall* (Ross and Quandamooka Land Council 1996b) by the people of Quandamooka. It is a migratory fish species found throughout tropical and subtropical seas, including Australian estuaries, coastal waters and some rivers (Virgona *et al.* 1998). In Moreton Bay, during the autumn and winter months of April to August, mature reproductive mullet aggregate in estuaries and travel northwards to spawn at sea. The spent adults move back southwards, re-entering the estuarine and river systems to resume feeding, as do the fry (mullet larvae), which are carried southwards by the prevailing currents where they enter the estuarine systems to feed and grow (DPI 2000; QFMA 1996b).

Moreton Bay is "the most important estuarine fishery for sea mullet in Queensland" (Kailola *et al.* 1993: 332). The Quandamooka people regard sea mullet as a source of food as well as a source of cultural, economic and spiritual sustenance. In the 'traditional' sense, sea mullet was caught for nutritional, medicinal and trade purposes, and applying sea mullet management practices sustained the cultural well being of the community (Ross and Quandamooka Land Council 1996b).

Sea mullet is also an important commercial fishery. Mullet comprise the largest component of the inshore net fishery along the Queensland coast and the fishery is worth an estimated $AUD8-10 million per year (Shane Hansford, QFS Senior Policy Officer, pers. comm. 2000). According to commercial fishery records, approximately 2000 tonnes of sea mullet are caught in Queensland each year (Virgona *et al.* 1998), with about half being derived from Moreton Bay fishing grounds (Virgona *et al.* 1998).

Most commercial operators target mature mullet for their roe (egg sacs) given the high export price they receive in overseas markets relative to domestic market prices for sea mullet meat (Halliday 1992). Consequently, comparatively few sea mullet are caught with seine nets along ocean beaches during the summer months or with gill and tunnel nets in rivers and estuaries throughout the year (Kailola *et al.* 1993). The vast majority of sea mullet (around 70-80%) in Queensland are taken during their winter spawning migration (Virgona *et al.* 1998). However, recent commercial catch statistics have indicated a decline in the total annual catch of mullet (Virgona *et al.* 1998) and this coincides with a decline in the total number of days commercial fishers spend fishing. The Queensland Fisheries Service (QFS - formerly the Queensland Fisheries Management Authority or QFMA) has suggested the following reasons for the decline in mullet catches:

a) a change in behavior of commercial fishers, with a tendency to fish for fewer mullet;
b) reduction in the abundance of mullet; and
c) reduction in the size of fish taken (QFMA 1996b:51)

Williams (1992) expressed concern over targeting spawning fish given their vulnerability to capture while aggregated in schools. The Quandamooka community has also expressed its concern over the declining sea mullet harvest and current harvesting practices. For example, community members have expressed concern over the high level of exploitation that has led to the sale of whole mullet for crab bait (Sinnamon 1997).

This wide-ranging concern from several quarters indicates that there is a significant problem and that the future of a healthy sea mullet fishery in the Bay is predicated on good management. We now review the management programs that the original (aboriginal) and present-day (government) management authorities have devised for sea mullet management. But first we feel it is important to examine the methodological framework within which we conducted this study.

METHODOLOGY

An alternative research approach to the prevalent scientific realist and positivist approach generally adopted by government agencies that employ scientists as their management bureaucrats has been used. Positivist paradigms assume that the environment exists outside of human perception, a view that forms the basis for the majority of scientific research. Cultural anthropologists and sociologists have criticized this approach, because it dismisses the recursive influence of humans on the environment (Berkes 1999; Linzey 1995; Pálsson 1998). A social constructivist approach caters for the human construction of the environment and while several authors such as Agrawal (1995), Bradley (1998) and Murdock and Clark (1994) have argued that the concentration on culture can artificially inflate cultural differences between management parties, culture forms an important filter that results in different perceptions of the environment (McCarthy 1996).

A constructivist research approach has far reaching implications for how the environment can be viewed and how resource management problems may be solved (Linzey 1995). Alongside multiple perspectives there exists an array of different management solutions to solve environmental problems (Linzey 1995; Taylor 1990). It allows for different cultural conceptions of the environment to be viewed on an equal basis as "no one culture has a worldview or interpretation of the world which can be seen as more 'correct' than that of another because they are both interpretations of the subjective and therefore unknowable universe" (Rose 1995: 167). Moreover, the constructivist approach allows for a comparison between the religious based indigenous knowledge and the scientific based Western knowledge. For,

> *"if science and religion are compared as legitimating belief systems, they can be compared on the basis of their similarities as accepted systems of knowledge, where each system legitimates certain social practices in the name of truth, reason and reality"* (Wright 1992: 43-44).

This type of research lends itself to an interpretivist qualitative approach, which requires a clear statement of the researcher/s' intent and purpose. This is especially important given the contentious nature of research regarding indigenous views and knowledge. This kind of research has predominantly been carried out by white, male, middle class academics (Wall 1995). Wall (1995) alleges that these attributes form a privileged point of view that determines the reader's way of seeing and provides voice to certain minority perceptions while silencing others. The power differential created by this approach has been the subject of extensive criticism. Simpson (1999: 6) for example, argues that the "widely accepted academic concept of TEK is fundamentally Western, not Aboriginal".

Consequently, a crisis stemming from the representation of 'others' has developed, particularly relating to who should represent whom (Linzey 1995). This is an argument that has fostered growing demands for indigenous people to become researchers of themselves (Linzey 1995; Nakata 2001; Simpson 1999; Tripcony 1997). There is no denying that there are definite advantages in indigenous people restoring and reclaiming their own knowledge and controlling its portrayal in academic literature (Nakata 2001). According to Nakata (2001:41) "nowhere is there an authoritative indigenous reference point from which to develop our ideas and ways of thinking, beyond the narrative of citing our experience". However this should not imply that cross-cultural research has no merit. Rather, beneficial outcomes may be achieved when indigenous research is undertaken with the overriding objective to increase knowledge and understanding of the interests and concerns of indigenous people.

There are, however, several strategies that non-indigenous researchers can adopt to counteract the crisis in the representation of the 'other'. Researchers can confine themselves to their *perception* of 'others' rather than the *representation* of 'others' (Berkes 1999; Jackson 1991; Linzey 1995; Wall 1995). This can be achieved by recording indigenous knowledge and views and clearly distinguishing them from the researcher's interpretation. Including indigenous people in the research process can also help to counteract the colonial domination of indigenous research (Berkes 1999).

For this current study, the primary intent and purpose was the achievement of a Master of Science degree for Barker. For Ross, the intent and purpose was an understanding of indigenous knowledge constructs to assist in the interpretation of archaeological data. We are both female academics, trained in a Western scientific paradigm. For both of us, indigenous knowledge constructs are foreign, and for a while they challenged our own worldviews. However, the length of time during which we have both been involved with this community has allowed us to view indigenous knowledge with less prejudice than we originally brought to our investigation.

The principal researcher (Barker) did not have a close association with the Aboriginal community of Quandamooka at the time the study was undertaken, having only worked in this area for two years. She had therefore not developed the necessary level of trust needed to perform cross-cultural collaborative research (Posey 1995). Consequently, we opted to rely predominantly on existing documents that had been written by members of the Quandamooka community either themselves or in conjunction with Ross[2], and published or otherwise made available in a public forum. In addition, we included specific interviews with nominated members of the Quandamooka community at particular stages of the research process. However, for the purposes of this publication, we use documented sources of information only, to avoid the direct appropriation of the intellectual property rights of members of the Quandamooka community.

Collection of information about government management strategies was based, similarly, on published articles and reports and on communications with specialist staff of the QFS fisheries management agency.

THE MANAGERS

The people of Quandamooka comprise the Koenpil, Nunukul and Ngughi people whose traditional estate includes the land and waters of the Bay extending into the Pacific Ocean (Ross and Quandamooka Land Council 1996a). The definition of Quandamooka includes both the land and marine environment in and around the

[2] Ross has over eight years of research collaboration with the Aboriginal people of Quandamooka.

Bay and is also the name of the customary law and the Aboriginal community of the Bay. Their knowledge of sea mullet management forms one element of our comparative analysis.

The Queensland Fisheries Service (QFS) was established in 2000 as the primary government agency responsible for fisheries management in Queensland. It has the current carriage of fisheries management in Moreton Bay, and the knowledge of sea mullet management held by their scientists forms the other element of this comparison.

We present the results of the sea mullet case study by outlining the roles and responsibilities adopted by each management party. These are based upon the legal framework from which they derive their management responsibilities, how they define Moreton Bay, and how the QFS approaches the incorporation of Quandamooka knowledge in management. We outline each of these factors below.

Aboriginal and Government Roles and Responsibilities in Sea Mullet Management

The legislative framework

As in other colonized countries, upon European settlement the Australian government charged itself with responsibilities for the management of sea resources. Up until the Australian Federal Court judgment that recognized Native Title rights to sea country around Croker Island in the Northern Territory, the Australian government had not officially recognized that Native Title rights extended over 'sea country' and had treated sea resources accordingly, as unowned and unmanaged common property resources (Rigsby 1998). According to Gordon's (1954) economic theory of fisheries as extended to wildlife management in general by Hardin's (1968) seminal paper 'The Tragedy of the Commons', resources which are not privately owned will be exploited and degraded if people are left up to their own devices. This rationale extended the basis for governmental management (Freeman 1999) as stated in several Queensland government reports such as *Fisheries: Managing for the Future Report* (DPI 1993) - the precursor to the *Queensland Fisheries Act 1994*) and *Review of the Queensland Fisheries Act Interim Report* published in November 1999.

At the federal governmental level, the Australian Fisheries Management Authority (AFMA) is charged with management of Australia's 200 nautical mile fishing zone as declared by the *UN Convention on the Law of the Sea 1994.* While the *Coastal Waters State Powers Act 1980* charges the State governments with fisheries responsibility over a 'territorial sea' that extends for three nautical miles from the land (Robinson and Mercer 2000), "from 1988 onwards, the common practice has been to manage individual fisheries in different ways" (Robinson and Mercer 2000: 358).

Several fisheries, including sea mullet, have been assigned to state government level management, with the *Queensland Fisheries Act 1994* providing the over-arching legislative framework for fisheries management in Queensland. Section 14 of this Act lists as its objectives:

1) To ensure fisheries resources are used in an ecologically sustainable way;
2) To achieve the optimum community, economic and other benefits obtainable from fisheries resources; and
3) To ensure access to fisheries is fair.

The Act does recognize "a limited right for Aboriginal and Torres Strait Islander peoples to take fisheries resources in accordance with tradition and custom" (Sutherland 1996: 4). Section 16 of the Act provides that:

1) An Aborigine may take, use or keep fisheries resources, or use fish habitats, under Aboriginal tradition…;
2) However, subsection (1) is subject to a provision of a regulation or management plan that expressly applies to acts done under Aboriginal tradition;
3) A regulation or management plan mentioned in subsection (2) may be developed only after cooperating with Aborigines… considered by the fisheries agencies to be appropriate, to reach agreement or reasonably attempt to reach agreement, about the proposed regulation or plan.

According to 'mainstream' legal provisions, then, Aboriginal people do have rights to the resources of Moreton Bay, but these rights are subordinate to the responsibilities that the government has assigned to itself. But there is another legal system for Moreton Bay.

The Aboriginal people of Quandamooka are the traditional custodians of Moreton Bay:

> *"My people are the traditional custodians of Quandamooka which is now called Moreton Bay … [and]… we continue to protect Quandamooka as our obligation is*

sacrosanct" (Alan Perry, former Quandamooka Land Council Chairman, in Sinnamon 1997:4).

This sense of responsibility is derived from customary law, which provides the central and unifying framework of living for the people of Quandamooka. It governs all aspects of the traditional way of life and the lives of other beings. Customary law confers a host of rights and associated responsibilities to the people of Quandamooka, including communal ownership rights. Ownership rights of the traditional estate do not, however, imply that the people of Quandamooka consider themselves above or apart from the environment:

> *"Like my ancestors before me, I will always come back to this place to share the feeling of the land with all living things. I belong here where the spirit of the Earth Mother is strong in the land and me"* (Noonuccal and Noonuccal 1998).

Rights to country and its resources are conferred by customary law:

> *We have a system of laws and we have a system of tribal councils which administered those laws. We also have Aboriginal people who were born and are still being born with a human blood right, the same as Aboriginal people all over the country who have inherited the blood right … For me, I speak on behalf of myself and my own family on the Koenpil side solely, for my great great grandfather, who was the Mookan, was the one who inherited the right of the Mooka, of the Quandamooka. He was the man or the Mookan of many Mookans before him who was born with that blood inherent right to oversee the law of the land. Not just the law of the land, but the law of society, and also how land was used and how it was exploited* (Ruska 1997: 44).

The community of Quandamooka wants to regain their management position over their traditional estate in order to "assure the ecological, economic and spiritual security for future generations" (Alan Perry in Sinnamon 1997:4) and for the "maintenance of lifestyle, spiritual attachment, culture and sustainable economic development" (Quandamooka community members quoted in Sinnamon 1997: 11).

From the above it becomes clear that both the present-day and the original managers of the Moreton Bay fishery consider that they have a legal right to be custodians of fishery resources within the Bay.

The definition of Moreton Bay

The QFS defines Moreton Bay as the *waters* in the Bay (QFMA 1996a). The land and freshwater elements, such as islands, mainland rivers and swamps, are not included in this definition. This view contrasts with that of the Aboriginal community of Quandamooka. Their ownership rights extend across a much wider traditional territory. Alan Perry, a former Quandamooka Land Council chairman, defines the traditional estate as follows:

> *"Our traditional estate takes in Moorgulpin known as Moreton Island, Minjerribah also known as North Stradbroke Island and the smaller islands. The western boundary extends along the coast from the Brisbane River, south to the Southport [on the mainland at the southern tip of South Stradbroke Island] region. The eastern boundary extends out into the Pacific Ocean"* (quoted in Sinnamon 1997:4).

Their holistic concept of the Bay is enhanced by their construction of the environment as a living sentient being. To repeat in part Alan Perry's statement, theirs is a sacrosanct obligation, with the well-being of the Bay directly connected to the well-being of the Quandamooka community itself. Thus, this ethical and spiritual sense of responsibility differs from the views of QFS managers who have a statutory obligation to fulfill a particular management role.

Therefore customary ownership rights and management responsibilities extend over the land, sea and waters (both fresh and marine) that make up Quandamooka (Ross and Quandamooka Land Council 2001) not just the Bay waters. This provides the first of the many differences in approach to fisheries management by the QFS and the Quandamooka community. This difference in the scope of the management geography of the fishery underpins many of the other differences between the two management agencies.

QFS approaches to sea mullet management

Under the Queensland Fisheries Act 1994, the principal avenue through which the QFS manages sea mullet and other Queensland fisheries, is the establishment of management plans, regulations and declarations. The Act

provides the statutory guidelines for structuring the management plans. The QFS has prepared and is in the process of preparing, a number of species-specific harvesting methods and area-specific management plans which will ultimately combine to provide management guidelines for all fisheries resources within Queensland. Special taskforces known as Management Advisory Committees (MACs) and Zonal Advisory Committees (ZACs) have been created to provide management advice specific to these plans. Committee members in these cases are typically nominated by the QFS.

At present there are two management plans that directly affect sea mullet management in and around Moreton Bay. The Subtropical Inshore Finfish Fishery Management Plan incorporates sea mullet management advice, while the Moreton Bay Fishery Management Plan provides management advice for all fisheries within the area.
Figure 2 shows the general process by which these management plans were produced, their current stage of development, how they interrelate to one another, and the representatives of organizations that have been included on the respective advisory boards.

Figure 2 indicates that in most cases, a single member of each identified stakeholder group was invited onto the respective MAC and ZAC boards. The only indigenous representative to be included came from the national Aboriginal and

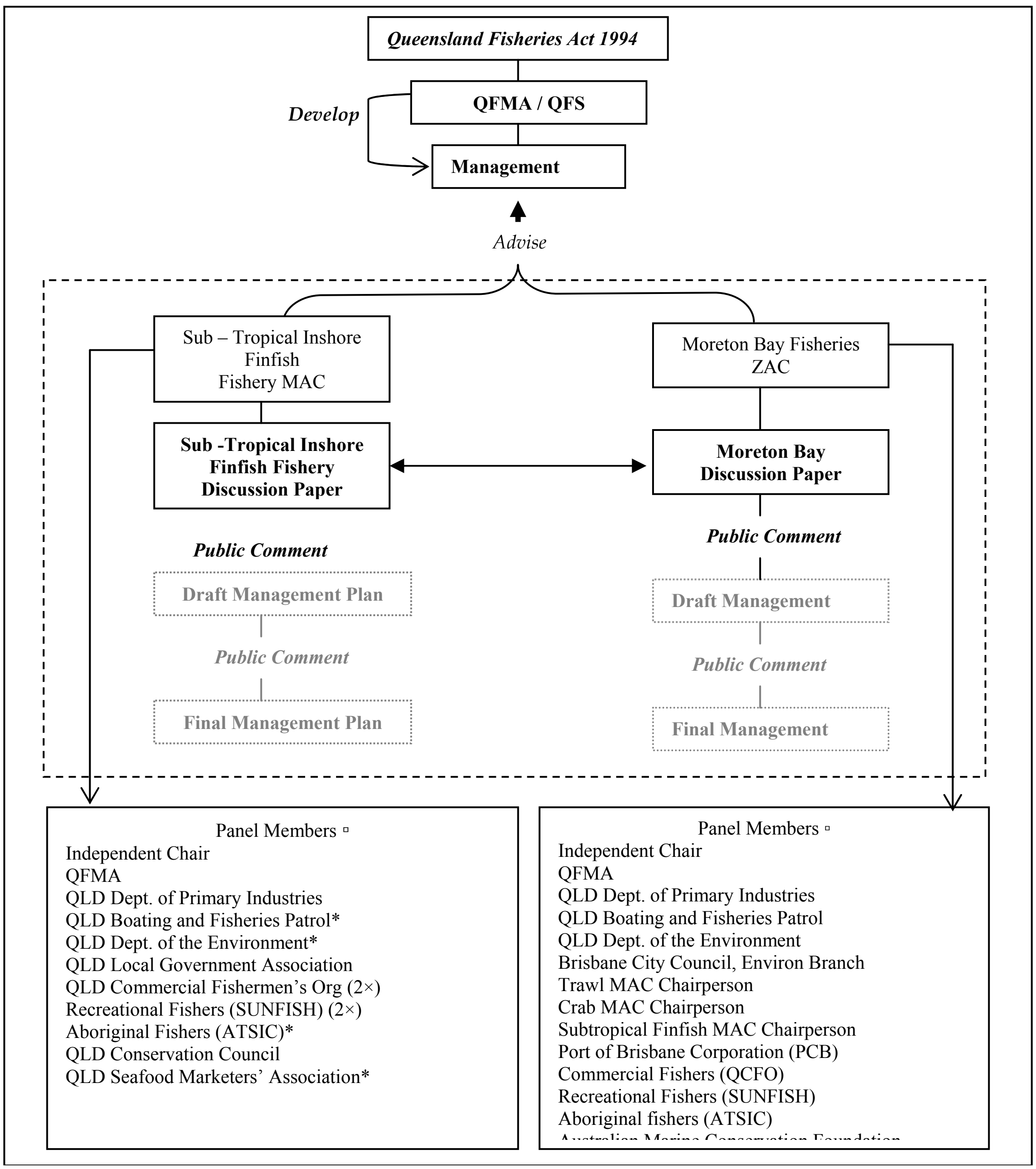

Figure 1 Management plans relevant to sea mullet management in Moreton Bay, their current stage of development and panel members involved on the advisory panels.

Torres Strait Islander Commission (ATSIC). This meant that the Quandamooka community itself may not have been represented. In the Subtropical Inshore Finfish Fishery discussion paper, the QFS rationalized that traditional or customary indigenous fishing did not require special provisions because:

> *"Indigenous people fishing for recreational or commercial purposes are subject to all prescribed fisheries legislation. No general fisheries permits, allowing for the taking, buying, processing or selling of … [fish] have been issued to indigenous people"* (QFMA 1996b: 16).

The QFS aims to cater for Aboriginal subsistence fishing by providing access to the fisheries, and by exempting Aborigines from fishing regulations, thereby recognizing the existence of an Aboriginal fishery to some extent (Smyth 1999). However, the individual based licensing system that the QFS operates presents various barriers to the implementation of Quandamooka management practices as outlined in Table 1.

It is important that appropriate management practices are devised to respond to the different fishing intensities, strategies and motivations of fishers. Commercial and Quandamooka community fishers use different fishing technologies that result in differing fishing intensities. The majority of Quandamooka fishing occurs at the time of the mullet spawning migration. As mullet enter Moreton Bay, fishers rely heavily on dolphins to drive the fish and hand-held tow row nets to catch the mullet (Ross and Quandamooka Land Council 1996b). Numbers of fish taken are comparatively low. Contemporary commercial fishers, on the other hand, utilize various technologies such as boats and echo-locating devices to exploit the spawning migration both out at sea and within the Bay. Commercial fishers therefore have access to almost all mullet schools that migrate past the coast and into the Bay (See also Kalikoski and Vasconcellos, this vol).

Pending the development of management plans, sea mullet are currently managed by a system of input controls on commercial operators and recreational fishers in accordance with the *Queensland Fisheries Regulation 1995*. This regulation specifies the operational level of rights for commercial and recreational fishers. Separate management practices and regulations have been devised for the commercial sea mullet ocean beach net fishery. A system of 8 zones has been created along the Queensland coast in order to reduce potential conflict between commercial fishers (QFMA 1996b). Each zone is assigned a limited number of commercial fishing operators. Commercial fishers gain access rights to a zone by purchasing a license. The license authorizes harvesting or withdrawal rights from that particular zone and licensees are able to harvest any fish (apart from barramundi) within these zones (Schedule 13, part 1.3).

Table 1. Effects of current QFS management strategies on the Quandamooka community involvement in management

Status	• Treated as a political or interest group rather than as traditional custodians of the Bay; • Other interest groups with greater political lobbying power and representation overwhelm the Aboriginal 'voice'.
Level of involvement	• Determined by the QFS. The *Fisheries Act 1994 (Qld)* charges the QFS with deciding the level of appropriate consultation needed with Aborigines to reach or attempt to reach an agreement about a proposed plan.
Interpretation of 'traditional' fishing	• QFS regulations specify that Quandamooka community fishing is for subsistence purposes only, whilst ethnographic evidence demonstrates that 'traditional' fishing also formed the basis of a lucrative trading base with neighbouring and visiting Aboriginal community members (Ross and Quandamooka Land Council 1996b); • Contributed to the exclusion of Aboriginal involvement in the Sub-Tropical Inshore Finfish Fishery MAC. • Neglects past and future Aboriginal interests in the commercial finfishery.

The licenses are seasonally based and there are three zones in the Moreton Bay region (but outside the Bay itself) that coincide with the traditional estate of the Quandamooka people. Although the *Queensland Fisheries Regulation 1995* does recognize that indigenous fishers can fish according to Aboriginal traditions, in practice this right is subordinate to the rights of license holders, who have priority in resource extraction.

The QFS zoning management strategy for the ocean beach fishery was created in response to a large proportion of commercial fishing occurring out at sea. Thus, the zoning strategy assisted in alleviating conflict between commercial fishers. However, current QFS management controls

perpetuate the view of fisheries as an unlimited resource, a notion inherent in capitalist thought. This is demonstrated by the QFS granting commercial licensees within the Bay unlimited access to sea mullet during the spawning season with no specific output controls either within or outside the Bay. Indeed, the boat, net and fish size restrictions are minimalist management strategies that are unlikely to deter the over-exploitation of these schools given the economic incentive to do so.

Regulations applicable to the commercial ocean beach fishery, the estuarine commercial fishery and the indigenous fishery are given in Table 2. The table reveals that current sea mullet management is based on input controls that focus on "the size and numbers of species, rather than on the fish species and the habitat of the species" (Ross and Pickering, in press:9) rather than on output controls and the principles of ecologically sustainable development.

Table 2: Regulations for Sea Mullet Fisheries

Winter Ocean Beach Fishery	
Seasonal	System of zones (K1-K8)
Input controls	Net restrictions: • only seine nets allowed • A seine net may be no longer than 500m
	Boat restrictions: • A primary commercial fishing boat must not be longer than 14m • A tender commercial fishing boat must not be more than 800m form the primary vessel (Schedule 13, Part 2.9 FRA 1995)
	Minimum legal size length: 30 cm
Estuarine Commercial Fishery	
Input controls	Minimum legal size length: 30 cm
Fish Habitat Areas	Commercial fishing closures including Fish Habitat Areas such as Swan Bay at the southern end of North Stradbroke Island
	Fish Habitat Areas A and Fish Habitat Areas B
Indigenous fishing	
	S16 – can fish according to Aboriginal traditions

In summary, the government management of sea mullet is formulated within bureaucratic systems such as MACs and ZACs, with each stakeholder group being represented. Management regulations focus almost entirely on input controls, such as licenses and restricting the number of fishers per management zone. But there is a pre-existing local system of mullet management for Moreton Bay that is based on long-term ecologically sustainable management. Despite the impact of colonization and the consequent dispossession of Aboriginal people, the people of Quandamooka have maintained their occupation of traditional country and their knowledge of resource management.

Quandamooka approaches to sea mullet management

According to Quandamooka tradition, in pre-colonial times, mullet elders guided the spawning migration of sea mullet northwards, up the east coast of North Stradbroke Island and into the Bay through the passages between the tip of North Stradbroke Island and Moreton Island, and at Cape Moreton on Moreton Island

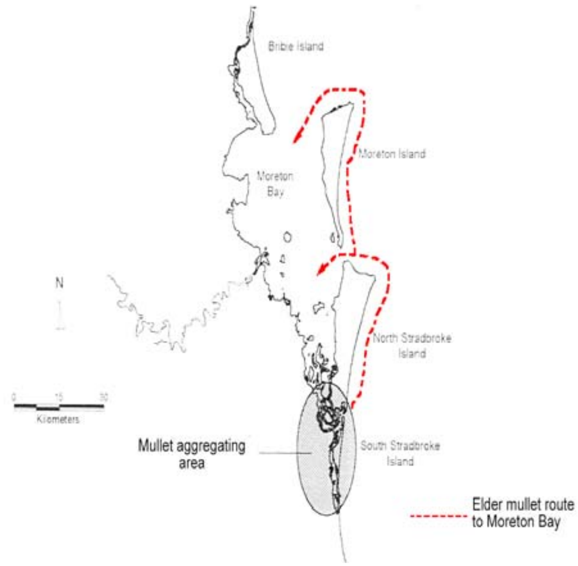

Figure 3. Traditional sea mullet route into Moreton Bay (Ross and Quandamooka Land Council 1996b:2)

(Ross and Quandamooka Land Council 1996b; – see Figure 3).

By allowing the mullet to follow this route into the Bay, rather than continuing on to the open sea, the fish could be easily herded toward the shore with the help of dolphins (Hall 1984; Ross and Quandamooka Land Council 1996b). It remains common practice amongst Quandamooka fishers to avoid catching the elder mullet until the elders have led the younger fish on the correct migration path into the Bay and thereby passed on the knowledge of the migration route (Ross and Quandamooka Land Council 1996b).

The Quandamooka people use a number of signs to indicate when the spawning migration has begun and where the fish are on their route. These signs are mostly land based indicators, although the most important signal came from the dolphins. In pre-contact times, Quandamooka elders would call the dolphins by hitting their spears on the surf, thereby

requesting their assistance in summoning fish towards the foreshore (Ross and Quandamooka Land Council 1996b). Dolphins would guide the fish into the net, however, tradition stipulated that the best fish were to be given to the dolphins in order to ensure they would grant approval for future catches (Hall 1984).

Sea mullet was and continues to be an important subsistence resource for the people of Quandamooka. In the past it was also used for trade purposes. According to Quandamooka tradition, access to sea mullet harvesting in Moreton Bay was confined to the people of Quandamooka unless neighboring Aboriginal communities requested and received permission to fish in that country:

> *"... when our systems of land tenure were fully applied, visiting people coming over to this country here from say Yugarra country, which is up around Ipswich, could not just come to Stradbroke Island, set up their own camp, go out and help themselves to the resources, take whatever they wanted by way of fish and shellfish and stay here as long as they wanted. They had to first obtain the permission of the traditional land law people of this country. If that permission was granted, then they were able to come here and share and enjoy the value of the environment and everything that it provided"* (Ruska 1997:44).

This approach to sea mullet management is more holistic than that used by the QFS. The Quandamooka people do not restrict their management of this resource entirely to the sea. The land resources play a part in signaling the harvesting sequence. Furthermore, the Quandamooka approach is one that incorporates both input controls over the resource (there are rules for when and where fish can be taken and by whom) and output controls (based on the numbers of fish and which fish can be taken at what stage during the migration path). This differs from the QFS management approach.

SEA MULLET MANAGEMENT: A COMPARISON

General management differences are bound to permeate species-specific management practices. Apart from variation in terminology, a clear difference exists in how the QFS and the Quandamooka community relate to sea mullet both directly (code of behaviour) and indirectly (moral obligation). For example, Quandamooka Aboriginal people view themselves as part of the environment and therefore show a high level of respect for nature. This relationship governs their resource management practices, which stipulate an equal coexistence between humans and nature. This discourages a 'formula' style approach to resource control. Rather, for the Quandamooka people, sea mullet harvesting is dictated by the signals of other resources both on the land and in the sea. In contrast, the QFS view sea mullet (and most other fisheries) as an economic resource. This is a perspective that warrants human control and exploitation. Clearly, these two viewpoints are in direct conflict with one another.

Other areas of divergence include access and withdrawal rights. The QFS is governed by legislation and relevant management authorities such as the MAC / ZAC committees which stipulate that access to Moreton Bay can be obtained following the purchase of a license to fishing zones in the area. Withdrawal of fishing rights is obtained by designating restricted fishing zones. In contrast, Aboriginal elders of the Quandamooka community represent the decision makers and they govern the collective rights of the community to fish sea mullet. With regards to access or withdrawal of fishing rights, the Quandamooka people hold the viewpoint that their community members can fish in their own country in accordance with customary law. They believe they should control whether or not people from outside the community can access the Bay and its resources.

The specific differences discussed infiltrate the respective resource management practices. Thus, while the QFS are enforcing restrictions in terms of input controls such as fishing boats or vessels, nets and fish sizes as well as declaring protected areas, their output control is non-existent. In contrast the Quandamooka people's resource management practices stem from a shared belief system, which respects and appreciates nature, thereby encouraging people to take only as much as is needed in an effort to ensure the sustainability of the environment and all its species. The Quandamooka community uses its knowledge of the sea mullet social structure, as well as environmental indicators and the interrelationship between sea mullet and predators (dolphins) to guide their harvesting practices. In this way Quandamooka resource management is active - the people are active participants in setting and administering the law as well as in the actual implementation of the law. For the QFS, on the other hand, management is passive - it is imposed by the government and the bureaucracy on those who actually do the fishing. The QFS is therefore

divorced from the actual practice of sea mullet harvesting.

DISCUSSION

The aim of this research is to examine different knowledge constructs to see if they present barriers to the joint sharing and application of knowledge and management practices. There are several broad conceptual differences between the two fisheries management parties, including differences in power and authority, management responsibilities, definition of the Bay and management goals. These represent important barriers to participatory management in their own right and each will be discussed in more detail below.

Authority and power

Both the QFS and Quandamooka community view themselves as legal custodians of the Bay's fishery resources. This should provide a common platform from which to pursue knowledge sharing and joint management arrangements. However, the QFS does not recognize the Quandamooka community as co-managers of the Bay. Although the QFS does acknowledge the people of Quandamooka as traditional custodians, this recognition is more of symbolic attachment than of responsibilities and requirements assigned to joint managers. The Quandamooka community is viewed, at best, as a stakeholder in the design of sea mullet management strategies. A contributing factor is that the rationale for government management is based on Hardin's 'Tragedy of the Commons' model. As Ruddle (1994: 64) explains, deeply embedded within this model, and within modern Western constructs of sea space and sea resources, is the "erroneous notion that the misuse of fisheries resources stems from the institution of common property, which was and unfortunately often still is, mistakenly assumed to be synonymous with open access". Thus, the concept of the Bay as common property to all contrasts strongly with the Quandamooka view that the Bay belongs to them.

Layt (1999) has also identified the limited role for indigenous owners in the Queensland Fisheries Management Authority (the pre-merged QFS). She criticized the QFMA for their reaction to Smyth's (1999) report '*Towards an Aboriginal and Torres Strait Islander fisheries strategy for Queensland*'. The report was produced in response to the recommendations of the Commonwealth Coastal Zone Inquiry to implement structures to foster the mutual exchange of coastal aquatic resources and thereby satisfy legal requirements under s14(3) of the *Fisheries Act 1994 (Qld)* to promote the involvement of indigenous people in the management and planning of fisheries resources (Smyth 1999). The report entailed recommendations derived from four regional workshops, comprising various parties including the Quandamooka Land Council and other Aboriginal communities and organizations (Smyth 1999). In essence, Layt argues that this document represented an ideal opportunity to incorporate customary law into natural resource law, but the opportunity was ignored.

Layt (1999) reported that QFMA only considered the recommendations in the report relating to the legislative process in accordance with Native Title notification procedures. In so doing, Layt argued, the QFS effectively separated Aboriginal political claims for involvement in fisheries management from Native Title property claims. This conceptual divide between political and property claims is alien to indigenous concepts of marine tenure (Layt 1999) and represents a major barrier to knowledge sharing and joint management arrangements in the Bay.

Management responsibilities

In terms of management responsibility, QFS management is confined to Queensland fisheries resources and under Australian statutory law, sea and land ownership are treated very differently. This can be seen in the narrow definition afforded to the Bay by the QFS compared to the holistic and ecosystems definition of the Quandamooka community. Underlying the QFS compartmentalized approach is the belief that the world is rational, that it can be easily divided and understood (Linzey 1995). This tends not to be the indigenous view.

The fluid Quandamooka definition of the Bay represents another challenge. The Quandamooka management responsibilities beyond the eastern boundaries of the Bay are not delineated. This contrasts with the well-delineated approach between the State and Commonwealth government arrangements for the management of the Australian coastline and represents a challenge in determining how far the interests of the Quandamooka community extend outwards from the eastern boundaries of the barrier islands.

The above definitional differences of the Bay pose several barriers to cooperation between the management parties, for they refer to different aspects of what constitutes the Bay and identify different management responsibilities over the

Bay. A number of communication problems result from the different constructs of Moreton Bay, and these are highlighted by Quandamooka members, stating that their concerns are often interpreted as being unrelated to fisheries:

> *"Management authorities often discover that issues identified by indigenous fishers for management of the resource often involve topics not immediately seen to be directly associated to the fishery by more conventional minds"* (Sinnamon 1997: 12).

This conflict can be seen in the dispute over the boundaries that are used to manage sea mullet harvests in the Bay. Measures that are based on the Bay as delineated by the western shores of Moreton, North and South Stradbroke Islands (the QFS definition) discount those fishing impacts that occur along the eastern shores of the islands and beyond (the Quandamooka definition). These impacts are mainly on the 'elders' of the sea mullet migration. Once these fish are taken, the Quandamooka argue, the younger fish will not know the way into the Bay (Ross and Quandamooka Land Council 1996b) and this then has an influence on the fishery within the Bay itself. This has prompted Quandamooka community members to argue that the QFS definition of the Bay does not serve the interests of sea mullet (Sinnamon 1997). The QFS responds that fishing zones on the eastern, oceanic side of the islands have imposed limitations on the impacts of commercial fishing outside the Bay, but declining numbers of mullet entering the Bay (Sinnamon 1997) suggest otherwise.

Essentially, the QFS is limited in its capacity to manage the Bay's fisheries if its responsibilities are confined to fisheries alone and not the wider environment. As Ross and Quandamooka Land Council (2001:10) note:

> *"There are fourteen separate pieces of legislation, administered by four different State government departments and nine local government authorities, which relate to the management of the Bay (QFMA 1996: 16-20). Each department and authority has a different responsibility toward the management of the resources of the Bay. Consequently, demarcation and compartmentalization of responsibilities under legislation and government structure makes an holistic approach to the management of the waters and resources of the Bay politically impossible, however desirable it may be".*

Management goals

The degree of overlap between the management goals of both parties can also help to determine the success of co-management arrangements. In essence, the closer they are, the greater the chance for collaboration. For Moreton Bay, both management parties aspire to achieve sustainability, providing a common platform from which to pursue cooperative management arrangements.

The QFS definition of sustainability emphasizes the *development* aspect of ecologically sustainable development (ESD). Brunk and Dunham (2000) argue that the prioritization of economics and development often leads to the depreciation of other values. The Quandamooka definition of sustainability emphasizes human benefits of ecosystems management, as the maintenance of spiritual and cultural aspects of the community are emphasized. However given the inseparability between the community and their environment, the environmental well-being of the Bay is considered to be reciprocally linked to the well-being of the Quandamooka people. Economic values are also considered an important factor for self-determination and self-sufficiency purposes, but they do not dominate, and therefore conflict strongly with the QFS approach to fisheries management.

The QFS establishes individual rights for fishers through legislative and regulatory means and various management advisory committees (such as MACs and ZACs). Quandamooka elders make decisions on behalf of the whole community through customary law. This difference of State and local responsibilities represents various challenges to cooperative management. For example, advisory committees represent a useful strategy for including stakeholder groups in the fisheries management process. However, because the Quandamooka community is considered by the QFS as a single stakeholder, rather than a group of people with a variety of rights and responsibilities to resource management in the Bay generally, they therefore have only a single Aboriginal representative on the QFS Management Advisory Committee (and that person may not even come from the Moreton Bay area). This means government managers can more easily take the path of least resistance and listen to the strongest lobbying presence, which tends to be the four representatives of the fishing industry (see figure 2). Such outcomes are unlikely to result in the best solution for all.

The disregard of the Quandamooka community management structure is partly a reflection of the differences in marine tenure and definitions of the Bay. But more importantly, the use of power and authority to privilege the QFS management structures over those of the Quandamooka community is reminiscent of Enlightenment thinking (Wallace *et al.* 1996).

Bodies of knowledge and paradigms

The sea mullet case study has identified several elements of the QFS and the Quandamooka community's management approaches to this fishery. Both management parties have property rights systems in place to manage fishing of the sea mullet spawning migration that passes through and around Moreton Bay. Further, both management parties specify operational rights for their respective fishers, yet substantial differences exist in terms of how these are orchestrated. We argue that the underlying basis for this difference is in the environmental constructions that inform the management practices of both agencies.

The QFS commonly refers to and manages sea mullet according to such terms as 'resources', 'stocks' and 'numbers'. This nomenclature is synonymous with business terms, what Newell and Ommer (1999) refer to as equating fisheries with disposable items. This exposes the view that humans are apart from and above the environment, and highlights the close connection between QFS management and the capitalist mode of thinking, again a reflection of Enlightenment or positivist thinking.

Quandamooka fishers and their community, on the other hand, although also placing economic value on the sea mullet spawning migration (as they traded these items), see economic value as just one element embedded within other, multiple values. These values essentially equate to the Quandamooka community's view of these fisheries as being within the environment and seeing themselves as part of that environment. This is embodied in such management strategies as fishing according to the sea mullet social structure and treating sea mullet with respect once caught. The Quandamooka community thereby respects sea mullet as living parts of the environment. This poses a challenge to joint management arrangements given the differing values and paradigms within which the management parties operate.

Several interesting elements are revealed by the above comparisons. Firstly, the concentration on fishing effort and the absence of output controls in the QFS management approach emphasizes human exploitation of these species. Embedded in this management approach is the view that humans can control the environment, a basis of human supremacy over the environment. On the other hand, Quandamooka management strategies include wider environmental considerations and reciprocity principles such as returning the best mullet to the dolphins in order to ensure a good catch next season. These are indicative that influences beyond the control of the Quandamooka community are considered integral to proper resource management and that the Quandamooka people view themselves as part of the wider natural and social environment.

Thus, while knowledge is available to manage the fish species on an ecological basis, it seems that the QFS does not consider this knowledge as a valid basis for 'scientific' decision-making. This could be due to a number of reasons, including:

- The inability of the QFS to use *qualitative* knowledge and measures;
- The supremacy of Western science and quantifiable measures; and / or
- the need for certainty and simplicity and the need to perpetuate current regulations and rules for administrative ease (Wilson, this vol).

CONCLUSION

The management practices employed by the QFS and the Quandamooka community are intrinsically political in nature. The QFS practices favor commercial interests while the Quandamooka community's approach favors community interests.

The application of a social constructivist methodology allowed a comparative study of some of the constructs inherent in the Quandamooka community and QFS approaches to sea mullet management to be undertaken. In light of Berkes' (1999) analytical model, the case study revealed that different cultural constructs resonate throughout the two different management approaches. Clearly, the construction or perception of the environment has far reaching implications for how values are assigned, what and how knowledge is constructed and what management strategies are devised.

The results indicate that Western constructs dominate fisheries management in Moreton Bay. Despite a change in Western environmental

values over recent decades, key principles, implicitly and explicitly embodied in current QFS management approaches, remain embedded in the Western constructs of the Enlightenment period. Recurring themes in the QFS management approach are the concepts of human supremacy over the sea and its resources, State authority and power, individualism, and economic dominance - all assumptions founded in a positivist theoretical framework. Quandamooka community management practices, knowledge and concerns are treated as those of a stakeholder. Moreover, current commercial management and harvesting methods undermine the application of Quandamooka management practices, thereby marginalizing the development of their knowledge and culture. The marginalization of resource management responsibilities can in turn lead to a loss of management practices and knowledge not just for the Quandamooka community but also for humanity as a whole. Such loss signifies the loss of another way of knowing and another way of interacting with the environment (Linzey 1995).

Principles inherent in the Quandamooka community's approach to sea mullet management reflect a constructive, holistic and spiritualistic indigenous framework for resource management. Instead of separating the economic well-being of the resources from ecological considerations, and devising separate management strategies for each, resource productivity is seen as being dependent on the ecological and human well-being, where the environment is managed as a whole.

Clearly, current QFS management practices fall short of the sustainability goal, however it may be defined. Following Brunk and Dunham (2000), distributive justice is not catered for as current QFS practices fail to provide fair access to fisheries, the Quandamooka community is excluded from meaningful engagement in management decision-making and Quandamooka management practices are dismissed. Current QFS management practices also deny ecological justice. Apart from the delimitation of Fisheries Habitat Areas, the inclusion of ecological aspects in the QFS approach to sea mullet management remains negligible. The continued targeting of mature sea mullet can only lead to an eventual collapse of the fishery.

We are not implying that Western management strategies and science should be discarded, for science can provide valuable insights into environmental management. Scientific knowledge is paramount in larger scale ecological studies that take into account the cumulative impacts of fishing for sea mullet that migrate between the New South Wales and Queensland borders. Indeed, indigenous knowledge does not represent a panacea for environmental management either, given the many uses of and influences on the Bay and the local scale focus for indigenous knowledge. Instead multiple perspectives, knowledge bases and management strategies are needed for Moreton Bay fisheries management, as voiced by Penny Tripcony (1997:9), a member of the Quandamooka Land Council:

> *"We believe that by marrying the two systems of knowledge (that is Aboriginal scientific knowledge, technology and attitudes to the environment; and Western science and technology), the collective wisdom of both cultures will ensure a more holistic approach to life. Science, technology and the environment ideally would no longer be discrete separate units, but as ongoing interactions within the total ecosystem".*

However, Penny Tripcony's vision for genuine collaboration in management will not be achieved until there has been a fundamental shift in dominant perceptions and values.

REFERENCES

Agrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. *Development and Change* 26: 413-439.

Berkes, F. (1999). *Sacred ecology: Traditional Ecological Knowledge and Resource Management*. Philadelphia: Taylor and Francis.

Bradley, J. J. (1998). 'How can a Whitefella know it all?' Indigenous science – western science and marine turtles. In R. Kennett, A. Webb, G. Duff, M. Guinea and G. Hill (eds.) *Marine turtle conservation and management in Northern Australia*. pp 25 – 32. Darwin: Centre for Indigenous Natural and Cultural Resource Management, Centre for Tropical Wetlands Management, Northern Territory University.

BRMG (1997). *State of the Brisbane river, Moreton Bay and waterways*. Brisbane: Queensland Department of Environment.

Brunk, C. and Dunham, S. (2000). Ecosystem justice in the Canadian fisheries. In H. Coward, R. Ommer and T. Pitcher (eds.) *Just fish: Ethics and Canadian marine fisheries*. pp 9 – 33. Newfoundland: Institute of Social and Economic Research, Memorial University of Newfoundland. *Coastal Waters State Powers Act 1980 (Cth).Convention on the Law of the Sea 1994 (UN).*

Crowthers, G., Finney, L., Gordon, K. and McCormick, K. (1997). *Minjerribah – an Indigenous Story of North Stradbroke Island*. Redland: Redland Tourism.

Davie, P. J. F. and Hooper, J. N. A. (1998). Patterns of biodiversity in marine invertebrate and fish communities of Moreton Bay. In I. R. Tibbetts, N. J. Hall and W. C. Dennison (eds.) *Moreton Bay and catchment*. pp 331 –346.

Brisbane: School of Marine Science, University of Queensland.

Dennison, W. C and Abal, E. G. (1999). *Moreton Bay study: A scientific basis for the healthy waterways campaign*. Brisbane: Southeast Queensland Regional Water Quality Management Strategy.

DPI (2000). DPI Note: Sea mullet (hardgut mullet, river mullet).http://www2.dpi.qld.gov.au/dpinotes/animals/aquaculture/f00087.html Accessed: December 2000.

DPI (1993). Fisheries: Managing for the future report. Discussion paper. Brisbane: The State of Queensland, Queensland Department of Primary Industries.

EPA (1999). *Conservation and Management of the Dugong in Queensland 1999 – 2004*. Brisbane: The State of Queensland, Environmental Protection Agency.

Freeman, M. M. (1999). They knew how much to take: Respect and reciprocity in Arctic sustainable use strategies. Paper presented at the *International Symposium on Society and Resource Management*, July 7-10, Brisbane.

Gordon, H. S. (1954). The economic theory of a common property resource: The fishery. *Journal of Political Economy* 62: 124 – 142.

Hall, J. (1984). Fishing with dolphins? Affirming a traditional Aboriginal fishing story in Moreton Bay, SE Queensland. In Coleman, R.J., Covacevich, J., and Davie, P. (eds), *Focus on Stradbroke: New Information on North Stradbroke Island and Surrounding Areas 1974-1984.* Boolarong Press, Brisbane, pp. 16-22.

Halliday, I. (1992). Sea mullet one of our most important fish. *The Queensland Fisherman*, July 26-29.

Hardin, G. (1968). The Tragedy of the Commons. *Science* 162:1243-1247.

Haysom, N. (1999). Some pioneering personalities of Queensland's fishing industry. *Journal of the Royal Historical Society of Queensland* 17(1): 25-48.

Jackson, P. (1991). The crisis of representation and the politics of position. *Environment and Planning D: Society and Space* 9: 131 – 134.

Kailola, P. J., Williams, M.. J., Stewart, P. C., McNeel, A. and Grieve, C. (1993). *Australian Fisheries Resources*. Canberra: Bureau of Resource Sciences and the Fisheries Research and Development Corporation.

King, M. (1997*). A Partnership Unexplored: The role of Aboriginal Traditional Ecological Knowledge in the Systematic Reserve Selection Procedure*. Unpublished Bachelor of Applied Science – Natural Systems and Wildlife Management thesis. Department of Natural and Rural Systems Management, The University of Queensland.

Layt, A. (1999). *Indigenous Involvement in Queensland fisheries and Native Title rights.* Unpublished industrial placement report. Gatton: The University of Queensland.

Linzey, A. (1995). *Traditional Ecological Knowledge: Alternative perceptions for Conservation Management*. Unpublished Master of Science thesis, Department of Geography, University of Auckland.

McCarthy, D. E. (1996). *Knowing as Culture: The New Sociology of Knowledge*. London: Routledge.

McDonald, G. and Brown, L. (1992) Economic values of Moreton Bay. In O.N. Crimp (ed.) *Moreton Bay in the Balance* pp. 81-92. Moorooka: Australian Littoral Society Inc. and the Australian Marine Science Consortium.

Murdock, J. and Clark, J. (1994). Sustainable knowledge. *Geoforum* 25(2): 115-132.

Nakata, M. (2001). Cross-cultural considerations: Indigenous academics are on foreign ground in their own land. *The Australian*, Wednesday February 21 2001, p41.

Neil, D. T. (1998). Moreton Bay and its Catchment: Seascape and landscape, development and degradation. In I. R. Tibbetts, N. J. Hall and W. C. Dennison (eds.) *Moreton Bay and Catchment*. pp 3 – 54. Brisbane: School of Marine Science, University of Queensland.

Newell, D. and Ommer, R. E (eds.) (1999). *Fishing Places, Fishing People: Traditions and Issues in Canada's Small-Scale Fisheries*. Toronto: University of Toronto Press.

Noonuccal, O. and Noonuccal, K. O. (1988). *The Rainbow Serpent*. Revesby: Finepress.

Pálsson, G. (1998). Learning by fishing: Practical engagement and Environmental Concerns. In F. Berkes, C. Folke and J. Colding (eds.) *Linking Social and Ecological Systems: Management practices and Social Mechanisms for Building Resilience*. pp 48 –66. Cambridge: Cambridge University Press.

Perkins, D. (1996). Moreton Bay, Australia: Multiple-use planning and Management for a Ramsar-listed Coastal Wetland. In *Proceedings of the 6th Meeting of the Conference of the Contracting Parties*. Brisbane 19-27 March. pp 18 –21. Gland: Ramsar Convention Bureau.

Pomeroy, R. S. (1994). Introduction. In R. S. Pomeroy (ed.) *Community management and Common Property of Coastal fisheries in Asia and the Pacific: Concepts, methods and experiences*. pp 1 – 11. Manila: ICLARM Conference Proceedings 45.

Posey, D. A. (1995). Collaborative research and intellectual property rights. *Biodiversity and Conservation* 4(8): 892-902.

QFMA (1996a). *Moreton Bay fishery*. Discussion paper no. 6. Brisbane: The State of Queensland, The Queensland Fisheries and Management Authority.

QFMA (1996b). *Queensland Subtropical Inshore Finfish Fishery*. Discussion paper no.3. Brisbane: The State of Queensland, The Queensland Fisheries and Management Authority. *Queensland Fisheries Act 1994 (Qld).*

Rigsby, B. (1998). A survey of property theory and tenure types. In N. Peterson and B. Rigsby (eds.) *Customary Marine Tenure in Australia*. pp 22 – 46. Oceania monograph No. 48. Sydney: University of Sydney.

Robinson, C. and Mercer, D. (2000). Reconciliation in troubled waters? Australian oceans policy and offshore Native Title rights. *Marine Policy* 24(4): 349 – 360.

Rose, D. B. (1995). *Land Management Issues: Attitudes and Perceptions amongst Aboriginal people in Central Australia*. Alice Springs: Central Land Council.

Ross, A. and Pickering, K. (in press). The Politics of Reintegrating Australian Aboriginal and American Indian Indigenous Knowledge into Resource Management: The Dynamics of Resource Appropriation and Cultural Revival. *Human Ecology*.

Ross, A. and Quandamooka Land Council (1996a). Aboriginal approaches to cultural heritage management: A Quandamooka case study. *Tempus* 6: 107-112.

Ross, A. and Quandamooka Land Council (1996b). Quandamooka perspectives on cultural heritage. *In Place* 2: 5-6.

Ross, A. and Quandamooka Land Council (2001). Marine resource management: Survival of indigenous knowledge and customary marine tenure in Moreton Bay, southeastern Queensland. Paper submitted to *Human organization*. Manuscript page numbers cited.

Ruddle, K. (1994). Local knowledge in the folk management of fisheries and coastal marine environments. In C.L. Dyer and J.R. McGoodwin (eds.) *Folk Management in the World's Fisheries: Lessons for Modern Fisheries Management*. pp 161 – 206. Colorado: University Press of Colorado.

Ruska, D. (1997). Bloodline to country. In R. Ganter (ed.) *Stradbroke Island: Facilitating Change*. Proceedings of a public seminar held by the Queensland Studies Centre with Quandamooka Land Council. pp 43 – 49. Brisbane: Queensland Studies Centre, Griffith University.

Salas, S., Archibald, J. and Haggan, N. (1998). Aboriginal knowledge and ecosystem reconstruction. In D. Pauly, T. Pitcher, and D. Preikshot (eds.) *Back to the Future: Reconstructing the Strait of Georgia ecosystem*. Vancouver: UBC Fisheries Research Reports 6(5): 22 –28.

Sillitoe, P. (1998). The development of indigenous knowledge: A new applied anthropology. *Current Anthropology* 39(2): 223-252.

Simpson, L. R. (1999). *The Construction of Traditional Ecological Knowledge: Issues, Implications and Insights*.

PhD Thesis, The Department of Native Studies, University of Manitoba.

Sinnamon, V. (1997). *Quandamooka Indigenous Fisheries – Discussion paper*. Dunwich: Document prepared for the Quandamooka Land Council.

Skinner, J. L., Gilliam, E., and Rohlin, C. J. (1998). The Demographic Future for the Moreton Region. In I. R. Tibbetts, N. J. Hall and W. C. Dennison (eds.) *Moreton Bay and Catchment*. pp 67 – 80. Brisbane: School of Marine Science, University of Queensland.

Smyth, D. (1999). *Towards an Aboriginal and Torres Strait Islander fisheries strategy for Queensland*. Final report to the Queensland Fisheries Management Authority on the outcomes of four regional workshops. Brisbane: Queensland Fisheries Management Authority.

Sutherland, J. (1996). *Fisheries, aquaculture and Aboriginal and Torres Strait Islander interests in Australia's coastal zone*: studies, policies and legislation. Canberra: Resource Assessment Commission.

Taylor, S. G. (1990). Naturalness: The concept and its application in Australian ecosystems. *Proceedings of the Ecological Society of Australia* 16: 411-418.

Tripcony, P. (1997). The Significance of Place: An Aboriginal view of country. Paper presented at the *Sixth National Conference of the Interpretation Australia Association*. Gatton.

Virgona, J., Deguara, K., Sullings, D., Halliday, I. and Kelly, K. (1998*). Assessment of the Stocks of sea mullet in New South Wales and Queensland waters*. Cronulla: NSW Fisheries Final Report Series Project No. 94/024.

Wall, M. (1995). *"Being a Maori is…"; Media constructions of the Maori "race" as the Black Other*. Unpublished Master of Arts thesis, The University of Auckland.

Wallace, M.G., Hanna, J.C., Moote, M. A and Burke, S. (1996). Moving toward Ecosystem Management: Examining a Change in Philosophy for Resource Management. *Journal of Political Ecology,* 3:1-36.

Williams, L. (1992). Moreton Bay Fisheries. In O, Crimp (ed.) *Moreton Bay in the Balance* pp. 71-79. Brisbane: Australian Littoral Society and Australian and Marine Science Consortium.

Wolfley, J. (1998). Ecological Risk Assessment and Management: Their failure to value Indigenous Traditional Ecological Knowledge and Protect Tribal homelands. *American Indian Culture and Research Journal* 22: 151 – 169.

Wright, W (1992). *Wild Knowledge: Science, Language and Social Life in a Fragile Environment*. University of Minnesota Press, Minneapolis.

QUESTIONS

Ross Wilson: How did you use dolphins to harvest mullets?

Tanuja Barker: It exploits the relationship between the fish and the dolphins during the seasonal migrations. The dolphins would guide the schools of fish into the bay where the nets were set – fishers would just scoop them up.

Ian Baird: The same thing happens in southern Thailand.

Tanuja Barker: Yes, and I believe it is the same in South America.

WHO'S LISTENING? ISLANDER KNOWLEDGE IN FISHERIES MANAGEMENT IN TORRES STRAIT, NORTHERN AUSTRALIA

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ABSTRACT
This paper addresses the fisheries management-related knowledge of indigenous Islanders in Torres Strait, northern Australia. Islander knowledge will be situated both culturally and historically, before turning to the contemporary context of fisheries management and development. Islander fishermen have recently established dialogue with scientific fisheries managers; I argue that the success of this dialogue depends on recognition of various political and legal strategies deployed by Islanders to control the allocation and management of fisheries resources within their traditional marine territories.

INTRODUCTION
To ask whether or not an indigenous society practices resource management risks simplistic response. It is always more revealing to ask *which* resources are conserved or managed, under what circumstances. The Torres Strait presents an interesting context in which to examine this question. Located between Papua New Guinea and the Cape York Peninsula of northern Queensland, this reef-strewn passage is home to a group of Melanesian Islanders who have an intimate and long-standing connection to the small islands, extensive reefs and tropical waters of their traditional territory.

For the period prior to colonization by Europeans, there is little direct evidence for the resource use and management strategies of Islanders. There is a suggestion, however, in the 1898 research of the Cambridge Anthropological Expedition to Torres Strait, that Islander culture involved collective awareness of ecological constraints, and of the possibility of human action directed toward sustainability. Stern taboos regulated human population size, for example (Haddon 1908: 107-9). The cultural ideal was two children per nuclear family, and it was contrary to tribal law to have more than three. Infanticide, or adopting-out of a fourth child to a family with fewer children, was the rule. Although Haddon has nothing to say on the motivation for this taboo, the limiting factor for human population size was surely not seafood supplies; it was almost certainly fresh water, in short supply on most Torres Strait islands.

Certain other renewable resources were in short supply, according to Islander oral history. There was no surplus of garden lands, and indeed the relatively barren sand cays of the central Strait depended on trade for vegetable produce from the more fertile Eastern volcanic islands. In the Eastern islands, seabird manure was used to boost garden production according to local informants today, but local cays and islets did not accumulate guano at a sufficient rate to meet the need. Hence, Eastern Islanders journeyed considerable distances to the outer limits of their sea territories, either northward to Bramble Cay near the Fly River estuary of Papua New Guinea, or southward to Raine Island, well down the Great Barrier Reef, where large cays are found that support large seabird concentrations.

Sand cays, as sanctuaries for nesting turtles and seabirds, are sacred places for Eastern Islanders. Mythology surrounding the creation of Bramble Cay, in the marine estate of Erub (Darnley Island), emphasizes the possibility of marine resource depletion, and human responsibility to protect resources (Scott, under review). Legendary ancestors used their magic to create the cay because nesting seabirds and turtles had been victims of human overexploitation nearer the home island. In response, ground was taken by clan leaders from the home island to create the Cay far enough away to afford these important resources some protection, but close enough to be of use, with the comings and goings of visitors to the Cay overseen by clan elders.

From the 1860s to the 1960s, Islanders were involved as seamen and divers with a range of industrial fisheries – bêche-de-mer, pearl shell and trochus shell (Beckett 1987; Ganter 1994). This experience provided a lesson in the exhaustibility of resources that would not have been depleted under pre-contact conditions. Islanders witnessed first-hand the depletion of wild pearl shell and trochus shell to the point that a crew might dive all day for what a man might formerly have easily gathered in half an hour. The patterns of commercial exploitation, and of management policy to the extent it existed, were, however, out of the hands of Islanders. Islanders were maritime workers for the most part, not owners of vessels. Even the small number of Islander-skippered commercial

vessels was strictly under the thumb of the colonial Protector until the 1970s.

The 1970s saw further crises: the giant clam, which under aboriginal conditions were an exhaustible resource and seen as such; and sardines, which under aboriginal conditions were effectively inexhaustible. Giant clams have the potential to be easily overexploited. Their meat is highly savored and involves limited harvesting effort. Yet, giant clams are present in significant numbers even on home reef areas. Food regulations limit the consumption of giant clam to infrequent occasions, as a means of varying the diet or during those periods when access to other sources of seafood is limited by unfavorable fishing conditions. Giant clams are key symbols in Islander attitudes toward conservation. Their shells should be turned upside down once the flesh has been harvested to serve as a refuge for other life forms. Individuals who fail to observe this practice are labeled *meme kurup*, a person uncouth and uncultured (Scott, under review).

A giant clam crisis occurred when a Taiwanese mother ship, careful to anchor beyond the visual horizons of inhabited islands, was eventually discovered by Islanders and apprehended. Giant clams had however been harvested in such large numbers over an extensive area of reefs that it took more than twenty years for clams to reestablish their former size and abundance.

From the early 1970s to the early 1980s, a turtle-farming program was initiated in the Torres Strait, by a foreign biologist. Large numbers of eggs were collected from nesting areas such as Bramble Cay and Raine Island and brought to Mer (Murray island) for incubation. From there, the hatchlings, which enjoyed much higher survival rates than they would in the wild, were dispersed to farms on various islands to be hand-fed in small pools. Juveniles were to be released to reinforce the wild population. Most hatchlings, however, were to be raised to adulthood, as breeding stock for turtle restocking elsewhere.

Sardines served as the primary food source for the large numbers of growing turtles. Sardines had always been a reliable and easily harvested food staple for Islanders. However, aggressive netting, an essential element in the maintenance of the turtle farm operation, resulted in an unprecedented sardine population collapse at both Erub and Mer. This in turn led to the retreat of formerly abundant species of large fish, particularly trevally, that normally pursue sardines onto the beaches of the home islands. Islander patience ran out when it was proposed that turtle farmers should turn to giant clams for turtle feed. Elders insisted that the project be terminated. According to Islanders, it took fifteen years for sardine populations to recover to former levels, and trevally are again abundant along local beaches.

These resource crises, mostly profit-driven, mostly decided by non-Islanders, have stiffened local resolve to gain management jurisdiction and ownership of their home seas. For both ecological and social reasons, Eastern Island fishers advocate limiting reef fisheries to locally controlled small-boat operations, in pursuit of diversified subsistence and commercial catches – principally tropical rock lobster, coral trout, spanish mackerel, red emperor, sand fish (i.e. sea cucumber), and trochus shell. Rotational use of fishing spots, the distribution of fishing effort over multiple species, and seasonal shifts in wind and weather patterns limiting small boat access to less than six months of the year are principal features in local management. These stand in marked contrast to the approach of larger non-Islander commercial boats targeting one or two species, who can work intensively during all seasons in nearly any weather. There is also a major difference in economic imperative. Relentless accumulation is disparaged by Islanders; in the words of one informant:

> *"them thing he happen on a needs basis, not on a craving for more and more. As soon as we satisfy, we stop and when the need come up again we go again".*

The rare individual who fishes hard at every possible opportunity is more likely to be the object of censure than praise.

BRINGING ABOUT A SEA CHANGE

Islander aspirations to assume primary control of resource and environmental management are being pursued along various avenues simultaneously. First, rights to use and manage marine resources may be reshaped through Native Title recognition. Mer (Murray) Islanders gained High Court recognition of their ownership to land above the high water mark through the landmark Mabo decision in 1992. Through a series of Federal Court determinations on claims subsequently lodged with the Native Title Tribunal, most other Islander communities have gained similar recognition. A sea claim covering the entire Torres Strait region was lodged in late November 2001 on behalf of the Islanders by the Torres

Strait Regional Authority (TSRA)[1]. Recognition of Islander title to reefs and seas below the high tide mark will meet with greater opposition than was the case with land, and elsewhere Native Title rights to the Australian offshore have received weaker recognition than terrestrial rights (High Court of Australia 2001), but Islanders hope that their own case will result in a more beneficial judgment, given the predominance of the sea for their cultural identity and economic prospects.

In the meantime, Islander concerns about the sustainability of certain fisheries, and frustrations with the lack of economic benefits accruing from commercial fishing in their traditional waters have erupted in conflict with non-Islander commercial fishing interests and central government authorities. In the early 1990s, Eastern Islanders declared exclusive economic zones within their traditional waters, in line with demands for economic independence and the management of the seas in accordance with traditional law. Periodically, non-Islander commercial fishing boats have been evicted from this zone, although more recently, a so-called "gentlemen's agreement" has led to non-Islander boats generally avoiding waters within a ten nautical mile radius of home islands. Islanders, however, seek a thirty-mile radius, and there is nothing in official licensing or regulation to prevent entry even into the ten-mile zone, so incidents at sea have continued.

The declaration of exclusive economic zones also reflected Eastern Islander anxieties about potential fishing pressure from some of the larger islands in Western Torres Strait, where Islander fishermen use hookah gear[2] to gain access to sandfish and tropical rock lobster at greater depths. These fishermen are described as more 'cash-driven'. Eastern Islanders believe that these factors, together with insufficient regard for traditional marine territories, led to the 1997 collapse of the Warrior Reef sandfish population in the Central Strait, and subsequent closure of the fishery. For this reason Eastern Islanders are adamant that their community territories must be respected, so that they may regulate access. They express some willingness to share with Western and Central Islanders, but on specific terms, including a ban on the use of hookah gear. For this reason, Eastern Islanders have made their participation in the blanket regional sea claim conditional on respect for community-level traditional territories.

A recent Cairns District Court decision dismissed armed robbery charges against an Islander man who had used a crayfish spear to confront licensed commercial fishermen operating in the traditional fishing territory of Mer. Ben Ali Nona's confiscation of $600 worth of coral trout from the intruders was deemed not to be robbery on grounds that he was acting on an 'honest right of claim'. The acquittal is the outcome of a provision of the Queensland criminal code rather than recognition of Native Title sea rights. But it has fuelled grassroots support for a movement centred on the Torres Strait Fisheries Taskforce (TSFT), a body of young, energetic fishermen determined to take control of fisheries management through the creation of a Torres Strait Regional Fisheries Council.

A Cultural Maritime Summit[3] in March 2001, in the wake of the Nona decision, was the occasion of a regional statement of Islander demands. These included suspension of all fishing by non-indigenous commercial fishermen throughout the Strait within a week. The Commonwealth fisheries minister visited the Strait within days, warning against further interference with licensed fishing boats, but commencing political negotiations on important issues.

Islanders have particularly urgent concerns over the environmental impact of commercial prawning, believed to be a major factor in the decline of tropical rock lobster, a resource that is vital to their own small boat fishery. Over the years, large numbers of lobster on spawning migrations have been caught in prawning nets, and either sold illegally, or returned to the water injured. Islanders for some time have been proposing government buy-back of prawning and rock lobster licenses held by outsiders. On his visit to the Strait, the Minister publicly rejected license buy-backs, professing lack of government funds[4].

Behind closed doors, however, both State and Commonwealth governments have yielded important ground. They have afforded the chair of the Torres Strait Regional Authority (an

[1] The next step involves the subjection of the Torres Strait claim to a Registration Test under the Native Title Tribunal (NNTT) to confirm that all relevant information concerning the claim has been documented. Once this stage is complete, the claim will proceed to notification and mediation. If no agreement is reached during the mediation stage, the claim will then go to trial. The entire process is likely to take several years.

[2] Hookah gear refers to the underwater breathing equipment used by professional fishermen for harvesting lobster, sandfish, and trochus shell.

[3] The Ngalpun Malu Kaimelan Gasaman Cultural Maritime Summit, 22-25 March 2001.

[4] Each prawning license is worth approximately A$ 800,000.

Islander-elected regional self-governmental body) equal authority to themselves on the top-level fisheries decision-making committee – the Torres Strait Protected Zone Joint Authority (PZJA). In addition, an Islander TSFT representative has been granted observer status.

Discussions are also underway on the subject of prawn license buy-backs, and other Islander proposals for dealing with the current crisis in the tropical rock lobster fishery. Current stock assessments indicate that numbers of breeding stock and juveniles are among the lowest ever recorded, and that future recruitment may be too low to support the fishery (Torres Strait Rock Lobster Working Group 2001). Many Islander fishermen regard the total exclusion of prawn trawling vessels as their long-term objective. In the interim, however, they have agreed on a number of trial measures, firstly, a 50% reduction of prawn trawling licenses as a minimal condition for tolerating prawning vessels in their waters. Although the Commonwealth has expressed support for a proposal to buy back 39 of the 79 licenses in the region, there is much disagreement on how this buy-back arrangement should proceed. The Commonwealth has taken the position that the prawning industry itself should purchase any buy-backs, but license owners and the industry more generally are unhappy with this. For the moment the Commonwealth, industry and Islanders remain at loggerheads. One possible approach that has been taken elsewhere in Australia is for the Commonwealth to suspend the prawn fishery as a means of applying pressure on the industry to co-operate. In the interim, Islander fishermen say they are holding the option of escalated direct action in reserve.

Meanwhile, the TSFT has successfully lobbied the regional Islander leadership to rescind a promise of prawn licenses to three private Islander enterprises, and restore them to the common benefit of Islanders. Some Islanders argue that prawning on a reduced scale is environmentally sustainable, and acceptable if Islanders are afforded a stake in the industry. One proposal is to establish an Islander prawning operation with one of the three licenses, while renting the other two licenses to provide financing, training, and other support.

A second Islander demand has been for the seasonally rotating exclusion of all prawn-trawling effort from areas of lobster migration. Currently, trawlers sweep the whole of the prawning grounds from March to December. The Islander fishermen's proposal would have all boats working north of the 10 degree parallel only in the first part of the year, and working only to the south of the line in the second part. Each area will therefore be closed for a full seven months, closures timed to coincide with the clockwise migration of lobster through the Eastern and Central Strait. There has, as yet, been no official action on this demand, although the scientific merits of the proposal have received some consideration of by the Australian Fisheries Management Authority (AFMA).

Islanders have stated that these demands are non-negotiable and served notice of their readiness if necessary to close down the prawning grounds by laying barbed wire across the bottom, or by dumping old vehicles on the grounds to serve as rock lobster sanctuaries, which would incidentally pose an elevated risk of snagging and damage to prawning gear.

Islanders recognize that trawling is only one of several possible impacts on the lobster fishery, and are taking other measures as well. Of particular significance is Islander commitment to a total ban on the use of hookah gear. In the Eastern Islands, deeper waters inaccessible to free divers are regarded as sanctuaries. Eastern Islanders see a causal relationship between the use of hookah gear and the reduction of lobsters moving up onto shallower reef surfaces. Islanders feel that a ban on hookah gear would dissuade most non-Islander divers from participating in reef diving fisheries, so a reduction in total fishing effort would also result. It is extremely interesting that Western Islanders, who do use hookah gear, have joined Eastern Islanders in supporting a total hookah ban throughout Torres Strait.

Similar concerns about the impact of "technology creep" on lobster, coral trout, and other stocks relate to the use of GPS and depth sounders that allow the targeting of specific fishing locations. Restrictions on their use would tend to spread fishing effort, at the cost of increasing the fuel and time costs of looking for specific bottom features. Islanders recognize that the proposed restrictions would be a lesser hindrance to Islander than non-Islander commercial fishermen, who are heavier users of these technologies, and whose local knowledge of productive sites is inferior to that of Islanders.

New arrangements in the rock lobster fishery, effective as of 1 December 2001, go some distance in addressing Islander concerns for rock lobster stocks. These include an increase in the

minimum legal size for tropical rock lobster[5], an extension of the existing two-month ban on the use of hookah gear by a further two months[6], and a new two-month ban on all other forms of commercial fishing[7], though still permitting traditional fishing by Islander fishers within the region. While these measures represent only partial fulfilment of Eastern Islander aspirations, they reflect the outcome of a more democratic approach to fisheries management in the region. Of particular significance is the fact that for the first time in its history the PZJA meeting, which endorsed this three-pronged approach to stock management, was held as an open forum with invited stakeholders, including the TSFT, in attendance as observers (Anon. 2001).

Against this backdrop, conflicts continue. In the final weeks of 2001 Eastern Islanders evicted a commercial trout vessel, which anchored out of sight at an uninhabited cay in the northwest part of their marine estate, but then sent dinghies onto reefs close to Mer. The commercial fishermen left peacefully following threats from Islanders that their catch would be confiscated if they didn't clear out. There is growing concern that such confrontations could escalate into more violent action. Younger Islander fishermen have made it clear that they are willing to resort to such action if challenged and if progress on other fronts stalls.

CONCLUSION

From an Islander perspective, local knowledge of marine resources has been continuous and evolving, and responsibility for their sea territories (even if inhibited by successive colonial regimes) has never been surrendered. Principles of resource conservation and management have a deep cultural history, and the application of these principles, together with specific knowledge contents, has evolved with changing conditions across a variety of fisheries.

As scientists we are coming to accept a democracy of knowledge traditions, in the dialogue between indigenous and scientific resource managers. But Islander experience is showing us that this new democracy has little meaning unless set within an institutional framework that restores authority to indigenous owners and governors of their traditional marine estates. The current format of the management structure established under the Torres Strait Treaty[8] is heavily biased towards Western scientific approaches and affords Islanders minority status and a limited advisory role. Current management provides an ineffective platform for them to raise environmental concerns or communicate their knowledge of the resources (Mulrennan and Scott, in press). Addressing these asymmetries will not be easy. Recent recommendations include a proposal to have active Islander hunter/fishers rather than a representative from the regional Islander leadership on the Torres Strait Fisheries Scientific Advisory Committee (TSFSAC). The inclusion of social science research expertise has also been recommended as a measure to enhance the cultural and socio-environmental aspects of natural resource management (Sen 2000). While such changes would likely result in the increased engagement of Islander knowledge and expertise in the research process, the establishment of true partnerships in management decision-making will require more substantial transformations, not just in the openness of scientific managers to Islander expertise, but in political structures of authority.

A combination of knowledge exchange, political negotiation, legal action, and – when progress along these avenues is too slow – direct action at sea, is responsible for the promising recent achievements of Islanders. Substantial political interests from within the Australian mainstream remain aligned against them; but one fact has emerged clearly that should aid the course of future progress: those in central governments who are committed to better fisheries policy, and who support Islander initiatives, are doing so because they know that the current regime is unsustainable. They *are* listening to Islanders, and in the latest round of proposed reforms, for the first time, they appear to have opened themselves to the idea of Islander leadership.

ACKNOWLEDGEMENTS

My thanks are due to the Erub Council, in particular Mr. George Mye (past Chair) and Mr. Elia Doolah (current Chair), for their support, and to the many other people of Erub for their knowledge, advice and friendship. Special thanks to Bluey Bedford, Kenny Bedford, James Bon, and other members of the TSFT who have allowed me to document their knowledge, attend

[5] The minimum legal size for tropical rock lobster is increased from 80mm to 90mm carapace length, or in the case of lobster tails, the minimum legal tail length is increased from 100mm to 115mm.

[6] The ban on the use of hookah gear is extended from 1 October - 30 November for a further two months, to 31 January.

[7] The new two-month ban is from 1 October – 30 November; this closure will commence 1 October 2002.

[8] Specifically I am referring to the Torres Strait Fisheries Management Committee (TSFMC), the Torres Strait Fisheries Scientific Advisory Committee (TSFSAC), and the Environmental Management Committee (EMC).

their meetings, and record their concerns and positions.

I am grateful also to Jeremy Beckett, Henry Garnier, Tony Kingston, and Victor McGrath for the valuable insights they have contributed to this paper. A very special debt of gratitude goes to my husband and co-researcher, Colin Scott (Anthropology, McGill University), for his many contributions to this paper and to this research more broadly.

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References

Anon 2001. Torres Strait Cray Industry to be Protected. *Torres Strait News: The Voice of the Islands*. 12-18 October, No 467: 5.

Beckett, Jeremy 1987. *Torres Strait Islanders: Custom and Colonialism*. Cambridge: Cambridge University Press.

Ganter, Regina 1994. *The Pearl-Shellers of Torres Strait: Resource Use, Development and Decline 1860s – 1960s*. Carlton, Victoria: Melbourne University Press.

Haddon, A.C. 1908. Sociology, Magic and Religion of the Eastern islanders. Vol VI. *Reports of the Cambridge Anthropological Expedition to Torres Straits*. Cambridge at the University Press.

High Court of Australia 2001. The Commonwealth v Yarmirr; Yarmirr v Northern Territory; HCA 56 (11 October).

Mulrennan, Monica and Colin Scott In Press. Co-management – An Attainable Partnership? Two Cases from James Bay, Quebec and Torres Strait, Queensland. *Anthropologica*.

Torres Strait Rock Lobster Working Group 2001. Management Proposals for the 2001/02 Season. Meeting of the Torres Strait Rock Lobster Working Group. Agenda Item 5, Thursday Island, August 1-2.

Scott, Colin Under review. 'Our Feet are on the Land, but our Hands are in the Sea:' Knowing and Caring for Marine Territory at Erub, Torres Strait. In R. Davies (ed.) Special volume on Torres Strait to be published by Aboriginal Studies Press, Canberra.

Sen, Sevaly 2000. Improving the Effectiveness of Research in the Torres Strait: A Review of the Torres Strait Scientific Programme. Report commissioned by the Australian Fisheries Management Authority.

Questions

Christina Soto: Why do you think the Western Islanders would agree to the Hookah ban?

Monica Mulrennan: They are concerned. They know if they don't do anything, the fishery will go downhill.

Christina Soto: In a previous presentation, it was stated that in Australia some commercial fishers got licenses as well as the "traditional" fishers. Do you think that the same thing is happening in the Torres Strait? If the islanders have increased power to manage the area, they may go for the fisheries themselves.

Monica Mulrennan: There is a very strong understanding among islanders that the deeper water areas are sanctuaries and if you allow the rock lobster in the deeper areas they will spawn and come up to the shallower areas and keep on producing. They also prefer free diving. They have also witnessed the damage commercial fisheries can do.

Annelore Reisewitz: What is the ethnic mix in the Torres Island? Are they all islanders or are there also whites? Are any of the islanders involved in the commercial fishery?

Monica Mulrennan: The eastern strait is inhabited almost exclusively by islanders whereas in the western strait there is a substantial white population and a commercial fishery. Many commercial fishers have made their homes there. There is limited involvement of the islanders in the commercial fishery. The prawn fishery constitutes 78% of the Torres Strait fisheries, but the islanders are not involved in it. The commercial fishery is incompatible with their preferences. The council is encouraging islander participation in commercial fisheries. It would occur at a very low level. The islanders have a low drive to do that. If there is a tombstone to be opened or a wedding coming up, then they are out there bringing in rock lobsters. Once that is over, they may not fish for several days.

A Collaborative, Consultative and Committed Approach to Effective Management of Dugongs in Torres Strait, Queensland, Australia.

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Abstract
The world's largest known population of dugongs in Torres Strait, Australia, supports an important subsistence fishery by the traditional inhabitants, Torres Strait Islanders, in the region. I obtained updated information on the life history and reproductive ecology of dugongs based on collecting specimens and data from dugongs harvested for food by Islanders. Information on life history parameters will help management efforts to ensure the sustainability of the traditional fishery. Data and specimens for the study were obtained over two years (1998-1999) when I resided in Mabuiag Island, one of the major hunting communities.

The collecting regime was developed within a sampling protocol that was continually negotiated with active participation by community members, especially the hunters. The contribution of hunters in terms of both information and co-operation in specimen collection has been central to the successful collection of data and specimens essential for my research. Hunter knowledge of the spatial and temporal patterns of dugong distribution has provided important insights to annual variability in catch rates and has supplemented information on reproduction such as habitat use by breeding animals.

Being able to live and work within the Mabuiag Island community presented a rare opportunity to build upon the mutual trust, cooperation and commitment by both communities and scientist. The involvement of Islanders as active participants in research, and acknowledgement of the diversity and complexity of socio-cultural factors within the community, has enabled collection of very rare and valuable specimens. Moreover, an individual and community sense of ownership of the research indicates high potential to considerably improve community based management strategies for dugong in Torres Strait.

Introduction
The dugong (*Dugong dugong*) is a large marine mammal that reaches a length of 3 m and weighs up to 420 kg. It has high biodiversity value as the only extant species of the Dugongidae family and as the only herbivorous mammal that is strictly marine (see Marsh *et al.* 2001). The dugong is listed in The World Conservation Union Red Data Book of Threatened Species as 'Vulnerable to Extinction' (IUCN 2000) and also in Appendix 1 of the Convention on International Trade of Endangered Species (CITES), which regulates trade in listed species. In Australia, the dugong is included as a 'Listed Migratory Species' and 'Listed Marine Species' under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*. Throughout its Australian range, the dugong is also protected under relevant state/territory legislation. In Queensland, the dugong is listed as 'Vulnerable' under the *Nature Conservation Act 1992*.

As large non-aggressive herbivores, dugongs have been hunted for food, clothing and other products by many coastal societies throughout their range (e.g. Reynolds and Odell 1991; Marsh *et al.* 2001; Rogan *et al. in press*). Anecdotal reports suggest that dugongs were once a very important subsistence resource in many countries in the Indian sub-continent and islands, South East Asia, East Africa, Western Pacific and the South Pacific (Marsh and Lefebvre 1994; Marsh *et al.* 2001). Where dugongs were used for subsistence they were also of major economic and cultural significance (see Marsh *et al.* 2001; Rogan *et al.* in press). With the growth of human populations, subsistence hunting of dugongs has probably contributed to the extirpation or severe depletion of local populations in several parts of their former range (Marsh and Lefebvre 1994; Marsh *et al.* 2001).

Today Australia is one of the only countries that has large populations of dugongs and is considered the dugong's stronghold (see Marsh *et al.* 2001). It is believed that the global survival of the dugong will be largely dependent upon Australian efforts (Bertram 1980; Marsh *et al.* 1999; Marsh *et al.* 2001).

Dugongs are of great cultural, nutritional and socio-economic value to coastal Aboriginal and Torres Strait Islander peoples of tropical Australia (Smith and Marsh 1990; Johannes and MacFarlane 1991; Bradley 1997). Globally, the largest population of dugongs is in Torres Strait (Figure 1) (Marsh *et al.* 1997; 2001) where the long-standing subsistence importance of

dugongs for Torres Strait Islanders has been traced back at least 2000 years in archaeological deposits (Vanderwal 1973).

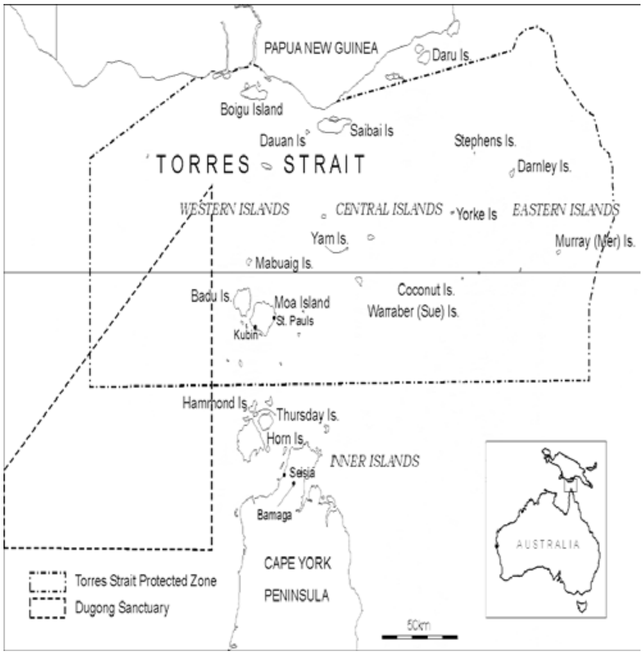

Figure 1. The Torres Strait region showing the boundary of the Torres Strait Protected Zone and the main communities in the Inner, Western, Central and Eastern Islands groups.

In spite of 200 years of profound external influences since contact with Europeans, access to large numbers of dugongs (and green turtles) has enabled Torres Strait Islanders to maintain much of their traditional way of life (Nietschmann and Nietschmann 1981; Nietschmann 1984, 1989). In addition to being an important source of fresh meat, dugongs also continue to sustain vital cultural practices, ceremonial feasting and rites of passage (Nietschmann 1984, 1989; Mulrennan and Scott 2001). This importance continues even though most basic necessities are now provided by a cash economy, based largely on government funding through employment opportunities or social security (see Kwan *et al.* 2001).

The Torres Strait Treaty, an international agreement between Australia and Papua New Guinea (PNG), protects the traditional way of life of Torres Strait Islanders including their right to hunt dugongs (see Kwan *et al.* 2001). The recent recognition of the potential for Native Title rights over the sea and the active pursuit for self-determination by Torres Strait Islanders as well as responsibility for biodiversity conservation means that Australia has considerable responsibility for dugong conservation (see Kwan 2001).

There is mounting national and international pressure to ensure that the subsistence consumption of a globally threatened species, especially the dugong, is sustainable in Torres Strait. Concerns about the sustainability of harvests and the need to reconcile management intervention with the socio-political and cultural needs of Torres Strait Islanders, should the harvest prove unsustainable, have become a priority for managers (Marsh 1996; Marsh *et al.* 1997). However, this debate has not been informed by information on the cultural, social, economic and environmental variables that determine hunting pressure and the dugong catch. Such information is crucial to the development of effective co-management strategies. A community-based management approach should be a major priority for government management agencies particularly as Torres Strait Islanders are demanding greater political and economic autonomy including their right to hunt and manage their marine resources, including dugongs (Kwan *et al.* 2001).

This paper describes how my research was conducted as a process of negotiation with Torres Strait Islander hunters (Figure 2). This process was central to the development of trust between the hunters and myself as a scientist. Such a collaborative and consultative approach provided a rare opportunity to obtain information based on both empirical data and the social context of dugong hunting that will

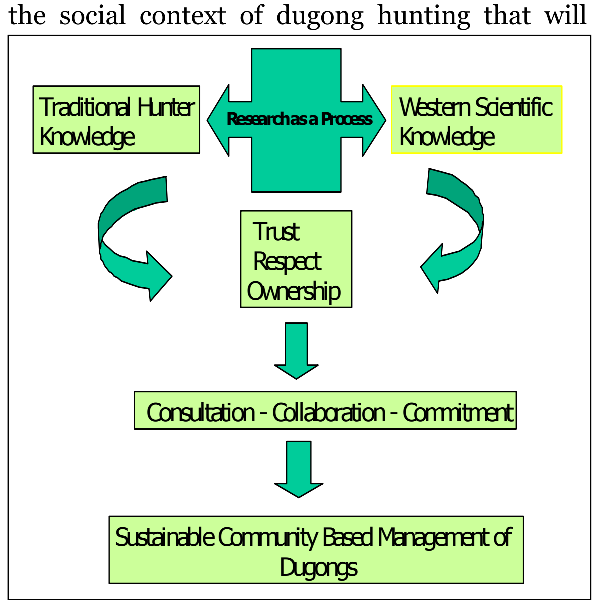

Figure 2. Conceptual diagram showing how the research process which obtained knowledge and established a relationship between hunters and the scientist, can contribute to effective management of a sustainable dugong fishery in Torres Strait.

assist in community based management efforts. The approach highlights the importance of hunter's and scientific knowledge in contributing to our knowledge base to ensure the sustainability of the dugong fishery in Torres Strait by providing insights into dugong movements. This commitment to a sustainable dugong fishery will require integration of scientific frameworks and Torres Strait Islander cultural, social, economic and political perspectives.

A collaborative approach to fieldwork: establishing relationships for the research process

My fieldwork in Torres Strait was mainly based on Mabuiag Island where I lived from September 1997 to November 1999. The success of my fieldwork was attributable in part to good relationships between the Mabuiag Island community and previous researchers, particularly Bernard and Judith Nietschman, who conducted their study on Mabuiag Island in 1976-77 (see Neitschmann and Nietschmann 1981; Nietschmann 1984; 1989). With the exception of Mabuaig Island, most Torres Strait Islanders have had little first-hand experience with researchers. Thus, the favourable experience of community members at Mabuiag Island working with other researchers was of significant advantage to my research.

My fieldwork was also successful because I adopted an approach which acknowledged the range and complexity of the social context of the consumptive use of dugongs by Torres Strait Islanders. Acknowledgement of the socio-cultural and nutritional significance of dugongs to Torres Strait Islanders was crucial in developing my sampling regime. I operated within a culturally sensitive protocol that guided my research activities and required an adaptive research process. My sampling protocol was a continuous process of negotiation in which community members, particularly the hunters, actively participated.

The capacity to recognise, acknowledge and reconcile my obligations to the communities (to respect their decisions) while maintaining the scientific integrity of my data and specimens was crucial to the successful completion of fieldwork. Acceptance of these protocols resulted in an exchange of short and long-term benefits to both the community and the scientist.

The hunters and the community benefited because I obtained critical scientific information required to assist in evaluating the sustainability of their dugong fishery. From my perspective as a scientist, the consultative approach provided an invaluable opportunity to collect important traditional knowledge from the hunters, as well as data and specimens from a species that is very difficult to work on. Moreover, the consultative approach fostered a relationship of mutual trust and respect that allowed:

- Effective explanation of the research aims to the community.
- Careful consideration of the impacts of the research activity on the hunters and the community.
- Opportunity to negotiate any changes to the sampling regime or the research aims (for example to explore the potential impact of high concentrations of heavy metals to the health of Torres Strait Islanders from the consumption of dugong meat and offal).
- Obtaining traditional information of relevance to the research plan and sampling regime.
- Adequate discussions about how the community could access and use the information, which allowed them greater commitment to the research aims.

The relationship established between the hunters, their community and I, was essential for us to work collaboratively. My living within the community, which engendered a sense of 'belonging', facilitated this collaboration and allowed many opportunities for me to exchange information with hunters, community leaders and other community members.

As dugongs caught by hunters in Mabuiag Island are butchered at specific landing sites belonging to individual families or clans, I attended most landings of dugongs to interview hunters. The collection of specimens from dugongs being butchered for food would not have been possible without the voluntary cooperation of local hunters. Most hunters willingly provided access to their dugongs to collect samples. In return, I made every effort to collect samples with minimum disruption to the traditional butchering or 'cutting' method.

Sometimes when it was not logistically possible or culturally inappropriate to interview a hunter at a butchering event (e.g. the dugong was being butchered for a funeral), information was provided later by the hunter, the crew or community members. I did not attempt to pursue sampling of an animal, if hunters indicated that they were unhappy with the sampling for any reason. Even on the rare

occasion when hunters appeared to be unwilling to provide specimens or undertake interviews, the information and some specimens would be offered to me later. My awareness and sensitivity to occasions when it was not appropriate to take dugong samples ensured that the hunters remained generally co-operative and willing to provide information on such occasions.

Members of the Mabuiag Island community willingly provided information and advice about how best to obtain samples and information for the project. In addition, Torres Strait Islander staff from the Australian Fisheries Management Authority (the Commonwealth agency responsible for fisheries, including traditional fisheries such as dugong and sea turtle) provided valuable advice, particularly about cultural protocols in individual communities. These protocols included knowing whom to ask permission to sample dugongs, particularly when dugongs were being cut for special occasions such as a funeral feasting or other significant event. Community members from Mabuiag Island I employed as research assistants also provided me with valuable advice on streamlining the sampling method.

The methods for obtaining local knowledge and working collaboratively with hunters required considerably more flexibility than conventional biological research, particularly in terms of sampling regimes, methodology and time frames. Documenting the research methodology has highlighted the potential benefits of recognising the importance of Islander collaboration in research of dugongs in Torres Strait.

Being able to live and work within the Mabuiag community presented me with a rare opportunity to build mutual trust, cooperation and commitment between the community and myself as a scientist. Strong support from the Chairman and staff in the Mabuiag Island Council was crucial to the successful completion of my fieldwork. The involvement of Torres Strait Islanders as active participants in the research, and my acknowledgement of the range and complexity of socio-cultural factors involved were central to the completion of this study.

An example of the benefits from the consultative and collaborative process: insights into reasons for the variability in the Torres Strait dugong catch

The benefits of the collaborative approach were demonstrated by the contribution of hunters' knowledge of the spatial and temporal patterns of dugong distribution in Torres Strait providing valuable insights into the variability of the annual catch.

Dugong hunting in Torres Strait has received considerable attention in the anthropological literature, (Haddon 1935; Nietschmann 1989; Raven 1990), and from geographers (Eley 1989; Schugg 1995) and marine scientists (Hudson 1986; Johannes and MacFarlane 1991). Islanders from Mabuiag have had a long history with researchers and have been involved in recording catch rates of dugongs since the 1970s (Table 1). The catch rate of the dugong subsistence fishery has been monitored by an Australian government management agency since 1991 (Harris *et al.* 1997; Marsh *et al.* 1997). There appears to be considerable variability in catch rates even acknowledging the inconsistency in catch monitoring methods used to obtain these estimates.

Bertram and Bertram (1973) reported an annual catch of only about 24 dugongs in Mabuiag Island while Nietschmann (1984) reported 103 dugongs caught in 1977, while the annual catch recorded in the 1990s ranged between 145 to 274 dugongs in the same community (Table 1). This variability is reflected in catch rates available for other Torres Strait communities. Nietschmann (1984) reported a total annual catch of 274 and 157 dugongs in the Western Island communities of Mabuiag, Badu and Kubin in 1977 and 1978 respectively (Table 1). Johannes and MacFarlane (1991) reported a total catch of only 26 from the same islands between 1983 and 1985. Raven (1990) reported similarly low catch rates (total of 16 animals during September 1986 to January 1987) in Boigu Island at a similar time. The magnitude of the annual catch rate monitored by AFMA since 1991 confirms this interannual variability (Table 1, overleaf).

There have been concerns that the current catch rate of dugong in the Torres Strait Protected Zone (TSPZ) is not sustainable (Marsh 1996, Marsh *et al.* 1997). However, the interannual variability in catch rates and uncertainties in assessing the status of the population (Marsh 1996, Marsh *et al.* 1997) have confounded such concerns. In addition to the apparent interannual variability in catch rates, the lack of up-to-date information on the population dynamics of dugongs, and methodological constraints which allow only relative rather than absolute estimates of abundance, make it difficult to draw definitive conclusions about the status of dugongs in Torres Strait.

While there have been previous concerns that catch rates of dugongs in the Torres Strait have at times been unsustainable, catch rates are highly variable because of a number of biological, environmental, social, cultural and economic factors (Kwan 2001). There is some evidence that large numbers of dugongs migrated into the region in late 1991, resulting in the high catches reported by AFMA in the preceding years (Marsh *et al.* 1997, Table 1).

Information from hunters suggests that dugongs regularly move over large distances from one area to another, presumably in search of food in Torres Strait (see Harris *et al.* 1997; Johannes and MacFarlane 1991; Kwan 2001). Hunters in Mabuiag consistently stated that dugongs stayed close to Mabuiag during the north west monsoon (November to April) and moved to Orman Reef (Figure 3) during the south easterly season (May to October) where they fed on 'new shoots' until they moved on when they had 'finished the food'.

The period May to September is reportedly the 'best' time for hunting because of the high local abundance of dugongs particularly at Orman Reefs. Hunters also reported that dugongs move to the northeast side of Orman Reef between Gariar and Beka Reefs to mate during September to October. Hunters said that dugongs 'move away' from the area after October (Figure 3). This is generally consistent with Harris *et al.* (1997) who reported that hunters from the Western Islands believe that the wind pushes dugongs in a north-south movement between Cape York and the south coast of PNG (see Figure 1). During the south-east season, dugongs apparently move north, but their movements are reversed in the north-west monsoon season when dugongs move south (Harris *et al.* 1997). This corresponds to the onset of the wet season in Torres Strait. Dugong herds in the Gulf of Carpentaria were also reported by Preen (in Aragones 1997) to disperse before and during the wet season.

Information from hunters about the movement of dugongs is consistent with increasing evidence from standardised aerial surveys in both Queensland (Lawler 2001; see Marsh *et al.* 2001) and Western Australia (see Marsh *et al.* 2001) that large numbers of dugongs commonly move considerable distances. In addition, satellite telemetry studies in Queensland (Marsh and Rathbun 1990; Preen 2001; Lawler 2001; see Marsh *et al.* 2001) and Western Australia (see Marsh *et al.* 2001) show that individual dugong journey large distances, making trips of up to 600 km within days (Preen 2001). Many of the movements of dugongs have been return trips (see Marsh *et al.* 2001). These movements may

Table 1. The annual catch of dugongs in Torres Strait Island communities obtained by various methods

Area	Method	Date	Estimated annual dugong catch	References
Mabuiag Is	?	1973	24	Bertram & Bertram 1973
	Continuous	1977	103	Nietschmann 1984
	Limited continuous (5 months)	1983-84	12	Johannes & MacFarlane 1991
	Survey	1994	274 (s.e. 175) 145	Harris *et al*. 1997
	Continuous	1998	160	This Study
	Continuous	1999	183 (s.e. 77)	This Study
	Survey	1999		AFMA, unpublished data
Badu Is	Survey	1994	107(s.e. 80)	Harris *et al.* 1997
	Survey	1999	200 (s.e. 66)	AFMA, unpublished data
Boigu Is	Survey	1994	256(s.e. 110)	Harris *et al.* 1997
	Survey	1999	128 (s.e. 59)	AFMA, unpublished data
TSPZ[1]	Continuous	1976-77	750	Nietschmann 1984
	Limited continuous	mid 1980s	110	Johannes & MacFarlane 1991
	Continuous	1991-92	954	Harris *et al*. 1994
	Survey	1991-92	1095 (s.e. 193)	Harris *et al*. 1994
	Survey	1991-93	1226 (s.e. 204)	Harris *et al*. 1994
	Survey	1994	860 (s.e. 241) 623 (s.e.	Harris *et al.* 1997
	Survey	1994-95	197)	Harris *et al.* 1997
	Survey	1999	692 (s.e. 150)	AFMA, upublished data
Bamaga	Survey	1997	116	M. Bishop pers.comm, 1997
Daru PNG,	Continuous	1976-77	74-120	Hudson 1986
	Continuous	1978-83	463	Hudson 1986

Notes: 1 - TSPZ (Torres Strait Protected Zone), see Figure 1

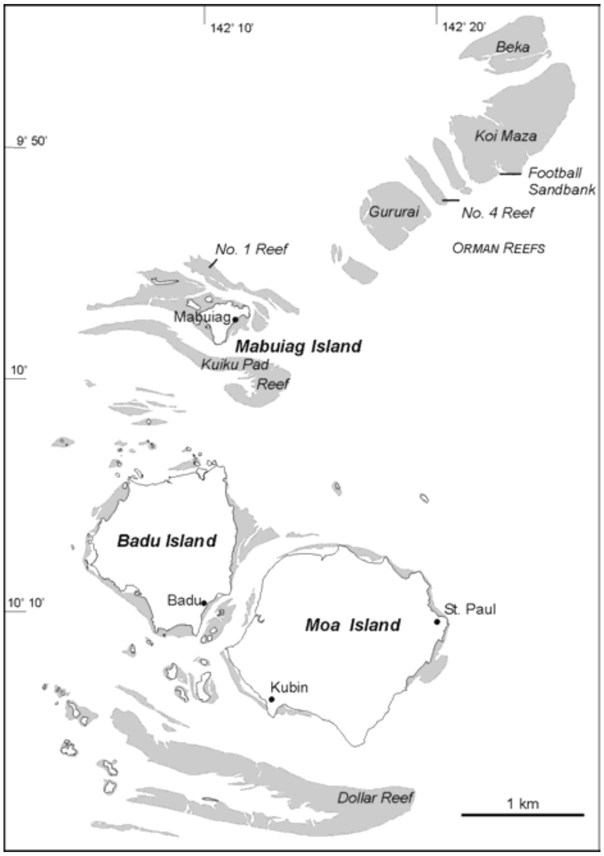

Figure 3. The main hunting areas used by hunters from Mabuiag Island.

be in response to changes in seagrass abundance.

The biomass of *Halophila* and *Halodule* spp., the preferred seagrass food of dugongs, is spatially and temporally highly variable (Walker *et al.* 1999). In light of the reports of the variability in the spatial and temporal distribution and abundance of dugongs noted by the hunters in Torres Strait, it is plausible that dugongs may undertake large-scale responses to cues that indicate suitable food sources in other areas or when locally available food resources are depleted.

Seasonal movement of dugongs reported by hunters in the Orman Reef (Figure 3) area may result from reduced biomass of high quality food due to sustained high grazing pressure over extended periods. The low abundance of dugongs in the area noted after October might reflect a migration out of the usual hunting area in the Western Islands to suitable feeding habitat outside the usual range of hunting activity. The recovery and regeneration of *Halophila* and *Halodule* (Preen and Marsh 1995; Preen *et al.* 1995) in the Orman Reef area may occur rapidly enough to sustain large numbers of dugongs in the subsequent year. Experimental evidence suggests that the recovery of *H. ovalis* and *H. uninervis* can occur within a couple of months to up to a year (Aragones and Marsh 2000).

The above discussion suggests that the interannual variability long noted by hunters in the Torres Strait dugong catch estimates (Table 1) reflect historical patterns of dugong distribution and abundance rather than overharvest. It is interesting to note that Haddon (1935) reported in 1888 that dugongs in Torres Strait had 'dwindled even to vanishing point in the islands'. Community perceptions of poor hunting success in Boigu Island in the late 1980s (Raven 1990; Johannes and MacFarlane 1991) were attributed partly to disregard for prior cultural practices aimed at ensuring success. This period is coincident with a period of overharvesting which resulted in the collapse of the artisanal dugong fishery in Daru (Hudson 1986) in the mid-1980s. Perceptions of Boigu Islanders were that although populations of dugongs are known to vary (noting the impacts of extreme events such as floods), dugongs always return (Raven 1990). The high catch rates reported in Table 1 indicate that dugongs were again abundant near Boigu in the 1990s. Reports of animals vanishing for long periods of time but known to return, is a view shared by the Inuit for many marine mammals upon which they depend for subsistence (see Johannes 2000).

Dugongs may move in response to extreme weather events that affect the availability of seagrass. Seagrass dynamics are prone to extreme fluctuations, resulting in losses over a variety of temporal and spatial scales, as a result of both anthropogenic effects and natural events (Johannes and MacFarlane 1991; Poiner and Peterken 1995). Anthrogogenic impacts include those of enriched nutrient inputs, smothering from increased sediment loads, resuspension and pulsed turbidity (see Marsh *et al.* 2001). Stochastic natural events such as floods and cyclones are also known to cause substantial losses of seagrass habitats (Poiner and Peterken 1995; Preen *et al.* 1995; see Marsh *et al.* 2001).

Some key seagrass habitats important to dugongs have been impacted. Seagrass areas in Torres Strait undergo 'diebacks', large-scale episodic loss and changes in distribution on temporal scales of up to decades (Williams 1994). Torres Strait Islanders widely reported such a massive dieback event in the mid-1970s and in the early 1980s (Johannes and MacFarlane 1991; Williams 1994). The cause of this dieback has not been confirmed although Islanders blamed the "Oceanic Grandeur" oil

spill and the use of dispersants. However this has been disputed by some scientists (see Johannes and MacFarlane 1991).

Coincident with the anecdotal reports from Islanders of an extensive seagrass dieback in the 1970s (see Johannes and MacFarlane 1991), Nietschmann (1984) noted that seagrasses were overgrazed in the Mabuiag Island area in 1976-77. Nietschmann and Nietschmann (1981) further noted that Islanders observed that *wati dangal* (lean dugongs with poor-tasting meat) were quite common in Torres Strait during this period. *Wati dangal* were reported to consume higher proportions of algae compared to *malu dangal* (fat dugongs with good tasting meat) who mostly ate seagrasses (Nietschmann and Nietschmann 1981).

Seagrass dieback also occurred in 1989-93 when some 1,400 km^2 of seagrass was lost in north-western Torres Strait. Scientists attributed this dieback to an unusually large but short-lived runoff event from the Mai Kussa river on the PNG coastline north of Boigu Island (Figure 1). The dieback may have been caused by a complex interaction of hydrological and sedimentary factors associated with the runoff event (Poiner and Peterken 1995). Recent modelling of dispersal pathways of sediments from the Fly River shows an increase in sediment load directed towards and through Torres Strait on a seasonal basis. Periods of increased rainfall in the PNG highlands cause increased sediment loads in the Fly River during the south easterly season in Torres Strait (May to October) (Hemer *et al.* 2001). This suggests considerable potential for the runoff from coastal rivers on the south coast of PNG to impact seagrass habitats in Torres Strait (see Figure 1).

The combination of information from hunters and scientific research has allowed considerable progress in our understanding of the factors that affect the spatial and temporal distribution of dugongs in Torres Strait. Knowledge of these factors provided important information to ensure the sustainability of the traditional dugong fishery in Torres Strait.

The commitment: a sustainable dugong fishery in Torres Strait

Recent declines in dugong populations reported in urban coastal areas of eastern Australia (Marsh *et al.* 1999; Marsh 2000) have highlighted the threatened status of this species, even in Australia. The ensuing controversy has caused governments, conservationists, the general public (Marsh *et al.* 1996; 1999) and Indigenous Australian peoples themselves to focus on the sustainability of dugong hunting by Aboriginal and Torres Strait Islander people. The socio-economic and cultural significance of dugongs to Torres Strait Islanders and the global ecological significance of this population, make it imperative that the dugong fishery in this region is sustainable. Furthermore, Torres Strait Islanders are demanding greater political and economic autonomy (Kwan *et al.* 2001). Thus, the development of effective co-management strategies should be a major priority for government management agencies.

Indigenous people, including those in Australia, are actively working with scientists to promote understanding and synergies between their respective knowledge systems. Indigenous and non-Indigenous Australians are becoming engaged in 'two way learning' about how to manage their country in contemporary contexts (Davies *et al.*1999; Baker *et al.* 2001). Research for this study was conducted as a process of active participation and negotiation with community members, especially the hunters. This approach allowed a rare opportunity to establish a relationship of based on mutual trust, cooperation and commitment between the communities and myself as a scientist (Figure 2). Such relationships have considerable potential to enhance the development of effective community-based management of dugongs in Torres Strait as they increase the likelihood of the Islanders trusting the scientist's empirical data.

References

Aragones, L. V. 1997. *Dugongs and Green Turtles: Grazers in the Tropical Seagrass Ecosystem.* Unpublished PhD thesis, James Cook University, Townsville.

Aragones, L.V., and Marsh, H. 1999. Impact of dugong grazing and turtle cropping on tropical seagrass communities. *Paci.* 5: 277-88.

Baker, R., Davies, J. and Young, E. (eds.). 2001. *Working on Country: Contemporary Indigenous Management of Australia's Land and Coastal Regions.* Oxford University Press, Oxford.

Bertram, G.C.L. 1980. Dugong Numbers in Retrospect and Prospect. In: *The Dugong: Proceedings of a seminar/workshop held at James Cook University 8-13 May, 1979.* Pp. 261-272. James Cook University.

Bertram, C. and Bertram, J. 1973.The modern Sirenia: their distribution and status. *Journal of the Linnaean Society of London* 5: 297-338.

Bradley, J.J. 1997. Li-Anthawirriyarra, people of the sea: Yanuwa relations with their marine environment. Unpublished PhD thesis, Northern Territory University.

Davies, J., Higgenbottom, K. , Noack, D., Ross, H. and Young, E. 1999. *Sustaining Eden: Community Indigenous Community Based Wildlife Management Australia.* International Institute for Environment and Development, London.

Eley, T., 1987. *Hunters of the Reef: The Marine Geography of the Kiwai, Papua New Guinea.* Unpublished PhD thesis, University of California, Berkeley.

Haddon, A. 1935. *Reports of the Cambridge Anthropological Expedition to Torres Straits*. Volume I. General Ethnography. University Press, Cambridge.

Harris, A.N.M., Dews, G., Poiner, I.R., and Kerr, J. (1994). The traditional and island based catch of the Torres Strait Protected Zone. Unpublished final report to the Scientific Advisory Committee of the Torres Strait Protected Zone.

Harris, A.N.M., Dews, G., Bishop, M. and Pitcher, R. (1997). Transfer of traditional fisheries monitoring to AFMA with training. Unpublished final report to the Scientific Advisory Committee of the Torres Strait Protected Zone.

Hemer, M.A., Harris, P.T., Coleman, R. and Hunter, J. (in review). Sediment mobility due to currents and waves in the Torres Strait, Gulf of Papua region. *Intercontinental Research.*

Hudson, B. E. T. 1986. The Hunting of Dugong in Daru, Papua New Guinea, during 1978–82: Community Management and Education Initiatives.In A. K. Haines, G. C. Williams & D. Coates (eds.), *Torres Strait Fisheries Seminar, Port Moresby, 11–14 February 1985*, AGPS, Canberra, pp. 77–94.

IUCN. 2000. *IUCN Red List of Threatened Animals,* International Union for the Conservation of Nature and Natural Resources, Gland, Switzerland.

Johannes, R. E. & MacFarlane, W. 1991. *Traditional Fishing in Torres Strait Islands*. CSIRO Division of Fisheries, Hobart.

Johannes, R.E., Freeman, M.M.R. and Hamilton, R.J. 2000. Ignore fishers' knowledge and miss the boat. *Fish and Fisheries 1:257-271*.

Kwan, D., Dews, G., Bishop, M. and Garnier, H. 2001. Towards community based management of natural marine resources in Torres Strait. In, Baker, R., Davies, J. and Young, E. (eds.), *Working On Country: Indigenous Environmental Management In Australia*. Oxford University Press.

Kwan, D. 2001. *A Biological Context for the Sustainable Use of Dugongs by Torres Strait Islander Communities*. Unpublished PhD thesis, James Cook University, Townsville.

Lawler, I. 2001. *Regional-scale movements of dugongs on the Queensland coast: evidence from aerial surveys and satellite tracking*. Proceedings of the Southern Hemisphere Marine Mammal Conference, Phillip Island, Victoria, Australia.

Marsh, H. 1996. Progress towards the sustainable use of dugongs by Indigenous peoples in Queensland. Pp. 139-51 in *Sustainable use of wildlife by Aboriginal peoples and Torres Strait Islanders*. Bomford, M. and Caughley, J. (eds). AGPS, Canberra.

Marsh, H. 2000. Evaluating management initiatives aimed at reducing the mortality of
dugongs in gill and mesh nets in the Great Barrier Reef World Heritage Area. *Marine Mammal Science*. 16(3): 684-94.

Marsh, H. and Rathbun, G.B. 1990. Development and application of conventional and satellite radio-tracking techniques for studying dugong movements and habitat usage. *Australian Wildlife Research* 17(1): 83-100.

Marsh, H and Lefebvre, L.W. 1994. Sirenian status and conservation efforts. *Aquatic Mammals* 20, 155-70.

Marsh, H., Harris, A. N. W. & Lawler, I. R. 1997. The Sustainability of the Torres Strait Dugong Fishery in Torres Strait. *Conservation Biology* 11, 1375–86

Marsh, H., Eros, C., Corkeron, P. and Breen, B. 1999. A conservation strategy for dugongs: implications of Australian research. *Marine and Freshwater Research*. 50: 979-90.

Marsh, H., Eros, C., Penrose H. and Hughes J. 2001. *The Dugong, Dugong dugon: Status Reports and Action Plans for Countries and Territories in its Range*. IUCN, UNEP-WCMC and Reef CRC.

McKenzie, L.J., Roder, C.A., Roelofs, A.J. and Lee Long, W.J. 2000. Post-flood monitoring of seagrasses in Hervey Bay and the Great Sandy Strait, 1999: Implications for dugong, turtle and fisheries management. *Department of Primary Industries Information Series Q100059*. Department of Primary Industries, Cairns, Australia.

Mulrennan, M. and Scott, C. 2001. Indigenous Rights and Control of the Sea in Torres Strait. *Indigenous Law Bulletin* 5(5): 11-15.

Nietschmann, B. 1984. Hunting and ecology of dugongs and green turtles in Torres Strait. *National Geographic Society Research Reports* 17, 625-51.

Nietschmann, B.1989. Traditional Sea Territories, Resources, and Rights in Torres Strait. In J. Cordell (ed.), *A Sea of Small Boats*. pp. 60-94. Cultural Survival, Cambridge, Massachusetts.

Nietschmann, B. and Nietschmann, J. 1981. Good dugong, bad dugong; good turtle, bad turtle. *Natural History* 90, 54-62.

Poiner, I.R. and Peterken, C. (1995). Seagrasses. Pp. 107-117 in *Environment Report for Australia, Technical Annex: 1*. Zann, L.P. and Kailola, P. (eds). Great Barrier Reef Marine Parks Authority.

Preen, A.R. 2001. Dugongs, boats, dolphins and turtles in the Townsville-Cardwell region and recommendations for a boat-traffic management plan for the Hinchinbrook Dugong Protection Area. Great Barrier Reef Marine Park Authority Research Publicaton No. 67, Townsville, Australia.

Preen, A.R, Lee Long, W.J. and Coles, R.G. 1995. Flood and cyclone related loss, and partial recovery, of more than 1000km^2 of seagrass in Hervey Bay, Queensland, Australia. *Aquatic Botany* 52: 3-17.

Preen, A.R. and Marsh, H. 1995. Response of dugongs to large scale loss of seagrass from Hervey Bay, Queensland, Australia. *Wildlife Research* 22, 507-19.

Raven, M. 1990. The Point of No Diminishing Returns: Hunting and Resource Decline on Boigu Island, Torres Strait. Unpublished PhD thesis, University of California, Davis.

Reynolds, J.E. and Odell, D.K. 1991. *Manatees and Dugongs*. Facts on File Inc.: New York, 192 pp.

Rogan, E., Kwan, D and Donovan, G. *In press*. 'Subsistence Hunting of Marine Mammals'. In *The Encyclopaedia of Life Support Systems (EOLSS)*, UNESCO.

Schugg, D. M. 1995. The Marine Realm and a Sense of Place among the Papua New Guinean Communities of the Torres Strait. Unpublished PhD thesis, University of Hawaii.

Smith, A., and Marsh, H. 1990. Management of Traditional Hunting of Dugongs [*Dugong dugon* (Muller, 1776)] in the Northern Great Barrier Reef, Australia. *Environmental Management* 14(1), 47–55.

Vanderwal, R. 1973. The Torres Strait: Protohistory and Beyond. In, K. Lauer (ed.), *Occasional Papers, University of Queensland Anthropology Museum,* vol. 2, University of Queensland, St Lucia, Pp. 150–94.

Walker, D. , Dennison, W. and Edgar, G. 1999. Status of Australian seagrass research and knowledge. In, *Seagrasses in Australia*. Butler, A. and Jernakoff, P. (eds.). Pp. 1-18. CSIRO Australia, Collingwood.

Williams, G. 1994. *Fisheries and Marine Research in Torres Strait*. AGPS, Canberra.

QUESTIONS

Melita Samoilys: Have you any idea of what may be driving the periodic loss of seagrass? Have the islanders had any suggestions?

Donna Kwan: It is probably run-off from the Fly River and other coastal rivers of Papua New Guinea. There has been a recent modeling study that has shown that there has been a 10% increase in sediment output from rivers.

Melita Samoilys: Is that likely to have been the cause of the very low populations in the 1980s?

Donna Kwan: Probably. I have a graph of the age structure of animals and there are some gaps in the age structure. The very young haven't come into the fishery yet, but there are age groups that are completely missing. There are no animals between the ages of 16 to 25 years old and this corresponds to the spawning period in the 1970s when the seagrass was low.

Nicholette Prince: Are there specific feasts that require the people to serve dugong?

Donna Kwan: If there is a feast, you have to eat dugong. However, in some areas there is such high abundance of the animals that people would eat it every day when they can go out and get it.

Ron Hamilton: The picture of the dugong carcass on the beach showed some lines along which it was probably going to be cut. I was wondering if those strips would be distributed to all the families and members of the community. We have a similar tradition with whales – when we bring in a whale, we divide it according to shares that belong to different families.

Donna Kwan: Every community has a different way of cutting dugong. The Mabuiag have longitudinal strips that are quite thick compared to others. The Badu have thinner strips, and say that the people from Mabuiag are greedy because they have such thick strips so they don't share much. There is a very strong sense of sharing of the catch.

FISHING FOR ANSWERS
THE INCORPORATION OF INDIGENOUS KNOWLEDGE IN NORTHERN AUSTRALIA: DEVELOPING CROSS CULTURAL LITERACY

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ABSTRACT
In northern Australia, traditional indigenous hunting of turtle and dugong species continues to be a vital part of cultural practice, yet daily attracts media controversy. Both turtle and dugong species have experienced documented declines in the last two decades. A community hunting planning and management initiative in Hopevale community, (now in the process of implementation) was established in 1999 to address some of these concerns and improve the sustainability of hunting practice. This initiative includes the imposition of a locally-decided quota for turtle and dugong take, and a restricted hunting season. This paper argues that the successful implementation of such initiatives necessitates the incorporation of entire cultural perspectives in a two way management process, and the development of multicultural literacy and tool boxes to facilitate effective co- and collaborative natural resource management regimes. Reconciliation of these dynamics is discussed in terms of the ways that local cultural institutions inhibit and/or enhance opportunities for sustainable management and harvest. The stronger the community input and implementation of local knowledge in such contexts, the more effective species management will be.

INTRODUCTION

> *"While working with indigenous hunters in the Aboriginal community of Hopevale in Queensland Australia, debate occurred over the inclusion of a 'protection of cruelty' section in the hunting management plan we were working on. Hopevale hunters argued that this section must include a clause stating that turtles once caught must be butchered while alive and on the beach. Despite having worked with indigenous people for a while, and thinking myself 'culturally in tune' I was upset by this idea. However it was pointed out to me that within indigenous culture, to kill a turtle and then butcher it was to deprive it of an essential right – that to life. It is only through live butchering that the turtle's spirit, through its blood can be returned to the ancestors and the sea."*

This quote reflects an essential difference in perspective between 'western' and indigenous groups when coming together in collaborative management programs, and exemplifies the need for both parties to acknowledge such difference in order to achieve real conservation and cultural protection gains. Reconciling and managing the impact of human use of a species achieves the dual goals of species conservation and indigenous and cultural rights to that species and is an essential management dilemma worldwide.

This paper explores some of the facets of this issue in an evaluation of an Australian indigenous planning exercise designed to manage both human impact on the two threatened species of the Green turtle and the dugong in Australia, while maintaining cultural hunting practices. I argue that the incorporation of indigenous knowledge within management entails the inclusion not only of the culturally charismatic aspects of culture but those that are culturally uncomfortable. The paper is divided into three sections: (i) a brief Australian context (ii) a discussion of the case study and, (iii) an analysis of lessons learned and their implications for future management.

"A Thumbnail Sketch…."
The last decade has been a dynamic one for Australia. Australians have been both challenged and confronted by the politics of self determination and emancipation, on the heels of the legacy left by colonial racial oppression that is deeply embedded in the psyche of indigenous Australia.

The declaration of 'Terra nullius' or 'land of no people' by Captain Cook, in 1788, gave a mandate for 'white' Australians, to ignore indigenous rights. Disease, economic oppression, assimilation, massacres; the establishment of missions and accompanying suppression of cultural practice, the removal of children from their families are all hallmarks of the Australian aboriginal experience (Pearson, N: 2000, Folds, R:1993). The High Court "Mabo" decision of 1992 overturned the concept of Terra Nullius and heralded a new era of 'reconciliation' and recognition for indigenous Australians. The response has included the enactment of new and amendments to existing legislation such as the

Native Title Act (Cwlth 1993), and the establishment of Inquiries and commissions such as the 'Deaths in Custody Inquiry' and the 'Reconciliation Commission' (Nettheim, G. 2001). The "Sorry" movement, which has induced Australians everywhere to apologise to indigenous peoples for the removal of their children or the 'stolen generation', and recent films such as *Radiance*, *Rabbit-proof Fence* and *One Night the Moon* illustrate the extent to which public awareness and appreciation of indigenous issues has changed.

In the field of resource management these changes have been expressed in growing Aboriginal involvement in and control over land and sea country, national parks, and ranger training programs (*Draft Resolutions* 2001). Indigenous protected areas and indigenous land use agreements are being piloted and implemented across the country (Langton *et al*. 2000). The successful determination and return of lands to Aboriginal owners under State and Federal land and Native Title legislation mean that co-management has become more than a catch phrase. It is now a serious management option.

In the Great Barrier Reef World Heritage region in North Queensland, co-management options are crucial management alternatives. Six of the seven species of turtle in the world are found along the reef (Zann and Sutton 1995; Limpus 1995). The region also boasts one of the world's most important dugong populations. (Marsh 1999). Moreover as the largest marine protected area in the world, (345,000 square kilometers), the Great Barrier Reef Marine Park Authority - GBRMPA, (the Commonwealth government statutory management agency for the reef), has the responsibility of managing the area responsibly and in perpetuity. It is also responsible for juggling the different demands of its multiple users (GBRMPA 1994). For the seventeen indigenous communities residing adjacent to the reef, and which use the Great Barrier Reef World Heritage Area, dugongs and turtle are the most highly valued traditional foods (Thompson 1934; Smyth 1997; Benzaken *et al*. 1997). Moreover, hunting is a very real expression of cultural practice.

However, in this World Heritage area, which is cloaked with environmental glamour, indigenous hunting is often perceived as disturbing the vision of 'a wild aquamarine paradise' touted by the tourist brochures. To green and animal rights activists, hunting endangered animals is not part of the environmental equation.

In this context, the development of co-operative management arrangements for turtle and dugong hunting is recognised as a significant first step towards indigenous people managing their own land and sea country, as well as contributing towards effective strategies for species management (Benzaken *et al*; 1997). Accordingly, the GBRMPA has instituted a number of co-management initiatives along the coast relating to indigenous peoples hunting practice within the GBRWHA (GBRMPA 2001). One of these, the indigenous hunting management and planning exercise at Hopevale community, is used as a case study in this paper.

CASE STUDY

Guugu Yimmithirr Bama ii: Turtle and Dugong Hunting Management Plan, Hopevale Aboriginal Community, North Queensland.

Hopevale is a community allocated north west of Cooktown. It has a local population of approximately 1,200 (HVAC 2002). Within the community there are thirty seven clan groups and the language is *Guugu Yimmithirr* (Smith 1987). Originally established as a Lutheran Mission, it is now a dynamic community, run by a local council of seven members, and funded through a variety of programs and initiatives. As for most indigenous people living along the tropical Australian coast, hunting turtle and dugong is an important part of their cultural, social, and economic life (Haviland and Haviland 1980; Smith 1997; Chase and Sutton 1987). The allocation in 1998 by GBRMPA of a grant to develop a hunting management plan was the culmination of a three-year community driven consultation coordinated through the Hopevale Land and Resource Management office (P Gibson, pers comm 2001). Priscilla Gibson was the Indigenous Ranger coordinator from Hopevale who initiated and managed the development of the Hunting Plan process and publication. This consultation identified the hunters' main areas of concern and formed the basis of the final planning document.

This case study review discusses three important dimensions of the planning exercise.

Dimensions of the planning exercise

1. Community Involvement

Community involvement in the plan was secured through several mechanisms aimed at:

a) Incorporating local knowledge about hunting practice and species; and
b) Maximising community ownership.

Children were brought into the process through an art competition that required them to draw images of hunting, which were then included as a backdrop to the final documents produced. Prizes for the winner of each grade were given at a special assembly. Children were also involved in the launching of the plan, singing hunting songs and a community barbecue afterwards. A display of all artwork and images as part of a community anniversary celebration built up community awareness about hunting.

Elders were continually consulted. They gave crucial input to the plan itself, blessed meetings, gave talks to government agencies and helped facilitate and launch community meetings.

Finally, a series of meetings was convened with various interest groups including hunters, women, and land title and management agencies – and the Hopevale Council, all of whom had a say and input into the various stages of the plan. The entire process aimed to *involve* rather than *consult* the community members. As such, it helped facilitate not only their interest and ownership, but charged the process with an integrity that reflected back to the managing agencies the seriousness of community commitment to this enterprise.

2. Protocols

The cultural sensitivities of the hunting process and associated Native Title issues were considered to ensure that several protocol documents and processes were developed. This included a document briefing their consultant on a plan of action, and written endorsements from key community individuals and agencies of the plan and its contents at all stages of its development. Following a series of meetings, a Turtle and Dugong Hunting Management Council was established. Constituent members included representatives from across the community. This Council is the body that now implements the plan, decides on issues of conflict regarding breaches of it, and acts as the point of contact between management agencies and the community on hunting issues.

3. 'Reverse' consultation

Finally, a reverse consultation process was used. In contrast to the convention where management agencies employ a consultant to write a plan and *then* consult the community, Hopevale employed a consultant to do this, and *then* consulted the agencies. A meeting was held where invitees from various departments and interest groups, (including conservation groups) came together and gave their input into the plan. This included discussion of aspects of the plan that made agencies and scientists uncomfortable, but that they needed to engage with if they were serious in committing to a co-management or community based wildlife management program.

In engaging both indigenous and agency representatives, this process revealed interesting differences between perspectives. For example, management agency staff supported the process of consultation, but at times expressed discomfort with the extent to which the process was being run independently of their own operations. The ways in which indigenous people conduct and have meetings, and achieve outcomes is very different from conventional bureaucratic approaches. In some cases the differences between clan groups and Native Title Land Councils caused friction, as even amongst the indigenous peoples involved there was a spectrum of opinion and difference that needed careful navigation.

Content

In determining the contents of the plan, several 'bottom line' principles were mutually agreed upon early on in the process. Crucially this included a decision to work within existing legislation; an interesting choice given a recent Australian High Court determination – the 'Yanner' decision had provided precedent for indigenous peoples to choose to manage their hunting through the exercise of native title rights. Secondly, the community decided to continue with the quota and allocation approach previously established. It was also decided to have both maintenance of hunting practice *and* protection of the species as a joint and primary aim, embodied ultimately in the plan's vision statement. Finally, the community was very clear that the plan should in no way impinge on, or negatively affect, future Native Title rights or opportunities.

Overall, the final contents of the plan (see Box 1) attempted to maintain a balance between upholding cultural practice and adherence to the legislative requirements.

Much heated discussion over content occurred between all parties, resulting in a process of reconciliation of differences over key areas. Issues included questions such as whether there should be a quota or not? Can hunting occur anyway? Does the government have the right to decide on issues that will impact cultural rights? Should there be a Prevention of Cruelty clause?

To what extent should tradition take heed of 'science' regarding the target species? Some of the traditional hunting areas overlapped with 'no take' zones in the park, leading to much discussion over who should give way on this issue.

Given the intricate web of relationships between various members of the community and the managing agencies, the exertion of control over, and punishment of illegal hunting was one of the greatest points of disagreement. Such discussion frequently illustrated the difference between cultural perspectives on management. The issues of enforcement and penalties were especially difficult to solve (see Purnomo this vol). These still remain the most difficult points of reconciliation between indigenous peoples and agencies involved in the issue of hunting, exacerbated by the dialectic between animal rights and cultural rights that underlie any discussion or action in this arena.

Debate over the content also reflected the extent to which agency staff were more comfortable with the culturally 'charismatic' aspects of hunting rather than those that are less 'palatable'. For example, agency staff and scientists could not understand why the plan did not include 'stories', and 'ethno-biological' knowledge about turtle and dugong, as this is what represented (to them*) appropriate* inclusion of the cultural aspects. These discussions also revealed that the agency perspective did not always recognise that in determining to stay *within* the existing legislative frameworks, the community was from the very beginning accepting a situation that they found culturally 'unpalatable'. In their view, the decision to stay within the legislative and therefore cultural mores of a society widely viewed as having suppressed indigenous people for centuries, was a 'big call'.

It has been at the stage of implementation that the differences in perspective between agency and indigenous approaches have produced most strain. It is at this point that the 'warm and fuzzy' stage of the planning process abruptly terminates and the real negotiation of issues occurs. This is a process complicated further by community politics, the political and economic imperatives of government and the reality that each party approaches implementation completely differently.

For example, the political situation has reflected that the rhetoric of support for indigenous hunting rights is not matched by reality. Events such as the Australian position on Indigenous whaling in the year 2000 International Whaling Commission meeting in Australia, and subsequent Federal government support for a whale sanctuary; have revealed a contradiction between support for local community based initiatives, and the political imperative to satisfy public reproach and indignation regarding hunting generally.

The turtle hunting ban imposed by the Federal Minister during 2001 and ongoing negotiations over dugong sanctuaries along the Great Barrier Reef, has underlined the irony of this situation. In this context, it is difficult for management agencies to successfully pursue co-management initiatives without exciting indigenous cynicism. This is particularly challenging when operating within a native title landscape.

Overall, this has had major implications for the implementation of hunting management plans such as that at Hopevale, mainly evinced through delays in the issuing of permits, and insufficient resourcing of the implementation process. In turn, community confusion over government processes and internal politics between clan groups regarding hunting responsibilities has further complicated this situation. It is clear that putting co-management or community wildlife management into practice is much harder than supporting its conceptual articulation. The ongoing evolution of the implementation of this and other such initiatives will be a test of the commitment of both parties to working together within these different cultural approaches, to broker efficient outcomes within the context of these different perspectives – and competing political imperatives each sustain.

Box 1.
Guugu Yimmithirr Bama Wii: Turtle and Dugong Hunting Management Plan

Vision: To develop and implement controlled and sustainable hunting practices that will minimise the impact on and may contribute to the protection and survival of Dugong (Girrbithi) and Turtle (Ngawiya) species for the enjoyment and use of future generations

Aims

1. To develop controlled indigenous hunting regimes for Dugong and Turtle through careful planning monitoring and management
2. To protect dugong and turtle habitat by managing the activities carried out on the land and sea by both traditional owners and visitors according to the desires of the traditional owners
3. To maintain the activity, knowledge and skill of traditional hunting for turtle and dugong, ensuring that this important cultural activity is continued through future generations
4. To assist the community to develop and reinstate customary laws to manage traditional hunting in conjunction with state and Commonwealth legislation
5. To revitalise respect for the law and sea management aspiration of individual clan grope, and identify ways in which these groups can work together to ensure the survival and prosperity of dugong and turtles

Other sections include:-

- Zoning restrictions
- Community Hunting license and conditions
- Compliance and communication
- Permit penalties
- Management group roles and responsibilities
- Cultural and natural resource management office
- Boating license and registration
- Safety equipment
- Details of catch
- Prevention of cruelty
- Seasonal hunting,
- Weddings, birthday parties and funerals
- Transportation of meat to other communities
- Turtle eggs
- Pregnant dugong and calves
- Barter and exchange
- Community education strategy
- Recommendations
- Summarised from; Hopevale Aboriginal Council and Nursey-Bray, M (1999) *A Guugu Yimmithirr Bama Wii; Girrbithi and Ngawiya, Turtle and Dugong Hunting Management Plan,* Hopevale Council

Implementation

The plan was finally launched in November 1999, and subsequently attracted national attention when it was nominated for and won the *Prime Ministers Environmental Award for Community Leadership and Environmental Sustainability, 2000.*

The Pew Foundation, the Australian Research Council, James Cook University, the GBRMPA and Hopevale Community Council have funded the subsequent implementation of this plan over its first and second seasons, with its third currently underway.

Plan implementation has included (i) the allocation of permits by the community, (ii) the establishment of ranger patrols and camps to monitor hunting progress, (iii) a reporting process for take that goes back to the agencies (and which includes information about the species caught - sex, age, number, gender place caught, when etc), and (iv) the imposition of a restricted hunting season. The Turtle and Dugong Hunting Management Council is scheduled to meet during each hunting period and to liaise between agency staff and the community on hunting matters, including breaches of the plan, and to reach decision on penalties.

Discussion – Developing cross cultural literacy

Indigenous peoples in Australia are very diverse and it would be inappropriate to deduce that the process of planning management that worked in Hopevale would automatically work elsewhere. Nonetheless there are a number of lessons that can be drawn from this case study that bear consideration for future initiatives.

Reconciling human need and cultural affiliation, with the biological and ecological needs of the target species is a key challenge. In this context, the concepts of 'rights', 'access' and 'equity', compete strongly with the discourse about the values of 'wilderness', 'pristineness' and 'animal rights'.

The importance of local knowledge and involvement in management programs is well illustrated. The need to build mutual trust between management agencies and local peoples - and between groups within the local communities - is vital (Merculieff 1994). In order to broker real collaborations and co-management; mutual trust, cross cultural respect and commitment to the project at hand must exist. This means developing programs that

are characterised by a real and respectful engagement with each other.

The need to develop flexible mechanisms that take into account differences in cultural perspective is crucial. This includes the engagement with and incorporation of the *entire cultural perspective*. In this case study, this may mean incorporating the culturally uncomfortable aspects of that engagement. For example (a) management agencies must come to accept and understand culturally uncomfortable practices such as turtle butchering, as quoted earlier, and (b) indigenous peoples, in turn, must recognise that some of the species they hunt *are* threatened and take appropriate action.

To facilitate the incorporation of local knowledge we need to develop multicultural literacy or a 'multi cultural toolbox' (Jacobs and Mulvihill 1995). Through the development of multi-culturally literate resource management systems we avoid the trap of reducing traditional value systems and perspectives into fragmented 'facts' of utilitarian value for 'appropriation' and exploitation as seen fit. Howitt (2001) notes that this approach will need to include an acknowledgment and practice of three aspects: (i) ways of seeing (ii) ways of thinking and (iii) ways of knowing.

It will also need to include a shift in our understanding of what 'local' and 'cultural' knowledge *is*. It entails restructuring and re-negotiation of the different layers engrained within 'knowledge' such as sacred/secret knowledge, male/female knowledge, traditional ecological knowledge, song, stories, experience, laws (tribal or otherwise), cultural mores and social traditions, ideological orientation (Johannes 1989).

In Australia 'knowledge' also comprises the historical appreciation of the history of racial division it has experienced and understandings that the current social and economic conditions prevailing in indigenous communities significantly influence environmental management regimes, and their ultimate success or failure. Drawing a curtain over the past does not make it disappear, and serious engagement by management needs to accept the history and politics from which these initiatives have burgeoned.

The case study used in this paper is a reflection of the important first steps that indigenous communities and management agencies in Australia are taking towards the facilitation of multi-culturally literate resource management in ways that involve and acknowledge the vitality and importance of the community contribution.

In the broader context, this case study is important because it unmasks the 'apoliticising' or 'green washing' about the environment that occurs in so much of the public debate about it. Land and sea management is, and will remain, an essential and political struggle for accession by different stakeholders, a whirlpool of emotion and political connections. At its heart, this example illuminates the fundamental relationship between power and knowledge, and how management regimes must be cognisant and familiar with these relationship dynamics in order to succeed.

There are approximately 5,000 indigenous / tribal local groups in the world, comprising up to 200 million people and 4% of the global population, yet these groups represent in between 90 – 95% of the world cultural diversity (Howitt 2001). In this context, it makes sense culturally, ecologically, legally, scientifically and in terms of management to support and incorporate indigenous and local peoples aspirations for sea country.

The advantages of such incorporation are many. They include decreased impact on the species concerned accompanied by an increased involvement in management by the communities and individuals most affected. Such approaches strengthen the maintenance of cultural integrity, and increase the visibility and viability of different cultural approaches. Finally, and of greatest advantage, is that such as an approach enhances the development of diverse and culturally appropriate management regimes. The development of such regimes is not only cost effective but also ensures a more holistic general management orientation. If the bottom line is sustainability, then management should be able to ensure the maintenance of both cultural practice, while protecting the species for future generations.

As Chief Tom Happynook (2000), concludes in relation to whaling; "The issue is not about whether or not to hunt; it is about sustainable use; if the use is sustainable then protecting endangered wildlife and maintaining cultural practice are perfectly compatible".

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REFERENCES

Benzaken, D., Smith, G., & Williams, R. (1997) "A long way together: The recognition of indigenous interests in the management of the Great Barrier Reef World Heritage Area". In D. Wachenfeld, J. Oliver and K.Davis, (Eds) *State of the Great Barrier Reef World Heritage Area Workshop Proceedings*, GBRMPA Workshop Series No. **22,** pp 471 - 495, GBRMPA, Townsville

Chase, A. & Sutton, P. (1987) "Australian Aborigines in a Rich Environment". In W.H. Edwards (Ed) *Traditional Aboriginal Society: A reader,* Mac Millan, Melbourne

Draft Resolutions (2001) 3rd Indigenous Ranger Conference Gulkulum 26 – 29 August 2000.

Folds, R (1993) 'Assimilation by any name…Why the Federal government 's attempts to achieve social justice for indigenous Australians will not succeed' in *Australian Aboriginal Studies* No 1 1993

GBRMPA (1994) *The Great Barrier Reef. Keeping it Great. A 25 Year Strategic Plan for the Great Barrier Reef World Heritage Area*.

Haviland, J. & Haviland, L. (1980) "How much food will there be in heaven?, Lutherans and Aborigines around Cooktown before 1900". *Aboriginal History, **4***(2):119-149

Hopevale Aboriginal Council and Nursey-Bray, M (1999) *A Guugu Yimmithirr Bama Wii; Girrbithi and Ngawiya, Turtle and Dugong Hunting Management Plan,* Hopevale Council

Howitt, R (2001) *Rethinking Resource Management: Justice, Sustainability and Indigenous Peoples* Routledge (Taylor and Francis group) London

Jacobs, P & Mulvihill,P (1995) 'Ancient lands: new perspectives. Towards multi-cultural literacy in landscape management'. In *Landscape and Urban Planning* 32: 7-17

Johannes, RS (1989) *Traditional Ecological Knowledge: A Collection of Essays*. IUCN

Langton, M., Epworth, D & Sinnamon,V (2000) *Indigenous Social, Economic and Cultural Issues in Land Water and Biodiversity Conservation* Centre for Indigenous Natural and Cultural Resource Management, NTU Darwin, Northern Territory on behalf of WWF

Limpus,C.J. (1995) *Conservation of Marine Turtles in the Indo – Pacific region. Final Report to the Australian Nature Conservation Agency,* Australian Nature Conservation Agency , Canberra

Marsh, Helene, Lawler,Ivan. (1999*) Dugong Distribution and Abundance in the Southern Great barrier Reef Marine Park and Hervey Bay: Results of an Aerial Survey in October – December 1999*, GBRMPA Research Publication No. 70.

Merculieff, L. (1994) "Western Society's Linear Systems and Aboriginal Cultures: The Need for Two Way Exchanges for the Sake of Survival" in Burch, ES. & Ellana, L. (Eds) *Key Issues in Hunter Gatherer Research*, Berg Press Oxford

Nettheim, G. (2001) *Discussion Paper 7: Governance Bodies and Australian Legislative Provision for Corporations and Councils*, Reconciliation and Social Justice Library, , The University of New South Wales and Murdoch University

Pearson, N (2000) 'The Light on the Hill Ben Chifley Memorial Lecture '*in Journal of Indigenous Issues* Vol 3, No 3 sep 2000 pp 4-15

Smith, A.J. (1987) *The usage of marine resources by Aboriginal communities on the east coast of Cape York Peninsula*. Unpublished Ph.D Thesis, James Cook University, Townsville.

Smyth, D. (997) "Recognition of Aboriginal maritime culture in the Great Barrier Reef Marine Park: an evaluation". In Wachenfeld, D., Oliver, J. and Davis, K. (Eds) *State of the Great Barrier Reef World Heritage Area Workshop Proceedings*, GBRMPA Workshop Series No. **22**, pp 496 - 502, GBRMPA, Townsville

Thompson, D. (1934) "The dugong hunters of Cape York". *Royal Anthropological Institute Journal*, **64**: 237-62

Zann, L & Sutton, P (eds) (1995) *State Of the Marine Environment Report for Australia*. GBRMPA.

Personal comments from:

Chief Tom Happynook, Chairman, World Council of Whalers Conference, October 2000
Mrs Priscilla Gibson, Hopevale Community, 2001
Professor Helene Marsh, November 2001

QUESTIONS

Saudiel Ramirez-Sanchez: You mentioned the possibility of having clear-cut categories for the fishers. However, fishers cannot be categorized as commercial or subsistence. Do you think that you can have the aboriginal people come up with their own categories?

Melissa Nursey-Bray: It is not just a matter of categories; it is more a need to allow people to manage the fishery themselves. Managers have to negotiate with the aboriginal people.

THE USE OF TRADITIONAL HAWAIIAN KNOWLEDGE IN THE CONTEMPORARY MANAGEMENT OF MARINE RESOURCES

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ABSTRACT

It is traditional for Hawaiians to "consult nature" so that fishing is practiced at times and places, and with gear that causes minimum disruption of natural biological and ecological processes. The Hoʻolehua Hawaiian Homestead continues this tradition in and around Moʻomomi Bay on the northwest coast of the island of Molokaʻi. This community relies heavily on inshore marine resources for subsistence and consequently, has an intimate knowledge of these resources. The shared knowledge, beliefs, and values of the community are culturally channeled to promote proper fishing behavior. This informal system brings more knowledge, experience, and moral commitment to fishery conservation than more centralized government management.

Community-based management in the Moʻomomi area involves observational processes and problem-solving strategies for the purpose of conservation. The system is not articulated in the manner of Western science, but relies instead on mental models. These models foster a practical understanding of local inshore resource dynamics by the fishing community and, thus, lend credibility to unwritten standards for fishing conduct. The "code of conduct" is concerned with how people fish rather than how much they catch.

The Hawaiian moon calendar emphasizes natural processes that repeat at different time scales: seasonal, monthly, and daily. The calendar is crucial to community-based resource monitoring and management. By identifying peak spawning periods for important food fish in a Hawaiian calendar format, traditional closures (*kapu*) can be applied by the community so as not to disrupt spawning behavior and other natural processes.

Detailed mental models have been constructed for several important inshore food species: *aholehole* (*Kuhlia sandvicensis*, a Hawaiian endemic), *moi* (*Polydactylus sexfilis*) and *limu kohu* (the seaweed *Asparagopsis taxiformis*). Conservation principles derived from the models can be verified by the fishermen's own observations and knowledge.

Community self-management of inshore fisheries around Moʻomomi Bay incorporates elements of traditional Hawaiian caretaker (*konohiki*) practices. This approach has been successful in maintaining healthy local populations of most important food species. Other communities are interested in applying the Moʻomomi model to their own localities. Caution is advised because the practices that are successful at Moʻomomi will lose vitality if transferred outside of the specific cultural and ecological context in which they evolved and are effective. The framework from the Moʻomomi model may be derived by other communities but the specific practices need to adapted to each local situation.

INTRODUCTION

Fishery management based on Western scientific thought has displaced indigenous knowledge systems throughout the world and, for the most part, Hawaiʻi is no exception. The Western view asserts that management should be left to professionals, and that the users of resources should not also be the managers of these resources (Berkes 1999). This view is fundamentally different from traditional Hawaiian[1] marine resource use and conservation where the resource users were the managers.

Long before any association with westerners, Hawaiians depended on fishing for survival. The need to avoid food depletion motivated them to acquire a sophisticated understanding of the factors that cause limitations and fluctuations in marine resources. Based on their familiarity with specific places and through much trial and error, Hawaiian communities were able to develop ingenious social and cultural controls on fishing that fostered, in modern terminology, "sustainable use" of marine resources. It is important to recognize these practices not as merely traditional, but as adaptive responses to marine resource availability and limitations. Hawaiian traditions incorporate conscious conservation (Johannes 1997) and demand an

[1] The term "Hawaiian" is used throughout to mean the original Polynesian settlers of the Hawaiian Islands and their descendents.

awareness of nature and attention to detail not found in contemporary fishery management.

In ancient Hawai'i, fishing activities and catch distribution were strictly disciplined by rules (*kapu*). Overseers (*konohiki*) enforced the *kapu* on behalf of *ali'i* (chiefs). Community self-management of inshore fisheries in and around Mo'omomi Bay is a contemporary version of the traditional *konohiki* or caretaker system. Education, family, and social pressure have become the means to elicit proper behavior rather than the harsh punishments of ancient times.

The survival of Hawaiian civilization for close to 2,000 years prior to European contact validates the traditional system. This knowledge system is dynamic, not static, and modern influences do not make it less traditional. It is legitimate in its own right and does not have to be recast in Western idiom or verified through Western science. However, the Hawaiian system does need to be communicated more effectively in order to incorporate it into a contemporary management framework. That is the purpose of this.

Tenets of Traditional Hawaiian Marine Resource Use

The most significant beliefs and values in Hawaiian culture revolve around three fundamental relationships: 1) the relationship between Hawaiian people and their local environment; 2) the relationship among humans; and 3) the relationship between people and their ancestry. The importance of the first two relationships stems from Hawaiians' dependence on one another and on the environment for survival. The third relationship demonstrates the belief that those who came before knew the correct and proper way.

The traditional practices of native Hawaiians are guided by cultural protocol. Protocol combines knowledge, practice, and belief, fundamental characteristics that evolve over time within a specific cultural and ecological context of most traditional systems (Berkes 1999). Protocol disciplines and brings responsibilities to fishing, as well as to other cultural activities. The most important of the responsibilities are:

Concern about the well being of future generations.

This is the ability to meet present food needs without compromising the ability of future generations to meet their needs. Irresponsible resource use is tantamount to denying future generations their means to survival.

Self-restraint.

Take only what one needs for immediate personal and family use, and use what one takes carefully and fully without wasting. A good Hawaiian fisherman is not the one with the largest catch but the one who can get what he or she needs without disrupting natural processes.

Reverence for ancestors and sacred places where ancestors rest.

Hawaiians inherited valuable knowledge from their ancestors. At one time, this knowledge was critical for physical survival. The "ancestry of experience" (Holmes 1996) stored in the memories of living Hawaiians is still transmitted largely through non-written processes. It is taught to succeeding generations by telling stories, creating relationships, and establishing personal meaning. Ancestors are worshipped because of the dependence on knowledge and skills passed from generation to generation.

Lokahi ("harmony").

Time spent in fishing cultivates intimacy and harmony with the ocean, reinforcing strong ties to specific places and close relationships with marine creatures that are a part of Hawaiian identity and spirituality. In ancient times, fishermen made offerings of fish and said prayer chants (*mele pule*) at a special class of temple known as *heiau ko'a*, dedicated to gods of fishing (Kamakau 1976).

Malama ("take care of living things).

The Hawaiian perspective is holistic, emphasizing relationships and affiliations with other living things. Nurturing and respect, important for good human relationships, are also beneficial in relationships with marine life.

Laulima ("many hands").

Sharing and cooperation maintains family unity and community interdependence. The intensity of subsistence fishing activities is determined by kinship obligations, generalized reciprocity, and communal exchange of productive labor and foods among family, friends and neighbors.

Ha'aha'a ("humility").

Hawaiians are a part of the living world, not superior to it. Excluding people from nature only serves to further alienate humans from other living resources and thus from their responsibilities.

'Imi 'Ike ("to seek knowledge").
The young fisherman was trained to watch for changes (major and subtle) in the condition of marine resources. Before becoming acknowledged as an expert, the apprentice had to understand the life cycle, diet, feeding habits, preferred habitat, and growing conditions of many marine food species.

Handy *et al.* (1972), Pukui *et al.* (1972) and Kanahele (1986) provide more detail about traditional values that guide Hawaiian behavior. The issue for Hawaiian civilization is no longer physical, but cultural survival. "The culture lives on through its practitioners" (Edith Kanaka'ole Foundation, 1995) and their activities have a strong sense of "place". The following case study reinforces the importance of having places where Hawaiian traditions can continue.

CASE STUDY

The northwest coast of the island of Moloka'i (Figure 1) is one of the few places remaining in the Hawaiian Islands where the traditional Hawaiian system still provides a framework for fishery resource use and conservation. Inshore fisheries around the main Hawaiian Islands have declined significantly during the past century (Shomura, 1987; Friedlander and DeMartini, in press). The relative isolation of the coastal area in and around Mo'omomi Bay and community consensus about appropriate behavior have protected local marine resources from overfishing.

Marine resources along a 12-mile length of wave-exposed coast on both sides of Mo'omomi Bay are mainly harvested by a community of native Hawaiians who reside in nearby Ho'olehua Hawaiian Homestead. Residents are far more dependent on subsistence farming and fishing (one-third of the food consumed by the 1,000 residents of this community) (Hui Malama o Mo'omomi, 1995; Pacific American Foundation and Hui Malama o Mo`omomi. 2001), than in most other communities in the state. Opened in 1924, Ho'olehua was the second homestead established after the US Congress passed the Hawaiian Homes Commission Act in 1921 with the intent of returning Hawaiians to the land. The first Ho'olehua homesteaders were selected for their self-sufficiency (Hui Malama o Mo'omomi, 1995) and succeeding generations have endured, despite the harsh land and ocean environment. The coastal area is rich in artifacts and human burial remains dating mostly from prehistoric Hawaiian communities and activities back to the 11th century (Summers, 1971).

The continuation of traditional Hawaiian practices in and around Mo'omomi Bay helps to maintain social and cultural identity and provides reinforcement of values shared by the Ho'olehua community. The repetition of subsistence fishing activities is one of the ways that knowledge, values, and identity are transferred to succeeding generations Cultural survival is thus entwined with resource conservation. The basic elements of fishery management are in place in the Mo'omomi area: a conservation ethic, community support, management knowledge, and a system of monitoring.

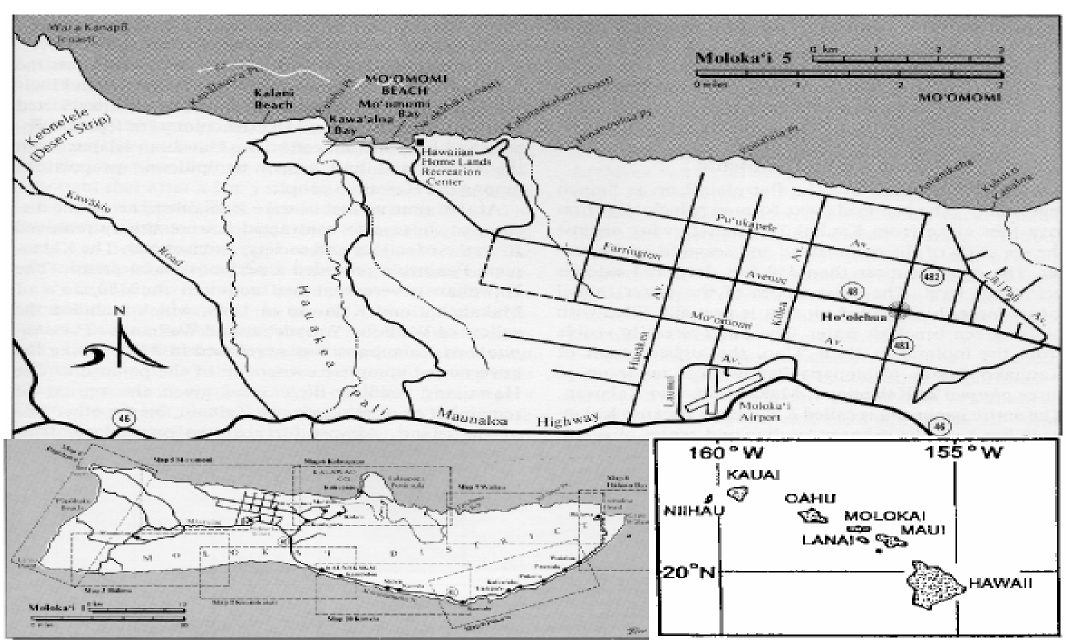

Figure 1. Mo'omomi and Kawa'aloa Bays located on the north shore of Moloka'i (adapted from Clark, 1989).

Conservation ethic

Fishing in and around Moʻomomi Bay continues to revolve around the subsistence use of local marine resources. Harvest practices are adapted to local environmental and ecological conditions. The community has no formal fishery management policies or institutions. Proper conduct of fishing is not controlled through formal rule making, as in Western regulations, but is inferred through internal cultural norms and values that guide and instruct the behavior of the community.

The wisdom and insights of leaders who hold and transmit traditional knowledge are crucial in lending credibility to the traditional system. The "code of conduct" focuses on how fishing should be practiced to maintain regular biological renewal processes, rather than on how much fish should be harvested.

Community support

The communal identity of Hoʻolehua Hawaiian Homestead is defined by a shared cultural heritage and is maintained by a system of interdependence and social reciprocity that is expressed in many ways, including the sharing of seafood gathered through subsistence. This system enables the homesteaders to live well and with confidence in a sometimes difficult environment.

Hui Malama o Moʻomomi was formed in 1993 to revitalize the traditional marine resource conservation system of the area by appealing to Hawaiian cultural beliefs, values, and conservation ethics. The Hui encourages responsible fishing based on individual conscience, social and family pressure, and the training of youths to become "good marine citizens." Networks of social ties and cooperation generated by subsistence activities create a collective interest in resource conservation and foster consensus about the proper conduct of fishing.

Management knowledge

Subsistence is the foundation of traditional Hawaiian knowledge. The homesteaders accumulate information that is essential for adaptation and survival in real life situations. This knowledge is not merely practical perception and "know how" but patterns of thought, understanding, and models of ecosystem workings.

The worldview and resource management perspective of Hawaiians is holistic. Humans are a part of the ecosystem. Land areas and adjacent marine waters are managed as interconnected and inseparable units known as *ahupuaʻa*. *Ahupuaʻa* were subdivisions of larger districts (*moku*). They typically extended from the mountain to the sea, providing the Hawaiian occupants with access to various natural resources for their subsistence (Costa-Pierce, 1987; Meller, 1985).

Despite substantial deterioration of Hawaiian ancestral marine resource knowledge in general, it remains dynamic, capable of being verified, regenerated, and even expanded for specific locations by new generations of Hawaiians. Hawaiian knowledge is a form of adaptive management. It takes a dynamic view of ecosystems, emphasizes processes that are part of resource renewal, acknowledges uncertainty and unpredictability, and stresses the importance of ecosystem resilience. The system continues to evolve through social learning; i.e., oral transmission, imitation, and demonstration.

Resource monitoring

The good Hawaiian fisherman is always watching the ocean, monitoring it for cues that signal what can be fished, where and when, in a manner compatible with local resource "rhythms" and to adapt fishing to changing environmental conditions. Key indicators include tidal cycles, waves and currents, day length, ocean temperature, habitat stability, sand movement, rainfall, wind velocity, and direction.

Many fish species aggregate to reefs for shelter, orientation of social behavior, and for food. Habitat complexity is one of the principal factors affecting spatial distribution of inshore fish abundance. Shallow-water habitats with low bottom relief and limited shelter are often associated with low standing stocks of fishes, whereas highly complex habitats harbor high fish biomass (Friedlander and Parrish, 1998). Native Hawaiians recognized the importance of *koa* (fish houses), special areas where fish were known to aggregate. *Koa* are focal points of fishing and resource conservation. The specific locations of *koa* are carefully guarded secrets of the Hawaiian families who held this knowledge. Western-trained scientists and resource managers acknowledge the existence of *koa* (Grigg, 1994; Friedlander and Parrish, 1998) but the concept remains poorly documented in fisheries science as well as contemporary management of Hawaiʻi's inshore fisheries.

Many natural processes that affect fish distribution are monitored by the community,

the most important of which is moon phase. The moon was as essential in scheduling the activities of the ancient Hawaiians as clocks are to modern man. The moon calendar is a predictive tool based on awareness of natural cycles and their relationship to fishing and farming success. Its wisdom reflects lifetimes of observations and experiences by many generations of Hawaiians in their quest for survival (Edith Kanakaʻole Foundation, 1995). Present-day residents of Hawaii still refer to the moon calendar to plan fishing and planting activities and a popular form of the calendar is published annually by the Prince Kuhio Civic Club. Most contemporary users, however, extract only superficial information.

The moon calendar emphasizes natural processes that repeat at different time scales: seasonal, monthly, and daily. Distinctions are made between two general seasons (*kaʻu* or dry; *hoʻoilo* or wet) and three general phases of the moon: *hoʻonui* (nights of enlarging moon); *poepoe (*nights of full moon); and *emi* (nights of diminishing moon). In addition to illustrating seasons and moon phases, Figure 2 also gives the Hawaiian names for the 12 months of the year. Specific names were also given to each night of the Hawaiian lunar cycle (Figure 3)

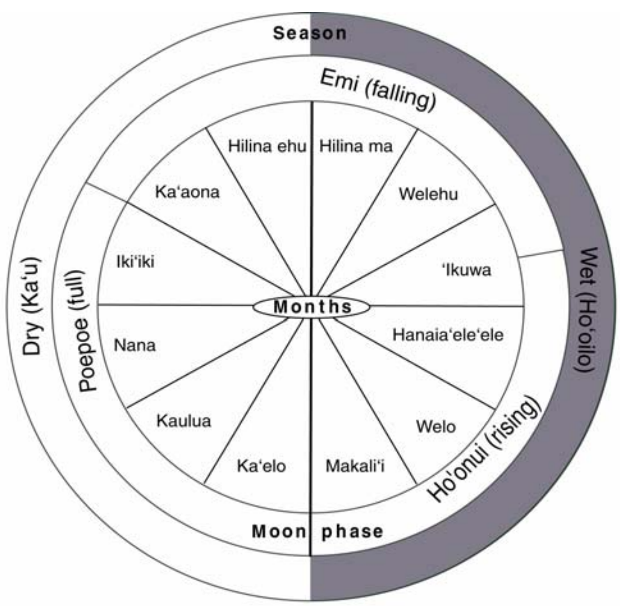

Figure 2. Hawaiian moon calendar showing months, seasons, and moon phases that are used to guide fishing activities. Names used for months in this calendar are specific to Molokaʻi.

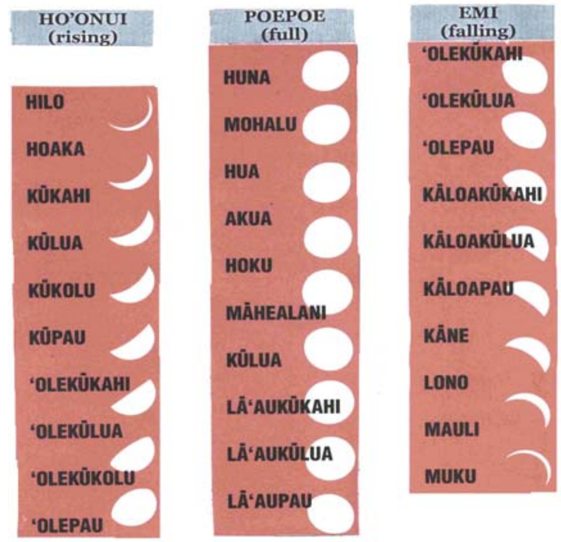

Figure 3. Hawaiian names for each night of the rising, full, and falling moon phases (adapted from Prince Kuhio Civic Club 2001).

Fish Spawning Calendar

By observing spawning behavior and sampling fish gonads, community monitors have constructed a calendar identifying the spawning periods of major food fish species. The Moʻomomi fish spawning calendar for the year 2000 is shown in Table 1. Peak spawning for *ulua*, *moi*, *uhu* and *aʻawa* occurred during the summer months. Late winter-early spring spawning was observed for *aholehole* and *kumu*. Surgeonfishes typically spawned in late winter, as well as in early spring. By identifying peak spawning periods for important resource species, traditional closures or *kapu* can be applied so as not to disturb the natural rhythms of these species.

Due to their local importance as food items, *aholehole* (Hawaiian flagtail, *Kuhlia sandvicensis*), *moi* (Pacific threadfin, *Polydactylus sexfilis*) and the red seaweed *limu kohu* (*Asparagopsis taxiformis*) were examined more closely and models of resource dynamics were constructed.

Applications of Hawaiian Mental Models

The traditional Hawaiian resource use system involved measuring and evaluating natural processes to produce representations of the workings of ecosystems, similar to Western science. Thus, theoretical constructs of Hawaiian scientific thought are mental models that recognize different states or "frames" capturing the essential aspects of dynamics that may apply to the same ecosystem at different times

(Starfield et al., 1993). However, Hawaiian knowledge relies on memory and does not incorporate the rigorous quantitative estimates or writings of Western science. There was no written Hawaiian language prior to the 19th century (Kuykendall, 1938), so traditional knowledge was orally transmitted from generation to generation through chants, stories, and demonstration.

Aholehole

The Hawaiian flagtail (*Kuhlia sandvicensis*) locally called *aholehole* is endemic to the Hawaiian Islands. Young occur in shallow water along the shoreline and may be found in tide pools, streams, and estuaries. They feed mainly on planktonic crustaceans but also on polychaete worms, insects, and algae. Length at maturity is about 18 cm, while spawning occurs year-round, though mainly during winter and spring months. The *aholehole* was used in sacrifices in ancient Hawaiʻi to keep away evil spirits when a white fish or pig was needed (Titcomb, 1972)

At Moʻomomi Bay, *aholehole* spawn during the wet season, typically in late winter-early spring. Much of the distribution of *aholehole* is based on the movement of sand in and out of nearshore habitats (Table 2). During the winter months, sand is transported offshore, providing ample space inside reef holes (*puka*) along the shore for *aholehole* to school. This change in habitat between seasons coincides with, and may be a cue to, the onset of spawning. During the summer months, sand is transported inshore resulting in reef *puka* being filled in and causing *aholehole* to move offshore. The conservation principles developed by Hawaiians to harvest *aholehole* included discouraging catch of sub-reproductive individuals and discouraging harvest during times of peak spawning.

Table 1. Moʻomomi Bay fish spawning calendar for the year 2000 for key resource species. Black boxes indicate months of peak spawning. Grey boxes indicate other months when spawning was observed (Friedlander et al. in press).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ulua (Caranx ignobilis)						■	■	■				
aholehole (Kuhlia sandvicensis)		■	■	■								
moi (Polydactylus sexfilis)					▒	■	■	■				
ʻuʻu(Myripristis species)							▒	▒	■	■		
kumu (Parupeneus porphyreus)	▒	■	■	▒								
aweoweo (Priacanthus species)								▒	■	■		
taʻape (Lutjanus kasmira)						■	■	■				
aʻawa (Bodianus bilunulatus)					■	■	■	■				
enenue (Kyphosus species)	■	■	▒	▒	▒							
uhu (Scarus species)					■	■	■					
uhu palukaluka (Scarus rubroviolaceus)					■	■	■					
ponuhunuhu (Calotomus carolinus)					■	■	■					
pualu (Acanthurus xanthopterus)		▒	■	■								
palani (Acanthurus dussumieri)		▒	■	■								
kala (Naso unicornis)		▒	■	■								
kole (Ctenochaetus strigosus)		▒	■	■								
manini (Acanthurus triostegus)		▒	■	■								

Table 2. Season movement patterns of *aholehole* (*Kuhlia sandvicensis*) in relation to changes in habitat.

Season	**Sand movement**	**Reef holes (*puka*)**	***Aholehole* distribution**
Winter	Offshore	Exposed	Inshore
Summer	Inshore	Filled	Offshore

Moi

The Pacific threadfin (*Polydactylus sexfilis*) or *moi* is a very popular and much sought-after sport and food fish in Hawaii that also supports a small subsistence fishery (Friedlander and Ziemann, in press). In ancient Hawaiian culture, *moi* were reserved for the ruling chiefs and prohibited for consumption by commoners (Titcomb, 1972). Hawaiians developed a number of traditional strategies to manage *moi* for sustainable use. *Kapu* or closures were placed on *moi* during the spawning season (typically from June through August) so as not to disrupt spawning behavior.

Moi are protandrous hermaphrodites, initially maturing as males after a year at about 20-25 cm. They then undergo a sex reversal, passing through a hermaphroditic stage, and finally becoming functional females measuring between 30 and 40 cm (fork length) at about three years of age (Santerre et al., 1979). Spawning occurs inshore and eggs are dispersed and hatch offshore (Lowell, 1971). Larvae and juveniles are pelagic until juveniles attain a fork length of about 6 cm, whereupon they enter inshore habitats including surf zones, reefs, and stream entrances (Santerre and May, 1977; Santerre et al. 1979). Newly settled young *moi*, locally called *moi-li'i*, appear in shallow waters in summer and fall where they are dominant in the nearshore surf zone fish assemblage.

Moi have a readily identifiable aspect of their life history (sex reversal) that has contributed to its decline in Hawai'i: continued overfishing results in relatively few females left in the population around heavily fished areas of the state. Hawaiians understood this, and prior to spawning season, females were normally released. Management was, and still should be, based on a detailed understanding of the life history of the species of interest (see also Barker and Ross, this vol).

At Mo'omomi, *moi* typically spawn near the northwestern end of Kawa'aloa Bay in the sand. *Moi* usually come inshore to spawn from June through August. Sand movement is very important in determining when and where *moi* spawn. In Kawa'aloa Bay, *moi* move inshore to spawn when sand has stopped moving, but before too much sand has moved in to fill in the *puka* in the reef. Shelter is an important controlling factor in reducing the risk of predation during the spawning period. Stable sand leads to higher infauna of *moi* prey (shrimp and crabs). Observation of sand movements and the height of sand waves can give a good indication of when *moi* will move inshore to spawn. As sand waves flatten out, the sand becomes more stable whereas steep sand waves indicate movement of sand.

Hawaiians developed a mental model of the life history of *moi* from which conservation principles and management practices were derived by integrating seasonal movement, spawning aggregation behavior, and the relationship of different life history phases to these behavior patterns. Table 3 is an attempt to construct a written representation of the knowledge concerning the behavior of *moi* and how it relates to Hawaiian conservation principles. Traditional Hawaiian conservation principles for *moi* included restrictions on harvest of *pala moi* (hermaphrodites) *or moi* (females), depending on population structure, and restrictions on harvest during the spawning season. Minimizing the disturbance to spawning and nursery habitats was another important conservation practice.

Awareness of the need to protect both immature moi and the female breeding stock from overharvest is an example of how Hawaiian resource knowledge can validate Western science, which has discovered and named this method of conservation as "slot limits." Not only was almost every basic fisheries conservation measure devised in the west in use in Oceania centuries ago (Johannes, 1978), including closed areas, closed seasons, size restrictions and restricted entry (Johannes, 1982), but some very sophisticated methods, including slot limits, were also practiced in Hawai'i.

Table 3. Seasonal movement of *moi* and related Hawaiian conservation principles

Fish size	Dispersed	Aggregated	Aggregated and spawning
Adults (*mana moi, pala moi, moi*)	Fall through winter	Spring -- in reef holes prior to spawning	June, July, and August -- one spawning per month cued by moon phase
Juveniles (*moi li'i*)	Leave for adult habitat after grown	In fall, as new recruits feeding in sand bottom areas with nearby rocky shelter	N/A

Limu Kohu

Seaweeds, collectively known as *limu* in Hawai'i, were the third component of a traditional, nutritionally balanced diet that also consisted of fish and *poi* (Abbott, 1984). Hawai'i is rich in *limu* species owing to the high volcanic islands and associated rainfall, which provides nutrients for the growth of *limu*. While the uses of seaweeds among other Polynesian peoples were either infrequent in the past or have been curtailed today (Abbott, 1984), Hawaiians continue to consume a wide variety of seaweeds. One of the most prized species is *limu kohu* (the supreme *limu*), or *Asparagopsis taxiformis*. There are several legends relating to how *limu kohu* got its dark red color, each referring to an event connected with legendary or real *ali'i* (royalty) (Abbott, 1984).

Fronting Mo'omomi and Kawa'aloa Bays, *limu kohu* grows in areas of intense surge from the splash zone on intertidal benches (*papa*) to boulder and flat limestone bottoms as deep as 40 feet. This seaweed is well suited to the shallow-water habitat off Mo'omomi, which is wave washed almost year round. There are, however, marked seasonal changes in the distribution of *limu kohu* (Table 4). During *ho'oilo* (wet season), the tides rotate in an opposite pattern from k*a'u* (dry season), when the highest tides occur during the day and the lowest tides occur at night. During the wet season, the coast is exposed to intense wave action generated by North Pacific swell and strong tradewinds. In these conditions, *limu kohu* is able to attach and flourish on long stretches of *papa* that experience less water movement during the dry season.

From January 2000-January 2001, seasonal changes in the distribution, abundance, and reproductive condition of *limu kohu* were studied at the major harvest site (*Kaiehu papa*). Information collected during 12 months of detailed observation is summarized in Table 4. The survey period began during the latter half of the 2000 wet season (January-April 2000), through the dry season (June-Oct. 2000) followed by the start of another wet season (Nov.-Jan. 2001). These data were collected by the authors and community resource monitors. Severe drought conditions later in 2001 severely retarded the growth of *limu kohu* on the *papa* over this time period.

Patterns observed in the relative abundance and height of plants (Table 4) indicate that the wet season provides the best growing conditions on shallow (0-1 m) benches, or *papa*. Marked changes in bench cover by this seaweed occurred during the wet season or after rainfall with young stands of *limu kohu* becoming one to two inches high during one cycle of the moon.

Limu kohu reproduces by spores. Observations during the wet season indicate that shallow-water plants bear spores after they have grown to a height of three inches, and sporing continues until full growth to 4.5 - 5 inches is completed (Table 4). As they grow taller, shallow stands of *limu kohu* are torn by high wave energy, starting with the fronds and eventually cutting off the main stems as they weaken.

Observations during *ka'u* (dry season) indicate that daylight exposure during minus tides, long days and reduced water movement make the shallow *papa* an inhospitable environment for *limu kohu* (Table 4). However, the longer days stimulate lush growths and sporing of this seaweed in subtidal areas of boulders and limestone flats to a depth of about 20 feet. At greater depths, growth is sparser because of limited sunlight.

There is a number of environmental factors that affect the growth of *limu kohu* on intertidal benches and subtidal areas (Table 5). The change of seasons from *ho'olio* (wet) to *ka'u* (dry) exposes growths of *limu kohu* on the intertidal benches to dehydration and sunburn and eventually causes die off. There is no conservation principle to be served by limiting the gathering of seaweed that is under such a "death sentence" and the largest harvest of *limu kohu* is made at this time of the year (May).

The continued availability of *limu kohu* at Mo'omomi Bay depends on the recruitment and growth of new plants. Success in reproducing (through sporing) and in attaching to local substrata are key processes that sustain the supply of this seaweed. Spores attach to suitable sizes of sediment and settle on the bottom wherever the preferred grain sizes are deposited. If particles are too small, they will be removed from the nearshore before settling.

The critical conservation principle derived from the mental model for *limu kohu* is to retain spores so they are more likely to settle out on local substrata (Table 5). That is why *limu kohu* gatherers are encouraged to rub off the root mass of plants against a rough surface (such as the collector's bag) as they are harvested. Many spores are trapped within the root mass and leaving this mass in the water increases the chance that spores will attach and grow near the original harvest location. Observations during

the peak harvest period in May 2000 (see Table 4) suggest that *limu kohu* may replant in shallow inshore areas of the *papa* as a result of this practice.

Table 4. Observations of the seaweed *limu kohu* at the major shallow-water (0-1 m) harvest site (*Kaiehu papa*), January 2000 – January 2001.

Time of Observations	Condition of Shallow Plants	Height of Shallow Plants	Condition of Reproductive Spores	Other Information
Wet Season (Hoʻoilo)				
Jan. 2000	Abundant	3-4 inch	Attached	
Feb. 2000	Long plants breaking off, dying back, losing red color	3-4 inch	Large numbers attached, some being released	Wave action breaking off plants
March 2000	Shorter, sparse and pale in color	3 inch	Large number being released from shallow plants; evident on deep plants (20 ft)	
April 2000	Still abundant but long plants have broken off; pale color	2-3 inch on bench; 3-4 inch in pools	Same as March	
Dry Season (*Kaʻu*)				
May 2000	Pale color; what long plants remain are overgrown with epiphytes and dying back; some plants very close to shore	2 inch	Few spores attached to shallow plants; increasing number on deep plants (20 ft)	Time of peak harvest; collecting may spread spores for regrowth
June 2000	Sparse and short growths	2 inch	Not evident on shallow plants; abundant on deep plants	Lack of rainfall
July 2000	Plants getting longer	3 inch	Sparse on shallow plants; abundant on deep-water plants	Less than 0.1 inch rainfall in month
August 2000	Abundant	3-4 inch	Sparse on shallow plants; abundant on deep-water plants	0.25 inch rainfall on 8/25
Sept. 2000	Sparse	2.5 inch	Not evident	0.33 inch rainfall in month
Oct. 2000	Abundant	3 inch	Sparse	
Wet Season (*Hoʻoilo*)				
Nov. 2000	Abundant	3 inch	Increasing on longer plants	0.79 inch rainfall in month
Dec. 2000	Scattered, red color	3 inch on bench; 3-4 inch in pools	Increasing on longer plants	0.11 inch rainfall in month
Jan. 2001	Abundant, dark purple color	3-4 inch	Abundant on shallow plants	0.32 inch rainfall in month

Table 5. Seasonal distribution of *limu kohu* (an edible seaweed) and related Hawaiian conservation principles.

	Limu Kohu Habitat	
Season	Shallow (0-1 m depth)	Deep (1.1 – 10m)
Wet (*Hoʻoilo*)	Growth favored by winter rainfall (introducing nutrients), minus tides at night, short days, ocean turbulence dispersing reproductive spores	Growth favored by water motion dispersing reproductive spores but inhibited by short days
Dry (*Kaʻu*)	Growth inhibited by lack of rainfall, "sunburn" during minus tides, long days	Growth favored by long days

Discussion

How Unified and Transferable is Hawaiian Knowledge?

Traditional Hawaiian marine resource use poses a paradox. Communities in different island areas, on the one hand, are characterized by a unifying worldview and similarities of basic designs or principles that are the result of centuries of continuing experimentation and innovation. On the other hand, the details of practice vary from one area to the next because they are adapted -- fine-tuned -- to local situations. Detail is important because of the "patchy" character and variability of shoreline and nearshore environments in the Hawaiian Islands.

Transferring this knowledge to other places risks losing its vitality. Even writing it down, as in this paper, changes some of the fundamental properties of this knowledge, making it more portable and permanent, but with a loss of vitality. This increases the chances of dislocation and misapplication outside the restricted context in which the knowledge evolved and is effective.

How is Hawaiian Knowledge Different from Other Kinds of "Local Environmental Knowledge"?

Hawaiian indigenous knowledge differs from similar kinds of environmental knowledge held by non-indigenous people in two important ways. First, Hawaiian knowledge evolved in the cultural and environmental context of the first inhabitants of the Hawaiian Islands, where it was essential for survival. Second, Hawaiian knowledge has deeper roots and is the product of many more generations of intelligent reasoning about the marine resources of the Hawaiian Islands than practical knowledge held by non-Hawaiians.

Further Applications

The Hoʻolehua Hawaiian Homestead community is self-reliant in its fishery conservation efforts. Conservation is based on local resources (intellectual and social) as much as possible. Homesteaders work with what they have, with what they know, and what they can do.

Much more could be done to explore the ways to integrate the traditional knowledge of native Hawaiians with contemporary fishery management. But how desirable is this integration? Berkes (1999) cautions that the use of indigenous knowledge is political because it threatens to change power relations between indigenous groups and the dominant society. The example of Hoʻolehua Hawaiian Homestead may, nevertheless, inspire new approaches and suggest more participatory and locally-based alternatives to top-down centralized resource management. There are other rural communities in Hawaiʻi with values and features similar to those of the Homestead. These ideas challenge conventional fishery resource management, but forcing indigenous Hawaiian conservation into the mold of Western conservation is not likely to work:

> *"The resource management systems of indigenous people often have outcomes that are analogous to those desired by Western conservationist. They differ, however, in context, motive and conceptual underpinnings. To represent indigenous management systems as being well suited to the needs of modern conservation, or as founded on the same ethic, is both facile and wrong." Dwyer (1994, p. 91).*

Hawaiian fishermen understand and interpret natural phenomena differently than Western-trained scientists. The Hawaiian system is based on knowledge that is:

- Generated as a consequence of practical needs in everyday life;
- Based on intimate acquaintance with a local situation;
- Linked to specific places and sets of experiences;
- Preserved through the memories of particular individuals;
- Orally transmitted;
- Continually reinforced by experience, trial and error, and deliberate experiment;
- Dynamic and evolving, not static and rigid.
- Transferred through the practices and interactions of subsistence fishermen; and
- Shared in the community to a wider extent than conventional scientific knowledge about marine resources.

The residents of Hoʻolehua Hawaiian Homestead tend to care deeply about what becomes of their subsistence resources, not only as a source of food for themselves and future generations, but also as part of their way of life and identity. Without the unique and highly successful system for community self-management that has been perpetuated, the local fisheries might be in the same state of decline as elsewhere in the populated Hawaiian Islands.

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References

Abbott, I.A. 1984. Limu: an ethnobotanical study of some Hawaiian seaweeds. Pacific Tropical Botanical Garden. Lawai, Kauai, Hawaii. 35 pp.

Berkes, F. 1999. Sacred ecology: traditional ecological knowledge and resource management. Taylor & Francis, Philadelphia, PA. 209 p.

Clark, J.R.K. 1989. The beaches of Maui County. University of Hawaii Press. Honolulu. 155 pp.

Costa-Pierce, B. 1987. Aquaculture in ancient Hawaii. Pages 395-410 in: Traditional marine resource management in the Pacific basin: an anthology (eds. K. Ruddle and R.E. Johannes), UNESCO-ROSTSEA, Jakarta.

Dwyer, P.D. 1994. Modern conservation and indigenous peoples: In search of wisdom. *Pacific Conservation Biology* 1: 91-97.

Edith Kanakaʻole Foundation. 1995. Draft Ke Kalai Maoli Ola No Kanaloa, Kahoʻolawe Cultural Use Plan. Consultants to the Kahoʻolawe Island Reserve Commission. 28 p.

Friedlander, A.M. and J.D. Parrish. 1998. Habitat characteristics affecting fish assemblages on a Hawaiian coral reef. J. Exp. Mar. Biol. Ecol. 224(1):1-30.

Friedlander, A.M. and E.E. DeMartini. In press. Contrasts in density, size, and biomass of reef fishes between the Northwestern.

and the main Hawaiian Islands: the effects of fishing down apex predators. Marine Ecology Progress Series.

Friedlander, A.M. and D.A. Ziemann. In press. Impact of hatchery releases on the recreational fishery for Pacific threadfin in Hawaii. Fishery Bulletin.

Friedlander, A., K. K. Poepoe, K. Poepoe, K. Helm, P. Bartram, J. Maragos and I. Abbott. 2002. Application of Hawaiian traditions to community-based fishery management. In Proc. of 9th International Coral Reef Symposium, Bali, Indonesia, October 2000.

Grigg, R.W. 1994. Effects of sewage discharge, fishing pressure and habitat complexity on coral ecosystems and reef fishes in Hawaii. Mar. Ecol. Prog. Ser. 103:25-34.

Handy, E., S. Craighill and M.K. Pukui. 1972. The Polynesian family system in Kaʻu, Hawaiʻi. Charles E. Tuttle Co., Rutland, VT. 206 p.

Holmes, L. 1996. Elders' knowledge and the ancestry of experience in Hawaiʻi. Ph.D. dissertation, University of Toronto.

Hui Malama o Moʻomomi. 1995. Proposal to designate Moʻomomi community-based subsistence fishing area, northwest coast of Molokaʻi. Prep. for Dept. of Land and Natural Resources, State of Hawaii. 37 p. + appendices.

Johannes, R.E. 1978. Traditional marine conservation methods in Oceania and their demise. Ann. Rev. Ecol. Syst., 9: 349-364.

Johannes, R.E. 1982. Traditional conservation methods and protected marine areas in Oceania. Ambio, 11: 258-261.

Johannes, R.E. 1997. Traditional coral-reef fisheries management. Chap. 16, p. 380-385 In: C. Birkeland (ed.) Life and Death of Coral Reefs. Chapman & Hall, New York.

Kamakau, S.M. 1976. The works of the people of old (Na hana a ka poʻe kahiko), translated from the newspaper ke au ʻokoʻa by M.K. Pukui. Bishop Museum Press, Honolulu, HI. 170 p.

Kanahele, G.H.S. 1986. Ku kanaka, stand tall: a search for Hawaiian values.. University of Hawaii Press, Honolulu. 530 p.

Kuykendall, R.S. 1938. The Hawaiian kingdom, vol. 1, foundation and transformation , 1778-1854. University of Hawaii Press, Honolulu. 462 pp.

Lowell, N.1971. Some aspects of the life history and spawning of the moi (*Polydactylus sexfilis).* MA Thesis, Univ. Hawaii, 45 p.

Meller, N. 1985. Indigenous ocean rights in Hawaii. Sea Grant Marine Policy and Law Report UNIHI-SEAGRANT-MP-86-01. UH Sea Grant College Program, Honolulu, HI. 41 p.

Pacific American Foundation and Hui Malama o Moʻomomi. 2001. Application of Hawaiian traditions to community-based fishery management. Completion report for two-year demonstration project in and around Moʻomomi Bay, Molokaʻi , Hawaiʻi. Prep. for Administration for Native Americans, U.S. Dept. of Health and Human Services. 53 p.

Pukui, M.K., E.W. Haertig and C.A. Lee. 1972. Nana I ke kumu (look to the source), Vol. 2. Hui Hanai, Queen Liliuokalani Children's Center. Honolulu, HI. 333p.

Santerre, M.J and R.C. May.1977. Some effects of temperature and salinity on laboratory-reared eggs and larvae of *Polydactylus sexfilis* (Pisces: Polynemidae). Aquaculture 10:341-351.

Santerre, M.J., G.S. Akiyama, and R.C. May.1979. Lunar spawning of the threadfin, *Polydactylus sexfilis*, in Hawaii. Fish. Bull. 76: 900-904.

Shomura, R. 1987. Hawaii's marine fishery resources: yesterday (1900) and today (1986). U.S. Dept. Commerce/NOAA, National Marine Fisheries Service Southwest Fisheries Science Center Administrative Report H-87-21. 14 p.

Starfield, A.M., D.H.M. Cumming, R.D. Taylor and M.S. Quadling. 1993. A frame-based paradigm for dynamic ecosystem models. A I Appl. 7(2 and 3): 1-13.

Summers, C.C. 1971. Molokai: a site survey. Pacific Anthropological Records No. 14: 40-41, Dept. of Anthropology, Bernice P. Bishop Museum, Honolulu, HI.

Questions

Melita Samoilys: How do we know the Moi were hermaphrodites?

Kelson "Mac" Poepoe: We cut them open and look inside to see the gonads.

Melita Samoilys: So they have both gonads, or are they sequential hermaphrodites?

Kelson "Mac" Poepoe: They can change from male to female. They change when they get to a certain size. If I look at a fish, I can say if it's a hermaphrodite, male, or female.

Michael Phelan: Does anyone stop fishing at the sites when they aggregate to spawn?

Alan Friedlander: There is an intricate social dynamic; you need to have the right proportion of males and females to spawn. If you break up the aggregation, there's no telling if it'll reform within a reasonable period of time to spawn. For

the most part, it's understood that in the spawning season, fish are not to be bothered.

Ian Baird: In Laos, the way of passing on knowledge is to get kids to start fishing early. As soon as they can put a net or hook out, they do it. In Hawaiian tradition, it seems to be the opposite where they observe but not practice fishing until a certain age. I've never heard of this practice being done. Why do they do that?

Kelson "Mac" Poepoe: They do that to respect the social structure. If you are a master fisherman, no one interferes with you. If I'm out there fishing and there are fishermen below me, they have to respect me. But we do start fishing at an early age.

Alan Friedlander: On that same topic, there are only one or two places on the Mo`omomi area that are accessible to kids. What people did before and what they still do is leave those places for the kids to experiment and to get their feet wet both figuratively and literally.

Tony Pitcher
This is a fascinating study. I wonder how it's regarded by the official regulatory agency. Here in Canada, we look enviously at the system in Haida'gwaii and that is controversial. How do you make it workable?

Paul Bartram: It's very threatening to government agencies. We try to fly below their radar.

Alan Friedlander: The state came by in 1995 and established Mo`omomi as a place that's legislated. That was a very top-down approach and made rules that the community wasn't buying into. Guys were coming down from Oahu to hammer resources because they are in better shape in Mo`omomi. The state has washed their hands of it because the community washed their hands of the state.

Kerry Prosper: What is the ratio of fishermen and enforcement? Is there a low ratio of enforcement because of the structured value system in the community itself, or is it like here where the enforcement is overpowering the community?

Kelson "Mac" Poepoe: Enforcement comes from peer pressure. We don't approach fishermen with a top down approach. We watch out for each other. We set rules, everyone knows them, and they can tell if their neighbor is doing something wrong

Jeremy Prince: What is the population size?

Kelson "Mac" Poepoe: There are 6000 people on the island. The island is open to everyone. Anyone can fish there if they want.

Alan Friedlander: But there's only one access road that goes in. It is a dirt road. By going down that road, you implicitly accept the rules set by the community.

TWO FISHERS' KNOWLEDGE SYSTEMS AND FRONTIER STRATEGIES IN THE PHILIPPINES

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ABSTRACT

This paper highlights two different fishers' knowledge systems in the Philippines. These fishers' knowledge systems underlie distinct strategies for sustaining a continued livelihood from the sea. They encompass paradigms for success in fishing and are oriented to contend with change and uncertainty. They incorporate ideas about closing or opening resources and sharing or exchanging opportunities with outsiders. What fishers seek to manage are the *conditions* of making a living, which include moral concerns of equity in relation to scarce *opportunities*. Not all resources are well known and some are highly enigmatic. Fishers' relations with resources are linked to the current economic and social values of fish within both market and community economies.

The Davao Gulf fishers can be seen as being caught up in a 'knowledge race' (as in an arms race) where the fishing strategies are adapted to quickly respond to changes in the behavior of fish and of other fishers, as well as of markets. Fish are viewed as instant money and successful fishing is often described as hitting a 'jackpot'. Fishing in the past 20-30 years has been characterized by a rapid rise and fall in deployment of geartypes. The fishers employ a frontier strategy, which results in their 'being well rounded' (i.e. technologically knowledgeable and innovative). Some aspects of this strategy include: 1) the wide repertoire of individual fishers, 2) the phenomenon of *dayo* or fishing visits or sojourns.

In the traditional capture or *mataw* fishery, for seasonal flying fish and dorado in Batanes, efficaciousness or 'luckiness' (*sagal*) is experienced as stemming from the agency of fish that 'go to' worthy fishers. A fisher 'with knowledge' (*mian kasulivan*) knows the ritual technologies of attraction and persuasion in order to maintain relationships with the invisible sector in nature. This knowledge also has a collective aspect aimed at establishing precedents and rules for sharing fishing grounds each season.

The paper does not apply the usual idea of an 'open access' commons as a salient condition in fisheries but rather asserts that potential resources are being approached by fishers as locally defined kinds of 'frontiers'. The 'frontier' seems a particularly helpful conceptual tool since it evokes perspectives on the active construction of 'resources', of 'knowledge', and of 'others', such that temporal frames in the development of the fishery become apparent.

INTRODUCTION

The title of this paper speaks of 'Two Knowledge Systems', in the sense that any one society will always have several kinds of knowledge that are put to work in daily life (Worsley 1997). Fishers' relations with resources are linked with the current values of fish within both market and community economies[1]. What does it mean to be 'knowledgeable'? How do fishers' knowledge systems relate to the economic and social values placed on fish?

In this paper I examine distinct strategies for sustaining a continued livelihood from the sea. Rather than resources, this paper begins with a view that what fishers seek to 'manage' are the *conditions* of making a living. These encompass moral concerns of equity in relation to *opportunities* that are scarce (and not necessarily resources). In fact, fishers are seeking to manage or negotiate *change*. Contending with change and uncertainty is the context for wielding knowledge, or different kinds of knowledge, and different kinds of technologies. Fishers therefore are people that are better described as intent firstly on sustaining *livelihood***,** rather than on 'conserving' their resources. Forms of fishers' knowledge are part of particular *strategies* to deal with change. How resources are perceived and exploited depends greatly on the expectations of the market and of major communities.

Fishers are always putting their knowledge to work, and expanding, refining and reassessing it to keep up with changing circumstances. Innovation is primarily motivated by how it may support varying modes of participation in global markets or other systems of exchange. It is for this reason that fisheries are the site of the quickest transformations anywhere. My discussion brings us to a consideration of the fishers' approaches to shared resources as 'frontiers' rather than 'open access' resources. By this I mean that in all cases the general value of 'being first' is underscored as a source of legitimacy and power.

A frontier strategy can involve a process of accelerating change, by intensifying effort, seeking to be at the cutting edge of knowledge and technological innovation, establishing networks and institutions, reciprocal relationships, facilitating access to technology, knowledge, markets and resources, because 'early birds' can benefit most or can establish prior claims. Fishers' strategies may incorporate ideas about closing or opening resources and sharing or exchanging opportunities with outsiders. On the other hand, an adopted frontier strategy may also be collective, concerned with controlling the way that precedents are established, and therefore refining and reemphasizing the value of *tradition*. Two cases from the Philippines (Fig 1) exemplify these contrasting strategies.

Figure 1: Map of the Philippines

The two groups of fishers discussed here belong to two distinct geographical settings. In the Davao Gulf the situation is extremely dynamic. Migrants and natives, and sojourning fishers (especially from the Visayas) contribute to rapid change in this fishery; knowledge is wielded as in an arms race, to keep up with the knowledge of other fishers and of the fish. By contrast, Batanes, a group of ten small islands just below Taiwan, is quite isolated from the rest of the Philippine archipelago, from other fishers (except for Taiwanese offshore fishers with more sophisticated technology), and from markets outside of the province—because of the strong currents of the Balintang Channel and the seas surrounding Batanes. It is apparent that fishers in both places are skilled, experienced, and knowledgeable, but nevertheless it can be seen that not all resources are well-known, or that these can be highly enigmatic.

FISHING IN SAMAL ISLAND: BEING 'WELL ROUNDED'

This was how I often heard fishers I interviewed describe their fishers' knowledge: it is, and they are, 'well rounded'. They meant that they knew more than one kind of technology, that they were not specialized to a single gear type but had tried their hand at many. They possessed different kinds of gear and shifted between them depending on what kind of fish they felt would 'let themselves be caught' ("*ang magpahuling isda"*) at a particular hour, tide, time of day, month, or season. Most said they could catch both 'fish near the surface' and 'coralline fish'; had fished in 'nearshore', 'off shore' and 'out to sea' fishing spaces. In the course of careers as fishers they had handled quite a large variety of gear and had been part of both small-scale and relatively large fishing expeditions. Periods of learning and developments in their technology were closely related to how and when the market links were forged. Meanwhile, being 'rounded' was also a result of the constant technological innovation that has been necessary to keep up with changes in fish behavior.

After putting together several biographical anecdotes of individual fishers, I realized that their wide range of experience was a reflection of intensification of fishing and the remarkably rapid turnover in technology which has taken place in the Davao Gulf. All these changes have taken place since the early 70s, the space of a single generation. In fact, communities along the east coast of Samal Island are themselves about the same age as the fishery; many houses and settlements were established only within the last 20-30 years. Samal was at first sparsely populated by natives not particularly oriented to the sea. As they said, 'fish were easy to catch'. Sometimes, it happens that there are fish that are just thrown onto the sand by the waves and can be picked up by hand (I observed this once).

The common 'original' fishing gear were the thrown net (*laya*), and the fishing spear (*bangkaw)* both of which could be used from shore or by waders, with no need for a boat. Practically all other terminology for fishing gears used today uses Visayan words (Box 1) .

Box 1. According to B, a fisher in Aundanao, his gillnet for *ukihuk* used to have a larger mesh size and was meant to be floating. Then a friend of his tried tying stones to the net so it would sink. The result was amazingly successful. In 1991-92 this method was guaranteed to catch many fish, up to 60 to 70 kilos each time. B, who is also a barangay councillor, proposed acquiring this new technology as a project of the Aundanao cooperative for a loan of P42,000 from the Department of Agriculture. With this money they procured nets for 5 groups of fishers and were able to pay back the loan in record time. For the success of this project the cooperative won a further P25,000 for having the "Best Project in Region 11". (They used the money to set up a *payao*, or fish aggregating device). However after 1992, the winning net design caught much fewer fish. B thinks the fish have learned to see the net and swim **over** it this time.

In the 1960s, (in the part of the island where I did fieldwork) fishing was still mainly practiced to procure food, except for a few avid fishers who brought their fish to sell in markets in Davao City or other towns on the mainland across the sea. By the 1970s, the population around the Gulf was growing from the influx of migrants; fishing was booming. Migrants included Muslim Tausug, and Visayans of all kinds. *Basnig* (box-shaped nets used with lights) enjoyed a heyday, dynamite became prevalent, and beach seines were also productive at this time. Gillnets did not become common in Davao Gulf until the late 1980s. Displacing other technologies, including the use of dynamite, they quickly evolved in size and dimensions.

Within the community where I did my fieldwork, one particular date could be cited as a turning point: in 1980 the first local *comprador*[2] established a fish buying station in the locality. With this, fish became not just of value as *food* but was instantly convertible to money or even other goods (like rice, soap, coffee, etc.) that could be taken from the comprador's store with no need for the intermediation of cash. In effect, fish *became money*; both the value of delivered fish and a fisher's debts would be recorded in the comprador's notebooks and these transactions made fish virtually as good as cash.

The evolution of fish from subsistence to a commercial resource follows in the footsteps of other natural resources such as *abaka* (Manila hemp), copra and logs from the forests which have historically characterized Mindanao as a regional frontier. People from other parts of the Philippines were attracted to migrate in by the perceived opportunities for gathering or producing money from the environment.[3] Government also encouraged migration to Mindanao as a 'land of promise'.

In 1997 there were already 6 'sari-sari store' owners that were also fish compradors in my fieldwork area. Between 1980 and 1997, fishers noted that 'everybody' in the barangay learned how to fish. However over the same time the typical volume of catch also dramatically declined. The transformations are reflected in the following typical statements:

'All kinds of ways of fishing are here already.'

'Now everybody, including children, know how to fish.'

'There was a lot of fish (before), just nearby.'

"The fish were large when the compradors started in the 80s, now they are quite small.'

'Before it was not unusual to catch 15-25 kilos at a time, now however it is more usual to catch 2-3 kilos, and rarely reach 10.'

'Before there was no hunger, life was not difficult.'

'Before, night-time fishers returning at break of day would be met on the shore by dozens of "kanaway" (or 'people meeting the boat'). The beach was 'like a city' for sheer number of people; only after distribution among all of the people would the fish be sold to the comprador.'

In discussing declines in yield however, fishers did not emphasize scarcity (although they do recognize limits in fish stocks relative to increasing populations of fishers), but rather they emphasized the agency of fish, their increasing evasiveness and 'smartness'. The fishers' response to this problem is to constantly figure out how to keep abreast, or ahead, by a strategy of constant innovation in technology. Fishers are engaged in a 'knowledge race', pitting human ingenuity against increasingly elusive resources. In spite of their small catches, many fishers I talked with seemed to feel that they are at the forefront of the technology race.

A kind of natural selection of technology is visible in response to apparent changes in fish stocks and behavior. Lights for attracting fish have become brighter with use of the remodeled

'combination' *Petromax* or *Aladdin* lanterns (See also Hamilton, this vol). (Large fishing boats meanwhile were sighted making use of ultrastrong 'superlites', said to be up to 2,000 watts, which some fishers think affected the minds of the fish.) Simple hook and line gears have become more and more specialized. The original simple *bundak* or small hook and line used to have only one hook attached to it, now it has at least a dozen, and in Peñaplata (a town on Samal Island) some are using up to 800 small hooks on a single line. Artificial baits have also become more sophisticated. Fishers spend their free hours fashioning beads and shiny 'marlon' threads into specialized bait for specific times of day and targeting particular types of fish. Gillnets were originally bought ready-made from hardware stores in Davao City, but most fishers now make their own gillnets, incorporating many innovations in design.

To inquire about successful fishing in Samal is to learn fine points about gear, technology and timing. They speak precisely of the depth of the waters in which they fish, and whether it is best to use a particular method when the current is 'coming in' or 'going out' of the Davao Gulf. The choice of gear depends on the species aimed for, the time of day or night these fish habitually feed, and on the nature of the sea bottom (sand, corals or mud). Most of the technology they use is not broad-spectrum, but highly specialized. Fishing activities are usually referred to using terms which relate directly to the species targeted (e.g. "manulingan", 'to catch tunas"; *"manginhason",* 'to get shells', etc.). Fishers stressed that they are "*suheto"* or possess all the necessary skills, are "*antigo"* i.e. 'experienced' or 'expert' with respect to certain kinds of gears, or that they have certain gears "*cabisado"* ('knowing something back to front') or "*memorized*", or that they are 'round' ('all-around').

'Now the nets are all longer—both in width and in length—and now there are many kinds.'

'The fish today are just like people, they learn quick.'

'You have to think which is the best way to get fish. You have to try different baits the fish might want to eat. If the fish doesn't eat it anymore, then you have to think up another kind that he will like to eat.'

"There would be fights out at sea because the pamboats were colliding. Now there are no fights because there are few fish. The tulingan are all being taken by the kubkub, by the Muslims like Haji Yusuf, that's why the Muslims have a lot of money."

'Before, there were many "dayo", but those fishers from other places won't be coming back like before because there are already many fishers here.'

Dayo are visitors or outsiders that have played a very significant role in the development of the technology and market networks in the Davao Gulf. In a substantial way, local fish and fishing grounds become more intimately known through the interest of strangers. Shellcatching for example was initiated in Samal by *dayo* from Cebu. Another kind of visiting fisher is the "Jolohano", Muslim gillnet fishers based their boats on the beach for periods up to one month, especially in May, August, and November in the late 1970s. They caught very many fish near the shore. Locals learned about gillnet technology from observation of these fishers.

Among the dayo I met in 1996-1997 were flying fish fishers from Leyte (in the Visayas). They were using a large net with large buoys, which also necessitated hiring some local help. They had brought four large motorized bancas. According to them, they were the only fishers in the entire Gulf with specialized technology for catching flying fish. They had another base in Davao Oriental across the sea.

From the point of view of locals, most sojourning *dayo* were usually technologically superior and also had the important ties to financiers and buyers. Locals were able to acquire their knowledge and, more importantly, their market links, through hosting and facilitating access to local resources. In a way, exposing the resource to outside exploitation is part of a tradeoff. Especially in the beginning it proved the only way to gain access to particular markets. Dayo try to maintain their welcome by portraying themselves as exploiting only particular economic niches by their specialized techniques, thus appearing not to compete with locals. The interaction between permanent residents and short-staying visitors has had an impact on the consolidation of communities and of larger networks. In this way, locals could participate in markets, exchange information, and enjoy other forms of reciprocity with outsiders who could potentially also be assimilated into the community by settling down and becoming local residents. At the same time, because there is a limited period for outsiders to enjoy these privileges, they will be clearly interested in maximizing exploitation. Intensified exploitation in turn, accelerates the gear turnover in Davao Gulf (Box 2).

Box 2. C's shell harvesting group numbered about 50 people, aged between 10-40, including parents and their children, traveling on four motorized boats. The group used nets to harvest shells. From their original base, they moved to other places around the Davao Gulf, reaching Balut Island, Sarangani. Talikud Island near Samal was where they stayed longest; they settled (*nagpundok*) there for three years. On subsequent expeditions, they also went to small islands in the Visayas, as well as to Bohol and Panlaw, Tagbiliran City. Typically they stayed 2-3 months, as long as shells could still be taken in sufficient quantity to support their daily living, before returning to deliver in Cebu. According to C, they explored every 'nook and cranny' of the coast. Shell harvesting opened and explored parts of the local waters and bequeathed some place names to parts that became known for certain kinds of shells. At present, the other original members of C's group are back in Cebu and have shifted to fishing or construction work. C married a local woman and settled in Talikud, he continues to handle nets for shells but this time these are financed and owned by local and Davao-based buyers.

Thus, individual fishers and local communities learned about their resources through the interest of outsiders. The locus for negotiation and control is the point of passage, rather than the resource itself, which is not fully known, usually not self-contained and has no established limits. It is the small number of opportunities to participate in the market that are subject to claim. However, it seems that in this frontier strategy, transferred to the Davao Gulf from the Visayas, the only way to control change is to participate in processes that would in fact accelerate the pace of change.

KNOWLEDGE/POWER: USING 'KNOWLEDGE' IN TRADITIONAL MATAW FISHING IN BATANES

Mataw fishing in Batanes is a special case. Strong currents separate the Batanes area from the rest of the Philippines. The only regular and frequent form of transport is by Fokker plane (3x a week) and therefore expensive, isolating the region from both national and international markets for fresh and dried fish.

Traditional fishing for dorado (or dolphinfish) in the summer season of March-May involves a special relationship between the fishers and the landscape known as *mataws*. Mataw fishing takes place on the eastern side of Batan Island, in Mananioy Bay or Valugan Bay, although some fishing trips may take them further, to the southern and northern parts of the island. This is an indigenous fishery involving highly formalized protocols in a *collective* strategy of frontier. The motif of 'firstness', and the power of 1st actions and precedents consistently runs through the mataw traditions.

Traditionally, the means of access (called the *vanua*) to these fishing grounds is ritually 'made' and 'dismantled' at the beginning and end of the season. Each summer is a new fishing season that is collectively managed by careful actions. *Mayvanuvanua* is a ritual of sacrifice performed by the group of fishers at the onset of the season. Its object is to negotiate for a season of safe passage and successful fishing, a form of collective contract and request put forward with the unseen powers and with the fish. It is held in their landing site along the coast (the *vanua*). At this ceremony, a 'Firstfisher' or *mandinaw nu vanua* is chosen from among the mataws. His job is to call the fish and to set good precedents by his actions on the first fishing trip and for the rest of the season. He is chosen to represent the group in recognition of his being a good fisher and a 'knowledgeable' person.

Traditionally, 'knowledge', or in Ivatan '*kasulivan',* is very important in gaining an edge in this formalized frontier. However mataw 'knowledge' is intended to make the self or body of the fisher as well as the vanua into "clean" and therefore attractive things. Fishing is an activity of getting to know and relating well with fish and other natural agents, both as individuals and as members of a group. Fishing is a highly social enterprise.

As one who 'has knowledge' (*mian kasulivan*), a traditional mataw can tap into the invisible potencies that can be found both in the natural environment and within himself, to influence nature: fish, the weather, and good fortune as a whole. In actual practice, *kasulivan* concerns knowledge of how to manipulate certain ritual materials (like sugarcane wine, a coin, a rare bluegreen bead), and of saying special and powerful words that form binding parts of the landscape—'like a curse'. 'Knowledge' is also needed for the rites of 'cleaning' (*maynamunamu*) of gear of individual mataws or of the vanua (which is collectively maintained) in the middle of the season.

The ritually constructed vanua can be seen as an ideal technology enabling one to catch many fish with the least effort, a collective 'technology of enchantment' (Gell 1999). Even if mataw fishing seems a highly individual endeavor, it is done in the context of responsibility for the fortunes of the group as a whole. To be chosen as Firstfisher or *mandinaw nu vanua*, and be the first to pass through the vanua, the first to fish, confers a dangerous power to perform influential actions, and it presumes knowledgeability.

'Firstfishers'[4] are said to be chosen for their proven ability to catch many fish (*sagal*). This is also a reflection of social esteem; they are in fact ideal leaders who do not harbor ill will toward fellow fishers, their character is affirmed by the fish and by nature. Arrogance brings wind and waves; calmness of character brings good seas and attracts fish. Knowledgeability is an innate talent or trait, part of being approachable to both fish and the invisibles.

Although 'knowledge' and relations between fish and fisher, and fish and the fishing group as a whole, may be traditionally a subject of much attention, interviews with retired mataws indicated that the younger generation is much more "masagal" or successful than their elders. Some old and retired mataws of Maratay told me they never equaled the catch totals of this current generation of fishers; compared with their experience, the seasonal catches of up to 100 and 200 fish in a fishing season by the contemporary mataws are simply phenomenal. They cited restrictions that set quotas and limited catch potentials before, and they also attributed this to improvements in the fishing gear. '*Many dolphinfish got away before*.'

Technological improvements have been made to different aspects of gear. Present-day hooks are smaller and lighter. Many mataws use hooks they have shaped themselves as well as commercial hooks. Fishing lines have also been improved, with many alternatives, and personal preferences vary among fishers. The more traditional kind of fishing line is the *tuyungan,* a stranded line (as opposed to the 'solid' or '*tansi*') that was formerly twisted out of *hasu* fiber. It is now much thinner as fishers make it out of drifted rope or fishing net fibers from Taiwanese fishing gear. The nylon version is also often bought commercially. (Much equipment in Batanes, from fishing gear to water containers is crafted out of drifted material from Taiwanese fishing boats: nets, metal clips, buoys, floats, plastic water bottles, etc.). Both the new 'drifted' and commercially available industrial materials made the work of fishing 'easier' as the manufacture of gear from indigenous materials was quite labor intensive.

When one inquires about the details of fishing paraphernalia among mataws, it turns out that there is much individual variation. The fishing line can be prepared with a hook on one end, or made *misamorongan,* that is, with hooks attached on either end. Each mataw has his personal style, and makes a lot of his gear himself, using many found materials. For example, one mataw said his father would bring 8 fishing lines to sea, but he himself takes only 5, and he doesn't like misamorongan because it is 'hard to fix' (arrange neatly in the boat). Another mataw uses 7 hooks: six on three *misamorongan* and one on a 'solid' line.

However, everyday talk is less about differences in gear, than about what part of the Bay they went to, how many flying fish they had, how many dolphinfish went to them, and how they got fish from others. Only when I interviewed several mataws on the details of their paraphernalia, did the discourse about the fish suddenly shift: They talked about fishing as a contest of wits between fisher and fish, and I heard a sentence that could have come straight out of the mouths of the Davao fishers: '*people have become smarter, but the dolphinfish have become smarter too.*'

The fishers of Batanes, including the mataws are no less empirical than the fishers of Davao, but for them, the dilemma of the changing times seems to be how to make tradition and 'knowledge' conform with different ideas about knowledge: 'Knowledge' retains potency, but seems anachronistic, to be known to use it is uncomfortable and sometimes a source of embarrassment.

The reality of mataw fishing is based on the substantiality of an order of power, 'knowledge', and the potential for human negotiation between visible and invisible worlds. An alternative 'modern' reality challenges the mataw traditional world. It is represented in an 'open sea', secular technology, market and different knowledge system.

At the onset of the season, mataws themselves create and reproduce one form of reality carefully. The continuation of tradition depends solely on whether they elect to perform the rites of *mayvanuvanua,* which affect the landscape. Accepting a modern context for fishing converts success into a matter of arbitrary chance, rather than as individual potency where everything is meaningfully interconnected; it means to cease relating to and, by virtue of having 'knowledge', using the power of the invisible that is potentially also inside one. This is the root of the dissonance between traditional and modern orders of time and space as it is being experienced by the mataws in Batanes. The person who decides to be modern must consciously drive a wedge between himself and the invisible parts of the world.

Fishers' knowledges and strategies: on the concepts of 'frontier' vs. 'open access'

A frontier, it has been observed, provides an 'institutional vacuum' for the unfolding of social processes (Kopytoff 1987:16); such processes can be seen at work in the Davao Gulf. By contrast with the Davao material, traditional mataw fishing in Batanes views 'knowledge' or *kasulivan,* in a very specific light. '*Sagal*' – something that some people have more of and which enables them to catch many fish – is a quality that is enhanced through communication and interaction with the fish and with the *anitu* (spirits, invisible beings), and knowing how to 'say things' in particular places. But both these sets of fishers are using knowledge within the context of particular strategies to negotiate with change.

I would like to conclude by discussion of the notion of a local 'frontier'—as opposed to the concept of an 'open access' commons. The concept of frontier presumes dynamic processes, encompassing within it a sense of temporality, phases and precedent, setting or pioneering strategies which also establish claims. This is why fishing is a matter of establishing habituated paths, and especially by getting there first. Competing perspectives are anticipated, given that the seascape must be shared with others. Change and uncertainty must be contended with. Different kinds of knowledge are important and key in negotiating access or setting protocols of access. The Batanes fishery is a very formalized frontier where traditions provide for instituting innovation.

It is appropriate to understand the fishing grounds of the Mataws in Batanes and small scale fishers in Davao gulf as frontiers, to each of which belongs a different system of knowledge. Fishery managers would do well to recognize the social dynamics underlying the generation and utilization of different knowledge among fishers.

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References

Gell, Alfred. 1999 (/1992). The Technology of Enchantment and the Enchantment of Technology. In *The Art of Anthropology*. The Athlone Press, London

Gudeman, Stephen. 1996. Sketches, Qualms, and Other Thoughts on Intellectual Property Rights. In Brush, S. & D. Stabinsky (eds), *Valuing Local Knowledge: Indigenous Peoples and Intellectual Property Rights*. Island Press, Washington, D.C.

Kopytoff, Igor. 1987. *The African Frontier*. Indiana University Press, Bloomington

Mangahas, Maria. 2000. *Managing Luck and Negotiating Change—Ethnographies of Fishing and Sharing in the Philippines*. PhD Dissertation in Social Anthropology, University of Cambridge.

Worsley, Peter. 1997. *Knowledges*. The New Press, New York

Zayas, Cynthia. 1994. Pangayaw and Tumandok in the Maritime World of the Visayan Islanders. In Ushijima, I. & C.N. Zayas (eds) *Fishers of the Visayas*. CSSP Publications and UP Press, Diliman, Quezon City

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[1] Gudeman (1986) discusses market economy as participated in for individual profit, and where knowledge may be 'owned' individually, while community economy is concerned with the reproduction of the community itself. Commonly held knowledge is part of the base of the community economy.

[2] A comprador is also a member of the community; s/he has a *suki* or guaranteed buyer to deliver the fish to, usually in the market in Babak, the capital of the municipality, which is about an hour away by jeep.

[3] Abaka cultivation in Samal (initiated by the Americans, developed by Japanese businessmen and migrant workers) declined after the war. Many migrants to Samal (usually from the Visayas) in the 50s had come to work in the logging industry. (By the late 60s, deforestation in Samal was nearly total; the forests were replaced by coconut trees.)

[4] I use the term 'firstfisher' to refer to the *mandinaw nu vanua*.

HOW SASI PRACTICES MAKE FISHERS' KNOWLEDGE EFFECTIVE

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ABSTRACT
Fishers' knowledge is an important component of natural resource management in *sasi* tradition. *Sasi* is a traditional resource management system which is practiced by people in the Indonesian province of Maluku. Harvest restrictions such as timing and fish size limitation, are examples of arrangements that are determined based on sasi traditions.

The fact that fisher's knowledge remains an effective component of *sasi* management in many locations in Maluku suggests that there is something important to learn about what makes it possible. In line with this, a study by the author identifies two causes: (1) the existence of several factors that have encouraged village leaders and the village community, including the fishers, to observe *sasi* management system, and (2) the willingness of the community to adopt modern scientific knowledge to enrich and bring up to date their traditional one. Some factors that support people's observance are local customs, religion/belief systems, and respect for the wisdom of elders. An example of scientific knowledge that people incorporate into their traditional knowledge is the information on contemporary environmental changes that affect their water resources.

This paper concludes with a proposed working model of how resource management should be constructed, especially in the case study area, so that the performance and contribution of local fisher's knowledge in *Sasi* management can be optimized.

INTRODUCTION
Strictly speaking, *sasi* is a Malukuan term for regulations or prohibition on doing something. These regulations or prohibition are established by and in an assembly of community members or their representatives, which forms a village council normally composed of *customary elders*[1]. This council is responsible for setting up arrangements, which include details regarding boundary definitions where the regulations are applied, and sanctions and punitive arrangements for those who do not comply with the regulations. Even though *sasi* refers more commonly to a community-operated natural resource management system (Kissya 1993; Rahail 1993), it may also apply to certain kinds of social affairs, such as regulations intended to prevent immoral conduct in the village (Kissya 1993). An example is a *sasi* that prohibits males from going to the area of a village's public water spring assigned exclusively for females, or vice versa (Kissya 1993).

Fishers' traditional knowledge is often adopted to shape resource use regulations, wherein enforcement is carried out using premises given by the *sasi* tradition. Fishing communities, for example, use traditional understanding about the relationship between intensity of harvest and annual fish production, as the basis for the establishment of several fish harvest restrictions. Enforcement mechanisms vary from place to place and may change over time. In some places, a police unit specifically established for *sasi*, may be in charge of monitoring and enforcement. In others, monitoring and enforcement may become the responsibility of all individual members of the village community. Fines and sanctions may also be used to discourage noncompliance and to support enforcement.

Even though arrangements involving traditional knowledge are becoming ineffective in several locations, they still work well in many others. My observation indicates that this might have been connected to the following factors: In places where such arrangements are effective, two features exist and apparently have played roles in making it possible. The first is that *sasi* is, most of the time, respected by people. The second is that while traditional knowledge is always the main element of resource use regulations, modern scientific advice is also considered whenever necessary. This paper presents a discussion which can verify the role of these features in supporting the workability of fishers' knowledge in resource management in the case study area.

WHY ENFORCEMENT MECHANISMS WORK IN SASI -- THE ROLE OF CULTURAL FACTORS
Cultural factors have been identified through field observations in Malukuan villages as being important to the formation and observance of regulations employed in *sasi* management. These factors are customs, religion/belief systems, and respect for the wisdom of leaders. For the most part, these factors are manifested

[1] Customary elders are persons selected by all members of clans to represent them in the village council

in the form of a moral power or understanding that encourages both leaders and citizens to abide by the regulations they have agreed upon in common. This finding is comparable with cases discussed in the literature (e.g. Wilson 1982, McNamara and Tempenis 1999, and Edgerton 1985), which indicate that beliefs and/or variations in the way rulings are determined and handed down by leaders are important elements for observance of a regulation in general. The following discussion will show where these cultural elements exist in natural resource management. That is, we will see how these three factors are connected to development and observance of sasi.

As mentioned in the introduction, one of the interesting findings made during my field work was that some *sasi*s are present and functioning in some villages but not in other, neighboring villages. My presumption is that variation in the use of *sasi* is caused by regional differences in the way the three cultural variables mentioned above are present and perceived by villagers in various locations. To see if this presumption is true, I conducted in-depth observations on this matter by using Kei Besar Island, in Southeast Maluku as the focus of the study. In addition, where appropriate, case study examples from other parts of Maluku also are presented to complement the information collected from Kei Besar. In each case a description of local customs, religious practices, and the role of and respect for leaders are cited to illustrate how they have influenced the performance of *sasi*.

The influence of belief

One of the important characteristics of *sasi* is the influence of either religious or local mystical belief systems, or both. The influence of belief can be traced back in time to the period where many people practiced individual property-protection systems that involved mystical belief. People at that time found it effective to involve supernatural power in the property protection system. In *sasi*, evidence of this influence can be found in the prayers delivered in ritual ceremonies marking the closing or opening of *sasi*. Even though the types of prayer vary depending on the religions or beliefs that are found in the different villages, their main message is similar; i.e., an expression of gratitude for the blessings of the year that passed, and a call for more blessings for the future years. In some villages, prayers also include a request for punishment for those who break a *sasi* rule (e.g. in Wattlaar and Hollath). But for most other villages this kind of a request is not normally included.

The following cases are examples of management practices involving the influences of belief which can be observed in Malukuan communities. One of these examples is belief in supernatural power, something beyond human capacity to fully understand, which can be used to help individuals or groups protect their properties. While in some places it is not unusual to hire a person to guard personal property, people in many villages find it more convenient to adopt a form of a supernatural mode of property protection. In other cases, both approaches may be used simultaneously.

Property protection involving mystical belief is widely practiced by Maluku peoples. While this system was initially adopted by their early ancestors, present day villagers still employ it in many locations. For example, in the village of Ler Ohoilim, in the eastern part of Maluku, one can observe bottles of water tied up with a piece of ribbon-like fabric, generally red in color, hanging about one meter above the ground on coconut trees. The people there have a devout person pray over the bottles in the hope that his/her blessing would protect the tree from robbers.

On Hatta Island, in the central part of the province, many villagers believe that one will have his or her stomach inflated and deflated following the rise and the fall of the sea tide if he or she ever disturbs a 'protected' object. They believe that a prayer delivered by an *orangpintar* (lit.: a capable person) makes such an occurrence possible. Further to the west, another example of belief in supernatural powers can be found in the Lease Islands, where the word *pakatang* is quite popular. This word refers to black magic, which is normally used by a person to take revenge or to punish someone whom he or she believes has somehow upset them. In some cases, however, people simply use it as a means of protecting their property. Apparently due to its 'black-side' nature, *pakatang* is less practiced these days than it once was.

Similar influence is also given by modern religions. Prayers delivered by a religious leader, even though rarely including a wish for specific punishments, are often believed to have a magical power too. My research discovered that while religions embrace different prayer contents, the general messages they deliver are similar. In the case of most *sasi*es of the past and some of today's *sasi*, rituals almost always include an offering to mystical objects. But, now

that religions have penetrated into the people's social lives, many inappropriate ritual segments have been revised. For example, beliefs that are inconsistent with religious teachings are put aside. And, no mystical practices are maintained in *sasi*. On the contrary, prayers that are more appropriate to modern religion have been adapted. In these cases, no offerings to spirits thought to inhabit rocks, stones, or trees are performed.

There are differences between these practices, and the above examples represent only few of the beliefs that were and still are alive in the communities of Maluku. Yet they all imply a similar phenomenon: that values, especially belief in the Supreme Being or a supernatural power, make a nonphysical, spiritual, control system effective. This suggests that people have found that property protection which takes advantage of people's belief in supernatural power is more practical than employing watchmen. Thus, what can be learned here is that the adoption of a supernatural property protection technique has been perceived by Maluku property owners to provide higher assurance of protection at less cost. Generally speaking, then, it is clear that mystical and/or religious beliefs have strongly influenced the kind of property protection system that the communities have developed, and that they are important in the case of *sasi* collective management systems.

The influence of customs

Some operational aspects of *sasi* are similar while some others vary. What is common for all cases is that a *sasi* almost always connotes a prohibition that follows a certain customary formality, and is assumed to be observed by every single individual who happens to be in the village, either temporarily or permanently. However, the actual forms of customary influence may be different from one *sasi* practice to another. These variations are apparently associated with differences in the way people of different localities adapt their customary laws into *sasi* formulation and implementation. Thus *sasi* practice may differ from village to village even though they may face similar circumstances.

Customs and customary values have involved in shaping the general design and control mechanism of *sasi*. A common characteristic of communities that adopted *sasi* in the past is their dependence on the natural environment for their sustenance. This has created a situation wherein they have had to manage their resources for the common good. Thus all resources that exist within the village domain are perceived to be the common property for all members of the community. In turn, this perception becomes an important customary value that every one in the community, from generation to generation, should respect. This means that every individual also has the right to participate in determining collective actions aimed at maximizing collective benefits. Consultative meetings facilitating the formulation process of *sasi* are an example of the result of the perceived need for collective action. Ideas and arguments are advanced by people, who are the actual stakeholders of the resource. Because of such meetings, many village communities in Maluku end up accepting the idea of *sasi*.

Although spatial and temporal variations might occur, the essence of collective action remains the same in all cases. In the old days, when the population of a village was generally small and their economic activities were limited, all members of the community might easily attend such meetings. However, now that the population has increased, holding an all-community meeting is quite a challenge. Instead, most villages in Maluku have adopted a representative system, where only members of the *saniri negeri* (lit: the village's customary deliberation council), are present at the meeting. There is some variation amongst villages with regard to the composition of a *saniri negeri,* but it normally is composed of *margas* (clans) or *soas* (groups of several clans). For more important cases, the meetings are attended by members of *saniri besar* (the village's customary consultative assembly), which includes all members of *saniri negeri,* village executives, customary elders, and other distinguished persons of the village.

Two things are worth mentioning concerning local variations. The first is the popularity of private *sasi*[2] in Southeast Maluku as compared to that in Central Maluku. Even though private *sasi* is found just about everywhere in Maluku, it is more prevalent in the Southeast. This apparently has something to do with the availability of more clearly stated individual rights in SE Maluku communities: *'hira i ni fo i ni, it did fo it did.'* (Theirs are theirs and ours are ours). What this suggests is that the people of Southeast Maluku are more likely to develop a private *sasi*. The second variation is associated with the past record of property rights transfers,

[2] private sasi is a sasi that is proposed by individuals and approved by the village council, so that enforcement is carried out following the usual arrangements of *sasi*..

which were common in many locations of Southeast Maluku. Granting pieces of land to groups of people belonging to another community was practiced extensively by early inhabitants of Southeast Maluku villages, including many in Kei Besar Island, with the hope that the newcomers would be able to guide the earlier inhabitants to a better life.

My field studies confirmed an important message, which was repeatedly stated by the villagers and their leaders. This message is that sanctions and other control mechanisms are not designed to intimidate people or to collect revenue from the ones who get caught committing violations. Instead, respondents reported that sanctions were established to persuade people not to betray the common interest. It is unlikely that they learned such a view from an external source, because they are generally isolated. Thus, principles that they follow must have come from something that they have acquired from internal sources, such as customary laws and religious values. Besides, as also emphasized by elders, this view is not a new invention. It is a customary value or *pusaka (*an heirloom), as the villagers claimed, which they have inherited from their predecessors. This claim is supported by a customary principle which says '*we carry out public matters according to customary laws*'. Thus, it can be argued that the message mentioned earlier in this paragraph is merely a reflection of their principles, which for the villagers comes from their customs or religious values.

Traces of customs or customary values are also found in primary control mechanisms that communities developed to sustain *sasi*. The following are several case illustrations of how sanctions, adopted by communities to help them as a form of control mechanism, are carried out in practice. In general, sanctions in *sasi* seem to be flexible because it is their effect which is actually the main concern. What is meant here is that a person caught violating a law has the potential to face the most severe punishment / sanction, available under customary law. However, another value in a community's custom allows for a moderate sanction to be considered when there is indication that the person is helpless and requires access to the resources to survive. Sometimes, circumstances might even prompt the leading decision-maker in the village to grant amnesty or pardon. More details on amnesty and other types of tolerance will be provided later.

Primary tools or control mechanisms normally consist of various moral sanctions, alienation, physical sanctions and fines of various kinds. Table 1 lists the types of sanctions that have been adopted by the village communities.

Table 1. Various types of sanction introduced by selected villages

Village	Shame		Harvest right revocation		Valuable item fines[2]		Labor fines		Physical punishment		Cash fines[3]		Performance[4]
	Past[1]	Pres[1]	Past	Pres	Past	Pres	Past	Pres	Past	Pres	Past	Pres	
Ohoirenan	√	-	-	-	√	√	√	√	√	√	-	√	*medium*
Weduar	√	-	-	-	-	√	√	√	-	√	-	√	*low*
Hollath	√	-	-	√	√	√	-	√	-	-	-	-	*high*
Wattlaar	√	-	-	-	-	√	√	√	-	-	-	√	*high*
Banda Effaruan	-	-	-	-	-	√	-	√	√	√	-	√	*low*
Kilwat	√	-	-	-	√	√	√	√	-	-	-	√	*medium*
Yamtel	√	-	-	-	-	-	-	-	√	-	-	√	*medium*
Hatta	√	-	-	√	-	-	√	√	-	-	-	√	*low*
Nolloth	√	-	-		-	-	√	√	√	√	-	√	*low*
Haruku	-	-	-		-	-	-	√	√	√	√	√	*medium*

Notes:
1. Past = implemented in the past, Pres = implemented in present times, after 1970
2. Common valuable items are *lela* (a small antique cannon from the Portuguese colonial era, priced at approximately Rp 300,000 each), some other antiques and gold
3. Cash is normally charged for the cost of the case process and fines, for which the amount is based on the level of the violation.
4. Performance: this category is based on the frequency of the violation within the past ten years, where low compliance is associated with more than ten violations; medium compliance is associated with five and ten violations; high compliance is associated with less than five violations.

Although different villages may introduce similar lists of sanctions to enforce *sasi*, the workability of these sanctions may not necessarily be the same in all cases. Given this, the way enforcement is actually carried out is an important issue. Formally, there are two distinct

methods of enforcing *sasi*, depending on the type of customs that apply in the communities where *sasi* is adopted. One method relies on the effectiveness of the traditional police, called *kewang*, while the other is built on the premise of an effective 'community watch' system. Through either one of the two systems a violation might be discovered and reported to an assembly meeting for action.

On Lease Islands, in Central Maluku, most responsibilities for control and enforcement are given to the *Kewang*, whose job is to monitor the implementation of all of the regulations, to apply sanctions against violators, to control territorial boundaries, to place signs of *sasi,* and to arrange and hold both periodic and emergency meetings. To carry out its function, a *kewang* organization normally has the following structure: two *kepala kewangs* (leading *kewangs), kepala kewang darat* (for land resources*)* and *kepala kewang laut* (for marine resources*)*. One of them also acts as the coordinator for both. Each of them, assisted by a *kewang pembantu* (assistant *kewang)* and several *anggota kewang (kewang* members), is responsible for their assigned tasks. In addition, the organization is also equipped with a secretary and a treasurer.

In Southeast Maluku, *sasi* control is based on the effectiveness of each individual reminding others about the importance of everyone participating in protecting their common resource. In some ways, this resembles a community watch system in western societies. There also is a strong indication that caste stratification characterizes enforcement mechanisms in this particular part of Maluku. The history of Eastern Maluku community development has made them acknowledge the existence of two[3] major caste categories, *mel* and *ren*. In the old days, outsiders were often invited by the original inhabitants of many villages to help them manage their natural resources. The consequence of this was that the outsiders, later called *mel*, became the first class in the social structure. The first inhabitants, later called *ren*, on the other hand, become the second class. Within this class arrangement, however, villagers prefer to use brotherly terms such as *adik* (younger brother) for the *mel* and *kakak* (older brother) for the *ren*. As a result, even though the *mel*s for all practical purposes are the ruling class, the *ren*s have a position by which their advice must be listened to by the *mels*.

One implication of the social stratification that exists in Southeast Malukuan communities is that, with the authority to rule the *ren*s, the *mel*s have the opportunity to maximize their share of benefits by asserting a more active role in resource management, and by taking advantage of their position. Their *sasi* arrangement shows that this opportunity has been implemented in practice. In Figure 1, it is shown that a portion of the revenue obtained by divers from the village collective sale, has to be surrendered to the village for common purposes including for redistribution. Table 2 shows that the redistribution is to secure the right of those who cannot dive such as children and woman. However, this table also shows that the marginal benefit is higher for the *mel* than for the *ren*. For example, the ruling group receives a larger share of the benefit generated from the resource harvest. Therefore, it can be argued that, given the *mel*'s social position, there is a tendency for this caste to increase its share even higher, by deceitfully taking some of the benefits which should go to the *ren*. This tendency, however is somewhat neutralized by the elder brotherhood status of *ren,* who will always be in the position of giving advice (read: reminders) if the younger brother attempts some irresponsible action. This is possible because monitoring everyone's actions with respect to the resource is not very difficult in many Southeast Maluku village communities. It is ease to see who comes in and goes out of the village, and how much they are taking. So, there is little chance that a person would be able to leave and take anything from the village without other villagers knowing.

Another implication of the existing caste system is that control is also carried out among the members of each group because they understand that the reputation of the group, and hence its credibility in the eyes of other groups, depends on the behavior of each individual member. Many respondents indicated that it would be a shame to have a violation perpetrated by a member of their group or clan. A quote from a respondent demonstrates this: 'Several years ago, I opted not to report a case of poaching which involved my clan member. Instead, I had him return the stolen trochus to the village, and told him not to poach again'. This indicates that from one point of view, the intense kinship relationships of the villagers could have an adverse effect on enforcement of regulations. In their society, however, individual homes are almost always open to everyone in the community, particularly those of the same caste or the same clan. Therefore it is not surprising that, as they emphasized in the interviews,

[3] There is another category of caste called *iri*, but it is not relevant to the discussion in this section.

monitoring other's behavior, both at home and at sea, is functioning well.

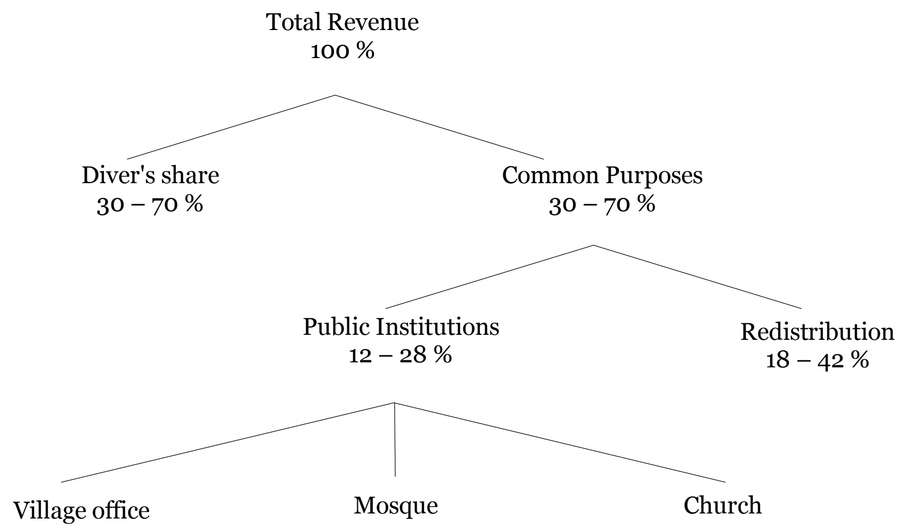

Figure 1. Diagram of revenue distribution in a *sasi* opening

Remark:

- Village institutions receive equal shares
- Redistribution to villlagers is carried out according to a plan as shown in Table 2

Table 2. The Ohoirenan's revenue redistribution (fixed share) scheme

Social category (i)[1]	Share factor (f_i)
Village head	5
Village secretary	4
Soa chief	3
Clan chief	2
Household head / widow	1
Unmarried aged 18[+]	.75
School drop-out	.50

Notes :

1. The benefit share received by a person of social category i is calculated as:

$$IR_i = RR \times \frac{f_1}{\sum f_i n_i}$$, where

IR_i, RR, and n_i are individual share, total redistributed revenue, and No. of people in category I, respectively

In Kei Besar, a good lesson that can be derived from the community watch system is that the system allows the development of awareness among villagers about the importance of observing rules. A friendlier atmosphere exists because 'community watch' is not a system where a guard watches for violations. Instead, it is, as understood by villagers, a system in which everyone is supposed to remind others not to violate local regulations. However, within this system, there are also potential drawbacks associated with the moral condition of the people. The example presented earlier where an individual was unwilling to disclose poaching because the poacher was a close family member is a case in point.

The *kewang system*, on the other hand, is a good alternative to the community watch system when it is unable to function well. Certain conditions need to exist for the *kewang* corps to be fully effective. For example, despite the prestige of being assigned to the corps, a *kewang* member still needs a sufficient source of income to support his family. Recently, many *kewang* members have experienced inadequate incomes due to declines in revenue associated with depreciation in the price of agricultural products. So, becoming a *kewang* member is not as attractive as it once was. Recently, the idea of providing a government subsidy to revive the *kewang system* was introduced (Haulussy, pers. comm.). However, this proposal will not be feasible because the costs that have to go to all *kewang* members may exceed the total revenue of harvest normally received by a village.

Religiousness

In addition to the formal sanctions and enforcement mechanisms, there are several intangibles that determine observance of sasi. One of these is religiousness. It is not unusual for Maluku people to characterize a village by looking at the prevalence of religious followers. A village is referred to as Christian (loc: *Kampung Kristen)* because the majority of its citizens are Christian, and it is called Moslem (loc: *Kampung Islam)* if most of the citizens follow Islamic teaching. When comparing the effectiveness of *sasi* in a number of villages of Kei Besar, in general it looks like the Christian villages were able to maintain *sasi* practices better than their neighboring Moslem villages. Wattlaar (Catholic), Ohoirenan (Protestant), and Hollath (Catholic/Protestant) are villages where the *sasi* management system has been sustained quite successfully, while in Banda Efaruan (Moslem) and Weduar (Protestant/ Islam), *sasi* is not functioning very well.

On the other hand, *sasi* practices in Saparua of Central Maluku provide evidence that it is not the type of religion *per se* that contributes to the performance of *sasi*. The fact that *sasi*es are functioning better in Christian villages of Kei Besar and in Moslem villages of Saparua appears to be an inconsistency. The argument put forward by Wilson (1982) and McNamara and Tempenis (1999) regarding the role of religiousness in law enforcement might provide a plausible explanation for these inconsistencies. Therefore, in the following paragraphs we will examine these religious aspects. Based on my field observation, special attention will be given to the leadership / organizational structure and the comprehension and practice of religious teachings amongst the people.

A distinction in terms of leadership and organizational structure is recognizable between the two major religions in Maluku, Islam and Christianity. The Christians have a more formal / coordinated type of organization, while the Moslems maintain a relatively loose structure. The Christian community form of governance is very effective, because each member is associated with one of the zonal groupings of the community. As a result, messages from a local Christian leader can be transmitted to virtually every member of the congregation within the respective village. A continuing flow of financial contributions necessary to sustain religious services can also be encouraged. The Moslem organizational style, on the other hand, does not have a solid structure. Consequently, Moslem villages do not have the same opportunity to mobilize collective action that Christian ones do.

Despite the fact that most Moslem communities are not traditionally well equipped with a solid administrative organization, there are cases where a devoted Moslem is quite influential in performing effective organizational functions for his fellows. The head of the religiously mixed village of Weduar, for example, notes that there was a period when leaders of the Moslem society in his village were able to establish good interaction with their community so that coordination could work well. Furthermore, the village head elaborated that this will be the case as long as religious leaders have a good appreciation of local history and customs; especially an appreciation of the fact that people in the village have a common heritage. He noted that a priest was expelled from the community recently because he had failed to recognize local customs and history. On the Moslem side, the same community is also facing difficulty because their leader is 'too young', and too immature to understand the customs and history of the village.

These illustrations carry two important messages. The first is that the efficient organizational arrangement featured by the Christian communities has the potential to contribute to the effective communication and administration necessary to mobilize support for public affairs. This may include support for the development of a co-management program such as is proposed in this study. However, the second advises that the actual effect of Christian organizational styles depends on how customary values are recognized, because, to villagers,

customs and religions are both important. What this means is that the highly organized administration such as that shown in the Malukuan Christian model, could fail to result in good coordination in the absence of an appreciation of local customs. Conversely, the loose organization common to the Moslems can be sufficient to mobilize people as long as customs are respected. So, it is clear that the significance of the organizational aspect of religions is subject to the incorporation of local customs and values.

Comprehension and practice of religious teachings is another important factor. In Maluku, religious teachings clearly can promote the social behaviors necessary to sustain the collective regulation of common use resources such as *sasi,* because they instruct people to be considerate of each other, a fundamental condition for a collective regulation. However, the extent to which a religion's teachings penetrate the life of its adherents is also a factor, as there is often a gap between the teachings and peoples' actual behavior. More specifically, what matters is whether or not people incorporate religious teachings into their lives. In fact, in several Christian and Moslem villages, only a few people practice what is taught by their religious leaders.

Ay is a village in the Banda Islands where a trochus fishery is a potential venture. In the past, trochus harvests generated a considerable amount of revenue for the village. However, because of poor management in the past, trochus harvest has generated little revenue for the past two decades. Several attempts to rebuild the trochus resource were made by villagers who realized the potential of adopting the *sasi* system, but none of them was successful. A distinguished Moslem educator of the village argued that there could not be a functioning *sasi* system until the people practiced the religion more thoroughly. To emphasize his contention, he pointed to the poor attendance of the village mosque. The statement of Dullah, a citizen of the neighboring island village of Kampung Baru, confirmed the educator's claim: 'The villagers of Ay are frequent champions of the *Kora* boat race held each year in the Banda Islands, but their victory celebrations do not conform to their religious beliefs because liquor consumption is associated with the celebrations, and this is forbidden by the Islamic teaching'.

Wisdom, the leader's improvised approaches

A story of a forgiven trochus poacher has become a legend for the people of Wattlaar Village. It is a story that shows a Rajah's wisdom in using a non-physical, yet effective, punishment on a *sasi* violation. *Bapak Raja* Rahail of Wattlaar is a seventy-year-old, respected leader who has been serving in the traditional role as a Rajah in Wattaar, a 'kingdom' that reigns over 46 kampongs (11 *desas*/ villages) in the northern part of the Kei Besar Island. Even though more stringent alternatives are available, his approach to various cases has been and still is mostly persuasive. Most of the villagers recall a specific case, the theft of *sasied* trochus by a poor woman. Some buried shells were found by a sand gatherer, who reported his find to the Rajah. The buried shells were taken to be the proof of a theft. The Rajah had a respected elder pray that the guilty thief would not escape punishment and announced a three-day grace period during which the thief could confess to committing the crime. The day before the deadline a poor woman admitted that she had stolen the trochus and said that she was prepared for whatever punishment the customary law stated she should receive. Wisely, the Rajah forgave the woman on the condition that she did not repeat the offence, and the villagers agreed with his decision. The people in the village believe that a prayer like the one mentioned in this case would affect the poacher by causing sickness or even death.

Another example of a leader's effective approach to violation cases can be found in Haruku, in Central Maluku. For those who have violated a *sasi* or any other regulation, *kewang* members will consider total forgiveness or at most some moderate penalty such as a gentle lash of a rattan whip, for violators who show remorse over having committed the crime. (Kissya, pers. com.).

Geographical markers such as rivers, big rocks or tips of forelands are often used to define *sasi* boundaries. People usually recognize that a place is under *sasi* when a certain type of sign is placed on those boundaries. These signs may be in the form of stone or leaf markers (Zerner 1990). *Sasi* rules apply to basically everyone, including outsiders who happen to visit or stay in the village. On rare occasions an exception may be made to the *sasi* in an emergency situation. A needy passer-by, for example, might be granted permission to take one or two pieces of *sasi*ed coconut to satisfy his hunger or thirst.

Once the *sasi* markers are placed, a *masa sasi*, which literally means the duration of *sasi*, is in effect, and no one is allowed to harvest the resource. When the time comes again for

harvest, i.e., when the *sasied* crops or fish have met a certain level of maturity or abundance, and weather permitting (in the case of marine *sasi*), another procession is held to mark the time to lift the closure. This procession or ceremony is called *buka sasi*, which literally means 'opening *sasi*'.

WHY TRADITIONAL KNOWLEDGE WAS EFFECTIVE – UPDATING BASED ON SCIENTIFIC ADVICE

In the past, communities found no difficulty in adopting and relying on traditional knowledge to manage their natural resources. Traditional knowledge was sufficient for the community to make the right decisions regarding resource use in order to meet objectives that could be both economic and non-economic in nature. An example of a non-economic objective is the ability to maintain their pride of having natural wealth. Ruttan (1995) notes that villagers have a tendency to be proud of the natural wealth of their village. Therefore, they had an incentive to conserve the resource endowment existing in the village in order to maintain their pride. Transforming traditional knowledge into *sasi* restrictions was an effective way by which to realize their objectives. Traditional knowledge helped maintain resources at a sustainable level with economic returns enough to satisfy the need of people at that time.

Changes in external circumstances, however, have left the *sasi* system vulnerable to failure. As happened in many locations, *sasi* failed to maintain its management function. Benda-Beckmann *et. al.* (1995) suggest that economic elements have been a major factor contributing to this failure and cite instances where community leaders often let citizens increase the rate of natural harvest for the sake of short-term gains. Other researchers tend to support Beckmann's concern, for example, Zerner (1994) notes that in the past immature trochus were not taken by traders because they had no commercial value. In my own recent field observations in Maluku market centers, I found traders purchasing considerable quantities of illegal immature trochus. Antunès and Dwiyono (1998) report similar findings.

Nowadays, traditional knowledge is neglected by communities in many locations because they believe that it is no longer enough to enable them to keep up with the current changes in external circumstances. While the traditional knowledge is based on long observations of natural dynamics, the current external changes happen so quickly that harvest adjustments made according to traditional knowledge rarely end up with the expected outputs. As a result, depletion may occur even though *sasi* restrictions are still observed. This never happened in the past because external changes took place gradually so that major adjustments were not necessary.

Nevertheless, people in several other locations still find traditional knowledge worth adopting in resource management. In these locations, communities succeed in neutralizing economic pressure on the *sasi* arrangement by adopting appropriate modifications. A success story regarding this can be found in Ohoirenan Village, where the involvement and advice of modern scientists has led to improvements in the reliability of information acquired from traditional learning processes. For example, people combine the growth prediction based on environmental data provided by local biologists with their knowledge about the spatial distribution of an economic marine commodity called trochus (*Trochus niloticus*). Their harvest strategy, which is based on these two types of information, is a *sasi* arrangement which include spatial harvest rotation based on traditional knowledge and size restriction based on modern scientific advice. The result is that the Ohoirenan village is able to maintain a more sustainable harvest compared to other villages.

The Ohoirenan village example actually represents a practical form of Fong's (1984) 'wedding' between science and tradition. It is a wedding that offers an opportunity to incorporate modern science into the traditional management system so that a community can make proper responses to economic and ecological changes. In the *sasi* context, this means that some of the practical aspects of the tradition are adjusted to allow for the inclusion of external variables beyond their control. As happens in Ohoirenan Village, the closure period would no longer be determined merely by the community's judgment. Instead, it reflects a compromise with various inputs, including those from outsiders.

The above discussion conveys an important message, i.e., that traditional knowledge can be effective in many locations in Malukuan communities due to at least two conditions. The first is that the *sasi* system, by which traditional knowledge is implemented, is observed by community members, and the second is that the communities are willing to incorporate outside knowledge to improve their traditional system.

Furthermore, the study also shows that observance of *sasi* is supported by several cultural factors and some other intangibles. Following this, the author recommends a process of knowledge transfer where knowledge and elements from communities where *sasi* is working, is used to improve conditions in communities where *sasi* is not effective.

CONCLUDING NOTE: A PROPOSED WORKING MODEL

Following from the above, the author proposes a working model, which communities may wish to adopt in order to make their traditional/local knowledge effective in resource management. The building blocks of this model areas follows: (1) operative components of local tradition[4], (2) local and scientific information on biological dynamics of natural commodities that need management and (3) information on local human and physical environment in the place where local knowledge is to be made effective in resource management.

Based on the findings of this case study on the Malukuan local knowledge about certain aspects of growth of *trochus*[5], the development of a working model in a community, as proposed here, may take the following steps:

1. Construct a dynamic model that simulates traditional resource management practice in the community, based on both local and scientific information.
2. Use the community's knowledge of historical records of the dynamics of the resource to calibrate and validate the simulation model.
3. Use the revised simulation model to predict the outputs of different harvest rates.
4. Use model predictions to identify elements of traditional community management that may need improvement.
5. Identify the community's human and physical circumstances, compare them to communities where local regulations are observed, and determine necessary actions which allow modification in management tradition to take place and promote community compliance with the modified management system.

REFERENCES

Antunès. I. And S.A.P. Dwiono. 1998. Wattlaar: An eastern Indonesian Village caught between tradition and modernity. Centre Orstom de Montpellier.

Benda-Beckmann, F. von, K. von Benda-Beckmann, and A. Brouwer. 1995. Changing 'indigenous environmental law' in the Central Moluccas' Communal regulation and privatization of *sasi*. *Ekonesia* no.2: 1-38. University of Indonesia.

Dwiono, S.A.P. 1996. Prospek Budidaya Lola di Maluku. *Marinyo* no. 5: 29-30. Yayasan Hualopu, Ambon, Indonesia.

Edgerton, R. B. 1985. Rules, Exceptions, and Social order. University of California Press. Berkeley, Los Angeles. London.

Fong, G. M. 1994. Case study of a traditional marine management system: Sasa village, Macuata Province, Fiji. South Pacific Forum Fisheries Agency. Food Agricultural Organization of the United Nations, Rome.

Kissya, E. 1993. *Sasi* Aman Haru-Ukui -- tradisi kelola sumberdaya alam lestari di Haruku (A tradition of managing natural resource sustainably in Haruku Island). Yayasan Sejati, Jakarta.

McNamara, R. P. and M. Tempenis. 1999. Can I Get a Witness: The Role of Religion in Policing. *In* Dennis J. Kenney and Robert P. McNamara, Police and Policing, Contemporary Issues. Praeger, New York.

Rahail, J.P. 1993. Larwul Ngabal -- Hukum adat Kei, bertahan menghadapi perubahan. (The Kei traditional law, defending against changes). Yayasan Sejati, Jakarta.

Ruttan, L.M. 1995. Customary management of trochus in the Kei Islands of Eastern Indonesia (Yet another critique of the tragedy of commons). Division of Environmental Studies, University of California, Davis.

Wilson, B. 1982. Religion in Sociological Perspective. Oxford University Press. Oxford. New York.

Zerner, C. 1994. Through the green lens: the construction of customary environmental law in Indonesia's Maluku Islands. *Law and Society Review*, no. 5: 1079-1122.

Zerner, C. 1990. Community management of marine resources in Maluku Islands. Prepared for Fisheries Research Development Project. Center for Research Institute of Fisheries, Jakarta.

[4] In the case of Malukuan, this means *sasi* tradition

[5] Trochus (*Trochus niloticus*), is a sedentary marine species whose shells have high economic value

HOW LOCAL FISHERS' KNOWLEDGE IMPROVES THE MANAGEMENT OF FISHERIES IN NEW ZEALAND – A SEAFOOD INDUSTRY PERSPECTIVE

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ABSTRACT

This paper focuses on how local fishers' knowledge contributes to the science based management of commercial fisheries in New Zealand. The role of the New Zealand Seafood Industry Council in communicating fishers' knowledge to fisheries management fora is explained. A case study of the Adaptive Management Programme for the bluenose (*Hyperoglyphe antarctica*) fishery (BNS 1), illustrates the contribution of the knowledge of fishers to the understanding of changes in a fishery over time. Fishers provide information from their local knowledge of changes in fishing methods, fish stocks and market behaviour and the relationships between these factors. Their interpretation and explanation of data, behaviour or the results of research is important especially when the scientific data are inconclusive. The future of fisheries management in New Zealand, and the role of Fisheries Plans, is discussed.

INTRODUCTION

Local fishers' knowledge is an important component of the decision making process for managing commercial fisheries in New Zealand. This paper will outline the seafood industry perspective rather than focus on customary or recreational fishers' knowledge. At approximately 2.5 million square kilometres of ocean, ranging over 30 degrees of latitude, New Zealand's marine exclusive economic zone is the fourth largest in the world and is 14 times larger than its land mass. The seafood industry makes an important contribution to the New Zealand economy and is the 4th largest export earner, worth NZ $1.43 billion in 2000. Approximately 650,000 tonnes is harvested from wild fisheries and aquaculture each year. This represents only 1% of the world's catch by volume, but makes up 2% of the world's catch in terms of value, as New Zealand is home to a number of high value species such as abalone and rock lobster. The total revenue to New Zealand from seafood and all associated businesses is NZ $4.5 billion a year, with around 26,000 people directly or indirectly employed in the commercial fishing industry.

Since 1986, New Zealand's main commercial fisheries have been managed under the Quota Management System (QMS). Under the QMS, existing operators in the fishery own a quota that represents an entitlement to catch a proportional share of the Total Allowable Catch (TAC) for an individual fish stock. The commercial proportion is the Total Allowable Commercial Catch (TACC). While the quota is issued in perpetuity, the quota is tradable either by lease or sale. The annual costs of managing the commercial fishery, including stock assessment research, are directly recovered from the quota owner on an annual basis.

The Fisheries Act of 1996 requires that a TAC is set at a level that will maintain a fish stock at or above, or move it towards, a level that can produce the Maximum Sustainable Yield. The Adaptive Management Programme (AMP), as well as other seafood industry based sampling programmes, is an opportunity for the fishers to play an important role in the management of their commercial fisheries. The success of these initiatives is largely dependent on the support of fishers of the objectives of the relevant AMP. It is therefore a partnership between fishers and their representatives.

One of the main conduits of fishers' knowledge in New Zealand is the NZ Seafood Industry Council (SeaFIC) which was formed in 1997 to represent fishers' generic interests. The seafood industry includes individuals and companies participating in fishing, aquaculture, processing, wholesaling, retailing and exporting of seafood products. SeaFIC is a company owned by 20 shareholders and managed by a Board of Directors elected by a majority of industry interests. SeaFIC shareholders - each of whom represents a particular sector of the seafood industry - collectively represent over 90% of the seafood industry by value. A majority of the fishing industry recently voted to fund SeaFIC by a compulsory levy collected on all fish landed and processed.

One of the objectives of the present Government is to involve those with a stake in fisheries in the management framework. The active and informed contribution of fisheries stakeholders is encouraged through participation in the decision-making processes. The seafood industry pays the full costs of both fisheries management and the research required to assess the sustainability of fish stocks, and the effects of fishing on marine biodiversity and the aquatic

environment. Fishers can attend Fishery Assessment Working Group (FAWG) meetings or be represented by their stakeholder groups or SeaFIC. Meetings consist of Government officials, research scientists, customary fishers, recreational fishers and environmental NGOs. The latter three groups can at times be under-represented due in part to their funding base. A generic function for SeaFIC is the provision of scientific advice. Its staff can represent commercial fishers' submissions, are able to attend all meetings, and unlike fishers, they are able to focus solely on fishery issues rather than commercial business.

The indigenous people of New Zealand (Aotearoa) - Maori, are another key commercial stakeholder in New Zealand's seafood industry. Traditionally Maori are a maritime people - without metal tools or a written language, their Polynesian forebearers crossed the Pacific Ocean centuries before Europeans made it across the Atlantic. In 1992 the Crown agreed to fund Maori into a 50/50 joint venture to purchase Sealord - New Zealand's biggest fishing company. In addition, Maori are entitled to 20 per cent of quota for all species not yet in the quota management system. The Sealord purchase was enshrined in the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992 which also set up Te Ohu Kai Moana - the Treaty of Waitangi Fisheries Commission. The Act also outlined the process for protecting Maori non-commercial customary fisheries rights. Maori now have a substantial interest in over 300,000 tonnes of quota, representing over 35% of the New Zealand TACC.

The Fisheries Management Process

The TACC for the main fish stocks is reviewed annually through a formal stock assessment process. The Ministry of Fisheries chairs a series of Fishery Assessment Working Groups (FAWG) that review recent trends in the fishery and the results of research programmes relevant to the fishery. Where sufficient information is available, a quantitative stock assessment of the fishery may be conducted and estimates of yields and reference biomass updated. The Ministry of Fisheries summarises the conclusions of the FAWG and identifies any fish stocks that may require a change in the level of TACC due to concerns regarding the sustainability of the current catch level. There is also the opportunity to propose an increase in the TACC where a higher catch can be supported by the fishery. The Minister of Fisheries makes the final decision regarding any proposed changes to the TACCs following consideration of submissions from the main stakeholders in the fishery, including commercial, recreational, customary, and environmental agencies.

An important opportunity for fishers' knowledge to be incorporated into the fishery management process has been the development of the Adaptive Management Programme (AMP). It was a research tool introduced by the Ministry of Fisheries (MFish) in 1991 as a basis for varying the TAC levels of fish stocks for which MFish has limited information on stock size. It allows for experimental increases in the TAC in instances where it is believed that there is a strong likelihood that the stock abundance is above the optimal yield level. This is coupled with a monitoring programme to track the response of the fish stock to the increased level of exploitation. Annual reviews ensure that the Minister of Fisheries does not breach his/her statutory obligations to ensure stock sustainability. The emphasis is on gaining useful information and improving the management of the fish stock.

In general, most TACC increases under the AMP are modest and are initially for a five-year term, with annual reviews. The quota owners, usually through the relevant stakeholder group, are required to fund the additional costs associated with monitoring the fishery. The monitoring regimes are generally multi-faceted and may include: trawl surveys, analysis of catch and effort data, a detailed logbook completed by fishermen, and catch sampling. These programmes are designed to monitor stock abundance and to collect sufficient information for an assessment of the sustainable yield for the fishery. The onus is on the seafood industry to provide the required data and arrange analysis of that information. If industry fails to fulfil their commitments they face a reversal of the TACC increase and a loss of credibility. The AMP is an integrated research programme which uses "fisher power" to obtain some of the scientific information. The 'carrot' for fishers therefore is the increase in quota. If they subsequently do not take part in the collection of data, the 'stick' is the loss of quota.

SeaFIC employs its own stock assessment scientists to assist industry stakeholder groups to participate fully in the annual stock assessment process and to provide advice to the fishing industry which is independent of the government research provider. Its Science Unit has, up to now, provided most of the scientific input into the AMP. SeaFIC often acts as the interface between the seafood industry and the

Ministry of Fisheries (MFish). In this buffer role, it is able to encourage open communication between the different sectors, providing a filter for the more extreme views.

BLUENOSE 1 FISHERY

One of the ongoing success stories of the AMP is the bluenose (BNS 1) fishery, presented here as a case study of how local fishers' knowledge and dedication improves the management of fisheries in New Zealand. By being actively involved in the design, implementation and interpretation of the results of the logbook programme, local fishers have guided the project with their knowledge and experience.

Bluenose, *Hyperoglyphe antarctica*, is a semi-pelagic species widespread in the Southern Oceans. It is found off the coasts of New Zealand, southern Australia (where it is known as "trevalla") and South Africa. Its maximum age is thought to be approximately 15 years and maximum size is about 90 cm for females and 80 cm for males, although specimens of 140 cm have been recorded (Horn 1995).

Bluenose have been landed by commercial line fishers since the 1930s and can be readily taken by trawl, line and setnet. Before 1981 there was little target fishing because most fishers concentrated on the more traditional "grouper" species (häpuka and bass) and bluenose was often mis-reported as häpuka. Bluenose is considered to be reasonably resilient to fishing pressure because of their pelagic juvenile stage, moderately fast growth, widespread distribution, and occurrence in untrawlable areas.

Bluenose is managed in New Zealand by division into six Quota Management Areas with BNS 1 encompassing the area around the northern North Island (Figure 1). The BNS 1 fishery initially developed as a bycatch of the hapuka/bass line fishery with bluenose sold locally to domestic fish shops. During the early 1980s, increased fishing effort was targeted at bluenose and catches steadily increased from around 200 tonnes in the early 1980s to 696 tonnes in 1990/91 (Figure 2). During this period, most of the increase in catch was taken from the developing target longline fishery in the Bay of Plenty. Bluenose was being recognised as a high quality fillet and as markets were developed, exports grew. An important target fishery for bluenose was established in east Northland in the 1980s. The fishery is now dominated by the bottom longline fishing method which accounts for around 90% of the total annual catch. The remainder of the BNS 1 catch is taken by other line methods and by bottom and midwater trawl.

In 1996, SeaFIC proposed that the BNS 1 fish

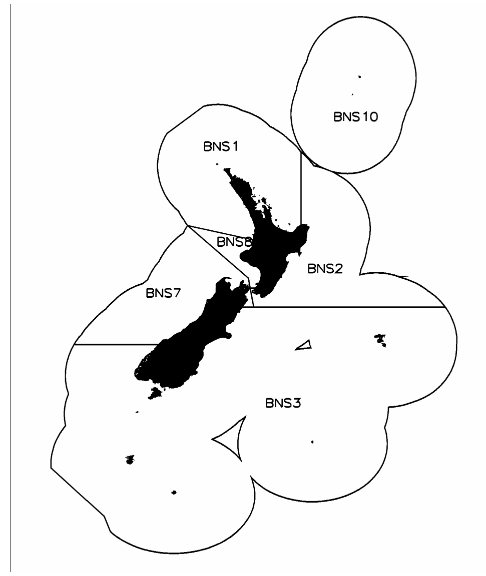


Figure 1. Quota Management Areas for Bluenose in New Zealand

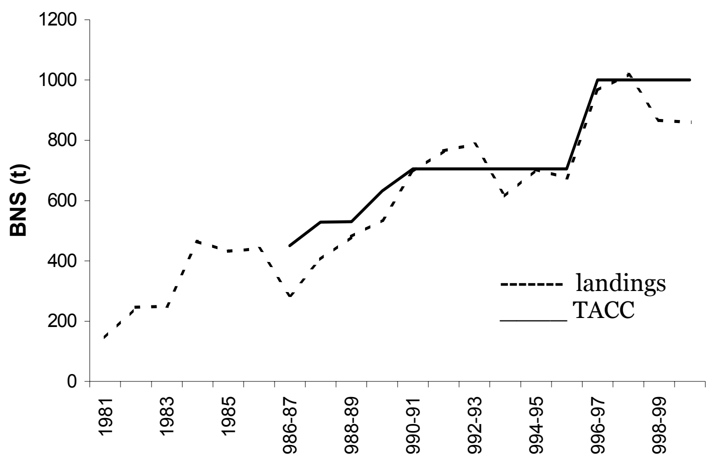


Figure 2. Catch and TACC(t) for BNS 1

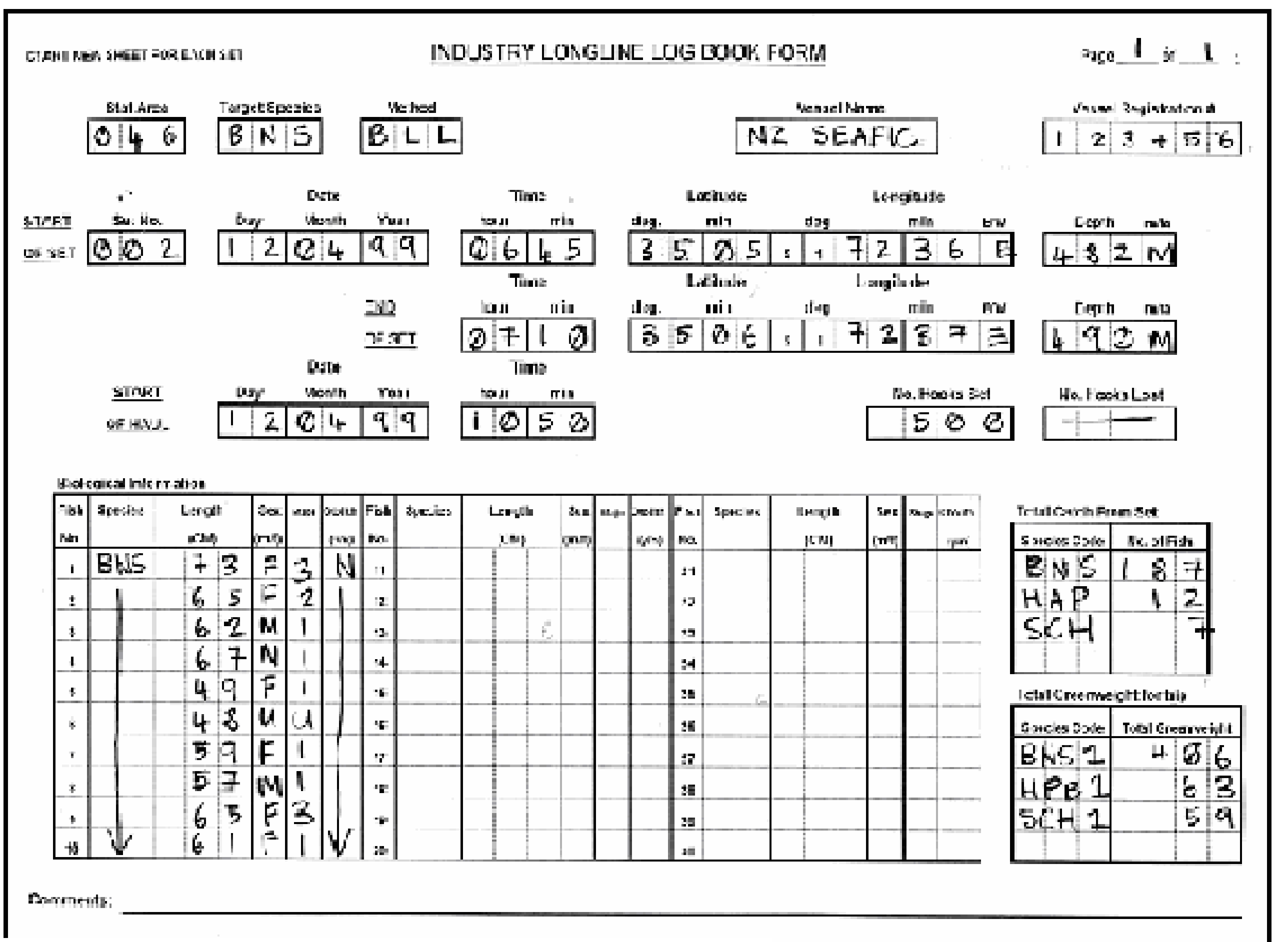
stock be included within the AMP with the intent of increasing the understanding of the biology of bluenose, determining the geographical extent of the species, and estimating the long-term sustainable yield for the stock. The programme involved an increase in the level of monitoring of the BNS 1 fishery in conjunction with an increase in the TACC from 705 to 1000 t. The TAC is 1,023 t with allowances of 8 tonnes for customary Mäori, and 15 t for recreational fishers, whose annual catch was estimated in 1996 by a national telephone/diary survey at 5,000 fish (Annala *et al* 2001).

The BNS 1 AMP is currently administered by the Northern Inshore Fisheries Company Ltd, which is the stakeholder group representing the commercial sector operating in the inshore fisheries around northern North Island. The commercial longline fleet is comprised of around 20 vessels operating from 4 main ports along the north-eastern coast of the North Island. The vessels are typically around 20 m in length with a crew of 1-2 (Figure 3). Fishing trips are usually of one to three days' duration. The level of fishing effort varies with the size of the vessel, with individual vessels setting between 200 and 2,000 hooks, and 1-3 longlines per day.

Figure 3 A Typical BNS 1 Longliner –the 'Lady Sarah'

The BNS 1 AMP is monitored from catch and effort data obtained from the target bluenose longline fishery and through a logbook programme which collects more detailed catch, effort and biological data. The Logbooks (Figure 4) which detail the location of the catch and the number of fish caught by species, are used to gather auxiliary information for the annual Catch Per Unit Effort (CPUE) analysis. These logbooks are placed on most of the long line vessels fishing in BNS 1 which target bluenose.

The general intent of these programmes is to use sole-operator fishermen on the smaller vessels or crew members where they are available to sample the biological characteristics of their own catch while actively fishing. This ensures that the collected biological data are correctly linked to the overall catch and effort data and are collected in conjunction with the fishing operation. Only a small amount of the catch (10 fish) is sampled as randomly as possible, but it is sampled routinely and frequently. This allows for the accumulation of large amounts of information and offsets the fact that individual participants only collect a small amount of data. Such a design automatically adjusts to changes in fishing practices, both in area and over time.



INDUSTRY LONGLINE LOG BOOK FORM

Page 1 of 1

Stat Area: 046 | Target Species: BNS | Method: BLL | Vessel Name: NZ SEAFIC | Vessel Registration: 123456

START OF SET — Date: 12 04 99 | Time: 0645 | Latitude: 35 05 | Longitude: 172 36 E | Depth: 482 M

END OF SET — Time: 0710 | Latitude: 35 06 | Longitude: 172 37 | Depth: 492 M

START OF HAUL — Date: 12 04 99 | Time: 1050 | No. Hooks Set: 500

Biological Information

Fish No.	Species	Length (CM)	Sex (m/f)		Status
1	BNS	73	F	3	N
2		65	F	2	
3		62	M	1	
4		67	M	1	
5		49	F	1	
6		48	M	4	
7		59	F	1	
8		57	M	1	
9		65	F	3	
10		61	F	1	

Total Catch From Set

Species Code	No. of Fish
BNS	187
HAP	12
SCH	7

Total Greenweight for trip

Species Code	Total Greenweight
BNS 1	406
HPB 1	63
SCH 1	59

Comments:

Figure 4. Example of a Completed Logbook Form

If fishers are too busy to do the biological sampling, coloured cattle tags are attached to identify the 10 fish from a set and they are subsequently sampled at the shed on shore.

Analysis of the logbook data has enabled a confirmation of trends in CPUE derived from the statutory reporting data and has enabled trends in fishing activity to be examined in more detail (Figure 5).

duration of the bluenose spawning season to be determined. Bluenose otoliths have also been collected from a subset of the fish sampled during each trip. A total of 7,360 otoliths have been collected so far. These samples will enable the age composition of the bluenose catch to be determined once a suitable aging technique has been established.

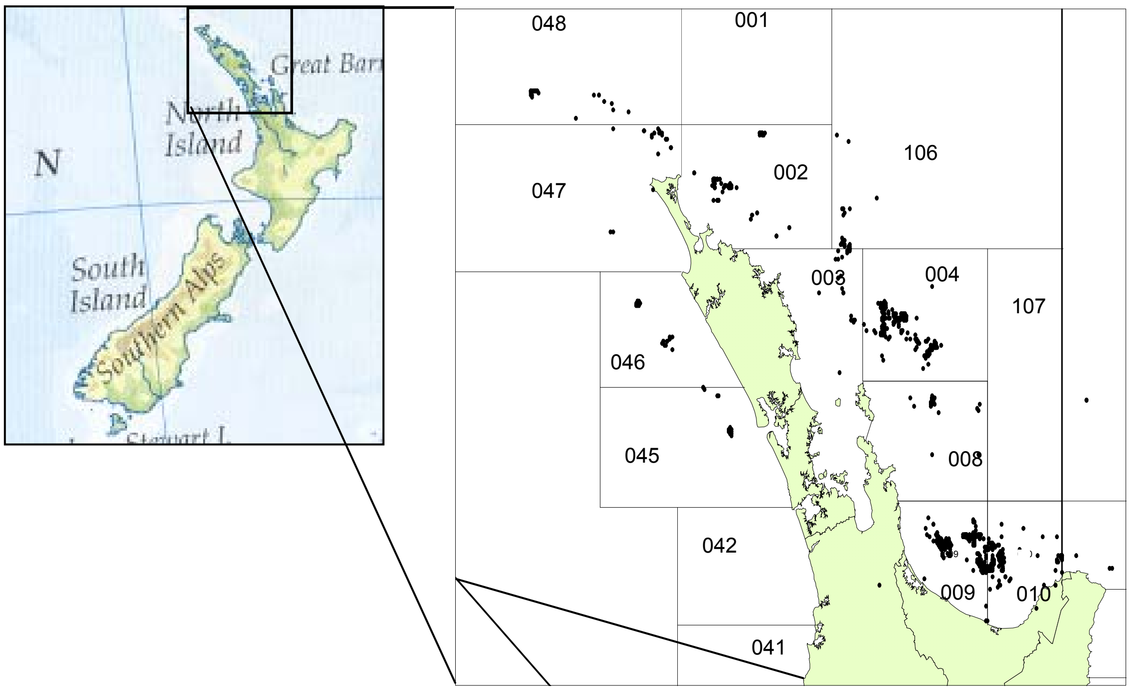


Figure 5 Distribution of bluenose longline sets identified from the logbook programme 1995 to 1998 (numbers indicate statistical areas).

The logbook coverage was assessed by the Fishery Assessment Plenary in May 2001 to be very good i.e. 34% of the days fished in 2000 and 76% of the vessels in the BNS 1 longline fishery had participated. The logbook programme has achieved an annual coverage of 30-40% of the total hooks set in the target longline fishery since 1996/97 (Table 1, overleaf).

The large quantity of length frequency data collected from the BNS 1 fishery by the logbook programme (25,528 fish have been measured) has enabled the determination of the length composition of the bluenose catch from each of the main fishing grounds in BNS 1 by fishing year. Gonad staging data collected from the logbooks have enabled the length at maturity of male and female bluenose and the timing and

The large quantity of high standard data collected by the BNS 1 logbook programme is attributable to the dedication of the participating fishermen. These data have been used to define important biological parameters of the species, including length at maturity and spawning period. In the absence of the logbook scheme, the collection of comparable data from the BNS 1 fishery could have only been achieved using an intensive, and prohibitively expensive, research programme. The data collected to date provide important baseline information from the fishery. Future trends in catch composition and fishing performance will be monitored against these data to examine the impact of the higher TACC on this fishstock.

Table 1. Annual Coverage of the BNS 1 longline fishery by the logbook programme

Data Source	Fishing Year	Days Fished	Hooks (1000s)	Number Sets	Total BNS Catch (t)	Number Vessels
CELR data	1995/96	792	836	1,377	510.4	18
	1996/97	1,255	1,238	2,237	734.3	22
	1997/98	1,120	1,156	2,078	709.9	20
	1998/99	1,364	1,406	2,361	919.4	20
	1999/00	933	1,222	1,607	651.7	21
Logbook	1995/96	61	74	121	37.9	8
	1996/97	420	507	590	348.0	18
	1997/98	310	418	544	264.4	10
	1998/99	336	441	383	199.1	14
	1999/00	319	472	361	170.0	16
Coverage	1995/96	8%	9%	9%	7%	44%
	1996/97	33%	41%	26%	47%	82%
	1997/98	28%	36%	26%	37%	50%
	1998/99	25%	31%	16%	22%	70%
	1999/00	34%	39%	22%	26%	76%

The Role of Fishers in understanding BNS 1 Stock Assessments

With time and experience, fishers gain through observation and trial-and-error, a knowledge of their environment that could never be gained in a classroom or by statistical analysis. Johannes *et al.* (2000) give examples of how the local knowledge of indigenous fishers of the behaviour and movements of marine fishes and mammals can be crucial to fisheries biologists and managers. Dunn *et al.* (2000) note that every analysis of catch and effort data requires a good understanding of both the fishery and the factors that can influence the CPUE/abundance relationship. The interpretation of catch and effort statistics therefore needs to take into account not only changes in the spatial distribution of the fish stock caused by changes in abundance, but changes in fisher behaviour, fishing technology and markets, and catchability between different fishers. This is where the knowledge of the local fishers' is crucial.

Fishers' knowledge and practical ability has been an important component of the annual review of information collected for the BNS 1 stock assessment. The participation of fishers, particularly in the programme design and initial discussions, has enabled the AMP to be put into the context of the commercial fishery, including its operational constraints. Fishers have knowledge of:

- the players in the fishery at the present time – whether skippers are experienced or new comers,
- changes in the fleet,
- local weather conditions and the constraints this can place in terms of a safe fishing operation, and
- economics and operational constraints (the commercial realities) e.g. how far from port a vessel can fish.

Discussion

The skill, knowledge and expertise of local fishers in New Zealand, has a recognized and important role in management decisions that contribute to a successful sustainable fishery. The people that are out there fishing generally have a detailed knowledge of the environment and what affects it. This is important in a fishery that is dynamic and constantly evolving.

For the Bluenose 1 fishery, local fishers have been able to contribute to the analysis of the historical perspective – they witnessed the fishery develop before scientific programmes were initiated and can therefore put the current fishery in context. Fishers can pinpoint when the watershed changes in technology were introduced and catchability subsequently improved, for example the adoption of radar and Global Positioning Systems. Changes in BNS 1

fishers' gear made a difference as fishers changed from "j" hooks to the more efficient circle hooks, and from wire to monofilament line (Peter Jones *pers comm.*). Fishers can explain fishing behaviour in relation to weather, time of year and time of day or month.

New Zealand is often colloquially called a big village and fishing involves a small community within that village. Fisheries management needs to be about relationships, credible input, trust and good liaison with fishers. Conversely fishers need to understand the policies, politics and management processes and where they fit in. The collection of the best available knowledge will enable the best stock assessments. The interpretation of scientific analysis can be challenging and some fishers choose to opt out and not contribute local knowledge. It may not just be because of a lack of understanding – the scientific terms, jargon and concepts can be too abstract. Opting out can also be due to apathy, self interest, feeling insubstantial, a reliance on others or simply a lack of time to take part.

Those that do contribute to the decision-making process are more likely to understand and accept the ultimate outcomes and have a sense of ownership especially if they are involved in data gathering. The information collected becomes more valid to them. In terms of commercial fishers' input to the BNS 1 stock assessment, there are two groups: the first is made up of the various types of fishers - those that lease quota, those contracted to large companies and the quota owner-operators. The second group is the representatives – the New Zealand Federation of Commercial Fishermen, Stakeholder representatives, SeaFIC and Customary groups. The members of the second group are 'bureaucrats' and are more likely to attend Government research or stock assessment meetings. They often personally obtain fishers' knowledge and input before attending fishery management meetings. When an important fishery issue is on the agenda, experienced fishers are often asked if they can also attend to contribute their knowledge and convey the impact a decision will make on their fishing operation.

Fishers can find that Fishery Management meetings are at times very technical in nature, the jargon and mathematical concepts are complex – the learning curve can be steep. It takes time to get to know the individuals and personalities, and to develop trust and respect. To the average fisher, scientists can appear as 'boffins' and modelers as 'number crunchers.' At first for fishers attending meetings, the adage of Mark Twain can hold true – *"that it is better to keep your mouth shut and appear stupid than open it and remove all doubt"*. A more effective and credible option has been for fishers to collect information on BNS 1 themselves with a soundly designed logbook programme, and contract SeaFIC scientists to analyse and present the results to the fishery management meetings. By taking part in and funding an AMP such as BNS 1, the fishers became more involved in the decisions made and gain ownership of the research.

It is extremely difficult to manage wild fisheries or the marine environment. However, people and their activities can be managed. Effective fisheries management requires the co-operation of those whose activities are being managed, both in relation to the provision of information and in relation to ensuring compliance. Consistent with this understanding, the overall direction in fisheries management in New Zealand is one of increasing collective stakeholder responsibility. Local fishers' knowledge is crucial to this process and is provided by representation, participation in data collection and investment in credible scientific research.

Recently there has been a gradual move towards co-management of fisheries with incentives created for commercial fishers to take responsibility for fisheries research (Harte 2001). Fishers have the opportunity to be part of the consultative processes for research planning and stock assessment working groups for inshore, mid-water, and deepwater fish stocks and also recreational, socio-economic and aquatic environment groups. The quantitative data collected by fishers in various industry logbook programmes is directly incorporated in the annual assessments of fish stocks. Fishers also provide information from their local knowledge of changes over time of fishing methods, fish stocks and market behaviour and the relationships between these factors. Their interpretation and explanation of data behaviour or the results of research can be important especially when the scientific data is inconclusive.

The future of fisheries management in New Zealand contains a new framework for the input of fishers' knowledge. The Government has a vision of increased stakeholder responsibility for fisheries management as set out in the Fisheries Act 1996 (Section 11A). It is encouraging the seafood industry to develop Fisheries Plans and

released a consultation document in March 2001. In his speech to the seafood industry's annual conference on 3 May this year, the Minister of Fisheries said:

> *"The big idea behind a fisheries plan is that with the right process, the right content and the right management it will allow stakeholders to step up to the plate and allow the Government to retreat... It is about stakeholder solutions where possible and regulation only where necessary."* [1]

Fishery Plans represent a new tool for local self-management and stakeholder involvement rather than centralised control. All players involved with the marine environment want sustainable fisheries and Fisheries Plans are part of the long term strategy to maintain this goal. The hope is that Fisheries Plans will involve more people with a direct interest in a fishery in its management and allow a better provision for their needs. Ideally this will mean greater consensus, a high level of voluntary compliance with the rules and improved management decisions. Local fishers' knowledge will hopefully be an important component of Fishery Plans that require a wide involvement of fishers' in their development to enable the full range of interests to be considered. However, how successful Fisheries Plans will be and when the first will be implemented in New Zealand - remains to be seen.

Acknowledgements

Peter Jones and Richard Cade kindly provided many helpful insights and information. The logbook programme was designed and implemented by Paul Starr, who recognised that fishermen are able to collect data of high quality to contribute to the stock assessment of their fishery. Local BNS 1 fishers have collected a large quantity of data often in difficult conditions. The success of the AMP is largely attributable to their dedication.

References

Annala, J.H., Sullivan, K.J., and O'Brien, C.J, Smith N.W.(Comps.) 2001. Report from the Fishery Assessment Plenary, May 2001: stock assessments and yield estimates. 515 p. (Unpublished report held in NIWA Greta Point library, Wellington, New Zealand)

Bernstein B.B. and Iudicello S. 2000 National Evaluation of Cooperative Data Gathering Efforts in Fisheries. National Marine Fisheries Service. 77 p.

Dunn, A., Harley S.J., Doonan I.J. & Bull B. 2000: Calculation and Interpretation of catch-per-unit effort (CPUE) indices. New Zealand Fisheries Assessment Report 2000/1 44 p.

Gilbert D.J, Annala J.H, and Johnston K. 2000 Technical Background to Fish Stock Indicators for State-of-Environment Reporting in New Zealand. Mar.Freshwater Res.,2000 51, p.451-464.

Harte M. Opportunities and Barriers for Industry-Led Fisheries Research. 2001 Marine Policy 25 (2001) p.157-167.

Horn P. 1995 Bluenose – widespread but where are the juveniles ? Seafood New Zealand Vol 3 (5) p. 31 –33.

Johannes R.E, Freeman M.M.R, Hamilton R.J. 2000 Ignore Fishers' Knowledge and Miss the Boat. Fish and Fisheries 2000 (1) p. 257-271

Langley, A.D. (in prep. A): An analysis of catch and effort data from the BNS 1 target line fishery, 1989/90 to 1999/2000.

Langley, A.D. (in prep. B): Summary of the BNS 1 longline logbook programme, 1995/96 to 1999/2000.

Ministry of Fisheries 2000 Review of Sustainability Measures and Other Management Controls for the 2000-01 Fishing Year, Initial Position Paper and Final Advice Paper. 400 p. Unpublished manuscript available from the Ministry of Fisheries, Wellington. New Zealand.

Vignaux, M. (1997): CPUE Analyses for Fishstocks in the Adaptive Management Programme. NZ Fisheries Assessment Research Document 97/24.

Questions

Tony Pitcher: The perception from outside of New Zealand is that the fisheries have been sold out to the industry. So what about the interests of the public and conservation?

Greg Lydon: I disagree. A lot of it is politics and it depends on government policy at the time. The current labor government is quite conservation minded. The fishing industry is taxed to pay for all the research. So if they get what they consider bad proposals for research, which will not take the debate further or increase their knowledge, they will not go for it. You are quite right in that the TAC has been cut. There has been an independent Australian assessment and it was not anyone's fault, it was a scientific thing. We are still learning about the species because it is a deep-water species and there is not a lot of information. But if there were any mistakes made, it was the science, it was not deliberate over exploitation of the resource.

Tony Pitcher: Still the interest of the industry is in making profit using conventional economic principles. What are the checks and balances of the public? Who will take care of future generations?

Greg Lydon: The public and the conservation groups are represented as much as the commercial fishers and have as much say. The TACC is being monitored and reviewed every year.

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[1] http://www.seafood.co.nz/items/documents/conf_speech_ph.PDF

John: How are the quotas managed?

Greg Lydon: A management system was set up in 1986 and management depends on the species or fish stocks. The quota is a property right you have got forever and you can lease it, transfer it etc. If the stock assessment shows the stock to be going down, the quotas are reduced accordingly. If the government sees that it does not have enough information, again the quotas are reduced proportionately.

HISTORICAL AND CURRENT KNOWLEDGE OF THE GREENLAND HALIBUT FROM QUÉBEC FIXED-GEAR FISHERS IN THE GULF OF ST. LAWRENCE

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ABSTRACT
Fishing for Greenland halibut (*Reinhardtius hippoglossoides*) in the estuary and the Gulf of St. Lawrence (NAFO divisions 4RST) has been practiced mainly with gillnets by coastal fishers of Quebec and Newfoundland since the beginning of the 1970s. However, little information is available on the development of this exploitation, for example, on the evolution of the fishing practices. In 1997, a project on the Greenland halibut fishers' knowledge was initiated with the aim of documenting the historical and current knowledge of this fishery. The specific objectives were to compile a qualitative database of information from the fishers and to integrate this information into stock status assessments. Semi-directed individual interviews were held with 21 fishers. The information collected touched on four themes: the fishing practices, the biology and environment of the Greenland halibut, the social dimension of the fishing activities, and the management and conservation of this species. The results presented here describe the changes in the fishing practices and strategies that took place between 1970 and 1997. We also examined the relationships between these changes, the prevailing socio-economic context, and the landings of Greenland halibut for the same period. In thirteen years, the Greenland halibut fishing has evolved from a traditional and subsistence fishery to an effective and competitive commercial exploitation.

INTRODUCTION
Greenland halibut (*Reinhardtius hippoglossoides*), a flatfish also known as turbot, is generally found in the Gulf of St. Lawrence at depths from 130 to 500 m. In summer, the main concentrations of adult and juvenile Greenland halibut are located in the St. Lawrence estuary, the areas west and north-east of Anticosti Island, and near the west coast of Newfoundland, in the Esquiman Channel (Morin *et al.* 1996; Figure 1). Until the mid-1970s, Greenland halibut landings consisted primarily of by-catches from other fisheries. Later, a directed fishery using mainly gillnets was developed and landings underwent two episodes of large increases followed by sharp declines at the end of the 1970s and the 1980s (Figure 2); landings were quite stable in the 1990s. Since 1993, virtually no fish have been taken with mobile gear because of the moratorium on cod trawl fishing and the mandatory use of the Nördmore grate by shrimpers. The turbot fishery is now dominated by gill-netters whose home ports are in Quebec and on the west coast of Newfoundland. The main fishing areas are the St. Lawrence River estuary, the northern part of the Gaspé Peninsula, and in the Esquiman Channel, close to the Newfoundland coast. The fishery extends from April to November, but mainly takes place in summer months (Morin and Bernier 1999).

The Greenland halibut landings showed large fluctuations in the past, but little is known about this period for two reasons. First of all, the management of the fishery was transferred in 1982 from the provincial authorities to the federal authorities, the Department of Fisheries and Oceans. Unfortunately, most of the fishery data were lost during the transfer so no information is available for the 1970s and the early 1980s. Secondly, from 1988 to 1992, the Gulf of St. Lawrence Greenland halibut stock assessment was not performed because it was thought that the Gulf of St. Lawrence stock was a sub-population of the larger Labrador and Eastern Newfoundland stock. Therefore, some pertinent fishery data were not collected. However, parasite research conducted in the early 1990s has made it possible to distinguish clearly between Greenland halibut of the Gulf, the Laurentian Channel and adjacent areas, and those of Labrador and the northern part of the Grand Banks (Arthur and Albert 1993). These findings have led to the conclusion that some Greenland halibut complete their entire life cycle within the Gulf and are now considered to be a stock isolated from the main Northwest Atlantic population found to the east and north of the Grand Banks of Newfoundland. Since 1992, fishery and population monitoring programs have been put in place; fishery and survey data are now gathered each year and a stock assessment is performed at the end of each fishing season.

An understanding of the factors responsible for the fluctuations in landings during the 1970s and 1980s is essential to a precautionary approach to the management of the Greenland halibut fishery. Indeed, the landing fluctuations may

have been caused by a change in the fishing strategy or by a change in resource abundance. The determination of conservation objectives, such as the protection of a minimum spawning biomass, has to take into account the response of the resource to various exploitation rates. Therefore, past events in the fishery, especially when large catch fluctuations were observed, should provide invaluable information on the stock dynamics. Thus, it is most important to learn from the past events.

The Greenland halibut fishery is relatively recent with the first significant landings made 25 years ago, in 1977. Some of those involved in the first years of the fishery are still active. They have valuable knowledge of the circumstances that prevailed in the 1970s and the 1980s that is not available elsewhere. In 1997, a research project was initiated with the aim of documenting the historical and current knowledge of Greenland halibut fishers. The specific objectives were to compile qualitative information on fishing practices and changes over time and to integrate this information into the current stock status assessments and to bring a better understanding to past assessments.

METHODOLOGY

The study area is located in the estuary of the St. Lawrence River and in the western part of the Gulf of St. Lawrence in the province of Quebec. These areas constitute the most important fishing areas since the development of the fishery in the 1970s. During the winter of 1998, semi-directed individual interviews were held in different localities on both sides of the St. Lawrence estuary and gulf (Figure 1). The interviews were conducted with 21 fishers: six on the north shore and 15 on the south. Among the fishers interviewed on the south shore, six had been involved in the developing fishery in the mid-1970s.

Fishers were selected in two steps. First, after consultations with five fisher's associations and DFO fishery management authorities, a list of 55 potential participants was produced, taking into account several criteria: the fishers had to be boat captains and owners, and had to have practised a directed fishery for turbot for at least five years. The 55 potential candidates were then contacted directly, with the aim of including fishers in the study from different age groups, and fishers who had expressed an interest and openness in being interviewed. From these preliminary contacts, the list was reduced to 43 fishers. A proportional draw from the different towns on both coasts was done and the final list included 21 fishers.

The information collected touched four themes: (1) the evolution of the fishing practices of the Quebec turbot fishers in the Gulf of St. Lawrence; (2) their empirical knowledge of turbot biology and its environment; (3) the social dimension of the fishery, such as internal rules governing sharing and access to fishing grounds; and (4) their perceptions and interpretation of DFO's science and fishery management of this species. The study elements were the same as those used in a lobster fisher study conducted in the Magdalen Islands (Gendron *et al.* 2000) and as proposed by Mailhot (1993) and Inglis (1994). The methods used to collect the information were also similar to the lobster project: each interview, which lasted an average of two hours, was tape-recorded and then transcribed. The interviews for the turbot project were conducted by scientists from the Maurice Lamontagne Institute.

After interview transcription, the compilation and analysis of information obtained from the turbot fishers were done in three steps. The information was first gathered together by subject for each interview. A chronological list of the fishing practices was then constructed for each fisher. Finally, the fishing practice histories of all fishers were compiled in chronological order. Of the 21 interviews, ten were fully analyzed for the present study: five from fishers active in the 1970s but now retired and five from still active fishers. All ten fishers come from the south shore. Given the dominance of the south shore in the development of the turbot fishery, the number and origin of interviewed fishers are sufficient to describe the general historical pattern of this fishery.

The results presented describe the changes in the fishing practices and strategies between 1970 and 1997. More precisely, information was gathered on the vessels, navigation equipment, the gillnets, fishing strategies and the fishing grounds. We also examined the relationship between these changes, the prevailing socio-economic context, and the landings of Greenland halibut for the same period.

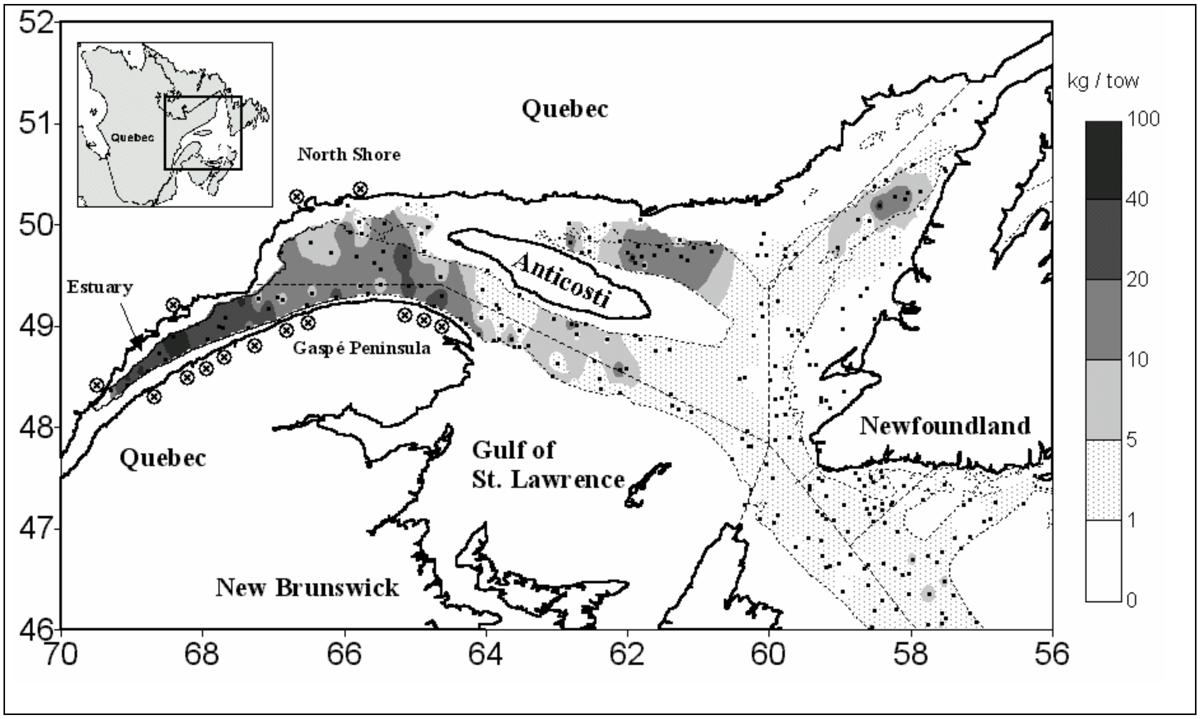

Figure 1. Distribution of Greenland halibut in the summer of 1997 on the DFO research survey. The symbols (⊗) indicate the areas where the interviews took place.

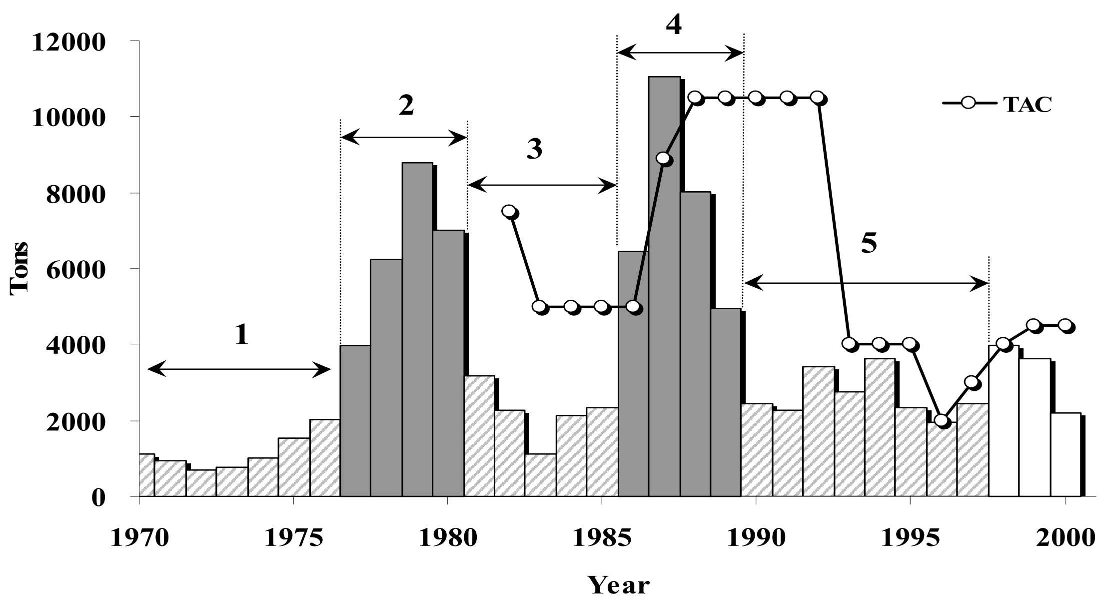

Figure 2. . Commercial fishery landings of Greenland halibut in the Gulf of St. Lawrence (TAC : Total Allowable Catch). The five periods described in the paper are indicated.

Results and Discussion

The Greenland halibut fishery has shown large fluctuations in landings over the years. An examination of the variation in landed catch (Figure 2) and the information gathered from Greenland halibut fishers (Table 1) allows the identification of five distinct periods. It was possible to link the fishing strategies to the major events that occurred in the fishery, such as the success of other groundfish fisheries, the abundance of turbot and the implementation of management measures. Therefore, the description of the relationships between the fishing practices, the prevailing socio-economical context, and the turbot fishing success (e.g., landings) is presented for five periods that cover the whole fishery, from the beginning of the 1970s to the end of the 1990s.

Table 1. Number of observations gathered among the interviewed fishers by year and by themes. An observation is a new comment expressed by one fisher for the first time. The same comment expressed many years consecutively by the same fisher is counted as one observation and is associated with the first year of its expression. The general themes are as followed : **boat**, type or length of the fishing boat; **boat equipment**, engine, winch or navigational equipment; **fishing gears**, number and type of gears; **fishing techniques**, configuration of nets or frequency of hauling; **mesh size**; **fishing success**, yields, catches or landings; **size of fish**; **fishing grounds**, location or depth of fishing; **fishing season**, month or duration of the fishing season; **crew**, number or origin of crew members; **other fishers**, behavior of turbot, shrimp or groundfish fishers; **market**, buyers, processing plants or prices.

	Boat	Boat equipment	Fishing gears	Fishing techniques	Mesh size	Fishing success	Size of fish	Fishing grounds	Fishing season	Crew	Other fishers	Market
<1972	1	2	2	2		1		1	1	2		1
1972	3	3	3	2	3	2	3	3	2	3	1	2
1973	1	1		1								
1974	1	1						1			1	1
1975	1		2			1		1			1	1
1976	1	1									1	
1977		2	2	2	3	1	1	3	1		2	
1978	2	2	2	1	3	2		3	1	1	1	
1979	2	1	1	2		1						
1980	1	2	2	2	2	1	2	1			2	
1981						1		1				
1982			3	1	2	1						
1983												
1984	1	1	2	3	2	3		2		1	1	
1985				1		1				1		
1986	2	2	3	4	5	5		2	1	3	2	
1987	2	2		1	1	3		1		1	1	2
1988		1	2	1		5		1	1		1	
1989				1		3		2				
1990				2	1	4				2		
1991			1	1		1	1	1		1		
1992	1	1	1	1		4		2	1		1	
1993	1	2	2	2	1	1		2		1	1	
1994				1	1	2		2				
1995			1	1		1	1	1		1		
1996			3	3	1	2		2		1	1	
1997		1	2	3		1		1		1	1	

1- The food fishery (up to 1976)

Some fishers remember having fished for turbot in the 1940s with their fathers. During those years, groups of four to five fishers would go to sea in September and October in small boats; they fished turbot with hand lines in shallow waters close to the shore. These men used their catch to make provisions of salt fish for the following winter. This practice was followed until the mid-1970s, with fishers keeping most of the catch for their families. Before 1975, no fish plant would process turbot. Although there were some opportunities to sell fish in a local market, or in some cases, in the Montreal market, the turbot fishery was a small-scale activity that could be characterized as a food fishery.

Landings were low, mostly below 1,000 tons per year for the whole Gulf of St. Lawrence.
At the beginning of the 1970s, fishing activities took place from spring to fall, when the fishing grounds were ice free. Fishers usually started their season in spring by fishing for herring that they sold to lobster fishers for bait. Cod and Atlantic halibut were fished in summer for the fresh-fish market. In fall, fishers directed their effort to turbot for the food fishery. Consequently, the turbot fishery was mainly practised by inshore fishers using cod fishing gear. They targeted large fish, so the gillnets they used had large mesh sizes (6 to 12 inches with the majority between 6 and 7 inches) and the longlines had large hooks. The turbot caught were so large that "they needed their two hands to hold it," as some of the fishers recounted.

Turbot fishing was labour-intensive and inefficient. Fishers experienced many operational problems that made the work very difficult. The buoys were not durable and often had to be replaced. It was difficult to find the gillnets at sea since most fishers had crude positioning equipment: only a chart, a compass, and a divider. Fishers used 10 to 20 nylon gillnets and much time at sea was required to remove the fish because the material tangled easily. Some of the fishers did not have any power equipment and they had to haul the gillnets by hand. There were few fishers, and each had his own fishing territory in front of his house. It was even difficult to find crew members because many men had left the region to work on the hydroelectric plant building projects which started in Quebec in the 1960s and the 1970s.

2- The market development and increase of effort (1977 - 1981)

The market for fresh turbot was developed in the mid-1970s when a processing plant near the fishing grounds began to buy turbot from the inshore fishers. At the same time, the cod fishery was declining and many cod fishers were looking for an alternative to their traditional activity. The inshore cod fishers directed their effort toward turbot while many of those who had trawlers obtained new licences to fish northern shrimp (Savard *et al.*, 2002). Since some of the hydroelectric projects were drawing to a close, many workers, some of whom had fished in earlier years, came back to their communities and were available for the turbot fishery. Turbot fishing underwent an increase in popularity, especially since the yields were very good and the prices paid to fishers were quite high. The landings went up rapidly to reach 9,000 tons in 1979, almost ten times what they had been in 1972.
The resident fishers who had fished turbot for many years tried to continue to practise their activity on the fishing grounds adjacent to their home ports. Some bought new boats with better equipment, but the fishery was still an inshore fleet with boats under 45 feet. With the increasing demand for turbot, fishers began to fish for a longer season from spring to fall. They gradually increased the number of gillnets that they were using regularly, from 10 to 20 at the beginning of the 1970s, up to 80 to 100 at the beginning of the 1980s. However they still went out every day from sunrise to sunset to haul a portion of their gillnets. They did not change the mesh size (6 and 6.5 inches) and the catch of large turbot was still good.

The resident fishers were joined by longliners from the tip of the Gaspé Peninsula who were shifting their activity from cod to turbot. These new fishers moved from the offshore cod fishing grounds to the turbot fishing grounds in the St. Lawrence Estuary, a sector well known for its abundance of turbot. By doing so, they were fishing on the same grounds as the resident fishers, and since gillnets are fixed gears, competition for fishing territory began. Because they had fished offshore, the longliners were bigger (about 60 feet) and very well equipped. They had four to six crew members, used more gillnets (at least 200), worked 24 hours a day, and could stay at sea for several days.

The inshore fishers began to experience a decrease in their catch rates in 1980. One fisher estimated that his catch in 1980 was about 60% less with four times as many gillnets. The fishers also noticed a decrease in the size of turbot and began to use smaller mesh sizes to maintain their catch. Some moved from their traditional fishing grounds to explore new areas where there were less fishers and where catch rates could be better. The competition for fishing grounds was high and the arrival of the new fishers changed the rules as fishing became less territorial.

The decrease of landings in 1980 marked the end of this period of development. It seems obvious that the main cause of the increase of landings at the end of the 1970s was the increase in fishing effort. Since there were very few management measures in place during this period, fishers could increase effort to satisfy the increasing demand of the new market. Moreover, resident fishers were joined by new fishers attracted by the success of this fishery, while their traditional activity, cod fishing, was declining. As some of

the fishers had noticed, the resource could not sustain such intense exploitation for long, and abundance as well as fish size began to decline in 1980.

3- Technological development (1981 - 1985)

Landings dropped after the 1979 peak and reached 1,000 tons in 1983, a catch that was equivalent to those landed in the first half of the 1970s. Many fishers left the fishery because of the lack of success. Some directed their effort to other species, while others stopped fishing and turned to something completely different. Those who continued to fish for turbot learned to be more efficient in adapting their fishing techniques to a resource that was sparsely distributed and less abundant. Some decreased the number of crew members during the years when turbot was less abundant, those who remained were often relatives of the licence owner.

In 1982, the management of the fishery was transferred from Quebec's provincial authorities to the federal Department of Fisheries and Oceans (DFO). Given the precariousness of the turbot industry, some management measures were then adopted in an attempt to better control the fishing activities and to protect the resource. Two of these management regulations had an impact on the strategy of resident fishers. First, during the 1970s, fishers were targeting large fish to satisfy the market demand. At the beginning of the 1980s, the mesh size was decreased gradually by fishers from 6 to 5.5 inches in response to the decrease in mean fish size (Morin and Bernier 1999) and in 1983, the 5.5 inch mesh size was made mandatory by the federal authorities. The second important management measure adopted at this time was the limitation of the catch by the imposition of a Total Allowable Catch (TAC). However, the TACs that were set failed to limit the fishery because they were either too high or not implemented. The Greenland halibut stock assessment was imprecise during the 1980s because of the lack of data and because of the uncertainties of the Gulf of St. Lawrence stock status. The Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC), a DFO scientific body that provided TAC recommendations to the DFO Minister until 1993, recognised the difficulty of assessing the Gulf of St. Lawrence turbot, so the first TAC was based on historical catches. Thereafter, CAFSAC indicated that the Gulf of St. Lawrence turbot was closely linked to the larger stock of Labrador and Eastern Newfoundland stock and that there was no biological reason to set a specific TAC for the Gulf of St. Lawrence (CAFSAC, Adv. Doc. 5/82 1983). Thereafter, TACs were set by the fishery managers.

The fishery had become very competitive by the end of the 1970s because of the arrival of new fishers (longliners) targeting this species. A few years later, fishers were still competing for the best sites to set their gillnets and obtain good catch rates. The management by TAC, if it did not limit the catch during this period, incited competition between the fishers to catch more fish before the TAC could be reached and the fishery closed. Turbot fishers had to adapt to become more efficient and increase their chance of success. Many bought new boats when the landings were still high. The new boats were often larger so they could carry more nets and store more fish. Since the boats had more powerful engines, they were able to reach the fishing sites faster, and go farther to explore new fishing grounds. Consequently, they exploited a larger fishing area with more nets. Some fishers extended their fishing territory from the south to the north shore, close to Sept-Îles. As fishers were exploring the territory to find sites with good catch rates, they noticed that the yields were better in deeper waters and adapted their nets to catch fish at greater depths.

Boats were also better equipped. They had new systems for more precise positioning, and radar to locate buoys and gillnets more easily even in bad weather. Before having such positioning systems, it was not unusual that fishers could not find their gillnets in fog and would lose the whole catch because the fish were not fresh enough when they were finally able to return and haul the nets. Fishers usually worked on a three-day rotation, hauling some of the gillnets each day. They changed the configuration of the nets to increase their catch by decreasing the height of the gillnets, which facilitated handling at sea and saved time. They also began to bag their nets by placing cables at equal distances between the head and bottom lines to form a bag that retained more fish.

The landings remained low from 1981 to 1985. Fishers who stayed active during this period were mostly resident. It seems that the longliners from the Gaspé Peninsula went back to the cod fishery, which was improving, while the turbot fishery was declining. The resident fishers, who had spent about five years improving their fishing techniques, were more experienced when turbot became suddenly, in one season, more abundant.

4- The increase of turbot (1986 - 1989)

Turbot fishers had to put in a lot of effort to catch enough fish to make a decent living in the years leading up to 1986, when catches increased substantially, with landings reaching a new record in 1987. Catch then declined again in 1988 and 1989. The increase in the 1986 catch rates was essentially due to the recruitment of the 1979 and 1980 year classes (Morin and Bernier 1999) to a fishery worked by more efficient fishers. The mean size of fish also increased in the following years as these year classes grew. The increase in landings was observed for both the mobile and fixed-gear fisheries. Before 1993, shrimpers were allowed to keep their groundfish by-catches and had specific catch allocations for cod, redfish and turbot that they could fish with groundfish trawls. The processing plants paid high prices for turbot; this and the high catch rates were a very strong incentive to fish turbot.

Most of the cod fishers had a groundfish licence that allowed them to fish for turbot as well as cod. However, they did not use it when turbot abundances were low. It seems that the success of the resident fishers in 1986 attracted many other fishers for the second time in ten years. As some of the turbot resident fishers mentioned, "when the fish come back, the number of boats increases". In addition to the mobile gear fleet, the Gaspé Peninsula longliners got involved in the turbot fishery again, and effort increased substantially. Not only did turbot fishers use more nets and spend more time at sea, the number of boats active in the fishery also increased rapidly between 1985 and 1987. There are some indications that not all catches were recorded during those years and that landings could have been at least 50% more than the amount declared. Some resident fishers explained that when the resource is rare, fishers tend to declare all catches because the weekly income counts in the computation of the unemployment insurance they get in winter. However, when fish is abundant, fishers may wish to keep some income for themselves without declaring it.

The effort increased substantially not only because of the involvement of other fishers but also because the turbot fishers increased their effort. They used the maximum number of gillnets and hauled their nets more frequently than before. Fishers mentioned that they used between 120 and 300 gillnets during that period. A fisher explained that it took two days to haul 120 gillnets. They were leaving at three o'clock in the morning and coming back at 11 o'clock at night. The following night, they would leave at 3 again and come back at 3 in the afternoon. Many kept that pattern for a few years and some mentioned that, at that time, they were spending days and weeks at sea to catch as many fish as possible. At one point, the fish were so abundant that they could not haul all their gillnets. Some mentioned that they had too many gillnets and that their boats were too small. One fisher even explained that he stopped fishing not because the catch rates were decreasing but because he estimated he was making too much money and would have to pay high income taxes. Despite high revenues, many fishers mentioned that they did not enjoy fishing during this period of high effort and competitiveness.

It seems that turbot fishers did not improve their fishing techniques during this period. They talked less about the configuration of their nets or their boat's equipment than about the very high catch rates they experienced. In fact, it seems that the fish were very abundant on all grounds and that the fishers did not need to adopt any sophisticated strategy to get good catches. Some mentioned that they came back to their old fishing grounds in front of their home ports because it was not necessary to go farther to get good catch rates. In 1989 and 1990, they noticed that catch rates were going down and their catches decreased. Many think that the resource was overexploited.

5- The implementation of management measures (1990 - 1997)

At the beginning of the 1990s, many marine species were declining in the Gulf of St. Lawrence. Cod and redfish abundances had decreased rapidly until a moratorium was imposed on the cod fishery in 1994 and on the redfish fishery in 1995. Shrimp was also declining, and the TAC was not reached in the main fishing area of Sept-Îles in 1992 and 1993. At the same time, there was a general willingness to ensure that all catches were recorded. Fishery management authorities negotiated with fisher associations for the implementation of TACs for some species (e.g., snow crab), the allocation of individual quotas (e.g., shrimp), and the obligation of weighing all catches at designated landing ports (e.g., all groundfish, shrimp, snow crab).

The turbot fishery also decreased at the beginning of the 1990s. Catch rates decreased substantially at the end of the 1980s and stayed low in the early 1990s. A fisher explained that he had two crew members at that time but could

have fished alone because there was not enough fish to keep them busy. Fishers began to experience high by-catches of snow crab in their nets and some had to move to deeper waters where snow crab is less abundant to avoid these by-catches. Snow crab was increasing at the beginning of the 1990s and was found in great numbers at the eastern part of its usual distribution range in the St. Lawrence Estuary (Dufour and Bernier 1994). However, by moving to deeper water, the fishers began to experience gear conflicts with the shrimp fishers.

The decrease in catches and catch rates in the early 1990s may have been actually much larger than what was observed. There are strong indications that fishers haul their gillnets less often when the fish is not abundant. Therefore, the immersion time can vary between one and three days, depending on resource abundance. The impact of this longer immersion time on the estimate of effort could be important; catch rates at periods of low abundance could be overestimated because of longer immersion time. In 1987 and 1988, fishers hauled their gillnets every two days while they reported that in 1990 and 1991 they were hauling their nets only every three days. Moreover, there are indications that not all catches were recorded during the 1986-1989 period, so catch rates for this period may have been much higher than those estimated.

Although the landings and the abundance decreased at least five fold between 1987 and 1990, the TAC was not changed until 1993, when a new study indicated that the Gulf of St. Lawrence turbot should be considered as a separate stock (Morin *et al.* 1992) and managed accordingly (CAFSAC, Adv. Doc. 15/92 1993). Until then, the TAC had remained high, at the level fixed for the abundance observed at the end of the 1980s.

Starting in 1993, a series of management measures was adopted for the conservation of turbot. The by-catches of the trawl fishery were reduced because of the cod fishery moratorium in 1994 and the redfish fishery closure in 1995. Shrimpers were also required to use the Nördmore grate to significantly reduce the groundfish by-catch. In 1994, any directed mobile fishery for turbot was forbidden and catches from mobile gear have been negligible since then. The TAC was decreased in 1993 by a factor of almost three, from 10,500 tons to 4,000 tons. Given the precariousness of the turbot stock status, the FRCC (Fisheries Resource Conservation Council) recommended in 1994 that strong conservation measures be taken to reduce the fishing effort on turbot and to decrease the proportion of immature fish in the catches. Since 1995, new management measures have been implemented: an increase in mesh size from 5½ to 6 inches, the adoption of a gillnet configuration that is more selective, the introduction of a minimum size limit for turbot (42 cm in 1996 and 44 cm since 1997) along with the application of a protocol to reduce the catch of small fish, the establishment of a dockside monitoring program to record all catches, and the gradual reduction in the number of nets used. The number of nets was finally set at 120 in 1995 but Quebec fishers voluntarily decided to use only 80 nets after 1995.

Inshore turbot fishers adjusted their fishing strategy to the new management measures. They decreased the height of their nets to facilitate handling at sea. Instead of having nets of 20 or 25 meshes in height, they now use nets with a height of 15 meshes (sometimes 12). Gillnets are now smaller, but fishers seem satisfied because their nets stay clean, they catch less snow crab, it is easier to work on the boat, and catch rates had been increasing during the last few years. Because of the reduction in the number of nets, fishers now haul them every day and take some days off during the week or on the weekend. The fishing season became shorter, from about 17 weeks in 1994 to 7 weeks in 1996. Because there are fewer fishers and fewer gillnets per set, fishers can cover more territory in search of good catch rates and large fish. However, competition for the catch is still present since fishers did not agree to implement an individual quota management program until 1999.

CONCLUSION

This study has been very useful for describing the historical pattern of the turbot fishery by Quebec fishers using fixed gears. Our approach allowed us to identify the main events associated with the five different landing periods and also to show the relative importance of resource abundance and fishing practices in the fishery success and in the landing fluctuations. The periods of high landings were both characterized by an increase of fishing effort with the introduction of new fishers and the use of more nets. However, the first period (1979) was in the context of market development for this species, whereas the second (1987) followed an important period of improvements to fishing efficiency. The similar landing values for the two periods could suggest that the abundance of turbot was comparable. However, scientific

information from DFO winter surveys conducted between 1978 and 1994 showed that the abundance of turbot could have been three times higher at the end of the 1970s and beginning of the 1980s than in the mid-1980s (Morin *et al.* 1995). This would indicate that improvements in efficiency made by fishers in the early 1980s contributed significantly to the high landings observed in the 1986-1989 period. In the 1990s, fishers also increased their efficiency but when the turbot abundance improved during the second half of the 1990s, the landings did not increase as they did during the two previous high landing periods because the TAC was limiting, being reduced and set to 4,000 t or less in comparison to 10,500 t in the late 1980s.

The drop in landings that followed the 1979 and 1987 peaks reflected a decrease in the biomass and a lack of interest in turbot fishing. The fishers that stayed in the fishery made a constant effort to increase their yield by improving their efficiency with the purchase of high-performance equipment and by changes in fishing methods. Our analysis of the changes made in the fishing equipment and practices over the past 25 years has clearly shown that the variations in landings are not linked exclusively to the abundance of turbot but also to changes in fishing practices and efficiencies that affected the fishing effort.

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1 List of Associations and representatives :
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Jean-Pierre Élément, Association des pêcheurs de la Côte-Nord

REFERENCES

Anon. 1983. CAFSAC Annual Report Vol. 5/82 p. 101.

Anon. 1993. CAFSAC Annual Report Vol. 15/92 p. 135.

Arthur, J.R. and E. Albert. 1993. Use of parasites for separating stocks of Greenland halibut (*Reinardtius hippoglossoides*) in the Canadian northwest Atlantic. Can. J. Fish. Aquat. Sci. 50: 2175-2181.

Dufour, R. and D. Bernier. 1994. Potentiel d'exploitation du crabe des neiges, *Chionoecetes opilio*, et des crabes *Hyas araneus* et *Hyas coarctatus* dans le Nord de la péninsule gaspésienne. Rapp. tech. can. sci. halieut. aquat. 1994 : viii + 51 p.

Gendron, L., R. Camirand and J. Archambault. 2000. Knowledge-sharing between fishers and scientists: toward a better understanding of the status of lobster stocks in the Magdalen Islands (Quebec). In Finding Our Sea Legs: Linking Fishery People and Their Knowledge with Science and Management. Neis, B. and L. Felt, Contributing Eds. St.John's: ISER Press.

Inglis, J. T. 1994. Introduction. In Nature & Resources (Traditional knowledge in tropical environments), UNESCO 30 (1).

Mailhot, J. 1993. Le savoir écologique traditionnel: la variabilité des systèmes de connaissance et leur étude. Évaluation environnementale du projet Grande-Baleine, Dossier-synthèse No. 4, Montréal, Bureau de soutien de l'examen public du projet Grande-Baleine, 52 p.

Morin, B, A. Fréchet, M. Aparicio, L. Lefebvre and B. Bernier. 1992. Evaluation du stock de flétan du Groenland (*Reinhardtius hippoglossoides*) du golfe du Saint-Laurent. CSCPCA Document de recherche 92/85, 39 p.

Morin, B., B. Bernier, D. Chabot and J.J. Maguire. 1995. Evaluation et biologie du flétan du Groenland (*Reinardtius hippoglossoides*) du golfe du Saint-Laurent (4RST) en 1995. Document de recherche sur les pêches dans l'Atlantique 95/59: 1-47.

Morin, B., B. Bernier, R. Arthur, G. Chouinard, A. Fréchet and P. Gagnon. 1996. Évaluation et biologie du flétan du Groenland (*Reinardtius hippoglossoides*) du golfe du Saint-Laurent (4RST) en 1995. Document de recherche sur les pêches dans l'Atlantique 96/53: 1-59.

Morin, B. and B. Bernier. 1999. Évaluation et biologie du flétan du Groenland (*Reinardtius hippoglossoides*) du golfe du Saint-Laurent (4RST) en 1998. Document de recherche du Secrétariat canadien pour l'évaluation des stocks 99/185: 1-57.

Savard, L. H. Bouchard and P. Couillard. 2002. Revue de la pêche à la crevette nordique (*Pandalus borealis*) dans l'estuaire et le golfe du Saint-Laurent pour la période 1982 - 2000. Rapp. tech. can. sci. halieu. aquat. *In prep.*

QUESTIONS

Paul Fanning: How much of the fishery is actually a turbot fishery?

Rejeanne Camirand: The fishermen that I interviewed were specialists of their activity – that is, they fished directly for turbot.

Jean Guy D'Entremont
The catch has not reached its TAC yet in the last couple of years. There was an understanding that the fishers fishing crab and turbot together were catching so much crab that they decided to avoid fishing turbot together.

Rejeanne Camirand: For the last two years there has been a high abundance of crab and fishermen fishing for turbot had some difficulty because a lot of crab got caught in the gill net.

Jean Guy D'Entremont: Is that your understanding of why the TAC was not caught?

Rejeanne Camirand: No fishers and no biologists comprehend why fishermen didn't reach the TAC in 1999 and 2000. The fishers said that the turbot was not catchable, possibly because it has moved out of the estuary or it was hiding.

Daniel Lane: Recently there has been the idea that fishing for turbot with gillnets is not very effective. Furthermore, it seems that the market allows to get much bigger and a greater quantity of turbot. Are any of the fishermen changing to longline?

Rejeanne Camirand: The fishers wanted to fish turbot with gill nets and to obtain DFO permission to keep the crab bycatch. But the DFO did not allow fishers to sell the crab.

Marine Resource Knowledge Related to Fish Classification in Haïti:
An Examination of Créole Terms, Local Knowledge, and Definitions Related to Fishing and Fish Classification in the Port-au-Prince Bay Area of Haïti

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Abstract

The Haitian fisher classifies his resources either by its morphology, habitat, economic value, or a combination of these. For morphological classifications, characteristics may include any combination of color, size, shape, etc. Certain of the fishers' classifications may follow taxonomic lines, for example: *Bouki* (*Pomacentridae*), *Fwoo-Fwoo* (*Tetraodontidae*), *Sol* (*Bothidae*), and *Venkatrè* (*Scorpaenidae*). Organisms may also be classified by the habitat in which they are found such as *flôt, gran dlo, gran fon, gwo dlo,* or *gwo lanmè* meaning they are found far from shore in deep and/or open waters; *zèb*, in sea grasses and algae on the bottom; or *wòch*, in rocky areas or coral reefs. Both *zèb* and *woch* fall into the category of *à tè* (on land or near land) or *nan sèk* (in the dry or near land) meaning that the subject is near shore and not in waters that are very deep. The most important classification of fish as far as the fishers are concerned is based on its economic value. This classification system involves the color of the skin of the fish and includes *pwason wos/wouj,* 1st Class (pink/red fish), *pwason blan,* 2nd Class (white/silver fish), and *pwason nwa,* 3rd Class (black fish). It is also directly related to the commercial value/attractiveness of the various fishes, and is usually discussed upon the landing of the fish between the fishers and the fish merchants as well as at the markets, although it is already clear to all which fishes belong to the different categories. There is a definite hierarchy in this classification system in relation to pricing, with *pwason wos/wouj* demanding the highest prices, *pwason blan* the next highest, and *pwason nwa* and the rejects/trash fish (4th Class) rounding out the bottom of the scale. Various sizes or developmental life stages of the same fish may be classified differently in terms of economic attractiveness according to this classification system.

Introduction

The traditional environmental information system used by indigenous peoples being commonly referred to these days as Local Indigenous Knowledge (LInK) has helped humans feed themselves, heal themselves, and to survive for untold millennia. Before the advent of "modern" science, this information, passed down from generation to generation, and in the process systematically modified and improved, was, and still is, undoubtedly responsible for the survival of many cultures.

The understanding of local knowledge and its importance to local communities in terms of their capacity to protect and manage their own resources is of vital importance for any "outsider" manager. The precise identification and denomination of living elements of the marine coastal environment (species, varieties, life stages, life forms, etc.) are an essential foundation for any resource management program. A management program which is to be community-based requires that these names, naming systems and concepts relating to the environment be anchored in the local language and local systems of representation. Furthermore, if management is to be co-operative, involving scientifically trained resource managers, community development specialists, and local knowledge resource users (fishers), then it is imperative to understand the extent to which scientific and local names and concepts concur or differ. Only with this information can an exacting and mutually respectful dialogue be established between manager and resource user.

Methodology

Step 1- Introductory meetings with fishers and others from the fishing communities were held in order to discuss: the overall aim and approach of the research; the data collection process (interviews, and tape recordings); and the identification of key informants (based upon extent and wealth of knowledge, familiarity with different geographic areas or fishing techniques or differing expertise with respect to specific ecological systems).

Step 2- Semi-directive interviews were conducted with individuals identified in Step 1. These began as exploratory, but then began to delve into more substantive matters, increasingly focused on: local names for natural objects (first "species" names and then also sex/life stage names, e.g. male/female, egg/juvenile/adult); relationships/associations/groupings of these

locally named species (ecological relationship and/or taxonomic relationship and/or symbolic or society-based relationship, for example fish used/eaten only by women, children, or the elderly, resources used only in times of hardship, etc.).

Target Area

This work is ongoing and the information presented herein was undertaken in the Port-au-Prince Bay area in Haiti concentrating on the Arcadins Coast from *Source Matelas* to *Montrouis* from 1998-2000.

Interviews

More than 175 interviews were held involving more than 250 individuals. Interview times ranged from anywhere between ten minutes and six hours, with individual interviews generally being between one to two hours long and group interviews two to six hours.

Data collection

As with most activities taking place in the Haitian country-side, individuals wandering by, or observing you from a distance, may become intrigued by the goings-on, and may freely join in on a conversation and offer their own "expertise" on the subject matter. This occurred on more than half of the occasions that interviews were being held in open or somewhat open community areas. In one example, a small group interview began with three individuals and by the time the session was finished four and a half hours later there were more than 32 individuals providing various inputs. Unless interviews are being undertaken specifically to gather an individual's knowledge (and therefore usually performed away from possible crowds) this type of community participation was encouraged.

Interviews in large groups were generally held only with books/pictures, individual and small group interviews were generally held with live specimens with the use of books for confirmation of identification if doubts were raised. Most participants in single person interviews also participated in at least one of the group interviews. At no time did any of the interviews feel rushed. There was always plenty of time to go over names and to make clarifications if needed. Approximately one half of the interviews were recorded for later review.

The relative proportion of information gathered using live specimens versus books/pictures is estimated to be approximately 50-50. The names of the more common and more commercially-attractive fish were generally well agreed upon, however, all fish, especially those identified by fishers down to species level were cross-checked with several identification guides. No data were entered unless corroborated by at least two individuals.

Location of interviews

Fishermen were interviewed at the headquarters of the *Association des Pêcheurs de Cont (APEC), Association des Pêcheurs de Mitan (APEMI),* and *Association des Pêcheurs de Luly (APEL)* as well as at various random locations along the coast, including certain markets where fishermen and vendors were encountered and willing to cooperate (all were willing to cooperate for anywhere from a few minutes of their time, to most of a day).

THE SITUATION IN HAITI

Marine resources have always been open access in Haiti. Fishers have the basic knowledge handed down from generation to generation by others (family, friends) that allows them to fish in basically the same way as the generation that preceded them. This knowledge includes fishing areas, how to make traps, when and where to fish, etc. In the past, up until perhaps fifty years ago, this knowledge was revered and respected as the best method for allowing what may be considered sustainable fishing. According to the older fishers, these techniques were used with a definite eye towards maintaining a strong, healthy and sustainable resource base. Different fishing methods were used at different times of the year in order to help manage the resources. Small and egg-bearing lobster, small conch and turtles, and juvenile fish were, in general, not intentionally harvested or were thrown back into the sea if accidentally caught.

Fishing methods: Traditional and Modern

In the past, when resources were abundant, there were generally no conflicts over one fisher entering another's fishing area because fishers at that time were not possessive of different areas. Resources were abundant. The concept of "I can't stop someone from making a living" especially since "the sea is for everyone", goes back further than any of the fishers can remember. It is really only recently that the fishers have begun to develop a sense of possession of certain fishing areas, brought about no doubt, by a decrease in productivity and an increase in the number of fishers (crowding), as well as the numbers of unsustainable/ destructive methods. These conflicts usually arise when a fisher using older

"sustainable" methods (i.e. traps, hook and line) reacts against a fisher using what would be considered a new, damaging method (i.e. compressors, small meshed nets).

Where and When to Fish and Methods

What may be referred to as the traditional rotation of fishing areas and seasons have not changed much over the past few generations. Now, however, with a tripling, quadrupling, and according to some of the fishers, a quintupling of fishers in the area over the past fifty years, there are fishers who will tend to fish only one area all year long and/or use only one type of method (Compare Mangahas, this vol). This gives rise to the correct impression that all waters are being fished at all times. The fishers described the current situation as one where any method may be used at any time depending on if the fisher feels it is in his best interest to change method/materials and/or location.

Fishers tend to be more active around the deeper open waters around the *Kanal* and *La Gonâve* areas from approximately September/October through to around April/May (the *Kanal* is the deeper waters of the Canal of St. Marc located between the north/north-east side of *La Gonâve* island and the Arcadins Bank; paralleling *La Gonâve*).

The main methods used during this season, both now and in the past, are hook and line and the *gwo nas* (large trap). The main reason for being in the *Kanal* at this time is the increase of migratory pelagics, which along with the usually present non-migratory pelagics, now increases the fishers' chances of catching something substantial. Hook and line during this season is generally used to catch Vermillion Snapper (*won*), Yellowtail Snapper (*kola*), Tilefish (*viv*), Lane Snapper (*agenté*), Dolphin (*dorad*), Wahoo (*mèlan*), Ballyhoo/Balao (*balawoo*), Barracuda (*békin*), and other "*gwo pwason*" "big fish". The *gwo nas* (large trap) may be used as *gwo nas fon,* laid on the sea floor down to approximately 100 ft., or as *gwo nas flôt*, floated in the water column with a buoy at 5 to 15 feet deep, depending on the target fish. The *gwo nas fon* is usually laid out along the shallower edges of the *Kanal* and is used to catch Parrotfish, Angelfish, Cardinalfish and other near shore fish. The *gwo nas flôt* is put out in this area with the hopes that something else will swim into it. It has been known to catch Yellowtail Snapper, Dolphin (fish), Wahoo and other fishes, including sharks.

During the season which extends from May/June through to August/September, fishers who still use more traditional methods fish closer to shore, both inside or very near the fringing reef at *La Gonâve*, near the Arcadins Islands or between the Arcadins Islands and the mainland. They have now switched over to *ti nas* (small traps) and are catching parrotfish (*pawoket*), goatfish (*babarin*), eels (*kong*), cardinalfish (*kadino*), angelfish (*magrit*), and other smaller reef fishes (*ral-ral, rebeka, bouki*, etc.) found closer to shore. The *ti nas* are usually placed in fairly shallow waters; usually where the bottom is visible from the surface; the water clarity in Haiti is such that this may be as deep as 80 ft. in certain areas. These traps may also be used as *nas flôt,* and as with *gwo nas flôt*, the hope is to catch anything that may stumble into the trap, including any Jacks (*karan*) *(Carangidae)* and Rainbow Runners (*pilot kola*).

The basic method of "law enforcement" in the past was chastisement by other fishers, or not being able to sell your catch because you've harvested an underdeveloped, unmarketable resource. This was/is the basic premise behind using sustainable methods and the "wisdom of the elders" technique, the only type of regulation ever used to any extent in Haiti.

The older fishermen are in agreement that the main type of fishing in their day was the use of traps both large and small, and hook and line.

CLASSIFICATION OF FISHES

This section discusses the classification of fish by fishers and merchants in terms of morphology, habitat, and economic value.

Morphology

The Haitian fisherman physically identifies and therefore classifies fish according to certain common characteristics. These characteristics may include any combination of color, size, habitat, shape, etc. Many of the fishers' classifications follow taxonomic lines, for example: *Bouki* (*Pomacentridae*), *Bouse* (*Balistidae*), *Fwoo-Fwoo* (*Tetraodontidae*), *Karan* (*Carangidae*), *Sol* (*Bothidae*), and *Venkatrè* (*Scorpaenidae*). Other fisher classifications which do not precisely follow taxonomic lines, may use one or a varied combination of several of the above mentioned characteristics. An example of this is fish which are classified by the fishers as *Magrit*. The Angelfish (*Pomacanthidae*) make up this entire taxonomic classification as well as the vast majority of the fisher classification. However, the fisher classification *Magrit* also includes the Atlantic Spadefish *Chaetodipterus faber,* a member of the genus *Ephippidae*. The *Magrit*

are all generally described by the fishers as colorful, large flat ovals, with a three-tailed appearance. Although not as colorful as the *Pomacanthidae*, the Atlantic Spadefish complies with the other two attributes, and is therefore included in the fisher classification of *Magrit*.

Habitat

Fish are also classified by the habitat in which they are found, such as *flôt*, *gran dlo, gran fon, gwo dlo,* or *gwo lanmè* meaning they are found far from shore in deep, open waters; *zèb*, in sea grasses and algae on the bottom; or *wòch*, in rocky areas or coral reefs. Both *zèb* and *woch* fall into the category of *à tè* (on or near ground) or *nan sèk* (in the dry or near land) meaning that the subject is near shore and not in waters that are very deep (greater than approximately 50 *bras* – 300ft. -- a *bras,* is equivalent to approximately six feet and is the distance from hand to hand measured by a fisher with outstretched arms).

Economic Value

This classification system involves the color of the skin of the fish and has been in use longer than any of the fishers can remember. It includes *pwason wos/wouj* (pink/red fish), *pwason blan* (white fish), and *pwason nwa* (black fish), and is directly related to the commercial value/attractiveness of the various fishes. It is usually discussed upon the landing of the fish between the fishers and the fish merchants, as well as at the markets, although it is already clear to everyone which fish belong to the different categories. There is a definite hierarchy in this classification related to pricing, with *pwason wos/wouj* demanding the highest prices, *pwason blan* the next highest, and *pwason nwa* and the rejects/trash fish (4th class) rounding out the bottom of the scale.

Pwason wos/wouj (pink/red fish), also known as the 1st class*,* includes the more commercially attractive pink and red fishes such as Snapper (red), Red Hind, Graysby, Stoplight Parrotfish, Glasseye Snapper, Bigeye, and Cardinalfish. These fishes are usually sold in higher class markets and hotels, and to wealthier individuals. Most of the fish classified as *pwason wos* are also classified as *pwason flôt*. The prize of prizes for the Haitian fisherman is the large Red Snapper.

Pwason blan (white fish – refers more to silver fish), also known as the 2nd class, includes Dolphin (fish), Barracuda, Wahoo, Triggerfish, certain of the larger Parrotfish, some of the lighter colored Snappers, Jacks (*Carangidae)* as well as sharks and Mackerel. These are commercially less attractive fishes than the *wos/wouj* 1st class fishes, are sold to a more middle class market and are generally considered to be middle quality fishes. The smaller of these fishes, as with the smaller *pwason nwa,* are more commonly eaten by the fishermen themselves or sold to the more destitute, including the elderly.

Pwason nwa (black fish) is also known as the 3rd class and contains most of the darker colored and usually least commercially attractive of all the fishes. They are also largely classified as *pwason wòch*, meaning they are found in rocky habitats and coral reefs, and include Butterflyfish, Damselfish, and Gobies. This group, however, also contains Groupers, and the Jewfish which can grow to well over 100 pounds. A large Grouper or Jewfish, although classified as a *pwason nwa,* may still earn a good price at the market due solely to its size. Pound for pound, however, a *pwason wos/wouj* demands a premium.

Because there tend to be more species of smaller fish, and their commercial value is lower because of their small size, clarity in naming becomes more difficult. The less economically important something is to an individual (or groups of individuals), the less time is spent in categorization. Because of this, there tends to be an often used categorization of *rejet* (rejects) which are sometimes referred to as a 4th class and which encompasses all of the smaller less desirable fishes including: *Bouki* (Damselfish), *Delaké* (Basslets), *Fwoo-Fwoo* (Burrfish), *Goud* (Butterflyfish), *Pé* (Blennies), *Pilot* (Hamlets and Gobies), *Ral-Ral/Rebeka/Girel* (Wrasses and Razorfish). Certain Parrotfish and especially juvenile Parrotfish are categorized as *flérin*. These too are often left for the old, the poor, and children and seem to be vaguely classified just slightly higher than most rejects. Because of similarities in appearance and size, many of the wrasses (*Labridae*) also fall into this category.

It is important to note that various sizes or developmental life stages of the same fish may be classified differently in terms of economic attractiveness according to this classification system. An example is the *Scaridae* (Parrotfishes) in which the small dark or black and white banded initial phase/juvenile may be classified as *flérin,* which is the same category as *pwason nwa/réjet*. As the fish matures, however, and changes color, it may eventually climb the classification scale to *pwason wos*; even skipping the intermediary classification of

pwason blan altogether. The dynamics of this classification system are therefore wide and varied with basically only the color and size of the captured fish itself having any bearing on its final marketable value.

Acknowledgements

Many thanks to UNESCO/CSI for providing all types of support for this research.

Questions

Richard Hamilton: Are the fish identified to a species-specific level?

Jean Weiner: Yes they are. It is only when the fish start getting smaller and less important that they put them together in one group.

Bill Montevecchi: The situation you describe is the tragedy of the commons. Do you see any way out of this? Are there any options?

Jean Weiner: We need to have serious public sector involvement. State intervention hasn't helped. Instead of being benign they are making the situation worse. In an attempt to help the fishers two years ago, they brought in the Cuban fishers with large trawlers. Haitians have small boats. The Cubans taught them how to use modern fishing techniques but the Haitians can't buy the 36-foot trawlers. That ended up being a major disaster. The money acquired was supposed to go for a fund to help the fishers but no one has seen the fish or the money.

Barbara Neis: You mentioned that the trash fish are becoming more commercially viable. Are there links between the names and this that you are describing?

Jean Weiner: Not really. As the resource base becomes more depleted, fishers move on to different species. Species that were never looked at 15 years ago have become very important for the fishers' survival today.

Anonymous: Are there any names for fish that no longer exist?

Jean Weiner: There are fish that the fishers say they don't see anymore. I don't know if they still exist.

PLATEAU FISHING TECHNOLOGY AND ACTIVITY: STL'ATL'IMX, SECWEPEMC AND NLAKA'PAMUX KNOWLEDGE

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ABSTRACT

The image of Aboriginal men perched over turbulent water with fish nets in hand is well known to many people. Though this picturesque scene may be viewed as romantic and daring, it is actually a way of life for many people in the Plateau region of British Columbia. The ability to carry out this practice relies not so much on bravado and adventure but rather on knowledge of the people passed down for generations.

In a museum environment, collection and presentation of many facets of various cultures is a primary focus. Documentation of Aboriginal fishing from the Plateau region of British Columbia has been very weak, however. The Canadian Museum of Civilization (CMC) has only a few artifacts related to fishing. These do not accurately reflect the importance of fishing to Interior Salish peoples, such as the Stl'atl'imx, Secwepemc, and Nlaka'pamux. Nor does the collection encompass the variety of tools and techniques employed by fishermen in this region.

Fishing activity is better represented in archival photographs held in the CMC, the Royal British Columbia Museum (RBCM), and Provincial Archives of British Columbia. These photographs span from circa 1868 (Frederick Dally photographs) to the 1950s.

INTRODUCTION

In 1999 I began research on the topic. Initially, I planned to conduct field research to document contemporary fishing practices. However, I was unable to continue field research, so shifted focus to summarize ethnographic fishing practices of Secwepemc, Nlaka'pamux, and Stl'atl'imx people; to analyze fishing tools held in museum collections; and to review various impacts on Plateau fishing practices throughout history. Finally, I provide a summary of comtemporary fishing practices as observed through my own field research and by others involved in fishing today.

FISHING IN THE PLATEAU REGION

There is general agreement among scholars that fishing activities, especially those related to salmon, have been the foundation of Aboriginal economic, cultural, and social lifestyles along the Fraser, Thompson, and Nicola rivers. All Interior Salish groups have access to fish and salmon is the most abundant. The principal salmon harvested along interior rivers are Chinook (*Oncorhynchus tschawytscha*) and Sockeye (*Oncorhynchus nerka*). Chum salmon (*Oncorhynchus keta*) were part of the Fraser River fisheries before the nineteenth century. Coho salmon (*Oncorhynchus kisutch*) travel up to the middle reaches of the Fraser River in the summer. Steelhead salmon (*Salmo gairdneri*), sometimes referred to as trout, is also available in the Fraser River[1]. According to Pokotylo and Mitchell (1998), the distribution and population densities of the Plateau people are directly linked to their access to this resource. Archaeological evidence of "extensive exploitation" of salmon dates back three thousand years (Lohse and Sprague 1998:25). Harris (1997) estimated that the Fraser Canyon supported large human populations prior to the devastation caused by introduced diseases. This large population could only be maintained with sufficient food resources, in this case salmon that was caught and cured along the banks of the river. In aboriginal times, the ability to process and preserve fish influenced the amount of fishing that would take place. Once the dry racks were full, one had to wait until the fish were sufficiently dry before removing them and filling the racks once again.

Little research has been done on the level of fish consumption other than salmon. However, a variety of other fishes is harvested in the Plateau area. Many of these species are resident year round, and so are consumed fresh. These fish include: largescale suckers (*Catostomus macrocheilus*), northern pikeminnow (*Ptychocheilus oregonensis*), peamouth (*Meilocheilus caurinus*), mountain whitefish (*Prosopium williamsoni*), Dolly Varden trout (*Salvelinus malma*), cutthroat trout (*Oncorhychus clarki*), longnose suckers (*Catostomus catostomus*), and lake trout (*Salvelinus namaykush*).

The geography of British Columbia's Plateau region is varied, from high mountains to rolling foothills and vast grasslands, all intersected by large rivers. Aboriginal people of this region have developed distinct languages and societies

[1] The health of all salmon stocks other than the Sockeye is now considered precarious or nearing extinction.

but share some cultural traits. Perhaps the most evident of these is their reliance on fishing. Interior Salish groups included in this research are the Stl'atl'imx, Secwepemc, and Nlaka'pamux (their traditional territories are shown in Figure 1).

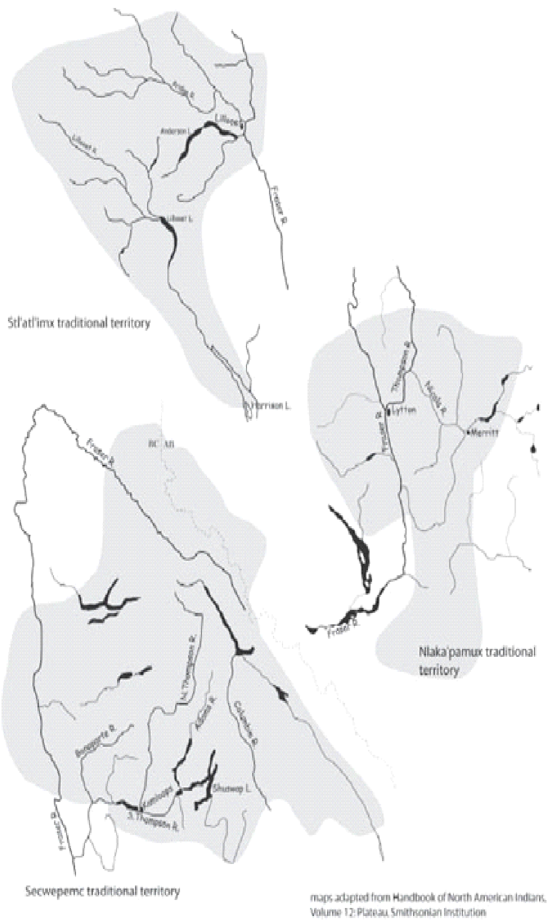

Figure 1. Maps of the traditional territories of the Stl'atl'imx, Secwepemc, and Nlaka'pamux Interior Salish groups of British Columbia.

Stl'atl'imx

The Stl'atl'imx are also called Lillooet and can be divided on the basis of dialect and geography into Upper and Lower divisions (Kennedy and Bouchard, 1998). The term Stl'atl'imx designates them as speaking the same language. The Upper Stl'atl'imx share more of the Plateau cultural traits while people living in the Mount Currie region tend to be tied closer to the Halkomelem peoples of the lower Fraser River.

A comprehensive study of Stl'atl'imx fishing is found in Hayden (1992), which compiles research on Stl'atl'imx resource use, both historical and contemporary. The Stl'atl'imx have some of the best salmon fishing and wind drying spots in their territory. In Aboriginal times, spring salmon began running in April, followed by a second spring salmon run in late summer, then a series of sockeye salmon runs starting in June. Due to the decline of many fish stocks today, the majority of Stl'atl'imx fishing is now centred on the sockeye runs of July and August at the Bridge River /Six Mile site near the town of Lillooet.

Teit (1906) noted that the Stl'atl'imx used a variety of fishing gear:

> *The Upper Lillooet gathered at different places along the Fraser River between Lillooet and the Fountain, where they caught large quantities of salmon with bag-nets. The spears used were similar to those of the Thompson Indians. Single and double pronged spears were used from the shore, and three-pronged ones from canoes or rafts. Very long-handled spears and gaff-hooks were used for catching fish in muddy pools or large eddies. Barbed hooks of antler with short handles, as well as spears with detachable points, were used for pulling out fish at weirs or dams. Metal hooks were used at the present day. Fish-traps were of two kinds, as among the Shuswap and Thompson Indians. They were set at gates or openings of weirs, in creeks near the outlets of lakes, or near mouths of creeks flowing into lakes. .. Fish were also caught with lines and baited hooks. The latter were made of bone, wood, and thorns of the hawberry-tree (Crataegus rivularius Nutt.). Copper hooks were also used, which were similar in shape to the double bone hooks of the Thompson Indians (227-228).*

Once caught, salmon was wind or smoke dried and kept over the winter. Some fish was rendered into fish oil, a practice that does not appear to be common today. The American Museum of Natural History has a number of Stl'atl'imx artifacts related to fish oil rendering which are not found in other collections. Teit collected these near the turn of the twentieth century. The process for rendering salmon oil is mentioned by Kennedy and Bouchard (1992; 1998) but it is not evident whether or not fish oil is still produced today. I did not see fish oil production in 1999 nor did I hear people talk of it.

Stl'atl'imx people are renowned for their wind dried salmon. Today, as in the past, they wind dry salmon in August when grasshoppers are singing. It is said that when grasshoppers make a particular clicking sound, it resembles the

sound of a knife cutting through a salmon's backbone, announcing that conditions are perfect for wind drying.

Secwepemc

The Secwepemc people are also known as the Shuswap and the two names are used interchangeably. There are seven divisions of Secwepemc people within seventeen bands. Their territory is in the southern interior of British Columbia, around the Thompson and Fraser rivers. Traditional villages and current Indian reserves are located along the rivers. There are two physiographic areas within Secwepemc territory, known as the Fraser and Thompson plateaus. The Fraser plateau is characterized by rolling lowlands along the Fraser River between the Coast and Rocky Mountains (Ignace 1998). The Thompson plateau includes narrow plateaus and highlands of Cascade and Coast mountains. The Secwepemc territory is rich in salmon spawning beds. It is estimated that "about 57% of all Fraser River sockeye salmon, as well as 25 to 34% of Fraser River Chinook and Coho salmon respectively" spawn in Secwepemc territory (Pinkerton and Weinstein, 1995:149).

Ignace (1998) and Teit (1909) have documented traditional Secwepemc fishing practices. According to Ignace (1998), fish weirs were important to Secwepemc fishing[2]:

> *The weirs consisted of a framework of poles, ticks, and rush, which were built across a creek like a fence. As they gathered in front of these fences, salmon were speared or dip-netted by the fishermen. Another form of weir consisted of two fences, the first one of which was built in such a way as to be penetrable by the salmon ascending the river, but preventing their return. The fish thus remained between the two fences until they were removed with spears (p. 206).*

Ignace went on to discuss the egalitarianism of the Secwepemc in sharing salmon and other resources. Men fished together and their catch was distributed among the various families participating in the fishing. Additional fish were caught and sometimes processed for the elderly or those incapable of doing this work themselves. This practice continues today.

The continuing importance of fishing to Secwepemc is evident in the cultural and educational material they produce today. Fishing activities are featured in the Secwepemc Heritage Centre in Kamloops. This exhibit includes a salmon trap, a *mineep* (toggle spear), a dip net, two leisters (one made with bone and wood, the other from a pitch fork), and fishhooks as examples of Secwepemc fishing technology. The Heritage Centre has produced a video entitled "how to make a pitch fork leister" which is used in schools. The Secwepemc Cultural Education Society (SCES) has produced a number of textbooks that include information on fishing. The Teachers Guide, for example, states as one of its learning objectives of the summer module, "Students will recognize the ingenuity of Shuswap fishing technology" (Mulligan 1988:37).

Nlaka'pamux

Nlaka'pamux people have been known by other names including Thompson, Couteau, or Knife Indians. They are divided into Upper and Lower groups; currently there are fourteen Nlaka'pamux bands. Nlaka'pamux territory, like the people themselves, can be divided into two areas. The upper area is characterized by dry grasslands along river valleys with the higher elevations covered with fir and aspen. The lower area is more influenced by the coastal climate with stands of cedar and fir (Wyatt 1998). Villages were located along the Fraser, Nicola, and Thompson rivers. One of the most important fishing sites and trading areas was near Spences Bridge, at the confluence of the Nicola and Thompson rivers.

Little research has been done on Nlaka'pamux fishing practices since James Teit's book *The Thompson Indians of B.C.* was published in 1900. Wyatt devotes two paragraphs to fishing in a chapter on Nlaka'pamux culture; she mentions their use of "a variety of hooks, gorges, nets, and traps" (Wyatt 1998:193). According to Teit (1900), the principal fishing gear was the bag or dip net. This type of net is attached to a hoop at the end of a pole and the fisherman dips it into the water to catch fish. It is used in areas where the fish "hug the shore" in their attempt to move upstream against a strong current (Teit 1900: 250).

Nlaka'pamux had numerous fishing sites along the Fraser River. While traveling along the Fraser River in 1868, photographer Frederick

[2] Aboriginal people have not been permitted to use weirs and traps for many years. As part of an Aboriginal Fishing Strategy project, the Secwepemc maintain a fish monitoring fence at Scotch Creek where people are allowed to catch salmon.

Dally had opportunity to see many active fishing sites from Yale northward[3]:

> *They build a light platform of poles jutting out of the clefts of the rocks overhanging the river with two or three short planks to stand upon. There are numbers of each in the rocky places of the Fraser River cañons for about 20 miles above Yale (I have not observed them anywhere else either on Vancouver Island or British Columbia). They certainly are very light and picturesque to look at, but for anyone but the most skilled to stand upon, most dangerous. An Indian will stand in the hot sun with only a shirt and pair of pants all day, over the boiling and wirling [sic] eddies below him intent on looking into the water, with his long pole and net ready to plunge it into the water, and bring up a heavy struggling salmon perhaps weighing 20 lbs. He skillfully lands the fish at his feet, strikes it a blow on the head, then puts his forefinger into its gills and dexterously throws it to his wife or family who are on the watch near at hand and at once proceed to gut it. Then they split it with many others on a light frame work of poles beneath which a fire is kept burning and what with the smoke and sun together they are thoroughly dried and seasoned and rendered fit for storing... Some of the salmon cured in that way are excellent eating. I enquired [sic] of an Indian whether any of those who fished from those light temporary looking structures over the river were ever lost. He informed me that two had been drowned during the late salmon season. Should an Indian happen to fall in there is not the faintest hope of his ever reaching land alive... Salmon in ascending a rapid river like the Fraser require to stop and rest in these eddies before making a spring for higher water, as the water is no where level in these cañons. Then is the Indians [sic] opportunity to catch them in his net (BC Provincial Archives MS2443 box 1 file 13).*

People stopped building and using fishing scaffolds around the 1960s (Kennedy and Bouchard 1992). I have found no reason for the abandonment of fishing platforms, but I suspect it may be that people now travel to fishing sites where the fishing is easier.

[1]Text has been edited from the original by adding punctuation and capitalization.

IMPACTS ON FISHING IN THE PLATEAU REGION

As in other parts of North America, there came a time when settlement of the Plateau region by non-Aboriginal people began. "First contact" between Plateau peoples and non-Natives is generally identified as the meeting in 1808 of Simon Fraser, an explorer for the Northwest Company, as he descended the river now named after him.

Fort Kamloops was built in 1811 and the Plateau peoples were drawn into the fur trade. Dried salmon became a commodity of trade. It was purchased for provisioning post employees, as transporting food to this remote region was very expensive. The Fort Kamloops trade journal of 1822 includes the notation, "Mr. Montigny(?) and 10 men started for Fraser River, he has goods to the Amount of 364 Skins, the principle cause or reason for sending him to procure dried fish for our winter. [illegible] we have nothing else to depend on but dried salmon" (HBCA B.97/a/1 August 26th). Teit (1906) also noted this practice. "Sometimes Hudson Bay Company employees would come as far as Spences Bridge, trading tobacco, ribbons, etc., for furs and dried salmon" (Teit 1900:260). Salmon was sold by the "stick" which was about 100 salmon (Teit 1900). The September 24th inventory for that year reveals a stock of 10,300 dried salmon "in store." (HBCA B.97/a/1 Sept.26th).

The 1858 Cariboo Gold Rush hurried the arrival of Europeans into the B.C. interior. An estimated 25-30,000 miners arrived that year (Laforet and York 1998). Almost immediately, salmon fisheries were affected as miners disrupted creeks where salmon spawned in search of gold. In 1858 there was an incident where Aboriginal people attempted to stop miners from disturbing salmon spawning beds (Souther 1993); this event foreshadowed many other confrontations over the next century. In 1860 construction of the Cariboo Wagon Road began, again increasing people's access to the interior.

The Indian Act, first passed in 1876, marked the beginning of legislated control of Canada's Aboriginal people. Native people in the Plateau region would soon feel the effects of legislation by the colonial governments (federal and provincial) on fishing and other activities. The earliest fisheries legislation was the Dominion Fisheries Act in 1878. It made no mention of Indian[4] fishing but restricted the use of nets in fresh water, which related directly to Aboriginal

[4] Indians is used here as the legal term with regards to the Indian Act. Any Aboriginal person not defined as an "Indian" under the Act could not, in effect, participate legally in the fisheries.

fishing practices (Ware 1978:20). The practice of bartering or selling salmon was not acknowledged in this legislation. That year, the Indian Reserve Commission under Gilbert Malcolm Sproat, began setting aside reserve lands in the Plateau region. Already at this early date, there were tensions over the land as settlers and miners had taken much. When reserves were surveyed, some fishing sites were identified and set aside as reserve lands in recognition of the importance of fishing in the region. In some instances, the reserve commissioner noted an "exclusive right" to fish for salmon in certain areas along the rivers (Harris 1998).

The following decade, Aboriginal people were specifically restricted from selling salmon by the British Columbia Fishing Regulations Act. The salmon run of 1886 was particularly small and with 6,000 commercial fishermen already on the Fraser River, competition for the fish was fierce (Newell 1997). In 1886, new fisheries regulations were enacted which restricted aboriginal peoples' access to fish (Newell 1997; Ware 1978).

At the turn of the century, a number of canning and fishing enterprises owned by Euro-Canadians were operating along the British Columbia coast. These owners actively lobbied government to restrict fishing by Aboriginal peoples as they were in direct competition for the same fish stocks. As a result, Native people throughout the province found themselves requiring "special" permission to fish by 1894. By 1910 the Fishing Regulations Act limited Aboriginal fishing to specific areas and times. In addition, it defined legal fishing gear based on Euro-Canadian models (Newell 1997).

Two railway lines were built along the Fraser to Lytton then along the Thompson River as far as Oregon Jack Creek. The Canadian Pacific Railway was completed in 1885 and the Canadian Northern Railway in 1915. Rock slides caused by railway construction in 1913-1914 disrupted the salmon runs (Newell 1995). Laforet and York (1998) described the events.

> *In 1913 a slide of rock and debris caused by CNR construction blocked the Fraser River, stopping the upriver passage of sockeye, and in February 1914 a slide at Hell's Gate compounded the already serious damage. Because it was the very populous 'fourth-year' run, the implications for succeeding runs were serious (p.100).*

While some of the devastation to the fisheries was ecological, there was also political fallout for the Aboriginal people. According to Souther (1993)

> *When the magnitude of the Hell's Gate disaster was acknowledged by officials in 1914, it was the Natives who again bore the brunt of restrictions, in the name of conservation. Traditional methods of fishing with dipnets and sidenets were banned and officials attempted to prohibit all fishing between Hope and Lytton (p.11).*

Chiefs and community members protested to government representatives and sent letters to the editor protesting fishing closures, demanding the restoration of fishing or, at least, compensation (Laforet and York 1998: 100). Testimonies at the McKenna-McBride Commission hearings in 1914 and 1915 often included complaints about disruption to fishing. In 1915 the Chief Inspector of B.C. fisheries stated that Aboriginal food fisheries had to be limited further as their effect on the commercial fishery was too profound. In 1922 the permit system was established whereby Aboriginal people had to apply for a permit to catch salmon for personal consumption (Newell 1997; Souther 1993). From that point on, B.C.'s Aboriginal peoples barely held on to their fishing rights, and were constantly at the mercy of government legislation, which openly supported commercial fisheries[5].

Disruptions and limitations to Aboriginal fishing have continued through the twentieth century. Legislation, guardian patrols, and outright intimidation of Aboriginal fishermen created a tension-filled environment that became part of the summer news of British Columbia, along with forest fires and tourist reports. While Pacific coast salmon provided a lucrative income for those involved in the commercial sector, the opportunity for Aboriginal people to fish for their own purposes was often curtailed or severely restricted. During the second half of the nineteenth century, a continuing history of protests, arrests, confiscation, and confrontation marred Aboriginal fisheries.

> *Nowhere was the issue of the Indian fishery more pressing than on the all-important Fraser River where over half the B.C. Indian food-permit salmon was caught. New fisheries regulations for British Columbia for the 1967 season*

[5] It is interesting to note that it was during this early turbulent time when most current museum collections of fishing artifacts were created. Fishing implements collected by James Teit, Charles Newcombe and Harlan Smith were acquired between about 1900 to 1920.

> *closed Fraser River fishing from Mission Bridge to Lytton from 3 to 25 July, citing the need to protect the crucial early sockeye run at Stuart Lake. Officers conducted 24-hour patrols, arrested Indians, and confiscated Indian nets – all in the name of fish conservation. But conservation for whom? As Indians were quick to observe, the industrial salmon fishery of the Fraser estuary remained open during this period (Newell, 1993:146).*

In addition to government pressures in the twentieth century, the increased occupation of land along interior rivers disrupted Aboriginal people's access to many fishing sites. Railway lines, highways, roads, and bridges sometimes facilitated access to fishing stations but they also made these places more accessible to everyone. Towns grew up along the Cariboo Highway and logging rapidly became the main industry of the province. Several large mines opened in the Plateau region. Increased industry and over-fishing by the commercial sector resulted in the serious decline of some species of fish, especially Chinook.

In 1977 the Fishing Regulations Act was amended again, requiring Native people to obtain a license rather than a permit. This license specifically stated that fish could not be sold or traded. In 1981 further amendments specified species and quantities of fish that could be harvested. Authors such as Newell (1997) and Harris (1998) provide excellent summaries of the effects of legislation on Aboriginal fishing although their research is not specific to the Plateau region.

In 1978, the Union of B.C. Indian Chiefs commissioned a study of the salmon fishing situation. The resulting document *Five Issues – Five Battlegrounds* (Ware 1978) provides a grim view of the Aboriginal fisheries at that time. Ware writes:

> *Despite the guarantees for Indian fishing [sic], the Fisheries Department is "granted" sweeping powers to abrogate these guarantees and abolish Indian rights. Such conflicts in laws and regulations made arbitrary and discriminatory actions against Indians possible, even likely. A case in point is the destruction of the Nicola fish dams because it was more likely that damage to the Nicola runs was caused by the mill dam erected by white settlers, rather than the Indian techniques which had been used for many generations (1978:28).*

Ware goes on to say that the "discriminatory actions" comprise the sum total of Canada's and B.C.'s approach to Aboriginal fishing. Through all of this, the belief of the Secwepemc, Stl'atl'imx and Nlaka'pamux was that their right to fish was inherent, given to them by their practices and the practices of their ancestors, not by any government.

The Sparrow Decision

In 1982 Ronald Sparrow, a member of the Musqueam Band near Vancouver was charged by Department of Fisheries and Oceans (DFO) for fishing with an oversized net, according to the *Fisheries Act*. The case went to the Supreme Court of Canada and the resulting "*Sparrow* Decision" brought Aboriginal rights to the forefront of Canadian politics and legislation. In the *Sparrow* case, anthropological evidence was used to demonstrate the integral aspect of fishing to the Musqueam way of life. Sanders (1995) summarized the decision:

> *In Sparrow Canada argued that any aboriginal rights to fish had been ended by the comprehensive system of regulation, permits and licences under the Fisheries Act. The Supreme Court of Canada rejected the notion of "extinguishment by regulation". It ruled that extinguishment required legislative measures showing a "clear and plain" intention to extinguish the rights in question. Without such a measure, the Musqueam aboriginal right to fish continued as an existing aboriginal right protected by section 35(1) [of the Canadian Constitution]. .. In managing the fishery in the light of section 35(1), the federal government had to accord Indians a priority over commercial and recreational fisheries (p.17).*

The *Sparrow* decision was celebrated as a victory by Aboriginal peoples throughout Canada but the effects in British Columbia were profound. While many communities were still actively involved in fishing in 1990, the *Sparrow* decision eased some of the tensions surrounding fishing rights and may have re-invigorated Aboriginal fishing practices.

PLATEAU FISHING TECHNOLOGY

Traditional technology used for catching fish was similar throughout the Plateau region in both Canada and the United States. Hewes (1998) found that, "fishing gear used by the Plateau peoples was remarkably similar throughout the region, probably representing centuries or

millennia of exchange in techniques" (622). Indeed, variations of fishing technology can be traced to the environment in which one is fishing (i.e. in a lake, stream, river, etc.) rather than to the cultural group of the user.

Throughout history, tools used were primarily long-handled dip or bag nets, harpoons and spears, leisters (three pronged spears), and gill nets. The construction of fishing gear varied slightly from place to place and not all people used all of the tools available. In aboriginal times, materials for the construction of fishing gear were taken from the environment – plant fibre, wood, bone, and stone. After contact, materials such as iron, steel, cotton, and linen were incorporated into the fishing gear. Today there is a mixture of traditional and contemporary materials.

Dip Net

All Plateau groups make use of the dip net see Figure 2). Romanoff (1992) and Kennedy and Bouchard (1992) distinguish between a set net and a dip net, though most Aboriginal people I encountered refer to either net as a dip net. Both nets are used in areas where salmon hug the bank of the river, taking advantage of eddies or areas where the current is not swift.

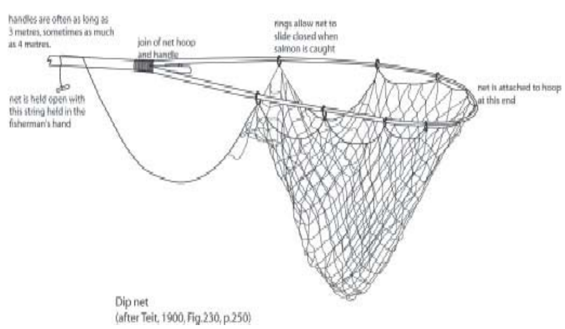

Figure 2. Diagram of the dip net.

The set net is the larger of the hand-held nets and the net is attached to the frame with sliding rings. A cord is attached to the net and held by the fisherman that keeps the net open; when this line is released, the net closes like a purse as it is lifted out of the water. Very often, there is a second person on hand to receive the fish and he or she removes it from the net. While the second person clubs the fish and pulls back its head to bleed it, the fisherman resumes position with his net.

Teit (1900) described Nlaka'pamux dip net fishing techniques and his observations of fishing at the turn of the twentieth century mirror the activities at the turn of the twenty-first century:

> *When he [the fisherman] is sure of a capture, he lets go the piece of stick, when the weight of the fish causes the horn rings to come together, and thus close the mouth of the net. The fisherman then draws the net ashore, pulls the stick, thereby opening the bag, and throws the fish out. It is then put into a rather large circular hole made by scraping away bowlders [sic], which are piled up around the sides, leaving a clear space of pebbles, sand, or gravel in the centre. The bowlders [sic] around the edges form a wall a foot or two high. Near this hole is kept a small stick to be put into the fish's mouth and gills, and to break its neck by pressing the head backward, as well as a short club of wood or stone for striking the fish on the head and killing it when first taken out of the water. (p.250).*

The smaller dip net is fixed and is used in eddies where the water flow is, in effect, reversed thus pushing salmon upstream. Fishermen take advantage of high concentrations of fish in these places, sweeping through the water with a dip net thus catching fish. The fisherman uses a sweeping motion, scooping up a fish and bringing it to shore. There is normally a second person on hand to remove the fish from the net and to club it. I observed this type of fishing at Siska in the summer of 1999. The individuals fishing were using an aluminum fish net purchased commercially, though admitted that the dip nets made traditionally were usually stronger and of better quality.

The CMC collection contains several dip nets but only one (II-C-934) purchased in 1999 is on a frame. The older nets are made with "Indian hemp" (*Apocynum cannabinum*)[6] and are in very good condition (II-C- 640 – dip net from North Bend, ¾" mesh; II-C- 642 – small fish net, collected by Teit; II-C- 643 – net from North Bend, collected by Newcombe; II-C- 639 – net from Ruby Creek, collected by Newcombe). Few people make Indian hemp nets today as it is time consuming and few remember the techniques for making the twine. People mentioned that they knew of old dip nets made with Indian hemp that were still used for fishing. There was general agreement that Indian hemp was superior to modern cotton or nylon twine.

The CMC also has a set of eight net rings made from bone (II-C- 650), collected by Newcombe between 1895 and 1901. Kennedy and Bouchard (1992) mention metal rings used on

[6] also sometimes called milkweed. For information, see Turner (1990), pp. 159-163

contemporary dip nets. The dip net bought for CMC in 1999 has sliced PVC pipe for net rings.

The American Museum of Natural History's collection includes two dip nets attached to a frame but the handles have been cut short. This may have been done to make it easier to transport them; some dip net handles can exceed four metres! The dip nets are 16.1/28 collected by James Teit, c.1905, 89" long; and 16/1024 collected by James Teit, c.1905, 229" long. Both are listed as Nlaka'pamux, having come from the Thompson River.

The Secwepemc used dip nets but not to the same degree as the Nlaka'pamux and Stl'atl'imx. The dip net displayed at the Secwepemc Heritage Museum is similar in size and construction to others described here. The Canadian Museum of Civilization has two nets from Kamloops (II-D-71 and II-D-78), collected by Harlen Smith, 1918. These small nets are without frames; one is described as a dip net and the other as a "triangular net."

Toggle Spear

The toggle spear, also called a harpoon, is a tool traditionally used in places where one could spear the salmon, normally at a weir or other type of barricade. Secwepemc used this tool for fishing from canoes at night. They would light a torch and hold it above the water attracting fish, such as lake trout and Chinook salmon. When the fish came within range, the fisherman would strike at them, hard and fast. Such a tool could be used while fishing through the ice in winter or from rocks in shallow streams. I did not witness this tool being used nor did I hear people speak of using toggle spears any longer.

Toggle spear handles were made of ash that had been seasoned and sometimes burned slightly to give it additional strength. Two prongs were joined with twine so that they would be strong and secure. The toggle spears were made of sharpened antler tips that have been shaped to fit snugly on the end of the prongs. These were secured to the handle with twine. When the fisherman struck a salmon with the toggle spear, its tip would enter the flesh and stay there. Teit described how fish were speared:

> *The spear, which has a handle fifteen feet or more in length, consists of two long prongs, each of which has a barb pointing inward fastened at the end. The spear-head is attached loosely with a line to the handle. When a fish is struck, the barbed points become detached from the spear-head. The fish, with the detached barbed points in its body, is then hauled ashore by means of the line (1900:251).*

The American Museum of Natural History has several toggle spears collected by James Teit. They are all made in the traditional manner, with either bone or metal barbs. Artifact 16/1050 is a two-pronged spear made of wood, bone, string, sinew, rope and pitch; the two tips are attached with a thin Indian hemp rope. The handle has been cut short, probably to facilitate shipping.

Leister

The leister or pronged spear (Figure 3) was traditionally made with a fir handle and bone spear points lashed or attached to the prongs. They were used for fishing trout and steelhead and were made in varying sizes depending on their intended use. Like the spear, the leister was used in places where there was some sort of barricade or where the water was fairly shallow. Visibility is an important factor in using this tool. "When the spear was thrust straight down, hitting the back of the fish, the outer prongs spread slightly apart and then settled in either side of the fish while the centre prong impaled the spine" (Kennedy and Bouchard 1992:287). Spear fishing salmon continues at some river sites (for example Spences Bridge) and in lakes for trout.

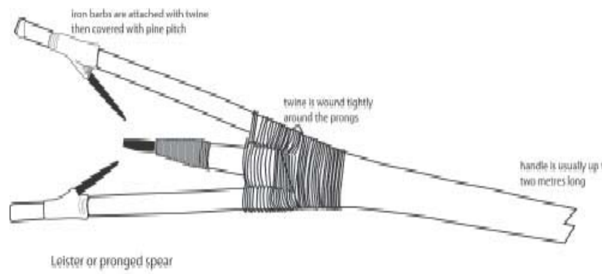

Figure 3. Diagram of the leister (pronged spear)

The American Museum of Natural History collection included several leisters. Artifact16/9325 is a Secwepemc fish spear, 40" long; one of its outside prongs is missing. Artifact 16/9324 is also a Secwepemc fish spear, the handle of which appears to have been broken. According to the artifact record, it was originally 55" long. It has metal barbs replacing the traditional bone. These may have been made with cut nails or other small pieces of metal. This type of leister is called a *mineep* (various spellings). Since the 1930s, the Secwepemc have used pitchforks for making *mineeps*; these leisters are used today and their production has become a unique Secwepemc craft. I purchased a pitchfork leister for the CMC collection in 1999 though this example is a model rather than a

functioning tool and the handle is shorter than it would be normally.

An unusual example of a Stl'atl'imx fish spear is one with a detachable head (16/5951). It is 91" long. It is made of wood and Indian hemp twine with metal barbs. The artifact information at the AMNH is not detailed and other authors have not discussed this type of fishing tool.The one Nlaka'pamux fish spear (16/1049) is 52" long and is made with bone points. I have not examined the AMNH collection first hand. Therefore, it is difficult to determine if the objects were made specifically for the museum or whether they had been used in actual fishing activities. One Secwepemc mineep exhibited in the Kamloops museum is in very good condition and had obviously been used for fishing. The handle had been burned off but as it is a found object, there is no way to know if it had been discarded or lost.

Gaff

According to Teit (1906), gaff hooks were not used much before the availability of iron. A variation of the gaff hook was made using bone but it was not as strong as its iron counterpart. The gaff is made from a piece of iron that has been bent and sharpened. It is lashed on to a fir sapling handle that has been well seasoned so that it is not heavy. Historically, lashing would have been made of Indian hemp twine but today baling wire is commonly used. The handle may also be scorched or slightly burnt which makes the wood stronger.

People required specific conditions in order to fish with a gaff. Near Deadman's Creek, for example, there is a rocky place that is ideal as a fishing station if the water is not too high. Men stand on the rocks here, holding the gaff in the water. Ideally, a few white rocks are placed on the river bottom to make it is easier to see fish as they swam over the gaff. The gaff may have a handle as long as 3.5 metres. To hold it steady, a man braces it with his shoulders and hands. Strength is needed to keep the gaff steady against the current; in clear water, fish can see the pole and will avoid it if it moves. When a fish arrives and is in an ideal position, the fisherman must quickly step backwards with the gaff still firmly braced. This requires a tremendous amount of skill, experience and strength. The fisherman must continue to step backward until he has hauled the salmon ashore.

Gill nets

The gill net is one artifact in common use today. In the area along the Fraser River around Sawmill Creek, the water is fairly slow moving and calm. Here people can use gill nets and fish from their boats. The people I met were simply "setting" a net that had a lead line and floaters attached. They let out the net, waited a while, then retrieved it; they caught between five and fifteen salmon with each set.

At Bridge River, there is a small bay over which the Narcisse[7] family has stretched several long nylon ropes. These are attached to spikes hammered into the rock. A gill net is attached to one of these ropes and with a series of pulleys, is hauled out into the water. The net has a lead line attached so it sinks. This particular bay attracts salmon as it provides a resting place out of the strong current. The water is turbid so fish are easily caught in the net. Once the net has several salmon in it, it is hauled ashore and the fish removed.

Kennedy and Bouchard (1992) suggest that gill nets were introduced to the Stl'atl'imx after contact and that they were suspended over the river by a pole or cable (1992:285). Teit (1906) mentions gill nets were set in lakes while dip nets were used in rivers. He collected at least two gill nets; one is at the Peabody Harvard Museum (86455) and measures nearly sixty feet long and made of Indian hemp. He collected stone sinkers (86457) and tule floats (86456) as well. A Nlaka'pamux net at the AMNH (16/9126) measures over 32 feet. Aboriginal people tend to purchase commercial nets today and have done so for a long time.

Fish hooks

Fishhooks were not used for salmon fishing. They were used for fishing fresh water species such as suckers, trout, whitefish, and peamouth. Some of the larger fishhooks (such as AMNH16/5966 and 16/5952) are made with metal barbs. The Secwepemc used fishhooks for fishing through the ice. The early examples are made from bone lashed to a piece of wood (AMNH NAE/0124; 16/1028; 16/4834). The CMC has four Nlaka'pamux fishhooks collected by Teit in 1915. Two hooks are made from two small slivers of bone lashed together at about a 70° angle with Indian hemp (II-C-245a and b). Another hook is made from deer bone (II-C-416); the shank and barb are lashed together with sinew. The fourth hook is made from hawthorne barbs lashed together (II-C-245c). Everyone buys commercially made fish hooks today.

[7] Arnie Narcisse is Stl'atl'imx fishes at Bridge River with his family.

Conclusion

It is ironic that despite everything that has impacted on Aboriginal fishing in the Plateau region, a description of fishing on the Fraser River in 1899 would be so similar to observations of fishing in 1999. Fishing remains intrinsic to Interior Salish people's cultural, social and economic lives. Fishing tools collected by James Teit at the turn of the twentieth century are unique now because of the materials used to make them, not for their form and function. Colonial activities and interests have encroached on fishing activity over the last 150 years. Some impacts were brought by commercial interests, who demanded a share of the fish. Immigrant populations and their conflicting use of the land and water impinged upon Aboriginal fishing practices. Perhaps the greatest intrusion was government legislation which attempted to legislate Aboriginal people's right to fish, resulting in years of threat and intimidation. Throughout all this time, Nlaka'pamux, Stl'atl'imx and Secwepemc people held fast to their fishing sites and tools.

It is important for museums to resist the urge to view Aboriginal people in the ethnographic past. Fortunately, in some regions, traditional practices remain despite modern pressures and impediments. This is the situation with Plateau fishing. To develop a current understanding of Plateau fishing technology, it has been necessary to collect artifacts made from modern materials and to photograph current fishing practices. However, descriptions of fishing by people such as Teit and Dally written over one hundred years ago, along with the artifacts and photographs collected, differ little from those I took in 1999.

References

Hayden, B. (Ed.) (1992). A complex culture of the British Columbia Plateau: Traditional Stl'atl'imx resource use. Vancouver: UBC Press.

Harris, C. (1997). The resettlement of British Columbia: Essays on Colonialism and Geographical Change. Vancouver: UBC Press.

Harris, D. (1998). The legal capture of British Columbia's fisheries: a study of law and colonialism. unpublished LL.M. thesis. Vancouver: University of British Columbia.

Hewes, G.W. (1998). Fishing. In Walker, D. E. (Ed.) Handbook of North American Indians, Volume 12: Plateau. pp.620-640. Washington, DC: Smithsonian Institution

Ignace, M.B. (1998). Shuswap. In Walker, D. E. (Ed.) Handbook of North American Indians, Volume 12: Plateau. pp.203-219. Washington, DC: Smithsonian Institution.

Kennedy, D.I.D. and Bouchard, R.T. (1992). Stl'atl'imx (Fraser River Lillooet) Fishing. In Hayden, B. (Ed.) 1992. A complex culture of the British Columbia Plateau: Traditional Stl'atl'imx resource use. pp.265-354 Vancouver: UBC Press.

Kennedy, D. and Bouchard, R.T. (1998) Lillooet. In Walker, D.E. (Ed.) Handbook of North American Indians, Volume 12: Plateau. pp.174-190. Washington, DC: Smithsonian Institution.

Laforet, A. and York, A.(1998). Spuzzum: Fraser Canyon Histories, 1808-1939. Vancouver: UBC Press.

Lohse, E.S. and Sprague, R. (1998) History of Research. Pp.8-28 in Handbook of North American Indians, Volume 12: Plateau. Washington, DC: Smithsonian Institution.

Mulligan, V. (1988). We are the Shuswap: Teacher's guide. Kamloops, B.C.: Secwepemc Cultural Education Society.

Newell, D. (1997). Tangled webs of history: Indians and the law in Canada's Pacific coast fisheries. Toronto: University of Toronto Press.

Pinkerton, E. and Weintstein, M. (1995). Fisheries that work: Sustainability through community-based management. Vancouver: The David Suzuki Foundation.

Pokotylo, D.L. and Mitchell, D. (1998). Prehistory of the northern Plateau. In Walker, D. E. (Ed.) Handbook of North American Indians, Volume 12: Plateau. pp.81-102. Washington, DC: Smithsonian Institution.

Romanoff, S. (1992). Fraser Lillooet salmon fishing. In Hayden, B. (Ed.) 1992. A complex culture of the British Columbia Plateau: Traditional Stl'atl'imx resource use. pp. 222-265. Vancouver: UBC Press.

Sanders, D. (1995). Pre-existing Rights: The Aboriginal peoples of Canada.

Souther, B. (1993). Aboriginal rights and public policy: Historical review and an analysis of the Aboriginal Fishing Strategy. Unpublished Master's thesis. Vancouver: Simon Fraser University.

Teit, J. (1900). The Thompson Indians of B.C. Franz Boas, ed. Memoirs of the American Museum of Natural History 2, Anthropology 1(4); Publications of the Jesup North Pacific Expedition 1(4). New York.

Teit, J. (1906). The Lillooet Indians. Franz Boas, ed. Memoirs of the American Museum of Natural History 4(5); Publications of the Jesup North Pacific Expedition 2(5). New York: G.E. Stechert.

Teit, J. (1909). The Shuswap. Franz Boas, ed. Memoirs of the American Museum of Natural History 4(7), Anthropology 1(4); Publications of the Jesup North Pacific Expedition 2(7). New York.

Turner, N. J., Thompson, L.C., and Thompson, M. T. (1990) Thompson ethnobotony: knowledge and usage of plants by the Thompson Indians of British Columbia. Victoria: Royal British Columbia Museum.

Ware, Reuben (1978). Five issue - Five battlegrounds: An introduction to the history of Indian fishing in British Columbia, 1850-1930. Unpublished manuscript submitted to the Union of British Columbia Indian Chiefs.

Wyatt, D. (1998) Thompson. In Walker, D. E. (Ed.) Handbook of North American Indians, Volume 12: Plateau. pp. 191-202. Washington, DC: Smithsonian Institution.

Questions

Frank Crabbe: How does the night fishing work?

Nicholette Prince: In some of the lakes people fished at night with a lamp. Fish come to the surface, attracted by the lamp. In the 1800s lamps were made of wood and had sharpened nails and barbs. Since the turn of the century, most of them are modified pitchforks and easier to maintain. After the 1930s they became the most typical lights. Some people fish off the bank with them.

Arnie Narcisse: This also takes place in the Thompson River. They use pots in front of the boat. People will drift miles down the river doing this. It is very dangerous.

Nicholette Prince: They have gas light as well. This type of fishing requires skill, it is not something that you do for fun. People develop the skill and become well known for fishing that way. The reason why I wanted to do this research is to find out why people fished the way they did.

KAT (AMERICAN EEL – *ANGUILLA ROSTRATA*) LIFE HISTORY

KERRY PROSPER AND MARY JANE PAULETTE
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LIFECYCLE OF KAT (AMERICAN EEL)

Kat (*Anguilla rostrata)* is a catadromous fish, which means it spends the majority of its life in fresh water prior to spawning in the sea. The actual birthplace of *Kat* is not known but the smallest larvae are found in the Sargasso Sea, east of the Bahamas in the Atlantic Ocean (see Figure 1). There are no documented cases of the presence of mature Kat in this area at this stage of life. It begins its life between January and March as a transparent larva (Figure 2), shaped like a willow leaf. The larvae feed on plankton over the next year, and develop into the transparent, glass eel, while traveling in the Gulf Stream to the North American coast.

In May the glass eel makes it way to fresh water where it slowly develops pigment and becomes known as an elver, and is now about 4 to 7 cm in length. Once in fresh water, they are known as yellow eel, and will be yellow to olive in colour for the next several years. They are carnivorous, feeding at night or on dull days on the bottom on a variety of organisms from snails to small fishes. In the fall, the eels will remain in the river or return to the estuary to over winter, burrowing down in the soft mud.

The winter eel fishery was the most active fishery for Mi'kmaq in the Antigonish area particularly in Antigonish Harbour. This fishery started at the fall freeze up until the spring thaw. During the early spring when fishing through the ice, you would get eel grass caught up on the eel spear. When cleaning the spear, I have noticed small glass eels sticking to the grass. This was my first visual contact with the glass eel during the winter spear fishery. (Prosper, Kerry 2001 Memory).

The yellow eel will remain in the inland water systems anywhere from 7-30 years or until they reach their sexual maturity. At this stage, they begin their seaward migration taking on a bronze to black colour with a silver sheen, thus called silver eels, and return to the [Sargasso] sea to spawn (Eales 1966).

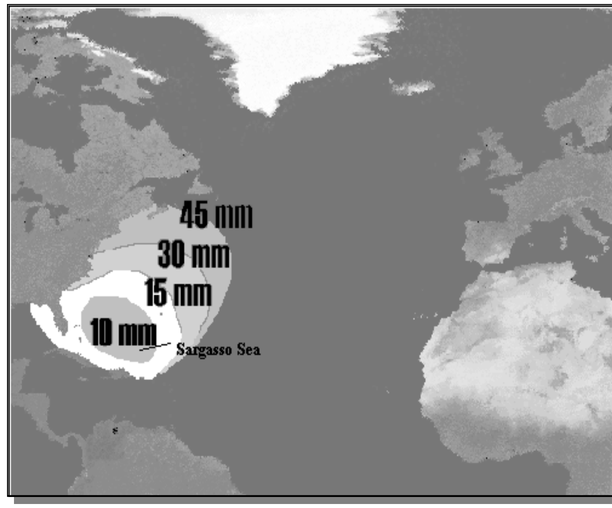

Figure 1: Map of the Sargasso Sea - pointed out here is the area where the smallest American eel larvae are found. The actual spawning area remains a mystery. The numbers represent the larvae's growth as it drifts with the Gulf Stream along the North American Eastern Coast. Available on-line: www.ecoscope.com/eelbase.htm

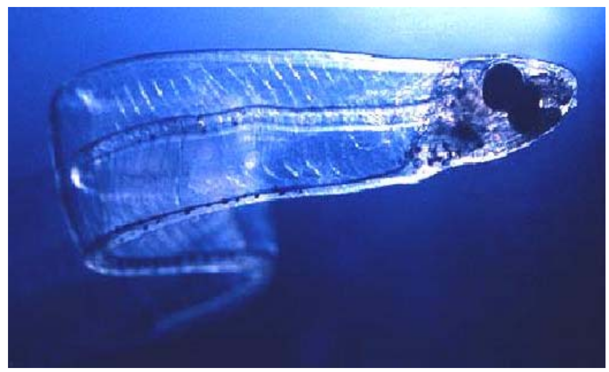

Figure 2. The larva of Kat (*Anguilla rostrata)* as it approaches the North American Eastern Coast from the Sargasso Sea. Available on-line from: www.ecoscope.com/asburyp1.htm

Distribution of American Eel [Kat] Larvae

As indicated in Figure 1, the larva changes in size as it drifts in the Gulf Stream. As it approaches and reaches fresh water it changes shape and appearance. "It is believed that the larvae (leptocephalus stage) undergo both active and passive swimming while in the Gulf Stream. Before the larvae undertake to bridge the roughly 160 kilometer gap from the Gulf Stream to coastal waters, they metamorphosis and are transformed into the glass eel (size range 5—8 cm). The body form now resembles the adult eel in shape but lacks pigmentation. It is better suited to the active swimming required for them to reach the coast." (Hutchison 1981 p. 5)

The Last Journey

The duration of qsow (silver eel's) oceanic travel varies, depending on environmental conditions and its ability to grow. If contamination levels are high, sexual maturity can be delayed or impaired, thus inhibiting growth. Kat (American eel's) potential to lay eggs depends on a length-weight relationship, therefore, its fecundity can range between 0.5 and 4.0 million eggs per female; large females (10,000 mm in length), potentially produce as many as 8.5 million eggs (Facey and Van Den Avyle 1987 in Atlantic States Marine Fisheries Commission 2000).

People often assume the Kat will spawn more than once in its lifetime. This is not true. Kat spawns only once and then dies. Therefore, regardless of when Kat is caught, it is prior to reaching sexual maturity. This will contribute to threats to biological reproduction and abundance.

Migrating Kat have been observed to cover 38 km in 40 hours (Stasko and Rommel 1977). Migration has been suggested to occur within the upper few hundred meters of the water column. However, Robins et al. (1979) photographed two Anguilla eel, believed to be pre-spawn American eel, at depths of about 2,000 m (on the floor of the Atlantic Ocean) in the Bahamas. (Atlantic States Marine Fisheries 2000 p.10).

Pre-Spawning Mortality

There are many possible factors which contribute to the Kat (American Eel's) pre-spawning mortality. These include:

- Chemical contamination of its inland water habitat and oceanic waters;
- Overfishing;
- Lack of policies and management plans;
- *Sargassum* seaweed harvesting;
- Loss of habitat due to deforestation, agricultural practices, obstruction of waterways from dams and causeways;
- Restocking practices of rivers and lakes with fish species that are valued by recreational fishers (ex. Stocking lakes and rivers with trout increases the competition for food amongst various fish species namely the American Eel.);
- Change in ocean climate.

The lack of knowledge of Kat has led to inadequate management of certain areas of the commercial eel fishery. Therefore, decisions are being guided by incomplete scientific research. Kat is a single panmictic population, meaning that it is of one single breeding stock. Offspring from any parents can inhabit any portion of the species range (any river system along the North American east coast). Therefore, absence of basic population dynamics data for American eels has precluded the evaluation of the effects of potentially high exploitation rates on regional stocks and the population as a whole. Also, extrapolation of exploitation rates for numerous regional stocks to an overall exploitation rate for the single panmitic population has not been done.

As with many fisheries the eel fishery has undergone various technological advancements that have increased fishing effort and catches. The commercial fishery brought about the use of motorized boats and electric floodlights instead of the traditional canoe and kerosene lantern. Kat is one of the few fish species that are caught on a year round basis as an elver, yellow and silver eel. Therefore, every living Kat is caught prior to sexual maturity thus contributing to its biological vulnerability and threatening its abundance.

Maritime Eel Landings 1920 - 2000

The location of American Eel fisheries in the maritime provinces in the 1960s is illustrated in Figure 3. Many areas along the Bay of Fundy and the Southern Gulf of Nova Scotia had not yet developed a commercial fishery and the potential was unknown as shown on the map (Eales 1966 p. 47). In recent decades this has changed dramatically. Figure 4 shows the explosion of the commercial eel fishery landings and values for the Maritime provinces in the 1980s and onwards until a sharp crash occurred in the late 1990s. The rise in landings and values was attributed to a new demand from the Asian markets.

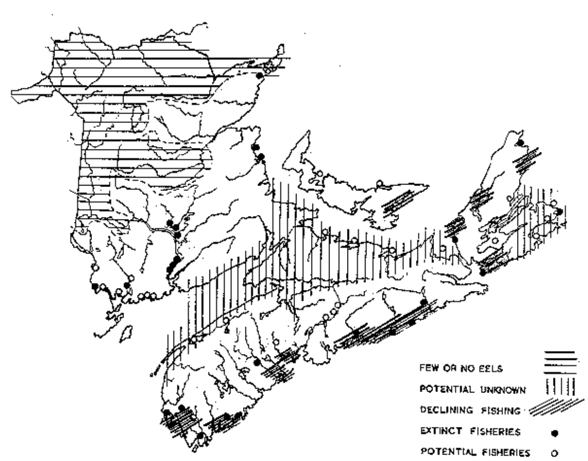

Figure 3: Map illustrating the location of American eel fisheries in the Maritime Provinces in the 1960s.

Figure 4 (overleaf) shows that the Nova Scotia eel fishery was on a moderate scale up to the mid-1960s, with the majority of commercial activity occurring in south shore areas and the upper Southwest Margaree river area. Antigonish, Tatamagouche, Shelburne, Yarmouth and the Cape Breton area were mostly food fisheries, with a small scale peddled fishery (selling of fish to customers in the local area) (Eales, J.G. 1966).

The New Brunswick landings were slightly less than Nova Scotia. The commercial activity occurred mainly in the St. John; Fredericton, St. George, Chatham, Tracadie and Richibucto areas. The peddled and food fishery occurred in Eel River Bridge, Shediac and other areas. (Eales, J.G. 1966).

From 1920 to 1965, the main method of fishing was with spears and eel pots there were approximately 280 people fishing for eels in 1962. Many of the eels were handled by dealers and were shipped and sold to the United States and Europe. The fyke net was introduced approximately from 1961 to 1965 in P.E.I. by the provincial government with their usage spreading to other Maritime Provinces as well. The landings at P.E.I. show a definite increase due to this change of method and increased effort.

Another change in the eel fishery occurred during the mid-1980s with the introduction of spearing eels using electrically powered light (*sasegwa*) for assistance (flamboying). Gas lanterns were now being replaced by high intensity lights and generators. This method of fishing was unlicensed in the Gulf area and continued until 1993. At this point, there was a freeze on all new eel fishing gear types. D.F.O. implemented a licensed eel spear fishery and banned the usage of electronic lights during night time fishing in 1993.

In approximately 1993, N.S. eel landings were on the rise, whereas P.E.I. and N.B. landings were beginning to decline. By 1994-95, N.S. landings then begin to decline to current levels. In the year 2000, N.S. experienced an all time low compared to pre-1965 figures. N.B. and P.E. I. Landings were reduced but only to the average rate compared to pre-1965 figures.

Environmental Indicators

People often view Kat behaviour as similar to Pulămoo (Atlantic Salmon, *Salmo Salar*). Pierre Biard, a Jesuit living in Acadie during the early 1600s describes this misconception:

"...in the middle of September [the Mi'kmaq] withdraw from the sea, beyond the reach of the tide, to the little rivers, where the eels spawn, of which they lay in a supply; they are good and fat" (Biard, Pierre in Thwaites 1896 in Holmes-Whitehead 1991 p.34-36.)

The fact is Kat behaviour is in total contrast to that of Pulămoo. For instance, Pulămoo spawns in the river whereas Kat spawns in the sea. Pulămoo's living environment is the ocean whereas the Kat's is the inland water systems. Pulămoo will spawn more than once in its lifetime whereas Kat will spawn once in the sea and then die.Kat is also noted for accumulating high concentrations of contaminants. Because eels live on the bottom of estuaries, rivers, and lakes, and spend the winter buried in the mud, they are susceptible to poisoning and accumulation of contaminants (PCBs, lead, pesticides) (Haro et al. 2000). They are able to live in areas unsuitable for many other types of fish. For example, studies performed at Kejimkujik National Park have identified highly acidic waters inhabited only by yellow perch and Kat (Parks Canada. Available on-line: parkscanada.pch.gc.ca/parks/nova_scotia/Kejimkujik_np/english/water_e.htm.). With these facts in mind, Kat can be used to tell us about the health of both the oceanic and inland water systems.

We should listen more to the animals...

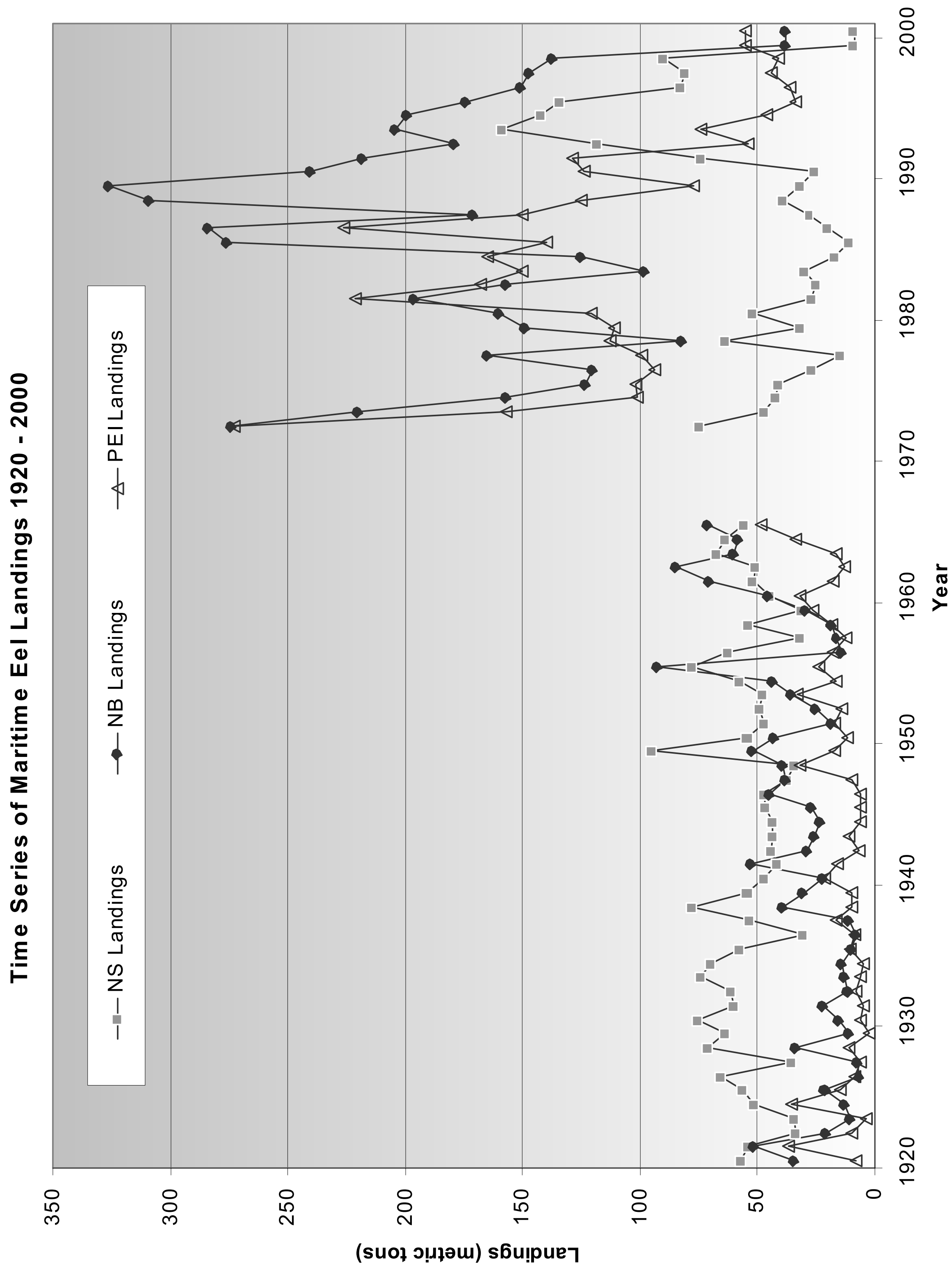

Figure 4. Maritime landings of Kat (American Eel) from 1920 to 2000, based upon Nova Scotia Department of Fisheries. Economic Branch. 1963 and Department of Fisheries and Oceans, Statistics Branch 2000. Available on-line at: www.dfo-mpo.gc.ca/communic/statistics/Historic/landings/1972qe.htm. The lack of data between 1965 and 1975 is due to catches being unreported. Legend: NS = Nova Scotia, NB = New Brunswick, PEI =

THE MI'KMAQ RELATIONSHIP WITH KAT

The Mi'kmaq people share cultural bonds with many inanimate and animate objects including Kat (the American eel). Animate objects are anything classified as living such as animals, plants, trees, and so on. Inanimate objects are classified as non-living such as hunting tools, decorative items, certain places, etc. The Mi'kmaq believe each animate and inanimate object possesses a *manitou* (spirit).

This belief led to the creation of many cultural bonds between the Mi'kmaq and inanimate and animate objects. Kat is considered one of these spiritual beings. As with many spiritual beings, Kat also serves as an important food source, a medicinal ingredient, and a ceremonial object. It is also believed to be the *Jipijka'maq* (the Great Horned Serpent). This spiritual being is referred to in many Mi'kmaq legends. To understand the diversity of the relationship between the Mi'kmaq and Kat, one must first consider the Mi'kmaq view and its connection to the environment as a whole.

The Mi'kmaq View

The Mi'kmaq believe *Kji-Niskam* (a Great Spirit) created all things in nature equally, therefore all creations should be treated with great respect. To ensure a proper balance with the environment, the Mi'kmaq practiced various traditions and customs. Leslie Upton, an historian (1979, p.11) interpreted this belief based upon archival reporting in the eighteenth and nineteenth centuries:

> *...the Micmacs [sic] accorded animals the same esteem they gave each other. They spoke of them as though the animals lived in the same way, each species a separate tribe living in two villages under its own chiefs...It was all one world indivisible.*

The Mi'kmaq believe this equality aspect applied to them as a people "for man was only one part of a totally interdependent system that saw all things, animate and inanimate, in their proper places" (Upton 1979, p.15).

The Mi'kmaq relationship with the environment and all of its components was guided by these beliefs. Various rituals were performed to give thanks to the spirits that the Mi'kmaq believed were responsible for their overall well-being. These rituals were practiced everyday, throughout the day, and not just on appointed days of recognition. The Mi'kmaq lived with nature and all of its components. As a result, many relationships were developed with both animate and inanimate objects including Kat. This article will highlight some important aspects to display the rich and diverse qualities of this relationship — how it was and how it is today.

Mi'kmaq Uses of Kat

Kat served as an important food source for the Mi'kmaq but its purposes were not restricted to food. It is also considered a multi-purpose item with its usage ranging from medicinal use to a type of binding material.

As a food source, Kat was prepared in many ways. It was sometimes prepared for a stew, baked, smoked and preserved for later use. The Mi'kmaq regarded Kat as:

> *...the favourite catch as it is even today. It mattered not one bit ...whether the meat was cooked or raw, and, if we found we had only tough meat at any time, we would cut and tear it into strips which we would pound on broad flat stones, and thus we were able to chew and swallow it easily.*
> *(Holmes-Whitehead 1991, p.10)*

In preparation for cooking, Kat was usually skinned. The kadaagel (eel skin) when dried would tighten. This tightening ability and its durability further enabled the Mi'kmaq to use the skin for an array of purposes. It was used for bindings for sleds, moccasins, clothing, tying spears and harpoons on sticks, and so on.

Kat was also used for decorative purposes such as the hair string described in the legend Sakklo'pi'k in Ruth Holmes-Whitehead's book Stories From the Six Worlds Micmac Legends. The hair string in this legend is made of "...painted eelskin, porcupine quills and sinews [which] are combined...into a new being—the hair ornament" (Holmes-Whitehead 1988, p.11). This story is about two shy women who wish not to marry any man of the People. Yet, a Chief's son attempts to propose to them but is immediately refused. Along comes a lazy and ugly man who jokingly boasts he could marry one of the women. Later, the ugly and lazy man is walking in the woods and meets up with an old woman. This old woman's hair "is fastened up with many beautiful sakklo'pi'k, many wonderful ornamented hair-strings which tie up her hair and then trail their ends down over her shoulders, all the way down to her feet" (Holems-Whitehead 1988, p.84). The old woman informs the lazy and ugly man she is aware of his wish to marry one of the two shy

women and offers her assistance to him. He accepts her assistance. The old woman then removes one of the sakklo'pi'k from her hair and hands it to him saying:

> *Take this. Carry it in your pouch, your medicine pouch. Carry it for awhile, then watch out for a time to get close to her, and throw this sakklo'ipi upon her back. But do not let her see you do this. Do not let her feel you do this. And do not tell anyone else about this at all*
>
> *(Holmes-Whitehead 1988, p 86).*

The lazy and ugly man agrees to follow her instructions and the next day comes upon one of the women wandering in the woods. He then takes her back to her family. Upon their return, she becomes his wife.

Kadaagel (eel skin) was also used for its medicinal properties. Its tightening ability enabled the Mi'kmaq to use it as a type of brace to relieve sprains. It was also worn next to the skin for relief from cramps, rheumatism, headaches, and lameness (Lacey 1977, p. 40, 56). In addition to the skin, other parts of Kat were also saved and buried until fall. These parts included the heart, liver, heads, and skins. When these parts were recovered in the fall, it was used as bait for trapping various animals (Denny 2002).

Kat also served as a ceremonial object. It was involved in various Mi'kmaq traditions such as the ritual Apuknajit (Feeding of Grandfather). This ritual was performed on January 31st to give thanks to the Spirits for surviving the hardest time of the year:

> *When darkness has settled, food is put out into the night preferably on an old stump or near a tree and offered to the spirits. In days gone by, eel skins and fish heads were offered. An elder would lead the family to a stump, give thanks for surviving thus far and ask for additional assistance until spring*
>
> *(Marshall 1997).*

Another Mi'kmaq tradition involving eels as a ceremonial offering is also described in *The Legend of Glooscap's Door* by Mi'kmaq author Rita Joe. A portion of this poem is displayed in Box 1. Kat and its involvement in various ceremonies as mentioned earlier demonstrates Kat was more than a tangible object—it was also a sacred being. The Mi'kmaq considered animals as equal in importance to their own existence. Therefore, animals must be treated in a certain manner. For example, a taboo existed on "roasting eels" which was documented by Nicolas Denys in 1672. The fact a taboo exists clearly indicates that Kat possesses spiritual qualities and should be treated with great respect.

Box 1: It is believed among the Mi'kmaq people that in order to have a successful hunt or fishing expedition, one must make an offering to the creator. This offering is referred to as *Pagetunowwedoomkawa'* (Prosper 2001, p.18). A portion of the poem <u>Legend of Glooscap's Door</u> briefly describes eels as *Pagetunowwedoomkawa'*:

> At Cape Dolphin near Big Brads d'Or
> There is a hole through a cliff
> It is Glooscap's door.
> And on the outside a flat stone
> It is his table.
> The Indians on a hunt leave on table
> Tobacco and eels.
> This brings them luck, so the story goes
> The legend lives on
>
> (Joe 1988, p.40).

The Mi'kmaq believe one should not take more than what is needed. *Kji-Keptin* Alec Denny recalls a memory concerning eels as a young boy. He was out spearing eels one day by himself and was eager to catch as much as he could. He caught so many eels that his boat was filled with them. He then came home to brag about his huge catch to his grandfather. His grandfather seeing how many eels he caught asked him: "What are we going to do with them?" There were obviously more eels than they could use. In order for Alec's grandfather to teach him the importance of only taking what was needed, he put Alec through a vigorous training program. Alec's grandfather told him to salt some of the eels and give it to the people during the mission in Chapel Island. He was then told to carefully clean the rest of the eels and to separate the hearts, livers, skins, guts and eel heads into cans. This was a long process and took two days to complete. Once this was done, he was not yet finished. He was then told to put these items into butter tubs his grandfather made him bury them near the river until fall. At this time these tubs were dug up and put into smaller cans and used as bait for trapping various animals. The Mi'kmaq people were careful not to waste anything and to only take what was needed—not to waste and the next time, Alec would be more careful to take only what was needed (Denny 2002).

Kat and Kejimkujik National Park

The Mi'kmaq share a long cultural history with Kat. Petroglyphs in Nova Scotia's Kejimkujik National Park, located in Southwest Nova Scotia, suggest the presence of the water creature Jipijka'maq - the Great Horned Serpent (Whitehead 1990). An example of these petroglyphs is shown in Figure 5.

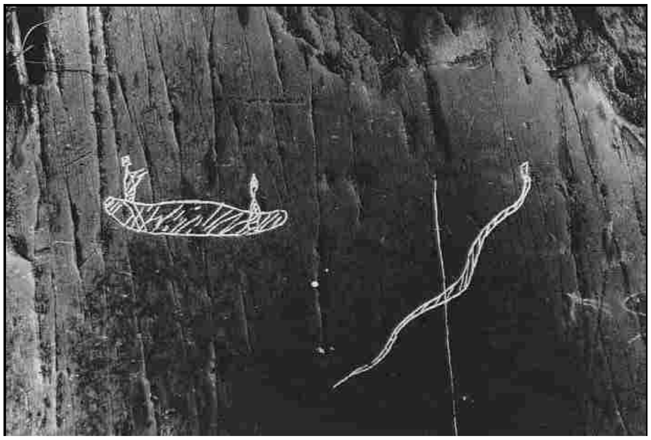

Figure 5. Petroglyphs from Kejimkujik National Park, southwest Nova Scotia. The one on the left portrays a Mi'kmaq man and woman in a canoe in the presence of a serpent.

The Mi'kmaq believe that Kat is Jipijka'maq. There are many similarities between Jipijka'maq and Kat. For example, it is said Jipijka'maq travel "about under the earth in their snake shapes...and sometimes they come up to the Earth World and carve great ruts in the land as they move across it" (Holmes-Whitehead 1988, p.4). In addition, a special distinction is made between snakes and Jipijka'maq. In the legend Miskwekepu'j, the contents of a bag is described as containing both "...snake bones and jipijka'm bones..." (Holmes-Whitehead 1988, p.13). Another similarity exists between Kat and Jipijka'maq behaviour when traveling over land. Kat, when traveling over land, will leave behind it a trail of skimogan (slime). This trail of skimogan enables Kat to reach its destination to the next water source. Each Kat would contribute its slime to this trail and go as far as its slime enabled it to. In turn, the next eel would continue the trail by depositing more slime along the trail. The Jipika'maq on the other hand would carve great ruts in the land as it moved across it. These ruts are referred to as the "track of the serpent people" (Holmes-Whitehead 1988, p.44).

Another connection Kat has to Kejimkujik National Park is the remains of the stone eel weirs located along the various rivers in the park. Traditionally the Mi'kmaq used these weirs to catch eels and other types of fish. The Mi'kmaq had to carefully choose where to construct these weirs due to the great deal of manpower and time that was involved in their construction. Where to construct and when to use the weirs required detailed knowledge of the local area and of various types of fish and their behaviours. Evidence of this type demonstrates the Mi'kmaq relationship to fish and other beings has been in existence for a long time.

Additional weirs have also been located throughout northeastern North America: A Sebaskong Lake Fish Weir dated at 5,100 years old in Maine and the Atherley Narrows site on Lake Simcoe in Ontario, dating around 4500 B.P. A third site—the 4,600 year old Boylston Street Fish Weir, was discovered in the 1950s and covers many acres in the Boston back harbour area (McNab 1998, p. 98).

Traditional Methods of Fishing Kat

The Mi'kmaq traditionally employed various types of tools when fishing Kat. They used stone eel weirs as mentioned earlier and different types of spears. The stone weir required the most labour and time to construct.

"Stone weirs often exhibited a V-shape across the stream, with the point of the V extending either upstream or downstream, depending on the direction of the seasonal migrations. A boxlike bark trap or net bag set in a gap in the weir's fence captured the fish" (Confederacy of Mainland Mi'kmaq and Robert S. Peabody Museum of Archaeology 2001, p.105). The weir sites were occupied by the Mi'kmaq for an extended part of the year. It was at these sites that the Mi'kmaq would "smoke and dry eels for the winter" (Confederacy of Mainland Mi'kmaq and Robert S. Peabody Museum of Archaeology 2001, p.100).

Kat was also fished using spears (Figure 6). There were two different types of spears, a winter and a summer eel spear. Each spear was comprised of bones and wood and was 15-20 feet in length. The winter eel spear had more prongs than the summer eel spear. In the summer, visibility in the water ranged from 4-7 feet and the eel could be caught easier than in the winter. In the winter, fishers would go out on the ice, cut holes and spear for eels (Prosper 2001, p.25). At this time, the eels were in the mud. The winter spear therefore had more prongs placed closer together to enable the fisherman to haul the eel out of the mud.

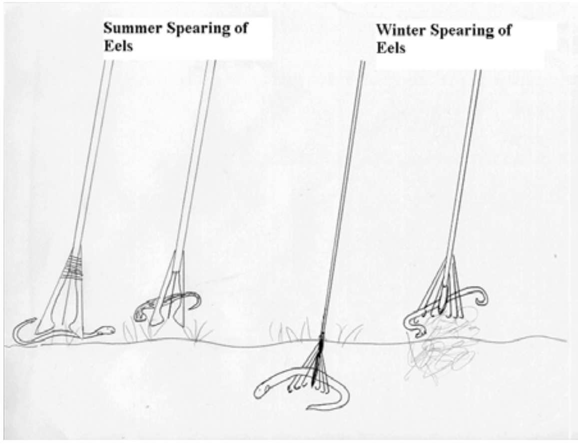

Figure 6: Pictures of the summer and winter spears. Source: Prosper 2001, p.25.

During the 1930s, anthropologist Frederick Johnson traveled throughout several Mi'kmaq communities in his "search of ethnological information" regarding the Mi'kmaq living in the Maritime Provinces (Confederacy of Mainland Mi'kmaq and Robert S. Peabody Museum of Archaeology 2001, p.113). Part of his study also included taking photographs of the Mi'kmaq and their lifestyle.

Overall, the Mi'kmaq and Kat shared a cultural and spiritual relationship within the environment. This relationship provided good health, happiness and long life for all within the environment. Yet, reflecting upon the past practices of the Mi'kmaq indicates to us our relationship with Kat is changing. This changing relationship tells us our environment is now altered. It remains to be seen what Kat can tell us about our environment and the future.
When we look at Kat today and its deteriorating environment we can assume they are suffering due to the high levels of contaminants and loss of habitat. Yet, due to their restrictions as animals, they are unable to verbally inform us of their hardships. On the other hand, the Mi'kmaq people also shared and lived in the same environment as Kat for thousands of years and can express verbally our social and physical problems. Therefore, the Mi'kmaq have become indicators, as has Kat, of the environmental conditions of our ecosystem.

The Paqtnkek Fish and Wildlife Society

The Paqtnkek Fish and Wildlife Society logo (Figure 7) contains the four traditional colours—white, back, red and yellow - each representing the four directions. Its circular shape demonstrates the holistic and collective qualities of the Mi'kmaq nation. Everything and every being within the circle is considered equal. The Great Horned Serpent petroglyph is used as a motif for Kat. According to various Mi'kmaq legends, the Great Horned Serpent's behaviour is similar to that of Kat (American Eel). "*Paqtnkek*" also holds a distinctive definition—"by the bay."

Figure 7. The Paqtnkek logo

Goals

- To promote capacity building within the community in the fields of research and information gathering regarding fish and wildlife.
- To provide information regarding fish and wildlife important to the Mi'kmaq people.
- Develop capacity to co-manage resources important to the Mi'kmaq people. Ex. *Kat* (American Eel).

Social Research for Sustainable Fisheries

SRSF is a partnership linking university researchers and capacity with Mi'kmaq and commercial small boat fisheries community organizations. Although administered at St. Francis Xavier University, SRSF engages and represents a working collaboration between Guysborough county Inshore Fishermen's Association, the Gulf Nova Scotia Bonafide fishermen's Association, the Mi'kmaq Fish and Wildlife Commission—Afton Band, and St.F.X. as well as other university-based social researchers. Additional fisheries and community organizations are linked with SRSF through relations with these core partners.

SRSF is funded by the Social Sciences and Humanities Research Council of Canada (SSHRCC) through its Community-University Research Alliance (CURA). The basic purposes of SRSF are: to develop fisheries-focused social research linkages between university researchers and community organizations, to build social

research capacity, and to facilitate specific fisheries social research activities that will examine the concerns of the partnered community organizations. Social research capacity, experience and linkages are developed through research-focused workshops and specific research projects.

Contact: SRSF, St. Francis Xavier University, PO Box 5000, CURA Box 21, Antigonish, Nova Scotia, B2G 2W5, Tel: (902) 867-2292 www.stfx.ca/research/srsf

NOTE

This factsheet contains Mi'kmaq words. These Mi'kmaq words and their English translations used in this factsheet are used in reference to Rand's Dictionary of the Language of the Micmac Indians.

Kat - An eel
Manitou - Spirit
Kji-Niskam - Great Spirit
Kadaagel - Eel skin
sakklo'pi'k - Hair string
Kji-Keptin - Grand Captain of the Mi'kmaq Grand Council
Apuknajit - Feeding of Grandfather
Pagetunowwedoomkawa' - Ceremonial offering of fish
Jipijka'maq - Great Horned Serpent
skimogan - Eel slime
Qsow - Silver eel
Pulămoo - Salmon.
Skimogan - Eel Slime
Sasegwa - Fishing eels with a light

If you are interested in hearing or exploring further some of these words, you can visit the on-line site regarding the Mi'kmaq language at: www.mikmaq.com/new/language/index.html or the Mi'kmaq Online - Mi'gmaq Online Talking Dictionary at www.mikmaqonline.org.

REFERENCES

Atlantic State Marine Fisheries Commission. 2000. Interstate Fishery Management Plan for American Eel (*Anguilla rostrata).* Fishery Management Report No. 36 of the Atlantic State Marine Fisheries Commission. Available on-line: http://www.asmfc.org/PUB/FMRS/American%20FMP.pdf.

Confederacy of Mainland Mi'kmaq and the Robert S. Peabody Museum of Archaeology. 2001. *Mikwite'lmanej Mikmaqi'k Let Us Remember The Old Mi'kmaq*. Halifax: Nimbus Publishing Limited.

Deny, Nicolas. 1908. *The Description and Natural History of the Coasts of North America (Acadia)(1672).* New York: Greenwood Press.

Denny, Alec *Kji-Keptin.* March 4, 2002. Personal communication to Mary Jane Paulette.

Environment Canada. Parks Canada. 1994. *Archaeological Sites on the Eel Weir Section of the Mersey River Kejimkujik National Park.*

Department of Fisheries and Oceans. 2000. Available on-line: http://www.dfo-mpo.gc/communic/statistics/stat_e.htm

Eales, J. G. 1966. *A Survey of Eel Fishing in the Maritime Provinces.* Ottawa: Industrial Development Service Department of Fisheries of Canada.

Haro, A., W. Richkus, K. Whalen, A. Hoar, W. Dieter Busch, S. Lary, T. Brush, and D. Dixon. 2000. Population Decline of the American eel: Implications for Research and Management. Fisheries 25(9):7-16.

Holmes-Whitehead, Ruth 1988. *Stories From The Six Worlds Micmac Legends.* Halifax: Nimbus Publishing Limited.

Holmes-Whitehead, Ruth 1991. *The Old Man Told Us.* Halifax: Nimbus Publishing Limited.

Hutchison, Susan. 1981. Upstream Migration of the Glass-eel (Anguilla rostrata) in Nova Scotia. *Manuscript and Technical Report Series Project Report No. 81-02.* Nova Scotia: Estuarine and Inland Fisheries Nova Scotia Department of Fisheries.

Joe, Rita. 1988. *Song of Eskasoni—More Poems of Rita Joe.* Charlottetown: Ragweed Press.

Kils, Uwe. No Date. Glass Eel Photograph [on-line]. Rutger's Institute of Learning and Coastal Sciences. Available on-line from: http://www.ecoscope.com/asburypl.htm.

Kils, Uwe. No Date. Distribution of Eel Larvae by length along the Eastern seaboard of North American [on-line]. Rutger's Institute of Learning and Coastal Sciences. Available on-line from: http://www.ecoscope.com/eelbase.htm.

Lacey, Laurie. 1977. *Micmac Indian Medicine—Traditional Way of Health.* Antigonish: Formac Limited.

Marshall, Murenda. 1997. Values, Customs and Traditions of the Mi'kmaq Nation. *The Mi'kmaq Anthology.* Lawrencetown Beach: Pottersfield Press. 51-63.

McNab, D.T. 1998. *Earth, Water, Air and Fire Studies in Canadian Ethnohistory.* Waterloo: Wilfrid Laurier University Press.

Nova Scotia Department of Fisheries, Economics Branch. 1963. *Notes and Statistics on the Eel Fisheries in the Maritime Provinces.* Nova Scotia Department of Fisheries, Economics Branch: Halifax.

Nova Scotia Museum. 2002. *The Mi'kmaq Portraits Collection.* Available on-line: http://museum.gov.ns.ca/mikmaq/mp0005htm

Parks Canada. No Date. *Kejimkujik National Park of Canada.* Available on-line: http://www.parkscanada.pch.gc.ca/parks/nova_scotia/Kejimkujik_np/english/water_e.htm.

Prosper, Kerry. 2001. *The Mi'kmaq and Kat (American Eel).* Antigonish: Social Research for Sustainable Fisheries, St. Francis Xavier University. Available on-line: http://www.stfx.ca/research/srsf/2005b1.htm.

Rand, Silas T. 1888. *Dictionary of the Language of the Micmac Indians who reside in Nova Scotia, New Brunswick, Prince Edward Island, Cape Breton and Newfoundland..* Halifax: Nova Scotia Printing Company.

Robertson, Marion. 1973. *Rock Drawings Of The Micmac Indians.* Halifax: Nova Scotia Museum.

Upton, L.F.S. 1979. *Micmacs and Colonists Indian-White Relations In The Maritimes, 1713-1867.* Vancouver: University of British Colombia Press.

THE BAREFOOT ECOLOGIST'S TOOLBOX

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ABSTRACT
Updating the Fishing Principle:

- Give a person a fish and they are fed for one day;
- Teach a person to fish and they are fed for life;
- Enable a village to fish sustainably and they are fed for generations.

Reaching the end of a fisheries ecology doctorate on Haliotids, I looked around and saw the seas, particularly coastal and tropical seas, full of small (1-50 km^{-2}) stocks. Extremely valuable to local communities in aggregate, Micro-stocks are myriad and complex to study, assess and manage sustainably. It was depressing; how could we ever hope to address the research and management needs of so many small resources. In the 1950s China faced a similar looking national health problem. They responded with barefoot doctors, not top-end surgeons and technocrats, but low cost, generalist, medical practitioners trained to go out and deal with all the basic village ailments.

Micro-stocks need assessment and management at local scales to prevent component stocks suffering the tragedy of the commons. Community based and Territorial Rights based systems will prove essential for sustaining these resources. But who will service the technical needs of all these communities of stakeholders? Certainly not the existing Universities and Government Agencies funded by shrinking central governments!

When the late Dr Philip Slucanowski and I asked ourselves these questions, the only answer was - Barefoot Ecologists. Embodying the spirits of Johannes and Pauly, and equipped with a toolbox borrowed from Walters, barefoot ecologists would be appropriately trained quantitative, ethno-fisheries ecology generalists, with a love for life, and insatiable curiosity. As with China's barefoot doctor campaign, local people trained and equipped to return to local communities will always be far more effective, than visiting foreign experts. Like the famous Hitch-Hiker's Guide to the Galaxy, the Barefoot Ecologist's Toolbox will be a hand-held computer designed to be useful in every situation, as long as the user does not panic! Armed with this thought and a working knowledge of the Walters personal toolbox, Philip and I set out to design the Toolbox.

INTRODUCTION
I started my scientific career working with the Western Australian lobster fishery, a classic large scale fishery as read about in primary texts (Phillips and Brown 1989) with a sustainable yield of >10,000t per annum caught over approximately 1,000 km of coastline. The larvae of western rock lobster (*Panulirus cygnus*, Palinuridae) have been found across the southern Indian Ocean. The adults migrate to the edge of the continental shelf and may march along it for considerable distances.

At this time I was also introduced to the seminal "Words of the Lagoon" (Johannes 1978).

HALIOTID FISHERIES
My next fishery was the Tasmanian abalone (*Haliotis rubra*) fishery. I had already competed unsuccessfully against many of the abalone divers in national spearfishing championships. So naturally I began my studies by talking and diving with them. Then I read the literature and found that abalone larvae remained in the water column for eight to ten days and had a dispersal distance of 60-80km (Tegner and Butler 1985). Size at maturity was assumed to be relatively uniform. The fishery was managed regionally (Prince and Shepherd 1992) with minimum size limits, limited entry and Individually Transferable Quotas (ITQ). But the divers did not ascribe to the scientific dogmas. They described "non-recovery bottom" which did not sustain fishing, local extinctions that were common at scales of hundreds to thousands of metres. I tested the alternative points of view (Prince 1989), and found that the dispersal power of haliotid larvae, juveniles and adults is limited to tens to hundreds of metres (Prince *et al.* 1987, 1988a, McShane *et al.* 1988). Functional units of stock, in the sense of Gulland (1969), have scales of hundreds to thousands of metres rather than the ten to hundreds of kilometers originally inferred. Regional fisheries consist of thousands to tens of thousands of micro-stocks.

If micro-stocks were biologically similar and fishing pressure was distributed evenly so that fishing mortality was similar for each micro-stock, this would have little implication for assessment and management (Fukuda 1973; Garrod 1973). In this case component micro-

stocks could be managed in aggregate and regional management should work. However, life is never simple. Maturity is a function of age not size, and growth is extremely variable (Prince 1989, McShane 1991, Nash 1992). Size at maturity varies with water temperature, latitude, exposure of the coastline, and food availability. Juvenile abalone suffer high mortality and remain hidden in the interstitial spaces of reefs, where they are virtually invisible to fishers and researchers (Prince *et al.* 1988). Maturing abalone emerge from cryptic habitats, and join stable adult aggregations which are highly vulnerable to exploitation by divers (Prince 1989). In the most productive areas, abalone mature and emerge to aggregate well above regional size limits. In nearby, less productive areas, "stunted" populations may emerge, whose individuals grow to a much smaller maximum size. As a result regional size limits will protect little, if any, breeding stock on productive beds, while totally protecting the breeding stock of the less productive "stunted" abalone beds from legal fishing.

Regional size limits commonly preserve little breeding stock, because they have been set for 'stunted' stocks, by researchers who for 'logistical reasons' selected relatively sheltered research sites with 'stunted' stocks for their diving programs. In addition, fishing pressure is never applied evenly but is focussed on preferred reefs. The availability of legal size abalone is the overriding priority for divers, but within this constraint, the choice of dive site is honed by remembered stock density, proximity to port, depth, and predictable sea conditions. On favored reefs, where minimum size limits have preserved little breeding stock, recruitment collapse is common.

Non-Recovery Bottom

The early fishery targeted reefs with the highest density of the largest abalone and recorded extraordinary landings. These large catches only lasted several years, sometimes several dives, before the original biomass was exhausted. After that, these areas provided a much lower catch for five to ten years, until the single generation of pre-fishery recruitment was exhausted. Catches from these areas then collapsed entirely, often into local extinction. Divers label this phenomena 'non-recovery bottom'.

Figure 1 (in Appendix 1) is a map of Cape Leeuwin, Western Australia, prepared with the help of one of the first abalone divers in the area. The original size of the abalone is mapped, which is indicative of the original size of maturity. The regional size limit (Figure 2, Appendix 1) had been set too small: while 70-90% of the breeding biomass was protected on the "small" reefs, and moderate levels (<30%) were protected in the "small to average" sized areas, the "average", "average to large" and "large" growing reefs could be legally stripped, provided a diver had sufficient quota. As the quota is allocated over a 700km stretch of coastline (Figure 2, Appendix 1), it is almost never limiting at the scale of these micro-stocks. With some intuitive understanding of abalone, the local divers, at first maintained a voluntary minimum size limit considerably above the legal minimum. Their voluntary size limit preserved 50% of breeding stock on the "average to large" reefs and limited the extent of "non-recovery bottom". This agreement stabilized catches around 30t/year during the early 1980s. However when a single 'bad egg' broke the voluntary agreement and began using the legal size limit, a short-lived competitive gold rush followed, substantially reducing breeding stocks. By the early 1990s only "small", and "small to average" size of maturity areas were producing; production had fallen to 7 t per annum.

The Tyranny of Scale

In haliotid fisheries, management, monitoring and assessment occur at spatial scales several orders of magnitude larger than the scale of functional units of stock (Figure 2, Appendix 1). The prompt application of regional size limits, limited entry, and ITQs in Australia and New Zealand effectively controlled development and stabilized the fishery (Prince and Shepherd 1992). But despite the superficial appearance of stability the "tragedy of the commons" (Hardin 1968) is still occurring for micro-stocks. With regional management, fishing pressure will always focus on micro-stocks closest to port, or in shallow and relatively protected water.

Even when abalone are legal size, divers know they should not strip reefs of breeding stock. But the current management system leaves them thinking; "If I don't do it, the next person will." Serial depletion and local extinctions continue below the scale of management, while pressure upon the remaining productive beds steadily escalates, all within the 'safe keeping' of a regional quota. The "tyranny of scale" prevents otherwise effective management strategies addressing the "tragedy of the commons".

Re-introducing and re-building breeding aggregations restores productivity, but there is no incentive to rehabilitate because there is no secure reward for voluntary long-term behavior.

When the one 'bad egg' in the Cape Leeuwin area (Figure 1, Appendix 1) was jailed, voluntary size limits were restored and implemented, brood stock translocations occurred, and production was rebuilt to >30t by 2001. Such rehabilitation does not normally occur because the organizational capacity required to voluntarily implement a complex of reef by reef size limits, quotas, translocations and closures, is generally beyond competing divers.

Complicating matters further, the tyranny of scale renders stock assessment unreliable (Prince 1989, Prince and Guzmán del Próo. 1993). Catch and effort data is aggregated over many (hundreds to thousands) of micro-stocks. Divers visually check remembered aggregations before deciding to dive, so catch and effort is normally linearly related. Aggregated CPUE trends reflect the choice divers make between dive sites. Higher catch rate areas, have higher densities of abalone because factors deter frequent diving (ie. deeper, exposed coast, far from port). Material factors such as beach price drive CPUE trends by influencing the choice of divers (Prince 1989).

Nevertheless, because research surveys are extraordinarily few, stock assessment processes remain wedded to catch rate data aggregated over hundreds to thousands of micro-stocks. When they exist, surveyed trends are normally aggregated over many micro-stocks, rather than used as indices of the micro-stock surveyed. This occurs because the complimentary catch data can only be collected on the larger scale, and, there are too few surveys to index a significant proportion of micro-stocks. Stock assessments typically interpret trends in an abalone fishery as the slow decline of a large and unproductive original biomass (Prince and Guzmán del Próo. 1993). But there is never sufficient fine scale data to show the reality, which is the combination of the disparate trends from many smaller but productive populations. These biases cause the actual level of depletion, along with the size and productivity of the original resource, to be under-estimated.

Too Much Environment and Not Enough Taxpayers to Pay for it All.

The tyranny of scale is not confined to abalone fisheries, it is observed widely across the world's fisheries. Many benthic invertebrate and tropical reef fisheries have the same intricate small-scale stock structure (Orensanz and Jamieson 1998). At larger scales, many teleost fisheries with multiple spawning stocks, for example the Norwegian (Maurstad and Sundet 1998) and the Nova Scotian cod fishery (Benham and Trippel in press) and Pacific North American salmon fisheries (Walters and Cahoon 1985), to varying degrees are all subject to tyranny of scale effects.

Fed by an explosion of remote spatial positioning technology, understanding of spatial complexity is growing rapidly. But in general thinking about stock structure remains crude. In my experience unrecognized spatial complexity is normally a primary factor when stock assessments fail unexpectedly. But interestingly, Patterson *et al.* (2001) do not even list it amongst the assumptions used to structurally condition models when attempting to estimate uncertainty in assessment and forecasting.

Dispersal and movement are not simple phenomena (Figure 3, Appendix 1). Species and populations maintain a range of differing behaviors (McDowall 2001). Invariably a few individuals move long distances in contrast to the majority behaviour of moving short distances. Over geological and evolutionary time frames, such minority behavior is vital for colonizing new habitat. Without it, the natural processes that create and destroy habitat, such as changes in sea level, would drive species extinct. We have tended to link the scale of functional stocks to the maximum distances moved by a species, the longest tagging movements, or the scale of genetic isolation. But for management purposes, the shorter 'normal' distances moved within one or two seasons, best indicate the scale of functional management units in a fishery.

With this view it becomes clear that the world's fisheries contain a myriad of micro-stocks (Figure 3, Appendix 1). We fisheries ecologists have been high-grading, selectively targeting the biggest chunks of protein (and funding) first. Research and scientific understanding has focussed on the conspicuous offshore industrial scale fisheries (Orensanz and Jamieson 1998).

Unfortunately the technical challenge of managing, monitoring and assessing the earth's fish stocks is proportional to the number of functional units, not their size or value. Likewise, the cost of the required research is not strongly linked to the value of resources, but more clearly related to the number of units involved. Larkin (1997) had a rule of thumb that the cost of research and management cannot sustainably exceed 10-20% of the value of the fishery. But when the annual cost of a single researcher with government overheads approaches $100,000;

what does one do with a fishery full of micro-stocks worth < $500,000/annum?

Reaching the end of my doctorate I looked around and saw coastal and tropical seas full of micro-stocks (1-50 km^2 in area), which are valuable to local communities in aggregate, but myriad and complex to assess and manage. How could we ever hope to address the needs of so many micro-stocks? We academics in universities and governmental agencies are too few to assess and manage all these micro-marine resources. The role of central government is shrinking, not expanding, as taxpayers demand leaner smaller government. There is simply too much environment, and not enough taxpayers to pay for it all.

With apologies to Aldo Leopold: Relegating conservation to government is like relegating virtue to the Sabbath. It turns over to [so very] few what should be the daily work of [a vast army] of amateurs.

Beyond Centralized Management

In the over-developed countries, fisheries management remains the last great bastion of the Command-Control Theory of government. Management, monitoring and assessment processes are the proper role of centralized governments. Fishers cannot be trusted and must be compelled by legislation to fish sustainably. But when it comes to micro-stocks the emperor has no clothes because centralized governments are incapable of allocating the decentralized resources required.

Take the example of Tasmania, Australia, which has the largest remaining abalone fishery. Despite its complexity the fishery has the financial and social capital required to manage itself. George III Rock, a 360,000 m^2 reef, produced an annual recruitment of approximately 5,000 abalone, into an adult population of around 25,000 abalone (Prince 1989). Recruitment had probably been higher from a previously larger parental biomass, and could be sustained even with a harvesting rate of 4,000 abalone/year, worth around $AUD150-200,000. After modest installation costs, an accurate annual stock assessment based on fishery independent surveying, would cost < $AUD15,000 per year, within Larkin's rule of thumb for affordable assessment and management. Multiplied up by the probable 10,000 micro-stocks in the fishery, the entire process might cost up to $15-20 million to extend to the entire resource.

In 2000, Tasmania's 125 commercial divers, and more numerous quota holders, paid the Tasmanian Government approximately $AUD16 million in license fees, for a Total Allowable Commercial Catch worth $AUD90-100 million on the beach. Most of the revenue is retained within Consolidated Revenue, approximately $AUD250,000 is spent on their most valuable fishery's research. An uncoordinated research program is left to a single researcher, two technical officers, a 4WD vehicle, and a dinghy. None of the micro-stocks is reliably assessed or managed and it would be politically unacceptable for a government of any persuasion to spend any more money on 'rich abalone divers'.

Centralized priority setting by modern 'small' government will, of necessity, neglect the needs of localized renewable resources in favor of spending revenue on schools, hospitals and the military. Centralized management is structurally unable to meet the challenge of spatially intricate renewable resources.

Abalone Gardens

It was gratifying to attend a recent (August 2001) conference at UBC and see so many agreeing on the need to make more use of the knowledge fishers in fisheries science. But it is time to recognize the full value of their humanity. Fishers are not tools for scientific research, they are the key to local management because they are the local community. Failure to recognize this will continue the de-humanizing processes that depleted our resources.

Sustaining and optimizing haliotid production requires maintaining productive breeding stocks on all abalone reefs. This requires reef by reef size and catch limits, which can only be assessed and implemented by informed and motivated divers. Divers must evolve from marine hunters, who compete amongst themselves, "bringing ruin to all", into marine gardeners, who co-operatively tend and harvest abalone gardens. They must become resource surveyor, assessor, manager and harvester.

Motivated diver behavior is currently the most under-utilised resource in the fishery. The tragedy of the commons socially constrains people so that they act against the long term communal good for short-term personal profit. Hardin (1968) argued that the 'Tragedy of the Commons' does not have a technical solution, rather that it is a social issue requiring society to change and develop new patterns of behavior. As

hard as it may be, governments need to change the social constraints causing negative impacts.

With species subject to the tyranny of scale, some form of Territorial User Rights Fishery (TURF) or Customary Marine Tenure (CMT) can provide the motivation and control needed for local communities and individuals to manage local resources (Orensanz and Jamieson 1998). The recent experience of Chile (Castilla *et al.* 1998) and Vanuatu (Johannes 1998a) demonstrates the "learning by doing" approach to management (Walters and Holling 1990) that local communities and individuals adopt when given local resource ownership. We of the over-developed world should be taking more notice of these experiences.

AGENTS OF CHANGE - BAREFOOT ECOLOGISTS

But who will service the technical needs of all those local stakeholder communities managing all those micro-stocks? Certainly not the existing universities and governmental agencies funded by shrinking central governments. Has anybody else noticed something missing in our field? There are experts, researchers and teachers, but where are the practitioners?

In the 1950s, China must have faced a similar-looking national health problem. Medical skills were required in every village throughout the country but there was a critical shortage of trained doctors. China responded with the barefoot doctor campaign – not investing in more expensive surgeons and fully trained doctors, but in low cost, generalist, medicos trained to go out and deal with all the basic village ailments. Before his death in the early 1990s the late Dr Philip Slucanowski and I debated how micro-stocks could be managed sustainably? The only answer we could find was Barefoot Ecologists.

To be practitioners of the field, barefoot ecologists need to be practically orientated, pragmatic integrated generalists – ethno-socio-quantitative fisheries ecologists. They need to be holistically skilled in the multiple disciplines required to work effectively with micro-stocks and diverse fishing communities.

Acting as Agents of Change in local communities, the barefoot ecologist must catalyze change and build social capital within fishing communities. Their role is to motivate and empower fishers and their communities and families, to research, monitor and manage their own local natural resources. The barefoot ecologist supports the development of social structures that foster community based management. The end goal is the development and implementation of long-term community-based monitoring systems applying appropriate technologies, and providing the expertise needed to annually update micro-stock assessments and facilitate dialogue about future management. Working to strengthen endogenous community structures in all situations, the barefoot ecologist is, on the one hand, an expert in data-less management (Johannes 1998b), gleaning local knowledge, reading the literature and recommending sensible 'rule-of-thumb' management. On the other hand, barefoot ecologists also need to be versed in quantitatively based Management Processes, like 'Adaptive Environmental Assessment and Management' (Walters 1986), and 'Back to the Future' (Pitcher *et al.* 1998), which can capture diverse information streams and simulate alternative scenarios for community discussion.

Barefoot ecologists will serve the communities to which they belong, rather than central government agencies, "big science", "science for science's sake", or the "publish or perish" imperative. In return for local loyalty, they will be rewarded with some share of a community's catch. (Here let us note that this type of advisory role is well developed and accepted in the agricultural sector of over-developed countries, but almost non-existent and even frowned upon, in the fishing sector.) It can be difficult at times for barefoot ecologists to maintain scientific objectivity, but it is time to explicitly recognize that everyone can be influenced by vested interests. All vested interests should be highly visible and linked as directly as possible to the long-term productivity of the resource.

None of this is meant to suggest a reduced role for government agencies or academic academies in the field of fisheries science and management. It is a call for clearer thinking about differing but complimentary roles. Government Agencies need to develop legislation that supports the evolution of social systems, like TURF and CMT, which encourage sustainable small-scale behavior. Government also needs to legislate to protect broader "non-fishing" community approved standards, providing for checks and balances, and establishing auditing procedures. Specialized expertise will always be needed to train and equip barefoot ecologists. Research agencies and universities have a continuing role in discovering and publishing scientific knowledge, and developing innovative techniques and tools for practitioners to use.

THE BAREFOOT ECOLOGIST'S TOOLBOX

Barefoot ecologists will need toolboxes. Like the famous Hitch-Hiker's Guide to the Galaxy, the Barefoot Ecologist's Toolbox will be a hand-held computer programmed to be useful in every situation, as long as the user does not panic! It will contain not only all the handbooks of a diverse training, but also the fisheries ecologist's equivalent of Excel, universally used and available software that can do anything, even if most people only use it for the basics.

Anyone watching Carl Walters work will have seen him using his own personal toolbox. His own software developed over decades that is now rapidly adapted to analyze and interpret the dynamics of every resource; from Florida Everglades water balance to western rock lobster sustainable yield. The basic ingredients include:

- Mapping software for mapping stocks and survey designs
- Spreadsheet for capturing and storing long term data sets (catch, effort and surveys)
- Data analysis and assessment models

But the real power of the Walters' toolbox is visualization, both for visual analysis of historic trends, and also for real-time scenario gaming of alternative futures (Walters 1986). It was the potential for unlocking insight and community involvement through visualization that really excited Slucanowski when he met Walters during the 1980s (Prince *et al.* 1991; Sluczanowksi *et al.*. 1992) and that provided our motivation for designing the barefoot ecologists' toolbox.

A MILLENIUM PROJECT PROPOSAL

Un-orchestrated competition amongst researchers for funding and kudos may make for a lively field of scientific endeavor. But it is time our field matured and began to integrate its skills and intellectual property, so that they can be applied efficiently to the obvious needs confronting our globe. If we do not, we risk becoming nothing more than global tourists and neo-ethno-colonialists, squirreling away the information of fishers for the advancement of our own careers. Scattered around the globe, we collectively possess the thinking, course material, field techniques, models and software code needed to begin training and equipping the hundreds of thousands of barefoot ecologists needed by our seas and oceans. It is not a matter of needing more science. It is a matter of corporate application. Working together, each contributing a small part, our global community of fisheries ecologists could look forward to fully equipped barefoot ecologists taking up their practices before the end of the first decade of this new millenium.

REFERENCES

Benham, A.A. and Trippel, E.A. (in press) Mapping Fishermen's knowledge of Groundfish and Herring Spawning and Nursery Areas in the Bay of Fundy, Gulf of Maine and Eastern Nova Scotian Shelf. Fisheries and Oceans Canada, Biological Station, St. Andrew's, New Brunswick, Canada, E5B 2L9.

Castilla, J.C., Manriquez, P., Alvarado, J. *et al.* (1998) Artisanal "Caletas" as units of production and co-managers of benthic invertebrates in Chile. In: *Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management* (Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management, Nanaimo, 6 March – 10 March, 1995). Jamieson, G.S. and Campbell, A. Eds. Canadian Special Publication of Fisheries and Aquatic Sciences 125 pp. 407-413.

Fukuda, Y. (1973) A gap between theory and practice. *Journal Fisheries Research Board of Canada* 30, 1986-1991.

Garrod, D.J. (1973) Management of multiple resources. *Journal Fisheries Research Board of Canada* 30, 1977-1985.

Gulland, J.A. (1969) Manual of methods for fish stock assessment. Part 1. Fish population analysis. *FAO Manual of Fisheries Science* 4, 1-54.

Hardin, G. (1968) The tragedy of the commons. *Science* 162, 1243-1248.

Johannes, R.E. (1978) *Words of the Lagoon: Fishing and Marine Lore in the Palau District of Micronesia.* University of California Press, Berkeley.

Johannes, R.E. (1998a) Government-supported, village based management of marine resources in Vanuatu. Ocean and Coastal Management 40, 165-186.

Johannes, R.E. (1998b) The case for data-less marine resource management: examples from tropical nearshore finfisheries. *Trends in Ecology and Evolution* 13, 243-246.

Larkin, P.A. (1997) The costs of fisheries management information and fisheries research. In: *Developing and Sustaining World Fisheries Resources: the State of Science and Management.* (Proceedings of the Second World Fisheries Congress, Brisbane, July-August, 1996). D.A. Hancock, D.C. Smith, A. Grant and Beumer, J.P. eds. CSIRO Publishing, Melbourne, pp. 713-718.

Maurstad, A. and Sundet, J. H. (1998) The Invisible Cod; Fishermen's and Scientists' Knowledge. In: *Commons in Cold Climate: Reindeer Pastoralism and Coastal Fisheries* (ed. S. Jentoft), Casterton Hall: Parthenon Publishing. pp. 167-185.

McDowall, R.M. (2001) Anadromy and homing: two life-history traits with adaptive synergies in salmonid fishes? *Fish and Fisheries* 2, 78-85.

McShane, P.E. (1991) Exploitation models and catch statistics of the Victorian fishery for abalone *Haliotis rubra*. *Fishery Bulletin* 90, 139-146.

McShane, P.E., K.P. Black and Smith, M.G. (1988) Recruitment processes in *Haliotis rubra* Leach (Mollusca: Gastropoda) and regional hydrodynamics in southeastern Australia imply localized dispersal of larvae. *Journal of Experimental Marine Biology and Ecology* 124, 175-203.

Nash, W.J. (1992) An evaluation of egg-per-recruit analysis as a means of assessing size limits for blacklip abalone (*Haliotis rubra*) in Tasmania, In: *Abalone of the World: Biology, Fisheries and Culture* (Proceedings of the 1st International Symposium on Abalone. La Paz, 21 November-25 November, 1989). S.A. Shepherd, M.J. Tegner, and S.A. Guzmán del Próo eds. Fishing News Books: Blackwell Scientific Publications. Cambridge, pp. 318-338.

Orensanz, J.M. and Jamieson, G.S. (1998) The assessment and management of spatially sturctured stocks: an overview of the North Pacific Symposium on invertebrate stock assessment and management. In: *Proceedings of the*

North Pacific Symposium on Invertebrate Stock Assessment and Management (Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management, Nanaimo, 6 March – 10 March, 1995). Jamieson, G.S. and Campbell, A. eds. Canadian Special Publication of Fisheries and Aquatic Sciences 125 pp. 441-459

Patterson , K. Cook, R. Darby, C. *et al.* (2001) Estimating uncertainty in fish stock assessment and forecasting. *Fish and Fisheries* 2, 125-157.

Phillips, B.F. and Brown, R.S. (1989) The West Australian Rock Lobster Fishery: Research for Management. In: *Marine Invertebrate Fisheries.* (J.F. Caddy ed.) Wiley Interscience Publications. New York. pp. 159-181.

Pitcher. T.J., Haggan, N., Preikshot, D. and Pauly, D. (1998) 'Back to the Future': a method employing ecosystem modeling to maximize the sustainable benefits from fisheries. In:*Ecosystem Approaches for Fisheries Management*. (Proceedings of the 16th Lowell Wakefield Fisheries Symposium AK-SG-99-01). University of Alaska Sea Grant, Fairbanks, Alaska, pp. 447-466.

Prince, J.D. (1989) *The Fisheries Biology of the Tasmanian Stocks of Haliotis rubra*. PhD. thesis, University of Tasmania, 174 pages.

Prince, J.D. and Guzmán del Próo, S.A. (1993) A stock reduction analysis of the Mexican abalone (Haliotid) fishery. *Fisheries Research* 16, 25-49.

Prince, J.D., Sellers T.L., Ford W.B., Talbot, S.R. (1987) Experimental evidence for limited dispersal of haliotid larvae (genus *Haliotis*: Mollusca: Gastropoda). *Journal of Experimental Marine Biology and Ecology* 106, 243-263.

Prince J.D., Sellers T.L., Ford W.B., Talbot, S.R. (1988a) Confirmation of a relationship between the localized abundance of breeding stock and recruitment for *Haliotis rubra* Leach (Mollusca: Gastropoda). *Journal of Experimental Marine Biology and Ecology* 122, 91-104.

Prince, J.D., Sellers, T.L., Ford, W.B., Talbot, S.R. (1988b) Recruitment, growth, mortality and population structure in a southern Australian population of *Haliotis rubra* (genus *Haliotis*; Mollusca : Gastropoda). *Marine Biology* 100, 75-82.

Prince, J.D. and Shepherd S.A. (1992) Australian fisheries for abalone and their management. In: *Abalone of the World: Biology, Fisheries and Culture* (Proceedings of the 1st International Symposium on Abalone. La Paz, 21 November-25 November, 1989). S.A. Shepherd, M.J. Tegner, and S.A. Guzmán del Próo eds. Fishing News Books: Blackwell Scientific Publications. Cambridge, pp. 744.

Prince, J.D., Sluczanowski, P.R., Tonkin, J.R. (1991) *AbaSim: A graphic fishery.* South Australian Department of Fisheries, Adelaide. ISBN 0 7038 1899 3 Software and Manual pp. 34.

Reference: China's Barefoot Doctors

Sluczanowski, P.R.W., Lewis, R.K., Prince, J.D., Tonkin, J. (1992). Interactive graphics computer models for fisheries management. (World Fisheries Congress, Athens, 3 May-8 May 1992).

Tegner, M.J. and Butler, R.A. (1985) Drift-tube study of the dispersal potential of green abalone (*Haliotis fulgens*) larvae in the southern California Bight: implications for recovery of depleted populations. Marine Ecology Progress Series 26, 73-84.

Tegner, M.J. (1989) The California abalone fishery: production, ecological interactions, and prospects for the future. In: *Marine Invertebrate Fisheries.* (J.F. Caddy ed.) Wiley Interscience Publications. New York. pp. 401-420.

Walters, C.J. (1986) *Adaptive Management of Renewable Resources*. Biological Resource Management Series. Macmillan Publishing Company, New York.

Walters, C.J. and Cahoon, P. (1985) Evidence of decreasing spatial diversity in British Columbia salmon stocks. *Canadian Journal of Fisheries and Aquatic Sciences* 42, 1033-1037.

Walters, C.J. and Holling, C.S. (1990) Large-scale management experiments and learning by doing. *Ecology*, 71, 2060-2068.

APPENDIX 1

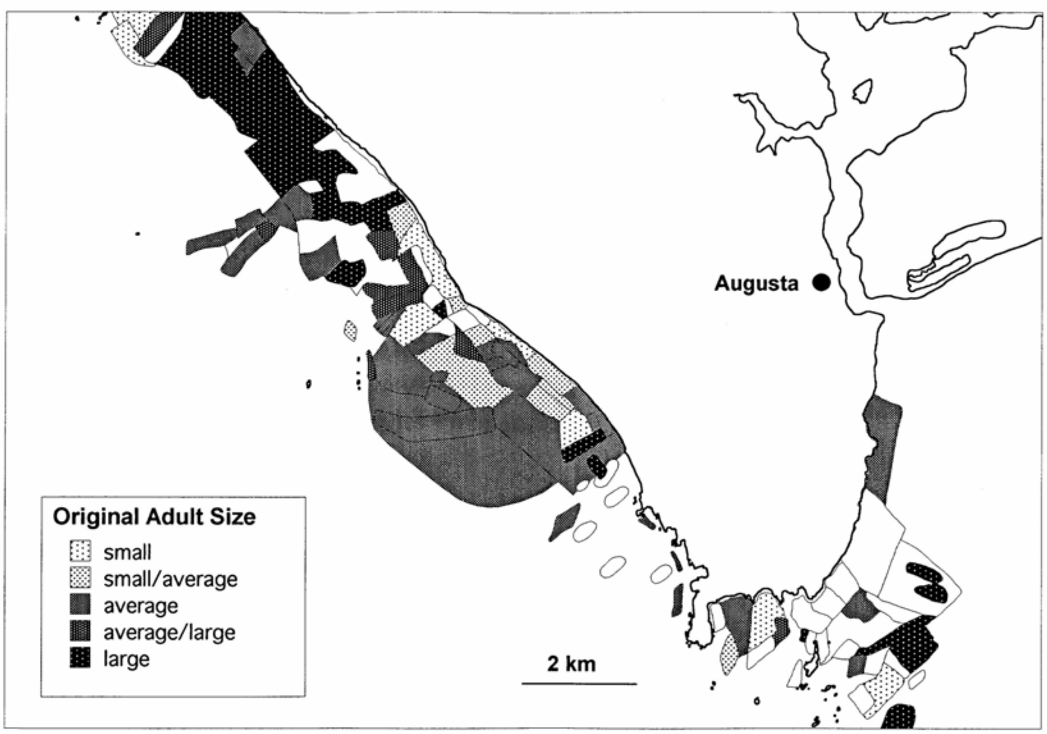

Figure 1. A map prepared in collaboration with one of the first commercial abalone divers to fish the area around Cape Leeuwin, Western Australia. The memory of the diver, together with aerial photography and ground-truthing dives have been used to qualitatively map the original 'unfished' size distribution of abalone as either small, small to average, average, average to large, or large, which is taken to be indicative of the size of maturity

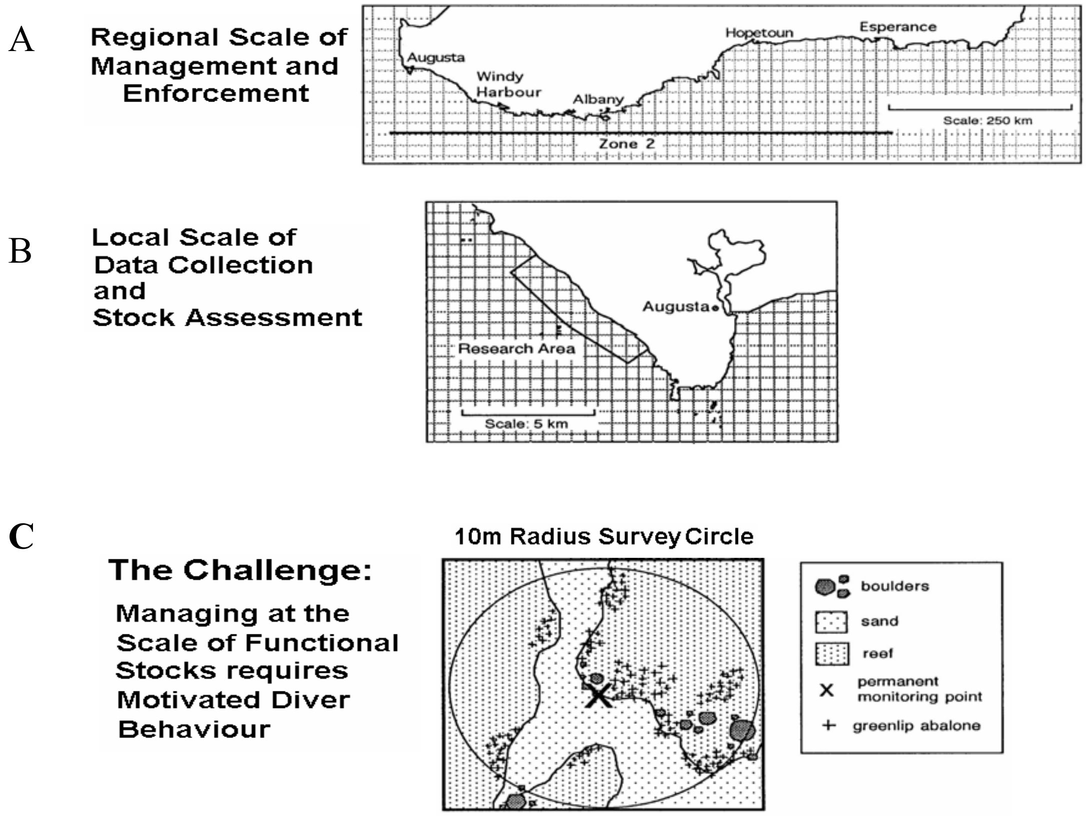

Figure 2: TYRANNY OF SCALE - whereby the mismatch between the scale of assessment and management, and the scale of highly variable functional units of stock, compromises sustainable management by leaving component units of stock subject to the tragedy of the commons

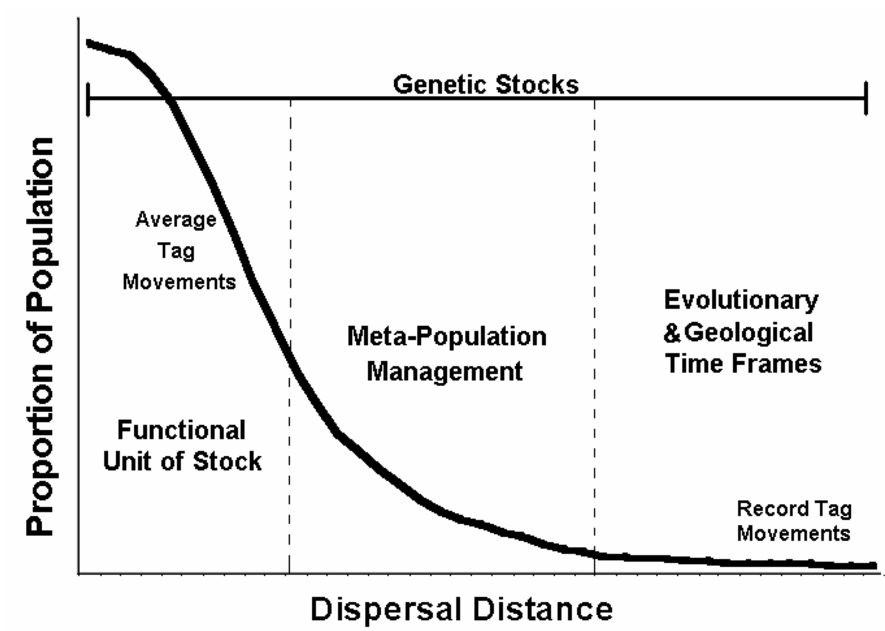

Figure 3. Dispersal and movement are never simple phenomena and should be conceptualized as a distribution curve rather than a mean distance or rate. Long distance dispersal by a few colonialist individuals is important to maintain a species distribution over geological time frames and will determine the size of genetic populations. Much smaller feeding and breeding movements by the majority of individuals determine the scale of functional units of stock for assessment and management purposes

An Example of Conservation and Exploitation Achieved Through a Voluntary Fishery Management System

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Abstract

The Inshore Potting Agreement (IPA) is a voluntary management system conceived by the inshore fishers of south Devon, England. The IPA has functioned effectively since 1978 to reduce conflict between static gear (trap and net) and towed gear (trawl and dredge) fishers. Although there is no legal recognition of the system, the IPA continues to be generally observed by both sectors of the fishing industry.

Fishers from the static and towed gear sectors were interviewed to determine how well the system functioned, what the system achieved, and what factors caused most problems. Fishers were also asked if the IPA could and should evolve further to ensure greater effectiveness and regulatory compliance.

Lessons that may be learned for fishery scientists and managers from the inception and later evolution of the IPA are discussed. In particular, the characteristics of the management system that have enabled the continuation of the inshore fishing industry's traditional practices, despite falling catches in other areas are discussed in the context of the fishers' knowledge that designed them. The general increase in living standards and earning expectations of people in society as a result of this is also discussed.

Introduction

It is widely accepted that fisheries globally are in decline, and the FAO (2000) reports that 72-75% of the world's major fish stocks are over-exploited, fully exploited, rebuilding or depleted. It must therefore be considered that conventional fishery management practices, based on predictive models of stock dynamics and aimed at maximising or optimising fishery output in the long term, have not been working well (Acheson *et al.* 1998; Hofman and Powell 1998; Lauck *et al.* 1998). To prevent further stock failures, it may be beneficial to utilise management systems that were historically successful in local environments. In order that this may be achieved, the preservation, study and use of fishers' traditional ecological knowledge (TEK) may be of vital importance.

TEK is information generated and transmitted over time by people who live and work in a particular location. The development of TEK enables people to survive and prosper in their local environment. Examples of TEK may include an awareness of which crops will grow under local conditions, or where migratory animals will be found at certain times of the year. This information may not be recorded, but will be passed from generation to generation by demonstration and word of mouth (Sillitoe 1998).

The central tenet of TEK research is that the information and techniques gathered and developed by communities should form the basis of their socio-economic development (Chadwick *et al.* 1998). The research agenda is therefore one of learning more about the system and the interactions therein, indigenous users' knowledge and decision making processes, and possible points of intervention (MacKay 1992). The successful extension of developmental programmes will be facilitated if local knowledge and practices are taken into account (Sillitoe 1998).

The present paper focuses on a voluntary fishery management system off the south coast of Devon, England, known as the Inshore Potting Agreement (IPA), that has been the focus of political (Woodlatch and Crean 1998), behavioural (Hart 1998) and biological (Kaiser *et al.* 2000) studies to date. The IPA was conceived and established by fishers to reduce conflict between those that operated static gears (traps and nets) and those that used towed gears (trawls and dredges). At present, there is no legal recognition of the system, though the IPA is generally well observed by fishers from both sectors of the industry, and is an excellent example of a management system that takes account of the social and economic forces that drive the exploitation of living resources. These forces have been identified as factors that should be included in fisheries management if sustainable exploitation is to be achieved (Auster and Shackell 1997; Langton and Haedrich 1997; Charles 1998; Hanna 1998; Murray *et al.* 1999; Knudsen and MacDonald 2000).

The IPA is regarded as a successful fisheries management regime because it has continued to function effectively for several decades. In order to understand the reasons for its success it is

necessary to record the historical development of the fisheries within the local area and the technological and biological changes that eventually led to its creation. We have sought to understand the perceived and actual benefits of the system for the fishers whom it affects. Our aims are to identify those features of the IPA that help to make it successful, to highlight those areas that might be improved or are considered to hinder its further improvement, and to characterise those features that may be adopted by fishery managers globally.

History and Background of the IPA

Edible crabs (*Cancer pagurus*) have been harvested from the inshore waters of south Devon, England, for hundreds of years. Fishers from local communities with a strong crab-fishing tradition believe that the crab fishing industry in the British Isles began in villages along the coastline of Start Bay (Fig 1). Static gear fishers that presently operate in Start Bay commonly maintain that they are third or fourth generation crab-fishers, though they also usually state that crab fishing could have a longer tradition within their family. Evidence for this history is available from of the 1891 Census, which indicated that of the 104 men between the ages of 15 and 65 living in the coastal villages of Beeson, Beesands, and Hallsands, 63 (60.6%) listed fishing as their occupation.

Before the expansion and modernisation of the crab fishing industry in south Devon, static gear boats were commonly either launched and retrieved by hand from beaches in front of fishing villages, or operated from deep-water ports. The wooden sailing and rowing boats used were typically five to six metres in length, and fishers worked in crews of two or three per boat, lifting 60-100 traps per day by hand. Traps were constructed to an inkwell design from withy (thin woven willow branches), and were usually laid in strings of up to five below each marker buoy. Willow used for trap construction was cut and then woven in autumn at the end of the main trapping season. The green branches then dried over winter before fishing restarted in the spring. Willow groves, cultivated originally for trap manufacture, can still be seen growing in the vicinity of traditional south Devon fishing villages.

Crab fishing continued in a similar manner until the 1930s, when inboard engines were first employed on inshore boats, and motorised capstans were used on beaches to retrieve boats from the water. The number of traps routinely operated remained small, essentially because the withy traps would disintegrate within one year, thus preventing the number of traps used being added to at the beginning of each season. The boats did not increase in size and continued to be operated either from village beaches or local ports. However, after the Second World War some larger boats operated from ports with motorised capstans, constructed from modified car axles, which were used to haul the pot strings. However, these were not used on the beach boats until the late 1950s because the additional weight made launching and retrieval too difficult.

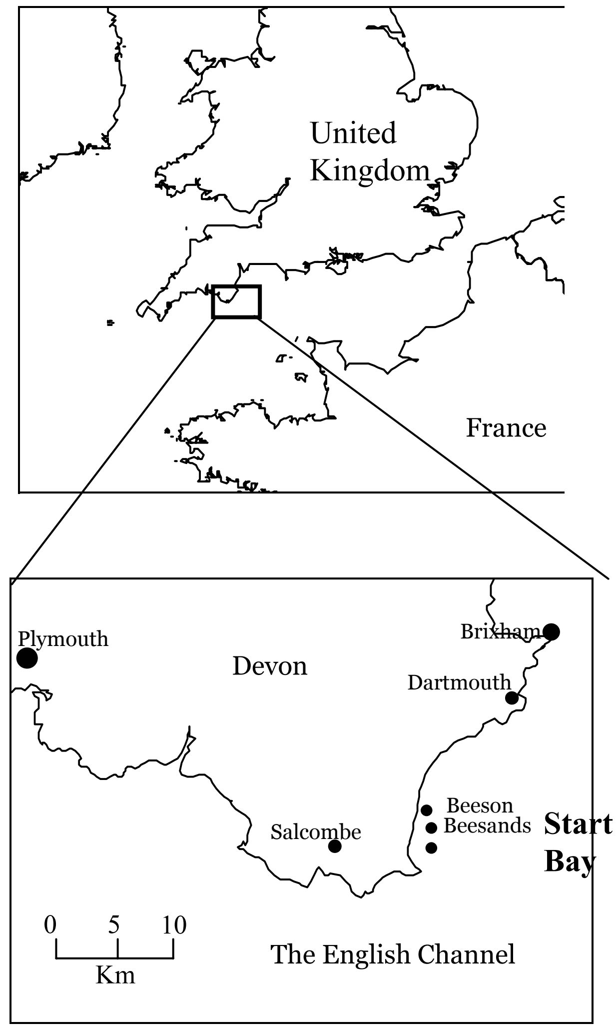

Fig 1: Fishing villages in south Devon.

In the early 1950s, traps began to be constructed from steel wire woven around a cherry-branch frame (hereafter called 'wire' traps). The inkwell design remained essentially unchanged, though these traps were dipped in a mix of tar and creosote to improve their longevity. Wire traps typically lasted from one to two years, allowing each boat to operate up to 200, though a small number of crabbing companies employed trap-

makers, thus allowing a greater number of traps to be fished.

After the introduction of larger boats with motorised capstans and net haulers, fishers continued to inhabit the same coastal villages around Start Bay, but by the mid 1960s all the commercial crab boats operated from the nearby ports of Salcombe and Dartmouth. Both towns are within 20km of the crabbing villages, while other ports are only accessible from the Start Bay area via a river ferry or a convoluted journey of at least 35km. Traps assembled from plastic frames and nylon netting were introduced in the early 1970s, and using boats of 10-12 m length, fishers typically operated up to 300 traps in strings of 30 per marker buoy. Developments in the south Devon static gear fishery are summarised in Table 1 (Appendix 1).

The modern crab fishery

In general, the current generation of static gear fishers has continued living in or close to the same traditional Start Bay communities. At present, inshore boats are typically 10-15 m in length, and are operated from deep-water ports by a skipper-owner and one to three crew. Up to 1600 traps are now worked from each boat, although the average number is 6-700 in strings of 40-80. If less than 800 traps are worked in total, all of the traps can be lifted once every two days, leaving every other day free for alternative employment. This work pattern changes during periods of particularly high catches, when fishers will lift their traps daily if weather permits.

The number of traps operated from each boat is no longer limited by the robustness of the trap construction. Modern traps constructed from man-made materials last for many years, if routinely maintained. Many skippers have experimented with more modern soft-eyed creels or parlour traps. Both of these designs feature non-return entries to prevent the escape of animals after entry (Figure.2). Despite this, fishers have commonly continued to use the inkwell design, as they state that these are more efficient than non-return designs on the softer seabed substrates where female (hen) crabs are targeted. In addition, inkwell traps are popular with fishers because unlike square or rectangular designs, they may be rolled across a deck, facilitating the hauling or shooting processes.

The only recent change to the inkwell design is that 'pot-locks' or rubber skirts were added to the funnels of the traps in the early 1990s, making it more difficult for captured animals to escape (Fig.2). Fishers say that before these features were added, crabs would only stay in the traps for as long as bait remained, which was typically three to four days. After this time, the crabs would climb out. Fishers believe that pot-locks or skirts slow the escape process, but state that few crabs will be caught unless traps are checked within seven to eight days of baiting. Lobsters are also generally believed to be able to climb in and out of inkwell traps 'at will', whether pot locks or skirts are used or not.

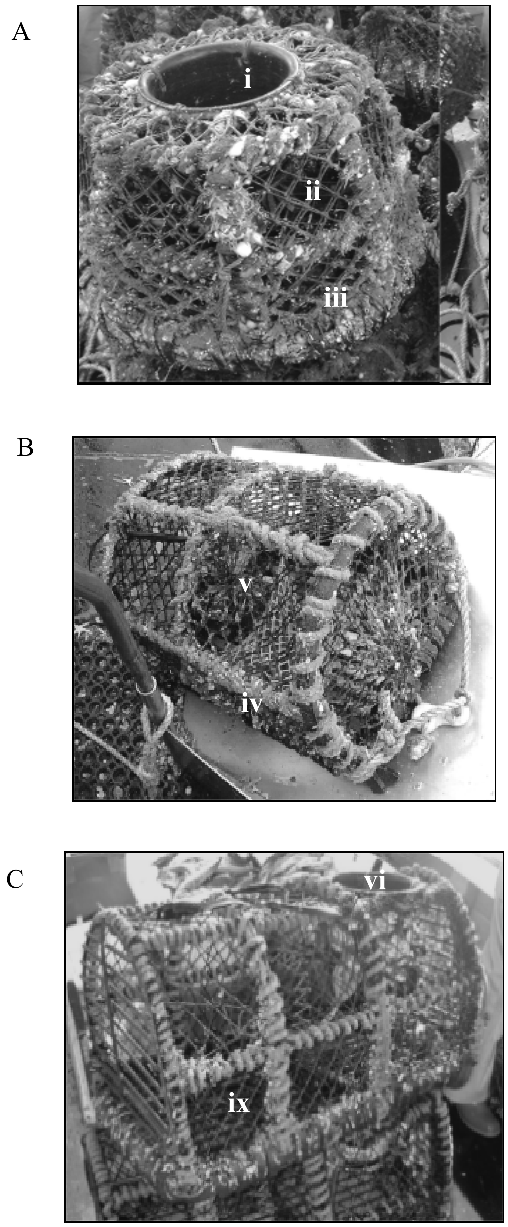

Figure 2: Different trap types used in the IPA. A- Inkwell (diameter 26"). B- Soft-eyed creel (length 36"). C- Parlour (length 42"). i- rigid plastic top entrance, ii- location of rubber skirt used to slow escape of captured animals, iii- heavily weighted base, iv- side entrance, v- soft mesh non-return valve, vi- rigid plastic top entrance, vii- baited chamber, viii- soft mesh non-return valve exit to parlour, ix- parlour chamber.

Conflict within the static sector

Traps were traditionally left in the water to fish over winter, though withy traps tended to rot and disintegrate after this time in the season. However, wire traps were repaired as required, and because of their greater longevity, fishers were able to increase the amount of gear used. This increase created competition for space amongst static gear fishers, such that gear had to be continuously left in favoured sites to prevent other fishers moving their gear to the location. In the IPA system, occupation of an area of the sea (and hence seabed) traditionally signifies the right to fish in that location, but only as long as gear is retained there.

The practice of leaving traps at sea over winter continues today. Space for additional static gear within the IPA is very limited, and fishers wishing to enter the static gear fishery are unable to do so unless they buy second-hand gear already positioned at sea. Vacant sites are also limited because some fishers leave weighted marker buoys in place to discourage other fishers from setting trap strings in unoccupied locations. As territories cannot be expanded, space for additional trap strings may only be created by moving existing strings closer together.

The towed gear sector

Towed bottom-fishing gears including otter trawls, beam trawls and dredges have been used in the inshore waters of south Devon for 5-800 years (Fox 2001). While some towed gear boats were launched from beaches adjacent to villages, the majority operated out of deep-water ports such as Plymouth, Brixham, Dartmouth and Exmouth. Whilst there are now a small number of towed gear fishers based in Salcombe and Dartmouth, the towed and static sectors of south Devon tend to operate from different ports.

Historically, scallop dredging was conducted on a part time basis by static gear fishers, starting at around Christmas time and lasting until the start of the crab-fishing season in April or May, when static gear fishing restarted in earnest. Scallops rather than fish were targeted because the dredges used could be hauled by hand or with hand-operated capstans, while trawling required more specialised equipment. However, the use of towed gear enabled static gear fishers to 'make a living' over the winter when crab catches were low. In the main, this practice stopped in the 1970s when scalloping became less profitable for part-time fishers and trapping became more time intensive.

The inshore towed gear sector now operates boats with dredges, beam trawls and otter trawls. Some boats seasonally use different towed gears to maximise potential earnings, though a local-area byelaw of the Devon Sea Fisheries Committee prevents vessels longer than 15.24m overall operating within six miles of the Devon coastline.

Conflict between sectors

Conflict between the towed and static sectors has long existed within the south Devon inshore fishery. However conflict was uncommon prior to the 1970s simply because towed gears could not be used effectively or safely where trap fishers operated on mixed or rougher ground. Catches were probably sufficient such that there was little need for boats to stray into areas typically fished with other gear types. In addition, static gear fishers used to move gear from one location to another as they followed movements of crabs, which allowed other fishers access to the grounds they vacated.

The potential for conflict between towed gear fishers and static gear fishers has increased through time. As traps became constructed from more durable materials, static gear fishers were able to operate more traps, and leave them in position year-round. The competition for space amongst static gear fishers finally eliminated the traditional pattern of seasonal trap movement in the 1980s, and thus the towed gear sector lost seasonal access to some sites. Most significantly, the development of towed gears such as rockhopper trawls and spring-loaded dredges, in conjunction with higher market prices for scallops and white-fish, meant that it became cost effective for towed gear fishers to target rough ground.

It may seem strange that fishers are unable to avoid each other's gear, but an appreciation is required of the methods of gear deployment if the complexity of the situation and difficulty of finding a solution are to be appreciated. Essentially, while towed gear fishers may attempt to avoid trap strings, static gear loss or damage is almost inevitable when towed and static gears are fished in close proximity. In particular, strong and complex inshore tidal streams make accurate towing difficult, so even when towed-gear fishers are aware of trap positions, interactions with gear can occur. The strong currents also pull marker buoys down-tide and away from the trap strings, or may even submerge them during peak flows, making accurate location of the gear difficult or impossible. In inshore areas trap strings may be

tightly packed together, leaving very little room for towed gear use. A further problem in inshore areas is that towed gears must be towed between banks, where static gear may have been positioned to avoid being buried by movement of bottom sediments.

The inshore potting agreement

In the mid-1970s, towed gear fishers expanded the area over which they operated into areas where static gear fishers had previously operated in isolation. Static gear fishers suffered significant losses of traps as a result, which reduced catches and income, and necessitated the extra expense of gear replacement. In response to this, in 1978 the Ministry of Agriculture, Forestry and Fisheries was asked to mediate a meeting between representatives of the static and towed gear sectors, the outcome of which was the Inshore Potting Agreement (IPA). It included areas designated for exclusive static or towed gear use and for seasonal static or towed gear use. The function of the agreement was to maintain the ability of static gear fishers to operate on traditional grounds without the risk of losing gear to the towed sector (Fig.3A).

Subsequent to the creation of the first agreement, fishers suggested a number of modifications. In 1982 a new agreement was established, when temporal and spatial adjustments were made to the design to reduce its complexity, and the diamond-shaped seasonal zone outside the six-mile British territorial limit was removed (Fig.3B). Further spatial and temporal adjustments were made in 1984 in response to requests for access to seasonal resources from towed gear fishers, who gave up seasonal access rights in other areas as compensation (Fig.3C). The current version of the IPA was introduced in 1993, with further minor spatial and temporal changes (Fig.3D). The surface area of the constituent parts of the IPA system from 1978 to present is detailed in Table 1 (Appendix 1).

METHODS

Copies of the 1978, 1982, 1984 and 1993 Inshore Potting Agreements were obtained from the South Devon and Channel Shellfishermens' Association. These were digitised using Arc View V.3.2, and the total area of exclusive use and seasonal access zones were determined using the British National Grid map projection. The areas of zones for seasonal static gear use were calculated as ([total size of each seasonal zone] x [% of the year the zone was allocated for static gear use]). Hence a zone of 50km² available for static gear use during six months of the year was calculated as (50 x 0.5) = $25km^2y^{-1}$.

In order to conduct interviews, towed and static gear fishers of the IPA were approached via their respective fishers' associations, the South Western Fish Producers' Organisation (SWFPO) and the South Devon and Channel Shellfishermens' Association (SDCSA). Meetings were organised to introduce the project to fishers, and interviews were subsequently carried out at sea under normal working conditions. If on analysis, gaps in the data were found, fishers were re-contacted for additional questioning. Neis *et al.* (1999) stated that fisheries researchers can greatly strengthen the quality of data gathered by conducting interviews on the fishing grounds and combining them with observation and follow-up interviews. Interviewing at sea also allowed fishers to provide additional non-elicited information regarding aspects of the fishery that would have been missed had interviews been land based.

The interview process followed a semi-structured system. Each fisher was initially re-informed of the project aims, and what was to be achieved during the day. A series of questions were posed to establish their position in the fishery, including age, experience, number of generations of fishers in their family, and other socio-economic data. These included the value of the boat, types of gears used, number of crew, how much had been caught over previous seasons, where products were sold, and from whom equipment or services were purchased. These questions served to establish each fisher's role within the fishery, and began the questioning process on non-emotive issues.

Finally, more contentious issues were covered, including what services the IPA provided each fisher, whether they felt the IPA served other fishing sectors, and any means by which the IPA could be improved. Fishers were also asked if they had conflict interactions with fishers of other industry sectors, or conflict with fishers of the same sector. By asking these questions last, it was hoped that more responses would be elicited, and that any responses would be more likely to be honest. However, notes were taken earlier in the day if these issues were covered without prompting.

During the course of the project, interviews were conducted with the skippers of nine static gear boats and five inshore towed gear boats. A member of the SDCSA committee and two members of the SWFPO committee were also

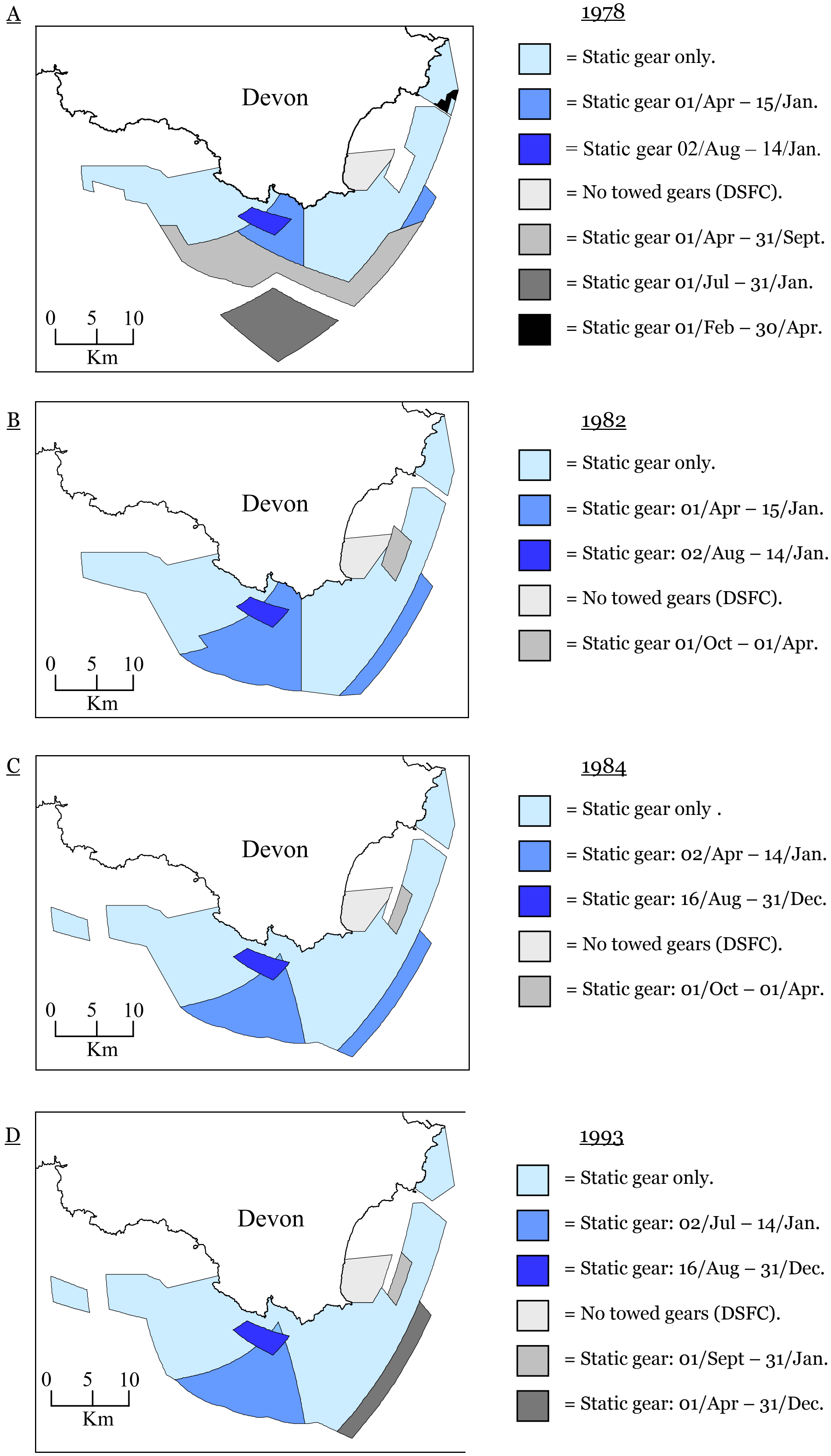

Fig 3: Inshore Potting Agreements for 1978, 1982, 1984 and 1993. 'No towed gears (DSFC)' refers to a Devon Sea Fisheries Committee local area byelaw banning the use of towed gears in Start Bay.

interviewed to determine relevant organisational positions.

RESULTS

Changes to the IPA

The total area of seabed covered by the first Inshore Potting Agreement (1978-1981) was 527.3 km^2. Included in this was a diamond shaped seasonal access zone of 67.7km^2 lying outside the six-mile United Kingdom territorial limit. Then in 1982, the total area covered by the IPA was reduced to 470.7 km^2. The majority of this reduction was due to the removal of the seasonal access zone outside the six-mile territorial limit. Despite this reduction in the total area, the area available for static gear use increased slightly to 444.2km^2y^{-1} as the static gear only area increased in size from 291km^2 to 330.7km^2.

The 1984 the IPA further increased in size to 479.9 km^2, and the amount of ground exclusively available to static gear fishers also increased to 357.1 km^2. The area of seasonally accessible ground was reduced to 90 km^2y^{-1}, continuing the general pattern of increasing exclusive access in exchange for reduced seasonal access for static gear fishers within the IPA.

The current IPA has operated since 1993, and covers 478.4 km^2, with 349.7 km^2 reserved for static gear use and 73.2 km^2y^{-1} retained for seasonal access. The majority of the loss of seasonal access area from 1984 to 1993 resulted from alterations to temporal rather than spatial access to seasonal zones.

Is the IPA a good system?

In response to the question "Is the Inshore Potting Agreement a good system?" all but one of the static gear fishers immediately responded positively (Table 3, Appendix 1). The exception was a fisher with gear positioned on the edge of the system (referred to as an 'edge' fisher in Tables 3-, Appendix 1) that stated that the IPA provided no personal benefit. This fisher reported that the IPA did little to stop towed gear fishers from working in static gear only zones, and that he was forced to co-operate with towed gear fishers by occasionally moving trap strings to allow them access to the ground he fished. Other static gear fishers, including those who operated on the interior of the system (i.e. had at least one other fisher's gear between their gear and any edge of the IPA; 'interior' in Tables 3-7, Appendix 1) stated that although they received no personal benefit from the IPA, it had generally protected the ability of the static gear sector to operate. Six of the eight static gear fishers who said the IPA was a good agreement also said that the IPA was not good enough and that more protection should be afforded to the static sector.

Towed gear fishers were divided between those who thought the IPA was a good system, and those who thought it disadvantaged them unfairly. The general difference in opinion was due to some defending the right of the static sector to access fishery resources, while some objected to the overriding principle that static gear fishers had property rights to the ground governed by the IPA. All members of the towed gear sector raised the property rights issue, with particular reference to one static gear fisher who, on retiring, had advertised his boat for sale 'with gear and ground'. Towed gear fishers objected strongly to the sale of fishing territories.

Gear protection

Almost all members of the static gear sector stated that the IPA afforded a degree of trap protection they would not have in the absence of an agreement (Table 4, Appendix 1). The two static gear fishers who felt that the IPA did not provide protection for their gear stated that, despite the agreement, the towed sector regularly fished in static gear only zones anyway, except in areas in which it was technically too difficult to operate.

Two towed gear fishers agreed that the IPA afforded static gear fishers some protection for their gear. However, other towed gear fishers claimed that the degree of loss that the static gear fishers suffered as a result of the activities of the towed sector was minimal, and was frequently exaggerated in order to create the maximum controversy. One towed gear fisher stated that if the IPA static gear only zones were opened to the towed gear sector, static gear fishers would benefit because any traps lost in the past would be quickly recovered.

There is also a gear protection aspect to the IPA for the towed sector, and in particular for those using otter trawls. Essentially, if traps are snagged while trawling then considerable damage may be done to the belly and cod-end of a trawl net. In this regard, two static gear fishers commented that the IPA benefited the towed sector considerably because the static sector operated only within the limits of the IPA. All towed gear fishers interviewed mentioned protection of trawl gear, but said that the IPA did not provide this service because even without a specific static gear area towed fishers would attempt to avoid trap strings.

Habitat protection

Six of the nine static gear fishers stated that the IPA functioned to protect benthic habitats within the IPA area. This was in contrast to interviewees from the towed sector, in which only one fisher indicated that the IPA functioned in this manner. With the notable exception of one scallop dredge fisher, interviewees from the towed sector generally accepted that towed gears caused damage to the seabed. However, they also said that the IPA did not protect benthic habitats because static gears also damaged the seabed, in particular when ropes are dragged across the seabed during hauling. Static gear fishers commonly considered these factors, but generally thought that the damage caused by static gears would be less significant than the damage caused by towed gears and so stated that the IPA functioned to protect the seabed.

Reserve function

There was almost uniform agreement amongst interviewees that the IPA functioned as a reserve for species targeted by the towed sector. Therefore it was felt that the IPA improved the long-term viability of the local fishing industry. Despite this view, towed gear fishers protested that static gear fishers used anchored gill and trammel nets to catch demersal fish species that could be protected by the existence of the IPA. Fishers from both sectors felt that the potential reserve benefits were therefore lessened.

Intra sector conflict

Most fishers from the static sector commented that they had conflict problems within their own sector, always as a result of competition for space (Table 5, Appendix 1). The majority of these problems were said to have occurred as a result of newcomers entering the fishery, or with vessels that were fishing a large number of traps. The most commonly reported periods for conflict interactions to occur were at the start of the static gear season in spring when additional traps were put out at sea after over-winter repair, and when seasonal zones were reopened after a period of towed gear use. At these times, territory boundaries between fishers were re-established, with the potential for ground to be acquired from neighbours.

Towed gear fishers less commonly stated that they suffered conflict within their own sector, but two commented that they were forced to be secretive when fishing within static gear only zones, in case other fishers noticed where they were working and began to operate in close proximity. Essentially, when towed gear fishers operated within static gear zones by finding vacant sites or by making personal agreements with static gear fishers, they tried to avoid competition from other towed gear fishers, or were worried that static gear damage would result, and their own agreement would suffer.

Inter sector conflict

All of the towed gear fishers interviewed admitted fishing inside the IPA static gear only zones, though accusations of static gear loss were also generally refuted. One scallop dredge fisher acknowledged that he regularly caught traps, but said that he replaced them whenever damage occurred.

A number of static gear fishers who used traps only stated that the use of anchored nets by static gear fishers represented a breach of the IPA. They commented that the IPA was established specifically to protect the right of trap fishers to operate, and that the use of nets was a considerable source of contention in dealings with the towed sector. All static gear fishers who mentioned this issue thought the towed sector would be more likely to respect the IPA if anchored nets were not used inside the limits of the system. Two towed gear fishers also commented that some static gear fishers positioned gear outside the limits of the IPA (Table 6, Appendix 1). One static gear fisher confirmed that some fishers did place traps outside the IPA area, and a number of trap strings from one fisher were consistently found located outside the IPA during the period of the study.

Most static gear fishers commented that they had experienced inter-sector conflict problems. The two exceptions were static gear fishers with territories within the IPA. Despite this, only half the interviewees from the static gear sector felt that towed gear fishers broke the spirit of the agreement by fishing in static gear zones. Three static gear fishers with conflict problems, including one who said he felt the other sector broke the IPA, still confirmed they worked with towed gear fishers to allow them temporary access to the ground over which they worked.

Among those fishers who expressed an opinion with regard to which sector caused most conflict problems, there was almost universal agreement that scallop dredgers were most at fault. The exception was one fisher who stated that he had most problems with anglers, as they frequently snagged ropes or traps while anchoring. Apart from dragging the traps away from their original location (which was said to reduce catches significantly), the interviewee claimed that the

gear was almost inevitably cut off rather than untangled, thus making hauling the traps difficult and time consuming.

Can the IPA be improved?

Predictably, most members of the towed gear sector were opposed to any suggestion that static gear fishers should be given more ground (Table 7, Appendix 1). However, only one member of the static sector said this was a means to improve the IPA. There was consensus between respondents from both sectors when additional restrictions were considered for static gear fishers. Suggestions from them included limiting fishers to traps only and banning the use of non-return trap designs. Input controls such as limiting trap numbers according to size and power of the boat, or number of crew, were also mentioned by half the static gear fishers and all but one member of the towed sector. Output controls recommended by static gear fishers included a total allowable catch (TAC) system, a raised minimum landing size for male and female crabs or increased quality standards. However, it was accepted that crab buyers and processors would have to participate fully in any output control system.

Six of the nine members of the static sector interviewed, and one member of the South Western Fish Producers' Organisation (SWFPO) committee recommended that the IPA should be legalised to prevent towed gear fishers operating in static gear zones. All active fishing members of the towed sector rejected legislation however, as they claimed that it would do little or nothing to prevent towed fishers from breaking the IPA. In fact, fishers from both sectors commented that legislation could seriously harm the IPA, as towed fishers respected the agreement only because of its voluntary nature. It was considered that legislative intervention would be counter-productive.

Interviewees from the towed sector most commonly suggested the IPA should be altered by the introduction of corridors through static gear zones, or the implementation of further seasonal access arrangements in existing exclusive static gear zones. The exception was one fisher who operated a small trawler, and regularly towed in pockets of open ground within the static gear only zones. He said he preferred the existing system because he would lose his advantage if larger vessels from the towed sector were to be allowed into restricted zones. The towed gear fishers in favour of greater seasonal access commented that the static fishers commonly abandoned their gear at sea over winter to avoid losing the site to other static gear fishers, but that this prevented towed gear boats from operating in these areas. Essentially, the right of all fishers to go fishing was accepted by every interviewee, but the suggestion that static gear fishers held property rights over territories within the IPA was strongly condemned by every towed fisher. In contrast, one member of the SWFPO committee and one towed gear fisher commented that the area of ground within the IPA was tiny in comparison to the area available to towed fishers that work in the English Channel.

DISCUSSION

Fishery benefits

Fishers perceived the Inshore Potting Agreement to serve a number of functions, primarily the limitation of conflict between the towed and static gear sectors. Although almost all fishers stated that they suffered conflict interactions, it was commonly considered that inter-sector conflict would be worse without the IPA. A typical comment was "It works 90% of the time. It isn't perfect, but whatever is done isn't going to be perfect".

By limiting conflict, it is likely that the IPA has served to protect a large portion of the trap fishing industry of south Devon, and enabled fishers from the static and towed gear sectors to operate effectively and profitably in relative harmony. In comparison, fishers from both sectors described a trap fishery that historically operated in the 'Exeter Roughs', a nearby area to the east of the IPA, which disappeared after scallops (*Pecten maximus*) were discovered there by dredge fishers in the mid 1980s. The substratum was composed of biogenic, coralline reef, but within a short period it was reported that the seabed had been flattened and the trap fishery ended. It was also reported that the scallop fishery had been very short lived, and that there was little sign of a recovery in the substratum, or crab or scallop fisheries.

Scallop dredges are considered to be among the most damaging towed bottom fishing gears (Dayton *et al.* 1995; Collie *et al.* 2000), though the use of other towed gears may also lead to long term changes in benthic community structure (Bradstock and Gordon 1983; Kaiser and Spencer 1996; Collie *et al.* 1997; Jennings and Kaiser 1998; Kaiser *et al.* 1998; Norse and Watling 1999). In this study, even towed gear fishers generally accepted that damage occurred as a result of their fishing activities. However, the argument that the IPA does not protect benthic habitats because static gears also cause

damage to the seabed is difficult to support. Studies by Kinnear *et al.* (1996) and Eno *et al.* (1996) indicated that trapping caused little incidental damage to epibenthic fauna. A study by Kaiser *et al.* (2000) also determined that the species diversity within IPA static gear only zones was higher than in seasonal access zones, which in turn was higher than in areas outside the IPA system where towed gear fishers were able to operate year-round. Importantly, biogenic fauna such as soft corals and hydrozoans were also more prevalent in exclusive use areas within the IPA.

Larvae of *Cancer pagurus* tend to be less selective of seabed characteristics at settlement than those of crustacean species of lower fecundity (Robinson and Tully 2000). However, other studies have shown that post-settlement survival of some sub-tidal crustacean species is higher in more complex habitats (e.g. Pile *et al.* 1996; Palma *et al.* 1998; Stevens and Kittaka 1998; Robinson and Tully 2000). Crustaceans are also physically damaged by towed bottom fishing gears (Kaiser et al. 1994; Hill *et al.* 1996; Kaiser and Spencer 1996), and a number of studies determined that crustacean densities decreased with increased towed gear use (Eleftheriou and Robertson 1992; Veale *et al.* 2000). Trap fishers commonly maintained that if towed gears were occasionally worked near but not alongside or over their gear, then catch rates could increase, as crabs were attracted to dead or dying by-caught animals. The rapid attraction of scavenging megafauna, including *C. pagurus*, to dredge tracks has been well documented (Caddy 1973; Kaiser and Spencer 1994). However, trap fishers also stated that it took several months for catch rates to recover if towed gear boats had worked repeatedly around their gear, and concluded that this was because the seabed had been damaged extensively. However, there is no published evidence to support this.

Of the species targeted by towed bottom fishing gears, scallops in particular may benefit from increased benthic heterogeneity within the IPA system. The presence of filamentous flora and fauna was identified as a critical factor that determines spat settlement in the scallop, *Pecten maximus* (Dare and Bannister 1987; Minchin 1992), giant scallop, *Placopecten magellanicus* (Stokesbury and Himmelman 1995) and Iceland scallop, *Chlamys islandica* (Harvey *et al.* 1993). As sessile emergent epifauna are at risk from towed gears (Collie *et al.* 1997; Sainsbury *et al.* 1998; Moran and Stephenson 2000), limits on towed gear use within the IPA may have important implications for spat settlement and later recruitment of adults to nearby fisheries. In addition, spat or undersized scallops may be damaged when in direct contact with towed gears (Caddy 1973; Brand 1980).

Spat may preferentially settle on structures to avoid being smothered by sediment (Brand 1980; Thouzeau 1991; Harvey *et al.* 1993), and high concentrations of suspended silt caused mortality in larvae and spat of different scallop species (Naidu and Scaplen 1979; Stevens 1987). Trawling may be a significant contributing factor to sediment re-suspension in shelf seas (Churchill 1989; Pilskaln *et al.* 1998; Auster and Langton 1999; Hall 1999), and consequently the reduction in sediment re-suspension by trawlers inside the IPA may also benefit scallop recruitment**.** Furthermore, the possibility exists that some commercially important scallop beds are self-seeding, with only occasional spatfalls originating in other areas (Sinclair *et al.* 1985; Darby and Durance 1989; Brand 1991; Young *et al.* 1992). For example, Buestal *et al.* (1979) determined that the scallop (*P. maximus*) spat settlement in the Bay of Saint-Brieuc reflected the status of the local parent stock. Therefore, if a scallop bed is fished to commercial extinction, there may only be limited potential for its resettlement and rejuvenation, and a reserve of mature scallops within the IPA could be vital to the continuation of the local scallop-fishing industry. Moreover, significant increases in scallop biomass have been clearly demonstrated in other closed area systems (e.g. Turner *et al.* 1996; Brocken and Kenchington 1999; Murawski *et al.* 2000).

Most interviewees thought the IPA had functioned to improve the long-term viability of the towed gear sector, though it was almost always in regard of protecting populations of demersal fish species rather than scallops. The possibility that the IPA may act as a reserve for fish species is uncertain. Fishery benefits in areas adjacent to reserves have been demonstrated infrequently, and it has been questioned whether a limited access system of only 480km^2 would protect a population of mobile demersal fish such that any net benefits would result (Horwood 2000). However, much smaller reserves have proved to be beneficial for some relatively sedentary species (Roberts and Hawkins 1997, Roberts *et al.* 2001). Regardless of any benefits of limited towed gear fishing, fish are taken within the IPA system in anchored nets and by recreational anglers. However, most fishers in the towed sector wanted access to the restricted ground within the IPA, and believed that the system protected valuable and scarce

target species. For example, fishers reported that unusually large ray (*Raja* spp.) are caught on banks within the IPA by both anglers and commercial netters.

Development of the IPA

The establishment of the IPA, and subsequent changes to its shape and size over time resulted from proposals originating from users of the inshore system. Though fishers were driven to form the IPA, the system has worked effectively. However, the diamond shaped seasonal access zone outside the six-mile United Kingdom territorial limit was less likely to have functioned successfully because there are few access restrictions for fishers from the European Union to waters beyond the six-mile limit. In the absence of statutory protection, or without enforcement of fishery regulations, any part of the IPA that operated outside the six-mile limit could only function with the consent of other fishers within the European Union. This consent would be open to accidental abuse through lack of knowledge of the system, or deliberate abuse. Healthy fish stocks are a collective good, and in most common property situations it is difficult to exclude people from such goods (Jentoft et al. 1998). Hence, without conventional fishery management measures such as the six-mile territorial limit, or power and effort limitations on towed gear use within six miles of the coastline where the bulk of the IPA exists, it is unlikely that the IPA would have survived.

Property rights refer to the entire range of rules, regulations, customs and laws that define rights over appropriation, use and transfer of goods and services (Kula 1992). Acheson *et al.* (1998) and Walters (1998) suggested that property rights must be established before any other fishery management regulation can be successfully applied. Towed gear fishers vehemently opposed an official system of territory ownership within the IPA, and maintained that access should be equal for all fishers. However, informal ownership arrangements do exist between static gear fishers. These arrangements have allowed static gear fishers to reduce the risk of operating in an open-access system, though ensuring access to seasonal grounds is problematic. One informant maintained that traps were historically fished close inshore early in the season, when male crabs were targeted on rough ground. During this period, towed gear vessels would cover ground further offshore. Over the summer and autumn, traps were moved further offshore onto softer ground to target female crabs, enabling the towed gear fleet to fish any suitable ground inshore. The informant stated that the system operated successfully because it allowed both sectors to cover all areas. In addition, when the traps degraded or were removed from the water over the winter period, towed boats were further able to target areas normally fished with static gear.

The movement of traps between sites probably worked in the past because effort was limited. It is likely that the reduction in the amount of seasonal access ground from 1978 to 1993 resulted from two factors, the difficulty that static gear fishers have in re-acquiring ground when areas are seasonally re-opened, and the difficulty of ensuring regulatory compliance in seasonal access zones. Not only is it logistically difficult to move a large number of trap strings from one place to another, there is also little to prevent a fisher from positioning gear in a site occupied by another the previous season. Occupying a territory continually prevents an annual race to position gear at the start of the season. It is also easier to manage and enforce a single use system than a multiple use, seasonally changing, system. Enforcement is a key factor leading to successful fishery enhancement from reserves (Roberts *et al.* 2001).

As a voluntary agreement, the IPA is based on goodwill. The use of anchored nets by static gear fishers to target demersal fish species has the potential to adversely affect the long-term viability of the IPA. Towed gear fishers stated that they did not feel trawl protection was achieved through the IPA, and beam trawls and scallop dredges were not damaged when they came into contact with traps. Further, because static gear and towed gear fishers do not generally use the same ports, the IPA does little to reduce social conflict for fishers when they are in port, a factor that has been credited with helping to maintain management systems in other areas (e.g. Acheson 1988). However, towed gear fishers stated that the benefit of adhering to the IPA was that the area acted as a reserve for the fish species they targeted. When static gear fishers used anchored nets within the area, towed gear fishers felt that this reduced the benefit to them of respecting the IPA, but without this benefit, goodwill alone may not be enough to preserve the system in the future.

WIDER APPLICATION

A number of authors have proposed that rather than attempt to manage a fishery or fish stock in isolation, managers should take into consideration the ecosystem within which the fishery exists. Proponents suggest that if an

ecosystem is sustainably managed as a whole, the individuals within will also be sustainably managed (Sherman, 1991; Botsford *et al.* 1997; Langton and Haedrich 1997; McGlade *et al.* 1997; Jennings and Kaiser 1998; Hofmann and Powell 1998; Pitcher and Pauly 1998). Essentially, it may be that the maximum long-term fishery production will be more easily achieved by controlling 'how' fishing is undertaken, rather than 'how much' is caught. The shift in emphasis towards non-technical fishery management measures stems in part from the failure of existing management programmes to meet biological goals (Murawski *et al.* 2000).

The IPA represents an interesting example of how fishing should be undertaken. Probably the most noteworthy features are that it was conceived relatively recently and has the general backing of both fishery sectors, but has protected the traditional practices of the local fishing industry. The IPA has evolved in modern society, despite the increasing pressures of lower catches but higher expectations of earnings and living standards. Because of this, fishers should be commended for the creation and function of the IPA, and features of the system that may be successfully adopted in other locations may be noted. These are:-

1. Management may be more successful if all existing uses of the managed area are taken into account. The IPA is an agreement over ground that historically had been used for the same purposes.
2. Management may be more successful if all existing users of the managed area are taken into account. The IPA has reduced in size to lie mostly within the six-mile territorial limit of the United Kingdom, thus reducing potential conflict issues concerning non-local fishers not party to the management system.
3. When existing use of the seabed permits, exclusive use zones have the greatest potential for management success. It is easier to enforce exclusive use systems, and reallocating seasonal territories has the potential to create conflict within sectors. Further, exclusive use zones may allow the effects of management strategies to be more easily quantified and related to changes in fishery use.
4. Seasonal limitations on gear types have the potential to work effectively, as different fishing sectors may wish to target the same areas at different times of the year. However, seasonal changes in use should not be overly complex in time or space. Care may also be required to ensure that on re-opening, fishers are able to return to previously occupied sites.
5. Within a management zone, long-term regulatory compliance may be more likely if users are restricted in their ability to switch methods to take advantage of increases in abundance of species targeted by other fishing sectors but protected and enhanced by the change in management. The use of anchored nets by static gear fishers has reduced the potential for long term viability in the IPA.
6. If gear types and effective effort can be limited at the inception of a new system, conflict between users is less likely to develop. Conventional fishery management regulations exist such that within six miles of the United Kingdom coast, towed gear fishers are limited to 12 dredges and power of no greater than 300hp. This has prevented large or non-United Kingdom vessels from fishing inside the IPA.
7. Regulatory compliance may be more likely to result when managers are able to meet regularly to discuss events occurring in a fishery, and when management is flexible and adaptable. When features of the IPA were found to be unworkable, changes were quickly made.
8. Conflict avoidance and regulatory compliance may be more likely if negotiation can be between bodies that represent fishers en masse. Two fishers' associations represent all of the static gear fishers and most of the towed gear fishers operating in the IPA. Information is rapidly disseminated within associations and peer group control may be applied.

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References

Acheson, J.M. (1988); The lobster gangs of Maine. University Press of New England, Hannover: 181pp

Acheson, J. M., Wilson, J.A. and Steneck, R.S. (1998); Managing chaotic fisheries. *In* Linking social and ecological systems: management practices and social mechanisms for building resilience. F. Berkes and Folke, C. (Eds.). Cambridge University Press, Cambridge: 390-413

Auster, P. J. and Langton, R.W. (1999); The effects of fishing on fish habitat. *In* Fish habitat: essential fish habitat and rehabilitation. American Fisheries Society V.22, Connecticut: 150-187

Auster, P. J. and Shackell, N.L. (1997); Fishery reserves. *In* Northwest Atlantic groundfish: perspectives on a fishery collapse. J. Boreman, Nakashima, B.S., Wilson, J.A. and Kendall, R.L. (Eds.). American Fisheries Society. Bethesda, Maryland: 159-166

Botsford, L. W., Castilla, J.-C. and Peterson, C.H. (1997); The management of fisheries and marine ecosystems. *Science* 277: 509-515

Bradstock, M. and Gordon, D.P. (1983); Coral-like bryozoan growths in Tasman Bay, and their protection to conserve commercial fish stocks. *New Zealand Journal of Marine and Freshwater Research* 17: 159-163

Brand, A. R., Paul, J.D. and Hoogesteger, J.N. (1980); Spat settlement of the scallops *Chlamys opercularis* (L.) and *Pecten maximus* (L.) on artificial collectors. *Journal of the Marine Biological Association of the United Kingdom* 60: 379-390.

Brand, A. R. (1991); Scallop ecology: distributions and behaviour. *In* Scallops: biology, ecology and aquaculture. S. E. Shumway (Ed.), Elsevier Science Publishers B.V., Amsterdam: 517-584.

Brocken, F. and Kenchington, E. (1999); A comparison of scallop (*Placopecten magellanicus*) population and community characteristics between fished and unfished areas in Lunenburg County, N.S., Canada. Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, Nova Scotia: 33pp

Buestal, D., Dao, J.C. and Lemaire, G. (1979); Collecte de naissain de pectinidés en Bretagne. Rapports et Procés-Verbaux des Réunions. Conseil International pour l'Exploration de la Mer 175: 80-84

Caddy, J. F. (1973); Underwater observations on tracks of dredges and trawls and some effects of dredging on a scallop ground. *Journal of the Fisheries Research Board of Canada* 30: 173-180.

Chadwick, M., Soussan, J., Mallick, D. and Alam, S. (1998); Understanding indigenous knowledge: its role and potential in water resource management in Bangladesh. Environment Centre, University of Leeds, Leeds: 46pp

Charles, A. T. (1998); Beyond the status quo: rethinking fishery management. *In* Reinventing fisheries management. T. J. Pitcher, Hart, P.J.B. and Pauly, D. (Eds.), Kluwer Academic Publishers. London: 101-111.

Churchill, J. H. (1989); The effect of commercial trawling on sediment resuspension and transport over the Middle Atlantic Bight continental shelf. *Continental Shelf Research* 9 (9): 841-864.

Collie, J. S., Escanero, G.A. and Valentine, P.C. (1997); Effects of bottom fishing on benthic megafauna of Georges Bank. *Marine Ecology Progress Series* 155: 159-172.

Collie, J. S., Escanero, G.A. and Valentine, P.C. (2000); Photographic evaluation of the impacts of bottom fishing on benthic epifauna. *ICES Journal of Marine Science* 57 (4): 987-1001.

Darby, C. D. and Durance, J.A. (1989); Use of the North Sea water parcel following model (NORSWAP) to investigate the relationship of source to recruitment for scallop (*Pecten maximus*) stocks of England and Wales. ICES CM.1989/K:18 1-19.

Dare, P. J. and Bannister, R.C.A. (1987); Settlement of scallop, *Pecten maximus*, spat on natural substrates off south-west England: the hydroid connection (Abstract only). *In* The Sixth International Pectinid Workshop, Menai Bridge, Wales, ICES.

Dayton, P. K., Thrush, S.F., Agardy, M.T. and Hofman, R.J. (1995); Environmental effects of marine fishing. *Aquatic Conservation: Marine and Freshwater Ecosystems* 5 (3): 205-232.

Eleftheriou, A. and Robertson, M.R. (1992); The effects of experimental scallop dredging on the fauna and physical environment of a shallow sandy community. *Netherlands Journal of Sea Research* 30: 289-299.

Eno, N. C., MacDonald, D. and Amos, S.C. (1996); A study on the effects of fish (Crustacea/Mollusc) traps on benthic habitats and species.

FAO (2000); The state of world fisheries and aquaculture (SOFIA) 2000. FAO, Rome: 142pp

Fox, H. (2001). The evolution of the fishing village: landscape and society along the south Devon coast, 1086-1550. Leopard's Head Press, Oxford: 208pp

Hall, S. J. (1999). The effects of fishing on marine ecosystems and communities. *In* Fisheries Biology and Aquatic Resources Series 1, T. Pitcher (Ed.). Blackwell Science Ltd, Oxford: 274pp

Hanna, S. (1998); Institutions for marine ecosystems: economic incentives and fishery management. *Ecological Applications* 8 (1, Supplement): 170-174.

Hart, P. J. B. (1998); Enlarging the shadow of the future: avoiding conflict and conserving fish. *In* Reinventing fisheries management. T. J. Pitcher, Hart, P.J.B. and Pauly, D. (Eds.). Kluwer Academic Publishers. London: 227-238.

Harvey, M., Bourget, E. and Miron, G. (1993); Settlement of Iceland scallop *Chlamys islandica* spat in response to hydroids and filamentous red algae: field observations and laboratory experiments. *Marine Ecology Progress Series* 99: 283-292.

Hill, A.S., Brand, A.R., Wilson, U.A.W., Veale, L.O. and Hawkins, S.J. (1996); Estimation of by-catch composition and the numbers of by-catch animals killed annually on Manx scallop fishing grounds. *In* Aquatic Predators and their Prey. S.P.R. Greenstreet and M.L. Tasker (Eds.). Fishing News Books, Oxford: 111-115

Hofmann, E. E. and Powell, T.M. (1998); Environmental variability effects on marine fisheries: four case histories. *Ecological Applications* 8 (1, Supplement): 23-32.

Horwood, J. W. (2000); No-take zones: a management context. *In* Effects of fishing on non-target species and habitats- biological, conservation and socio-economic issues. M. J. Kaiser and S. J. de Groot (Eds.), Blackwell Science Ltd. Oxford: 302-312.

Jennings, S. and Kaiser, M.J. (1998); The effects of fishing on marine ecosystems. *In* Advances in Marine Biology V.34. J. H. S. Blaxter, Southward, A.J. and Tyler, P.A. (Eds.). Academic Press. London: 203-354.

Jentoft, S., McCay, B. and Wilson, D.C. (1998); Social theory and fisheries co-management. *Marine Policy* 22 (4-5): 423-436

Kaiser, M. J., Edwards, D.B., Armstrong, P.J., Radford, K., Lough, N.E.L., Flatt, R.P. and Jones, H.D. (1998); Changes in megafaunal benthic communities in different habitats after trawling distrubance. *ICES Journal of Marine Science* 55: 353-361

Kaiser, M. J., Spence, F.E. and Hart, P.J.B. (2000); Fishing-gear restrictions and conservation of benthic habitat complexity. *Conservation Biology* 14 (5): 1515-1525

Kaiser, M. J. and Spencer, B.E. (1994); Fish scavenging behaviour in recently trawled areas. *Marine Ecology Progress Series* 112: 41-49

Kaiser, M. J. and Spencer, B.E. (1996); The effects of beam trawl disturbance on infaunal communities in different habitats. *Journal of Animal Ecology* 65: 348-358

Kinnear, J. A. M., Barkel, P.J., Mojsiewicz, W.R., Chapman, C.J., Holbrow, A.J., Barnes, C. and Greathead, C.F.F. (1996); Effects of Nephrops creels on the environment. Fisheries Research Services Report 2/96, Agriculture, Environment and Fisheries Department, Scottish Office, Aberdeen

Knudson, E. a. M., D. (2000); Sustainable fisheries: Are we up to the challenge? *Fisheries* 25 (12): 4 and 43.

Kula, E. (1992). Economics of natural resources and the environment. Chapman and Hall, London: 287pp

Langton, R. W. and Haedrich, R.L. (1997); Ecosystem-based management. *In* Northwest Atlantic groundfish: perspectives on a fishery collapse. J. Boreman, Nakashima, B.S., Wilson J.A. and Kendall, R.L. (Eds.), American Fisheries Society. Bethesda, Maryland: 151-156

Lauck, T., Clark, C.W., Mangel, M. and Munro, G.R. (1998); Implementing the precautionary principle in fisheries management through marine reserves. *Ecological Applications* 8 (1, Supplement): 72-78

MacKay, K. T. (1992); User participation in aquaculture research and development. *World Aquaculture* 23 (1): 20-24

McGlade, J., Price, A., Klaus, R. and Metuzals, K. (1997); Recovery plans for the North Sea ecosystem, with special reference to cod, haddock and plaice. University of Warwick, Warwick: 41pp

Minchin, D. (1992); Biological observations on young scallops, *Pecten maximus*. *Journal of the Marine Biological Association of the United Kingdom* 72: 807-819

Moran, M. J. and Stephenson, P.C. (2000); Effects of otter trawling on macrobenthos and management of demersal scalefish fisheries on the continental shelf of north-western Australia. *ICES Journal of Marine Science* 57: 510-516

Murawski, S. A. (2000); Definitions of overfishing from an ecosystem perspective. *ICES Journal of Marine Science* 57: 649-658

Murawski, S. A., Brown, R., Lai, H.-L., Rago, P.J. and Hendrickson, L. (2000); Large-scale closed areas as a fishery-management tool in temperate marine systems: the Georges Bank experience. *Bulletin of Marine Science* 66 (3): 775-798

Murray, S. N., Ambrose, R.F., Bohnsack, J.A., Botsford, L.W., Carr, M.H., Davis, G.E., Dayton, P.K., Gotshall, D., Gunderson, D.R., Hixon, M.A., Lubchenko, J., Mangel, M., MacCall, A., McArdle, D.A., Ogden, J.C., Roughgarden, J., Starr, R.M., Tegner, M.J. and Yoklavich, (1999); No-take reserve networks: sustaining fishery populations and marine ecosystems. *Fisheries* 24 (11): 11-25

Naidu, K.S. and Scaplen, R. (1979); Settlement and survival of giant scallop *Placopecten magellanicus* larvae, on enclosed polyethylene film collectors. *In* Advances in Aquaculture. T.V.R.Pillay and W.A. Pill (Eds.). FishingNews Books, London: 379-381

Neis, B., Schneider, D.C., Felt, L., Haedrich, R.L., Fischer, J. and Hutchings, J.A. (1999); Fisheries assessment: what can be learned from interviewing resource users? *Canadian Journal of Fisheries and Aquatic Science* 56: 1949-1963

Norse, E. A. and Watling, L. (1999); Impacts of mobile fishing gear: the biodiversity perspective. *In* Fish habitat: essential fish habitat and rehabilitation, American Fisheries Society V.22, Hartford, Connecticut: 31-40

Palma, A. T., Wahle, R.A. and Steneck, R.S. (1998); Different early post-settlement strategies between American lobsters *Homarus americanus* and rock crabs *Cancer irroratus* in the Gulf of Maine. *Marine Ecology Progress Series* 162: 215-225

Pile, A. J., Lipicius, R.N., van Montfrans, J. and Orth, R.J. (1996); Density-dependent settler-recruit-juvenile relationships in blue crabs. *Ecological Monographs* 66 (3): 277-300

Pitcher, T. J. a. P., D. (1998); Rebuilding ecosystems, not sustainability, as the proper goal of fishery management. *In* Reinventing fisheries management. T. J. Pitcher, Hart, P.J.B. and Pauly, D. (Eds.), Kluwer Academic Publishers. London: 311-329

Piskaln, C.H., Churchill, J.H. and Mayer, L.M. (1998); Resuspension of sediment by bottom trawling in the Gulf of Maine and potential geochemical consequences. *Conservation Biology* 12 (6): 1223-1229

Roberts, C. M., Bohnsack, J.A., Gell, F., Hawkins, J. and Goodridge, R. (2001); Effects of marine reserves on adjacent fisheries. *Science* 294: 1920-1923

Roberts, C. M. and Hawkins, J.P. (1997); How small can a marine reserve be and still be effective? *Coral Reefs* 16: 150

Robinson, M. and Tully, O. (2000); Spatial variability in decapod community structure and recruitment in sub-tidal habitats. *Marine Ecology Progress Series* 194: 133-141

Sainsbury, K. J., Campbell, R.A., Lindholm, R. and Whitelaw, A.W. (1998); Experimental management of an Australian multispecies fishery: examining the possibility of trawl-induced habitat modification. *In* Global trends: fisheries management. E. K. Pikitch, Huppert, D.D., Sissenwine, M.P. (Eds.), American Fisheries Society V.20. Bethesda, Maryland:107-112

Sherman, K. (1991); The large marine ecosystem concept: research and management strategy for living marine resources. *Ecological Applications* 1 (4): 349-360

Sillitoe, P. (1998); The development of indigenous knowledge. *Current Anthropology* 39 (2): 223-251

Sinclair, M., Mohn, R.K., Robert, G. and Roddick, D.L. (1985); Considerations for the effective management of Atlantic scallops. Canadian Technical Report on Fisheries and Aquatic Science: 113

Stevens, B. G. and Kittaka, J. (1998); Postlarval settling behaviour, substrate preference, and time to metamorphosis for red king crab *Paralithodes camtschaticus*. *Marine Ecology Progress Series* 167: 197-206

Stevens, P. M. (1987); Response to excised gill tissue from the New Zealand scallop *Pecten novaezelandiae* to suspended silt. *New Zealand Journal of Marine and Freshwater Research* 21: 605-614

Stokesbury, K. D. E. and Himmelman, J.H. (1995); Biological and physical variables associated with aggregations of the giant scallop *Placopecten magellanicus*. *Canadian Journal of Fisheries and Aquatic Sciences* 52: 743-753

Thouzeau, G. (1991); Experimental collection of postlarvae of *Pecten maximus* (L.) and other benthic macrofaunal species in the BAy of Saint-Brieuc, France.I. Settlement patterns and biotic interactions among the species collected. *Journal of Experimental Marine Biology and Ecology*. 148: 159-179

Turner, W. H., Tammi, K.A. and Rice, M.A. (1996); "Bags to drags," the story of the bay scallop restoration project. *Journal of Shellfish Research* 16 (1): 276

Veale, L. O., Hill, A.S., Hawkins, S.J. and Brand, A.R. (2000); Effects of long-term physical disturbances by commercial scallop fishing on subtidal epifaunal assemblages and habitats. *Marine Biology* 137: 325-337

Walters, C. (1998); Designing fisheries management systems that do not depend upon accurate stock assessment. *In* Reinventing fisheries management. T. J. Pitcher, Hart, P.J.B. and Pauly, D. (Eds.), Kluwer Academic Publishers. London: 279-288

Woodhatch, L. and Crean, K. (1999); The gentleman's agreement: a fisheries management case from the Southwest of England. *Marine Policy* 23 (1): 25-35

Young, P. C., McLoughlin, R.J. and Martin, R.B. (1992); Scallop (*Pecten fumatus*) settlement in Bass Strait, Australia. *Journal of Shellfish Research* 11 (2): 315-323.

APPENDIX 1

Table 1: Summary of the principle developments in the south Devon static gear fishery.

Year	Developments
Pre-1930	Wooden sailing and rowing boats of 5-6m length. 60-100 withy traps and two or three fishers per boat. Traps in strings of up to five below each marker buoy. Beach boats hauled ashore by hand.
1930-1950	Inboard motors introduced early 1930s. Some larger boats (up to 10m) with motorised capstans operated from deep-water ports by 1950. Beach boats hauled ashore using motorised capstans.
1950-1960	Beach fishers began to move to larger deep-water port boats. Up to 200 cherry and wire traps operated from each boat, though more from port boats. Remaining beach boats equipped with motorised capstans.
1960-1970	Beach boats disappear. Typical boat size 10-12m.
1970-1980	Plastic traps introduced. 300 traps in strings of up to 30 used. Inshore Potting Agreement (IPA) established 1978.
1980-1990	More traps operated from each boat. Seasonal movement of traps within static gear only zones abandoned mid 1980s.
post-1990	Typical boat size 10-15m. Pot-locks and rubber skirts introduced early 1990s. Up to 1600 traps operated from each boat, though average 6-700. Traps used in strings of 40-80.

Table 2: Area of the IPA and static gear zones 1978-1993.

	1978	1982	1984	1993
Total IPA Area (km^2)	527.3	470.7	479.9	478.4
Static Gear Only Zones (km^2)	291.0	330.7	357.1	349.7
Seasonal Static Gear Zones [Area x % of year] (km^2y^{-1})	135.7	113.6	90.0	73.2
Total Static Gear Area [Static Only + Seasonal] (km^2y^{-1})	426.7	444.2	447.0	422.9

Table 3: General function of the IPA. Absence of a remark indicates either no strong opinion expressed or no comment.

Gear Type	Area	Person	Generations of fishers in family	The IPA Is a Good System	The IPA Is Not Good Enough	The IPA Has No Personal Benefit
Static	Interior	1	4+	Agree	Agree	Agree
		2	1	Agree		
		3	3+	Agree	Agree	
		4	3+	Agree	Agree	
	Edge	5	2	Agree	Agree	
		6	1	Disagree		Agree
		7	1	Agree		
		8	3+	Agree	Agree	
		9	No data	Agree	Agree	Agree
	Committee	10	1	Agree	Agree	
Towed	Inshore	11	1	Agree		
		12	1	Agree		Agree
		13	1	Agree		
		14	1	Disagree		
		15	No data	Disagree		
	Committee	16	No data			
		17	No data	Agree		

Table 4: Benefits of the IPA to fishers. Absence of a remark indicates either no strong opinion expressed or no comment.

Gear Type	Area	Person	The IPA Provides Trap Protection	The IPA Provides Trawl Protection	The IPA Protects Benthic Habitats	The IPA Acts as a Reserve for Target Species
Static	Interior	1	Agree	Agree	Agree	Agree
		2	Agree		Agree	Agree
		3	Agree			Agree
		4	Agree		Agree	Agree
	Edge	5	Agree		Agree	Agree
		6				
		7	Agree		Agree	Agree
		8	Agree			Agree
		9	Agree		Agree	Agree
	Committee	10	Agree	Agree	Agree	Agree
Towed	Inshore	11			Agree	Agree
		12	Agree	Disagree	Disagree	Agree
		13	Agree	Disagree		Agree
		14		Disagree	Disagree	Agree
		15		Disagree	Disagree	
	Committee	16	Agree	Disagree	Disagree	Agree
		17	Agree	Disagree		Agree

Table 5: Interactions between fishers of the same sector. Absence of a remark indicates either no strong opinion expressed or no comment.

Gear Type	Area	Person	Have Had Conflict Within Own Sector	Our Sector Break IPA 'Rules'
Static	Interior	1	Agree	
		2	Agree	
		3	Agree	
		4		
	Edge	5	Agree	Agree
		6	Agree	
		7	Agree	
		8	Agree	Agree
		9	Agree	Agree
	Committee	10	N/a	
Towed	Inshore	11		Agree
		12	Agree	Agree
		13		Agree
		14	Agree	Agree
		15		Agree
	Committee	16	N/a	Agree
		17	N/a	Agree

Table 6: Interactions between fishers of different sectors. Absence of a remark indicates either no strong opinion expressed or no comment.

Gear Type	Fishing Area	Person	Other Sector Violate the IPA	Cooperate with the other sector	Have had Inter Sector Conflict	Worst sector
Static	Interior	1				
		2			Agree	Scallops
		3	Agree		Agree	Scallops
		4	Agree			Scallops
	Edge	5	Agree		Agree	
		6	Agree	Agree	Agree	Angling
		7		Agree	Agree	Scallops
		8	Agree		Agree	Scallops
		9		Agree	Agree	
	Committee	10	Agree	Agree		
Towed	Inshore	11		Agree		
		12	Agree	Agree	Agree	Scallops
		13	Agree	Agree	Agree	
		14	Agree	Agree		
		15				
	Committee	16	Agree			
		17	Agree		Agree	

Table 7: How can the IPA be improved? Absence of a remark indicates either no strong opinion expressed or no comment.

Gear Type	Area	Person	Should Give Static Gear Fishers More Ground	Should Limit Static Gear Fishers to Traps Only	Should Put in Corridors or Seasonal Areas	Should Legalise the IPA
Static	Interior	1	Agree	Agree		
		2		Disagree		Agree
		3				Agree
		4				Agree
	Edge	5		Agree		Agree
		6				
		7			Agree	Agree
		8		Agree		
		9		Agree		
	Committee	10		Disagree	Agree	Agree
Towed	Inshore	11				Disagree
		12	Disagree	Agree	Agree	Disagree
		13	Disagree	Agree		Disagree
		14	Disagree	Agree	Agree	Disagree
		15	Disagree	Agree	Agree	Disagree
	Committee	16	Disagree	Agree	Agree	
		17		Agree	Agree	Agree

INTEGRATING SCIENTIFIC AND LOCAL ECOLOGICAL KNOWLEDGE (LEK) IN STUDIES OF COMMON EIDERS IN SOUTHERN LABRADOR, CANADA

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ABSTRACT

Research on the history and status of Eider Ducks in Labrador and Newfoundland is needed. These ducks are an important part of the subsistence and traditional diet of coastal Labradorians. Two subspecies of Common Eider, a northern one (*Somateria mollissima borealis*) and a southern one (*S. m. dresseri*), occur in southeastern Labrador. Little is known about the non-breeding behavioural ecology and abundance of these subspecies. By working with hunters [by means of Local Ecological Knowledge (LEK) interviews and collecting duck heads], analyzing existing scientific data and collecting new scientific data, we are assessing the seasonal occurrences and distributions of these subspecies in southeastern Labrador. LEK data is also used to reconstruct the history of shifts in and intensity of local hunting and egg-harvesting pressures on the eiders in St. Peter's Bay, Labrador. We hypothesize that with the decline in the commercial cod and salmon fisheries in St. Peter's Bay and as a result of technological innovation, harvesting pressure has shifted from the nesting population (*Somateria mollissima dresseri)* to the wintering population (*S. m. borealis)* in this area. The history of local hunting pressures and technological and fisheries changes are explored.

INTRODUCTION

This project is being carried out under the auspices of a national interdisciplinary research program, Coasts Under Stress (CUS). CUS is a 5-year Major Collaborative Research Initiative, funded by SSHRC (Social Sciences and Humanities Research Council) and NSERC (Natural Science and Engineering Research Council). CUS study areas are in coastal communities in Newfoundland and Labrador and British Columbia. A major goal of CUS is to reconstruct ecosystem change by identifying how changes in the environment and society have affected human, community and environmental health. In order to do this, Local Ecological Knowledge (LEK) is collected and documented and combined with information collected using more 'traditional' natural and social science methods. The LEK referred to in this paper is hunters' LEK. When they hunt in the same areas for years, and sometimes generations, hunters acquire detailed knowledge of their environments, local resources and local hunting practices. This knowledge has a relatively large temporal and a small spatial scale (Fisher 2000).

Obtaining good quality LEK to combine with science depends on the systematic collection of qualitative data from a reasonably large sample of experienced or "expert" hunters. Because most existing scientific data tends to be collected at larger spatial scales and shorter time scales than those that inform LEK, it is wise to combine LEK with linked scientific research. When scientific research is linked to what harvesters know and have experience about, both scientists and harvesters can share their expertise. This sharing of information produces a more comprehensive research design, potentially improved data collection and contributes to a better understanding of natural processes and human interactions with nature. In a study on the harvesting of lobster populations Gendron et al. (2000) concluded, "the incorporation of the information given to us by fishers increased the credibility of the scientific conclusions concerning the harvesting of lobster populations."

In our study, we integrate LEK about Common Eiders from hunters in southern Labrador and scientific research to examine:

1. Seasonal distributions of two subspecies of Common Eider.
2. Decadal level changes in spatial distributions and abundance of these two subspecies.
3. Changes in human impacts on eiders.

This research is being carried out on the southern coast of Labrador with an emphasis on St. Peters Bay. This bay was established as a federal migratory bird reserve in 1949 at the request of the Newfoundland government to protect the eiders that were breeding there. According to records obtained from the Battle Harbour Regional Development Association, Dr. Les Tuck visited the area in June 1950 and

reported very few nesting eiders. In 1959 after having no increase in colony size reported by local sources, Tuck suggested the sanctuary status be cancelled, as it was serving no useful purpose. This cancellation however was deferred for several years because St. Peters Bay was the only federal migratory bird reserve in Newfoundland and Labrador at that time. In 1980, after an assessment by the Canadian Wildlife Service that found fewer than 40 nests during an incomplete survey, the decision to cancel the reserve status was implemented.

The Common Eider

The Common Eider, *Somateria mollissima,* has been traditionally used as a local source of meat, eggs and feathers by coastal Labradorians. Two primary subspecies of Common Eider occur in Labrador - a southern Eider (subspecies *dresseri*) that mostly breeds in southern Labrador, Quebec, Newfoundland, the Maritime Provinces and Maine, and a northern Eider (subspeceis *borealis*) that breeds in northern Labrador and Arctic Canada and over-winters in southern Labrador and Newfoundland.

The two subspecies are very similar. The main distinguishing characteristic is the shape of their bills. The size of the eider and color of plumage are harder to use as distinguishing characteristics, however, the southern eider usually has a slightly bigger head and greenish plumage under the eye whereas the northern eider does not (Figure 1).

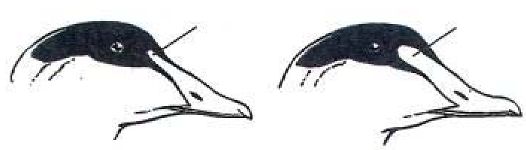

Figure 1. The northern eider, (*S. m. borealis*, left) has a bill that elongates into a narrow point at its base and the southern eider, (*S. m. dresseri*, right) has a bill that is more rounded at the base (from Peters and Burleigh, 1951).

Questions

The central questions in this research are:
1. Have local hunters living on the south coast of Labrador developed valuable LEK about eiders?
2. Can this LEK be collected in a systematic fashion and combined with scientific data?
3. Have distributions and population sizes of the nesting and over-wintering eiders changed over time?
4. Are these changes related to shifts in local human pressure?

METHODS

Collecting LEK in a Systematic Fashion

In order to collect LEK in a systematic fashion a protocol has to be followed. The main tool used to collect LEK in this study is a semi-structured in depth interview schedule with a map component. Before the interviewing process began, the section of the project involving human participants had to be approved by the Interdisciplinary Committee on Ethics in Human Research (ICEHR) at Memorial University of Newfoundland. Consent forms that described the risks and benefits of being interviewed, confidentiality agreements and semi-structured interview schedules, were submitted to the ICEHR. This committee approved these documents and then the process of selecting interviewees began.

The first interviews were conducted in December 2000 in Mary's Harbour, Fox Harbour, Port Hope Simpson, Charlottetown and Cartwright (Figure 2). These were background interviews conducted to support several CUS projects. Information on local terms for various birds and fish and information on local observations of these different species as well as local uses for them were gathered. These interviews were conducted to help us design our interview schedule, to ensure we used appropriate terms in our interview, and to identify the hunters in these communities. The people who were selected for these interviews were all retired fishermen.

A second set of interviews, which concentrated on hunters, was conducted from May to August 2001 in Forteau, Red Bay, Lodge Bay, Mary's Harbour and Fox Harbour (Figure 2). A method called snowball sampling was used to select experienced hunters living in the area who had hunted in St. Peters Bay. Using the sampling method of snowballing local leaders in the community were asked to identify experienced hunters in the area and then these experienced hunters were asked to provide additional names of others whom they thought would be appropriate to interview. Thus, those interviewed were among the most experienced Eider hunters in their communities with the

best knowledge of the history of hunting and Eider behaviour and distributions in St. Peter's Bay. Neis et al. (1999), used snowball sampling to identify local fisher "experts". By using snowball sampling the people who have the most knowledge of the topic in question are interviewed.

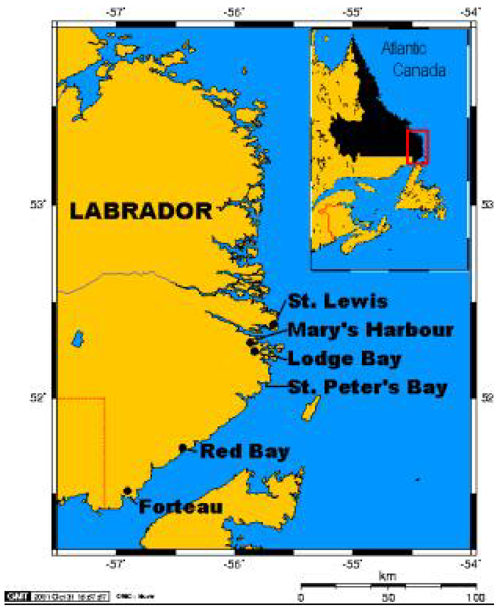

Figure 2. Study area on the south Labrador coast.

Conducting Interviews

At the beginning of an interview the hunters signed a consent form, which they read or had read to them. They also filled out an archival deposit form that enabled them to decide what they wanted to be done with the transcripts, maps and cassette tapes that were used to record the information in their interview. Interviewees were given a choice whether to be taped or not. They also had the option to decline to answer a question or stop the interview at any time. The semi-structured interview schedule provided hunters with a chance to elaborate on questions and introduce information if they desired. In this way the interview was guided by the interviewer but had the freedom to add information they believed was relevant and important as well as answering the questions being asked. Each interview included approximately 100 questions and lasted an average of 1.5 hours. The subject areas included asking hunters for information on the abundance of eiders in St. Peter's Bay, the location of breeding areas, over-wintering distributions and migration patterns. They were also asked to describe changes in these factors and changes in their hunting practices over their careers as hunters. They were asked if these changes in their hunting practices might have affected the breeding and over-wintering populations of eiders. Hunters' opinions of hunting regulations, conservation and about the establishment, disestablishment and possible reestablishment of a federal migratory bird sanctuary in St. Peters Bay were sought as was hunter awareness of Eider subspecies' morphological and behavioural differences.

Information that could be mapped such as the hunters' boat routes when hunting, the most popular hunting locations, eider migration routes, nesting locations, brood rearing areas and wintering distributions were recorded on a 1:60,000 (L/C 5030) nautical chart that covered the area from Battle Harbour south to Green Bay (Figure 3). Hunters used different colors to map different things on the chart. Aqua was used for the boat route while hunting, brown for the best hunting areas, red for migration routes of the eiders, blue for nesting areas, orange for eider brood rearing (or crèching) areas, and purple for wintering locations. Hunters were shown pictures and mounted heads of the two subspecies to demonstrate the difference between the shapes of bills of the southern and northern subspecies of Common Eider that breed and over-winter in Labrador and Newfoundland.

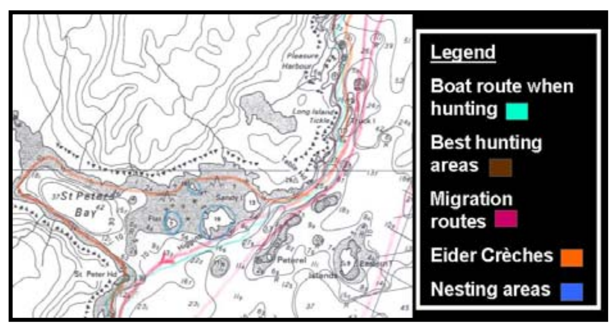

Figure 3. Scanned image of a chart that was used to record hunters' local ecological knowledge.

Interviewees

In the initial set of background interviews that was conducted in December 2000, interviewees' ages ranged from men in their 40s to their 80s. Most of these fishers were retired. In the second set of detailed species-specific interviews that were conducted in May to August 2001, interviewees' ages ranged between 27 and 84 (Figure 4). The majority of hunters were between 40 and 60. All of the hunters had been hunting for at least 12 years in the St. Peters Bay area and 50% of them had hunted for 30 years or more

in this area. All hunters had been hunting since they were around 14 years old. A majority of the hunters were fishers. Twenty-eight percent of hunters were current fishers and 39% of hunters were former fishers.

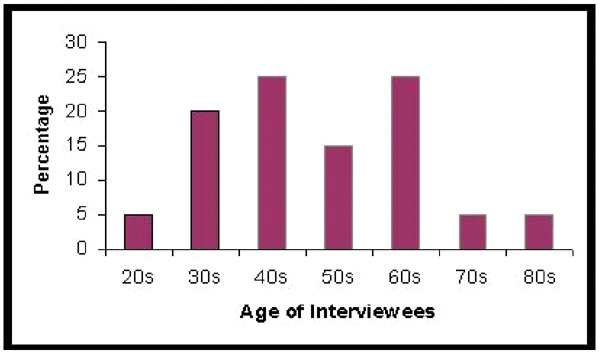

Figure 4. Age range of 20 interviewees

Eider Head Collection

Eider heads were collected from hunters in winters of 2001 and 2002 to determine the ratio of hunted southern to northern Common Eider subspecies during the over-wintering season in various places along the southern Labrador coast.

Surveys for Common Eiders

Estimates of the current nesting population of Common Eider in St. Peter's Bay (52°04' / 55°46'), Labrador, were made on the basis of systematic surveys that commenced on 29 May 2001. Prior to this, pack ice prevented boats from traveling along the coast and into St. Peter's Bay.

Surveys were divided into two time periods: 29 May to 12 June 2001 (pre-hatching) and 19 July to 4 August 2001 (post-hatching). Each survey was conducted from a 20-foot open boat that completely circumnavigated the islands in St. Peters Bay. The "inside" islands, Harbour, Higgins, Black and Goose Islands, were surveyed sequentially (Figure 5). On clear days when the wind was less than 20 knots (29 May, 11 and 12 June), the survey would continue to the "outside" islands, Double, Western, Eastern, Rock in the Run and Peterel Islands, that were surveyed sequentially (Figure 5). All islands were surveyed within 18 to 20 m of the shore at a speed of about 10 km/hr. When the tide was low the survey was carried out farther from the shore, the furthest distance being about 30 m, and at a slower speed of 3-5 km/hr because of dangerous shoals. This distance was still close enough to count birds.

St. Peter's Bay has many shoals, and weather conditions had to be very good to do a complete survey around all the islands in a single day. When winds increased to about 20 knots/hr the survey would be discontinued because it was not safe. St. Peter's Bay is also a very foggy place. On some days fog had lifted by late morning and on other days St. Peter's Bay was blanketed in thick fog for the entire day. On these days it was impossible to conduct research.

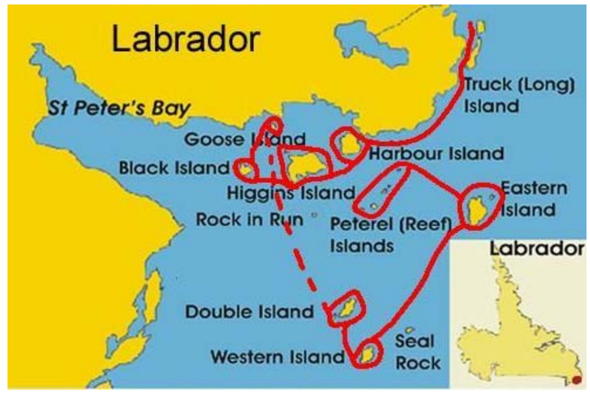

Figure 5. Survey route around islands in St. Peters Bay.

Pre-hatching population surveys

The objective of the first surveys in St. Peter's Bay was to conduct a Common Eider breeding male census in order to estimate the total breeding population in St. Peter's Bay. Five breeding male surveys were conducted on 29, 30 May, 5, 11 and 12 June 2001. Parameters measured on the first three surveys were: total number of male breeding eiders observed, their locations, time of day and weather. During the last two surveys the total number of adult males, juvenile males and pairs was also recorded.

Post-hatching population surveys

To determine how much of the breeding population and how many broods were still around by mid July to early August, and to determine how Eider broods occupy different areas and habitats, population surveys were conducted around the islands and along the shoreline of St. Peter's Bay. Surveys took place from 19 July to 4 August 2001. Parameters measured included: total number of birds, number of broods, brood sizes, ratio of ducklings: adult females, species (subspecies if possible), sex, activity, location, time of day and weather. Survey routes were the same as those carried out in May and June.

Subspecies Discrimination

Observations to determine subspecies were carried out in St. Peter's Bay to help determine the ratio of southern to northern Common Eider subspecies during the breeding season. On 5 June 2001, a 2-hour observation based on visual discrimination between subspecies was conducted on Higgins Island. When eiders came within 80 m on land or while swimming, the shape of their bill could be discriminated and birds could be identified to the subspecies level. On 10, 11, and 12 June 2001, observations to discriminate subspecies were conducted from the boat survey when eiders flew by within 5 to 10 m.

Pre-Hatch Nest Surveys

To compliment breeding male survey data and nest counts that were collected in St. Peter's Bay during June 1999 (K. Chaulk, CWS, unpublished data) nest surveys were conducted on 11 and 12 June 2001 on Long (Small), Long (Big), Higgins, Goose (Small) and Goose (Big) Islands. The number of eider nests on each island and the number of eggs in each nest were counted. The survey was conducted by a survey crew of 3 to 4 people who were evenly spaced along a survey line that ranged in length from 50 – 300 m. Surveyors would zig-zag back and forth making sure all suitable nesting areas were inspected. The survey line would traverse back and forth over the island until the entire surface was covered.

The age of some embryos inside the egg was determined using a technique called 'candling' (Resource Inventory Committee 1997). By holding the eider egg up to the sun and looking through a cardboard tube at the embryo the age of the embryo was estimated. When the relative ages of the eggs in the nest were determined hatching date was predicted.

Post-Hatch Nest Counts

A post-hatch nest survey, which could not be conducted in June, was completed on Black Island on 21 July, 2001. The procedure was the same as the previous nest surveys.

Brood Surveys

Brood surveys were conducted on 20, 28, 29 and 30 July 2001, in order to help determine the distribution of eider broods that left St. Peter's Bay soon after they hatched. The coastline, including all coves and bays from St. Peters Bay to Henley Harbour, was surveyed for Common Eider broods (Figure 6). Data collected included total number of birds, number of broods, brood sizes, ratio of ducklings/adult females, activity, time of day and weather. Their location was mapped and the size of the ducklings relative to the adult hens that were with them was estimated.

Figure 6. Eider brood survey route, from St. Peters Bay to Henley Harbour.

Results and Discussion

Seasonal Distribution of Subspecies

When hunters were shown heads of the two different subspecies of Common Eider, *dresseri* (southern) and *borealis* (northern), most hunters could remember seeing eiders with different shaped bills but did not realize they were different subspecies. Some hunters had noticed the differences in size and shape of the bills but thought that these differences were due to age: *borealis* with the smaller, more pointy bill being a young eider and *dresseri*, with the larger more rounded bill, being an old eider.

Hunters recognized *dresseri* to be the most common eider during the breeding season. After having being shown a *dresseri* head one hunter said:

> "*I can identify the green with the birds, yep, in the spring of the year we'd see them.*"

Nesting eiders in St. Peter's Bay on the south coast of Labrador were visually observed to be 97% *dresseri*. A majority of *dresseri* nesting

in this area is consistent with records in previous scientific documents.

Most hunters noted that *borealis* were the eiders they would see mostly during over-wintering. After having being shown a *borealis* head one hunter said:

> *" Usually this is the one you would see mostly staying around in the winter time".*

Over-wintering Eiders (borealis)

Eiders occur on the south Labrador coast throughout winter. These over-wintering populations have been hunted intensively for decades. Individual hunters, however, report taking fewer per year now than 40 and even 20 years ago. Some hunters noted that over-wintering populations have declined and/or changed location. One hunter said:

> *"In winter there's still some around but its not like it used to be."*

Some hunters speculated that the decline and/or changed location in the over-wintering population is most likely due to the use of speed boats and semi-automatic rifles to hunt eiders. One hunter remarked:

> *"After speedboats came around it didn't seem like there were as many birds. The boats kept them drove out."*

Most hunters noted that the location of eiders in the winter has not changed at least in the past 20 years. The eiders still frequent the same places, along the shoreline, bays, coves and islands. Where the eiders can be found on a particular day however, has much to do with the weather and the ice.

Nesting Eiders (dresseri)

Hunters mapped the locations of nesting eiders between Cape St. Lewis and Bad Bay. They noted that during the late 1990s, new nesting sites were established between Bad Bay and Henley Harbour, where nesting sites had not been observed previously. Some hunters said that eiders nested on all islands in St. Peters Bay. Other hunters said that only some of the islands have nesting eiders on them. Most hunters said that Black, Higgins, Double and Western Islands have nests on them (Figure 7).

Eider nesting surveys indicate that nesting eider numbers have been increasing recently in St. Peter's Bay. Nest counts conducted in 2001 were compared with previous ones carried out by the Canadian Wildlife Service (CWS) in 1999. Five islands in St. Peter's Bay that were surveyed in 1999 were re-surveyed in 2001. Two of these islands had no nests in 1999 and in 2001. The other three islands showed an increase in nests (Figure 8).

During the summer cod fishery, before 1992, eiders were hunted during summer. Fishers would be at their summer homes on the headlands and some would take the opportunity to hunt. Hunters who did kill eiders during the summer in the past say that during the last 10 years regulations have been enforced more and the consequences of getting caught poaching are so great that they do not want to take the risk. Some hunters report that eggs are harvested but this practice has diminished greatly over the last 30 years.

Reduced human pressure could give these birds a chance to recover. As one hunter noted:

> *"There are more pairs of ducks now than there were 25 years ago."*

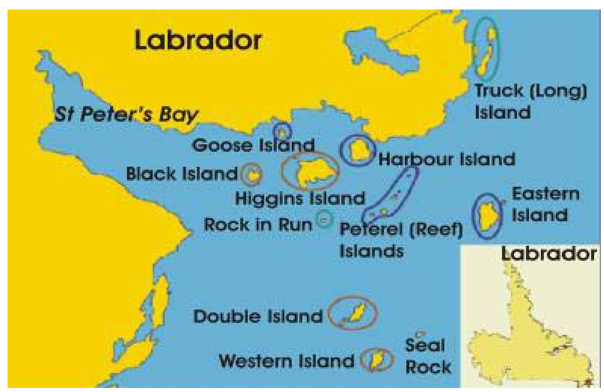

Figure 7. Eider nesting islands in St. Peters Bay

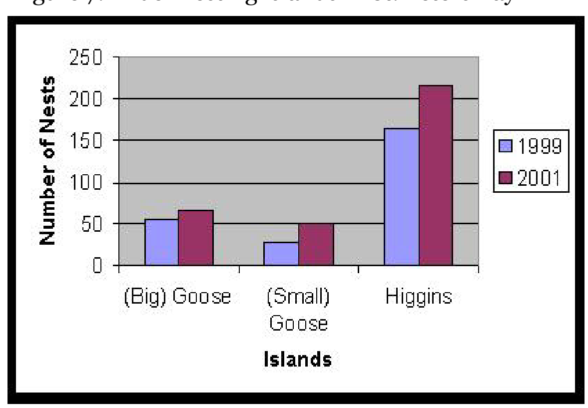

Figure 8. Nest counts for three islands in St. Peters Bay during 1999 and 2001.

Migraton and Movements

While mapping movement patterns, hunters noted that during fall migration most eiders flew south in November. During spring migration, the greatest number flew north between 1 and 15 May. During fieldwork commencing 18 May 2001, it was observed that all nesting eiders appeared to have already arrived. Hunters reported that during the last 10 years, fewer eiders have been observed migrating in fall than during spring. Most hunters reported that spring and fall migrants are now flying further from the land.

Conservation

Most hunters agreed that eiders need more protection, including enforcement during the breeding season. There were many differences of opinion, however, as to whether St. Peters Bay should be re-established as a migratory bird reserve. Most hunters thought the seasons and bag limits were sufficient as long as people obeyed them. One hunter noted,

"Y*ou wouldn't want the season opened earlier because you would like to see the older birds fly back*."

CONCLUSIONS

Local Ecological Knowledge (LEK) collected and analyzed in a systematic fashion can be a key tool in biological studies. Where it exists, it can be of great benefit to both researcher and harvester to work together to share information so that a more complete understanding of nature is achieved. In our study, we have shown that scientific data and LEK point to local changes in Scientific evidence and LEK suggest that breeding populations in St. Peter's Bay have increased in recent years, and harvester observations suggesting that nests are located in areas uninhabited at least since the 1950s indicate that this population may be at a 50-year peak. The reduced egging and hunting during the breeding season could be contributing to the growth of the eider breeding population (southern subspecies, *dresseri*). Overall, during the period 1960-2000, there appears to have been a marked shift in hunting mortality on breeding to wintering eider populations, and hence from southern (*dresseri*) to northern (*borealis*) subspecies.

ACKNOWLEDGEMENTS

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REFERENCES

Fischer, J. 2000. Participatory research in ecological fieldwork: a Nicaraguan study, in, B. Neis, L. Felt, eds., *Finding Our Sea Legs: Linking Fishery People and Their Knowledge with Science and Management*. ISER Books, Memorial University of Newfoundland. St. John's. 41-54.

Gendron, L., R. Camirand and J. Archambault 2000. Knowledge-sharing between fishers and scientists: towards a better understanding of the status of lobster stocks in the Magdalen Islands, in, B. Neis, L. Felt, eds., *Finding Our Sea Legs: Linking Fishery People and Their Knowledge with Science and Management*. ISER Books, Memorial University of Newfoundland. St. John's. 56-71.

Neis, B., D.C. Schneider, L. Felt, R.L. Haedrich, J. Fischer and J.A. Hutchings 1999. Fisheries assessment: what can be learned from interviewing resource users? Canadian Journal of Fisheries and Aquatic Sciences 56, 1949-1963.

Peters, H.S. and Burleigh, T.D. 1951. The Birds of Newfoundland. Department of Natural Resources. St. John's. Resource Inventory Committee Publications, 1997. Live Animal Capture and Handling Guidelines for Wild Mammals, birds, Amphibians and Reptiles. Copyright © 1997 Province of British Columbia. Html created March 1998.

HOW FISHERS' ENDEAVORS AND INFORMATION HELP IN MANAGING THE FISHERIES RESOURCES OF THE SUNDARBAN MANGROVE FOREST OF BANGLADESH

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ABSTRACT

The aquatic resources of the Sundarban Mangrove Forest (SMF) are an important component of its biodiversity and are an important source of food and income for human populations. The SMF is the biggest mangrove forest in the world and covers an area of 6,017 km^2. Over 200 species of fish identified in the SMF are harvested by between 110,000 and 291,000 fishermen using approximately 25,000 registered small fishing boats. The water body inside the SMF, i.e. inshore fishing area, covers an area of 1,874 km^2 , and the estimated annual production of finfish and crustaceans is about 3,054 t, equivalent to a yield of 16.3 kg/ha. In addition, about 215 million tiger shrimp fry (Post Larvae-PL) are caught to supply shrimp farms. The Sundarbans also includes a 20 km wide marine zone, i.e. offshore fishing area, which covers 1,603 km^2. A seasonal winter fishery of Dubla Island operates in this zone, consisting of about 30,000 fishermen and associated people. The annual production of the marine zone is estimated at 8,733 metric tonnes, or 54.5 kg/ha. Apart from the obvious structural complexity of this fishing area, the fishing area is strongly influenced by climate: fishing in the offshore area is very hazardous from May to August due to severe weather conditions.

There are 14 different fishing methods and gears used by the fisherman inside the Sundarbans. These may be clustered into three major groups based on target species and fishing gear. Shrimp fry fishing in particular is considered to be very destructive. This paper attempts to describe fishing practices and issues arising in the SMF and adjacent 20 km marine zone of the Bay of Bengal. Bycatch of turtles is a significant issue and 90% die in the net. Large sharks of 200-240 kg. are sometimes caught, sawfish and rays are also frequently caught in the fishers' net. Molluscs may be of some ecological importance for converting mangrove leaf litter into detritus. Hence, over-harvesting of molluscs may undermine the trophic pyramid. The use of Sundri and other trees as stakes and anchors by the fishers damages the forest. Regulation of fishing methods, mesh size, and participation of fishers in the current fisheries management systems is essential for sustainable fisheries development in the Sundarban Mangrove Forest.

INTRODUCTION

The Sundarban Mangrove Forest (SMF) contains the most diverse and rich natural resources of Bangladesh. It is located at the great delta of the Ganges, Brahmaputra and Meghna rivers at the edge of Bay of Bengal, and constitutes the largest contiguous single-tract mangrove ecosystem in the world (Figure 1, Appendix 1). This forest is also an important nursery and breeding ground for many species of shrimp, crab and finfish, and provides habitat for diverse aquatic wildlife e.g.: Estuarine crocodile (*Crocodylus porosus*), Turtles (*Lepidochelys olevacea*), Dolphins (*Platanista gangetica* and *Peponocephala electra*), and molluscs like the Giant oyster (*Crassostrea gigas*) etc.

The SMF covers 6,017 Km^{-2}, of which 1,874 Km^{-2} or 31% is comprised of waterbodies, lakes, rivers, canals and creeks. The Sundarbans include a 20km wide Marine Zone in the Bay of Bengal, which covers an additional 1,603 Km^{-2}. The hydrology of Sundarban mangrove forests is influenced by the tides in the Bay of Bengal.

Over 200 species of fish identified in this forest are harvested by 110,000 to 291,000 fishers using approximately 25,000 small and motorized boats. The Sundarban Mangrove Forest fishery has been managed by the Bangladesh Forest Department since 1897. Fisheries management is limited to issuing permits for economic reasons, regulations for conservation reasons. Conservation science is almost totally lacking. Research on aquatic fauna, finfish, and fisheries is sporadic at best.

THE FISHERS AND THEIR GEAR

There are 14 different fishing methods and gears used by the fisherman in and around Sundarban. These are grouped as:

Single species-single gear fisheries

A single primary type of fishing gear takes most of the total catch of a single target species. Other gears take only small quantities of the target species. Bycatch of other species by primary gears tends to be minor. Examples include the gillnet fishery for hilsha (*Tenualosa ilisha*), longlines for mud crab, longlines for prawns, and pull, push and set bagnets for shrimp post larvae and oyster fisheries.

Single species-multi gear fisheries
A particular gear generally targets a single species, but significant quantities of these target species are also taken by other gear. Examples include gillnet fisheries for fatty cat fish and sea bass.

Multi species-Single gear fisheries
Single gears tend to be nonselective, and take many species, e.g. set bagnet, cast net, long line, gill net, shore net, canal gill net, shore seine, otter fisheries etc. Fishing gears fall into 4 classes on the basis of whether they are used in the inshore or offshore fishery and the group of fish or crustaceans they are used to capture.

Class-A: Used in the inshore fishery to catch adult fish and crustaceans. The estimated total catch from these gears in 2000 was 3,038 t. The gears are as follows: (1) Gillnets (2) Cast nets (3) Canal gill nets (4) Shore nets (5) Long line (6) Crab long line (7) Angling rod (8) Otter gill net (9) Otter lift nets etc.

Class-B: Used in the offshore fishery for adult fish and crustaceans. The estimated total catch from these gears in 2000 was 8,710 t. The gears are as follows: (1) Set bagnets (2) Beach seine nets (3) Gillnets etc.

Class-C: Used in the inshore fishery to catch crustacean larvae. The estimated total catch for these gears in 2000 was about 215 million. The gears are: (1) Fine meshed pull nets (2) Fine meshed push nets and (3) Fine meshed set bagnets etc.

Class D: Besides, without using gear, some Sundarban fisher used to collect live and dead molluscs shell by hand from the forest floor and giant oyster from the colonies in the mud. Types, number of gears, number of fishers, and boats in Sundarban are shown in Table 1 (Appendix 1).

How Fishers' Information Helps in Managing the Fishery

A new era for fisheries management dawned in 1999 with the launch of the Sundarban Biodiversity Conservation Project. A new Aquatic Resources Division was formed to deal with the conservation of aquatic biodiversity and sustainable development of fisheries resources within the Sundarban Mangrove Forest.

Under this program, fishery research and stock assessment has been started in the SMF. Fishers are being interviewed and asked to provide information on the status problems and prospects of their fisheries. A lot of information and issues have come up and are being taken into consideration for fisheries management. The fishery information and issues that came out are as follows:

1. The offshore set bagnet fishery often catches turtles *(Lepidochelys olevacea)* which are not desired. Turtles are slow swimmers and can be passively swept into nets by the tide. They cannot find their way out and 90% of them drown and die in the net. The remaining 10% are sometimes returned to the water alive. Two to four species of large sharks of 100-240kgs, and big sawfishes are sometimes caught in the set bagnet as bycatch. Stingrays are frequently caught.

2. During the interview, one complete set of articulated jaws of a large shark was received from a fisher, who reported it as having a large head, 100 kg of weight and about 3m in length. The appearance of the jaw and the fisher's description indicates a rare species of the genus *Glyphis* of Sundarban.

3. Fatty catfish (*Pangasius pangasius*) are very famous for their taste and can fetch much money. However, they are now rarely caught, so fishers who used to target them are now switching to other fisheries for their subsistence.

4. Onboard and port storage facilities are poor due to the lack of ice in the fishing area. Set bagnet fishers land daily at Dubla fish drying yard after 12-16 hours of fishing. As a result, most catches start to rot unsorted. Fishers must therefore dry the fish rather than selling it fresh. The quality of the final product is generally low, and fresh fish gives more cash income for the fishers and more revenue for the forest department. So there is a loss of production and revenue.

5. Dubla fisherman hut is famous in the Sundarban offshore fishery and consists of about 11 fishing and fish landing centres. Fishers from some of these centres catch large quantities of small shrimp by small meshed set bagnet. But this is not very lucrative as prices are poor for small shrimp.

6. Offshore set bagnet fishers catch a lot of juveniles, sub-adults, small shrimps and fish, which is destructive to recruitment and the food chains. This catch does not provide much opportunity for added value after processing.

7. Some fishers use long gill and seine nets of 1.5-2.5 inch stretch mesh in the marine zone between November and early April, when it is easy to catch large number of juvenile hilsha. As a result, hilsha stocks have been depleted abnormally in the rainy season during recent years. Hilsha fishers and fish traders are suffering as a result and thinking of switching over to other fisheries.

8. Shore seine and canal gillnet fisheries in the inshore area can block long area of shore and the mouths of small canals. These gears are capable of catching virtually all fish (juvenile / adults and small fishes) present, resulting in overfishing and depletion of fish stocks in recent years.

9. During September to December, when rainfall is over and tides are lower, some very dishonest fishers illegally use poison in the small canals at low tide to catch almost all kinds and size of species, causing pollution and depletion of fish stocks.

10. Set bagnets and pull and push nets for shrimp post larvae in the inshore area, rivers and canals, also catch enormous numbers of eggs, larvae and fry of many fishes, shrimps, prawn, crabs, and molluscs. Thus, the shrimp fry collection fishery has a high bycatch mortality causing heavy depletion of all kind of fish stocks. Genuine and commercial fishers want to halt the shrimp post larvae fishery to allow fish stocks to recover.

11. Snails, clams and giant oyster are of ecological importance for converting mangrove leaf litter into detritus. Excessive collection for lime, shrimp feed and chicken feed, damages the trophic pyramid of the ecosystem.

12. Local fishers for inshore and offshore fishery using enormous Sundri (*Heretiera fomes*) timber as pole to anchor the net and the boat to the sea and river bed and using enormous Goran (*Ceriops decadra*) and Gewa (*Excoecaria agalocha)* sticks to act as fish drying racks and Nypa leaf for thatching the fishers boats for sleeping and fish drying sheds put additional pressure on forest resources.

Discussion and Recommendation

The bycatch of turtles in set bagnets seems to be of great concern for the conservation of aquatic bio-diversity. Nobody eats turtle meat, or uses any parts of a turtle in this region. The introduction of turtle exclusion devices may address this problem, but needs a lot of trial, training and motivation. Present fishery management will look into developing and implementing turtle bycatch mitigation.

We were fortunate to able to contact Dr. Leonard J.V. Compagno, a leading shark taxonomist of the Shark Research Center, South African Museum, who has been able to examine Glyphis type material. The findings to date are very preliminary and leave many questions unanswered about the taxonomic status and biology of these rare animals. More observations and research will be conducted in future in this regard.

Fatty catfish (*Pangasius pangasius*) in Sundarban have been severely overfished due to their excellent flavour and high value. As a result, they were listed as critically endangered in the 2000 IUCN red list. People are highly motivated to restore stocks and a minimum 5-year ban on by gillnet and long line fisheries is under consideration.

Some traditional artisanal fishers in the Dubla area catch small shrimp *Metapaneus brevicornis, Parapenaeus stylifera, Acetes indicus* and *Nematopalaemon tenuipes* by small meshed set bagnet. Only 10% is sold fresh, the remaining 90% is sun dried for making poultry feed. There is a high bycatch of juveniles of other finfish species. These small shrimps are also an important food for other fishes. The closure of three fishing and landing centers is under consideration to protect juveniles and improve the stock of the food for other fishes.

There is considerable scope for enhancement of the production and value of the catch from the Dubla offshore fishery by improved handling and processing. This would require a number of changes in current fishing practices. The aim is to improve handling and transporting a large part of the catch as fresh, high quality, fish to either processing factories or the consumer market, leading to increased production, higher prices and additional employment. The main products for processing are the shrimps and high value table fish: groupers, croakers, snappers, sea bass, pomfret, Grunts, Indian salmon and the like. These can be deep frozen, packed, and exported. Other alternatives to sun drying Dubla fish species include exportable products such as Sashimi, fish fingers, and fish balls from Ribbonfish and paste and filets from Anchovy. This additional product for export would have

the following advantages: higher price, less drying area required, less wood needed, more income and employment through an extended processing plant operating seasons. With this in mind, new initiatives for motivation and negotiation among fish processing plant owners and fishers are being considered. Facilities for ice in Dubla and improved fish processing methods will be developed under the present management systems.

Sharks, sawfish and stingrays are not commonly used in the community other than their jaws, saw blade and tail, which are used as show items. The meat is used by some Indigenous people, but fetches an extremely low price. Measures planned to protect biodiversity include introduction of different devices or techniques in the net to avoid these species with fishers' participation in training and trials.

Offshore set bagnet fishers should be forced to refrain from catching juveniles, sub-adults, small shrimps and fish to improve recruitment and availability of food for other fishes. A bag end mesh size of at least 2.5 to 3.0 inch stretch mesh should solve this problem, but will have to be introduced in consultation with fishers and fish traders.

Shore nets and canal gill nets will be regulated by mesh size, riverbank zoning and season to improve recruitment by ensuring that only adults are taken in the fishery.

Catching of fish by poison is destructive, and induces health hazard and pollution. This practice is illegal and it needs close watch to stop it. So increased and regular patrolling inside the forest and motivating and engaging fishers against this is under way to stop this malpractice.

Hilsha stocks are dwindling every year, because of recruitment problems, primarily capture of juvenile hilsha. A ban on small mesh seine and gillnets from November to April is being considered to improve hilsha stocks.

Fine meshed set bagnets, and pull and push nets have been identified as the most destructive of all the fishing gears in the Sundarban. Bycatch mortality is very high. Data from 1994 reveal that in catching of 253 million shrimp fry about 90% of the larvae of many other species was destroyed as bycatch. (Chantarasri 1994). This destruction of juveniles is continuing, leading to serious annual depletion of fish stocks. Shrimp farmers prefer natural postlarvae, as they seem to be stronger and better survivors. This ensures continuing high demand for natural post larvae. Sufficient shrimp and prawn hatcheries and nurseries must be established to ensure supply of abundant and healthy shrimp post larvae to the shrimp farm. Alternative livelihood options must also be considered for the postlarvae collector to reduce and stop this destructive method of fishing. Integrated coordination between the Department of fisheries, shrimp farmers and Forest department is working to supplement natural shrimp post larvae to the shrimp farm. So efforts are underway to stop shrimp post larvae collection from Sundarban water to recover fish stocks and aquatic biodiversity. A recent government ban on post larvae collection is going to be enforced, but will take time.

The snails, clams and giant oyster are distributed on the forest floor and mud respectively inside Sundarban. These molluscs are used for preparing lime, shrimp and chicken feed. Live and dead shells are collected, but high collection rates are causing damage to the trophic pyramid of ecosystem. Data generation and restriction on live molluscs collection and on species, season and area is being considered to recover and improve the ecosystem.

Use of timber, wooden sticks and nypa leaf for making anchor for boat and nets, fish drying rack and thatching boat, temporary shed and fish depots respectively are also a significant cause of forest resource depletion. Motivating and teaching fishers about these destructive methods, increased patrolling and enforcing regulation, supplying alternate material for making anchor and fish drying rack, will be introduced to reduce the forest resources depletion.

New fisheries management pattern and systems with pragmatic regulations after consultation with fishers is underway to improve the Sundarban fishery in a sustainable way. To increase fish stocks and improve biodiversity, hence forth, rivers and canals within the wild life sanctuaries comprising an area of 1,39,000 ha and 18 other important canals inside Sundarban declared closed to fishing. Seasons are also declared closed for fishing of Mud crabs, Eeltail cat fish, Sea bass, Giant fresh water prawn, mullets during April to June.

REFERENCES

Chantarasri 1994

APPENDIX 1

Table 1: Type of gears, number of gears, number of fishers and boats in Sundarban

SI no.	Type of gear / Method of fishing		No of gears	No. of Fishers	No of boats	Remarks
01	Gill nets	Fatty cat fish gill net	0 6	20	06	Operates in the inshore fishery area.
		Hilsha gill net	500	2,000	500	Operates both inshore and offshore area.
		Other gill nets	420	1500	420	For larger sea species e.g. Indian salmon, croakers, mackerels etc. and for small finfish e.g. ladyfish, mullet, catfish, paradise threadfins. Operates both in offshore and inshore fishery area.
02	Cast net		2505	5000	538	Operates from river bank and some from boats in inshore area for mixed fish.
03	Shore seine net		20	120	20	Operates in offshore area.
04	Pull net		85,000	1,20,00	....	Use no boats but pull the net along the bank of river of inshore area for shrimp/prawn fry.
05	Push net		25,000	37,000	...	-Do-
06	Long line		705	1410	705	Operates in the inshore area.
07	Crab long line		3000	6,000	3000	-Do-
08	Angling rod		500	1000	100	-Do-
09	Set bagnet (SBN)	For adult fish and crustaceans	2963	17,700	1902	Operates in the offshore area.
		For crustacean larvae	20,000	40,000	16,970	Operates in the inshore area for shrimp/ prawn fry only.
10	Shore net		385	1540	385	Operates in the inshore area
11	Canal gill net		250	800	250	-Do-
12	Otter gill net		3	11	3	-Do-
13	Otter lift net		6	20	6	-Do-
14	Oyster & gastropod collection.		-	1100	200	No gear is used but are collected by hand from inshore and offshore area.
	Total		**1,41,263**	**2,35,22 1**	**25,005**	

Shrimp fry means *Penaeus monodon* post larvae and prawn fry means *Macrobrachium rosenbergii* post larvae.
Source: Sundurban Fores Office 2000.

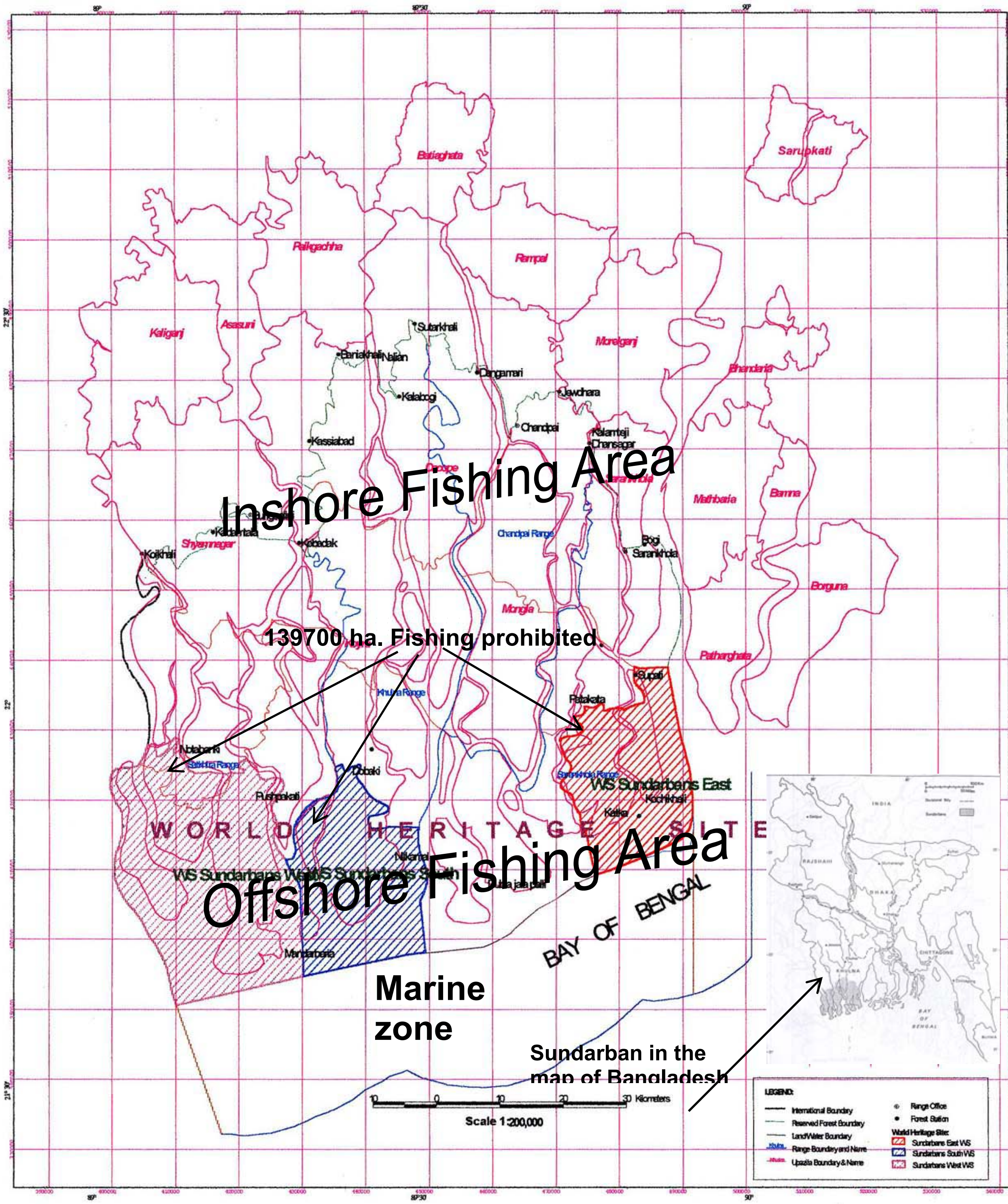

Figure 1: Map of Sundarban, showing Inshore, Offshore area, river systems, world heritage site, Wildlife sanctuary and fishing prohibited area.

WHAT'S IN THERE: COMMON NAMES OF BRAZILIAN MARINE FISHES

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ABSTRACT

The common names of plants and animals carry much of the information that humans have about these organisms. This is illustrated here for a sample of 537 fish species, representing 65% of the marine and brackish water fishes of Brazil, for which 3,012 common names were compiled and analyzed. Overall, 40% of the names originated from Latin (via Portuguese), and 24% from Amerindian languages (Tupi, Guarani). Languages from around the Mediterranean rim (Spanish, French, Greek, Arabic) also contributed numerous names, while names from African languages were relatively rare. The words used to name the Brazilian fishes are mainly primary lexemes, subsequently modified according to morphology, color patterns, non-fish animals and inanimate objects. Attributes earlier hypothesized to lead to fish being given specific common names (commonness, ease of observation, size in relation to humans, and striking appearance) were tested, and three found to apply. On the other hand, a hypothesis initially based on studies of Amazonian fishes and languages, and later corroborated for Austronesian languages, associating low frequency sounds [a] with large fishes, and conversely for high frequency sounds [i], led to ambiguous results. The diversity of Brazilian marine and brackish water fish names, while culturally and linguistically interesting, is a problem in terms of standardizing national fisheries statistics. Thus, the suggestion is made to initiate a consultative process that would extract from the wealth of names documented here a set of standard fish names that would perform for Brazil the same useful roles that the list of North American common names of fish does for Canada and the USA.

INTRODUCTION

Inconsistencies in common names of fishes between different places can cause a serious problem when dealing with the scientific literature, or with catch statistics, especially in tropical and developing regions where small-scale fisheries exploiting a wide array of species are very important. Before we can discuss how to incorporate traditional or local ecological knowledge into fisheries management, we must answer what may appear to be a trivial question: which species are we talking about? This is the reason why this work was initiated, later to evolve into an analysis of the way common names are attributed to Brazilian fishes.

There is an extensive literature on why and how organisms are named, constituting a discipline, ethnobiology, which deals with the study of the complex relationships people establish with plants and animals (Berlin 1992). The utilitarian reasons for naming organisms are obvious and long recognized, but have been complemented by Lévi-Strauss (1966), who argued that things are named as a result of an "intellectual need," i.e., because of an inherent striving for order. Indeed, according to this view, it is only after things have been named that they can be evaluated as being useful or not.

This contribution aims to show how fishers and other Brazilians perceive marine fishes and how this may have influenced how these species were named. As well, we re-evaluate the role of 'utility' in the naming process.

MATERIALS & METHODS

A database with 3,012 common names of marine fishes from Brazil was compiled based on the following ten sources: Brandão (1964), Carvalho and Branco (1977), Lima and Oliveira (1978), Santos (1982), Nomura (1984), Suzuki (1986), Godoy (1987), Soares (1988), Carvalho-Filho (1999), and Szpilman (2000). According to the detailed taxonomy in FishBase (Froese and Pauly, 2000), these names refer to a total of 537 species representing 65% of the marine and brackish water fishes of Brazil. The broadly asymptotic shape of our plot of cumulative number of names versus source suggests that our sample includes a substantial fraction of the existing names, and hence can be considered representative (Figure 1).

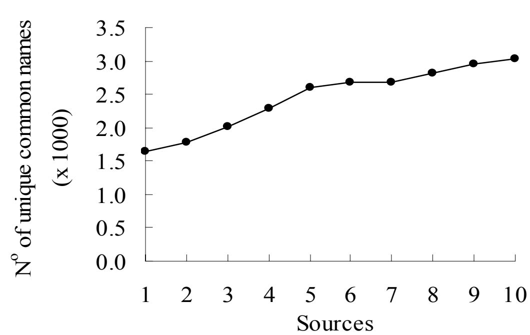

Figure 1. Cumulative number of common names of Brazilian marine fishes successively extracted from ten sources.

The common names of each species were complemented by translations (from Portuguese to English), and information on their gender (female, male or indeterminate), origin (language or language family), structure (multiple choice descriptors of the name's 'core' and theirs modifiers), and life stage (juveniles, adults or both). The origin of the common names was defined according to Tibiriçá (1984), Ferreira (1999) and Bueno (1998).

The four attributes required for fish to be named proposed by Berlin (1992), i.e., commonness, striking appearance, ease of observation and size in relation to humans, were tested using an approach developed by Palomares *et al.* (1999) and data available in FishBase (Froese and Pauly, 2000). The corresponding hypotheses are presented in the next section, along with the results. The influence of size in the naming process was also analyzed using the relationship between an index that represents the total salience of organisms, the 'specific species recognition ratio' (SSRR), and the (base 10) logarithm of the total length (Hunn, 1999). We applied the two methods suggested by this author to analyze this relationship; both are briefly described below:
(a) sampling unit method, where the sampling unit was family; SSRR is the ratio between the number of common names and the number of species included in each family (Hunn 1999). A total of 102 families was included in this analysis.
(b) single species point method, where the sampling unit was species (Hunn 1999). According to this author, "SSRR of a species ... is 1 if it corresponds 1:1 to a basic folk taxon [common name], it is 0.5 if it is one of two species included within a single basic folk taxon; it is 0.33 if it is one of three such species; and it may be 2.0 if it is 'split' between two basic folk taxa; and so on". We introduced a variant to this method, wherein we simultaneously allow for: (i) the same common name to be used for more than one species, and (ii) for each species to have different common names. Then, we add partial SSRRs to obtain the total SSRR.

Sound-symbolism was tested according to Berlin (1992) and gender issues related to the naming process were analysed using maximum length data for each species and gender available in FishBase (Froese and Pauly 2000).

RESULTS & DISCUSSION

Diversity and origin of fish names

The first result of this analysis is the high nomenclatural diversity associated with Brazilian marine fishes. Although this is a locally well-known problem, it had not been previously quantified on a national scale. From the total of 537 species analyzed, about 130 have only one common name, while two or three names are available for 80 and 50 species, respectively (Figure 2 a, b). Conversely, we have the extreme cases of three species with 30 names each, *Cynoscion virescens, Macrodon ancylodon* and *Opisthonema oglinum*, which are widespread along the coast and commercially important (CEPENE, 2000; Godoy, 1987; Szpilman, 2000).

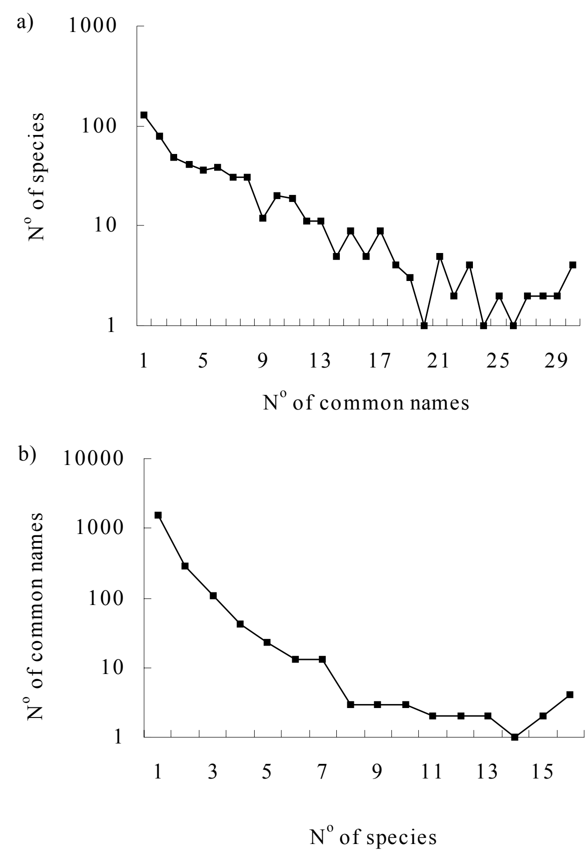

Figure 2. Nomenclatural diversity of Brazilian marine fishes: a) frequency of scientific species that have one to thirty common names; b) frequency of common names that correspond to one to sixteen scientific species.

Each of half of the 3,012 names pertains to only one species (Figure 2 a, b). The other extreme is three cases where the same common name is used for 16 different species, even from distinct families: "sardinha" (sardine) for species included within the families Clupeidae and Engraulidae, "manjuba" (silverside) for

Clupeidae, Engraulidae and Atherinidae, and "solha" (sole) for Achiridae, Bothidae and Paralichthyidae.

Forty percent of the common names of Brazilian marine fishes originated from Latin through Portuguese, followed by Amerindian languages (24%) and others (Greek, Arabic, French). The Amerindian languages represented in our sample names were mainly Tupi and Guarani, both closely related and forming the basis of the called "Língua Ge[ne]ral" encouraged by the Jesuit Order (Bueno 1998). The contribution from African languages is surprisingly low considering that African cultures had a strong impact on Brazilian culture since the late 18th century, (Freyre 2000), and people of African ancestry were predominant among Brazilian fishers in the mid 19th century (Figure 3). Castro (2001) suggests that Brazilian dictionaries frequently attribute words from African languages to Tupi, or do not identify them as such, for reasons that she identifies as "extra-linguistic". We found two examples of this: (a) the word "xangó" (a sardine), derived from a language of the (African) Bantu family, and labelled as a "Brasilianism" in the dictionary issued by Ferreira (1999), and the word "carimbamba" (a jack), also originated from a Bantu language, but attributed to Tupi by the same author.

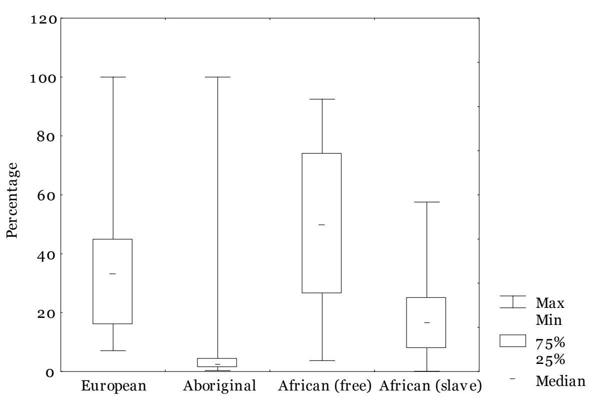

Figure 3. Origin (and status) of the fishers registered in

The core, first and second modifiers of common names of Brazilian fishes consist most frequently of primary lexemes (in 1,793 names or 38% of the total), followed by references to morphology, color pattern, non-fish animals, inanimate objects, size and others (Figure 4). Morphology and other descriptors of the fish body, such as colour patterns and size are quite important in naming fishes in Brazil, while habitat and economic value do not seem to influence this process as much as they do, e.g., in Haïti (Wiener, this volume).

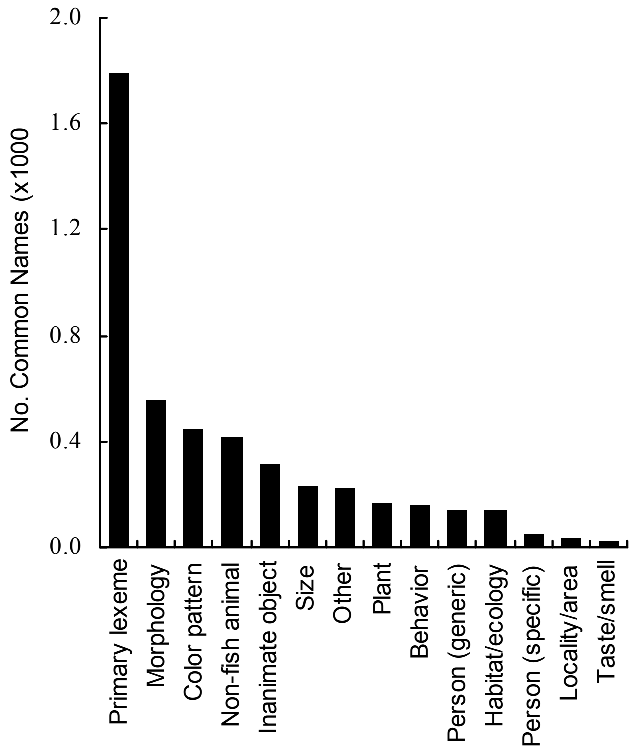

Figure 4. Descriptors used in the core, and in the first and second modifiers of the common names of Brazilian marine fishes.

Test of Berlin's attributes

Attribute (1): Commonness

We tested the hypothesis that the common fish species that sustain fisheries should be named more frequently than those which do not. This is corroborated, as 78% of the species listed in FishBase as exploited by commercial or artisanal Brazilian fisheries have common names (Table 1). Conversely, species identified as "of no interest" were named in only 26% of the cases. Thus, this attribute applies to Brazilian fishes and seems to show the utilitarian influence on the naming process.

Attribute (2): Striking appearance

We followed Palomares *et al.* (1999) in linking striking appearance to monotypy, i.e., the fact that taxonomists tend to create extra families (or higher taxa) to accommodate single species with striking attributes. In general, sixty-two per cent of the monotypic families were named, which is slightly lower than the ratio of 67% for all species included in the analysis (Table 1). This attribute seems not to be pertinent. However, we should consider the confounding effect of the commercial importance, as monotypic families for the exploited category

presented a naming ratio of 71%, while the non-exploited species were named in only 32% of the cases.

Attribute (3): Ease of observation
Ease of observation is an important attribute, as 73 to 75% of the more accessible species (reef-associated and pelagic) were named, while lower values were obtained for species that occur in deeper water (Table 2). Thus, this attribute also applies to Brazilian fishes.

Attribute (4): Size in relation to humans
Among the attributes of fishes, and other organisms for that matter, size is the most important. Notably, people cannot name what they cannot see. On the other hand, what they can see, at least with unaided eyes, is, according to May (1988), only the "tip of the biodiversity iceberg". Thus, the larger the specimens of a given species can be, the higher the probability is of that species having a common name (Table 3); this corroborates Berlin's fourth attribute. We also observed an increase of the number of common names per species with maximum length. JW Wiener (*pers. comm*) has found an opposite trend, and we think this is due to our last length classes being rather large (to account for the fact that large fishes vary more in size than small fishes). To evaluate this issue in a rigorous manner, we used the methodology proposed by Hunn (1999) and the results are presented in the next section.

Size again
Our plots of the scientific species recognition ratio (SSRR) against the logarithm of length at both family and species levels (Figure 5a and b) show a clear, dome-shaped pattern, very different from the linear relationships advocated by Hunn (1999) for mammals, birds and fishes. This pattern may be due in part, to our having counted what may be spelling variants of the same names as full common names. However, these results are consistent with our observations of few names in large species, notably for the largest extant fish, the whale shark, which has only one (exclusive) name in Brazil, "tubarão-baleia". In fact, three out of the seven graphs presented by Hunn (1999), all related to birds, show the same dome-shaped pattern, although he fitted them with a linear relationship. Actually, good linear adjusts occurred only in association with small sample sizes. Thus, we suggest that it is not "large" organisms that have many common names, but "middle-sized" ones, with the size with the most names varying among taxa.

Table 1. Analysis of the first and second of Berlin's attributes: the first is expressed by commercial importance, the second by monotypy (one species per family). Importance and monotypy data from FishBase (Froese and Pauly, 2000).

IMPORTANCE	All Brazilian species	Spp. with local names (%)	Monotypic spp.	Mono. spp. with common names (%)
Exploited[1]	466	78	80	71
Non-exploited[2]	336	26	25	32
TOTAL	802	67	105	62

1) This includes the following categories listed in FishBase: highly commercial, commercial, minor commercial, and artisanal fisheries. The last category also comprises subsistence fisheries; 2) Includes all categories not listed in 1.

Table 2. Analysis of the third of Berlin's attributes (ease of observation), as captured by habitat types. Habitat data from FishBase (Froese and Pauly, 2000).

HABITAT	All Brazilian species	Species with common names (%)
Pelagic	154	75
Reef-associated	162	73
Demersal	300	60
Benthopelagic	73	44
Bathydemersal	40	5
Bathypelagic	73	3
TOTAL	616	56

Table 3. Analysis of the fourth of Berlin's attributes, as expressed by fish size. Length data from FishBase (Froese and Pauly, 2000).

LENGTH (cm)	All Brazilian species	Species with common names (%)	Common names per species
Small (1-30)	204	50	2
Medium (31-70)	176	71	6
Large (71-2000)	179	79	8
TOTAL	559	66	5

'Fishness'
'Fishness' expresses a smooth, slow and continuous flow, and is related to the presence of low-frequency vowels such as [a] in common names (Berlin 1992), and contrasts with the high-frequency sounds of vowels such as [i], related to the rapid motion typical of birds. The common names of Brazilian fishes indicate 'fishness' rather well (Figure 6).

As well, sound-size symbolism implies that high-frequency vowel [i] should be related to small sizes and low-frequency vowels to larger sizes, as shown for frogs and toads, butterflies, and Amazonian fishes by Berlin (1992), and for Philippine fishes by Palomares *et al*. (1999). However, this does not appear to hold for Brazilian marine fishes (Table 4). Moreover,

combinations of these vowels with the two most common consonants in the common names [c] and [p] did not show, either, any relationship with size (data not shown).

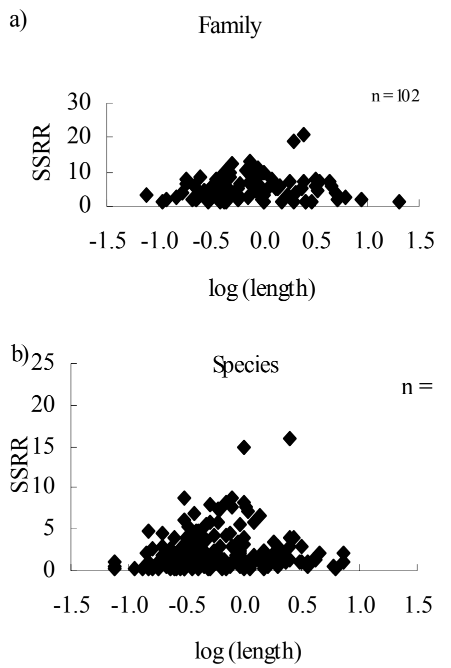

Figure 5. Relationship between the scientific species recognition ratio (SSRR) and the logarithm of length, in meters: a) Sampling unit method (Family level); b) Scientific species point method (Species level).

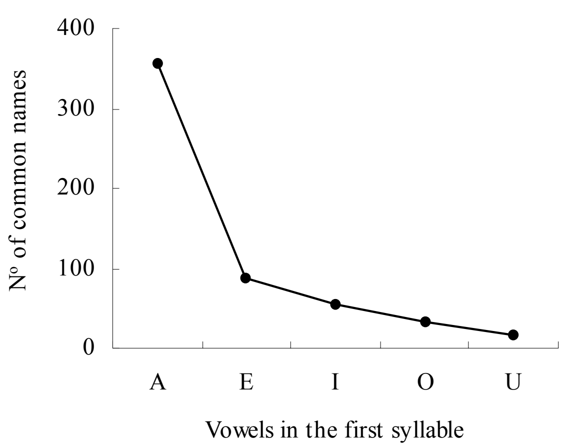

Figure 6. Vowels in the first syllable of the Amerindian names (Tupi and Guarani) of Brazilian fishes.

Table 4. Number of names with [a] or [i] as the first vowel in the common name for three classes of fish length.

LENGTH (cm)	[a]	[i]
Small (1-30)	73	20
Medium (31-70)	165	38
Large (71-2000)	117	29
TOTAL	355	87

Are fishers gender biased?

Fish common names of the masculine gender (in Portuguese) were mainly attributed to larger fish and feminine words to smaller fishes (Table 5). This can be interpreted as reflecting gender bias among the overwhelmingly male fishers, since the females of 64% of fish species reach maximum sizes in excess of those reached by the males (see Pauly 1994, who discusses a related bias among scientists).

Table 5. Mean length of fish species whose names are expressed by a word of masculine or feminine gender as identified by the ending letters.

GENDER (& ENDING)	Number	Length (cm)
Masculine (o)	404	175
Feminine (a)	527	98

Need for standardization

Brazil has longstanding problems with standardization. Thus, the first attempts to introduce the metric system to weights and measures was strongly opposed up to the late 1800s, notably by people who viewed diversity as one of Brazil's strengths (Marcílio and Lisanti 1973). The notion of standardizing the common names of fishes can thus be expected to meet much resistance, in spite of the advantages of such standardization, as evidenced by the wide official use, in the USA and Canada, of the list of common names of North American fishes (Robins *et al.* 1991).

Given this resistance, the success of such standardization demands a broad consultative process, including all parties directly or indirectly involved with fishes: universities, governmental institutions such as the Brazilian Institute for Environment and Renewable Natural Resources (IBAMA), the Ministry of Agriculture, non-governmental organizations, associations of recreational and commercial fishers, etc.

The principles to be used in this process may be based on those used since 1948 by the Committee on Names of Fishes for United States and Canada (Robins *et al.* 1991), with modifications as required by the Brazilian context. The main idea here is to have a unique common name for each species, which should be simple, descriptive (using color pattern, structural attributes, ecological characteristics or geographic distribution), and reflect the ethnic diversity of Brazil in terms of names' origins. Moreover, non-descriptive names,

notably those honouring people should be avoided, along with the names of other organisms.

The final list would be made available by an appropriate national organization, and also through FishBase, a well-established international database on fishes. National fisheries statistics would be presented using this official list, which would avoid the problems due to the use of a multitude of ill-defined names.

CONCLUSIONS

Commonness, ease of observation and size are strongly related to the probability of Brazilian marine fishes having common names, and this can be interpreted from both utilitarian and non-utilitarian perspectives.

The nomenclatural diversity of Brazilian marine fishes poses a big problem in the standardization of national fisheries statistics. We recommend start of a consultative process that would extract a set of standard names from the >3,000 names documented here. These standard names would then perform for Brazil the same useful roles that the list of North American common names of fish does for the USA and Canada.

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REFERENCES

Berlin, B. (1992). *Ethnobiological classification. Principle of categorization of plants and animals in traditional societies*, Princeton, New Jersey. 335 p.

Brandão, J. M. (1964). Glossário de nomes dos peixes: sistemático, português, inglês. *Boletim de Estudos de Pesca* 4 (6): 1-59.

Bueno, F. S. (1998). *Vocabulário Tupi-Guarani - Português*. Éfeta Editora, São Paulo, Brazil. 688 p.

Carvalho, V. A. and R. L. Branco (1977). Relação de espécies marinhas e estuarinas do nordeste brasileiro. *P.D.P. Documentos Técnicos* (25): 1-60.

Carvalho-Filho, A. (1999). *Peixes: costa brasileira*. Melro, São Paulo. 320 p.

Castro, Y. P. (2001). *Falares africanos na Bahia*. Topbooks Editora e Distribuidora de Livros, Rio de Janeiro. 366 p.

CEPENE (2000). Boletim estatístico da pesca marítima e estuarina do nordeste do Brasil - 1999. *Boletim estatístico da pesca marítima e estuarina do nordeste do Brasil*: 1-150.

Ferreira, A. B. H. (1999). Dicionário Aurélio Eletrônico - Século XXI. Lexicon Informática Ltda., Rio de Janeiro, Brasil.

Freyre, G. (2000). *Casa grande & senzala*. Record, Rio de Janeiro. 668 p.

Froese, R. and D. Pauly (2000). *FishBase 2000: concepts, design and data sources*. ICLARM, Los Baños, Laguna, Philipinnes. 344 p.

Godoy, M. P. (1987). *Peixes do estado de Santa Catarina*. Editora da UFSC, Florianópolis, Brazil. 571 p.

Hunn, E. (1999). Size as limiting the recognition of biodiversity in folkbiological classifications: one of four factors governing the cultural recognition of biological taxa. In: Folkbiology. D. L. Medin and S. Atran (eds.). Massacchusetts Institute of Technology, Cambridge, Mass.: 47-69.

Lévi-Strauss, C. (1966). *The savage mind*. The University of Chicago Press, Chicago. 290 p.

Lima, H. H. and A. M. Oliveira (1978). Segunda contribuição ao conhecimento dos nomes vulgares de peixes marinhos do nordeste brasileiro. *Boletim de Ciências do Mar* (29): 1-26.

Marcílio, M. L. and M. L. Lisanti (1973). Problèmes de l'histoire quantitative du Brésil: métrologie et démographie. *Colloques Internationaux du Centre National de la Recherche Scientifique* (543): 29-37.

May, R. M. (1988). How many species are there on Earth? *Science* 241 (4872): 1441-1449.

Nomura, H. (1984). Nomes científicos dos peixes e seus correspondentes nomes vulgares. In: (eds.). Editerra, Brasília, Brasil: 27-63.

Palomares, M. L., C. V. Garilao and D. Pauly (1999). *On the biological information content of common names: a quantitative case study of Philippine fishes*. Proceedings of the 5th Indo-Pacific Fish Conference, Nouméa. p.861-866. Société Française d'Ichtyologie & Institut de Recherche pour le Développement.

Pauly, D. (1994). *On the sex of fish and the gender of scientists*. Chapman & Hall, London. 250 p.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea and W. B. Scott (1991). Common and scientific names of fishes from the United States and Canada. *American Fisheries Society, Special publication* 20: 183 p.

Santos, E. (1982). *Nossos peixes marinhos (Vida e costume dos peixes do Brasil)*. Editora Itatiaia Limitada, Belo Horizonte, Brasil. 265 p.

Silva, L. G. (1988). *Os pescadores na história do Brasil*. Vozes, Recife. 222 p.

Soares, L. H. (1988). Catálogo dos peixes do litoral do Estado do Rio Grande do Norte. *Boletim do Departamento de Oceanografia e Limnologia do Centro de Biociências da Universidade Federal do Rio Grande do Norte* 7: 1-39.

Suzuki, C. R. (1986). *Guia de peixes do litoral brasileiro*. Edições Marítimas, Rio de Janeiro, Brazil. 394 p.

Szpilman, M. (2000). *Peixes marinhos do Brasil: Guia prático de identificação*. Instituto Ecológico Aqualung, Rio de Janeiro. 288 p.

Tibiriçá, L. C. (1984). *Dicionário Tupi-Português - Com esboço de gramática de tupi antigo*. Traço Editora, Santos, Brasil. 200 p.

Wiener, J. W. (this volume). Marine resource knowledge related to fish classification in Haïti. *Fisheries Centre Research Report*.

FISHERS' KNOWLEDGE ROLE IN THE CO-MANAGEMENT OF ARTISANAL FISHERIES IN THE ESTUARY OF PATOS LAGOON, SOUTHERN BRAZIL.

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ABSTRACT
This paper analyses the ecological knowledge of small-scale fishers in the estuary of Patos Lagoon, obtained from interviews and questionnaire surveys, and discusses its potential role in the local co-management of artisanal fisheries. This study demonstrates that fishers' knowledge can provide a valuable set of information about the characteristics of practices, tools and techniques that led a more sustainable pattern of resource use in the past. Such knowledge can contribute to the formulation of present management plans to better adapt rules to local social and environmental conditions. However, the use of fishers' knowledge in the co-management of artisanal fisheries was shown to be hampered by three identified factors: the low expectations among scientists and decision makers of the value of fishers' knowledge for management; the lack of incentives for fishers to act according to their ecological knowledge due to problems in the definition of property rights; and the contradictory paradigms in place about the role of scientific and local knowledge in the management of the estuarine ecosystem.

INTRODUCTION
Worldwide crises in fisheries management have triggered changes in the process of governance and in the approach to study of common property resources (CPRs). The co-management theory and the theory of the commons have played an important role in restructuring the field of fisheries CPRs management (Berkes 1989; Pinkerton 1989; Ostrom 1990). The essence of co-management, as defined by Pinkerton (1989), is the involvement of fisher's organizations and fishing communities in management decision-making through power sharing: sharing both between government and locally-based institutions, and among differently-situated fishers. It represents a way to decentralize decisions, delegate rights and roles to communities and move towards a joint decision-making process.

One of the strongest aspects of fisheries co-management that differentiates it from other models of participatory management is the knowledge of the environment and resources that fishers pursue. Fishers' knowledge is used here interchangeably with Local/Traditional Ecological knowledge (TEK) to refer to the cumulative body of knowledge, practice and beliefs, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings with one another and with their environment (Berkes 1999; Neis and Felt 2000). TEK contains empirical and conceptual aspects, is cumulative over generations, and is dynamic, in that it changes in response to socio-economic, technological and other changes (Berkes, 1999). It is well known that the knowledge held by fishers in many areas of the world, especially in small-scale traditional societies, may be extremely detailed and relevant for resource management (Berkes and Folke 1998). In fact studies have shown that it is the complimentary characteristics of local knowledge and scientific knowledge that make co-management stronger than either community-based management or government management (Pomeroy and Berkes 1997).

Artisanal fisheries in the estuary of the Patos Lagoon, located in the Southern Brazilian coastal zone, are going through a tragedy of the commons. Fisheries resources are decreasing sharply, compromising the livelihood of more than 10,000 small-scale fishers (Reis 1999). The failure of past historical institutions to manage these resources triggered the establishment of new institutional arrangements in 1996, redefining rules and rights by which to manage the resources (Reis and D'Incao 1998; Kalikoski *et al.* in press). A co-management forum (Forum of Patos Lagoon) composed of different stakeholders was established to (1) discuss and develop alternative actions to mitigate and/or resolve the problems of the fishers and the crisis in the artisanal fisheries sector, (2) recover the importance of artisanal fisheries and (3) share decisions to address problems more effectively. The role of small-scale fishers' knowledge in this new institutional arrangement has not yet received the required attention, and the exchange of knowledge between fishers and scientists has not yet been explored to its full potential.

The present scarcity of information raises the question if it is possible to identify an informal knowledge system used by small-scale fishers that could improve co-management in the estuary of Patos Lagoon and hence help in the maintenance of local ecosystem resilience. The assumption is that, in the context of the Patos Lagoon co-management Forum, such knowledge may contribute to developing or re-formulating local management plans to better adapt them to local social and environmental conditions. This paper aims to contribute to the subject by analysing two questions: 1) how has the local social system developed management practices based on ecological knowledge for dealing with the dynamics of the ecosystem in which it is located?; and 2) what are the current barriers and opportunities to using TEK in the Forum of Patos Lagoon co-management?

METHODS

Fieldwork in the estuary of Patos Lagoon was carried out from April 2000 to August 2001. Data were obtained from primary and secondary sources. The primary sources were (1) researcher observations of the Forum of Patos Lagoon meetings, (2) informal conversations, (3) in-depth semi-structured interviewing, and (4) a questionnaire survey. Details of interviews and survey procedures are described in Kalikoski *et al.* (in press) and in Kalikoski (in prep.). Supplementary data were obtained from secondary sources including analysis of scientific publications, local newspapers, meeting minutes, laws, decrees and policy statements from national profile sources such as: Federal Institute for the Environment (IBAMA) and the Federal Sub-Secretary for Fisheries Development (SUDEPE).

Interviews and questionnaires focused on four levels of analysis, consistent with the description of TEK as a *knowledge-practice-belief complex* as proposed by (Berkes 1999). Level one relates to the local knowledge of the animals and ecosystems, such as the behavior and habitat of fish, and the timing of fishing seasons. Such local knowledge may not, in itself, be sufficient to ensure the sustainable use of resources. Therefore, level two refers to the existence or sophistication of a resource management system that uses local environmental knowledge to devise an appropriate set of practices, tools and techniques for resource use. However for a group of fishers to manage resources effectively, appropriate institutions or a social organisation must exist for co-ordination, co-operation, rule making and rule enforcement (Ostrom 1995; Berkes 1999). Accordingly, the third level of analysis is about institutions – the set of rules in use to coordinate the management of the resources. Lastly, the forth "worldview" level represents the system of belief that "shapes human-nature relations and gives meaning to social interactions" (Berkes 1999). As put by the author distinctions between the levels of management systems and institutions are sometimes artificial, and although the four levels are hierarchically organised, there is often feedback between the knowledge levels such that worldviews may themselves be affected by changes occurring, for instance, with the collapse of a management system.

THE ESTUARY OF PATOS LAGOON ECOSYSTEM

With an area of approximately 10,000 km², Patos Lagoon is recognized as the world's largest choked lagoon, stretching from 30°30' to 32°12' S near the city of Rio Grande where the lagoon connects to the Atlantic Ocean (Figure 1). The estuarine region encompasses approximately 10% of the lagoon, and is occupied by diverse and abundant flora and fauna. The estuary is shallow, with variable temperature and salinity depending on local climatic and hydrological conditions (Castello 1985). The dynamics of estuarine waters are mainly driven by the wind and rain regime with only minor influence of tides. The Patos lagoon system communicates with the ocean via a channel between a pair of jetties, about 4 Km long and 740 m apart at the mouth. All the estuarine dependent marine organisms enter and leave the estuary through this channel for nursery, reproductive and feeding purposes. Of the more than 110 species of fish and shellfish species that occur in the estuary (Chao *et al.* 1985), four represent important fisheries resources, and have sustained artisanal fisheries for more than a century. Short descriptions of these species life-cycle and dynamics are provided in Table 1.

Different species' life history characteristics create a well defined seasonal variability in the diversity and abundance of resources in the estuary and also in the availability of resources to artisanal fisheries (Figure 2). Artisanal fisheries landings have declined steadily since the mid-1970s, to ca. 5,000 tonnes in the late 1990s, the lowest landings recorded in the last 50 years. Fisheries landings also present a marked interannual variability, with a period of approximately 6 years, which seem to be related to the occurrence of strong ENSO events. Figure 3 uses Holling's (1986; 1992) model to represent the dynamics of artisanal fisheries resources in the estuary of Patos lagoon by accounting for four major phases in resource life cycles in the

estuary and coastal areas. The phases are: *exploitation*, in which fisheries resources enter the estuarine environment for growth or reproduction purposes, leading to the *conservation* phase in which resources increase in size and maturity. Adults leave the estuary in the *release* phase to spawn and recruit in the marine environment closing the cycle with the *renewal* phase. The influence of climatic conditions is conspicuous in the transition from the *renewal* to *exploitation* phases because of its effect on recruitment success and on the migration/dispersion of resources towards the estuarine environment.

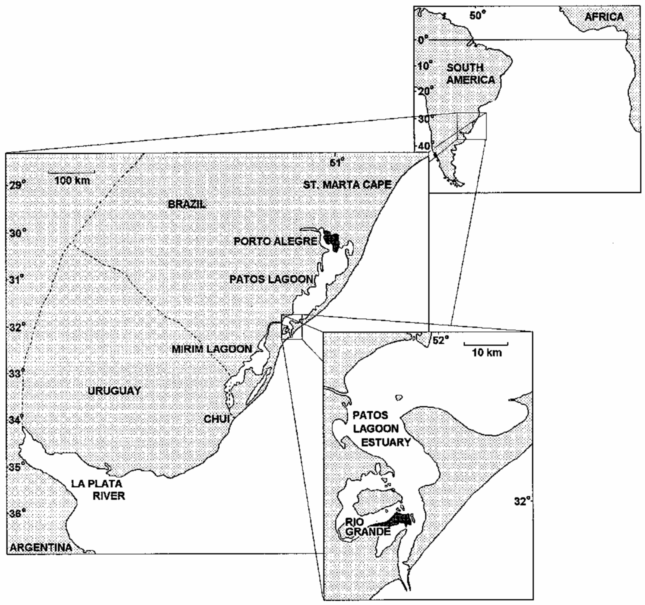

Figure 1. Location of the Patos Lagoon estuary in Southern Brazil (source Seeliger *et al.*, 1997).

Table 1. Summary of biology and life-cycle of main artisanal fisheries resources in the estuary of Patos lagoon (sources Reis, 1986; D' Incao, 1991; Vieira and Scalabrin, 1991Haimovici, 1997;).

Pink shrimp, *Farfantepenaeus paulensis*	Estuarine dependent species. Adults spawn in shelf waters below 50 m deep, producing demersal eggs that hatch into planktonic larvae. When approaching estuaries the larvae develops a benthic habit settling in shallow areas where they will grow for a few months until reaching the pre-adult phase when they migrate to the ocean reinitiating the cycle. The growing phase in the estuary may last between 4 and 10 months when they reach ca. 7 cm of length. Larvae enters with varying success into the estuary all year round but mainly in the spring and summer depending on environmental forcing of wind and freshwater outflow.
Marine catfish, *Netuma barba*	Slow-growing, anadromous species with a calculated life span of approximately 23 years, though adults may occasionally attain 36 years of age and a total length of 98 cm. At the end of the winter the species migrates into the Patos lagoon estuary. Reproduction takes place in early spring in the estuary followed by spawning in the coastal waters. *N. barba* has low fecundity and after the reproduction the males incubate the eggs for up to 2 months in the bucal cavity. Between spawning seasons, adults disperse over the entire shelf.
Croaker, *Micropogonias furnieri*	Species depends on the estuary of Patos lagoon as a nursery and feeding ground. Croackers spawn during spring and summer in coastal waters under the influence of freshwater runoff from the Patos lagoon. Adults normally migrate into the estuary in September-October and leave the area in December-January. Young and subadults croacker occur throughout the year near the coast and in the estuary of Patos lagoon. Adults are dispersed over the shelf and migrate from Uruguay to southern Brazil during the fall and winter and towards Uruguay in the summer.
Mullets (mainly represented by *Mugil platanus*	Mullets occur year round in the Patos lagoon and adjacent coastal waters. Juveniles are more abundant in the winter and spring in nursery areas of the lagoon. In the fall, adult mullets leave the estuary and initiate their reproductive migration. Spawning occurs in warmer offshore waters at about 27°S between the end of the fall and winter. Eggs and larvae are transported from spawning ground towards the surfzone, followed by long-shore migration to the estuary of Patos lagoon.

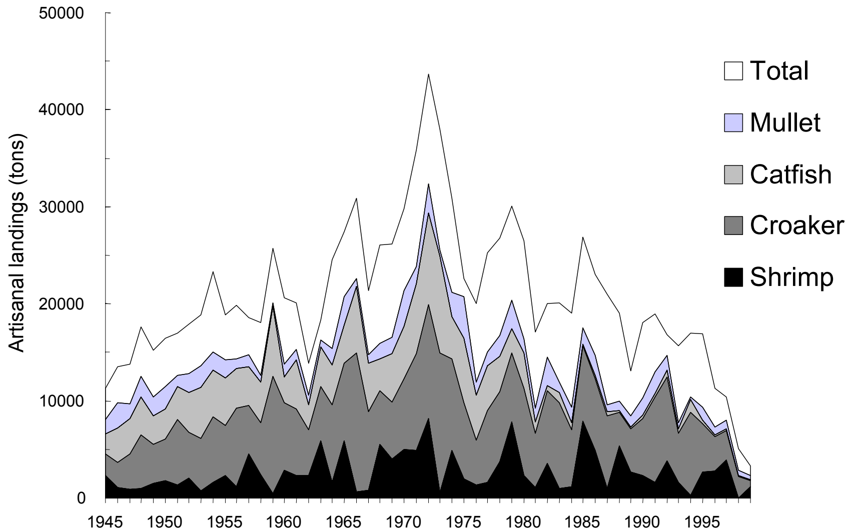

Figure 2. Artisanal fisheries landings in the estuary of Patos lagoon.

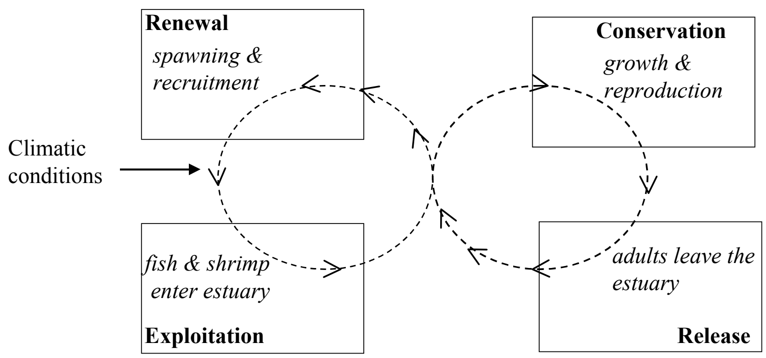

Figure 3. Four phase model of estuarine and coastal fisheries resource dynamics (adapted from Holling, 1986; 1992). During the cycle of exploitation, conservation, release and renewal, biological time flows unevenly. It is slow from the exploitation to the conservation phase, very rapid to the release, rapidly to renewal and back to the exploitation phase.

FISHING PRACTICE AND ECOSYSTEM RESILIENCE

The fishing calendar

One of the single most important characteristics of estuarine artisanal fisheries is the fishing calendar. Since the time when practically no formal rules existed for fisheries management (before 1960s), artisanal fisheries followed a calendar of activities (rules in use) determined by the abundance of different fisheries resources during the year and by the fishing technologies in use. The calendar was based on the experience of local fishers. As such it represents a form of traditional ecological knowledge with important consequences for the resilience of artisanal fisheries because it created natural limits to the exploitation of CPRs.

From January to May, fishers captured shrimp and mullets. Mullets were fished mainly in two periods: in January when the adults were returning from the spawning grounds in the sea, and during the spawning runs, which normally occur between the months of April and June. The catfish season normally began in July and lasted until early November. This fishery targeted the large catfish entering the Lagoon to reproduce and also on the spawning grounds in the upper estuary. The fishery during this period captured mostly fish of good weight and with well developed gonads. A less extensive fishery also occurred during the summer months, especially in February, when catfish migrate back to the sea and the males were incubating the young in their mouth. Few fishers were involved in this fishery because catfish was normally "thin" and did not have a high value, and also because other fisheries, such as shrimp and mullet, were more attractive at that time. The croaker season started in October or right after the catfish season and normally lasted until early summer.

According to fishers, the fishing calendar in the estuary of Patos Lagoon is strongly influenced by the strength of the intrusion of salt water and the rainfall regime. Many fishers consider saltwater to be the single most important factor controlling artisanal fisheries activities. This influence is particularly conspicuous in the shrimp fishery, as shrimp are thought to be more influenced by climate than other fisheries resources. A good fishing season usually occurs if the salinity of the estuary is ideal in the period from October to December; the earlier the estuary is replenished with saltwater the earlier will be the shrimp season. A similar relationship between rainfall regime and shrimp production was demonstrated by Castello and Moller (1978). Fishers also view a warm winter as beneficial for the shrimp season. The moon is also considered an important factor in determining the timing and success of a fishery. For instance, the full moon usually determines good catches of shrimp but it is not good to capture croaker, as explained by a fisher: "*When the moon is bright the croaker is more active and difficult to catch with gillnets*". The last quarter moon is considered excellent for mullets; normally, according to fishers, the last quarter moon of May triggers the schooling behavior of mullet spawners.

Resource use by small-scale fishers in the estuary of Patos Lagoon was and still is to a large extent conditioned by the availability of the resources in the estuarine environment which is in turn controlled seasonally by the influence of the weather and also affected by the influence of the moon on the behavior of the fish. As explained by a fisher:

> " *...nature makes its own fishing closure with the moon, the bad weather, and also the fish, because if it is too windy the fish don't move and you cannot catch them. For instance, if the mullet sees the net it does not enmesh. If it is not the right time, and the fish do not want to be captured, you cannot catch them*".

But, as will be shown in the next section, resource use practice changed markedly as new fishing technologies were introduced and as the industrialisation of fisheries brought exploitation beyond the limits of the carrying capacity of resources.

Changes in fishing practice and resource conditions

In the past 50 years, fisheries in the estuary of Patos Lagoon and coastal areas experienced changes in fishing technologies and materials that significantly altered resource exploitation and the sustainability of artisanal fisheries. Artisanal fisheries were initially based on a beach seine fishery at the mouth of the estuary and in other specific locations along the migratory route of the species inside the Lagoon (Barcellos 1966; Costa 2001). The nets were approximately 300 meters long and were utilised to encircle the fish schools of mullet, croaker, black drum, catfish, and even shrimp, close to shore. The mullet fishery was carried out in two main places in the mouth of estuary on either side of the channel. Each fisher had his turn on a specific day of the season, which was sorted out among fishers of each community. It was common to capture over 60,000 fishes (ca. 90 tonnes) in a single shot, and in order to handle the large catch volume, the fishery was often carried out by groups of 20 to 30 fishers.

Older fishers recall that the beach seine fishery remained important until approximately 1964 when gillnet fishing intensified (this is also confirmed by Barcellos 1966). Gillnets were the most appropriate type of technology to be used in the large areas of the lagoon where fish were naturally more dispersed than at the mouth of the estuary. The intensification of gillnet fishing in turn decreased the viability of the beach seine fishery.

The introduction of motors and the widespread use of gillnets allowed fishers to start fishing mullets in the lagoon as early as October. This gillnet fishery was considered unsustainable by elders who believe the lagoon functions as a nursery area. Unlike the beach seine fishery, which captured only adult fish during a short time window, the gillnet fishery targeted immature fish, and lasted for a longer time, over larger areas including those where the resource was vulnerable to exploitation. Today croakers and catfish as well as mullets are mainly fished using gillnets.

Many assume that the increase in the number of artisanal fishers and the changes in fishing practice and technologies in estuarine fisheries increased pressure on resources which became gradually less abundant to the point of collapse of some important fish resources of the past, e.g. catfish (Reis 1986; Rodrigues 1989). However, fishers and scientists agree that one of the main causes of decline of fisheries CPRs in southern Brazil is the intensification of industrial fisheries observed during the 1960s and 1970s (Haimovici *et al.* 1989; Haimovic, 1997). The fishing areas and technologies employed by industrial

fisheries, as viewed by fishers, have a much greater impact of resources because of the amount of fish caught, and the fishing time. These fisheries operate in areas of the continental shelf that were before (and still are) inaccessible to artisanal fishers for most of the time. Fishers recall that since these industrial vessels started fishing, the fish that used to enter the lagoon are disappearing, and to balance the decrease in production, artisanal fishers, in turn, started to increase the amount of gear in the estuary and intensify their shallow coastal water fisheries (many stated that, when weather permits, the coastal area is visited regularly during the croaker fishing season, capturing the fish before they enter the lagoon). The end result has been an overall decrease in fisheries production.

The pink shrimp fishery has also experienced marked changes in fishing technologies and practice in the last few decades. The shrimp fishery was initially carried out along the Lagoon beaches and shallow areas using a manual trawl net dragged by two to four people, or beach seine nets. The manual trawling nets were later (in the mid-1950s) modified into fixed nets (bag nets). Bag nets were fixed around the channels, the mouth of the net placed facing the ebb currents of the estuary, so that shrimp were caught passively through the currents. Beginning in the 1960s, otter trawling from boats became widely used in the shrimp fishery. Most of the trawling was done in deeper waters of the estuary and in areas with "cleaner" bottom (although fishers acknowledge that many of them used to trawl also in shallow nursery areas). Stownets, introduced in the 1970s, are now the dominant type of gear used in the estuarine shrimp fishery. Stownets are fixed in shallow areas of the lagoon and operate by attracting shrimp to the net with light produced by gas lamps. The fishing operation with stownets has changed over the years. The nets were initially placed close to small inlets, because *"shrimp was initially caught in the currents*". Now the nets are placed mostly in the shallows where according to fishers, the young/smaller shrimp are caught before migrating from the nursery areas.

Fishers maintain that the introduction and widespread adoption of stownets impacted negatively on the operation of other types of fishing technologies (such as bag nets and trawling) because a large proportion of the shrimp is caught before they are able to migrate to the channel areas and lower parts of the estuary. It also triggered an intensification of trawling in the estuary to compensate for the decreasing yield of shrimp. The end result has been an increase in fishing effort and the over-exploitation of shrimp in the estuary. D'Incao (1991) estimated that the intensity of the stownet shrimp fishery in the estuary of Patos Lagoon is so high that few shrimp leave the Lagoon to complete the species life cycle.

Fishers interviewed cited stownets and trawling as fisheries that frequently produce high bycatch rates. According to them, artisanal trawling can produce little bycatch depending on the area of the estuary and also on the characteristics of the otter board and the height of the net – the higher the net in the water column the higher the bycatch. Fishers have found ways to reduce the amount of bycatch (if not for conservation reasons, for practical reasons since bycatch increases the handling time on the catch on board) by decreasing the height of the net, and also avoiding trawling in areas with high bycatch rates, such as shallow estuarine waters and specific locations off the coast which are known as nursery areas. Despite fishers' knowledge of trawling methods with low bycatch, since the introduction of stownets in the estuary, all types of trawl fisheries became forbidden without any scientific evaluation of potential impacts on the ecosystem.

MANAGEMENT LESSONS FROM TRADITIONAL PRACTICES

What can be learned from the above forms of resource use? When resources were still abundant, the fishing calendar worked in a way that allowed fishers to benefit from the most abundant resources in a season while limiting the amount of fishing pressure (time) over a particular species and/or a critical period. For instance, fishing for catfish was normally discouraged during the summer months when the males are incubating the young. It was also unnecessary, given the availability of other resources such as croacker and shrimp. Similarly, the capture of large amounts of shrimp below the optimal size (between late spring and early summer) was in part prevented by the type of fishing technology in use, and also by the existence of alternative fishing resources. A failure of a fishing season, normally due to low shrimp abundance, resulted in a re-distribution of fishing effort to the other resources available in the period, but never to the point of over-exploitation because the characteristics of the fishing practice were more compatible with the carrying capacity of the system and a smaller number of people was involved in the activity.

An informal fishing calendar was still in place until the mid-1990s, but to a much lesser extent than in the past. Figure 4 shows the changes in fishing calendars of the main artisanal fisheries resources between the 1960s and the early 1990s. Species such as mullets, that were fished mostly in late fall (April to June) during the spawning run, in the early 1990s were fished almost equally throughout the year. For other resources, such as catfish, the collapse of the stock brought a change in the fishing calendar from spring to winter months when the few remaining catfish sustain a smaller-scale fishery in the upper estuary. The change in technology (from beach seines to gillnets) also made fishers capture croakers during the same period as mullets, since both species are present in the estuary at different life stages throughout the year and are vulnerable to the same gear.

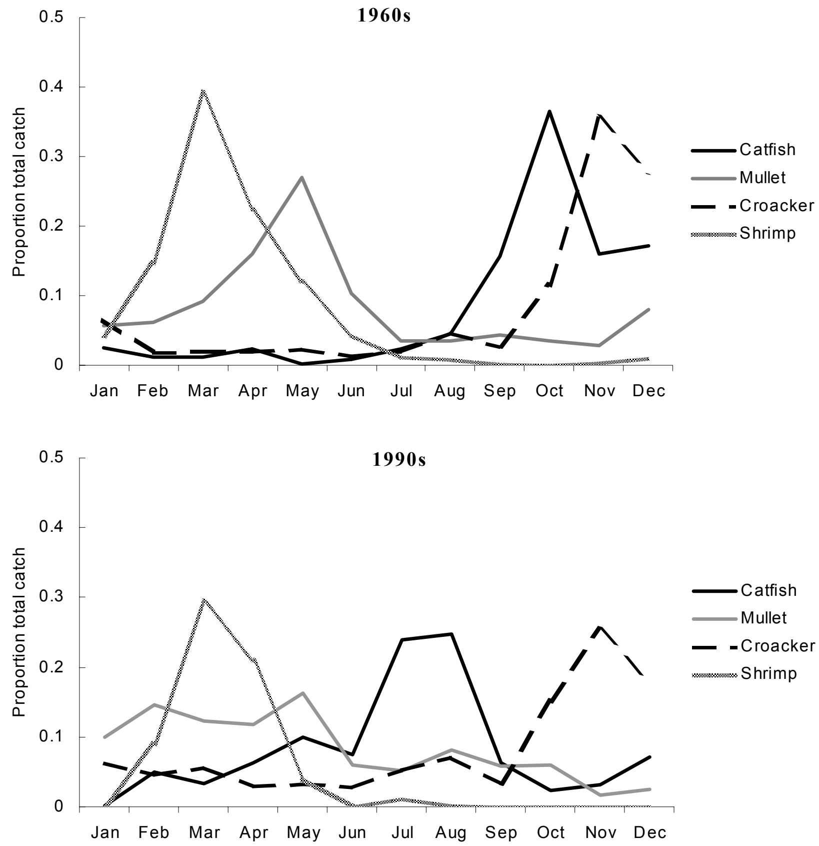

Figure 4. Fishing calendar of artisanal fisheries in the estuary of Patos lagoon and coastal waters during the 1960s and 1990s. The lines represent the proportion of the total annual catch of each species obtained in a single month.

Also, before the advent of industrial fisheries, a large proportion of the species habitat in the Patos lagoon and in the southern Brazilian shelf worked as *de facto* spatial refugia, since artisanal fisheries were limited to specific areas of the estuary of Patos lagoon and adjacent coastal shallow waters. Thus, the increasing competition between artisanal and industrial fisheries and the technological improvements in resource location and capture undermined important factors that made artisanal fisheries resilient in the past, i.e., the limited time and areas of resource exploitation**.** The fishing technologies and resource use practice in the past were intrinsically dependent upon nature, through the influence of the moon, the behavior of the fish, and weather conditions, which created natural mechanisms for limiting excess exploitation by artisanal fisheries. Referring back to Holling's 4 phases model (Figure 3), artisanal fisheries were practically limited to two phases in the resources dynamics: the *exploitation* phase, when resources such as croaker, catfish and mullets were entering the estuary, and the *release* phase, when all these species and pink shrimp were leaving the estuary to the shelf waters. The other two phases (*renewal* and *conservation*) were not targeted by fishers until technological advances and the industrialisation of the fisheries which in turn made the resources available to be exploited at any time and area. In conclusion, the hypothesis put forward here is that up to a certain point in time, the pattern of resource use by artisanal fisheries in the estuary of Patos

Lagoon served conservation purposes because it made resources less vulnerable to over-exploitation while helping maintain the cycle of resource renewal. Besides serving conservation purposes, the fishing practices adopted by artisanal fishers sustained a very productive fishery from the early 1900s until practically the late 1980s (Reis 1999). For instance, in 1960 artisanal fisheries were responsible for over 80% of the total fisheries landings in southern Brazil (ca. 27,000 tonnes/year; IBAMA).

The above analysis of the fishing practices adopted by artisanal fishers in the estuary of Patos Lagoon showed that indeed there was an informal knowledge system used by fishers to deal with the dynamics of the resources. These fishing practices were part of an informal resource management system that helped maintain a productive and resilient small-scale fishery. Resource use practice in the estuary of Patos Lagoon has been changing over time in response to changes in technology, increasing fishing pressure and influences from internal and external (mostly from government agencies) institutional transformations that shifted the management of fisheries CPRs from informal community-based, to central government-based, and to the present situation of co-management (Kalikoski *et al.* in press).

The Patos Lagoon estuary experience has shown failures in both decentralised (community-based) and centralised (government-based) forms of resource management due, to a large extent, to the mismatch between local knowledge and social institutions (Kalikoski *et al.*, in press). The local, informal, decentralised management system present until the 1960s failed because it was never formally institutionalised. Therefore the attempts to control access and attenuate the over-harvesting problem with locally devised rules never reached higher levels of decision making. This system was easily eroded by the external influence of economic development policies aimed at the industrialisation of local fisheries and by a centralised management model adopted by the federal government after the late 1960s (Kalikoski *et al.*, in press). By relying on a system of economically driven policies, this centralised management disregarded the sustainable resource use practices by small-scale fishers and drove many resources to over-exploitation and collapse.

The artisanal fisheries management situation in the estuary of Patos Lagoon called for a cross-scale linkage between local institutions and government. Steps towards a co-management arrangement were taken in 1996 with the creation of the Forum of Patos Lagoon (Reis and D'Incao 1998). This study demonstrates that fishers' knowledge can provide a valuable set of information about the relationship between fishers and the local environment, and about the characteristics of practices, tools and techniques that led a more sustainable pattern of resource use in the past. Local knowledge can broaden the knowledge base needed for management and hence improve institutions that mediate the interaction between communities and their use of the resources. However, the co-management of fisheries CPRs in the estuary of Patos Lagoon is still at its infancy. There are barriers to be overcome before fishers can play a significant role in management decisions.

It is possible to identify 3 inter-related factors influencing the use of local knowledge in the co-management of estuarine resources:

1) *Illiteracy and socio-economic marginalization create low expectations of the management value of fishers' knowledge among scientists and decision makers*. There are many myths about artisanal fishers that still haunt management arenas and hinder a more productive interaction between scientific and local knowledge. Diegues (1995) paraphrased some of the most common myths about artisanal fishers in Brazil:

> *"artisanal fishers are beach beggars, they are a social problem that needs to be treated by social aid programs"; "artisanal fisheries are in transition to industrial, capitalist fisheries, and therefore are doomed to disappear"; "artisanal fishers are unintelligent and resist the technological innovations"; "artisanal fishers are predators, individualists and are not able to organise themselves"*.

Over time, these myths helped to exclude fishers from decision-making and consequently made them more vulnerable to the management process. As put by Pauly (1997) the marginalization of fishers and their limited formal education have often blinded managers and scientists to their ecological knowledge which is used in many successful common property systems as basis for traditional community-based management.

Despite their limited formal education, artisanal fishers developed resource use practices that maintained a productive fishery in the estuary of Patos lagoon until the late 1960s when their

informal systems of management practices were eroded by formal top-down management procedures. Fishers' knowledge of sustainable fishing practices were also identified during interviews and meetings of the Forum of Patos lagoon in the form of requests for changes in local fisheries management. Fishers' requirements mirror many of the principles one can read in higher level environmental institutions, such as the FAO Code of Conduct for Responsible Fisheries (Table 2).

2) *Misfit between institutions and the characteristics of common property resources hinders fishers' stewardship of resources and the use of their knowledge to that effect.* Although they recognise the need for management, fishers still do not comply with the management rules in place in the estuary (such as the fishing closure in the winter months and the banning of trawling). In a condition of scarcity and competition, fishers' stewardship of resources is an important yet difficult aim to achieve. Where stewardship of resources exists it is in the best interests of those who control it not to overfish. As put by Johannes (1981) in this case "self-interest thus dictates conservation". Users' interest in working towards the sustainability of the particular resource is conditioned to the benefits they expect to achieve (Ostrom *et al.* 1999). However, solving fisheries CPR problems involves two distinct elements that are important to the husbandry of the resources: restricting access and creating incentives for users to invest in the resource rather than overexploit it.

Limiting access alone can fail if resource users compete for shares, the resource can become depleted unless incentives or regulations prevent over-exploitation (Ostrom *et al.* 1999). Besides, as can be observed in Table 2, traditional users of the estuary of Patos Lagoon feel threatened by sharing access rights with the more recent industrial users group. Resources outside the mouth of the estuary are still open to be freely caught by industrial purse-seiners as there are no rules regulating this activity in the coast, despite the damage it may cause. This creates a dilemma inside the estuary as small-scale fishers complain that the resources they do not catch today will not be available to them in the future but rather will be fished by industrial fishers outside the estuary. Efforts to exercise stewardship in such circumstances are unlikely to succeed.

Examples of CPR management worldwide has shown that although the development of local ecological knowledge is a necessary condition, it is usually insufficient in itself to achieve sustainability if it does not become accepted and legitimized by management institutions (Johannes 1981; Berkes 1999; Castro 2000; Seixas 2000).

Table 2 Comparison between selected principles of the Code of Conduct for Responsible Fisheries (FAO, 1997) and adjustments to local fisheries management suggested by small-scale fishers during interviews and Forum of Patos Lagoon meetings.

Principles of Responsible Fisheries (FAO)	Adjustments to fisheries management according to fishers knowledge in the estuary ofPatos Lagoon
• *Control of gears that are damaging to the ecosystem*:	- Stop industrial trawling in the coast because it kills large quantities of fish that are discarded. - Switch trawling nets by gillnets with large mesh sizes, which are more selective and less damaging. - Forbid or reduce artisanal fisheries in the nursery shallow waters of the estuary (such as stownets and trawling) because they capture large quantities of juvenile fish and shrimp. - Adapt artisanal otter trawling nets to reduce bycatch (implementing by-catch reduction devices) and restrict the use of artisanal trawling only in the channel areas of the lagoon;
• *Monitoring and enforcement*	- Increase enforcement in the estuary all year round and not only during the shrimp season; - Increase enforcement in the 3 miles zone along the coast, where many industrial trawlers operate illegally.
• *Marine protected areas*	- Close the inshore area around the mouth of the lagoon (specially to industrial purse seiners). This is an area that according to fishers fish concentrate before entering the lagoon. By turning it into a protected area fishers believe that more fish will make their way to nursery and reproduction areas in the lagoon. The establishment of marine protected areas is also congruent with a precautionary approach to fisheries management.
• *Adaptive management*	- Adjust fishing calendars according to the environmental conditions and resource abundance. An intricate system of time/area openings has been suggested by fishers as a way to accommodate management rules to the characteristics of the shrimp fishery.

A fundamental incentive to conserve relies on the definition of property rights to common property resources (Ostrom 1990). As long as property rights to resources remain open, no one knows what is being managed or for whom, and any incentive to conserve will disappear because there is no guarantee that the benefits of any management action will be accrued by the same individual or group that practice conservation.

3) *The difficult transition to a "civic science" in the management of coastal resources.*
Two types of paradigms about the role of science and local knowledge are evident in local environmental management institutions. The first, which has been the dominant, is based on the idea that scientific knowledge is objective and factual, and provides the 'truth' on which decisions should be made (Holling *et al.* 1998). This paradigm has no room for local traditional knowledge, for uncertainties, or for a systemic view of the problems. This conventional way of conducting science has been shown to act against sensitive and precautionary environmental management by drawing decision makers to examine only those phenomena where cause and effect can be either proven or shown to be reasonably unambiguous (O'Riordan 2000).

The second paradigm is based on the recognition that conventional science is value-laden, and that information and decisions can be manipulated by powerful vested interests. It acknowledges that knowledge about the ecosystem is incomplete, therefore uncertainties are high and surprises (when actions produce results different to those intended) are inevitable (Holling *et al.* 1998). It calls for the integration of different forms of knowledge (scientific and local) in order to better understand the nature of complex problems and to reduce uncertainties, where possible. More importantly, this paradigm recognises that management of CPRs should not rely merely on science but on a *civic science* (Lee 1993), that is "deliberative, inclusive, participatory, revelatory and designed to minimise losers" (O'Riordan 2000).

By stimulating the exchange of information and knowledge between scientists and fishers, the Forum of Patos lagoon is creating the conditions for a transition towards a civic science in the co-management of artisanal fisheries. One important indicator of this move is the process of defining and revising rules to regulate the fisheries of the Patos Lagoon estuary from the bottom-up, with inputs from small-scale fishers (the rules devised locally were legitimised by the federal government as decrees IBAMA 171/98 and 144/01). However, while Forum decisions that relate to small-scale fisheries management are triggering the transition towards a civic science paradigm, the overall process of governance of other resources and activities within the coastal zone of the Patos Lagoon is not. Instead, the overall coastal zone governance system is still locked into a top-down management system based on a conventional scientific approach (*sensu* Holling *et al.* 1998) (Asmus *et al.* 1999). An example of this approach is seen in the Environmental Impact Assessment of the enlargement of the jetties in the mouth of the estuary of Patos Lagoon (FURG 2000). The EIA study had many uncertainties which were not made explicit or communicated. The project had many outcomes that are not well defined and there are many questions that still remain unanswered, such as the ones raised within the Forum:

> "*will the project impact the amount of shrimp entering the Lagoon? What will be the impact of the project on the behavior of the fish that migrate through the channel of Rio Grande? What will be the impact of the project on the estuarine ecosystem? How will the project affect navigation conditions for small-scale fishing boats off the mouth of the estuary?*"

As defined by O'Riordan (2000), the above characteristics create a mix of uncertainties and ignorance about the possible consequences of the project which calls for a civic science approach. Contrary to civic science's principles of inclusivity and participatory research, neither the small-scale fishers' communities of the estuary of Patos Lagoon directly affected by the project nor the Forum of Patos Lagoon were consulted during the EIA.

Therefore, although the Forum is moving slowly towards a civic science approach to artisanal fisheries management inside Patos lagoon, activities in the estuary, with a direct effect on artisanal fisheries, are not taking into account bottom-up or participatory approaches. However, because many of the 21 institutions that participate of the Forum represent interests beyond fisheries (e.g. Public Ministry, Environmental Agency), opportunities are being created for the Forum to challenge decisions which impact artisanal fisheries, thus empowering local institutions and fishers' communities to call for better governance of the natural resources in the region. In this sense this study put forward that small-scale fishers and their knowledge – including the set of practices, tools, techniques and appropriate informal institutions embedded in a different world view system – may represent a future oriented concept for sustainable resource management in the estuary of Patos Lagoon.

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References

Asmus, M. L.; Calliari, L.; Tagliani, P.R. and Kalikoski, D.C. 1999. Ecosystem Based Integrated Coastal Zone Management in the Estuary of the Patos Lagoon: Opportunities and Constrains. Proceedings of the Workshop Ecosystem Based Integrated Coastal Zone Management, UBC, Vancouver, Canada. 10 p.

Barcellos, B. N. 1966. Informe geral sobre a pesca no Rio Grande do Sul. BRDE-CODESUL. Porto Alegre, Rio Grande do Sul. 115 p.

Berkes, F., ed. 1989. Common property resources: ecology and community-based sustainable development. Belhaven, London, UK.

Berkes, F. 1999. Sacred Ecology. Traditional ecological knowledge and resource management. Philadelphia. Taylor and Francis. 209 p.

Berkes, F. and C. Folke. 1998. Linking Social and Ecological Systems. Management practices and social mechanisms for building resilience. Cambridge University Press, UK, 459 p.

Castello, J. P. 1985. The ecology of consumers from dos Patos Lagoon estuary, Brasil. Chap. 17:383-406 In A. Yañez-Arancibia (Ed.) Fish community ecology in estuaries and coastal lagoons: Towards an ecosystem integration. 654 p.

Castello, J. P. and O. O. Moller. 1978. On the relationship between rainfall and shrimp production in the estuary of the Patos Lagoon (Rio Grande do Sul, Brazil). Atlântica, Rio Grande, 3:67-74.

Castro, F. 2000. Adjusting to change: the crafting of community lake management systems in the Brazilian Amazon. The Eighth Annual Conference of the International Association for the Study of Common Property, Bloomington, Indiana, US, May 31- June 4th, 2000.

Chao, L. N.; Pereira, L. E. and J. P. Vieira. 1985. Estuarine fish community of the Patos lagoon, Brazil. A baseline study. Chap. 20, 429-450 In A. Yañez-Arancibia (Ed.) Fish community ecology in estuaries and coastal lagoons: Towards an ecosystem integration. 654 p.

Costa, J. S. 2001. Navegadores da Lagoa dos Patos. Asaga náutica de São Lourenço do Sul. Hofstatter. 212 p.

Diegues, A. C. S. 1995. Povos e Mares: Leituras em sócio-antropologia marítma. NUPAUB, University of São Paulo, Brazil, 260 p.

D'Incao, F. 1991. Pesca e biologia de Penaeus paulensis na Lagoa dos Patos, RS. Atlântica (Rio Grande) 13(1): 159-169.

FAO. 1997. Fisheries management. FAO Technical Guidelines for Responsible Fisheries, 4, Rome, 82 p.

FURG, 2000. Relatório de Impacto Ambiental: Ampliação dos molhes do porto de Rio Grande. University of Rio Grande, Rio Grande, Brazil.

Haimovici, M. 1997. Recursos pesqueiros demersais da região sul. Programa REVIZEE. Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal. FEMAR. 80 p.

Haimovici, M.; Pereira S. D. and P. C. Vieira. 1989. La pesca demersal en el sur de Brasil en el periodo 1975-1985. Frente Maritmo 5:151-163.

Holling, C. S. 1986. Resilience of ecosystems; local surprise and global change. p. 292 - 317. In Clarck, W. C. and R. E. Munn (Eds.). Sustainable development of the biosphere, Cambridge University Press, Cambridge, Mass.

Holling, C. S. 1992. Cross-scale morphology, geometry and dynamics of ecosystems. Ecological Monographs 62(4): 447-502.

Holling, C.S.; Berkes, F. and C. Folke. 1998. Science, sustainability and resource management. In: Berkes, F. and Folke (eds). Linking Social and Ecological Systems. Management practices and social mechanisms for building resilience. Cambridge University Press, UK, 342-362.

Johannes, R. E. 1981. Words of the Lagoon. Fishing and Marine lore in the Palau district of Micronesia. University of California Press. 245 p.

Kalikoski, D. C. in prep. The Forum of Patos Lagoon: an analysis of institutional arrangements for conservation of coastal resources in southern Brazil. Ph.D. Dissertation. University of British Columbia, Canada.

Kalikoski, D. C.; Vasconcellos, M. and L. Lavkulich. In press. Fitting institutions to ecosystems: the case of artisanal fisheries management in the estuary of Patos Lagoon. Marine Policy.

Neis, B. and L. Felt. 2000. Finding our sea legs: linking fishery people and their knowledge with science and management. Institute of Social and Economic Research. 318 p.

O'Riordan, T. 2000 (Ed.). Environmental science for environmental management. Second Edition. Prentice Hall. 520 p.

Ostrom, E. 1990. Governing the commons. The evolution of institutions for collective action. Cambridge University Press, Cambridge, UK.

Ostrom, E. 1995. Designing complexity to govern complexity. P. 36-46. In S. Hanna and M. Munasinghe (Eds.) Property Rights and the Environment. Beijer International Institute of Ecological Economics. 141 p.

Ostrom, E.; Burger, J. Field, C.B., Norgaard. R.B. & D. Policansky. 1999. Revisiting the commons: local lessons, global challenges. Science 284: 278-282

Pauly, D. 1997. Small-scale fisheries in the tropics: marginality, marginalization and some implication for fisheries management. p. 40-49. In: E.K. Pikitch, D.D. Huppert, and M.P. Sissenwine, eds., Global trends: Fisheries Management. Bethesda, Md.: American Fisheries Society.

Pinkerton, E., (ed.). 1989. Co-operative management of local fisheries: new directions for improved management and community development. Vancouver: University of British Columbia Press.

Pomeroy, R.S. and F. Berkes. 1997. Two to tango: the role of government in fisheries co-management. Marine policy, 21: 465-480.

Reis, E. G. 1986. Reproduction and feeding habits of the marine catfish Netuma barba (Siluriformes, Ariidae) in the estuary of Lagoa dos Patos, Brazil. Atlântica, Rio Grande, 8:35-55.

Reis, E. G. 1999. Pesca artesanal na Lagoa dos Patos. História e administração pesqueira. P. 81 – 84 in Alves, F. N. (ed.) Por uma história multidisciplinar do Rio Grande. Fundação Universidade Federal do Rio Grande. 241 p.

Reis, E. G. and F. D'Incao, The present status of artisanal fisheries of extreme southern Brazil: an effort towards community based management. Ocean & Coastal Management, 43 (7), 2000, 18pp

Rodrigues, G. 1989. A atividade pesqueira no estuário da Lagoa dos Patos. Subprojeto A pesca artesanal na Lagoa dos Patos. Projeto Lagoa dos Patos. University of Rio Grande, Rio Grande, 27 p.

Seixas, C.S. 2000. The Ibiriquera lagoon, Brazil: a resilient social-ecological system? Papers of the International Association for the Study of Common Property, June 2000, Bloomington, Indiana, USA. http://www.indiana.edu/~iascp2000.htm.

Seeliger, U.; Odebrecht, C. and J. P. Castello. 1997. Subtropical Convergence Environments. The coast and sea in the Southwest Atlantic. Berlin, Springer, 308 p.

Vieira, J. P. and C. Scalabrin. 1991. Migração reprodutiva da tainha (Mugil platanus, Gunther, 1980) no sul do Brasil. Atlântica (Rio Grande) 13(1):131-141.

COGNITIVE MAPS: CARTOGRAPHY AND CONCEPTS FOR AN ECOSYSTEM-BASED FISHERIES POLICY

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The bellman himself they praised to the skies –
Such a carriage, such ease and such grace!
Such solemnity too! One could see he was wise,
The moment one looked in his face!

He had brought a large map representing the sea,
Without the least vestige of land:
And the crew were much pleased when they found it to be
A map they could all understand.

"What's the good of Mercator's North Poles and Equators,
Tropics, Zones, and Meridian Lines?"
So the Bellman would cry: and the crew would reply,
"They are merely conventional signs!"

"Other maps are such shapes with their islands and capes!
But we've got our Captain to thank"
(So the crew would protest) "that he's brought us the best –
A perfect and absolute blank!"

From Fit the Second in "The Hunting of the Snark: An Agony in Eight Fits" by Lewis Caroll, 1876. Illustration by Quentin Blake, Folio Society Edition, 1976.

ABSTRACT
Mental concepts of the health of a marine ecosystem and its fisheries can influence the goals and design of management policies. We discuss how such cognitive maps, held by individual humans, and deriving from an interplay of science, traditional and local knowledge, are fostered by the *Back to the Future* approach to fisheries policy. *Back to the Future* seeks to use the structure and abundance of past ecosystems to guide restoration policy, and engages all sectors in positive and remedial action.

A blank map is ideal for hunting a beast that no-one knows the form or whereabouts of. Lewis Carroll's Bellman and crew of snark-hunters neither needed nor desired much idea of where they were going. Later in the poem, the blank map seems to be there for them to sketch their own futures.

Henri Poincaré said that we all carry a map of the world in our heads (Figure 1), but our maps are not a perfect representation of the reality that surrounds us. Illusory and mistaken elements of the map may prompt erroneous behaviour, giving rise to all kinds of shocks and surprises. Using our mental map of the present to guide our steps to a better future is therefore an uncertain process. Present maps can at least be checked for errors against what we see in front of us now, but our mental maps of past times are subject to greater error from omissions, misconceptions, misinformation, and even disinformation from those who seek to rewrite history. Nevertheless, mental maps of the present and past are at least grounded in some kind of reality. In contrast, our mental maps of where the future might lead are imbued with dream, myth and wishful thinking. Such dreams of the future are the very stuff of humanity, but whilst they are pivotal to our spirituality and ethics, they rarely offer us much practical help in dealing with impacts on the natural world of which we are an integral, and in the case of marine ecosystems, very damaging, part.

The term 'cognitive map' was first defined by Tolman (1948) and used to denote a mental map of the actual spatial relationships in a rat's view of escaping from a maze. Since then the term has been used in a broader way to indicate mental maps of sets of conceptual relationships about environment, society, institutions, governance and human impacts on the natural world (Lazlo *et al*. 1996). In political science, cognitive maps have been used as a qualitative reasoning tool to try to analyse, predict and understand decisions, especially in the context of conflict and games theory (Axelrod 1976; Levi and Tetlock 1980). Mathematicians have taken the rather

Figure 1. Mathematician Henri Poincaré (1854-1912) said we all had maps of the world in our heads. Poincaré's mental world, however, was likely very different from yours and mine, populated as it was with the arcane equations of the Diophantine proposition and with Poincaré's conjecture, that has baffled all-comers since he died. Appropriately for someone concerned with maps, Poincaré invented topology.

inconsistent and imprecise concepts in the political science literature and formalised a theory of cognitive maps using algebra (e.g. Chaib-draa and Desharnais 1998), computational science (e.g. Park 1995) and fuzzy logic (e.g. Kosko 1986). Recently, fuzzy cognitive maps have become a part of artificial intelligence research in designing functional ways to represent human knowledge and causal inference, a way of programming the actors in a virtual world (e.g. Miao and Liu 2000). The overall success of these ventures in forecasting human social behaviour remains to be demonstrated.

In this paper we use the term 'cognitive map' in the broader sense to describe the totality of the way in which humans envisage natural marine ecosystems, with all their constituent organisms, fisheries, physical environment and modes of human intervention such as management, or lack of it. In fact, the term ecosystem itself implies a cognitive map of humans embedded in a natural world.

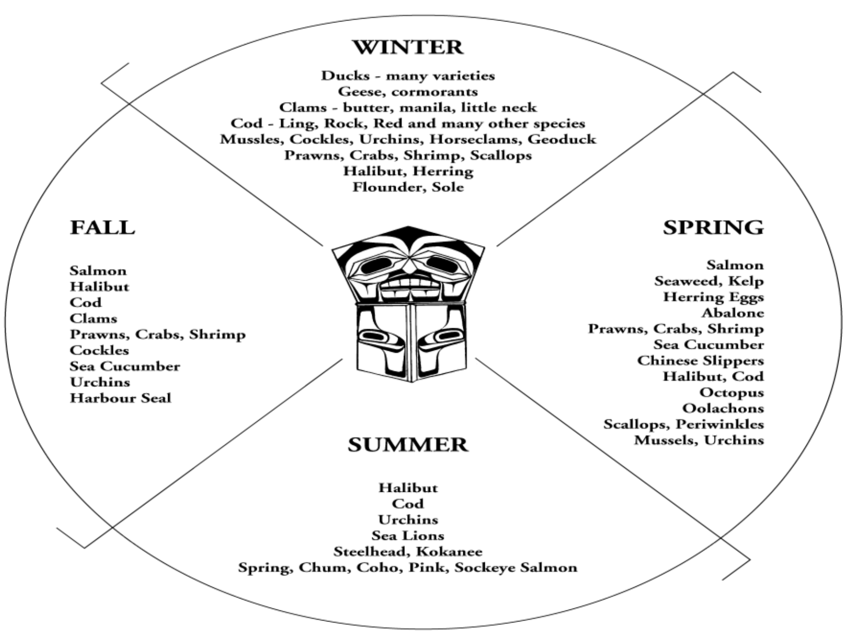

Figure 2: A seasonal cognitive map of traditional food gathering in the Heiltsuk Nation in central British Columbia. In Winter 19 items are named; spring 17; Summer 11; Fall 11 items (Brown *et al.* 1997). Chart prepared with the assistance of Cameron Brown, Beverly E. Brown and Cyril Carpenter.

COGNITIVE MAPS OF ECOSYSTEMS AND *BACK TO THE FUTURE*

Before it reaches an 'adoption of policy' stage, our *Back to the Future* ecosystem modelling entails two stages: first, the construction of ecosystem models of past and present; and secondly, the choice of a desirable management goal from comparing the benefits and costs of restoring each past ecosystem from the present state. The scientific modelling of past ecosystems can help us improve our maps of the past. The design and analysis of sustainable and responsible future fisheries improves our perception of how a restored future might come to look like the past. So cognitive maps of marine ecosystems and the dynamics of how their status might be changed are integral to the Back to the Future policy agenda.

What might a cognitive map of an ecosystem look like? What elements are captured in the mind? Major features are the species, like valleys, coasts, lakes and rivers. We may imagine that the relative abundance and food web of animals and plants is captured in mountain chains, lake regions, watersheds and plains. Fisheries are perhaps like villages, town and cities. Clearly these representations of the features of natural ecosystems may take many different forms in different individuals, but given our recent evolutionary heritage as humans, it is reasonable to assume that we all have the ability to capture similar map features of the natural world in our heads. This forms the basis of the concept of human biophilia (Wilson 1984). To assume the contrary, that all cognitive maps are arbitrary and unrelated is at best solipsist, and at worst, postmodern.

Cognitive maps exist at different scales and units. That of an Aboriginal or traditional harvester links many species and natural assemblages, those sought and those associated to place, season, weather, ocean conditions and past experience (e.g. Figure 2). At a conceptual or spiritual level, the Canadian First Nation's ecosystem concept is of an ecological, environmental, human and spiritual whole. At the other extreme, the cognitive map of a stock assessment scientist tracks one or a very few fished species and their immediate ecosystem linkages over relatively vast distances. In the first case, the map relates species and abundance to geographic location. In the second, the primary 'geography' is a graph showing change in abundance over time. Figure 3 shows the catastrophic decline in abundance of Rivers Inlet, BC, sockeye salmon, representing an annual loss of $12 million to fishers and $65million in retail value, a foregone future for the Oweekeno Nation and serious consequences for forest and wildlife through the cutoff of marine phosphorous and nitrogen deriving form salmon carcasses. The graph tells us nothing about where or why the decline occurred, issues that would be an integral part of the equivalent cognitive map of the people concerned. There are good reasons to assume a large role for changed ocean conditions in the decline. However, 97% of the salmon fishing occurs in the Rivers Inlet watershed, even though looking at the watershed to the exclusion of the ocean is like looking beside the campfire for something you lost in the forest- it is easier to see, but there's little hope of finding what you seek (Haig-Brown and Archibald 1996).

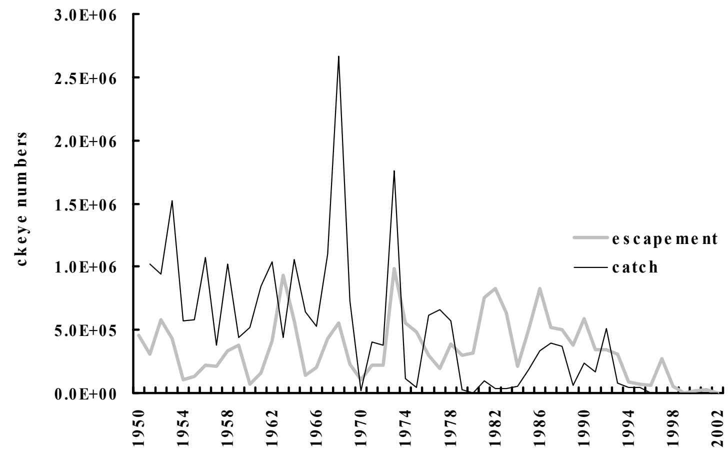

Figure 3. Estimated numbers of Rivers Inlet Sockeye caught and allowed to spawn (escapement) since 1980. Vertical axis in millions (Source: R&SPG 2003).

expressed in Aboriginal food gathering and illustrated in Figure 2. The concept of the adjacency principle (Pitcher and Power 2000; Coward *et al.* 2000; Pauly 1999) is embodied in this diagram. Traditional place-based economies have used traditional and local knowledge (T/LEK) and, from the early to mid 20th century, government agencies often employed local managers who used semi-quantitative ecological and locally-based management. This era has been replaced by large-scale corporate fisheries managed with highly quantitative single-species techniques run by a bureaucracy perceived as remote with no local roots. So a person in a local

Most scientific representations of ecosystems do not provide something equivalent to the powerful ownership and 'stewardship' relationship

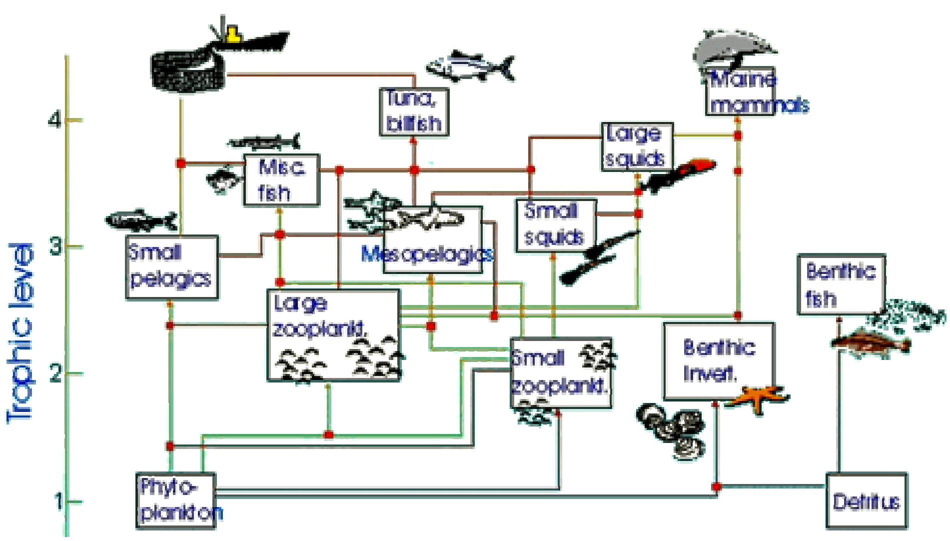

Figure 4. Schematic of a generic Ecopath mass-balance model of an ocean ecosystem showing trophic linkages against trophic level (plants are defined as trophic level 1). Actual models today often have over 50 compartments and many different fisheries (diagram courtesy V. Christensen).

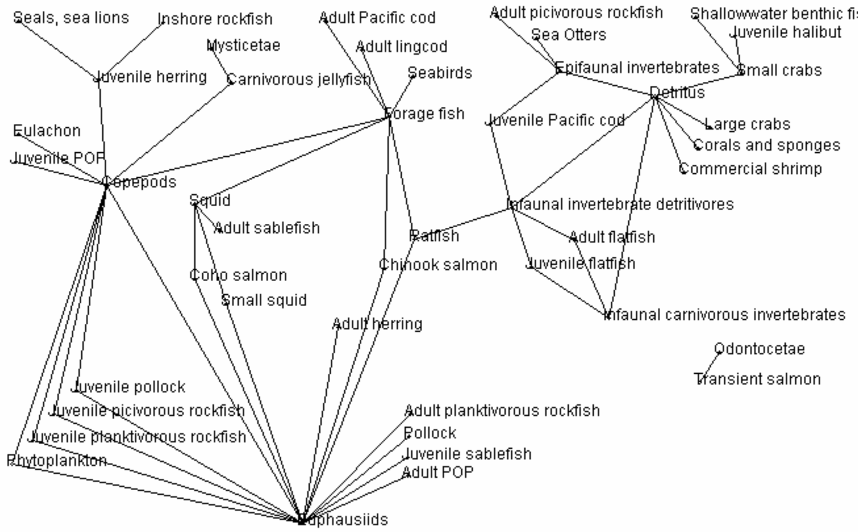

Figure 5. Important food web linkages (links >25% of diet) in the Northern British Columbia ecosystem, as drawn up by a mass-balance Ecopath model. (Ainsworth et al. 2002). The ecosystem scientist's cognitive map of the system is based on diagrams like this.

fishing community in the 1950s would have a very different cognitive map of the same fishery today. These trends have led to a fragmentation of knowledge (Haggan 2000).

The first challenge in creating a common cognitive map of the entire ecosystem is to make disparate maps mutually comprehensible. The progression from the holistic ecosystem knowledge of First Nations, through a stage of studying the bits and then trying to put them back together is, in the worst case, like Humpty Dumpty. At best, it is a 'Blake's progress', leading from the innocence of fisheries scientists in the 1950s and 60s, helping fishers to increase their catch, through the bitter experience of the failure of single species management epitomized by the Newfoundland cod, to, today an emerging informed knowledge of the whole, (Blake 1795, Haggan 2000).

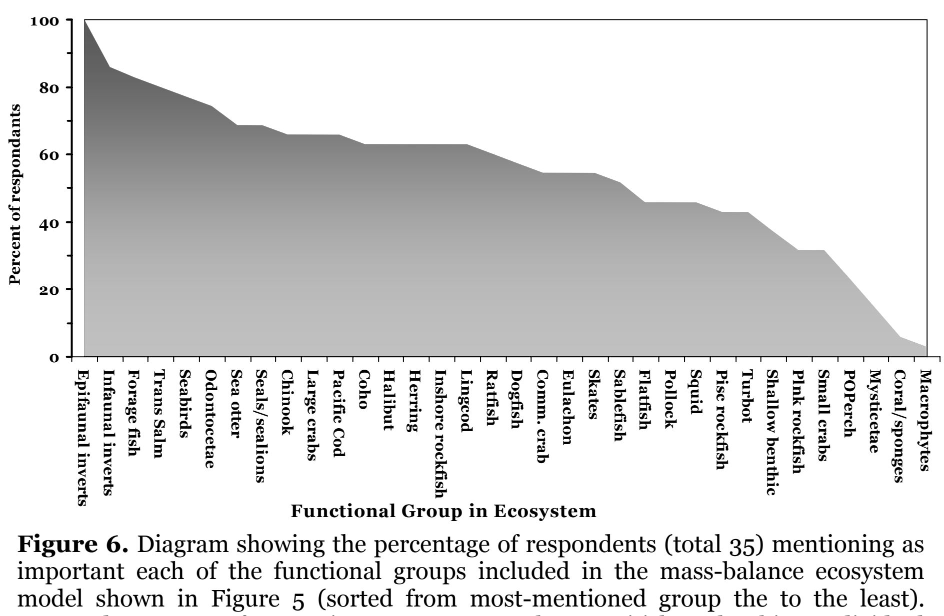

Figure 6. Diagram showing the percentage of respondents (total 35) mentioning as important each of the functional groups included in the mass-balance ecosystem model shown in Figure 5 (sorted from most-mentioned group the to the least). Respondents were from Prince Rupert, Northern British Columbia. Individual cognitive maps may contain only shadows for organisms held in full focus by scientists.

The 'new ecosystem science' began with the development of a system to relate individual quantitative and scientific studies to each other using the 'Ecopath' mass balance approach (Christensen and Pauly 1992), an approach that tracks the trophic flows between predators and prey (Figure 4). This re-linking of separated components opened the door to the use of T/LEK information on presence /absence, relative abundance and trends to improve the models built by scientists (Pitcher 1998). The resulting new cognitive map has come a long way from the single species concept, in that it shows the relationship between species (Figure 4), but is imprecise, in that it smears biomass over the entire ecosystem in tonnes per square kilometre.

Ecosim, the dynamic version of Ecopath (Walters *et al.* 1997), allows modelers to explore the ecological and economic impacts of different fisheries, conservation and management strategies over time. The valuation methodology has been substantially expanded to include social benefits to present and future generations (Sumaila 2001, Sumaila *et al.* 2001) and to look for fisheries allocations that optimise specified objectives. Moreover, the spatial version, Ecospace (Walters *et al.* 1998), enables the assignation of species to their preferred habitat, thus opening the door to the possibility of transferring detailed spatial knowledge of species from scientific surveys,

T/LEK, bathymetry and other sources. Spatial management plans, such as zones restricted to some fishing gears, or fully no-take areas, can also be explored and optimal fisheries searched for. The cognitive map delivered by Ecospace actually behaves rather like a real ecosystem and hence may engage the maritime community.

Alternative scientific representations of food web relationships, such as Multi-Species Virtual Population Analysis (MSVPA: Magnusson 1995) cover mainly the fishy portions of an ecosystem with greater rigour than ecosystem models. But MSVPA does not include most invertebrate, mammal and bird species, and does not address spatial distribution. Although these, and allied, models may be useful in fishery management, the MSVPA cognitive map is partial and is likely only to be understood by expert practitioners.

Figure 5 illustrates one aspect of the cognitive map of a scientist working on a trophic model of an ecosystem. The *Back to the Future* concept enhances this map by including perceptions of change in each of the main trophic linkages – change both from the past and for what might yet be. The cognitive map of the whole ecosystem implicit in Ecopath and *Back to the Future* analysis is perhaps closest to the concepts used in former times by pioneering ecologist/ naturalists such as Aldo Leopold (1933), Charles Elton (1926) and Alistair Hardy (1956). It reflects the classic division of ecology in autecology and synecology made in ecology textbooks (e.g. Krebs 2002).

Unsurprisingly, community members interviewed in Prince Rupert, a fishing town in northern British Columbia in the summer of 2000 (Pitcher *et al*. 2002b), revealed cognitive maps that differ from those of scientists. Figure 6 summarises an indication of those differences as reflected in the number and type of organisms mentioned as being important for the food web. Whilst high scores for salmon, crabs, seabirds and killer whales and low scores for small crabs and sponges are not surprising, baleen whales and kelp received unexpectedly low scores. The cognitive map of the ecosystem scientist, on the other hand, covers all organisms equally but weights organisms by the relative importance of trophic linkages as shown previously on Figure 5.

Differences in cognitive maps were also found among the interviewees. Figure 7 shows the percentage responses for ecosystem groups in four categories of respondent: commercial, recreational and aboriginal fishers, and conservationists. It is evident that conservationists put consistently high values on a patchy set of organisms, while they tend to almost ignore others. In contrast to our ecosystem scientist and naturalist mentioned above, a survey of a random set of traditional single-species ecologists, might be similar to this conservationist profile. Recreational and Aboriginal fishers have similar shaped profiles to each other, but recognize different organisms, while, at least in this data, commercial fishers have the most balanced set of scores.

It has to be emphasised that the conclusions made here are very preliminary, since the interviews were carried out by the snowball technique and were neither random, nor stratified by category. Some fishery sectors may be been missed from the survey. Moreover, the effects of scale and changes in fishing gear locations were not covered in the survey.

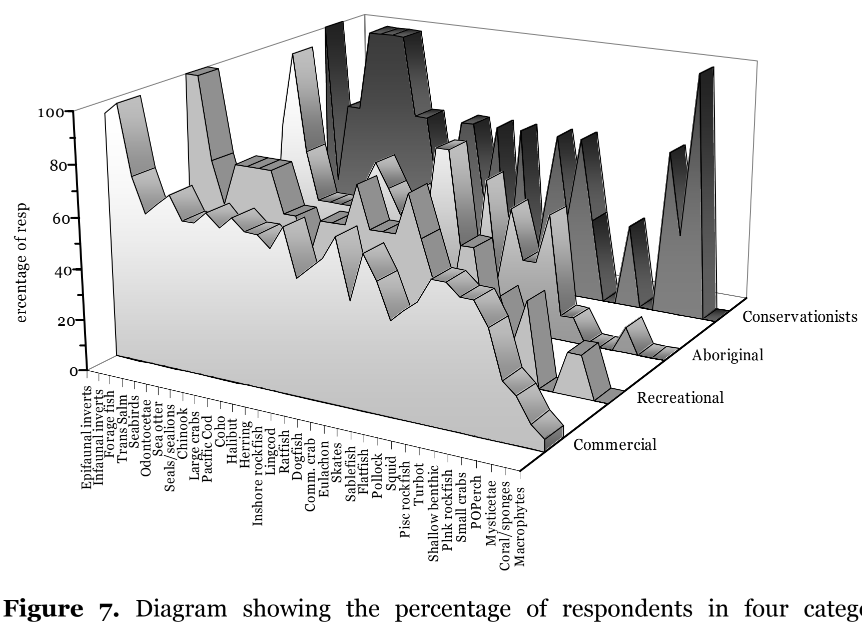

Figure 7. Diagram showing the percentage of respondents in four categories mentioning each of the functional groups included in the mass-balance ecosystem model shown in Figure 4. Respondents were from Prince Rupert, Northern British Columbia.

"THOSE WHO CANNOT REMEMBER THE PAST ARE CONDEMNED TO REPEAT IT"
(*George Santayana (1863-1952)*

The temporal dimension of a journey from TEK through single-species fishery science to an ecosystem science that *includes* T/LEK overlays the history of serial depletion of fisheries (Pauly *et al.* 1998). For example, recent work on the North Atlantic has demonstrated a ninefold reduction in table fish species between 1900 and the present (Christensen *et al.* 2003). Depletion like this has been driven by three ratchet-like processes (Pitcher 2001) that adversely affect ecology (Odum's ratchet), economics (Ludwig's ratchet), and the cognitive map of the system (Pauly's ratchet, = 'shifting baseline', Pauly 1995), the latter expressing how successive generations perceive abundance at the start of their careers as what 'ought' to be there. In response to this rather deep problem, the authors conceived the *Back To the Future* approach (Pitcher 1998, Pitcher *et al.* 1999) where different knowledge systems, history, archaeology and other sources are combined to reconstruct past abundance as a way to set restoration goals that relate to productive potential rather than present scarcity. The *Back To the Future* process draws up a set of cognitive maps of the entire system as it was, as it is, and what it might become if the wit and wisdom of the scientific and maritime community could be harnessed to restoration.

Back To the Future, is, in fact, a deliberate 'cognitive intervention' designed to expand knowledge of the system and the potential for restoration. The political drivers of change are intended to be public awareness of the extent of ecosystem depletion in relation to the past, coupled with re-kindled belief in the potential for restoration. The latter has been sadly eroded since Peter Larkin's 'stained-glass cathedral' era of the 1960s by a series of unexpected collapses, failures or fish stocks to rebuild and by a deep pessimism on the part of fisheries agencies, who these days are wont to portray themselves as helpless in the face of climate changes.

However, the future is not all black, since large area closures in US waters have shown that biomass of commercial fish stocks can rebuild, and that there is a future for fisheries provided that action is taken (Mace, pers comm.). Seeing positive results on their catches, artisanal fishers in the tropics have begun to ask for protected areas to be set up (Roberts *et al.* 2001). At the ecosystem scale, spatial models developed for marine protected areas in Hong Kong have shown the potential for restoring depleted fisheries through no-take areas, artificial reefs and other measures (Pitcher *et al.* 2002a). Cognitive maps engendered by these simulation models, coupled with consultations with fishers government and marine industry (e.g. Pitcher *et al.* 2002b), contribute to a better collective understanding of the marine ecosystem, the potential for restoration and the obstacles that have to be overcome. Such wide support, driven by a cognitive map that includes the past and the potential for restoration, encourages participation and commitment from all sectors (Pitcher 2000).

CONCLUSIONS

Is fisheries science drawn on a blank cognitive map, like Lewis Caroll's snark hunters, as some scientific practitioners would have you believe? We don't think that this has ever been the case. For example, Finlayson (1994) describes convincingly how misplaced confidence in models (Walters and Maguire 1966) and policies (Hutchings *et al.* 1997a, 1997b) led to the collapse of the Newfoundland cod stocks. Finlayson interprets this unhappy saga in terms of failed institutions, but underlying this in turn are the flawed mental maps of individuals who dealt with fisheries management policies.

Back to the Future encourages much more complete cognitive maps than hithertofore used in attempting to set goals for management. First, it embodies the widespread call for ecosystem-based management, or for an ecosystem approach to management (Cochrane FAO 2003). Questions that may appear purely the realm of policy using single species ecology, such as 'what is an acceptable degree of restriction on harvest?' (Healey 1997), turn out to have clearer answers if one evaluates the consequences for the rest of the ecosystem under a rebuilding policy.

Secondly, in *Back to the Future* the baseline relationship of the map's structure with the perceptions of the present state are integral, but changes in ecosystem structure may be rendered easier to conceive because the map already contains comparative elements of 'then and now' – rather like the geomorphological shadows of past coastlines or river beds on a landscape map. And major changes in peoples cognitive maps of ecosystems may be more easily accommodated than might at first sight be thought. For example, the dissonant image of a drowned landscape is conjured up by archaeologists retrieving stone tools from the present day sea bed, as has happened in Hecate Strait Northern British Columbia (Fedje and Christensen 1999). Hence, we think that the cognitive maps of humans are profound, subtle, complex and malleable enough to accommodate the possibility of major changes

for the better, despite everyday miserable evidence to the contrary. At one extreme, the world's great religions would not work if this were not so, but in our case, BTF expresses a hope that a future may see healthier fisheries and ecosystems, in sharp contrast to the pessimism surrounding fisheries policy both globally and in Canada.

Modelling is imperfect, even when uncertainty is accounted for as explicitly as possible. The *Back to the Future* cognitive map, based on a linked series of past and future model representations, is only a representation of reality: "The map is not the territory" (Korzybski 1995). So we may ask what of our policy goal for the future, derived from modelling that is imperfect and flawed? Another saying by the originator of the cognitive map concept, Henri Poincaré is relevant here "It is far better to foresee even without certainty than not to foresee at all."

REFERENCES

Ainsworth, C., Heymans, J.J., Pitcher, T.J. and Vasconcellos, M. (2002) Ecosystem Models of Northern British Columbia For The Time Periods 2000, 1950, 1900 and 1750. Fisheries Centre Research Reports 10(4), 41pp.

Axelrod, R. (1976) Structure of Decisions: the Cognitive Maps of Political Elites. Princeton Univ. Press.

Blake, W. (1795) Songs of Innocence and of Experience. London.

Brown, C.R., Brown, B.E. and Carpenter, C. (1997) Some of the traditional food gathering of the Heiltsuk Nation. BC Ministry of Education, Skills and Training.

Chaib-draa, B. and Desharnais, J. (1998) A Relational Model of Cognitive Maps. Intl J. Human-Computer Studies 49: 181-200.

Christensen, V. and Pauly, D. (1992) ECOPATH II: A system for balancing steady-state ecosystem models and calculating network characteristics. Ecol. Modeling 61: 169-185.

Christensen, V., Guénnette, S., Heymans, S., Walters, C., Watson, R., Zeller, D. and Pauly, D. (2003) Hundred year decline of North Atlantic predatory fishes. Fish and Fisheries 4: 1-24.

Cochrane, K.L. (2003) The use of scientific information in the design of management strategies. Pages in FAO Technical Report 424: 95-127.

Elton, C.S. (1927) Animal Ecology. 296 p

Fedje, D.W. and Christensen, T. (1999) Modelling Paleoshorelines and Locating Early Holocene Coastal Sites in Haida Gwaii. American Antiquity 64(4).

Finlayson, A.C. (1994) Fishing for Truth. Institute of Social and Economic Research, Memorial University, Newfoundland, 176pp.

Haggan, N. (1998) Reinventing the Tree: reflections on the organic growth and creative pruning of fisheries management structures. Pages 19-30 in Pitcher, T.J., Hart, P.J.B. and Pauly, D. (eds) Reinventing Fisheries Management. London, Chapman and Hall, 435pp.

Haggan, N. (2000) Back to the Future and Creative Justice: Recalling and Restoring Forgotten Abundance in Canada's Marine Ecosystems. Pages 83-99 in Coward, H., Ommer, R. and Pitcher, T. (eds) Just Fish: Ethics in the Canadian Coastal Fisheries. ISER Books, St. Johns, Newfoundland. 304 pp.

Haig-Brown, C. and Archibald, J-A. (1996) Transforming First Nations research with respect and power. Qualitative Studies in Education. Vol. 9 (3) 245-267.

Hardy, A. C. (1956-59). The Open Sea: its Natural History. Parts I and 2. London, Collins.

Healey, M.C. (1997) Comment: The interplay of policy, politics, and science. Can. J. Fish. Aquat. Sci. 54: 1427-1429.

Hutchings, J.A., Headrich, R.L. and Walters, C. (1997a) Reply: scientific inquiry and fish stock assessment in the Canadian Department of Fisheries and Oceans, and, Reply: The interplay of policy, politics, and science. Can. J. Fish. Aquat. Sci. 54: 1430-1431.

Hutchings, J.A., Walters, C. and Haedrich, R.L. (1997b) Is scientific inquiry incompatible with government information control? Can. J. Fish. Aquat Sci. 54: 1198-1210.

Krebs, C. (2002) Ecology: The Experimental Analysis of Distribution and Abundance. Prentice Hall, 608 pp.

Korzybski, A. (1995) Science and Sanity: an Introduction to Non-Aristotelian Systems and General Semantics. Institute of General Semantics, New York. 927pp.

Kosko, B. (1986) Fuzzy Cognitive Maps. Intl J. Man-Machine Studies 24: 65-75.

Lazlo, E,. Artigiani, R., Combs, A. and Csanyi, V. (1996) Changing Visions. Human Cognitive Maps: Past, Present and Future. Praeger, Westport, Connecticut, USA, 133pp.

Leopold, A. (1933) The Conservation Ethic. J. Forestry 31: 634-643.

Levi, A. and Tetlock, P.E. (1980) A Cognitive Analysis of Japan's Decision for War. J. Conflict Resolution 24: 195-211.

Magnusson, K.G. (1995) An overview of the multispecies VPA: theory and applications. Rev. Fish Biol. Fish. 5: 195-212.

Miao, Y. and Liu, Z-Q (2000) On Causal Inference in Fuzzy Cognitive Maps. IEEE Transactions on Fuzzy Systems 8(1): 107-1119.

Pauly, D. (1995) Anecdotes and the shifting baseline syndrome of fisheries. Trends Ecol. Evol. 10: 430.

Pauly, D. (1999) Fisheries Management: Putting our future in places. Pages 355-362 in Newell, D. and Ommer, R. (eds) Fishing Places, Fishing People: tradition and issues in Canadian small-scale fisheries. University of Toronto Press, 374pp.

Pitcher, T.J. (1998) "Back To The Future": a Novel Methodology and Policy Goal in Fisheries. Pages 4-7 in Pauly, D., Pitcher, T.J. and Preikshot, D. (Eds) Back to the Future: Reconstructing the Strait of Georgia Ecosystem. Fisheries Centre Research Reports 6(5): 99pp.

Pitcher, T.J. (2000) Fisheries management that aims to rebuild resources can help resolve disputes, reinvigorate fisheries science and encourage public support. Fish and Fisheries 1(1): 99-103.

Pitcher T.J. (2001) Fisheries Managed to Rebuild Ecosystems: Reconstructing the Past to Salvage The Future. Ecological Applications 11(2): 601-617.

Pitcher, T.J., Haggan, N., Preikshot D. and Pauly, D. (1999) 'Back to the Future': a method employing ecosystem modelling to maximise the sustainable benefits from fisheries. Pages 447-466 in Ecosystem Approaches for Fisheries Management, Alaska Sea Grant, Anchorage, USA, 738pp.

Pitcher, T.J. and Power, M.P. (2000) Fish Figures: Quantifying the Ethical Status of Canadian Fisheries, East and West. Pages 225-253 in Coward, H., Ommer, R. and Pitcher, T.J. (Eds) Just Fish: the ethics of Canadian fisheries. Institute of Social and Economic Research Press, St John's, Newfoundland, 304 pp.

Pitcher, T.J., Buchary, E.A. and Hutton. T. (2002a) Forecasting the Benefits of No-take Human-made Reefs Using Spatial Ecosystem Simulation. ICES J. Mar. Sci. 59: S17-S26.

Pitcher, T.J., Power, M. and Wood, L. (eds) (2002b) Restoring the Past to Salvage the Future: Report on a Community Participation Workshop in Prince Rupert, BC. Fisheries

Centre Research Reports 10(7): 55 pp.
Roberts, C.M.; Bohnsack, J.A.; Gell, F; Hawkins, J.P. and Goodridge, R (2001) Effects of Marine Reserves on Adjacent Fisheries. Science 294: 920-1923.
Sumaila, U.R. (2001) Generational cost benefit analysis for evaluating marine ecosystem restoration In Pitcher, T.J., Sumaila, R. and Pauly, D. (eds) Fisheries Impacts on North Atlantic Ecosystems: Evaluations and Policy Exploration. Fisheries Centre Research Reports 9(5). 94 pp.
Sumaila, R.S., Pitcher, T.J., Haggan, N. and Jones, R. (2001) Evaluating the Benefits from Restored Ecosystems: A Back to the Future Approach. Pages 1-7, Chapter 18, in Shriver, A.L. and Johnston, R.S. (eds) Proceedings of the 10th International Conference of the International Institute of Fisheries Economics and Trade, Corvallis, Oregon, USA, July, 2000. (on CD-ROM)
Tolman, E.C. (1948) Cognitive Maps in Rats and Men. Psychological Review 55(4): 189-208.
Walters, C.J. and Maguire, J. J. (1996) Lessons for stock assessment from the northern cod collapse. Rev. Fish Biol. Fish. 6: 125-137.
Walters, C., Pauly, D. and Christensen, V. (1999) Ecospace: prediction of mesoscale spatial patterns in trophic relationships of exploited ecosystems, with emphasis on the impacts of marine protected areas. Ecosystems 2: 539-554.
Walters, C., Christensen, V. and Pauly, D. (1997) Structuring dynamic models of exploited ecosystems from trophic mass-balance assessments. Reviews in Fish Biology and Fisheries 7: 139-172.
Watson, R. and Pauly, D. (2001) Systematic distortions in world fisheries catch trends. Nature 424: 534-536.
Wilson, E.O. (1984) Biophilia: The Human Bond with other Species. Harvard Univ Press. 176pp.

Papers in Abstract

This section reports the abstracts of papers, and their discussion, which were delivered at the conference, but which were not submitted as papers for this publication.

CHANGES IN TECHNOLOGIES, MARKET CONDITIONS, AND SOCIAL RELATIONS: THEIR LINKAGES WITH FISHERS' TRADITIONAL ECOLOGICAL KNOWLEDGE (NEW BRUNSWICK'S INSHORE FISHING FLEET IN THE SOUTHERN GULF OF ST. LAWRENCE).

Omer Chouinard and Jean-Paul Vanderlinden
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New-Brunswick's inshore fleet is, by tradition, practising a multi-species fishery. Nevertheless, technological changes as well as market conditions have increasingly led this fleet to specialize towards one (lobster) or a few species (lobster, scallop, herring). While the extent of this specialization is small in comparison to the specialization of midshore and offshore fishing fleets, it did have consequences in terms of fishers-resource interactions.

Using New-Brunswick's southern Gulf of St. Lawrence inshore fleet as a case study, the purpose of this presentation is to show how fishers' traditional ecological knowledge may have evolved in the face of technological changes, institutional changes and market conditions. Surveys were conducted with fishers between 1997 and 1999; these surveys were targeted at acquiring data on technological changes, changes in fishing strategy, changes in social relations, and changes in fishing territories. Analysis of these data allowed the identification of fishing territories as a key indicator of the inshore fishery's sustainability. From this indicator it is possible (1) to derive the evolution of fisher-resource interaction, and (2) to analyse the impact of this evolution on inshore fishers' ecological knowledge.

Fishers' ecological knowledge evolved in concert with the evolution of their knowledge of institutional and economic conditions. This knowledge contextualizes recent changes in terms of access to the resource (e.g., development of a native fishery) and in terms of management (e.g., bottom seeding of scallop beds). This allows a better understanding of the role that fishers' ecological knowledge may play in the future of fishery management.

DISCUSSION

Eduardo Espinoza
How is the information from fishermen evaluated?

Omer Chouinard
Fishermen asked for a wider space for both lobsters and crabs and were given the go-ahead in 1996, twenty years after they asked for it. There is a lot of waiting before regulation is implemented because the way of thinking is that fishermen have to solve the problems by themselves. But they can only do a certain amount on their own. They need assistance from the state.

Cyril Carpenter
I am from British Columbia and I am a retired fisherman. I worked in Newfoundland, New Brunswick, and Quebec. We overfished herring in British Columbia. We bought our boats in Panama and worked in your country. While we were there, the Canadian government allowed mid-water trawlers to harvest miles and miles of herring. When herrings were spawning, we asked the company to stop fishing but that didn't happen. There were circumstances beyond the power of fishermen that controlled the rules. We asked the company why they wouldn't let us stop fishing during spawning season when it is detrimental to the herring. When did the federal and provincial governments in the East support protection of the resources?

Omer Chouinard
As I mentioned before, it took a long time for the government to react. We know that the herring is in trouble and now they are more cautious with the resource. The problem is that fishermen tend to work where the herring spawn.

FISHING AT KOMODAH, KITKATLA TERRITORY: RETURNING TO SELECTIVITY

Charles R. Menzies and Caroline F. Butler
Department of Anthropology and Sociology, University of British Columbia, Vancouver, British Columbia, Canada

In response to a perceived decline in fish stocks, the Department of Fisheries and Oceans (DFO) has implemented a policy of selective harvesting in the Pacific fisheries of British Columbia, requiring avoidance or live-release of non-target species. DFO sponsored test fisheries have prioritized non-Indigenous fishing gears and technologies (such as fish wheels and mobile traps) and have seemingly ignored the ecological and technological knowledge of First Nations. In order for selective fishing strategies to be both

ecologically sound and commercially viable, gear and fishing methods need to be site specific in design. In this paper we describe a pilot project that explores the conservation potential of traditional Tsimshian fishing methods (primarily stone wall traps and beach seines). We have identified key elements of local ecological understandings and historical practices through working with Tsimshian fishers. This knowledge is critical for creating locally relevant and ecologically sound fishing technology.

DISCUSSION

Cyril Carpenter

I want to add more information on fish traps. We were active members in maintaining them. Contrary to what the fisheries are doing, what we did was take the small and weak for our food, open the gates when we had enough, and chased them out of the traps, and let them out when they were ready. We have archaeological evidence of fish traps over 400 years old with gates to chase the salmon out when we had enough to process for one day. It enhanced the stock in that it allowed the strongest of the species to go upstream. In Bella Bella and other places this has been going on for over 5000 (is this right?) years. Now we take the biggest and most vibrant out of the stock because we are using big mesh gear.

Saudiel Ramirez-Sanchez

How do you approach the problem of the technology when you only look at that aspect? When First Nations use their knowledge, there are values attached to it that you didn't mention. If you want to use their traditional knowledge again, how would you reattach the values to them?

Charles Menzies

I have to confess to being a materialist in that I see knowledge emerging out of the utilization of the resource. We have different cultural frames, but the day-to-day interactions, if you listen to elders, entail very detailed information. I think that it's important for people to remember the values, but knowledge is not necessarily structured by a cultural framework. I start from the directly observable.

THE LEADERSHIP ROLE OF CALIFORNIA FISHING MEN AND WOMEN PROMOTING SCIENCE IN FISHERIES POLICY AND FISH RECOVERY

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Organizations representing commercial fishing men and women have played a key leadership role for over quarter of a century in California bringing science to bear on fishery policy and efforts to restore fish habitats and populations. Programs initiated by the fishing industry for the restoration and management of a number of fisheries, and support for legislation to tax themselves, include, among others: research into the cause of the decline in Dungeness crab populations, research into spawning herring populations, and research into the biology of market squid. In addition to incorporating a role for science in the policies they initiated, California fishing men and women also became engaged in lending their knowledge, skills and assistance to marine scientists including: albacore research, collecting information on watersheds on salmon populations and also on rockfish in nearshore waters.

Several fisheries restoration projects began as concepts initiated by the fishing industry, which integrated science with agency managers, and resulted in the development of new tools for stock assessment and management. Currently in its eighth year, the Sacramento River Winter Run Chinook Captive Broodstock Program is providing groundwork for recent interagency proposals to preserve endangered coho salmon using similar science-based intervention rules and technologies. This success facilitated the formation of additional partnerships with recreational anglers, thereby gaining national attention in the role of Non-Government Organizations (NGOs) working with scientific institutions in coastal salmon recovery efforts. More recent examples of academic-industry partnerships are fishery supplementation initiatives to enhance San Francisco Bay ecosystem function and environmental services, in particular for native herring and oysters.

New large scale coastal observations have been proposed using fixed platforms and biological sampling together with the local knowledge of fishing men and women underpinning the development of the science necessary to create

marine protected areas. Active participation of fisherfolk in the measurements necessary to reduce uncertainty in marine and aquatic systems is essential for creating information and social equity – THIS MAKES NO SENSE. Potential benefits of academic-industry partnerships will need to expand to embrace other issues such as invasive species, which are as large a threat to ecosystem function as the collapse of fisheries. Active participation in science by well-informed industry and NGOs helps to increase the flexibility of bureaucratic decision-making systems that traditionally resist change and ignore the biological consequences of inaction.

DISCUSSION

Eduardo Espinoza
We have the same situation in the Galapagos. How do you get fishermen's participation?

Natasha Benjamin
The fishermen are coming to us when they see a problem with the resource.

Eduardo Espinoza
Do you have any salaries for them? We have a participatory process with the fishermen and they want a salary because they lose days out at sea when they attend meetings.

Natasha Benjamin
A lot of these are volunteers. We try to use fishermen in those projects and we try to give them money when we can.

Eduardo Espinosa
That is a cost for the participatory process because then in the future you need to pay them every time.

Natasha Benjamin
We have incorporated them in our research program, and they get compensated for them.

Ed Burton
Is that getting serious play in DC?

Natasha Benjamin
There are quite a few co-sponsors. They have just been introduced.

Unknown
Does the federation represent all fishermen and species?

Natasha Benjamin
It is definitely focused on salmon and albacore.

Sheila Heymans
I don't know about First Nations in California. Did they catch these species as well, and do they still participate in the fishery?

Natasha Benjamin
I don't know about the First Nations in California.

Sheila Heymans
Can they be part of the federation if they want?

Natasha Benjamin
Yes, but membership mainly comes from the commercial fishery.

Burton Ayles
What is an urban commercial fishery?

Natasha Benjamin
It is the fishery which takes place in San Francisco bay in the middle of the city.

Kathy Scar
In the PCFFA, is there mandatory participation? Is it a volunteer organization? Is there funding that goes towards research?

Natasha Benjamin
Participation is for people who want to participate and get involved with the legislation. Once the bill is passed, it covers the entire fishery. The California Fish and Game controls the funds.

INCORPORATING INDIGENOUS INTERESTS AND KNOWLEDGE INTO MANAGEMENT OF THE GREAT BARRIER REEF MARINE PARK

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The Great Barrier Reef Marine Park was established in 1975 and covers an area of more than 346 000 square kilometers. It is the largest World Heritage Site in the world, and the largest multiple use Marine Protected Area. It includes the maritime estates of over 40 coastal indigenous groups of Australia.

In the mid-1990's the Great Barrier Reef Marine Park Authority (GBRMPA) embarked on a review of management of the Far Northern Section of the Marine Park which covers an area of approximately 85 000 square kilometers. The Far Northern Section lies adjacent to Cape York Peninsula, a remote region which is often stated

to be an indigenous domain where indigenous peoples represent the majority of the population and have an ongoing cultural relationship with the land and sea. Indigenous people with connections to the Far Northern Section of the Great Barrier Reef Marine Park engage in turtle, dugong, finfish, crayfish, and shellfish fisheries, and have historically been involved in pearl, beche-de-mer and trochus fisheries.

The review of the Far Northern Section was primarily aimed at meaningfully involving indigenous groups in marine planning and management, whilst reviewing the conservation requirements of important marine habitats and species. The review is the largest marine planning exercise of its type conducted in Australia to date. Negotiations took place with over 12 indigenous groups between 1995 and 1999, and involved GBRMPA, Queensland Fisheries Service, Queensland Parks and Wildlife Service, the commercial fishing industry, recreational fishers, non-government conservation organizations, and the general public.

Indigenous knowledge of marine species and habitats, in conjunction with cultural values, have been incorporated into a package of proposed plans and strategies for management of the Far Northern Section, including: a new Zoning Plan which is due to come into force late in 2001, formal agreements regarding the development and implementation of more detailed Marine Park management strategies, and roles in day-to-day management.

However, as time passes, indigenous aspirations have shifted from desiring high levels of marine protection towards improved fisheries management and economic advancement, and there is an increasing focus on the requirement to incorporate indigenous fisheries interests into the wider fisheries management framework, and to recognize the special interests of indigenous groups with custodial obligations to care for 'sea country' in fisheries management. The debate over the existence of Native Title in the marine environment continues, and political priorities of governments also change over time.

USING FISHERS TRADITIONAL KNOWLEDGE TO IDENTIFY PRIORITY AREAS FOR CONSERVATION IN THE PACIFIC OCEAN

Lance Morgan
Marine Conservation Biology Institute, Redmond, WA, USA

In some ways, conservation in the sea is no different from conservation on land; protecting places is a more comprehensive, robust, cost-effective and politically viable strategy than imposing separate regulatory regimes on each species. Interest in marine protected areas (**MPAs**) as a new paradigm for conserving marine biodiversity and strengthening fishery management has increased dramatically in the last few years because the dominant paradigm–command-and-control regulation–has failed to stop biodiversity loss and fisheries collapse. In the sea, as on land, successful place-based strategies require identifying conservation targets, so the first step of a rational MPA strategy is producing a map of the most important places to protect.

A credible map of delineated and named priority areas would catalyze progress in marine conservation by making them tangible in the minds of people. The conventional approach to priority area designation is by means of a workshop of scientific experts. While this results in the production of a map it remains lacking due to several key reasons. Priority designation is first and foremost a subjective term and needs to be clearly defined. Second, place-based knowledge in the sea is patchy at best among scientists and little information is available that has significant temporal resolution. Thus the opportunity to use fisher's knowledge in these efforts has high potential for assisting in documenting priority areas. Accessing and interpreting this information however remains an outstanding challenge. Here I describe our approach to delineating priority areas in the Northeast Pacific Ocean and the role for fishers' knowledge in the process. As the interest in MPAs increases many groups are initiating efforts that could contribute to a map of priority areas, and everyone involved—scientists, managers, NGO staff—would benefit by incorporating traditional knowledge of fishers.

DISCUSSION

Bob Johannes
Did you have any experts on marine TEK in your group?

Lance Morgan
Not specifically. There were a few people who were involved in it. One of the tasks was to talk about it.

Chad Paul
In Canada, the fish stock is prioritised in the following way: the first priority is for conservation, then for aboriginal use, then for recreational use and what they term other stakeholders. 9% of British Columbia is not under a treaty. If you want to consult in my area you should not use "stakeholders".

Lance Morgan
I apologise for that.

Ted Ames
On the issue of fishermen versus scientists, you mentioned that scientists focus more on species and fishermen focus more on family and self. I take exception to that because fishermen are saying that they're a part of the system too. They are not severed from the fishery.

Lance Morgan
I agree. Part of it is trying to reflect the conversation that we had. It's not perfect. The other part is that, as I said, it's a generality that we're trying to fix.

Simon Lucas
I come from the Hesquiat Peninsula. I know what you're trying to achieve, but what made our Hesquiat nation whole is that about 20 years ago, there used to be a commercial seine fishery in our area and the elders said "No, it's against our philosophy" so we got rid of it. Most of the communities you showed are First Nations people. In British Columbia, you say that you will have marine parks and you will consult with environmental groups. You have to make sure that you consult across the board. Consult with the First Nations too, and not just grab some Indian off the street to ask his opinion.

Lance Morgan
What will happen is that large regions will be selected and there will be intensive effort within a smaller region.

Simon Lucas
One of the problems in Nuu-chah-nulth is the overpopulation of sea otters. We have to talk to lots of people to get rid of them. Our neighbours have no more clams or sea urchins because of them. One of the things you have to remember is that one of the most endangered species on the coastline is our people.

THE NOVA SCOTIA LEATHERBACK TURTLE WORKING GROUP: A MODEL FOR SUCCESSFUL COLLABORATION BETWEEN FISHERS AND SCIENTISTS

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The leatherback turtle (*Dermochelys coriacea*) is a highly pelagic marine reptile. Therefore, working with this species anywhere but on nesting beaches is challenging. When we began studying the distribution of the leatherback in Atlantic Canada, we addressed this difficulty by turning to commercial fishers for help. Fishers have some of the best opportunities to observe leatherback turtles at sea, although their observations of this species are traditionally unreported. In 1998, we enlisted the assistance of more than 200 volunteer fishers in reporting turtle sightings. In just one season, we collected 171 geo-referenced sightings of leatherback turtles—more than twice the extant number of published records of this species in Atlantic Canada. Our findings served to further substantiate an earlier claim (Bleakney, 1965) that these animals are seasonal migrants to Canadian waters. As important as the data that we collected, is what made that data collection possible: developing and maintaining our relationship with the volunteer fishers. Our current level of knowledge of the movements and distribution of this critically endangered species could not have been possible without journeying first into the heart of one Nova Scotia's most vital cultures, the fishing community, complete with its brand of politics, family structure, and vernacular.

DISCUSSION

Ian Baird
You mentioned that fishers were not likely to be willing to contact you if you were associated with environmental groups, yet one of your posters says that you receive funds from the World Wildlife Foundation.

Kathleen Martin
That's one of the first posters that we made. Fishers did call with concerns over it. They were not necessarily interested in being involved

because they were wary of the World Wildlife Foundation.

Shauna Rheiswitz
Did you get any historical sense from the fishers about changes in the population? Are the leatherbacks less abundant or more abundant?

Kathleen Martin
They appear to be just as abundant, which is exciting when you're working with endangered species. However, we cannot be sure because we may be surveying in an important foraging ground. When we talked to the fishermen, they said that their grandparents saw them and had photos. They knew when the turtle season began. There are years that appear to be bumper years, like 1997, when 25-30 turtles appeared in St. Arliss Bay.

Shauna Rheiswitz
Are those bumper years related to El Nino?

Kathleen Martin
I don't know – it could be. We just started, so we cannot say at this stage. There could be a cycle that we aren't aware of yet, like a two-year nesting cycle.

TRADITIONAL ECOLOGICAL KNOWLEDGE IN OCEAN AND COASTAL MANAGEMENT: A SURVEY OF RECENT EXPERIENCE IN ATLANTIC CANADA

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In Canada's Atlantic Provinces, scientific researchers and community development practitioners have long worked with organizations and individuals to collect and apply traditional ecological knowledge. In this paper we review several recent projects supported by Fisheries and Oceans Canada. Since the early 1990s, ocean and coastal planning staff of the Department have worked with a range of indigenous and non-indigenous communities to document traditional knowledge. Most of these projects have involved semi-structured interviews, mapping, some level of verification and digital treatment with geographic information systems. Community participants have volunteered information on ecology and patterns of use as well as local perspectives, such as attachment to place. The precise collection methodologies have varied somewhat between projects and regions, but the results are generally comparable. Valued coastal resources and medicinal plants have been inventoried through a collaborative project with Bras d'Or Lakes Mi'kmaq. Inshore fishing grounds have been mapped for most areas of Atlantic Canada. Observations of spawning and juvenile fish have been documented in the Bay of Fundy, on the Scotian Shelf and in eastern New Brunswick. Other sensitive areas, including the locations of deep-sea coral, have also been described. Applications fall into several broad categories. Traditional knowledge has been used to supplement scientific data for environmental assessments in aquaculture and hydrocarbon exploration. In a planning context, traditional knowledge has been used for search and rescue, marine protected area selection, oil spill response planning, education and communication. Cartographic portrayals of different activities in space and time have supported conflict resolution in fisheries management and in multiple use ocean environments. In a final application, we describe how fishers' knowledge was used in the planning stages of a multibeam survey and later, a scientific survey of coral habitat. The paper concludes with a discussion of successes, failures, and lessons learned.

DISCUSSION

Vivian Barrier
I work with a Salish tribe in Puget Sound. How do you carry across the knowledge to the table without losing all the details, especially if the information can only be used for conservation and fisheries management?

Paul Macnab
That's not something the government will take to the table ever. The knowledge resides in the community, and it is up to the community to decide whether they want to bring it to the table or not. Some of the comments on the last few slides don't apply to the Mi'kmaq.

THE TULALIP TRIBES CULTURAL STORIES PROJECT: RECORDING AND USING TRADITIONAL KNOWLEDGE FOR CULTURAL LANDSCAPE RECOVERY, WATERSHED MANAGEMENT AND SALMON PROTECTION

Terry Williams, Julia Gold and Preston Hardison
Tulalip Natural Resources, Marysville, WA, USA

Over the past two centuries, the ancestors of the Tulalip Tribes have witnessed great changes to the health of their homelands – the salmon return in fewer numbers to spawn, many of their traditional relationships to the land have been

broken, and many culturally important species and habitats have dwindled. Over the past two decades, the Tulalip Tribes have embarked on a program to manage and restore their watersheds and protect and recover habitat for salmon. For indigenous peoples, any environmental restoration involves biocultural restoration, since the culture cannot be separated from the land. The Cultural Stories Project has been developed to complement the biophysical models the Tulalip developed for watershed management. The project uses interviews with elders and other tribal members to document the cultural and traditional uses of resources and their importance to Tulalip Tribal members, whose stories are used to characterize historical cultural landscapes and resources, the perceived current state of these landscapes and resources, and the future desired states. This information is correlated against historical accounts from the literature and scientific documentation, and these are then integrated into the biophysical watershed models to establish a vision for restoration efforts. We describe the methodology for this process, some of the software tools developed, and issues concerning privacy, indigenous knowledge protection, and the use of indigenous knowledge in interaction with external federal, state and municipal agencies involved in watershed management and Pacific salmon endangered species protection. Finally, we explore the importance of this process for the cultural health and well being of the Tulalip Tribes and their homeland.

ENVIRONMENTAL SENTINELS: REFRAMING COMMERCIAL FISHING IN PURSUIT OF VALUE, INTEGRITY AND SUSTAINABILITY

Bryan Price
SARDI Aquatic Sciences, Henley Beach, SA, Australia

The traditional western model of fisheries science emphasized the importance of "independent", high quality scientific advice – which is most commonly utilized to support the power of the relevant political authority /management organization. Regardless of purported institutional aims, actual incentives for fisheries scientists to effectively service stakeholder or resource needs are usually minimal or negative.

Fisheries science may at times have high explanatory value; but is also commonly very expensive, involves small sample sizes relative to environmental variability, and has been prone to overlook factors that are "common knowledge" to grass-roots fishermen. Societal environmental expectations (and impacts) require an increasing burden of monitoring and research on aquatic environments – all of which are necessarily parasitic on the same limited (usually decreasing) revenue stream.

South Australia's River Murray Fishery and Lakes and Coorong Fishery have grasped environmental and resource monitoring as an opportunity to dramatically change the perception and profitability or their small-scale fisheries. Specific voluntary, self-funded initiatives they have working now include:

- A daily resolution, location-specific environmental data collection system (inclusive of habitat, pollution, human use and icon species quantification);
- A GIS-based model linking habitat data to location-specific daily catch-effort data that quantifies the impacts of management on fish abundance and health;
- A cooperative stock assessment system whereby industry research is "benchmarked" by independent, cost—effective fisheries science

Resulting data already have high management value (e.g. Coorong National Park now uses data on tourist use in operational management and future planning). In the River Murray Fishery, the replacement value of core data actually exceeds the annual production value of the fishery. Perceived integrity of fishers, especially with environmental groups, has increased beyond any expectations. Knowledge is power, and these fishers now express increased control over their own fishery's destiny, as well as greater ownership of the sustainability of the aquatic systems on which their futures depend.

DISCUSSION

Saudiel Ramirez-Sanchez
I think your typology for power is interesting. You say that information is power, but information by itself isn't power unless you structure it in different ways. By presenting information in a certain way, you also exercise power.

Bryan Pierce
Yes, that's true, but I argue that's principle-based power because we are expressing what we believe.

DEVELOPING A SET OF INDICATORS FOR EVALUATING THE CONDITION OF A RESOURCE. CASE: FRESHWATER FISHERIES IN LAOS PDR.

Niels Jepsen1, Douglas Wilson2 & Sommano Phounsavath3
1Danish Institute for Fisheries Research, Dept. of Inland Fisheries, Silkeborg, Denmark; 2Institute for Fisheries Management and Coastal Community Development, Hirtshals, Denmark; 3Living Aquatic Resource Research Centre, Vientiane, Lao PDR

Indicators of ecosystem health have emerged as a popular concept among fisheries management professionals who think they have the potential to provide useful information to managers that can be clearly communicated to stakeholders. Through a project involving several case studies in Asia and Africa, we tried to define a list of parameters or indicators that are simple, robust and make sense to the local people. These indicators can be evaluated through the knowledge of both fishers and fisheries science professionals and thus provide a biologically valid base for management actions. The relevant indicators will vary between areas and types of fisheries, but we hope that the approach and the methods will have global relevance.

Through interviews with fishers along the Xe Don River, a Mekong tributary in Laos, we have attempted to learn the ways that local people understand the condition of the resource and what information they believe indicates changes in this condition. Our main purpose is to explore how the "indicator approach" can be helpful in making statements about the condition of the resource, which can be utilized in management. We have identified a list of candidate indicators, which may prove to be a valuable tool in the management of the fisheries. The indicators are currently being evaluated for both sociological and biological validity by a cross-disciplinary team through collected data as well as literature reviews. The final evaluation of the indicator-approach will be performed after six additional case studies have been carried out.

DISCUSSION

Richard Hamilton
From all the talks that we've heard, it looks like there is a lot of emphasis on Laos and the Mekong River. What is the objective? Is it to help the people there and improve the fisheries?

Niels Jepsen
There are different objectives, but when we choose our case studies, it is to reduce cost. We go into places that already have things going on and build on top of the projects. That's part of the reason. Another part of it is that the Mekong is very important and has had problems in its fisheries, so there is need to do some kind of management there. There are also case studies of coastal fisheries and different types of fisheries. We are trying to spread this out and learn from all these case studies.

Ian Baird
I also thought that your project had something to do with discourse analysis between government and people, but you don't mention much about it in your talk.

Niels Jepsen
That's because we haven't done it yet. We will do it next month.

A METHOD TO ESTIMATE THE ABUNDANCE OF ARAPAIMA GIGAS (CUVIER 1817)

Leandro Castello
Instituto de Desenvolvimento Sustentável Mamirauá, Tefé-Amazonas; Brasil

Arapaima gigas is an over-exploited commercial fish species in the Amazon. This work aims to develop and test a method to assess *Arapaima* wild populations. A team of 8 local fishermen made direct counts of *Arapaima* individuals (juveniles and adults) in closed lakes. The validity of the counts was tested through the comparison of its estimates with mark and recapture abundance estimates for the same populations. The applicability of the counting method was tested surveying 105 lakes. The replicability of the method was tested through a series of experiments aiming the method's dissemination- THIS DOESN'T MAKE SENSE.

The correlation between the counts and the mark and recapture estimates is high (r^2=0.99). The size-classes estimation is also considered reliable (juveniles: r^2=0.95; adults: r^2=0.96). 987 adults and 2963 juveniles were counted in 105 lakes. Higher densities of adults were found in unfished lakes. The dissemination of the method was confirmed by a series of high correlation indices (r^2=0.87; r^2=0.92; r^2=0.79).

The counting method is accurate, precise and cheap. The higher abundance of older individuals found in the unfished lakes suggests site-fidelity. The method can be taught from one fisherman to another without the use of mark and recapture abundance estimates. The methodology proposed is considered ideal for community based fishery management programs. Particularly this work shows that

fishermen's empirical knowledge may be the best tool for management of *Arapaima*.

DISCUSSION

Christina Soto

If you didn't have abundance of the fish, on what basis was the fishery closed?

Leandro Castello

That's a problem in the Amazon. Decisions are made based on nothing or on biased reports. We don't have good studies on the status.

Christina Soto

Were any fisheries reopened as a result of this technique?

Leandro Castello

Yes. An extension team applied this research within these communities. We had special permits from the government to do this legal harvesting.

Kathy Scar

I'm really impressed with the work done here. One of the reasons why it was so different is that the focus isn't on how to get villagers to give data to scientists and let them go off and use it. Rather, the focus is on how to maintain fishers' knowledge and share that knowledge within a community, particularly at a point in time when fisheries all around the world are being shut down and there is no information transfer between generations. You've taken that information and demonstrated that there is value in it, and allowed fishermen to help fishermen. This isn't about how to get information when I already have a lot of knowledge. I'm really impressed and I was wondering whether or not that concept of fishermen training fishermen is adopted anywhere else.

Leandro Castello

This knowledge only exists in populations where the population is healthy, so there is interdependence between the fish and the knowledge. Both fish and knowledge have to exist so they can both be managed. Today there are only 4 communities using this method and they are getting very good results. We have 30 communities that are implementing this strategy and hopefully in a couple of years, we will have 34 communities using it. Although this method may seem ideal, do take into consideration that the Amazon has over 1000 communities. We can't ever reach them all.

USING FISHERS' KNOWLEDGE TO EVALUATE GREAT LAKES FISHERY MANAGEMENT POLICY

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Fisheries management in the Laurentian Great Lakes remains a challenge due to the low abundance of native lake trout stocks (*Salvelinus namaycush*), the introduction of invasive aquatic species, lack of cooperative management between tribal and state regulatory agencies, and social conflict between treaty-right Native commercial fishers and non-Native state-licensed, recreational sport fishers. Since 1985, fisheries management in the Great Lakes has been governed by a court-imposed fisheries management policy—the 1985 Consent Decree/Order. This policy utilized unique management provisions to promote: 1) conservation and rehabilitation of lake trout, 2) reduction of violence and discord between treaty-right Native commercial fishers and state-licensed sport fishers, 3) equitable fishery allocation, and 4) more collaborative management between state and tribal regulatory agencies. To assess the effectiveness of the 1985 Consent Decree/Order at achieving these goals, individual, in-depth interviews were conducted with tribal commercial fishers and state-licensed sport fishers, as well as biologists and representatives. Exploration of fishers' knowledge provided fundamental insight into how this fishery management policy impacted the Great Lakes fishery and critical socioeconomic variables—such as social conflict, economics of the fishery and fishing opportunities—that previous assessments have not provided. Furthermore, their knowledge offered a rich context for understanding changes to the fishery over time, such as the movement of fish stocks with warming water temperatures and diminishment of fishing opportunities for Native small-boat commercial fishers.

DISCUSSION

Christine Dyer

How does your evaluation affect policy?

Laura Cimo

During the negotiations for the recent agreement, the Court put a gag order on the parties so we could not talk to them about policy. The result was that they did not use this information and the fishers were not consulted, as happened in 1985. We are hoping that there is

an opportunity to present this information in the upcoming discussions for inland fishing treaty rights.

Saudiel Ramirez-Sanchez
The previous presentation argued that knowledge is shifting. If you bring in the voice of people into policy, how do you deal with the shifting knowledge? Policy cannot predict how knowledge is changing.

Laura Cimo
Knowledge is flexible, but the policy is structured so that you could not change it and so people keep going to court. We would like to have more flexible agreements. I think the latest 2000 agreement is more flexible. Hopefully we will have better dispute mechanisms, but I don't know if that will work. There is a real power differential – the state has power.

The Fishermen and Scientists Research Society: Collaborative Improvement of the Knowledge Base for Modern Fisheries Management

Kees C.T. Zwanenburg1, P. Fanning, P. Hurley and W.T. Stobo
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The collapse of the eastern Scotian Shelf cod fishery in the early 1990s was the catalyst for development of the Fishermen and Scientists Research Society (FSRS). Fishermen were faced with devastating declines in incomes while the Department of Fisheries and Oceans (DFO) suffered staff and budget reductions and a deteriorating relationship with its clients and the general public. A new model, which would improve the scientific basis of stock assessments and re-build trust between scientists and fishermen, was needed. The FSRS was established in 1994 to bring fishermen and scientists together to share information and conduct collaborative research in support of long-term sustainability of fisheries. The project was designed to obtain more accurate indicators of fish stock health and establish viable methods of co-operation and collaboration. At present the Society has over 200 members throughout Atlantic Canada, manages a comprehensive annual survey of fishes, and is involved in a wide range of research project in collaboration with DFO, NGO's and Universities. We trace the development of the Society from the early steps of developing a common language and overcoming mistrust, to the present organization, which brings fishermen's knowledge into the scientific arena and provides an effective forum for deliberation of issues germane to the long-term viability of fisheries. We also review results of a number of major co-operative research initiatives of the Society.

Discussion

Kathleen Martin
You said that the projects were generating revenue for themselves. What do you do to raise funds?

Paul Fanning
The government funds them and any overhead is retained by the society. When lobster biologists wanted to do a study, they were able to take money from the DFO to contract scientists. It was fairly cheap because we made the fishermen buy the traps themselves. It still requires coordination, but we are only talking about small amounts of money, on the order of $1500 or so. Fishermen can't do these things on the water for free, so there has to be some amount of money. At the very least, we have to cover their expenses.

Chad Paul
You were saying that your organization involves vested interests. What about Mi'kmaq? Are they involved?

Paul Fanning
They aren't yet because the background of the organization is groundfish and they haven't taken an interest in it. Their interest is mainly in lobsters and the gulf area, neither of which is in the organization. The society is of limited geographical scope and does not take representative membership. Members come into the society if they wish. Some scientists from DFO are involved and some are not. Sometimes they start out with projects that work with the organization, and end up joining it. There are members of the society that come from a Mi'kmaq background, but they don't represent the Mi'kmaq.

FISHERIES IN THE GALÁPAGOS ISLANDS: THE PARTICIPATION OF FISHERS IN FISHERY MANAGEMENT

E. Espinoza, J.C. Murillo, M.V.Toral, R.H. Bustamante, F. Nicolaides, G.J. Edgar, J. Moreno, C. Chasiluisa, M. Yépez, J.C. Barreno, S. A. Shepherd, J. Viscaino, M. Villalta,R. Andrade, A.F. Born, L. Figueroa1, P. Guerrero1 y M. Piu1
Área de Investigación y Conservación Marina, Estación Científica Charles Darwin
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Exploitation of marine resources within the Galapagos Archipelago has passed through several phases in which whales, fur seals and lobster were exploited. Recently, with the commencement of a sea cucumber fishery in 1992, fishing capacity increased greatly. In order to reduce threats to the natural values of unique Galapagos marine ecosystems and provide a scientific basis for sustainable management of Galapagos fishery resources, a joint fisheries monitoring program (Programa de Monitoreo de Pesqueria - PMP) involving the Charles Darwin Research Station, the Marine Resources Unit of Galapagos National Parks and the four Galapagos fishing cooperatives has been operating since January 1997.

Within the framework of the PMP, monitoring of fishing activity and catches now occurs cooperatively on a daily basis. Management decisions are made on the basis of the fisheries knowledge existing in the fishers' community. This process is institutionalized in a participatory process that involves the local users of the Galapagos Marine Reserve and the results are directly utilized by the decision-making bodies.

The present paper summarizes the state of the development of the participatory process and the implementation into sustainable fishery management procedures.

DISCUSSION

Laura Cimo
A few years back there were real problems between fishers and the marine park service. The fishers started to protest and destroy the homes.

Eduardo Espinoza
Yes, that's true. We are trying to build new relationships.

Laura Cimo
Do you think relations are regrouping?

Eduardo Espinoza
All relations are better than they were two years ago but rebuilding is a long process.

Achutosh Sarhur
You distinguished between fishers' knowledge and scientific knowledge - is fishers' knowledge not scientific?

Eduardo Espinoza
By scientific knowledge I mean the information that scientists are getting without the fishermen. The data we get from the fishermen is fishers' knowledge.

HOW CAN WE HAVE MORE PARTICIPATION BY THE FISHERMEN IN FISHERIES SCIENCE?

Virginia Boudreau
Guysborough County Inshore Fishermen's Association, Canso, Nova Scotia, Canada and Social Research for Sustainable Fisheries, Community Research Coordinator Social, St. Francis Xavier University, Antigonish, Nova Scotia, Canada

There has been a change in view on research and what research is by the fishermen since this partnership "Social Research for Sustainable Fisheries" has started. Before the fishermen engaged in research it was thought of as something to use to change something that DFO had decided to do. Since this project, research is now regarded as something that will answer the issues and concerns that are important to them, the fishermen, to understand what is going on in their ecosystem – to enable them to do something about it or to stop doing something harmful, regardless of DFO decisions. This has resulted in a change in perception of the fishermen as to what fisheries science is.

Discussions of the challenges, services and benefits to engaging fish harvesters in fisheries science from the perspective of a fishermen's association are: volunteer base; contact (regular) with the membership; administrative /managerial base to work from; finding a way to pass on information and skills. The fishermen want to have a role in policy changes because such changes affect the very lives of the fishermen and their families. The big question is how to go about this.

There are also many challenges to community-based research – we are trying to gather information, to "research" the local fisheries in a way that is defensible, credible and transparent – in a manner that will stand up to inspection at all levels to be considered "fisheries science". The impacts of having a community-based, directed

and conducted research carried out by familiar people within the identified community are undetermined. This is a question that has arisen within our own project – are we compromising the credibility of this work by carrying it out ourselves? Should we disengage ourselves from the information gathering process to minimize potential bias and invisible influences? Can research carried out at a truly grass-roots level be considered valid and stand up to rigorous inspection in a fisheries science environment?

DISCUSSION

Bryan Pierce
How has the academic community embraced being approached by fishermen who are initiating these projects?

Virginia Boudreau
It is extremely receptive. Most of the issues that fishermen identify are not just personal issues. They may be specific to the area, but there are commonalities as well, so academics are welcoming the initiatives.

Denise McCullough
I would like to know what sort of research the fishermen do.

Virginia Boudreau
For this particular project it is social science.

Robert Blyth
What percentage of fishermen in the county are involved in your association?

Virginia Boudreau
Approximately 85% belong to the inshore association. There is a Halifax county groundfish association that the others are involved with, and some are involved in both.

Robert Blyth
Why aren't the remaining 15% involved?

Virginia Boudreau
They are not involved because we don't have a groundfish management board. Although there are fishermen with groundfish licenses, they are not active. They belong to the Halifax county association.

THE LEGAL AND INSTITUTIONAL CONTEXT OF INCORPORATING INDIGENOUS KNOWLEDGE INTO FISHERIES MANAGEMENT

Terry Williams and Preston Hardison
Tulalip Natural Resources, Marysville, WA, USA

In the last two decades, indigenous knowledge has increasingly become an object of national and international law and policy. An increasing number of international processes are beginning to address legal and ethical issues surrounding the use of traditional knowledge, such as formal United Nations conventions, intergovernmental agreements and standards of practice, non-governmental organization policies, and academic society ethical guidelines. Indigenous peoples themselves are increasing their involvement in these processes, but their involvement at the international level is problematic and uneven. Here we review the evolving context of indigenous standing in international conventions such as the Convention on Biological Diversity (CBD), the United Nations Human Rights fora, (the International Labor Organization (ILO) 169, the Draft Declaration on the Rights of Indigenous Peoples, the Working Group on Indigenous Populations and the Permanent Forum for Indigenous Peoples), and the conventions administered by the World Intellectual Property Organization (WIPO). We then review some of the major policy and guideline documents from inter-governmental organizations (IGOs) and non-governmental organizations (NGOs), focusing on those related to fisheries management. We then review the significant barriers to the development and implementation of these laws and guidelines in national law and standards of practice. Foremost among these are 1) the lack of substantial indigenous participation in the drafting of these norms; 2) the related problem of communication between these international processes and indigenous and local communities; 3) the issue of tribal sovereignty and government-to-government relations; 4) the limitations of contract law; 5) the difficulties of defining and obtaining "prior informed consent" for the use of traditional knowledge, and 6) the existence of indigenous social movements to block the "biopiracy" of indigenous knowledge. We suggest policies to surmount some of these barriers.

FISHING IN MURKY WATERS
ETHICS AND POLITICS OF RESEARCH ON FISHER KNOWLEDGE

Anita Maurstad
Associate Professor, Norwegian College of Fishery Science/University of Tromsoe, Tromsoe, Norway

Fisher knowledge is increasingly seen as an important source of information for the management of fisheries and natural resources. Many academics and managers are involved in projects with the purpose of documenting and gathering this knowledge. With reference to my own experiences with interviewing Norwegian fishers on local knowledge I will discuss problematic ethical and methodological aspects of such documentation. Fisher knowledge is embedded in a social and cultural context and transfer of knowledge is relational. Fisher knowledge is also a professional asset, and contains information that is often known only to a small group of local people. Transferring fisher knowledge to science puts fisher knowledge in a completely new setting and the question is what it implies for fishers to have their knowledge moved beyond its traditional borders.

DISCUSSION

Colin Scott
One of the big differences between the situation you are describing and the indigenous cultures that I have worked with is that there is an assumption within these cultures that knowledge belongs to the community and that it is not safe to share knowledge into a centralized control. This is different from what you have been describing. It seems that the Norwegian fishers have the cultural assumption that the state is still the central authority. Perhaps that is what makes the fishers think that sharing of this knowledge is dangerous.

Anita Maurstad
There is a very ambiguous relationship between Norwegian fishers and scientists. In a way they collaborate and are very close – the scientist does the data collection and fishers contribute. But on the other hand there is distrust when the fishers feel that they do not get a voice. In an institutional context, trust can be defined according to how the knowledge is used. Today there are many interests who can access and use local knowledge for their purposes – there are many new actors now such as the tourist industry and other parties that can access this knowledge. Up to now there has not been a sharing kind of relationship.

BUILDING NETWORKS FOR INDIGENOUS KNOWLEDGE AND ENVIRONMENTAL MANAGEMENT

Preston Hardison
Tulalip Natural Resources, Marysville, WA, USA

Indigenous knowledge presents many complexities for information management. Focusing on indigenous knowledge itself, developing norms suggest that much of what has been considered in the public domain should be protected, either through laws or through ethical guidelines for traditional publishing or use. Other difficulties arise from the use of telecommunications, databases and working in networked environments. Some of these are in common with the development of any communications network, while others are particular to traditional knowledge. Tackling these problems will require much more formal discussion among tribes, natural resource managers, scientists, and other organizations on networked information policy. Building from experience in developing international biodiversity information networks such as the Clearinghouse Mechanism of the Convention on Biological Diversity, the Inter-American Biodiversity Information Network and the Indigenous Biodiversity Information Network, I suggest some of the elements that should be addressed in developing communications policy. These include addressing: 1) Participation; 2) Obtaining consent; 3) Privacy; 4) Security; 5) Repatriation of information; 6) Data custodianship; 7) Oversight and monitoring information flow; 9) Documentation and indexing standards; 9) Open network protocols and metadata standards; and 10) Open database standards. I note some of the limitations of using technology to store and transmit traditional knowledge, review some of the failures of current practices to address the policy issues above. Building cooperative networks is vastly different from building databases and websites on the Internet, and will require a substantial investment of time, resources and will to make them happen.

DISCUSSION

Kathleen Martin
What is the best place to look for information on this?

Preston Hardison
I am not sure in the Canadian context but there are good books by the National Research Council published in 1998 and 1999.

Marcel Shepherd
Referring to your initial presentation, don't you feel we are in a race against time? Laws are there to slow things further. Genetic and drug companies are patenting traditional knowledge. You talk about mutual benefit, but I don't see that happening.

Preston Hardison
We are all here because we are living off Pleistocene indigenous capital. The legal approach is not a pretty one and all these things have a cost. Most indigenous folks I work with realized there are real things they can get out of the projects, but there is also a long history of exploitation and as a result there's frustration. There are also cases where sharing knowledge has created more problems than it has helped solve. What we are trying to do is to steer the parties to understand that the economics are not the issue. What they are looking at is a trust-fund to pay a whole region. But now the real thing is to get those kids learning and that knowledge transmitted.

Marcel Shepherd
I do a lot of work on the Fraser and I put things in context for myself. If we move our management system to a more conservation-oriented structure rather than production-oriented, there will be a lot more willingness to share knowledge. Under the current regime, First Nations have the right to hold back their information until they see things change.

Tony Pitcher
There is one database out there, www.fishbase.org, which is completely free to use. It was set up in the Philippines and not in North America. All scientists who have collaborated to this database agreed to the sharing of all the data. A part of the project is to record native and indigenous names of fish. That was a part of an agreement with aboriginals.

Ian Baird
That is not quite true. I'm a collaborator and I have photos in there. Fishbase says that you have to contact the contributor before you use the photos.

Preston Hardison
Everyone can make his or her own copyright protocols. Copyright is not a bad thing – it is just how you write it.

Ron Hamilton
There is a terrible history in my community that has made people reluctant to share. How many people are aware of the bad blood scandal? Some fifteen years ago, a gentleman came and collected blood samples from our community. There was a piece of paper that we had to sign – a kind of informed consent. The gentleman went out of the country and sold that blood to European scientists. The blood is now used in studies that we never consented to.

Another thing. I am a singer. Twenty years ago I wanted to make an album of songs to share our songs with the larger community. I wanted to find someone who knows their business, and I phoned a Haida helper, who recorded the elders singing - that album is in the Smithsonian. She said that the songs will belong to her. That is upsetting because the songs do not belong to her.

The third incident: I was here during 1988 to 1992 and I often lectured. I often shared things that my people would say were very, very delicate to be talked about and would yell at me for sharing with non-native. One time I talked about large format royal paintings, and these were unknown in this country. An art student drew sketches of the paintings while I was talking and then claimed that he owned them. I was being generous and I feel now that I have been robbed.

I want to tell the people here who call themselves scientists and academics that I am capable of giving informed consent, but to have a PhD candidate say "I'm a post-modernist, I won these" is insulting. That kind of arrogance can be masked in a lot of ways. That kind of mentality gets in the way of people who truly have things to say.

Social Research for Sustainable Fisheries

Christie Dyer and Jessica Paterson
Project Officers, Social Research for Sustainable Fisheries, St. Francis Xavier University, Nova Scotia, Canada

Social Research for Sustainable Fisheries (SRSF) is a collaborative project in Nova Scotia between St. Francis Xavier University and three community partner organizations: Guysborough County Inshore Fishermen's Association, Afton First Nation, Gulf Nova Scotia Bonafide Fishermen's Association. This is one of the 37 Community-University Research Alliance (CURA) projects throughout the country aimed at creating and developing community-based research capacity.

This project focuses on building and enhancing Mi'Kmaq and non-native fish harvester

organizations' capacities by increasing and developing their ability to conduct and carry out social research. The communities themselves have identified the research issues they want to address. This partnership enables the transfer of skills and capacity from the university to the partner organizations through: customized workshops, student internship placements from the university's Interdisciplinary Studies in Aquatic Resources (ISAR) program, guidance from social science researchers and core research staff who are dedicated full-time to the partner projects. The development of skills through this process serves as the basis for the organizations to carry out their own research that will enable them in the future to assume greater governance of marine ecosystems and resource harvesting.

The process of SRSF is focused on research and education. The partnerships between the fish harvesters and the social science researchers work to develop and deliver 'action' research, while contributing to the building of community organizations' research capacity. Currently we are developing research expertise in: collecting and using traditional ecological knowledge; documenting family and community histories in fishing; developing skills in the design and conduct of research, interviewing skills and survey design.

ICONS: A Software System for Integrating Traditional Knowledge and Natural Resources Management

Preston Hardison and Terry Williams
Tulalip Natural Resources, Marysville, WA, USA

ICONS in presented as a tool for information management, for integrating some aspects of indigenous knowledge into natural resources management, and a model for developing networking standards and protocols. ICONS has a number of modules for managing different categories of information: 1. Organizations; 2. Persons (staff, members, experts); 3. Sources (bibliographic citations); 4. Peoples (indigenous and local communities); 5. Projects; 6. Events; 7. Geographic Areas; 8. Species (with subsystems for observation/specimen-level information, and for common names); 9. Stories (for traditional Stories and case studies); 10) Practices (technologies and traditional practices); 11. Internet Sites; 12. Databases; 13. Acronyms; 14. Encyclopedia (user-defined definitions and discussion forum for concepts and terms). The modules can be linked to form relationships: e.g. the Stories can be linked to places (Geographic Areas), species used (Species) and practices performed (Practices). The data can be linked to other databases, such as geographic information systems (GIS). ICONS incorporates existing standards and protocols, and is open to adopting others where they are proposed. It is available freely, and the code is open for use by others. The use of ICONS within the Tulalip Tribes Cultural Stories Project is presented.

Assembly of Map-Based Stream Narratives to Facilitate Stakeholder Involvement in Watershed Management

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Watershed stewardship activities throughout North America have evolved into a process that requires more involvement in planning and decision-making by community stakeholders. Active involvement of all stakeholders in the process of watershed stewardship is dependent on effective exchange of information among participants, and active involvement of a wide range of stakeholders from "communities of place" as well as those from "communities of interest." We developed a map-based stream narrative tool as a means to (a) assemble a wealth of incompletely documented, "traditional" ecological or natural history observations for the rivers or streams, and (b) to promote a higher level of active involvement by community stakeholders in contributing to information-based, watershed management. Creation of stream narratives is intended for use as a tool to actively engage local stakeholders in the development of a more comprehensive information system to improve management for multiple stewardship objectives in watersheds. Completion of map-based stream narrative atlases provides a valuable supplement to other independent efforts to assemble observations and knowledge about land-based natural resources covering entire watersheds. We are confident that completion of stream narrative projects will make a valuable addition to the information and decision making tools that are currently available to the public and resource agencies interested in advancing the cause of community-based approaches to watershed and ecosystem management.

MIGRATION PATTERNS AND SPAWNING HABITS OF AN IMPORTANT FISH, HELIGOPHAGUS WAANDERSI, OF THE PANGASIIDAE FAMILY IN THE MEKONG RIVER BASIN

Sintavong Viravong
AMFC/LARReC, Vientiane, Lap PDR

The use of local ecological knowledge to investigate migration patterns and spawning habits of fishes in the Mekong River was discussed in the previous paper. In this paper, the migration pattern and spawning habits of *Heligophagus waandersii* is presented. Its distribution has been reported from the Mekong Delta to Bokeo, even to Luang Namtha Province in northern Lao PDR.

The Khone Falls at the border between Cambodia and Lao PDR constitute a barrier between two migration patterns for this species. Below the Falls, *H. waandersii* migrate upstream during October to February, whereas from May to July, the species migrates downstream. This migration system appears to be a movement between important flood-season floodplain habitat in the south and dry-season refuge habitats associated with deep pools within the Mekong River in the north (i.e. *H. waandersi* was one of the species most often reported to be associated with deep pools during this survey). Above the Khone Falls, two upstream movements were identified, one during the beginning of dry season (i.e. from November to February) and one during the early flood season (May to August). Based on reports on the occurrence of eggs in the abdomen of the fish, spawning appears to occur early into the wet season, i.e. May-June. One report from the Mekong Delta in Vietnam suggests the species spawns all year round. Juveniles (with sizes between 2 and 16 cm) of the species were reported from many sites both north and south of the Khone Falls. Based on this survey, it can be hypothesized that *H. waandersi* consists of several sub-populations within the Mekong Basin.

INSHORE GROUNDFSH SPAWNING AND NURSERY GROUNDS IN THE BAY OF FUNDY: LEARNING WITH AND FROM FISHERMEN

Jennifer Graham
Center for Community-based Management, St. Andrews, New-Brunswick, Canada

This project builds on Trippel and Benham's 1997-1998 report (currently under review) on spawning and nursery areas as identified by fishermen around the Bay of Fundy. Identifying areas of importance for the reproductive life of groundfish is crucial for management. An emphasis on local spawning and nursery areas can also help identify local stocks that may have historically formed the bulk of coastal fisheries.

This poster explores some of the challenges and opportunities of using a community-based research approach with inshore fishing associations to validate, define and rank areas identified in the earlier study.

The historic coastal fisheries of the Bay of Fundy are in serious decline. This gives a sense of urgency to the task of learning as much as possible about coastal stocks; it also makes it difficult to locate active fishermen still fishing some of the areas in question. Random samples of fishermen are not an appropriate means to collect local information; rather it is essential to determine what layers of information are required and who holds this information. This requires thinking about the kinds of fish that particular vessels target, the areas in which they operate presently and in the past, as well as what seasons they are on the water.

The fixed gear sector in particular may hold information that is extremely specific – both geographically and temporally. A genuine community-based research process requires developing tools, such as appropriately scaled maps, with which to present information at the level of detail which fishermen possess. It also requires creating venues for fishermen to jointly assess their own distinct pieces of information to consolidate a larger body of knowledge over which they have ultimate ownership and control. In this way, a local knowledge project presents opportunities to learn from and with inshore fishermen.

THE CONTRIBUTION OF FISHERS TO THE MANAGEMENT OF SEA-URCHIN FISHERIES IN BARBADOS AND ST. LUCIA

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Fisheries for the roe of the white sea-urchin *(Tripneustes ventricosus)*, known as the sea egg, are important in Barbados and St. Lucia. In Barbados, the resource has a history of fluctuation leading to the first conservation legislation in 1879. In the 1970s and 1980s the abundance of sea urchins declined dramatically, and by the late 1980s the fishery had collapsed in Barbados. Likewise, St. Lucia also experienced collapse of the fishery with over-exploitation being a major contributing factor in both cases. In the 1980s and 1990s the fisheries authorities of both countries instituted multi-year closed seasons to facilitate recovery of the fisheries and establish new management arrangements in which fishers participated. A project was instituted in Barbados, using formal participatory methodology, to elicit from fishers their knowledge about the biology and ecology of the resource, fishing practices, and how the interaction of these may have contributed to the decline. Participatory methods were also employed to bring fishers from 17 communities together to plan their involvement in the recovery and management of the fishery. These methods and their results are examined. In St. Lucia a formal co management arrangement was instituted, based on a period of research and consultation. The agreement involved fishers in all stages of management, including monitoring urchin size and population density, determining when and where fishing would be allowed, and otherwise regulating the fishery to the extent that fisher knowledge and observations are shown to be the main inputs to management. Both cases demonstrate the use of fisher knowledge in managing the sea urchin fisheries, but with important differences in how the information was obtained and used. The roles of social and cultural factors in access to and use of fisher knowledge are illustrated. How fishers perceive the value and use of their knowledge is also explored.

GENERAL DISCUSSION

27th August 2001

Ron Hamilton
This is a question to Leanne Sommer. When you were presenting, you were talking about protecting the interests of various aboriginal groups in the area. Whenever the notion of protecting aboriginal rights happens here, the ugly head of racism rears up. What is your experience in your area?

Leanne Sommer
There is an expression of racism. In the most remote part of the marine park, the management agencies were able to argue with the recreational and commercial fishery sectors that there were several legitimate reasons why they were taking aboriginal concerns over everyone else's. One is that Cape York is still aboriginal land, had ongoing cultural relationships, and was mostly populated by aboriginal people. Also, more recently, there has been a targeted effort to get native titles to come to the negotiating table. When it comes, we need legislation in place to take people's interests seriously. Thirdly, the management agency is prepared to support indigenous groups in resolving conflicts between sectors of the community. For example, the management upholds fishing closures wanted by the indigenous people because it is good conservation and other sectors did not have better arguments to keep the area open. There are also meetings to see if a compromise can be reached.

Ron Hamilton
You used the word "subsistence use". I wondered if your definition includes subsistence if it is based on commercial exploitation. When I use a resource and sell it to provide for my family, I call it subsistence, but that's not seen as subsistence. In Australia, does the definition of subsistence include commercial use?

Leanne Sommer
In the context that I gave, it's purely fishing for family use. It's a fine line and it's untested whether fishing beyond family use and involving some sort of trade will be recognized as a native title right. On the whole, in Queensland, there are no indigenous people involved in commercial fishing. You can draw a line between indigenous and commercial fishing, and they don't cross at all.

Bob Johannes
In your community, Ron, I guess in the old days, the community caught fish and kept it within the community. In a lot of communities now, fish is sold within the community as well as outside the community. Is it still subsistence fishing?

Ron Hamilton
It's interesting, because within my community there's a long history of people from my community catching fish in super abundance so they supply the community with food and still have some for trade. Captain James Cook, in April of 1778, documents in detail people trading everything for the buttons on his uniform. He writes, "Nowhere in the world have I seen such a highly developed sense of ownership. Every blade of grass belongs to one man or another." Somehow or another, our concept of ownership gets lost when we become the minority, and we end up with people outside our community defining what subsistence is for us. So we have ridiculous situations where people have to go to court for 20 years to prove that we had a concept of ownership. When the Mckenna-Mcbride commission went to re-map, they set territories. In 1914 to 1916, they had another commission to decrease the size of Indian reserves. Early on, when they were forcing us into postage-sized stamps, they justified it by saying that we don't use the land anyway, we use the sea. But when I was a boy, we were arrested for taking herring eggs. It was okay for the Japanese to do that. There are no aboriginal sea otters on the island. We saw the near extinction of whales. Twenty years ago, my uncle and I chased what we thought was a northern fur seal for a better part of the day because I had never seen one before and I was begging him to take us closer so I can see it. I still haven't seen one. Today I'm a criminal because I catch a salmon and sell it because it's not subsistence fishing. It's okay for you to make millions of dollars selling fish, but if I catch and sell fish to support my family, I'm a criminal. Somewhere between Cook and today, rights have been redefined, because someone defined subsistence for me.

Cyril Carpenter
This morning there was mention of 37 organisations around the world that study indigenous knowledge but very few study marine resources. In BC, Alaska, Washington, Oregon, and California, there's certainly much documentation about First Nations' knowledge and the way they enhance the resources that should be available to the public and not collecting dust. If it's going to international conferences like this, the way we enhance the

resources should be documented for the benefit of the community. We have always said that we don't want to be looking in after we have been driven out and driven to a poverty level beyond imagination. When you read the paper about Matthew Coomb's statement on genocide, he's not exaggerating. The BC experience is so dark. It throws western civilisation history into darkness when you review the First Nations experience. We have research in our area; we have worked with universities, with a lot of people, to be a part of society.

Nigel Haggan
Many nations such as the Heiltsuk have done in-depth studies. There is a great body of knowledge of information out there. The suggestion that Bob made is that it's time that there is a centre for this knowledge. It will not be just a centre for putting information together. It's not that the information doesn't exist, but there's a lack of a focus for it. We can dwell on the bad treatment of the First Nations in BC. In Canada, there is some fairly enlightened legislation in aboriginal rights and titles. What's missing is the means to implement that legislation. In the Sparrow case, which dealt with the aboriginal right for food and ceremonial purposes, the court spoke of the importance of using a loose interpretation of the word, but in practise, the Government of Canada has taken the narrowest interpretation of the word. Percy Star, from the Kitasoo, said of salmon for ceremonial use: "I don't know when someone's going to get married or someone's going to die. I need to prepare for that." They say that people should have enough for food, ceremonial and social use but what it is has never been defined. There's room to define it, but is there will?

Saudiel Ramirez-Sanchez
Another thing we overlooked is that we as researchers ignore categories that exclude power politics. How much do we as researchers contribute to categories? There's only a part of knowledge that we use. There are others that we can take into account.

Ian Baird
In 1998, I returned to BC for a conference called Coastal Zone Canada. They invited lots of people from different countries, and there was section on co-management. A lot of people showing up in Canada expected to see an advanced country on the topic of co-management, what they realised is that there's really little to get. They realised that they were not there to learn from Canadian experts, but to convince the government how far behind it is. Compared to the rest of the world, DFO hasn't really done any real giving away of power. There's no real co-management in this country yet. We should look at countries such as the Philippines that have made the effort. Canada should not get away with this forever. We should be embarrassed with this situation.

Bob Johannes
There's nothing I would disagree with there.

Nigel Haggan
No, but I think the focus of such a centre would not be exclusively Canadian, but international.

Ian Baird
Right. But it should be clear that the centre isn't placed here because Canada is the best example of co-management.

Chad Paul
There is a lot of focus on all the tributaries in this conference but my people live in the headwaters. We have to make deals with our brothers and sisters to access the fish. That should be addressed.

Eduardo Espinoza
There is a lot of talk about participation of fishermen, but the big question is how to put a value on different sources of knowledge be it fisheries, science, or socio-economic. It is important to put it in a balance for sustainable fisheries and to include it in their management.

Pascale Baelde
When you compare the value of the knowledge, what we can forget is that we tend to see knowledge as a commodity. The value of knowledge is what we make of it and the collective decision. If not, we will keep bouncing against each other's knowledge and arguing whose knowledge is better.

Nigel Haggan
We work with the First Nations House of Learning on campus and the past director, Joanne Archibald, has a saying: "knowledge has power when it's shared." And what this gentleman is saying is that we need to share all the knowledge – not get one type of knowledge at the expense of others.

Pascale Baelde
Many of the talks today referred to taking fishers' knowledge and transforming it to the benefit of science. We should accept their knowledge without having to fix it until it fits with our knowledge.

Nigel Haggan
When you open a can of worms, the only way to put it back is to use a bigger can. We need a bigger can. We need a bigger context.

Bob Johannes
In the context that I was talking about this morning, we sat down with people in villages and swapped information. We put the information together and told them, “You are faced with modern problems that you weren’t faced with before; this is what we suggest you do.” Then we left. It wasn’t just taking their knowledge and leaving.

Pascale Baelde
I was saying the opposite. I meant that we take the fishers’ knowledge, but only when it fits.

Simon Lucas
There’s an assumption that all Indians think alike. I’ll use an example. In my territory, they made a marine park but they didn’t talk to us. They used the name Maquinna Marine Park, which doesn’t have any relevance to us, but has relevance to the tribes on either side of us. The brightest minds in our tribe didn’t speak English. One of them, Alice Paul, would say, “life is enormous” and the ocean “is where our life line is”. There’s another elder who would say that we have never seen where the first raindrop drops but the first raindrops contain life. It’s a benefit to the fish where we eat. What we are dumping into things these days, all these bright minds allow it. We don’t want the things we dump into the water but we allow our fish to swim through it. We have to address the contradictions that we and the country and the world make. They say go with the flow, but we’re worried about home. Our people left some resources alone and we supported the government when they shut down the herring fishery for eight years because we thought it was important to save it. Our whole lives centred on the ocean and the mountains. The hereditary system in our nations allows us to know what parts of the oceans our chiefs owned and that’s connected to the land. But some smart guy came along and said we’re going to call it Maquinna Marine Park when we had been using our own names for 20,000 years.

AUGUST 28TH, 2001; NO DISCUSSION

AUGUST 29TH, 2001

Melita Samoilys
I have a question for Francis. Are there any enclosures for spawning aggregations of groupers and has the trade in live reef-fish moved in?

Francis Hickey
The government just started to bring in the live reef-fish trade, but it basically self-destructed in about three months. They were not happy with the way things were going. In another area, there was a conflict with a tourist development because they brought in barracuda and sharks and the tourists weren't into it. They eventually realized that they were not getting as much fish as they needed. To get fish to Hong Kong and to come back requires high overhead so they eventually backed off. They spent 100,000 Australian dollars for it in a few months and did not get anything back. We asked them to stand down until they have a management plan in place.

Melita Samoilys
Do they have enclosures on spawning aggregations?

Francis Hickey
Yes. Most communities don't identify spawning aggregations in the area, but when they do, they have some rules against fishing during the aggregations, like not setting nets.

Nigel Haggan
Bob said that the fishers of Palao had an intimate knowledge of spawning aggregations and identified them. Why do you think they did not in this case?

Francis Hickey
They are less inclined to fish than they are in Laos. They are more into gardening. Most of the fishing was traditionally near the inshore region.

Melita Samoilys
In Palao and the Solomon Islands where they have knowledge of spawning aggregations, they have large aggregations. Perhaps where Francis is describing, the fish are not near the reefs.

Brent Peacock
I have a question on turtles. You mentioned that most of the natives were harvesting turtles. Were they part of a cooperative?

Kristin Bird
Most were in small cooperatives having from 10 to 50 fishers, but they are very fragmented.

Brent Peacock
Are these cooperatives financially viable?

Kristin Bird
Not really. The cooperatives are trying to come together more and that is why delegates from different cooperatives went to different communities and saw that coming together brings more success. They want to learn techniques to use in their own communities.

THURSDAY, 30[TH] AUGUST

Barbara Neis
A lot of issues that I was going to discuss have already been brought up today, including gender issues, ethics, management of information, who you talk to and the fact that knowledge is collective and not individual; the issue that if you want to understand the knowledge of the fishery often you need the woman who manages the books; the points that Jerry made - do we actually have a crisis of science or of management? Can we deal with the crisis of management in isolation? Can we pursue and gather knowledge from fishery workers and not address the management problem arising from attracting interest? There is so much commercial interest in Laos now where there was no interest before.

I was very struck by Ron's image yesterday of the boat people who are drifting around. Are we the latest drifters? Think of the legacy of those drifting people. They know nothing about the fisheries, then they learnt about it from the local people and then they destroyed those people. We have to be very careful of what we are doing. One of the Projects in Memorial looks at the relationship between fishers and science over time. We see a pattern emerging – scientists works with fishers, learn from them and then move away and the science becomes free standing. Then in a crisis, we have a new interest in fishers' knowledge. We are precisely at that point in fisheries now. Where will this go and what role will we play in directing where all this will go? Will we move fisheries in the direction of recovery or in the direction of depletion?

I want to propose that we talk about the new center and how to move towards a more mature research ethic and work collectively within our community. We have benefited enormously from the presence of the First Nations. They have been patient and tolerant as we went through our own research projects. The people I've worked with are not always so patient. How can we have a center that doesn't involve moving researchers around the world and separating them from their communities? It is very easy to get funds to move us around. It is harder to move fisheries people around.

Cyril Carpenter
I'll give you an example of what we are doing to fund some of our own programs. The salmon needs to be addressed – what is the future of the salmon fishery in our area? We need to negotiate. We have recorded two hundred and forty fish traps in our area and we only got the tip of the iceberg. Our people were managing all these salmon. The fish traps were designed to coral salmon and we took only the small and the weak as a whole community effort. We had trade. Our canoes were 70 feet with two sails on them to have ballast.

Going back to the marine resources, we have negotiated with the DFO to manage the fisheries ourselves, but they are not willing to do that. They are not willing to let the First Nations manage their own resources, to enhance it and to benefit from it. We have rivers on our central coast. We have tributaries that spawn salmon. We are involved with the sport fishery and logging. The only way we are going to manage our fish resources is if we join the industry and stakeholders. We are the largest stakeholders. We have 57 villages in our area and 7 provinces. We organized ourselves into that form of government and we managed whole valleys. We now see small reserves established in 1915 by the Mckenna-Macbride Commission. Now they are realizing that the history we are putting to the public tells us a lot more about management skills. We were really good at it. We had enhanced the resources and that model is what we want back. We want a kind of resolution coming from an international conference like this. We all feel helpless unless we have a plan for the future.

Ron Hamilton
You began this wrap-up by saying that we should talk about the possibility of having a research center. I have in my home several thousand slides. I have a bunch of songs in my own head that I can sing. The slides show people in feasts, utilizing sea cucumbers, seal meat and blubber from way back. I am willing to give copies of all that material and much more as a way to contribute something. We are always pushed aside when people are making decisions. We are much more than stakeholders because we are in a relationship with that resource that goes much deeper than a stakeholder.

Cristina Soto
As feedback for future conferences, I think we needed more free time for discussion. It has been a great conference but there have been many times that people have been excited about talks and didn't have enough time for discussion. Marcel Shepherd had an interesting idea about a small panel that can be set up, where you have a central theme. We did not get into some deeper issues like confidentiality and power.

Ian Baird
Small group discussions are often a very good tool that is used a lot in international workshops.

Bruce Burrows
We could have used some time in smaller groups or in workshops. I agree on the marginalization of traditional knowledge. I think it has been laid at the feet of scientists, but very often, local knowledge is suppressed because of power relations in the society. If they speak against the interests of powerful people, they get suppressed.

Bryan Pierce
My view is that this group is relatively unusual relative to the fisheries science community in general. I can't think of any of my colleagues that will think the same way as the First Nations. I'm happy to have the institution be a center of a network, but local knowledge should remain with the people.

Jeremy Prince
Yes, nodal networks would be good. It should be a place where people can train and then go back to their communities.

Nigel Haggan
An International Center is a paradox anyway; it has got to be a network.

Pascale Baelde
We still have not defined the role of the center. Is it for researchers to do new research or is it to empower people with knowledge to act in their interests?

Simon Lucas
Having a place to talk about world issues right now is a good dream but there are things we have not talked about. In Canada we had people die when the water went bad. The rest of Canada did not talk about it. When a human being dies, we get all excited. When an animal or fish die, they don't get that exposure. When disaster happens, like that oil spill that ended up on our beaches – and we were the ones to clean it up because nobody would take responsibility – there should be no borders. Disasters need to be tackled immediately. There are more oil tanks and tour boats traveling through our waters. While we talk about resources, these things are happening.

Tony Pitcher
I want to reflect on what we academics have done to ourselves when we say that research does not empower local communities. If we go back to the Victorian era, we see how science empowered communities, from engineering to medicine improving the quality of life. A century and a half later, we are saying that we should not do research. I hope that if the center becomes established, it will be an international center and hopefully we can bring in some stock assessment people. It will not only be relevant to BC and Canada, but also to the entire world.

Adam Faulkner
Indigenous knowledge is practical knowledge. A lot of fisheries management really stifles aboriginal people because it makes it a crime for aboriginal people to practice their culture. When that happens, the knowledge is gone.

Arnie Narcisse
In 1911 my great grandfather was signatory to a statement of declaration that the people made of their territory. In the letter he questioned the need for hatcheries in that territory. The industrial fishery on the Fraser River started around 1888. This points out the decimation in 23 short years of the greatest run of salmon in the world. If his question had been given more attention we won't be in the situation that we are now. 90 years later we are now fighting against fishfarms, another incursion. I sense a very real defeatist mentality creeping in Government minds. All stocks have gone to hell, habitats have gone to hell, but we are lucky because we got all these fishfarms. The problem is that the fish are not native to this territory and they transport all sorts of problem over here. This is analogous to the small pox when the Europeans came here. We got to begin to adhere to the advise of the elders. My whole world is 10 miles long. All sorts of things have happened to reduce my ability to catch fish in that 10-mile stretch. There is a place for academia - they can put these things together. All we want is the same as yesterday.

Maria Manghans
I agree with the comments about the lack of discussion in the conference and I think that breaking up into smaller groups would be a good idea. As for the center, I think that a number of localized centers of knowledge will be better. Maybe the knowledge should stay in the territory that it belongs to. Another thing: I came here because I thought there would be an exhibit on fisheries knowledge and I really wanted to see that. Maybe that is something you can do for the center – you can have little exhibits not for the world to see the community but for the community to remember their knowledge. Bring the world to the communities not the communities to the world.

Michael Phelan
Will a center be just another beurocracy?

Ian Baird
What a center should really consider is the issue of traditional knowledge and power. There should be a strong ethical code associated with the center so that any information that goes into it is approved by the people who retain copyright to that information, and they can pull it out if they no longer want it there. It should have a mission statement, which should view local ecological knowledge as a way to empower local people. The explicit objective should be to empower the local people.

Stephanie Henry
There has not been much mention of the central and north coast. We average around ninety people. We have seen a decline in sockeye. We have all these commercial fishers from the province out in the river, making income in our territories and we feel like outsiders there. A few days ago we were digging clams and an RCMP told us to bring our status cards. We had to prove that we lived there. A speaker here said that we were reluctant to share information. We are not reluctant. We are cautious about handing out information about of our resources, such as the location of spawning areas. There are a lot of reasons why we are loosing sockeye but we need more communication. People from the Fishery Center should come over. This is a good beginning of the dialogue.

Brent Peacock
I am from the Okanagan nation and my background is in Education. A UBC center should also be an educational center. Part of being a scholar is to share knowledge with the people who require it – that is the only way people will learn. It is the responsibility of academics to share their knowledge.

Preston Hardison
Having a center is fine, but there is an issue on how it presents itself and what is its scope. Two years ago, Daryl Posey published a book about spiritual and cultural values of biodiversity. Every author in the book was non-indigenous. There is a capacity out there in the indigenous peoples who want to form networks but don't have the resources. It is hard for them to get money or support. It is great that there's a need for the center and to pull in resources from the University, but it should not be a global center. Indigenous folks need support to build their capacity to build their own network. If initiatives come along and indigenous folk want the network, facilitate it. If they want to own it, they can. The problem with centers is that they take on a life of their own.

Pascale Baelde
We need to make sure that the motives and interests of the center are agreed from both sides. Arnie said that all they want is the same as yesterday. Researchers want to restore the ecosystem. These are two groups of people talking about different things. Are we sure these things fit together? There is a cultural dimension that was mentioned, that we should not miss.

Arnie Narcisse
That is basically why we are participating in the Back to the Future modeling. We are interested to reconstruct the past abundance. That is also what the DFO is trying to do, to rebuild the resource. We have to have some idea of what there was before.

Saudiel Ramirez-Sanchez
What is knowledge? Are we assuming it is an inventory, like we do with species? How are we to educate people about the knowledge that they already have?

Barbara Neis
My own view is that it would be more than an inventory of knowledge.

Jeremy Pierce
A lot of people are not convinced that there should be a database. It should be a local thing and there should be some universal links, with an emphasis to integrate everybody together.

Bill Montevecchi
There has been a lot of good focus and good support in this conference. People are talking and that is the most important part of this process. I have really benefited a lot from the presence of the First Nations. Their respect for the environment is overwhelmingly impressive. Research in its purest form is just that – re-search or look again – essentially a process of renewal. I agree about the comments on education – it is fundamental.

Bryan Pierce
We can decide when to gather again and discuss management systems. The only way to change is to support the people on the water, add value on them and become their symbionts and friends.

Nigel Haggan
As I said previously, an international center is a contradiction. We have a memorandum of understanding on our web site that encapsulates a lot of these elements. We would like to have feedback on that.

Barbara Neis
Anita left me her comments on the center in which she says that she supports the center, but the Fisheries Center is not the place for it. It will need to have a socio-geographic base.

Saudiel Ramirez-Sanchez
There is an ethical problem when we are dealing with science. We can get to a point where science is neutral. Can scientific work really be apolitical? Can it be really outside of social relations?

Barbara Neis
We live in a world that is structured around power relations. Even when you think you're neutral, you are aware of whom you're working for. I think Anita's paper was very important. Fisheries scientists are focused on how to get the traditional knowledge into the stock assessment. But the point is that if you don't understand the management system than you are not doing good science and you will not be aware of the consequences of using the information on the fishermen themselves and on the government. That is the reason why we need interdisciplinary research and why we need social scientists, and not just training biologists to do interviews.

We are a community of people who are working together and we share concerns and issues. I am wondering how we can, as a community work together with other communities. Rather than creating something new, I think we should look for other organizations that are already out there.

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