



# 1993 - 2000 Report



The Fisheries Centre  
University of British Columbia

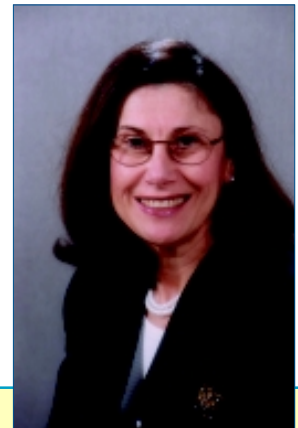
# FOREWORDS



*I want to congratulate* all the members of the Fisheries Centre whose achievements are recorded in this excellent report. Over a very short time period, the Centre has contributed many exciting new initiatives in the areas of sustainable development and the planned growth of our fisheries. British Columbia is a vast treasure-house of natural resources, but we must exercise responsible stewardship over the complex ecosystems that surround us if we hope to preserve that treasure for future generations. The Fisheries Centre brings together government agencies, First Nations, and the University in a vital collaboration, offering an excellent model of how to address an issue of both regional and global importance through multidisciplinary research and teaching. Many problems lie ahead, but this report gives us reason to be optimistic about our ability to find solutions.

**DR MARTHA PIPER**  
**PRESIDENT, UNIVERSITY OF BRITISH COLUMBIA**

*I am delighted* that, in its first eight years, the Fisheries Centre is successfully fulfilling its mandate as one of 26 interdisciplinary research units within the Faculty of Graduate Studies. The output reviewed in this report not only underlines the Centre's influential global role in its field, but also reflects the remarkable drive and enthusiasm of its members. An internal report in 1996 identified poor accommodation as one of the main weaknesses and so we are pleased to see reported here the success in attracting Canada Foundation for Innovation funding that will provide a new home for Fisheries Centre members. The Faculty of Graduate Studies is proud to provide continuing support for the Fisheries Centre in its activities.



**DR FRIEDA GRANOT**  
**DEAN, FACULTY OF GRADUATE STUDIES, UNIVERSITY OF BRITISH COLUMBIA**

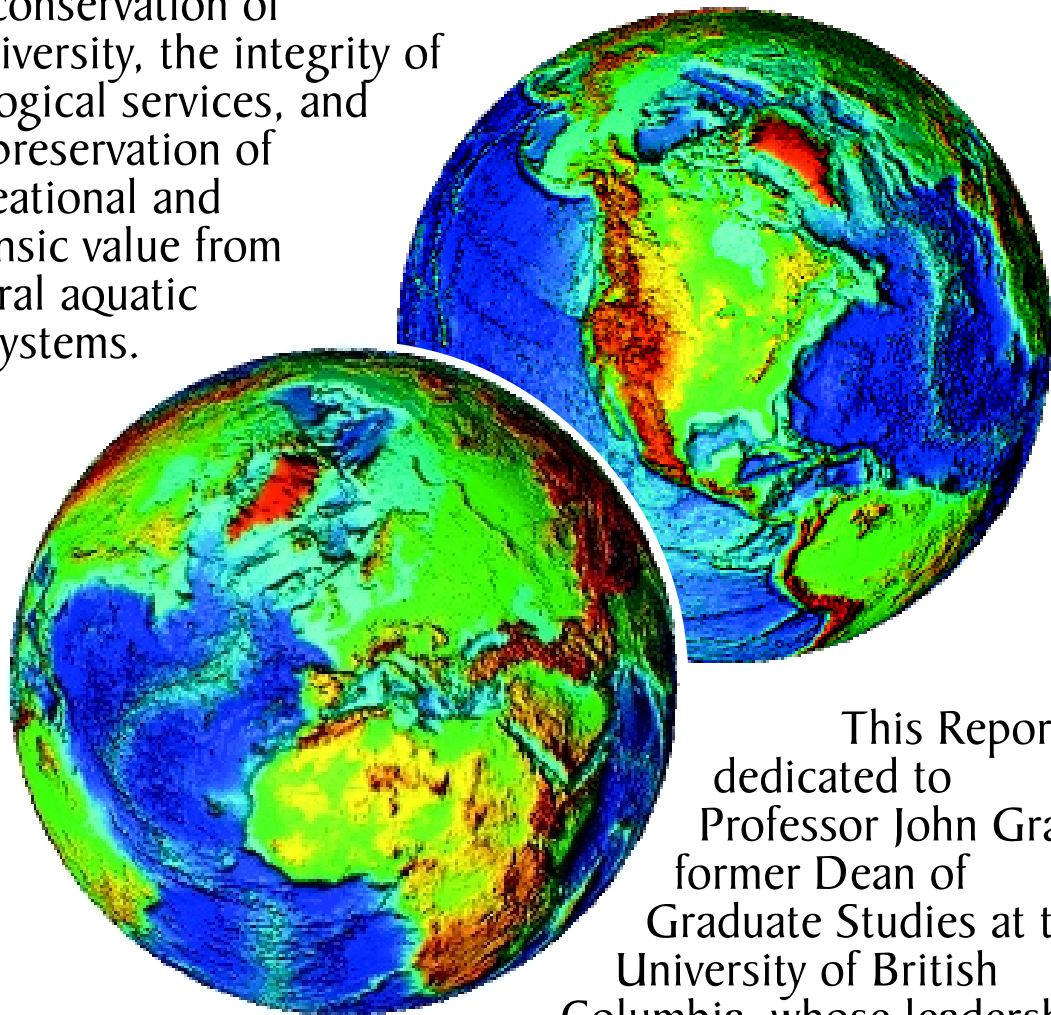
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# THE ECOSYSTEM IMPERATIVE

Research performed at the Fisheries Centre aims to reconcile the extraction of sustainable economic and social benefits from human fisheries with the conservation of biodiversity, the integrity of ecological services, and the preservation of recreational and intrinsic value from natural aquatic ecosystems.



This Report is dedicated to Professor John Grace, former Dean of Graduate Studies at the University of British Columbia, whose leadership, in 1992, caused the Fisheries Centre to be founded.



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*Note: Blue typeface refers to boxes within the text.*





## THE FISHERIES CENTRE AND A NEW THALASSOCRACY

**A**round 4000 years ago, in bronze-age Levant, great seafaring Phoenician and Minoan civilizations thrived. They are referred to as thalassocracies, for whom sustainable fishing and ocean-based trade formed the foundation of their way of life, rather than the more popular vocation of those times, armed conquest. Since then, humans have so depleted the oceans of their Pleistocene heritage of abundant large fishes, sea birds, reptiles and mammals that many of us now believe that restoration, rather than sustaining our present depleted misery, should become the over-arching policy goal for fisheries. The restoration of aquatic ecosystems requires a new period of thalassocracy, run by a generation of thalassocrats, and this sensibility has become implicit in research planned and carried out at the University of British Columbia Fisheries Centre. Many fisheries agencies (even in democracies), despite the best of intentions, often come to implicitly favour the short-term interests of industry, and so we need independent groups like the Fisheries Centre to train and provide a home for our new breed of thalassocrats. They can act as ambassadors for healthy and wealthy fisheries, and serve as a counter-balance to work for the conservation of marine ecosystems with the Fisheries Centre's client communities of academics, fishers, and the public.

*Early Minoan fresco depicting flotilla of ships on a sea journey to another country for trade. Other parts of the fresco depict fish, dolphins and a sea battle. From Akrotiri, Thera, an island north of Crete in the Aegean, about 4000 BP. This advanced civilization appears to have been destroyed by a major volcanic eruption on Thera about 3650 BP.*

This document reports the activities of the Fisheries Centre at the University of British Columbia from the date when I arrived as its first Director at the beginning of 1993, to the end of the 1999/2000 academic year. As the first such report issued by the Centre, we have taken advantage of the long time frame to elaborate on the development of several pivotal research themes, rather than fragmenting the information into year by year accounts of our progress. This approach also allows us to inject more of the stuff of scientific research; its





*Fishing vessel and catch (a shark and a tuna) depicted on a clay seal, early Minoan, Palace of Knossos, Crete, about 3800 BP.*

direction and change of direction, the chance meetings and discoveries, and the underlying philosophy that have led to the present state-of-the-art research being undertaken at the Fisheries Centre.

While all the Centre's activities are directed towards the sustainability of fisheries, some have particular attributes that enable them to be neatly classified in one theme or another. Most, however, present a matrix of themes and techniques, and indeed changes of emphasis over time from one discipline to another. A trans-disciplinary approach is taken in all our work, so our difficulty in circumscribing the different projects into individual themes is, in fact, a very positive aspect of the Centre. We have tried hard since our inception to develop a co-operative team approach to research and graduate teaching - in contrast to the classical 'big important professor' system. The 'big important professor' can be imagined at the top of a pyramid of postdoctoral researchers and graduate students and assistants. Pyramids are, of course, neat, but they cannot move adjacent to each other as the bases bump into each other first. We like to think of ourselves as more like a network of nodes and interactions which can shift flexibly project by project.

It is stressed that our research work concerns fisheries, whereas most other Canadian aquatic institutions focus on fish biology or oceanographic research. The Fisheries Centre strives for world class interdisciplinary research in fisheries, with global as well as national foci, and with international partners of high calibre. We are pleased that since its beginning the Centre has become a recognized independent forum for debate on the many issues surrounding fisheries, such as First Nations and Aboriginal fisheries, recreational fisheries, the ethics and Code of Conduct for fisheries and striking a balance between the relative role of conservation and exploitation.

However, the major challenge that faces global fisheries - to rebuild and reinvigorate the aquatic ecosystems in which they are embedded rather than attempt to merely sustain their present generally impoverished state - and the increasingly central role of our Centre in research in this endeavour, requires more and closer linkages. We are therefore very pleased to report that the Fisheries Centre, together with its partners in British Columbia, have succeeded in a bid for a new Fisheries Ecology Research Laboratory, that, as well as providing a new home for our thalassocrats, will enable us to accelerate to a critical level the impressive research momentum demonstrated by members of the Fisheries Centre in its first eight years.



**PROFESSOR TONY J. PITCHER**  
**DIRECTOR, UBC FISHERIES CENTRE**





# SUSTAINABLE?

RIGHT: Racial and economic violence in Cilacap, Indonesia. Trawlers are burned and attacked in spreading racial violence. In the 1970s such violence was attributed to indigenous small-scale artisanal fishers opposed to trawlers. The Indonesian government banned trawlers in 1980, but now the trawlers are returning - and so is the violence.



ABOVE: Fishers display catch from a homemade reef bomb blast in Kepulauan Sangerang (Spermonde Archipelago), South Sulawesi, Indonesia. The stunned fish sink to the sloping bottom 3 to 15 metres below and are collected by hookah. (Photo: T. Okey)

LEFT: Massive catch of pollock in the codend of a trawler, Alaska. This fishery involves large discards, and may have altered the ecosystem.





# THE FISHERIES CENTRE



*Aerial view of the University of British Columbia, at Point Grey, Vancouver.*

The Fisheries Centre at the University of British Columbia (UBC) is one of 25 research units located within the Faculty of Graduate Studies. It was founded in 1993, consists of a core of six UBC faculty members, and is home to a day-to-day community of about 80 thalassocrats: about 13 research associates, 5 postdoctoral research fellows, 30 graduate students, 10 full-time and part-time staff, adjuncts and visitors. The Centre includes the Marine Mammal Research Unit and the British Columbia Government's Fisheries Research section, currently housed in post-war, temporary huts. The mandate of the Centre is to act as a focus for the outputs of fisheries research and policy studies at UBC. Its major objectives are to establish and maintain a fully international, multidisciplinary perspective in fisheries research and to provide a forum for the foundation of concepts of management and sustainable development of fisheries appropriate for the 21st century.

## HISTORY

The Fisheries Centre's roots within UBC go back to the formation of the Institute of Fisheries in the 1950s by the late Dr Peter Larkin. In 1968, the unit was renamed the Institute of Animal Resource Ecology (IARE) to reflect its broadening interests, and was led for many years by the respected ecologist Dr C.S. 'Buzz' Holling. The IARE included a Co-operative Fisheries Unit led by another well-known scientist, Dr

Ray Hilborn. Members of the unit developed and taught new methods in Adaptive Environmental Assessment and Management. IARE had a strong influence in the field around the world, particularly in the late 1970s, and provided in-service training for Canadian fisheries agencies. Much of the success was due to cross fertilization of ideas between fisheries and other ecologists. However, the In-

### *The Larkin Legacy*

Peter Larkin came to the UBC campus in 1948 as British Columbia's first Chief Fisheries Biologist, with a joint appointment in the UBC Ecology Department, where he started courses on ecology and population dynamics. Apart from four years in Nanaimo as Director of the Canadian government's Pacific Biological Station (1963-1966), Dr Larkin spent the remainder of his career at UBC, rising to become head of the Zoology Department, Dean of Graduate Studies, and Vice President of Research. Peter had strong links with precursors of the Fisheries Centre. He set up, in 1952, the British Columbia provincial government's Fisheries Research Section (now part of the Fisheries Centre) on the UBC campus in an innovative liaison between research and management in an academic environment. He founded the Institute of Fisheries in the Zoology Department and became its second director from 1955. After returning from Nanaimo, he remained a member of the Institute, which later became the IARE, until his retirement in 1989. After retirement, Peter remained active at UBC heading a Royal Society of Canada evaluation unit, and was instru-



Continued overleaf



stitute was closed in the 1980s and most of its members were scattered elsewhere.

In the late 1980s, a debate at UBC about research in natural resources, led by Dean John Grace, resulted in the launch of the Fisheries Centre in 1991 as an autonomous institute within the Faculty of Graduate Studies to focus and promote the interdisciplinary study of fisheries on campus. Three members - Drs William Neill, Mike Healey, and Carl Walters - were absorbed into the new Centre and brought with them the accumulated ecological wisdom of the IARE. And the present head of the BC Fisheries Research and Development Section, which had been based on the UBC campus for many years and was to join the Fisheries Centre, was an alumnus of IARE - Dr Arthur Tautz. The important methodology of Bayesian analysis and adaptive management, developed at IARE, became a cornerstone of the new Fisheries Centre, which re-published a textbook on the subject by Dr Walters.

However, the main fruits of this continuum of fisheries research at UBC were not to mature until a chance encounter nearly five years later. It was interesting that in the scientifically advanced north-east Pacific in the late 1980s one of the former IARE members would write that “aquatic ecology desperately needs methods, viewpoints, and theories that will expand horizons beyond the details of my lake or my organism”, while in the tropical south-west Pacific, at the International Center for Living Aquatic Resources Management (ICLARM) in Manila, such an integrating method for analyzing ecosystems was about to be launched on the global stage, following its birth in Hawaii. Linkages formed across the Pacific in the mid-1990s between the researchers involved were to lead to some of the most important conceptual advances in the history of fisheries science, advances that have swept the discipline of aquatic ecology beyond “my lake” to whole oceans and from “my organism” to the entire gamut of aquatic biodiversity.

During its first two years, Dr Les Lavkulich, now Director of the Institute of Resources and Environment (IRE), served as Acting Director while a search was made for the Centre’s first Director. Dr Tony Pitcher, was appointed in January 1993. Dr Pitcher had worked in England, Ireland, Scotland, Wales and Germany, and came from a position as Special Research Fellow in



*Dr William Neill*



*Dr Michael Healey*



*Dr Carl Walters*

Continued from Page 7

mental in setting up the North Pacific Universities Marine Mammal Research Consortium, administered by the Marine Mammal Research Unit of the Fisheries Centre.

During his career, Peter served on the boards or councils of many prestigious national and international institutions. He was a frequent recipient of honorary degrees and special awards. For instance, in 1995 Peter received the Order of Canada and the UBC Science Council Award for Career Achievement, and, in 1996 the Murray A. Newman Award for Conservation and the Order of British Columbia. He died in July 1996.

The Fisheries Centre hosts the Larkin Lectures ([see Box, page 12](#)), and has named the Larkin Room in his honour. The room includes a collection of important artwork and Larkin memorabilia. The Peter A. Larkin Memorial Fund was established by the Canadian Aquatic Resources Section of the American Fisheries Society (AFS) to provide support for students to attend annual AFS meetings. [For a full obituary see: Northcote, T.D. \(1996\) Obituary of Peter Anthony Larkin. Rev. Fish Biol. Fish. 6: 374-377.](#)



*Dr Art Tautz*



*Dr John Grace*



*Dr Les Lavkulich*



the Marine Resources Assessment Group, a consultancy company located at Imperial College, London. In London, Tony Pitcher had worked as project manager and researcher on a major interdisciplinary program focussing on species changes in the African great lakes, on artisanal fisheries in Sumatra and Thailand, on fisheries for small pelagics in the Adriatic and on length-based analysis techniques. In North Wales, in addition to a well-known research group focussing on the experimental analysis of fish schooling behaviour, and fisheries research in Zimbabwe, Malawi, Angola, Kenya, Chile and Ecuador, he had set up and run the world's foremost 1-year intensive masters course in fisheries, and founded the international journal ***Reviews in Fish Biology and Fisheries***, which was later to attract an ISI impact factor of 4.4. Such experience, foresight and determination were later responsible for bringing together the Fisheries Centre and ICLARM research groups from opposite sides of the Pacific.



*Large school of mahogany snapper (Lutjanus mahogoni) in the Hol Chan Marine Reserve, Belize.*

*Quillback rockfish (Sebastes maliger) taken at Race Rocks off Victoria, Vancouver Island.*





# MISSION AND OBJECTIVES

The Fisheries Centre's mission statement, developed early in 1993, is even more relevant and urgent now, eight years later:

***Our planet's fisheries have reached their ecological limits. Furthermore, these increasingly scarce and depleted biological resources are impacted by diverse human economic, political and social activities. Future policy and planning essential to the successful stewardship of global fishery resources must be founded on research that encompasses many traditional disciplines, acknowledging human as well as biological and environmental perspectives.***

The mission statement expresses the world wide need for a new fisheries science and for well trained fisheries scientists. Analytical tools developed in a broad spectrum of parent subjects, including biology, oceanography, economics, engineering, mathematics, sociology, planning and policy are employed to assess, appraise and forecast the impact of both human and natural processes on fisheries resources. A wide range of fisheries policy and management problems has been studied from the outset, including assessment and management of artisanal and commercial capture fisheries, recreational fisheries, coastal and watershed management, conflict resolution and the co-management of shared fishery resources, and the conservation of endangered exploited species in both marine and freshwater environments. From the start, the Centre has served as a forum, previously lacking, for debate on policy matters related to allocation and sustainability, First Nations issues and recreational fisheries.



Commercial salmon vessel, Alaska. The commercial fishery for Pacific salmon involves three main gear types (troll, gillnet, and seine) and six species, and competes with Aboriginal and recreational salmon fisheries. Despite the Pacific Salmon treaty negotiated between Canada and the United States, transboundary conflict persists.



ABOVE: Artisanal fishing canoes (bancas) in San Miguel Bay, Philippines.



LEFT: Recreational angler near Darwin, Australia, with a narrow-barred Spanish mackerel, a widespread pelagic species taken in commercial, artisanal and recreational fisheries in the Indo-west Pacific.



## CENTRE ACTIVITIES

Activities of the Fisheries Centre comprise:

- Publication of academic research based on grants and contracts
- Workshops and meetings, and publications based upon them
- Sponsorship of public and professional seminars
- Graduate teaching within the UBC Faculty of Graduate Studies
- Professional training
- Other professional activities



*Male California sea lion.*

## RESEARCH

Much of the Centre's research is related to ecosystems, directed especially towards understanding large-scale ecosystems, in which fisheries resources are the driving concerns. Ecosystem modelling tools such as [ECOPATH WITH ECOSIM](#) have been developed at the Centre and are now in use world wide. In fisheries management, the Centre has developed knowledge and tools using a combination of ecosystem modelling, multispecies assessments and bioeconomics. Research on conservation and biodiversity is focussed on endangered species of fish, amphibians and marine mammals.

Details of a number of projects are provided in [RESEARCH THEMES](#), and a complete list of projects is given in [Annex 11](#). Most of the conceptual development has been by Fisheries Centre faculty and its crew of research associates and adjuncts, while the research itself has been performed in part by research associates, research assistants and graduate students as thesis topics.

## INTERNATIONAL CONFERENCES AND WORKSHOPS

The Centre has held 15 international workshops since 1993 ([Annex 4](#)). Basic costs have been met from grant funding, but many have been sponsored by outside bodies and from funds sought by members. The workshops have been co-sponsored by many institutions in British Columbia:

- UBC
- BC Science Council
- Fisheries and Oceans Canada
- BC Government Ministry of Fisheries
- BC Ministry of Environment, Land and Parks;

*A Fisheries Centre seminar.*



and around the world:

- US National Oceanic and Atmospheric Administration (NOAA)
- World Wildlife Fund for Nature (WWF)
- South African Deep Sea Angling Association
- Norwegian Society for Fisheries Economics.

Edited output of most of the Fisheries Centre workshops is published in the **Fisheries Centre Research Reports** series, and some have also become the basis of peer-reviewed, externally published volumes (see [Annex 2](#)).

## RESEARCH SEMINAR SERIES

More than 135 research seminars have been held in the Centre since 1993 ([Annex 5](#)). The series is sponsored by a grant from the British Columbia Government. In addition to many Canadians, speakers have come from the United Kingdom, France, Italy, Norway, Iceland, South Africa, Tanzania, Australia, Chile, Thailand, China, Hong Kong, Indonesia, Philippines, Mexico and the USA. Internal work-in-progress seminars by graduate students and staff are held in the same series. A separate series of graduate students' symposia on fish population dynamics and management began in 1995 through the initiative of Alida Bundy, then a Fisheries Centre graduate student, and Elizabeth Babcock, School of Fisheries at the University of Washington, Seattle. The series is seen as a unique venue for fisheries students to meet and discuss their work and to foster communication between graduate students in different west coast universities. A third series comprises public lectures, the Larkin Lectures ([see Box](#)), and is held in honour of the late Professor Peter Larkin, a well respected fisheries scientist with UBC from 1948 until his death in 1996.

### *The Larkin Lectures*

The memory of the late Dr Peter Larkin, one of fisheries' best known researchers and an almost legendary figure on the UBC campus, has been enshrined in an important public lecture series, the Larkin Lectures, funded through an endowment established by colleagues, family and friends in his honour upon his retirement and, later, when he passed away. Larkin Lectures to date are:

1. The late Professor Ray Beverton, Cardiff, Wales: "Fish, Fact and Fantasy: A Long View" (1995). Professor Beverton became ill before the scheduled lecture date and was unable to deliver the lecture orally. It was published in 1998 in *Rev. Fish Biol. Fish. 8: 229-250*.
2. Dr John Caddy, FAO, Rome: "Fisheries Management After 2000: Will New Paradigms Apply?" (February 1996). Published in 1999 in *Rev. Fish Biol. Fish. 9: 1-43*.
3. Dr Kevern Cochrane, FAO, Rome: "Reconciling Sustainability, Economic Efficiency and Equity in Fisheries: The One That Got Away?" (March 1999). Published in 2000 in *Fish and Fisheries 1(1): 3-21*.
4. Dr Pamela Mace, NMFS, USA: "MSY Revisited" (February 2000). Published in 2001 in *Fish and Fisheries 2(1): 2-32*.
5. Dr Dayton Lee Alverson, NRC, Seattle USA: "The Good, the Bad and the Ugly: Factors Influencing the Scope and Quality of Fisheries Science and Management Decisions" (February 2001).



*Mementos of Peter Larkin in the Larkin Room.*





## Student Voices

One would expect graduate students to have a different world view from that of their advisors. But at the Fisheries Centre they can continue fulfilling their degree requirements and pursue cutting-edge science. It's a close knit group, bonded not only through Friday afternoon get-

togethers beneath a ceiling covered with signatures of students and researchers dating back half a century, but also by the intensive cross fertilization of ideas among research staff and students. Students are exposed to a variety of projects beyond their thesis topics by advisors who remain enthusiastic in their own research and infect the students with the excitement of new approaches and findings.



Fisheries Centre faculty, staff, and students gather in the Ralf Yorke Room.

Faculty of Arts; Aquaculture in the faculties of Agriculture and Applied Science; Watershed Restoration in the Faculty of Forestry; and First Nations issues in the First Nations House of Learning in the Department of the Provost. Within the Faculty of Graduate Studies, the Institute for Resources and Environment (IRE) provides a home program (Resource Management and Environmental Studies) for most of the Centre's graduate students. New links are forming with the Global Issues Institute and the Sustainable Development Research Institute.

## GRADUATE TEACHING

The Fisheries Centre has a unique niche on the UBC campus, with strong graduate teaching links to Oceanography and Zoology in the Faculty of Science; Anthropology, Sociology, Education and History in the

## Opening the Doors: Aboriginal Initiatives

The world's first Chair of Aboriginal Fisheries has been approved by UBC. The holder of the Chair will teach, supervise graduate students, conduct research, provide outreach to First Nations communities and work with First Nations educational programs and regional colleges to find ways to provide transfer credits and create bridges between institutions. The new Chair will explore ways in which the traditional knowledge and values of Aboriginal peoples can complement and inform fisheries science and management and equally importantly will create a supportive context and example for Aboriginal students seeking a career in fisheries. This initiative will include:

- a graduate course in Aboriginal Fisheries
- accelerated enrolment of Aboriginal graduate students
- approaches and tools for cross-validation of traditional knowledge with science
- increased involvement of First Nations in research projects
- collaboration on [FishBase](#) to enter names of fish species in First Nations languages to make traditional knowledge, stories and legends available
- a code of ethics for use of traditional knowledge
- collaboration to include Aboriginal perspectives on the health of salmonid stocks and habitats.

The Centre's graduate teaching is firmly linked to the latest research progress in a wide range of topics. Graduate students get the benefits of leading edge science as lectures often describe new findings accepted but not yet published in journals, let alone textbooks.

## ABORIGINAL INITIATIVES

The aim of several Fisheries Centre projects has been to provide an alternate forum where people from different sectors of the fishery can



work together to seek solutions to intractable issues. It is hoped that the resulting discussions and access to a broad range of interdisciplinary expertise will, over time, enable solutions to be reached.

Within this overall objective, the question of Aboriginal fishing rights resonates throughout the Pacific Rim from Alaska and the western seaboard of North America through Australia, New Zealand, Japan, Hawaii, southern Chile and Mexico. In Canada, British Columbia is home to 197 First Nations, nearly all of whose communities are located near strategic fishing locations. The abundance and diversity of the area's fisheries resources founded unique cultures and sustained them over thousands of years while trade routes proliferated throughout what is now the province of British Columbia and as far afield as South America. These peoples were wealthy by any measure of human well-being. All this came to an abrupt end with the development of industrial fisheries in the 20<sup>th</sup> century. By 1992, official figures from Canada's Department of Fisheries and Oceans showed that First Nations communities accounted for only 4 percent of the salmon catch. Although First Nations make up a significant part of the commercial salmon and other fisheries, this was solely under commercial fishing licences, not as a recognition of Aboriginal rights. Conflicts between the Aboriginal fisheries and other fishing sectors remain.

In 1996, the Fisheries Centre and the UBC First Nations House of Learning (FNHL) - an institute that aims to make UBC resources more accessible to First Nations people and to improve the University's ability to meet their needs - entered into a partnership responsive to Aboriginal community concerns about fisheries and to accelerate the enrolment of Aboriginal students in graduate fisheries programs. This partnership has resulted in a joint initiative entitled "Opening the Doors: Improving First Nations Access to Science" (see Box page 13).

In December 1997, the Centre and FNHL signed a Memorandum of Understanding with the British Columbia Aboriginal Fisheries Commission, representative of almost 90 percent of the province's First Nations. It provides an additional avenue of communication with First Nations and assists partners in accessing funding for research projects and educational programs that satisfy both academic and First Nations criteria.

## PROFESSIONAL TRAINING

In addition to formal teaching, the Centre offers a number of professional training courses of interest to fisheries scientists and to organizations of commercial fishers. Several faculty members have considerable international experience in running similar workshops,



*Vivian Narcisse hanging salmon for wind-drying at Xwisten (Bridge River), British Columbia.*



*Dr Jo-ann Archibald, Director, First Nations House of Learning.*



*A dipnet fisher at Moricetown Canyon, BC, catching sockeye salmon in a backwater pool.*



and indeed there is an international demand to which the Centre is responding. Recent examples are courses on [ECOPATH WITH ECOSIM](#), [RAPFISH](#), decision analysis, scientific writing, watershed reconstruction and marine mammal research. Clients have included FAO, DFO, and the British Columbia Ministry of Environment, Land and Parks.

## OTHER PROFESSIONAL ACTIVITIES

Faculty and other Fisheries Centre members are engaged in a variety of external activities related to their profession, both nationally and internationally, as editors of key journals, consultants, research advisors, members of external research teams, advisory committees, review and evaluation panels, organizers of workshops, members of boards of directors and directors of foundations. They also give public talks and press interviews. Dr Andrew Trites and researchers in the Marine Mammal Research Unit hold a unique, annual one day public symposium on marine mammals, at which individuals and organizations air viewpoints and new information. The Marine Mammal Research Unit and members of the associated North Pacific Universities Marine Mammal Research Consortium (NPUMMRC) have worked with graphic artists at the Vancouver Aquarium to produce a display booth, drawing attention of visitors to the marine mammal research being done. (See Annex 8 for other professional activity by Faculty members.)



*Dr Daniel Pauly and Dr Tony Pitcher at South Africa's Cape of Good Hope on a visit to help the new government's initiative to prioritize equity issues in fisheries research.*

## FISHERIES CENTRE ACADEMIC PLAN 2000

The Fisheries Centre's Academic Plan 2000 aims to consolidate its research profile in the area of applied ecosystem analysis and to develop its pivotal role in interdisciplinary research that addresses critical global problems in aquatic ecosystems and their embedded fisheries. Hence, goal 1 of the UBC Academic Plan 2000 (Retention and Renewal of Faculty and Staff) is as critical to the future status of the Centre as it is to the broader community of UBC. The description above of the Fisheries Centre's research, teaching and related activities addresses Goals 2 (Learning Environment), 3 (Research Excellence) and 4 (Links with the Community) of the UBC Academic Plan 2000. At present, although 12 associated UBC faculty members and 25 Adjunct Professors currently help in research and teaching, the Centre lacks full-time faculty with expertise in First Nations issues, in economics and in aquaculture. In addition some Faculty are nearing retirement.





The Fisheries Centre needs up to six professorial chairs over the coming five years in order to meet all of its research and teaching goals. As a start, a strong proposal has been put forward for one of the new 21st Century Canadian Research Chairs. In addition, the number of core funded support staff is severely inadequate and, currently, short term project funded staff are carrying out necessary work. More support staff are required to cover the Centre's needs. The proposal, now approved, to the Canada Foundation for Innovation (CFI) for a new building to house the Centre and related institutes, is an integral part of the Academic Plan. The new facilities are described later in this report. (See page 22.)



UBC Main Library and clock.

## FINANCING

The Centre is core funded by the University of British Columbia, but this covers only salaries and a tiny amount of office support. In 1999 this UBC support amounted to 10.6% of the total Centre budget: annual research and project income totalled 3.2 million dollars. Research projects and income have grown more than seven-fold since 1993. (See Annex 9.)



### *A Hive of Activity*

Fisheries Centre members are an active lot; the old brown huts that make up the Centre are always bustling. In the nerve centre - the Ralf Yorke room, an inauspicious (like Ralf himself) 4-door seminar-cum-coffee area - there may be a seminar at one end, flanked by elderly blackboards; at the other, a group of oblivious students working at computers; between them, a formal or informal meeting at a large round table that occupies the better lit area; and at any time Centre members are likely to burst in and out.



# OUTPUT OF THE FISHERIES CENTRE

## PUBLICATIONS



Four to six Fisheries Centre Research Reports are published each year.

The Centre's publication record is prolific by any standard, from newsletters to research reports, edited volumes and primary literature. Over the period 1993-1999, for example, the average number of peer reviewed publications per faculty was 5.3 per year, and the total output more than 8 published items per year. Publications by Centre members show a large number of papers in leading journals, and reflecting the training mandate of the Fisheries Centre, a significant proportion of students as senior authors, co-authors or occasionally, sole authors. The average citation rate of Fisheries Centre publications is over 50 per paper per year (see Annex 3).

The Fisheries Centre also publishes the **Fisheries Centre Research Reports** series (see Annex 2), consisting of papers from international workshops and research projects run at the Centre. **Fisheries Centre Research Reports** (ISSN 11989-6727) is abstracted in **Aquatic Science and Fisheries Abstracts (ASFA)**, ensuring that researchers around the world can become aware of this material.

A bimonthly newsletter, **FishBytes**, has been produced and distributed internationally since 1995. It contains news of research and personnel at the Centre as well as other items of broad fisheries interest. The North Pacific Universities Marine Mammal Research Consortium (NPUMMRC), administered by the Centre, produces another newsletter, **Marine Mammal Research**, and an annual report.

## SOFTWARE, DATABASES AND THE DISSEMINATION OF INFORMATION

"No fish is an island" - the credo of ECOPATH.



Creation of computer programs, particularly for simulation modeling, is a core element of the Centre's output. Advances in the **ECOPATH WITH ECOSIM** suite, emanating mainly from the fertile mind of Carl Walters, have become regular features. The **ECOPATH** home page (<http://www.ecopath.org>), from which **ECOPATH WITH ECOSIM** can be freely downloaded, includes examples and files that allow published examples to be replicated. Another software development project at the Centre is the conversion from DOS to the Windows environment of the widely used **FISAT** and stock assessment software initiated by FAO and ICLARM, a task being undertaken by programmer Felimon 'Nonong' Gayanilo.



Other software produced by the Centre has included a model for Lake Kariba, a modelling system for small freshwater lake fisheries, and 'effmod' - a spatial multispecies fishery assessment system, all three programmed by Carl Walters. Steve Mackinson developed **CLUPEX**, expert system software available on CD-ROM which predicts the structure, dynamics and distribution of shoals of herring. Peter Rand and James Scandol developed **NERKASIM**, a spatial modelling package for investigating the ocean migration of Pacific salmonids.

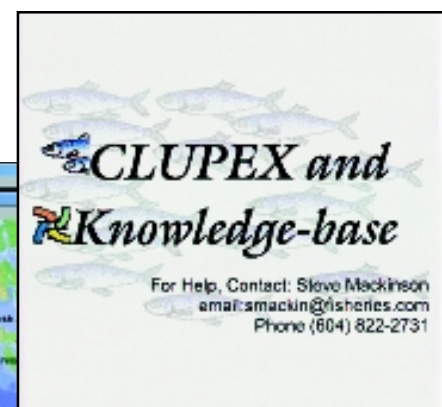
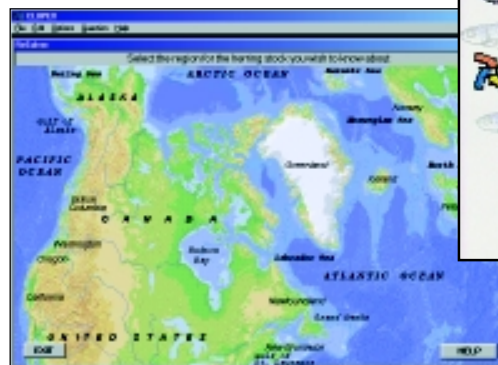
A Steller sea lion database management system is being developed by the NPUMMRC to access information about hard and soft anatomy samples housed at the US National Marine Mammal Laboratory, which is available on the NMML World Wide Web (WWW) site (<http://nmml.afsc.noaa.gov>). There is also a CD-ROM of Prince William Sound, Alaska, produced by Tom Okey, that includes models of five aquatic ecosystems, a database of Alaska's fishes, a dictionary of Alutiiq terms, and videos and pictures of animals and plants.

The Centre's World Wide Web site (<http://www.fisheries.ubc.ca>) includes a wealth of up-to-date information, including curriculum vitae of faculty members, current and past students and postdocs, and information about the Centre's research projects. Research output, such as new models and new versions of existing models, are posted on the Centre's home page after they are validated and documented; registered users are notified. The NPUMMRC also has an Internet site (<http://www.marinemammal.org>), and in 1998 released a 24 minute video (*If Alaskan Sea Lions Could Talk*) on the Consortium's research.

In 1999, the Fisheries Centre joined the testing and development of an innovative new approach to aquatic information dissemination - ONEFISH, a web-based directory (<http://www.onefish.org>) for the fisheries and aquatic research community. The site is primarily being developed by the Support Unit for Fisheries and Aquatic Research (SIFAR) in partnership with the Fisheries Department of FAO in Rome. Output from the Fisheries Centre is fully listed and searchable on the ONEFISH site. The Fisheries Centre is also involved with **FISHBASE**, a global database of fish biology (see page 65).



*Sardines take only one day to sun-dry on racks at the shore of Lake Kariba. These dried sardines, called kapenta, are bagged and exported throughout Central Africa.*



*See Page 58 for more on CLUPEX.*





# THE TEAM

The Fisheries Centre comprises a core group and two research units, the Marine Mammal Research Unit and the Fisheries Research and Development Section of the British Columbia Ministry of Environment, Lands and Parks.



*Annual Fisheries Centre welcome party, held at the Director's house.*

## CORE MEMBERS AND STAFF

The core group is composed of 5 faculty and a community of about forty research associates carrying out interdisciplinary fisheries and ecosystem research, supervising graduate students in related topics, and teaching graduate students in several faculties (see Annex 1). The Fisheries Centre is headed by the Director (who reports to the Dean of the Faculty of Graduate Studies). Core faculty members are assisted by associate faculty at UBC, a group of senior and junior research associates and emeritus members, adjunct professors, postdoctoral researchers and five full-time and five part-time support staff (see Annex 1).



*Dr Andrew Trites*

## MARINE MAMMAL RESEARCH UNIT

When the Fisheries Centre was created, there was growing concern amongst both the public and the North Pacific fishing industry about the status of marine mammals. The impact of commercial fisheries on marine mammals and the effects of the mammals on fish stocks were the major uncertainties. The Centre's Marine Mammal Research Unit was established in 1993 by Dr Andrew Trites to study the natural history and biology of marine mammals, interactions between humans and marine mammals, and marine mammals as indicators of ecosystem change. Methods employed include captive studies, field studies, and simulation and data analysis studies. The multidisciplinary approach combines the talents of marine mammalogists, physiologists, ecosystem modellers, fisheries specialists and oceanographers.

The Unit administers the North Pacific Universities Marine Mammal Research Consortium - the result of a proposal by Dr Trites to combine and synergize the scattered existing research effort on marine mammals in the region. The Consortium was formed in 1992 to undertake a long term program of research on the relations between fisheries and marine mammals in the North Pacific and eastern Bering



*Male and female Steller sea lions.*



Sea. It is funded by the US Congress and unites the marine mammal research of the four participating institutions: UBC, the University of Alaska, the University of Washington and Oregon State University.

## BC FISHERIES RESEARCH AND DEVELOPMENT SECTION

The Fisheries Centre houses 15 members of the Fisheries Research and Development Section of the Fisheries Branch, Province of British Columbia Ministry of Environment, Lands and Parks, working on freshwater management, mitigation and recreational fisheries in the province, over a long coastline, in 22,000 small lakes and hundreds of larger waterbodies, and in thousands of kilometres of rivers and streams. These habitats are home to more than 350 species of marine and brackishwater fish, and an estimated 10,000 distinct stocks of Pacific salmon. The Section provides invaluable input to the Centre through financial support, student support, shared equipment and joint research activities.

Special emphasis is placed on applications of geographic information systems to watershed and coastal zone management. The research program balances studies of the high profile



ABOVE: Steelhead (*Oncorhynchus mykiss*).



LEFT: BC Fisheries scientist Bruce Ward shows National Post reporter Mark Hume the diversity and abundance of aquatic life generated by inorganic nutrient addition in the Keogh River - part of BC Fisheries' watershed restoration program.

## Government Affairs

Although the Fisheries Centre's work often lies outside Canada, much vital and ongoing research involves partnership with fisheries scientists of the Canadian Federal Government, the Department of Fisheries and Oceans (DFO). For example, the Fisheries Centre has signed a formal agreement with DFO Atlantic region for the supply and analysis of data on discards, and for work in ecosystem simulations. Two productive and forward-looking workshops were held in 2000 with the Pacific and Newfoundland regional DFO on the BACK TO THE FUTURE reconstruction of past ecosystems. Centre members have taken part in DFO stock assessment reviews; students and postdoctoral fellows have worked with DFO on shrimp, eulachon, herring, groundfish, salmon and invertebrate fisheries and eight DFO scientists are adjunct professors at the Centre, serving on the supervisory committees of over a dozen graduate students. In alternate years, DFO staff mount a graduate teaching course for Fisheries Centre students - always a popular option. Members of the Centre also liaise with the social science, economics and policy wings of DFO.

As independent scientists, it is inevitable that Fisheries Centre members don't always agree with the official view that binds those employed by the government. However, relations have always been cordial, and such differences are easily overcome by our mutual excitement in new ideas, and by enthusiasm for rebuilding Canada's fishery resources.



Canadian Coast Guard research vessel Ricker on a shrimp trawl survey off the west coast of Vancouver Island.





ABOVE and BELOW: Fisheries Centre students, hosted by UFAWU, the local fishers' union, tour the docks in Steveston, BC, home to Canada's largest salmon fishing fleet.



salmon fisheries with research on herring, halibut, groundfish and invertebrate fisheries that, while less well known, far surpass the value of salmon landings. Key research areas include salmon rearing and the land-water interfaces - for example a student research project tracking the importance to coastal forests of marine derived nitrogen from salmon carcasses. Co-operative research with other provincial government scientists includes fish-forestry interactions, ecosystem restoration, conservation biology and biodiversity, decision support, computer simulation modelling, and policy analysis.

## GRADUATE STUDENTS

Graduate students are the life-blood of academic research institutions. Fisheries Centre graduate students and post doctoral fellows have come from Canada, Australia, Belize, Brazil, France, Kenya, Indonesia, Mexico, Malta, Nigeria, Norway, Spain, South Africa, Tanzania, Namibia, Thailand, the United Kingdom and the USA. Since 1993, student numbers have more than doubled to about 30 (see Annex 1 for a list including thesis titles, research areas and supervisors).

## INTERNATIONAL ADVISORY COUNCIL

A six-member International Advisory Council was formed in 1993 to help in establishing the Centre, and to provide on-going guidance on its activities and focus. A new Council was appointed in 2000 (see Annex 1). The Council has met at UBC once, in 1996, to provide an evaluation of progress of the Centre to that date; a satisfactory report was sent to UBC senate.



Fisheries Centre student success stories (clockwise from top left): Sylvie Guénette (Québec, Canada - Post-doctoral Fellow, University of British Columbia), Melanie Power (Newfoundland and Ontario, Canada - PhD candidate, Fisheries Centre), Ratana Chuenpagdee (Thailand - Faculty, Virginia Institute of Marine Science, USA), Trevor Hutton (South Africa - Research Officer, Lowestoft, UK), Laura Vidal (Mexico - PhD student, Yucatan, Mexico), Marcelo Vasconcellos (Brazil - Research Officer), Edward Nsiku (Malawi), Eny Buchary (Indonesia - Research Officer, University of British Columbia), Steven Mackinson (United Kingdom - Research Officer, Lowestoft, UK).





## ACCOMMODATION AND FACILITIES

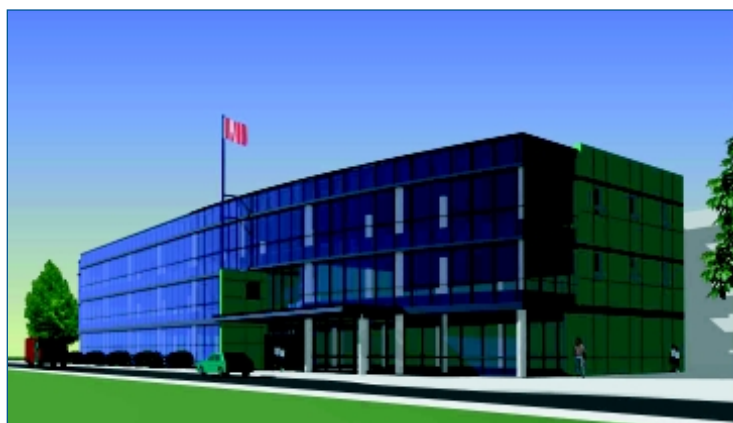
The Fisheries Centre has been housed since its founding in three post-war 'temporary' huts. Renovations to two rooms were completed in 1997, and to six others (with external funding) in 1999, but the accommodation is generally poor and units are split between different sites.

## THE FISHERIES ECOSYSTEM RESEARCH LABORATORY

The Fisheries Centre and partner institutions have determined to establish a Fisheries Ecosystem Research Laboratory (FERL) that will house the Fisheries Centre, including the provincial Fisheries Research and Development Section, the Marine Mammal Research Unit and the Institute for Resources and Environment (IRE). About \$12.7 million in funding from the Canada Foundation for Innovation (CFI), the BC Government Knowledge Development Fund (KDF) and UBC's Blusson Fund has been approved. The purpose of FERL is to contribute to the rebuilding of fisheries through enhanced scientific inputs and aquatic ecosystem policy and management. FERL will focus on fish stock assessment, marine ecosystem modelling, environmental analysis and modelling, and aquaculture management. It is expected that FERL will be a prominent institution in marine ecosystem modelling, in the study of the interaction amongst scientific, economic, sociological and environmental aspects of aquatic ecosystems, in rapid appraisal of the sustainability of fisheries, and in interface issues between aquaculture and fisheries of wild stocks. For the latest news on FERL, please see <http://www.fisheries.ubc.ca/Announce/FERL.htm>.



*"The Huts": the Fisheries Centre's current home.*



*Planned Fisheries Ecosystem Research Laboratory.*

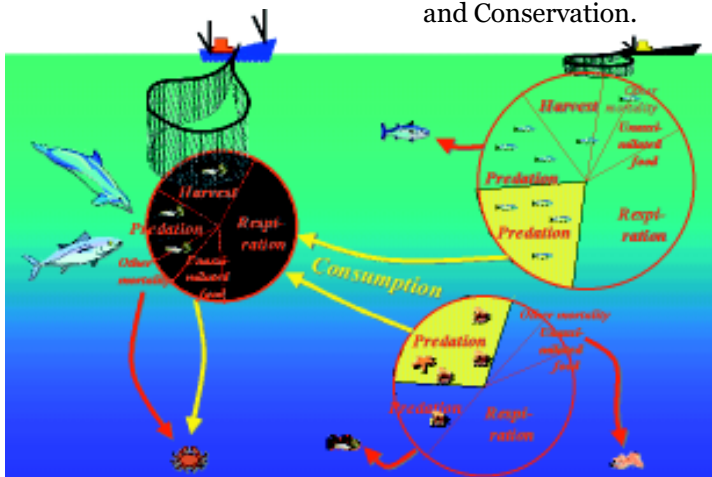


## THE ECOSYSTEM IMPERATIVE

An outstanding feature of the Fisheries Centre's research on biodiversity and conservation is the recurrent reference to ecosystems. While it may be a truism to state that conservation of endangered species, whether salamanders in a lake or marine mammals ranging around the North Pacific, has to be understood within an ecosystem

perspective, the implication is that conservation of ecosystem structure and integrity is paramount. Thus, answers to such questions as why Steller sea lions are declining, or what are the optimum size and shape of marine protected areas, or what are the effects of forestry on lake species, are increasingly being sought using quantitative ecosystem analysis. And endangered species are not the only focal points of ecosystem analysis: if fisheries are to provide sustainable yields, sound ecosystem-based management is essential. Balanced ecosystem management implies reconstructing present-day damaged systems to something like their former state.

In a few short years, building on its predecessor institutes at UBC and using the knowledge and skills of its team of thalassocrats, the Fisheries Centre has established a compelling reputation for research on a wide range of fisheries management and aquatic conservation issues, spanning the globe with ecosystem-oriented case studies and students. The results of that work, the directions it takes science and society, and the powerful tools its members have developed are outlined in this report under three main themes: Ecosystems and Ecology; Fisheries Management; and Biology, Biodiversity and Conservation.



Feeding relationships are the critical structure in marine ecosystems.

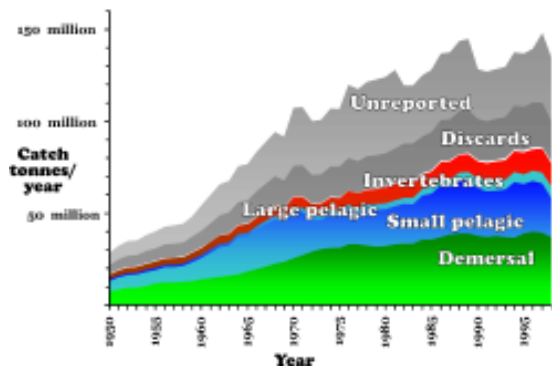
TOP: The Big Fish Eat the Small Ones (1557) by Pieter Brueghel the Elder.

LEFT: The ECOPATH model tracks all trophic flows, including fisheries.



# ECOSYSTEMS AND FISHERIES

The underpinnings of traditional single-species fisheries science began to break down in the early 1980s when large temperate water fisheries began to collapse in spite of assessments indicating their stability. Tropical fisheries were also giving aberrant signals - often by not collapsing despite evidence of overfishing. So it became clear that new and more comprehensive ways of assessing fisheries had to be devised. We had to find ways to use information much broader than classical population dynamics including fish behaviour, human behaviour and the entire natural food web within which fisheries are embedded.



World fisheries catch from 1950. Shaded elements represent Fisheries Centre estimates of unreported catch and bycatch, not usually shown.

## FORECASTING THE IMPACT OF FISHERIES

Director Tony Pitcher has brought a focus on ecosystems to the Centre, aiming to systematize, quantify and forecast the effects of fisheries. He has demonstrated that fishing selectively removes long-lived, slow-growing individuals both within and among species, and that the chances of reversal are compromised by three hard-to-reverse, ratchet-like processes: shifts towards more volatile life histories and local species extinctions (Odum's ratchet), economic overcapacity of the fishing industry (Ludwig's ratchet), and the cognitive inertia caused by using, as a reference baseline, the situation as it was at the start of one's career (Pauly's ratchet).

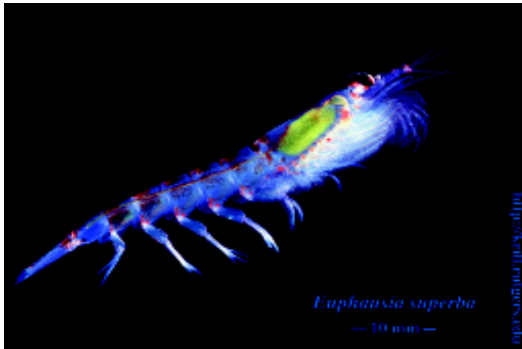
This thesis is being tested through new data and ecosystem simulation. Local extinctions of species have been examined using ecosystem modelling on halibut in the Strait of Georgia and giant yellow croaker in Hong Kong. This work has forecast reductions in the trophic level of landed fish and shifts in the dynamics of small schooling fish. Dr Pitcher and colleagues (Eny Buchary, Reg Watson, Trevor Hutton, Nigel Haggan and Tony Courtney) at the Centre have been working on the restoration of Hong Kong's marine ecosystem, using ecosystem simulation modelling to design protected areas to control fishing, and to forecast the benefits of deploying protected human-made reefs to replace lost habitat (see [Towards Responsible Fisheries Management](#)). This work has included a keynote address at an International Artificial Reefs symposium held in Italy in 1999 and elsewhere.

An international workshop, sponsored by industry and government, was held at the Fisheries Centre in November 1995 to discuss a rational basis for krill exploitation, bringing together experts on krill from Australia, Chile, Japan, Germany, South Africa, the United Kingdom, Canada and the USA. Papers and

Coral reef near Bira, Sulawesi, Indonesia. (Photo: T. Okey)







Antarctic krill, a vital forage organism in the Antarctic ecosystem.



Bycatch in a prawn trawl before bycatch reduction devices were in use, Bonaparte Gulf, Northern Australia.

Sorting prawns from bycatch in the Gulf of Papua - bycatch may outnumber prawns 10:1.



discussions are published in *Fisheries Centre Research Reports 3(3), 1995*, and eventually led to a multi-authored book, edited by Inigo Everson, in the *Fish and Aquatic Resources* published by Blackwell Science. Current work, performed jointly with Tarsicio Antezana and Jorge Cornejo at the University of Concepcion, Chile (Oceanography and Fisheries department), is examining how ecosystem models can help us evaluate the potential ecosystem impacts of krill fisheries in the Antarctic.

## ESTIMATING THE TRUE FISH CATCH

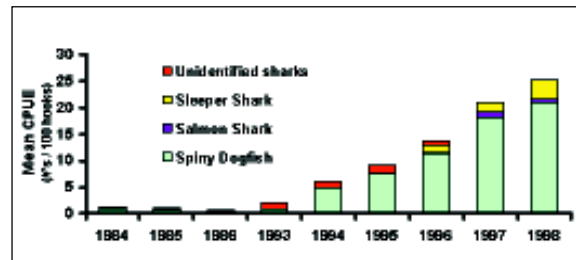
The general focus of fisheries management on fish landings has meant that the large proportion of discarded (and otherwise not reported) fish - perhaps more than 50 percent on average - is often not taken into account in assessments, quite apart from waste and the conservation issues raised by the inclusion in discarded bycatch of marine mammals, turtles, sharks, seabirds and other non-target organisms. The Centre hosted a workshop to consider bycatch discards and their impact on the ecosystem in October 1994, attended by more than 50 researchers and commercial fishers from Australia, Canada, Mexico and the USA. (A summary of the bycatch workshop was published as *Fisheries Centre Research Reports 2(1), 1994*).

From an ecosystem perspective, the issue becomes important because the total numbers of fish killed, and hence extracted from the food web, can be much more than reported landings. In addition to discarded bycatch, illegal and unreported catches are a major problem in many areas of the world, and are very sensitive to the precise details of fisheries legislation and its enforcement. For example, after steelhead (sea-going rainbow trout) catches were made illegal in British Columbia, almost no catches of steelhead were reported. Sometimes journalists, environmentalists, or fishers themselves, "blow the whistle". For example, in Canada, poorly worded legislation requires that hundreds of dead and dying swordfish caught on longlines have to be thrown away and are not reported. In Europe, more the three quarters of the swordfish sold on the Spanish market is said to have been illegally caught.

Issues of discarded bycatch and unreported fishing have been revisited by the Centre in a number of recent projects that have sought more knowledge of alterations to ecosystems as a result of fishing. For example, in the SEA AROUND US project (see page 35), Tony Pitcher and Reg Watson are field testing a simple method of estimating total fish extractions from irregular patterns of legislative influences and patchy information.



A critical issue for fisheries policy is how such changes might be reversed. Bycatch discards can be reduced through the use of technology - such as devices increasing the selectivity of fishing gear (techniques pioneered especially by Norway and Australia). Reducing illegal fishing is more difficult. Fisheries Centre research associate Nigel Haggan points out that it can be done only through public pressure as there can never be enough resources to police the sea. In this regard, the Fisheries Centre supports the efforts of ISOFISH, a group that exposes illegal fishing for long-lived, deep sea Patagonian toothfish (known in restaurants as Chilean Sea Bass), by listing vessels and owners on the World Wide Web (<http://www.isofish.org.au>).



Average annual shark bycatch per 100 hooks, compiled from International Pacific Halibut Commission longline survey data collected in the Gulf of Alaska between Nuka Point and Cape St. Elias.

## ECOSYSTEM MODELLING

Prior to the 1990s, the major fisheries assessment paradigm was based on determining the maximum sustained yield (MSY) that could be taken from individual target species using one or both of two simple models developed during the 1940s. This elegant and simple theory, called by the late Peter Larkin a “stained-glass cathedral”, predicted catches at different levels of fishing effort; it considered the direct relationship between stocks of fish and their human predators. Elaborated to include economic perspectives, apparently successful applications made these models irresistible tools of choice for managing fisheries.

But Carl Walters and Tony Pitcher independently pointed out in the 1980s that misplaced confidence in such models led to the collapse and depletion of many fisheries. Meanwhile, Daniel Pauly discovered, also in the 1980s, that heavily overfished tropical multispecies fisheries did not collapse, but shifted their species composition. The complexity of these tropical fisheries, indeed the sheer number of species being caught, further highlighted the need for a model or models that accounted for all the species involved. Hence, as outlined below, the Fisheries Centre

*FACING PAGE: An example of ECOSPACE modelling. Upper panel: map of c. 400 x 200km zone of Hong Kong (yellow shading) and South China Sea. Grid is c. 10km<sup>2</sup> cells used in model; blue zones are depths. Panel 2: grid map showing habitats represented in model. Panel 3: Grid map showing management zones: dark green are no-trawl zones (except prawn trawls); light green*

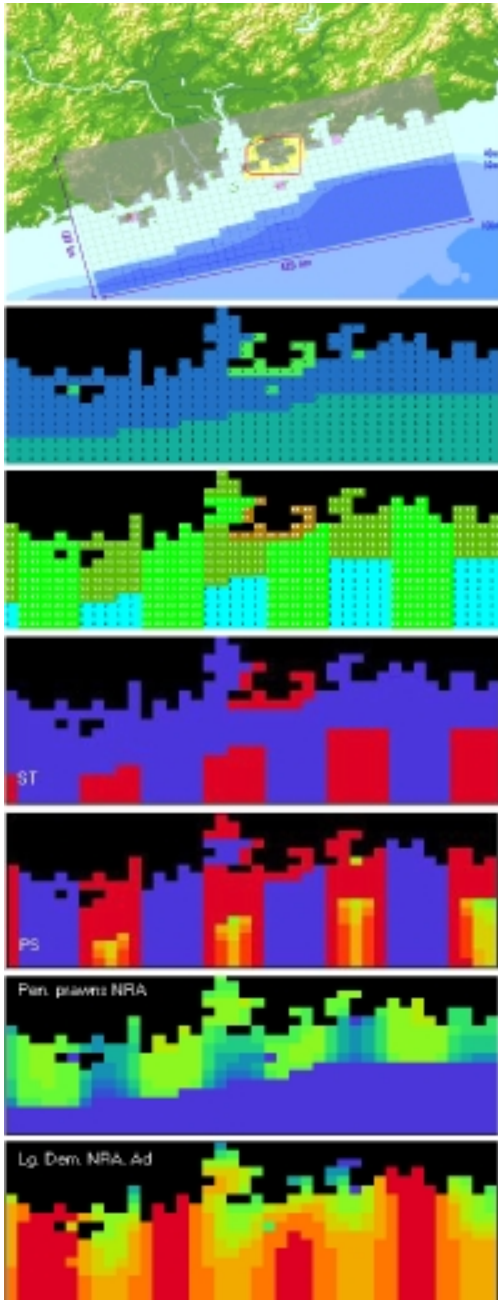
Continued on Page 27

## Improving the Accuracy of ECOPATH Inputs

A basic problem in constructing ECOPATH models, indeed when making any assessments or forecasts in fisheries, is knowledge of the accuracy - or uncertainty - of the data on hand. Most national and global estimates are based on FAO catch and effort data submitted by the statistical offices of member countries, which the organization itself admits are incomplete and suffer from various inaccuracies beyond its control. Reg Watson at the Fisheries Centre has been primarily responsible for development of a database that will consist primarily of catch data obtained directly from research organizations in various countries, or from area specific reports, and as far as possible corrected for inaccuracies, omissions, double accounting and the like. This will allow assumptions and predictions to be made that are based on best catch and effort data. Sources of corrections include direct observations, estimates of discards and illegal and other unreported catches (see graph page 24), climate, primary production, upwelling, depth, spawning grounds and other environmental considerations.

One overall limitation to fisheries catches at all levels is primary productivity of the oceans. The European Union's (EU) Joint Research Centre in Italy is working with a global system for assessing primary productivity based on satellite observations, and as part of an effort to make this work more widely applied, has begun co-operative activity with Villy Christensen on linking ECOPATH and satellite information. For example, a mechanism is now being developed to allow ECOPATH users to obtain primary productivity for any ecosystem through a direct link to the EU database.





Continued from Page 26

areas represent suggested no-take MPAs. Panels 4-7 illustrate ECOSPACE results after 25 years: hot (red) is high; cold (blue) is low. Fishing effort of stern trawlers (4) and purse seiners (5). Biomass of prawns (6) and large groundfish (7).

has considered it a priority to develop a number of modelling tools designed to improve both our knowledge and analysis of fisheries, and enable better consideration of the entire food web.

## DEVELOPMENT OF ECOPATH

Work on quantifying marine food webs had progressed little by the 1970s and consisted mainly of rules of thumb about the ratio of the biomass of organisms at different levels of the web. Working in Hawaii in the early 1980s, Jeffrey Polovina invented a short-cut description of food webs based on the principle of mass-balance ('everything has to go somewhere'); ECOPATH had begun. Daniel Pauly and Villy Christensen, at the International Center for Living Aquatic Resources Management (ICLARM), Philippines, improved Polovina's method and produced the first generally applicable quantitative ecosystem model, ECOPATH II, in the early 1990s. For the first time scientists could relate fishery yields to their supportive food webs, and see the potential effects of organisms operating at one trophic level on other parts of the ecosystem. A fascinating research technique had been invented, but many ecologists held strong reservations about the mass-balance assumption and the utility of ECOPATH as a management tool as it had descriptive rather than predictive capacity.

Enter the Fisheries Centre. Following a DFO and UBC funded workshop on applications of ECOPATH to the north Pacific, led by Drs Pauly and Christensen in November 1995 (*Fisheries Centre Research Reports 4(1), 1996*), Carl Walters was inspired to work on the problem of making ECOPATH more dynamic. His solution, described later as an "unexpected product of the workshop", was a biomass dynamics model called ECOSIM. It uses differential equations with respect to time, derived from the basic ECOPATH equation, and enables users to address the ecosystem implications of given fisheries policy options. A key feature of the ECOSIM model is to assume that most potential prey are unavailable to predators most of the time, through habitat choice or other refuging mechanisms. This is known as 'arena foraging' and contrasts with the classical Lotka-Volterra equations for describing predator-prey interactions, which assume proportionality between predators and prey mortality. In fact, for each organism in the ecosystem, the ECOSIM user can set a parameter between extreme bottom-up control and extreme top-down (Lotka-Volterra) control trophodynamics. In its latest version, ECOPATH can include fisheries and bycatch explicitly, bioeconomics, a number of parameters from network theory and a Bayesian method for estimating errors (ECORANGER). The combined model, together with later improvements and inclusion of spatial considerations is now known as ECOPATH WITH ECOSIM (EwE).





Development of **ECOSIM** led to an active association between Villy Christensen at ICLARM and the Fisheries Centre that resulted in his being appointed as an Adjunct Professor in 1997, and then, when funding became available, an appointment as a visiting scientist in 1999. Carl Walters, one of the founder members of the Centre, has worked on a wide variety of fisheries, ranging from rock lobsters and prawns in Australia to rockfish and salmon in British Columbia, in which it has been important to model explicitly spatial relationships involving movement and redistribution of both fish and fishers. Models that explicitly represent spatial structure and movement are used to evaluate policy alternatives such as marine protected areas for insuring direct and effective limitation of exploitation rates no matter how uncertain the manager may be about total size of the stock available to harvest. Spatial modelling 'shells' that he has developed are now being used on fisheries around the world.

**ECOSIM** allows comparison of ecosystems backwards and forwards in time. In its latest form, **ECOSIM II**, a collaboration with Jim Kitchell from Wisconsin, can tune the dynamics to time series of biomass or fishing effort, or even bird and marine mammal counts. It also includes non-trophic 'mediation' relationships, whereby one organism reduces mortality of another, for example, by providing a refuge from predators. And **ECOSIM** now includes a policy interface that searches for an optimal combination of fishing gears and efforts that maximizes specified economic, social or conservation objectives. Moreover, a simulated fishery manager can perform assessments and manage the fishery over time in order to investigate the effects of uncertainty on the likely outcome of the optimal policy. Two FAO-sponsored Fisheries Centre workshops led by Kevern Cochrane from FAO report on these **ECOSIM** developments (**Fisheries Centre Research Reports 6(2): 1998, & 9: 2001 in press**), and a book jointly published by Blackwells and FAO is due in 2001.

The major deficiency of **ECOPATH WITH ECOSIM** had been its assumption of spatial homogeneity. Largely due to Carl Walters' extraordinary insights, a new routine - **ECOSPACE** - was formulated in 1999, which helps reduce structural uncertainty in ecosystem models by allocating the biomass dynamics, including predation, feeding and fishing rates, of each species to a spatial grid of cells, accounting for movements between cells, defining preferred habitats for each species and areas closed to fishing. Current improvements to **ECOSPACE** include: an efficient hydrodynamic model for assessing effects of circulation and upwelling; more efficient modelling procedures; and simple ways to enter migratory patterns and to simulate seasonal spatial dynamics associated with migrations.



*Prawn tagging study on the Great Barrier Reef, Australia.*



*ABOVE: Artisanal fisher, San Miguel Bay, Philippines.*

*BELOW: Commercial trawlers in San Miguel Bay, Philippines.*





A Hong Kong fish market.

An important aspect of the development and utility of the Centre's ecosystem models is that they mutually reinforce one another through iteration. **ECOSIM** and **ECOSPACE** results provide feedback to the basic **ECOPATH** model, thus allowing improvement in its parameters, which in turn further improves the estimates derived in **ECOSIM** and **ECOSPACE**. Moreover, the methods are under continual improvement. For example, Steve Martell, a graduate student working with Carl Walters, has devised a way to describe seasonal dynamics, and Alisdair Beattie, a student of Daniel Pauly, has devised an automated procedure for adding the best grid cells to seed locations as protected areas.

## SOME APPLICATIONS OF ECOPATH WITH ECOSIM

Some of the recent applications of **ECOPATH WITH ECOSIM** by Fisheries Centre researchers and students include:

- Ecosystem effects of fishing down top predators in the Central Pacific, and whether a shark fishery might help mitigate the decline of threatened seal population (Carl Walters).
- Costs and benefits of protected artificial reefs in marine reserves on seven sectors of Hong Kong's fisheries (Tony Pitcher; **Fisheries Centre Research Reports 6(1), 1998**).
- Comparison of pre- and post-trawling ecosystems in the Gulf of Thailand illustrate Odum's ratchet (see page 24) and fishing down the food web (Villy Christensen).
- Ecosystem-based precautionary management rules for small schooling pelagic fish such as sardines and the trophic role of such forage fish suggest that optimal harvests of these fish would be much lower than at present (Marcelo Vasconcellos and Tony Pitcher).
- Comparative policy evaluation for upwelling fisheries (Steve Mackinson).
- The effect of increased detritus recycling on ecosystems (Marcelo Vasconcellos).
- Status of ecosystem and fisheries of the Red Sea (Dawit Tesfamichael).
- Optimal policies using **ECOSIM** show that multispecies, multi-gear small-scale fisheries in San Miguel Bay, Philippines, are on the verge of massive overfishing (Alida Bundy).
- Reopening Looe Key Reef, an MPA in Florida, to even moderate angling would remove most large predators (groupers) from a system that undergoes unexpected seasonal fluctuations of abundance (Judson Venier).



Herring school.

Bagan is a bamboo platform for lift nets. In the Java Sea there have been conflicts between bagans and trawlers, which ram them at night.



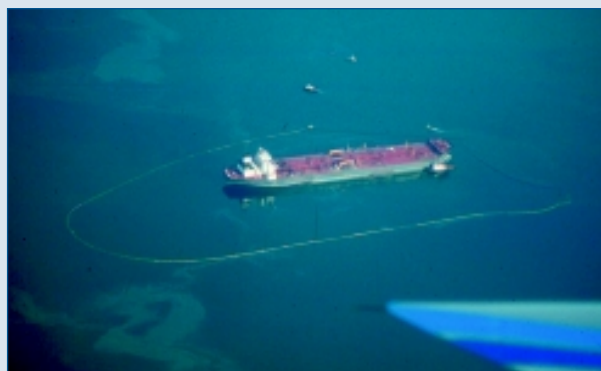
- Combining 15 **ECOPATH** models of areas of the Gulf of Mexico into a single, spatially structured **ECOSPACE** model highlighted the key role of shrimp trawl fisheries, and the massive amount of fish they discard (Laura Vidal).
- A 1980 ban on trawling in Indonesia's Java Sea increased resource availability for small scale fishers and **ECOSIM** simulations predict that lifting the ban might produce good harvests for only five years, followed by the same resource decline that prevailed before the ban (Eny Buchary).
- **ECOSIM** predicts that negative impacts of growth in the multi-sector small-scale fishing on Lake Malawi (Central Africa) on ecosystem structure far outweigh that of the relatively small commercial trawler fleet (Edward Nsiku).
- Tracking the fate of radioactivity using an **ECOPATH** model of Eniwetok lagoon, Marshall Islands, the site of the first US hydrogen bomb tests, and radioactive caesium in the Baltic Sea (Johanne Dalsgaard).



*Traditional line fishing in Lake Malawi using dugout canoes. Sustainable fishing methods cause little harm to fish resources and biodiversity.*

## Prince William Sound and the Exxon Valdez

The tanker *Exxon Valdez* went aground in Prince William Sound, Alaska, in 1989 and spilled some 36,000 tonnes of crude oil into a largely pristine marine environment. Fisheries Centre researchers, led by Tom Okey and Daniel Pauly, drew up a model of the post-spill ecosystem (1994-1996), using an immense body of information gathered during the *Exxon Valdez* Oil Spill (EVOS) research program. During 1998 and 1999, a series of four workshops,



sponsored by the EVOS Trustee Council and mostly held at the EVOS office in Anchorage, Alaska, revised the model and formed a cohesive picture of the food web in the Sound.

The revised model contains 48 biotic components, and its outputs include simulations of population trajectories through time and habitat-based redistribution of organisms in space. It can be used to help guide future research programs in the region and to assess the impact of the EVOS programme. (*Fisheries Centre Research Reports 7(4), 1999*). A CD-ROM is available that includes the model and its documentation. (Photos: T. Okey)







- The ecosystem impacts of seamount fisheries, in cooperation with the University of the Azores (Sylvie Guénette, Tony Pitcher, Telmo Morato Gomes).
- [ECOSIM](#) analysis of environmental change in the Georgia Strait, BC, and its herring and shrimp fisheries (Steve Martell).



*The Azores - TOP: Tony Pitcher, Sylvie Guénette, and Telmo Morato Gomes; BOTTOM: The volcano on Pico, taken from Horta, Faial, where the University of the Azores laboratory is located. This harbour is the home base for Portugal's fishery protection frigate.*

## TOWARDS AQUATIC ECOSYSTEM POLICIES

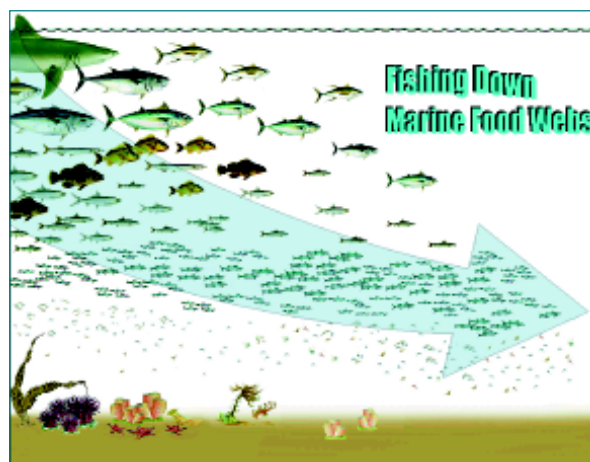
As [ECOPATH WITH ECOSIM](#) has evolved, the Centre's ecosystem projects have been enhanced to include its additional capabilities and dimensions. Analyses leading to the discovery of fishing down marine food webs employed many [ECOPATH](#) models of ecosystems. The first major project to use these capabilities, entitled [BACK TO THE FUTURE](#), used the ability of the models to reconstruct past ecosystems. The successful application of the models to relatively small ecosystems in this project encouraged a far more ambitious project, [SEA AROUND US](#), in which the spatial as well as temporal capabilities of [ECOPATH WITH ECOSIM](#) are employed to embrace the large number of ecosystems that make up the North Atlantic Ocean. Each of these projects is described in more detail below.

The aim of these projects is to create awareness of the need to rebuild the world's aquatic ecosystems for the benefit of future fishers and consumers of aquatic products. If successful, this work will lead to the ultimate analysis - of all the world's oceans.



## FISHING DOWN MARINE FOOD WEBS

In a cooperative study with members of the **FISHBASE** team (see page 65), Daniel Pauly and Villy Christensen used **ECOPATH** to determine the global impact of fisheries on the trophic levels of landed organisms - work supported by NSERC. Trophic level data came mainly from various **ECOPATH** models and other information in **FISHBASE**. These were used to analyse 45 years of world fisheries catch statistics (beginning in 1950) from FAO. The results showed there has been a systematic shift in the composition of fisheries at the global level, with their mean trophic level declining from 3.4 to 3.1 in this period. Of individual oceans and seas investigated, the northwest Atlantic showed the greatest decline, from 3.7 to 2.8 in three decades. However, other examples can be found on both the Pacific and Atlantic coasts of Canada, the Black Sea, now dominated by jellyfish, and the South China Sea, where many large fish exist only in the memory of older fishers.



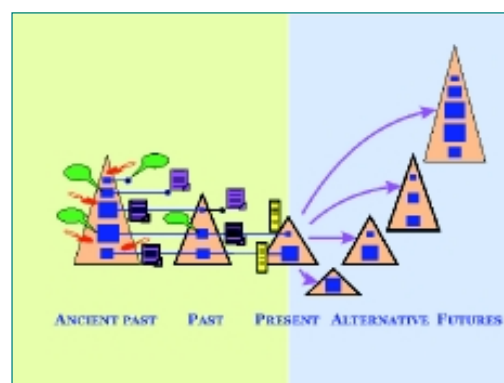
*Evidence shows that marine ecosystems have not only been depleted through time, but the trophic level of fished organisms has been reduced.*

Targeting organisms lower in the food web means greater harvests (of less appetizing fish!). But as the mean level decreases further, instances have been found where catches themselves begin to decrease, implying a major breakdown in ecosystem functioning. The results of this study, published in 1998, received great attention in the media, prompting more detailed studies in individual areas, both to verify and extend the applicability of the approach. The main thrust of this work at present is in the **SEA AROUND US** project.

## BACK TO THE FUTURE

In a depleted system, Daniel Pauly and Tony Pitcher have argued that rebuilding rather than sustainability is the correct goal of natural resource management (see **Reinventing Fisheries Management** page 42, and **Fisheries Centre Research Reports 4(2), 1996**). The **BACK TO THE FUTURE** concept is an exciting new approach to reconstruct past marine ecosystems - before modern industrial fishing began - as a way of understanding the present, and to show, as preliminary evidence is already demonstrating, the futility of present fisheries management policies that seek to maintain only the status quo. Two core elements in this project are **ECOPATH WITH ECOSIM** ecosystem simulation software, and the use of UBC as a neutral forum where opposing interests in fisheries can come together to share knowledge. Partnership with the UBC First Nations House of Learning (FNHL) is equally important to the **BACK TO THE FUTURE** approach in Canadian waters - Aboriginal involvement that the Centre has encouraged and facilitated. This approach requires major inputs not only from ecologists but also

*Diagram of the BACK TO THE FUTURE process: Ecosystems are represented by pyramids, whose height is proportional to the complexity of the food web. Reconstructions of past ecosystems lead to alternative futures.*





Ling cod off the southern coast of British Columbia are severely depleted.

from economists, historians, archaeologists, linguists and, importantly, the traditional knowledge of indigenous peoples and experienced coastal fishing communities.

BACK TO THE FUTURE uses the following steps:

- construction of ecosystem models of present and past ecosystems
- evaluation of economic and social benefits of each ecosystem
- choice of a system that maximizes benefits to society
- design of instruments to achieve this goal and evaluation of their costs
- and finally adaptive application and monitoring of management measures.

## What Is It Worth to Reconstruct the Past?

Many years ago, in the 1960s, Colin Clark, a brilliant mathematician associated with the former IARE at UBC, showed why fisheries tend to become depleted. Under certain conditions, money gains would be maximized by catching all the fish (or, in Clark's example, whales) and investing the proceeds elsewhere. Clark proved that destroying natural renewable resources by catching everything becomes rational economic behaviour once the discount rate was twice the natural renewal rate of the fish or whales. This was a profoundly dismal and alarming finding, and has never, until now, been countered at the theoretical level. Some tried to modify the theory using various fudge factors (including some invented by Clark), but the paradox refused to go away. Colin Clark's finding meant that the only arguments in favour of conservation were non-monetary ones, which governments and the fishing industry have found easy to ignore, despite lip-service to sustainability.



Ancient Roman mosaic in Antakya, Turkey. (T. Okey)

Now, the BACK TO THE FUTURE procedure relies on reconstructing past abundances, with smaller, but sustainable fisheries. Under Clark's analysis this would rarely be a rational economic choice. But the lay person's common sense says it should be. At the Fisheries Centre, Rashid Sumaila, in collaboration with Gordon Munro, has begun simple, elegant, groundbreaking work that explains the anomaly. Sumaila represents the paradox as a two-player game between present and future resource users: both players have to trade-off their discount rates if they are both to get a benefit from natural resources. The game-theoretical solution in most cases is a discount rate approaching zero, and hence it can become rational to conserve or rebuild natural resources. Where this new analysis has been used (in the Strait of Georgia and in Hong Kong) restoration of past ecosystems provides the maximum value. Rashid Sumaila bravely presented this work at an international congress of fisheries economists in Corvallis, Oregon in July 2000, where it was well received.

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To date, projects have covered the first three of these stages.

The first application of BACK TO THE FUTURE used ecosystem modelling to reconstruct the Strait of Georgia ecosystem as it might have been 100 and 500 years ago. A model constructed at a Centre workshop in November 1995 (*Fisheries Centre Research Reports 4(1), 1996*) served as the starting point. Centre postdoctoral fellows and graduate students (Johanne Dalsgaard, David Preikshot, Silvia Salas and S. Scott Wallace) worked under the direction of Tony Pitcher and Daniel Pauly to collate government fisheries data, researching archival and archaeological sources, and interviewing Aboriginal elders under the direction of the First Nations House of Learning. Information on past commercial fisheries was provided by displaced fish-





ers on a retraining program working under the direction of Duncan Stacey, a well known historian on fisheries matters in British Columbia. A study of pictographs and petroglyphs by Judy Williams was included. There was also an analysis of fish names in Saanich, the language of a First Nation in this area. This pilot work was the focal point for a November 1997 workshop, financed by the Peter Wall Institute for Advanced Studies at UBC, and attended by a variety of stakeholders including First Nations, commercial fishers, academics and government scientists, representing different knowledge bases. The new opportunity to cross-validate these and other knowledge bases using ecosystem modelling resulted in descriptions of the modelling and the protocol, ethics and tools needed for co-operation between academic, Aboriginal and other knowledge traditions, including papers by First Nations author Dr Jo-ann Archibald of the First Nations House of Learning. The workshop highlighted the need for strong reduction in fishing effort, establishment of large marine protected areas, and rehabilitation of small streams (***Fisheries Centre Research Reports 6(5), 1998***).

The second BACK TO THE FUTURE application, comparing the ecosystem of Hecate Strait in northern British Columbia in 1900 with the present day, was the result of a workshop in May 1998, in collaboration with the North West Maritime Institute at Prince Rupert, and sponsored by UBC, DFO and COFRI, at which most participants were Aboriginal or commercial fishers. The results indicated that the biomass of most marine resources in Hecate Strait was 25 to 100 percent greater at the beginning of the 20<sup>th</sup> century than at the present time (***Fisheries Centre Research Reports 7(3), 1999***).

In collaboration with Yvonne Sadovy and Wai-Lung Cheung at the University of Hong Kong, Eny Buchary, Rashid Sumaila, Nigel Haggan and Tony Pitcher compared the Hong Kong ecosystem with its fisheries in the 1950s to that of the 1990s, using the BACK TO THE FUTURE method. This period has seen massive depletions, local extinctions and exhibits a strong signal of fishing down the food web. The work included interviews with over 500 small-scale fishers, and was presented at the 3rd World Fisheries Congress in Beijing in 2000. Bioeconomics shows that restoration would bring immense economic and conservation benefits and economic advantages to some, but not all, of Hong Kong's fishery sectors. Currently, the investigators are trying to work out how to move to the next stage.



*Salmon drying, a Native subsistence fishery in Alaska.*

*Dried croakers from the Hong Kong inshore fisheries.*





*Tai O - a traditional fishing village on Lantau Island, Hong Kong.*



*Sea Around Us leaders, clockwise from top left: Principal Investigator Dr Daniel Pauly, and Senior Research Fellows Dr Villy Christensen, Dr Reg Watson, and Dr Rashid Sumaila.*

One ambitious new project is attempting to pilot the entire BACK TO THE FUTURE procedure. In 1999 a new 5-year project commenced that is using BACK TO THE FUTURE as part of a broader analysis of the health and future of coastal communities in Canada (***Coasts Under Stress***). The project is led by Rosemary Ommer from the University of Calgary, and involves about 70 scientists and social scientists, funded jointly by SSHRC (Social Sciences and Humanities Research Council of Canada) and NSERC and in partnership with First Nations groups, fishers associations, IPOST (the Institute for Pacific Ocean Science and Technology), the Northwest Maritime Institute and DFO. The Fisheries Centre's contribution, from Sheila Heymans, Marcelo Vasconcellos, Tony Pitcher, Nigel Haggan, Theresa Ryan, Dorothee Schreiber, Melanie Power and Rashid Sumaila, examines past and present ecosystems on Canada's east and west coasts using the BACK TO THE FUTURE techniques. The objective is to work towards restoring these marine ecosystems to provide optimum social and economic benefits to society.

## SEA AROUND US

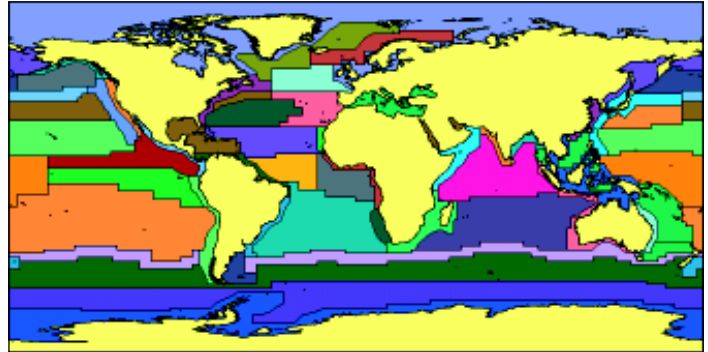
The results of the Fishing Down Marine Food Webs study, and related work in BACK TO THE FUTURE, Alaska and elsewhere, gave rise in 1999 to a new and far reaching project called the SEA AROUND US. The project, funded by the Pew Charitable Trusts, hopes to pave the way for reform of fisheries management. This effort, led by Daniel Pauly, is the first to develop a rigorous methodology for - and then the actual determination of - how much ocean resources have changed over the past 50 years. The aim is to show, through making clear the alterations that fisheries have caused in the ecosystems making up the oceans, the need for radical changes in current fisheries policies and practices.

The methodology employed and tested in this project is based on the full range of innovative methods developed at the Centre. For example, **ECOPATH WITH ECOSIM** simulates ecosystems with their embedded fisheries. Catch and effort data are being mapped onto ecosystems rather than arbitrary statistical areas, and improved by taking into account discards and illegal catches, a process that should provide a better picture of total extractions (see graph page 24). Energy consumption in the various fisheries is being determined and compared. The status of fisheries according to a wide range of indicators is being assessed using **RAPFISH**, a multidisciplinary, rapid evaluation method (see page 40). BACK TO THE FUTURE policy analysis tools, involving reconstruction of past ecosystems, are being used with a new economic methodology that will allow a broad base of interested participants to evaluate the ecological, economic, social and cultural benefits of re-



building these ecosystems. All of these results are being expressed in ways that allow them to be raised to basin-scale, in contrast to most work which generally applies only to one local area.

A workshop in April 2000, involving rigorous peer review, evaluated the methodology, and eleven papers are published in ***Fisheries Centre Research Reports 8(2), 2000***. The final results of the North Atlantic pilot project are expected in June 2001. Currently, the SEA AROUND US project is likely to be extended in year 3 to the South Atlantic and then in year 4 to the Pacific, while an increasing number of analyses output from the project will become global in scope.



Map of the world oceans' biogeochemical provinces, originally devised by Alan Longhurst.

## Logo Logic

The SEA AROUND US project's name was prompted by Martha Piper, the President of UBC, who referred to Rachel Carson as a pioneer of marine conservation. Rachel Carson's *The Sea Around Us* was published in 1951. SEA AROUND US also conveniently expresses the fresh insights to be gained. The logo of the SEA AROUND US project depicts elements of a marine ecosystem. The logo, designed by Mary Boone (who also designed the Fisheries Centre's logo) consists of three segments representing marine life - fish, mammals/reptiles, and plants. The fish segment is moving toward the other three puzzle pieces, and the counterclockwise motion represents rebuilding. In full colour, the fish segment is in UBC Gold, as a metaphor for the lasting value of fish. The remaining segments are in marine blue. These colours are also present in the Fisheries Centre's logo.



## ECOSYSTEM RESEARCH ON MARINE MAMMALS AND FISHERIES

ECOPATH WITH ECOSIM has found direct application in the Fisheries Centre's marine mammal ecological research. Analysis of isotope ratios in whiskers and tissues of Steller sea lions indicated a large reduction in primary production in the North Pacific since the mid-1970s. Certainly, the removal of whales and the collapse of several fish stocks - Pacific Ocean perch, herring and yellowfin sole - in the 1950s and 1960s meant the loss of huge amounts of biomass from the region. Another factor is climate change from variability in weather and climate patterns, particularly related to the Aleutian low pressure system.

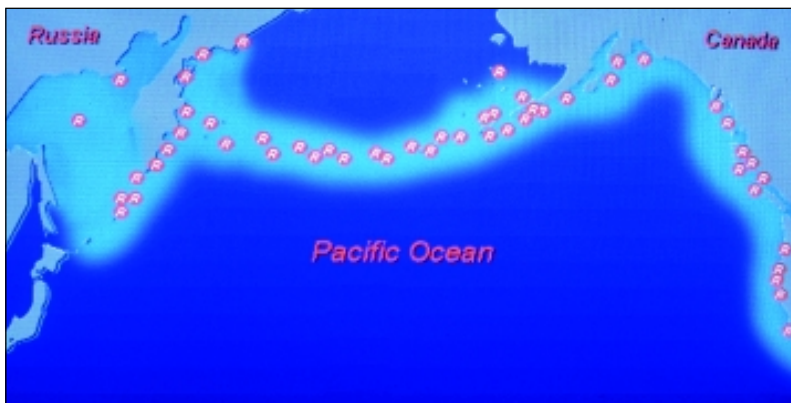




Sediment core samples support the view that climate change in the region has had a major effect on the structure of marine communities and productivity at all trophic levels.

The David and Lucille Packard Foundation, and a grant by the US Congress, funded a team of researchers headed by Andrew Trites and including Steven Mackinson, Daniel Pauly and Marcelo Vasconcellos of the Fisheries Centre and Patricia Livingston of NMFS Seattle and Alan Springer of the Institute of Marine Science, Fairbanks. They constructed an **ECOPATH** model of the ecosystem of the eastern Bering Sea during the 1950s, before large scale fisheries began. A second model was constructed for the 1980s, after many marine mammal populations had declined. Total catches in the eastern Bering Sea rose from 0.3 to 2.6 tonnes per km<sup>2</sup> in this time. Results suggest that neither previous whaling nor present commercial fisheries can account

for the observed changes. Changes cannot be solely explained by trophic interactions, suggesting that environmental factors, such as changes in water temperature or ocean currents, may indeed have had a role (**Fisheries Centre Research Reports 7(1), 1999**).



*Distribution of Steller sea lion rookeries in the North Pacific ocean.*



*Steller sea lion haulout in Alaska.*

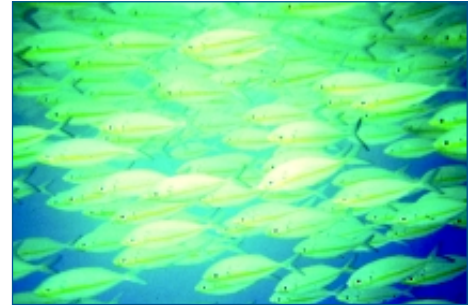


# TOWARDS RESPONSIBLE FISHERIES MANAGEMENT

As outlined in the section above, the Centre's focus on ecosystems has produced major developments in ecosystem modelling, principally through development and elaboration of **ECOPATH WITH ECOSIM**, and has a strong bearing on management directions for fisheries in the future, from microsystems such as marine protected areas to the global level. But the management tools used and developed by the Fisheries Centre have benefited from the Centre's heritage on the UBC campus, as well as from the expertise of its members. The process of Adaptive Environmental Assessment and Management, which has been elaborated and refined at the Centre through a multitude of uses world-wide, was first developed in the 1970s by scientists of the then IARE, including Carl Walters. The Centre's prowess in stock assessment methods can also be traced back in part to research by people such as Ray Hilborn in the IARE and the late Peter Larkin at the Institute of Fisheries.

Today, the Fisheries Centre continues this tradition of innovation and improvement in fisheries management tools which include:

- **RAPFISH**, a simple quantitative technique for evaluating the status of fisheries at the individual, group or national level in relation to a wide variety of management aspects
- spatially explicit stock assessment modelling shells where movement of both fish and fishers is an important factor in management
- examining global fisheries trends from a conservation perspective, leading to new insights concerning their status
- use of the Centre's independence in a variety of approaches to bring together, at a neutral forum, conflicting fisheries stakeholders for the resolution of management issues.



*Schooling fish in Pulau Menjangan, Bali.  
(Photo: T. Okey)*



*Steelhead biologist Bruce Ward has spent 26 years studying steelhead - over the last decade their return to Vancouver Island's east coast has been reduced to 10% of their former abundance.*

*Bringing home the bacon: low-tech anchovy fishing vessels clustered off the coast of Peru. Sustainably managed, this community fishery provides fishmeal to feed the world's pigs and chickens. Its boom and bust nature results from El Niño and overfishing.*



## DESIGN OF ADAPTIVE MANAGEMENT POLICIES (AEAM)



ABOVE: Hoover dam on the Colorado River, USA.



RIGHT: Base of the Tanner trail between Glen Canyon dam and Lake Mead.

Adaptive Environmental Assessment and Management (AEAM) is a process in which environmental dimensions are integrated equally with social and economic considerations. The basic approach was first described in a well-received 1978 book by IARE. AEAM is now used world-wide to bring together interdisciplinary teams of scientists, managers and resource stakeholders to develop models and policy options for a wide variety of resource management problems. A classic 1986 textbook by Carl Walters on the subject, *Adaptive Management of Renewable Resources*, was reprinted by the Centre in 1997 as low-cost student edition (see [www.fisheries.ubc.ca/Books/books.htm](http://www.fisheries.ubc.ca/Books/books.htm)).

Carl Walters has continued to be involved in AEAM development, and in applications to several major riparian ecosystems in:

- Florida Bay, to develop policies to reverse seagrass die-offs that threaten major recreational fisheries in the area
- the upper Mississippi River, to find ways to manage 26 navigation dams to allow better flood control and restoration of riparian vegetation communities, while maintaining recreational fishing opportunities created by the navigation dams
- the Kootenay River, to design experimental water release and fertilization schedules for the Libby Dam in Montana, to determine habitat requirements of threatened stocks like white sturgeon and burbot in the Canadian portion of the river and Lake Kootenay
- the Great Barrier Reef, Australia, evaluating the ecosystem impact of developing fisheries that target top predators in reef systems.

Low tide of lagoonal patch reef, Lizard Island, Northern Great Barrier Reef, Australia.



In addition, Dr Walters has used a workshop process to develop AEAM for the Florida Everglades, the Hudson River, the upper Columbia River, and Lower Colorado (Grand Canyon) River, USA. The emphasis in the workshops has been to bring water/power management interests together with ecological managers to develop sensible large-scale management experiments that aim to restore major ecosystem functions, without creating undue risk to endangered species. In the Grand Canyon, for example, the process is assisting scientists and managers in development of a simulation model for the riparian zone of the Colorado River from Glen Canyon Dam to Lake Mead. The model examines ecosystem variables and processes at multiple scales in space and time, ranging from hours-me-





tres for benthic algal response to diurnal flow changes, to kilometres-decades for sediment storage and the dynamics of long-lived native fish species. Its aim is to help screen policy options ranging from changes in diurnal flow variation to major structural changes that restore more natural temperature and turbidity regimes. The effects of policy change can be accurately predicted for some but not all components of the ecosystem. Experimental manipulation of water flows to test some of the model predictions is in progress.

Laboratory, field and collaborative case study projects have examined experimental management policies to discover sustainable harvesting regimes for fish populations. Two projects studied factors that may prevent recovery of populations that have been overfished in the past. First, overfishing may result in better conditions for individual growth, but better growth may then result in more individuals becoming cannibalistic and suppressing survival rates of juvenile fish. Such cannibalism effects were studied in rapid turn-over laboratory populations by Robert Ahrens. Second, overfishing may result in an increased abundance of prey species that are in turn competitors with or predators of juvenile fish, again causing reduced juvenile survival rates. This idea is being tested in British Columbia lakes where abundant trout populations have apparently declined much more than expected through fishing, while other species (minnows, suckers) have increased.

## RAPID APPRAISAL OF THE STATUS OF FISHERIES - RAPFISH

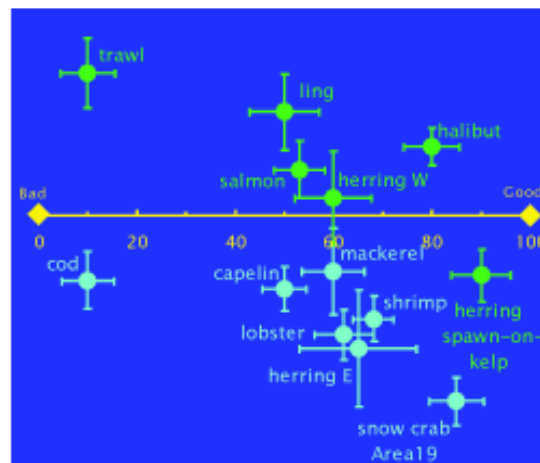
After suitable rebuilding of depleted stocks, ecological sustainability remains a primary goal of fisheries science. Conventional stock assessment generally does not include ecosystem considerations. Moreover, conventional analyses assessment usually ignores the profound social, technological and ethical considerations that overlay the fisheries themselves. Fisheries typically differ greatly in these considerations - for example in equity of entry to a fishery, degree of habitat destruction, in the incidence of illegal fishing, and in the amount of discarded fish. Potentially, dozens of attributes are available to measure the performance of fisheries in these various dimensions, but combining them to assess the relative health of a fishery is a daunting task. And it is hard to present results in a way that busy decision makers can readily assimilate. Now, a new technique devised at the Fisheries Centre shows considerable promise.



Artisanal dipnet (jaring anco) fisherman and son near Singapore. (Photo: T. Okey)

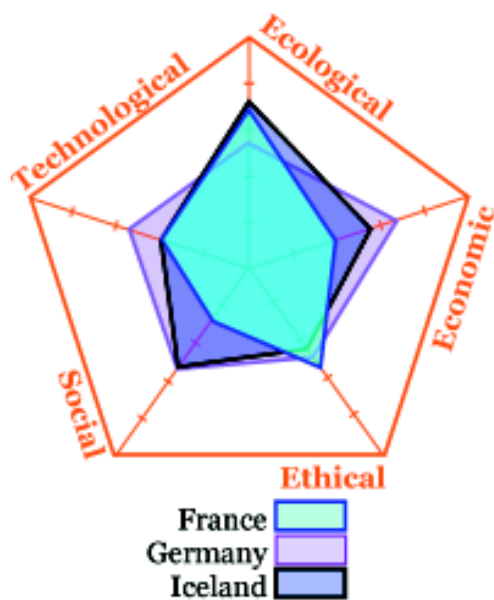


Blackfin tuna going to market in Baia Formosa, Brazil.



Two-dimensional RAPFISH plot of the ecological status of Canadian fisheries lying between the best ("Good") and worst ("Bad") possible scores. Bars show approximate confidence intervals.





*Rapfish kites comparing the average score of three countries in five evaluation fields.*

Tony Pitcher, David Preikshot and other members of the Centre with Leif Nøttestad from Bergen, Norway, have published a series of papers that develop a cost effective, rapid and simple ordination technique for fisheries appraisal called **RAPFISH**. Easily scored attributes of a fishery are rated using ranked scales between the 'best' and 'worst' possible status. Status is defined in relation to pre-defined policy goals, which can be altered in a flexible manner. The scores are compared using a non-parametric statistical ordination technique (multi-dimensional scaling - MDS), followed by simple standardization procedures. The technique produces status values for each fishery between zero and 100% and these ratings may be combined hierarchically. In this way status may be compared quantitatively and objectively among and between fishery sectors, such as large and small scale, among gear types such as trawls and fixed gears, among jurisdictions such as different countries, or among habitats such as inshore and offshore. Status can be evaluated independently for several different evaluation fields. At present, ecological (including ecosystem), economic, social, technological and ethical evaluation fields have been drawn up and tested.

**RAPFISH** is not intended for use in setting fishery quotas but as a way of tracking changes in the status of a fishery either historically, or in forecasting the outcomes of alternative policies. Results may be combined in various graphical forms, most commonly in 'kite' diagrams which have multiple axes, and whose outer edges indicate 100% status or 'healthy' conditions. The approach is hierarchical, allowing in depth analysis of subgroups or individual fisheries, and/or the individual fields that together form an arm of a kite.

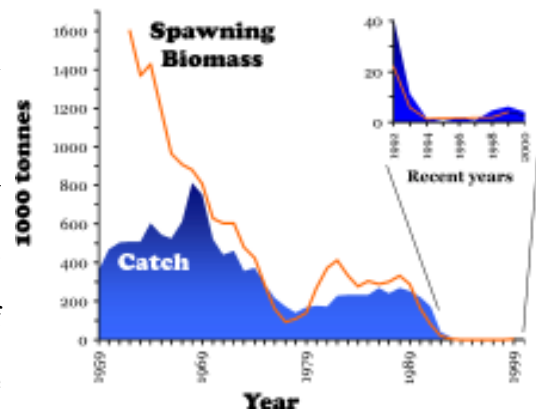
**RAPFISH** kites for different fisheries, fishing areas or periods can be compared at a glance and their implications for fisheries management quickly assessed. The technique has so far been applied to 24 tropical artisanal fisheries, 32 African lake fisheries, 29 world fisheries for small pelagic fish like sardines, herrings and anchovies, to a comparison of distant-water fleets of the former USSR with domestic fisheries in Mauritania and Senegal (see **Distant-water Fleet Impact Study page 53**), and to a comparison of fisheries on Canada's east and west coasts (see **Ethics page 44**). David Preikshot employed **RAPFISH** to quantify the prevalence of 'Malthusian' overfishing in over 50 small-scale tropical fisheries, including Malawi, Philippines and Indonesia.

Recently, **RAPFISH** has been applied to the FAO Code of Conduct for Responsible Fisheries as a way of measuring compliance by a given country or fishery. Through the FAO Programme for Visiting Experts from Academic and Research Institutions, Tony Pitcher compared the compliance of 42 Canadian Atlantic and Pacific coast fisheries and showed that **RAPFISH** was indeed a useful tool. A major task was to extract and systematize the many sustainability indicators explicitly



mentioned in the Code. Overall, Canadian marine fisheries exhibited a similar level of compliance but with important differences, such as higher technological sustainability and attention to ethical considerations in Atlantic coast fisheries.

Thanks to work by a volunteer conservationist and professional programmer from Burnaby, Patricia Kavanagh, **RAPFISH** can now incorporate uncertainty using Monte Carlo simulations. And, in cooperation with Edith Cowan University, Perth, Australia, its mathematical basis has been improved by Jacqueline Alder. Analyses are presently cumbersome because they entail a combination of spreadsheets, Visual Basic subroutines, statistical packages and production language programming. The aim is to develop easy-to-use spreadsheet-based **RAPFISH** software in the near future. Currently, a large number of analyses from the North Atlantic SEA AROUND US project, and from Latin America, are in progress and will help to further test and develop the method.



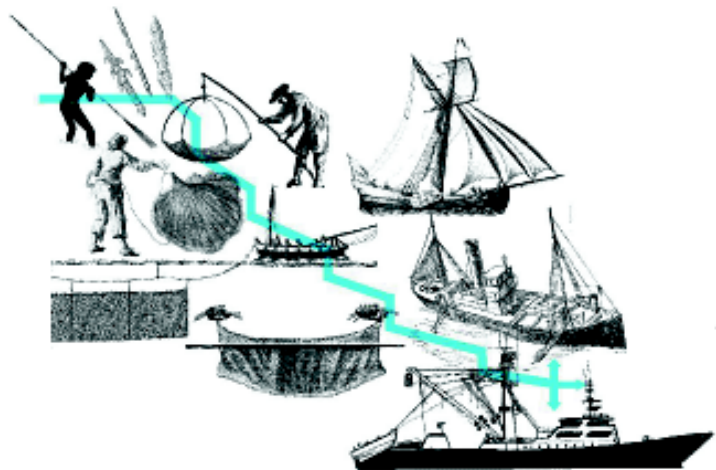
*Collapse of the Newfoundland cod fishery (from DFO data). Inset shows recent years on expanded scale. The catch equalled the spawning biomass for many years, yet standard theory says it should have been 20%.*

## REINVENTING FISHERIES MANAGEMENT

In February 1996, the Fisheries Centre gathered together more than 100 researchers to discuss new approaches in a reinvention of fisheries management. Traditional forms of management have been unable to prevent severe depletion of aquatic resources world wide and confidence in the discipline has been eroded at the very time when it is needed most. The symposium focussed on six themes, each led by one of the Centre's International Advisory Council members (see Annex 1):

- the production base and ecosystem management
- assessment, risk and adaptive management
- the role of policy in responsible fishing
- the role of the interface between the social and natural sciences
- the role of economic tools in reinventing fisheries management
- the role of institutions and partnerships.

The results were published in **Fisheries Centre Research Reports 4(2), 1996** and selected papers published in a 1998 peer-reviewed volume, **Reinventing Fisheries Management**, edited by Tony Pitcher, Daniel Pauly and Paul Hart, from Leicester University, UK (see Annex 3).



*Through time, biodiversity ramps down with successive developments in fishing technology. (Modified from the cover diagram of Reinventing Fisheries Management, 1998.)*







*An 80m Icelandic freezer trawler.*

## FROM INFORMATION TO POLICY

Mike Healey has researched the translation of scientific information into resource management policy, mainly in collaboration with T. Hennessey of Rhode Island University. Using case studies and theories of political agenda setting they have identified five ways in which scientific information is used in policy development, and the conditions necessary for the successful introduction of science at each stage of the policymaking process. The most significant recent finding is that attempts to be fair to all users in publicly managed fisheries can lead to overwhelming complexity and even a breakdown of the management system.

### Bioeconomics

The Fisheries Centre is addressing the economics of ecosystem management through the development of an economic component of [ECOPATH WITH ECOSIM](#). Ussif Rashid Sumaila (jointly with the Centre and Christian Michelsen Institute, Bergen, Norway) and Gordon Munro of the Department of Economics, UBC, are incorporating discount rates, prices and costs (both market and non-market) into ecosystem models. They aim to determine and value different ecosystem alternatives and then add social values that attempt to capture cultural and societal concerns. The objective is to identify the best ecologically and economically sustainable ecosystem alternatives. To address non-market values, methods are used to capture the socio-cultural importance attached to the various ecosystems by communities that interact with them, as well as intra- and inter-generational equity. Ultimately, the goal is to define and incorporate the motivation of both fishers and regulators into the ecosystem models. Then the harvest mix that gives the highest overall economic benefit without impairing the sustainability of the system can be determined as well as the equity (distributional) effects on different stakeholders under different ecosystem alternatives and fisheries management regimes.

Several applications have been completed. In the distant-water fleet study outlined above, the analysis showed that because of overexploitation of fish resources in Namibia's EEZ by distant-water fleets in the years before independence, the country had inherited an altered ecosystem whose production potential was severely reduced. And had Namibia employed the same fishing effort in those years in the absence of such fleets, the country would have made in excess of 100 percent more economic rent from exploiting these resources. A study of the Strait of Georgia ecosystem (see [Ecology and Ecosystems](#)) showed it is possible to triple the long term benefits from the ecosystem after a restoration or rebuilding effort has been implemented. In Hong Kong, the economic benefits of combinations of artificial reefs and marine protected areas were able to be realistically assessed using the principles above (see also above - [What Is It Worth to Reconstruct the Past?](#)).



*Fish market, Bodrum, Turkey. (Photo: T. Okey)*

In line with the interdisciplinary mandate of the Fisheries Centre, Daniel Pauly also encourages students to work on the human impacts on fisheries and ecosystems. Ratana Chuenpagdee developed and tested a new approach using binary questionnaires to rank the relative damage of various 'injuries' to coastal ecosystems (e.g. mangrove deforestation vs. oil spills, tourism development vs. shrimp farming) which led to surprisingly consistent results across a wide range of respondents. The technique is currently being developed further in combination with [RAPFISH](#).

Trevor Hutton, supported by South African funding, working with Tony Pitcher, carried out neo-institutional and game theoretical bioeconomic analyses of two South African fisheries (hake and linefish) that show why the new democratic government encounters problems in trying



to extend the equity to previously disadvantaged coastal communities. Results were not hopeful for an easy resolution of this problem.

In 1999, one of the Centre's first Aboriginal students, Stephen Watkinson, funded by the David Suzuki Foundation, contrasted the present state of resources in Rivers Inlet, BC, with that prevailing in the 1950s. Although hampered by lack of consistent data, the results indicated that jointly, Aboriginal and sport fishers operating from lodges realized less than 10 percent of the catch, the rest being taken, as allocated, by commercial fisheries. And, the great increase in commercial fishing was sufficient to explain the decline of species other than salmon. These results had a large media impact in the province, mainly because they were connected with issues on logging and bear hunting activities in the adjacent watershed.



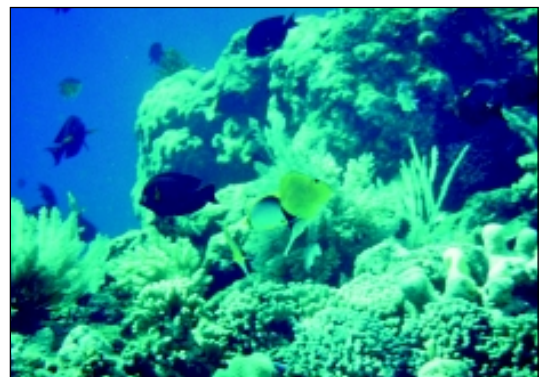
Recreational fishing boat in Chatham Strait, Alaska.

## ETHICAL ASPECTS OF FISHERIES

Researchers from the Fisheries Centre, the University of Victoria's Centre for Studies in Religion and Society, the Institute for Social and Economic Research at Memorial University of Newfoundland, and a spectrum of fishing industry partners from Canada's east and west coasts collaborated during 1997-1999 in an innovative project entitled *Ethical Analysis as a Basis for Policy Decision-Making: Canadians and Fish Stocks, East and West*. The research was made possible by a strategic grant from the Social Sciences and Humanities Research Council of Canada. The objective was to use interdisciplinary methods to explore the potential of a common code of ethics to win a broad base of government, industry and public support for the introduction of necessary changes in fisheries management. From the Fisheries Centre Tony Pitcher, Daniel Pauly, Melanie Power, Nigel Haggan and Russ Jones were five of the 15 team members, while other Centre members were asked to contribute through co-authoring chapters in a book on the project findings.

The project team included fisheries scientists, economists, geographers, lawyers and students together with an artist, an ethicist and two theologians. Meetings to develop a common mind were held in 1997 on both the east and west coasts, attended by representatives of a variety of sectors and viewpoints in the fishery. Between the two meetings, the voices of other community groups were heard, and a

Coral reef near Bira, Sulawesi, Indonesia. (Photo: T. Okey)

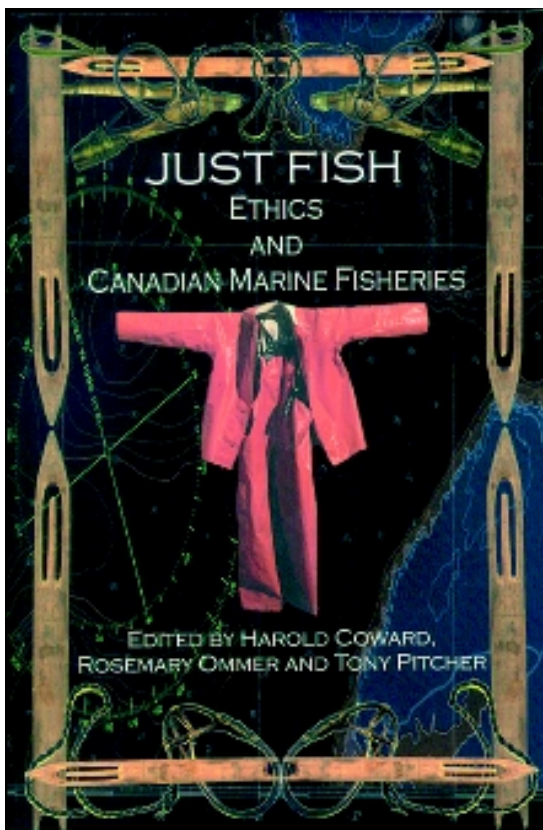


third and final workshop was held in October 1998 in Queen Charlotte City, Haida Gwaii, where the viewpoints of the Haida community were expressed.

The project identified ethical and other value components of the scientific, economic and political decisions that affect the marine ecosystem, and the value judgments that underlie such decisions. It was found that any sense of resource stewardship had been lost during the processes of industrialization and globalization. A group of Centre students led by Daniel Pauly found that, on both Canadian coasts, ecosystems supporting the fisheries had suffered significantly from excessive fishing. **RAPFISH** was used by Tony Pitcher and Melanie Power of the Centre to quantify nine ethical attributes of fisheries on Canada's east and west coasts, encompassing four kinds of justice:

- creative - involving co-operation between government and local participants in fishery management
- distributive - fair distribution of the resource among community members
- productive - the best way of managing the ecosystem to produce desired results
- restorative - restoration of ecological and social damage towards earlier, undamaged conditions.

Overall, west coast fisheries scored significantly worse than those on the east coast. The project determined that ecosystem justice is also needed, in which an ethically acceptable relationship is formed among all competing and complementary interests of an ecosystem community. The final products of the project were a book published by ISER press in 2000 entitled ***Just Fish: Ethics and Canadian Marine Fisheries***, edited by Harold Coward, Rosemary Ommer and Tony Pitcher and illustrated by Pam Hall from St. John's, Newfoundland. A summary brochure of the same title was prepared by Rosemary Ommer, and presented to meetings of decision makers on both coasts.



Cover of *Just Fish*, designed by Newfoundland artist Pam Hall.



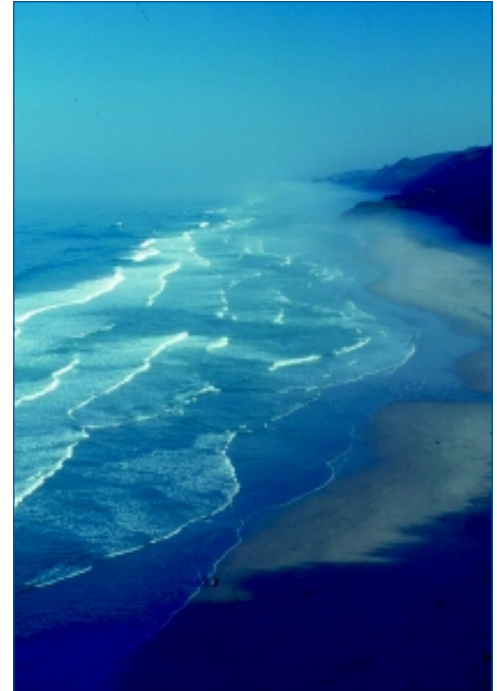


## CO-OPERATIVE AND COMMUNITY-BASED MANAGEMENT

The Fisheries Centre has made repeated efforts to utilize its independence from public and private sector fishery groups to help resolve fisheries issues both nationally and globally. In common with many such initiatives on Canada's west coast, few of these have stood the test of time and money, but the Centre has not given up.

### THE COMMON GROUND FISHERIES FORUM

In 1993, Ron Macleod, recently retired from DFO, and Nigel Haggan, then a First Nations fisheries advisor, with support from Lynne Pinkerton, now at SFU, proposed that the Fisheries Centre offer its services as a non-aligned forum and facilitator at the regional level to bring together all sectors of the BC fishery - commercial, sport, processors, First Nations, government, science, law and environment. The idea was to find agreement on key issues and terms by assisting co-operative projects, demonstrating new fair approaches, and seeking support for new policies. In a series of meetings, the Common Ground Fisheries Forum, chaired by Ron MacLeod and Tony Pitcher, developed a draft code of conduct for British Columbia fisheries and identified several potential projects. Sadly, continuing funding could not be found and the initiative dissolved in 1995.



*San Mateo coastline, central California.  
(Photo: T. Okey)*

### PACIFIC FISHERIES THINK TANK

In 1996, the Fisheries Centre and the Simon Fraser Institute of Fisheries Analysis jointly set up the Pacific Fisheries Think Tank to encourage the development of a fresh vision for Pacific fisheries. Stakeholders are not directly involved. This approach uses workshops on specific problems and/or forms teams to analyze the problem and provide management options. The Think Tank, which is currently not operational, had a number of activities including:

- A west coast workshop in development of a Canadian Code of Conduct for Responsible Fishing, initiated by Canadian fishers in response to Canada's signing of the Rio Convention and a generic Code of Conduct drafted by FAO (December 1996)
- A Vancouver workshop on the 'ecolabelling' initiative of new Marine Stewardship Council, sponsored by Unilever and WWF (January 1997)

*Chinook salmon, along with coho, suffered a severe decline over the past decade.*



- A workshop entitled *British Columbia Salmon: a Fishery in Transition*, on issues relating to fish stocks and management structures and the building of a vision of a sustainable salmon fishery (February 1997)

## *The Future of British Columbia's Fisheries*

What will BC's fisheries look like in 50 years time? A local newspaper, the *Vancouver Sun*, has run a series that includes both pessimistic and optimistic predictions: most local fisheries scientists are among the pessimists. In 1995 Carl Walters undertook a thorough investigation of British Columbia's fisheries, mainly focussing on salmon, for the David Suzuki Foundation's Pacific Fisheries Project. His book *Fish on the Line: the Future of Pacific Fisheries* reviewed present trends in catches, hatcheries, harvesting methods, and management. He found most existing management practices inappropriate in face of the need for continuous adaptive management to respond to natural and human-caused fluctuations in fisheries. Benefits would come only from increasing the involvement of local communities in managing BC resources.



CLOCKWISE FROM TOP: Sockeye salmon; Eulachon; Salmon trawler.



Other members of the Centre are involved in the independent analysis of a number of specific BC fisheries and areas, such as the controversial BC trawl fishery. The bottom-scraping trawls target a unique species flock of rockfish in which new species are still being discovered, and many of whose diets and basic biology are hardly known. Trawls also damage 10,000-year-old sponge reefs that provide refuge for juvenile fishes. Eulachon, of great importance to BC First Nations culture, increasingly comprise discards in a new trawl fishery for shrimp, as the search for new fisheries shifts inexorably down trophic levels. Halibut, according to conventional wisdom now protected from overexploitation by privatization, have inexplicably halved their growth rate in recent years. And salmon fisheries, despite brave attempts by the federal government to reduce catching power by buying back fishing vessels, suffer from a grossly overcapitalized fishing fleet owned by a few big players, and are threatened by climate change. Recent work conducted at the Fisheries Centre indicates that BC's marine ecosystems, and its major fish stocks, have suffered from a century of serial depletion, and provide a clear example of fishing down marine food webs (see page 32).

Local fishing communities in BC are in serious decline, along with many of the resources on which they depend. At the same time, Canadian governments put huge subsidies into fisheries: the national figure is estimated at somewhere between 100% and 200%. The Fisheries Centre, as an independent non-government research unit, shares, and will continue to publicize, these concerns. Fisheries must accept more controls and become more responsible than in the past, in order to allow rebuilding of benefits of natural ecosystems and biodiversity because the alternative will, for sure, lead to degraded ocean ecosystems that most of us regard as unthinkable (SEE BACK TO THE FUTURE). The Centre is not, as sometimes claimed, in favour of banning all fisheries - all of us love seafood. Our mandate, in BC as elsewhere, is to actively seek practical and ethical ways of reconciling profitable exploitation and thriving local fishing communities with the conservation of biological diversity and ecosystem function. The Fisheries Centre invites comments on our work and aims on our web page at <http://www.fisheries.ubc.ca>.



- A workshop on Exploring Co-operative Management on principles, functions and criteria (April 1997)
- Think Tank members from SFU, Robert Brown and Kelly Voden contributed to stakeholder workshops in Hong Kong (October 1997) (see above) .

## CANADIAN OCEAN FRONTIERS RESEARCH INITIATIVE (COFRI)

In 1995, the Fisheries Centre began work with the Canadian Ocean Fisheries Research Initiative (COFRI). Tony Pitcher chaired one of four elements to the initiative, which brought together academics, BC manufacturing and fishing industries, federal and provincial fisheries agencies to seek new cost effective ways of assessing commercial fish such as salmon, hake, herring and squid. The traditional approach of test fishing using large DFO vessels was seen as costly and sometimes inaccurate. A number of research projects to develop remote controlled devices were proposed, but, after some pilot work, sufficient funding was not found. COFRI helped to fund the BACK TO THE FUTURE pilot workshop in Hecate Strait.



*Kokanee salmon (land-locked sockeye).*

## INSTITUTE FOR PACIFIC OCEAN SCIENCE AND TECHNOLOGY (IPOST)

Some of the technological momentum and partnerships developed in COFRI have continued in the Institute for Pacific Ocean Science and Technology (IPOST), a collaboration between BC industry, academia and government. The Director of the Centre, Tony Pitcher, is a member of the Board of Directors of this new institute. Through pump-priming activities, IPOST is concerned to develop practical and ecologically responsible strategies for seafood sustainability by tackling a wide range of science issues, including ecosystem-based analyses and management. IPOST is a potential partner in the new Fisheries Ecosystems Research Laboratory, and at present has interests in the Centre's krill fisheries project, and economic aspects of the BACK TO THE FUTURE project in the Hecate Strait.







*Hauling salmon on a seiner in Alaska. Note the anti-mosquito gear.*

## CO-OPERATIVE APPROACHES TO INFORMATION GATHERING FOR STOCK ASSESSMENT

Research by Carl Walters on the effectiveness of stock assessment methods for spatially-complex fisheries has revealed the inadequacy of information generally used for fisheries assessment. Traditional assessment approaches can cause high risks of overfishing in situations where undetected spatial collapse occurs, such as the Newfoundland cod. One way to obtain the quality and quantity of spatial information needed is through radically different arrangements for working co-operatively with fishers, where information gathering (surveys, rapid reporting) is seen as a basic responsibility, and part of the cost of doing business for fishers. Case studies in this area have ranged from the “Seagrid” proposal, where commercial salmon troll fishers provide detailed, hourly data on salmon migrations, to co-operative depletion experiments with Australian fishers to measure densities of coastal species such as crabs and reef fish.

Dr Walters has also shown that traditional recruitment relationships used in single species population assessment can be extended in a relatively simple way to multispecies settings where juveniles are subject to varying environmental conditions, predation regimes, and food supplies on various spatial scales. Such multispecies recruitment relationships have been useful not only in fisheries contexts as dynamic components in [ECOPATH WITH ECOSIM](#) applications but also in conservation contexts, such as explaining recruitment failure of giant sturgeon in the upper Columbia River system.

## SOME SPECIFIC MANAGEMENT ISSUES

### MARINE PROTECTED AREAS

*Marine reserves provide a refuge in which slow growing species like this lunartail grouper (*Variola louti*) can attain their maximum size.*



Increasingly, marine protected areas (MPAs: also known as marine reserves, no-take areas, sanctuaries or parks, i.e., areas in which no fishing is allowed) are seen as useful fisheries management tools in the face of disappointments with standard management practices. Many argue that MPAs are essential to protect heavily fished resources, to provide a hedge against uncertainty and mistakes, to act as a buffer against overfishing, to enhance spawning biomass and recruitment, and to allow habitats to recover. But significant scientific questions remain regarding their design and ways of monitoring to measure their cost effectiveness and benefits. In 1997, the Fisheries Centre hosted a meeting of over 60 researchers in this field from around the world, including many internationally acclaimed authorities on marine reserves. Tony Pitcher underlined the importance of MPAs: “I believe that the first country in the world to have the courage to declare large parts of its ocean as permanent no-take marine reserves will be the



country, and given present trends it may be the *only* country, with healthy fisheries in 50 years time.” (*Fisheries Centre Research Reports 5(1), 1997*)

The Centre’s **ECOSPACE** simulations allow the effects of size and location of MPAs to be estimated. Very small MPAs may in fact increase the catch of fish as fishers concentrate at the perimeter. Thus to be effective for conservation, MPAs need a short perimeter relative to surface area, or should be sited in bays with limited adjacent exploited areas. Hence, biogeography suggests that a few large MPAs would be more beneficial than many small ones. But statistical and other biogeographical factors have to be traded-off against this finding. First, replication is necessary to evaluate statistically the outcomes of MPAs. Moreover, protected corridors allow recolonization sites, any one of which might be wiped out by chance. These issues were evaluated by Fisheries Centre researchers in designing an MPA system in Hong Kong (see Box above). Indeed, the most powerful uses of **ECOSPACE** with MPAs are in situations where the policy choices are known, and outcomes cannot be compared using existing models. Using the AEAM approach, Steven Martell has examined how MPAs might help to rebuild BC shrimp and lingcod stocks in the Georgia Strait.

MPAs are not normally thought of as being of benefit to migratory species. So could MPAs have saved the Newfoundland cod from collapse? Working with Tony Pitcher, the Centre’s Sylvie Guénette constructed a spatial model including several stocks, migrations and range dynamics, and showed that in the 1980s, only very large MPAs, comprising 80 percent of the fishes’ range, could have formed a hedge against mismanagement; a reserve of half this size would have only slowed the collapse. But, had reserves been deployed in the 1960s, before heavy fishing by foreign fleets, the outcome might have been rosier.

## Marine Reserves and Artificial Reefs in Hong Kong

In 1996-1997, a detailed study of Hong Kong fisheries made at the request of the Hong Kong Government showed that halving the fishing effort would produce considerable benefits in all fishery sectors, as well as for conservation efforts. There are more than 300 trawlers and many thousands of gillnetters in the area; average size of fish caught has fallen 90% since the 1940s, and is now only a few centimetres. The study, which involved cooperation with Prof. Rudolf Wu at Hong Kong City University, Dr Robin Kennish at Environmental Resources Management (ERM) Ltd. and Paul Mak from Furano Ltd., determined the exploitation status of the resources and the likely impact of various management measures. Preliminary indications were that catches of larger and slower growing species might be at least doubled with optimal management. A baseline **ECOPATH** model of the Hong Kong inshore ecosystem was constructed and used to predict the impact of various fisheries management scenarios. (*Fisheries Centre Research Reports 6(1) 1998*)

The Fisheries Centre has subsequently obtained a series of contracts jointly with ERM Ltd. to investigate the use of marine protected areas deployed with protected human-made reefs, a subject of keen interest to Keith Wilson at the Hong Kong Agriculture and Fisheries Department which had initiated a \$HK100 million program of marine restoration. Alternative designs for reef emplacements have been evaluated, and local fishing community workshops have sought stakeholder input and consent using **ECOPATH WITH ECOSIM** (especially **ECOSPACE**). Tony Pitcher, Eny Buchary, Rashid Sumaila and Nigel Haggan are quantifying the effects of the MPA-AR deployment to provide costs and benefits to each fishery sector and to ecosystem rebuilding (see also [BACK TO THE FUTURE](#)).

*A dwindling trap catch on the Caribbean island of St. Lucia - the result of overfishing that might be reversed by marine reserves.*





TOP: A sand-shell bottom in the Gulf of Maine, USA, devastated by a single trawl pass.



ABOVE: A cobble-shell bottom in the Swan's Island Conservation Area, Gulf of Maine, where trawling is prohibited - and rich biological communities develop on the sea bed, undisturbed by human activity.

Hook and line medium scale boats used to fish grouper in Progreso, Yucatan, Mexico. These wooden boats may do five or ten day trips, and carry small boats (alijos) used to expand their search areas.



Ying Chuenpagdee, Sylvie Guénette and Russ Jones, a research associate of the Fisheries Centre from the Haida Nation, recently completed a world wide study of MPAs with special emphasis on community participation and indigenous peoples (***Fisheries Centre Research Reports 8(1), 2000***). The successful establishment of marine reserves or marine protected areas depends largely on public support and community participation, from the planning process onward. Yet, in practice, many MPAs are established using a traditional 'top-down' approach. Opposition from user groups, resource use conflicts and economic concerns are common, and are the most important factors which often lead to MPAs not being fully implemented and hence failing to meet their expectations. Participation of indigenous people is often limited due to barriers in the planning process such as cultural differences, and time and format constraints. As a result, indigenous peoples' interests and concerns are not well represented in MPA design and planning.

Generally, MPAs are being promoted as complements to traditional fisheries management in situations where these are seen to be impracticable or unsuccessful. To realize the potential benefits expected from the establishment of MPAs, scientists have argued that not only should they be designed appropriately, but that success in implementing them will depend on how well biological concerns are reconciled with the socio-economic needs of fishing communities. An international workshop on the economics of MPAs was held at the Centre in July 2000. The meeting was sponsored by the Research Council of Norway, the Christian Michelsen Institute, Bergen, and the BC Government. It was led by Rashid Sumaila and six keynote speakers from among the world leaders in the field, and, along with Reinventing Fisheries Management, was one of two most exciting and successful meetings that the Fisheries Centre has ever held. A ***Fisheries Centre Research Report*** is due to be published early in 2001, and no less than two peer-reviewed special issues of journals are being prepared from papers delivered at the meeting; one in ***Natural Resource Modelling*** and the other in ***Coastal Management***.

## DECISION-MAKING BY COMMERCIAL FISHERS

A group of academic fishery researchers, graduate students, government fisheries scientists, fisheries consultants and a large contingent of commercial fishers gathered at the Centre in November 1993 to discuss the impact of fishers' decision-making on fisheries management. The hypothesis was that fishers were short-term oriented. But they disagreed, saying that they wanted to remain in the industry and for their children to carry on the business. Present management institutions were seen as too





impersonal. Thus, the main outcome of the workshop was the perceived need for management councils through which fishers could develop personal relationships with managers to make co-operation more likely. The proceedings appeared in *Fisheries Centre Research Reports 1(2), 1993*.

Supported by a Mexican scholarship, Silvia Salas and Tony Pitcher analyzed day-to-day decisions of artisanal fishers from three ports in the Yucatan. Fishers, who, at the start of a day, chose to outfit their boat for lobster, grouper or octopus, were greatly influenced by price and availability, but also by a range of non-monetary factors. In one port, a minority of fishers did better than average by pooling their catch, but these arrangements shifted by the day, and it remained a mystery why this was not found in other ports.



*Fishing octopus in San Felipe, Yucatan, Mexico. The traditional and unique gear used in this area to fish octopus is called jimba - two wooden sticks attached to six or eight thin ropes that hold a crab for bait.*

## RECREATIONAL FISHERIES

Recreational fisheries provide a melting pot of varied fishing interests and issues. Social aspects of these fisheries, rarely valued, normally far outweigh economic concerns, though significant economic and ecological benefits have recently been recognized. Equity considerations are an issue and, moreover, the contribution of the sector to global fisheries catches remains unknown. There is a need for accurate and detailed evaluation of both direct and indirect socio-economic benefits and impacts. Adaptive management plans can be formulated on the basis of this information as well as information directly from sports fishers.

Sean Cox and Carl Walters, supported by an NSERC strategic grant, have investigated BC recreational fisheries for rainbow trout using field and modelling studies of angling quality, effort response and exploitation rates, and have developed a method to directly assess the effects of access control on angling quality, and the sustainability of fisheries on wild stocks.

The Centre hosted an international conference in June 1999 on Evaluating the Benefits of Recreational Fishing. The meeting was sponsored by the South African Deep Sea Angling Association, the BC Ministry of Fisheries, US National Oceanic and Atmospheric Administration (NOAA), DFO, and the Atlantic Salmon Federation. With the aim of evaluating the benefits of sport fisheries and identifying their economic, social and ecological features, some 80 participants discussed a range of issues such as allocation of resources, components of value - social, economic, environmental, ecological and human - and codes

*Fly fishing for steelhead on Squamish River.*



of ethics, particularly in view of animal rights concerns. The proceedings, including keynote and contributed papers and discussion sessions, were published in ***Fisheries Centre Research Reports 7(2), 1999***, and a book edited by Tony Pitcher and Chuck Hollingworth containing selected papers is in preparation for the ***Blackwell Fish and Aquatic Resources Series***. A second conference is scheduled for 2002 in Darwin, Australia.

## DISTANT-WATER FLEET IMPACT STUDY



Russian factory trawlers in St. John's harbour, Newfoundland.

Sponsored by the World Wildlife Fund as part of their Endangered Seas Campaign, a Fisheries Centre study in 1998 showed that distant-water fleets (DWFs: fishing fleets operating outside their own national waters) could halve the potential earnings of domestic fisheries. Daniel Pauly led a team that included Ramón Bonfil, Tony Pitcher, David Preikshot, Ussif Rashid Sumaila, Hreidar Valtýsson and Miriam Wright, as well as Gordon Munro. Using **ECOPATH WITH ECOSIM** the ecological, economic and social impacts of DWFs were assessed, and costs and benefits of DWFs drawn up. **RAPFISH** was used to evaluate the relative ecological, economic, social and technological status of domestic small pelagic fisheries and distant-water fleets in West Africa. Here, it was found that the presence of these fleets could decrease the sustainability of the domestic fisheries by some 20 percent.

Transfer of benefits from one state to another was discussed in terms of exclusive economic zones (EEZs), which provide a framework for sharing the benefits of affected fisheries. For fisheries beyond these zones, formal agreements involving all potential players were seen as necessary to avoid depletion of the resources. Results were co-published by WWF and as ***Fisheries Centre Research Reports 1998, Vol. 6(6)***.

Historical photo of an old whaling station in Haida Gwaii (Queen Charlotte Islands), BC - photo mid-20<sup>th</sup> century.



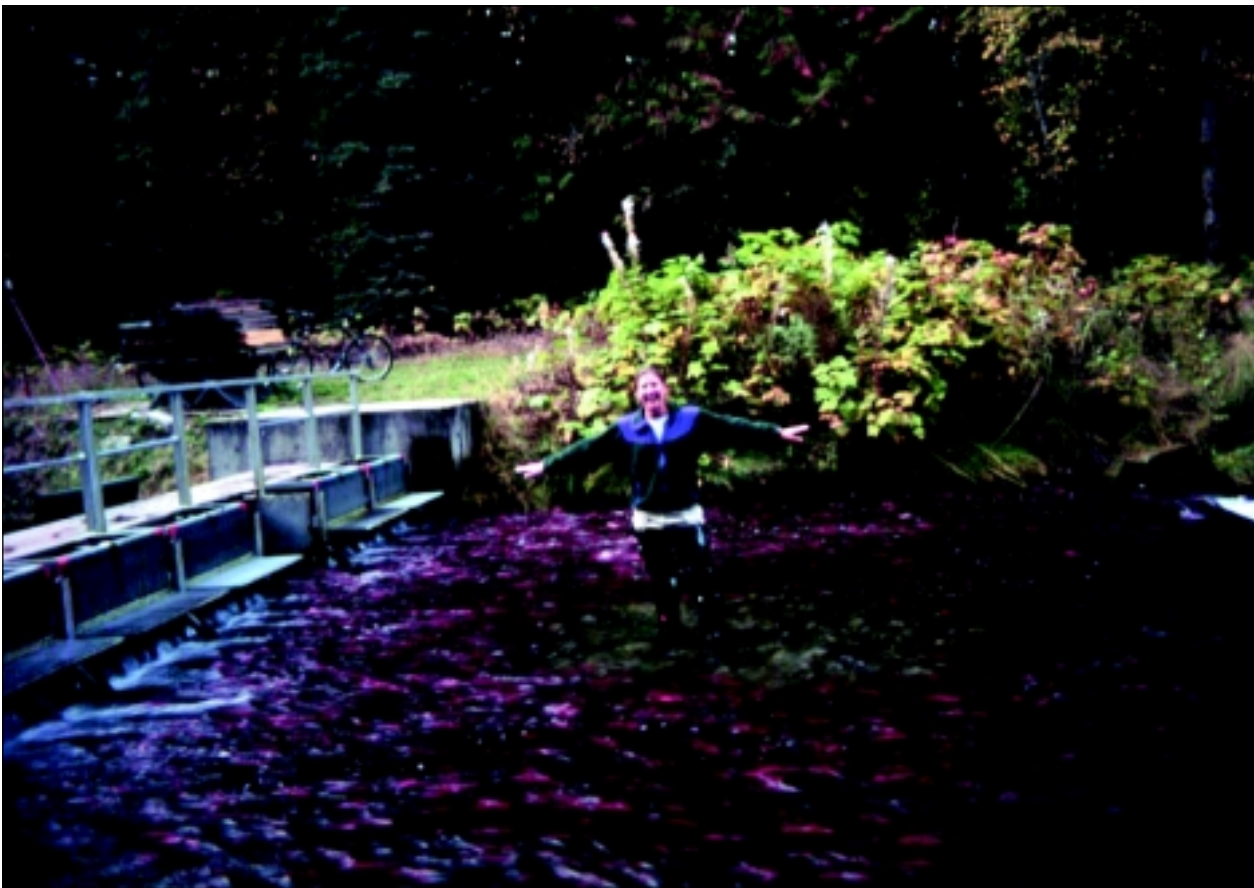
## COMMERCIAL WHALING

The first international workshop at the Centre, held in June 1993, investigated new management procedures proposed by the International Whaling Commission (IWC) in the event of a resumption of commercial whaling, following the world wide moratorium that took effect in 1986. Researchers from Australia, Canada, Iceland and the USA generally agreed with the proposed new IWC procedures, but no peer review had been done and it was felt essential that they be published in order to be evaluated by parties outside the IWC. The proceedings of this workshop appeared in ***Fisheries Centre Research Reports 1(1), 1993***.



## LIVING WITH UNCERTAINTY

Carl Walters has developed a number of Bayesian assessment methods for making best use of limited information to represent changes in uncertainty (about abundance and productivity) during fisheries development, and to define needed changes in assessment approaches for reducing uncertainty more rapidly and safely (survey designs, use of direct abundance assessment methods by fishers). A key part of this work is to design effective policies for limiting harvest rates during development in relation to uncertainty (precautionary approaches) based on spatial restriction of fishing and use of concepts such as 'proven production potential' to limit quotas to levels that have a high probability of being sustainable.



*Fisheries Centre graduate student Lisa Thompson (now a post-doctoral fellow in California) with kokanee salmon (*Oncorhynchus nerka*) spawners from Kootenay Lake, BC, waiting to pass through a counting gate at the Meadow Creek spawning channel, constructed in 1967 and operated by the BC Ministry of Environment, Lands and Parks. Each fall as many as 1 million kokanee return to spawn, and each spring approximately 9 million kokanee fry hatch out of the gravel and swim downstream to the lake.*





# BIOLOGY, BIODIVERSITY AND CONSERVATION

The term biodiversity, the wealth of species with which we share this planet, carries with it profound responsibilities of stewardship, the enormity of which is still only beginning to be realized. Much aquatic biodiversity, for example, is still not documented, a prerequisite to its conservation and management. Moreover, it is increasingly apparent that fundamental evolutionary and conservation biology issues are intimately intertwined with the maintenance of biodiversity, and that biodiversity in itself has an immense value to humans.

Arguably, the whole of human cultural history is predicated on biodiversity and ecology (see **Jared Diamond's *Guns, Germs and Steel***, Norton Press 1998), and few will deny that it has a critical but undetermined role in our future. The Fisheries Centre is involved in aquatic biodiversity and conservation research at a variety of levels - ecosystem, national and global - and on the conservation biology of a wide range of aquatic species, from sea lions, schooling fish and salmon, in African lakes, and beyond to the species of coastal forests including endangered salamanders. The following account covers most of the major activities, but a number of other projects and linkages are listed in **Annex 12**.



*Peter Brown of the BC Ministry of Environment, Lands and Parks holds a Gerrard rainbow trout (7 kg), a strain, unique to Kootenay Lake, that is closely monitored to ensure the population's continued health.*

## SALMON ECOLOGY

The ecology and management of the six Pacific salmon species are the research focus of Mike Healey and his graduate students and postdoctoral researchers. Research projects include:

- modelling the biophysical controls on marine migration and production of sockeye salmon (with Carl Walters and Paul LeBlond)
- distribution and capture success of salmon trollers in relation to oceanographic conditions off Vancouver Island (with Rick Thompson at the Institute of Ocean Sciences, Sidney, BC)
- bioenergetics of upstream migration and spawning of sockeye and pink salmon (with Scott Hinch of Forest Sciences, Pete Rand of North Carolina State University, and Tony Farrell of Simon Fraser University, BC)
- habitat choice in relation to food, predators and cover by juvenile coho salmon.



Research on biophysical controls of salmon production and migration pointed out the importance of relatively weak ocean circulation in determining oceanic distribution and migration paths of salmon, and has led to a re-evaluation of the conventional model of oceanic salmon migrations. Patterns of coastal migration, in particular the choice of migration route around Vancouver Island (an issue of considerable importance to management of salmon fisheries) were closely related to local oceanic conditions rather than offshore conditions, as had been previously thought. Results from the same study have demonstrated density-dependent marine growth in sockeye salmon. As part of this project, the software package [NERKASIM](#) was developed by postdoctoral fellows Peter Rand and James Scandol. [NERKASIM](#) explores the bioenergetics of migrating marine fishes in a variety of contexts.

Analysis of the distribution and capture success of salmon troll vessels revealed that distributions of vessels (and presumably fish) were strongly related to both bottom topography and circulation patterns off the west coast of Vancouver Island. Capture success of individual vessels was not related to the local density of boats, however. Interviews with fishers revealed that information sharing was highly developed in the fishery, resulting in a rapid diffusion of information about capture success through the fleet. As a result, salmon capture rates conformed to those expected under the ideal free distribution model of predator and prey distributions.



*Spawning sockeye salmon.*

Recently, many sockeye salmon migrating up Vancouver's Fraser River to spawn have died before they reach the spawning grounds, possibly from energetic exhaustion. Research on the bioenergetics of upstream migration and spawning has shown that the complexity and diversity of salmon spawning habitats generates a range of opportunities for alternative mating tactics, especially among males. Females tend to focus on ensuring a quality incubation environment for their eggs, and there is diversity in how females achieve this objective. Recent work has focused on quantitative measures of migration rates and spawning behaviour, and the energetic cost of these behaviours using new forms of physiological telemetry. Results show that females migrate more efficiently than males, large salmon more efficiently than small salmon, while all demonstrate low energetic efficiency through river areas that have a constriction of some kind. On the spawning grounds, dramatic behaviour patterns associated with nest building and defending a mate are individually very costly. Digging displays in females and posture displays in males accounted for up to half the





ABOVE: The Institute for Marine Research 85m Arctic research vessel G.O. Sars in dock in Bodø, Norway.

RIGHT: Mid-water trawl gear on board the G.O.Sars, used to sample herring schools in the Norwegian Sea, can be set precisely to within a metre, using differential GPS and pressure sensors on the warps.



BELOW: Herring school, whose behaviour had been recorded for two hours with sonar, captured in its entirety along with its accompanying predators, cod and haddock.



energy spent during spawning. In terms of total energy expenditure, migration to the spawning grounds and spawning each account for about half the total energy cost.

## SCHOOLING PELAGIC FISH

Investigations of small schooling fish such as herring and anchovy have been an important area of Tony Pitcher's research group in the Centre. Globally, collapses of large fisheries for these species have been spectacular and unpredicted - e.g. the California sardine in the 1950s and the Peruvian anchovy in 1972. The Centre's work has consequently focused on predictive modelling:

- Tony Pitcher and his students developed a meso-scale model that shows how schooling behaviour acting alone without any environmental change can bring about collapse of the fishery on a particular stock. Rashid Sumaila and Steven Mackinson subsequently made a bioeconomic analysis of this model.
- Marcelo Vasconcellos developed analytical and ecosystem-based models that provide a rigorous analysis of risk aversion management policies for the Brazilian sardine.
- Sylvie Guénette, with co-operation from DFO in obtaining data and NSERC funding, developed a spatial model that addresses the outcomes of marine reserves for shoaling fish.
- Tony Pitcher, Steven Mackinson, Sylvie Guénette and Taja Lee, in co-operation with the Institute of Marine Research and the University in Bergen, Norway, measured and sampled herring schools and followed their diurnal vertical migrations and anti-predator dynamics. On board the Norwegian institute's 85m research vessel (*G.O.Sars*), they used a new technique based on high-resolution sidescan sonar developed for tracking schooling fish. The results reveal that herring have remarkably fluid schooling dynamics driven on the microscale (metre/minutes) and the meso-scale (kilometre/hours), just as predicted in fish school theory developed by Tony Pitcher.
- The work above led to two important discoveries of behavioural factors sufficient to drive most Norwegian herring behaviour and migration in their 14-year life history: (a) active predation on herring by pods of fin whales in the Norwegian sea, and (b) herring in coastal waters intimately accompanied by their predators, just like game animals in the Serengeti.
- The Centre subsequently hosted two 'schooling' visitors from Bergen: Ole Arve Misund, who gave a graduate course on fisheries sonar, and Leif Nøttestad, who analyzed cruise data and is helping with the development of [RAPFISH](#) and Norwegian sea ecosystem modelling.





- Steven Mackinson, using information from the Norwegian cruises, and from cruises on DFO herring charter vessels in the Strait of Georgia BC, developed fuzzy expert system software (CLUPEX, see page 18), which predicts the structure, dynamics and distribution of adult herring. The system uses information on local biotic and environmental factors to predict changes in the structure, dynamics and meso-scale distribution of two species of herring. In general, the expert system model predicts school parameters with 80% accuracy, but predictions are less good when unusual environmental conditions prevail. CLUPEX is available from the Fisheries Centre as a CD-ROM.
- In partnership with the New England Aquarium, Boston, Nathaniel Newlands constructs spatial models of mesoscale phenomena in schooling bluefin tuna, using simulation and optimization techniques in a GIS modelling framework. The work uses semi-automated image analysis of images from aerial survey photos, data from acoustic and archival pop-up tags, environmental parameters like temperature and currents, and distributions of prey organisms like squid. The aim is to simulate schools of tuna entering and leaving the Gulf of Maine in order to provide baselines for estimating bluefin tuna numbers and biomass, a controversial issue as tuna are threatened by severe overfishing and illegal fishing in some parts of the North Atlantic.



*Giant trevally (Caranx ignobilis) school, one of the main recreational fisheries on Australia's Great Barrier Reef.*

## MARINE MAMMALS

The North Pacific has seen major changes in abundance of a number of marine mammals and sea birds in recent decades. Of particular interest to the Fisheries Centre is conservation of the Steller sea lion in Alaska, where its population has been unaccountably dwindling for two decades: more than 75 percent of the animals have disappeared since 1980. In 1990, the species was declared threatened under the US Endangered Species Act, and populations west of Prince William Sound were further classified as endangered in 1997.

The Fisheries Centre's Marine Mammal Research Unit (MMRU), directed by Andrew Trites (along with other members of the NPUMMRC), has been examining the recent decline of Steller sea lions, looking for ways of rebuilding their numbers. Possible causes of decline were grouped into a number of categories: nutritional stress,

*Breaching humpback whale, resident in the Strait of Georgia until the 1920s.*





*Juvenile Steller sea lion in a "squeeze cage" at the Vancouver Aquarium - to allow the trainer to take samples.*



*Steller sea lion females.*

*Steller sea lion pup.*



increased predation, abnormal behaviour, rookery disturbance, pollution and toxins, intentional and incidental catches, parasites and disease. Since 1993, MMRU has researched many of these hypotheses, through field, captive and laboratory studies, and historical data analysis. The research has been supported by the North Pacific Marine Science Foundation from coastal Alaskan communities, private foundations, sectors of the fishing industry and, recently, major funding from the US National Oceanic and Atmospheric Administration (NOAA).

Nutritional stress has been a primary area of research, given that sea lions have become physically smaller over the years. Additional data on size changes are sought, along with dietary changes over time and between sites, shifts in the forage base and their causes, energy use in different activities and energy derived from various prey. One study by David Rosen suggests that Steller sea lions have to consume 35-80% more pollock than herring to get the same energetic benefit, partially due to the higher costs of digesting pollock. Another surprising result is that they do not seem to use the heat released from digestion to offset thermoregulatory demands. He and Dr Trites have created and tested various morphological condition indices to measure sea lion health. The energetics of Steller sea lion swimming were studied by Lei Lani Stelle: drag coefficients and swimming efficiency were calculated and the approach is useful in modelling pinniped energy budgets. A specially designed swim mill was used for this work (funded by Alaska Science and Technology Foundation).

Arliss Winship is using information from the energy budgets to determine sea lion food needs, which can then be related to actual diets and changes in food supply. Additional model parameters come from captive feeding experiments conducted in partnership with the Vancouver Aquarium Marine Science Centre. Substantial weight loss in captive Steller sea lions followed a change in diet from herring to pollock or squid, due both to the lower energy density of the latter group and the higher cost of their digestion. Sea lions appear to lower their metabolism to limit weight loss, a process referred to as metabolic depression. Loss of weight when shifting to a pollock diet is significant, because **ECOSIM** indicates that pollock contributed over 50 percent of ecosystem energy flow at mid-trophic levels in at least one area - the Bering Sea - in the 1980s, compared with only 10 percent in the 1950s. Thus, a 'junk food' hypothesis was formulated: that Steller sea lions are eating more less-nutritious pollock, and are hence under nutritional stress. Behavioural observations of Steller sea lions using rookeries and haulouts by Linda Milette, Boyd Porter and others show shorter feeding trips in the area of population decline compared to where populations are increasing. The declining popu-



lation consumes primarily pollock, while the increasing population has a diverse diet including herring, sandlance, rockfish, salmon and pollock, supporting the junk food hypothesis.

MMRU researchers have developed remote monitoring systems for investigating sea lion foraging patterns, and have continued this work with other partners in comparative studies of foraging behaviour in different areas. Research by Russ Andrews has shown great differences in foraging time and prey ingestion rates in different areas, which have important consequences for time spent away from pups, length of pup suckling time, and consequently pup growth rates, the latter potentially an indicator of future survival. Moreover, sea lions do not wean their pups until nearly one year old, the start of summer, a finding contrary to the earlier assumption that weaning took place during the first winter. Research by Jan McPhee has shown that energy expenditure of Steller sea lions can be estimated by measuring their heart rates. This technique has been developed with captive animals and now needs to be tested on wild animals.

Predation of Steller sea lions by killer whales was found to be of possibly significant impact when sea lion populations are 50,000 or less, which is now the case. The possible role of diseases is the subject of a current collaborative research project to test the hypothesis that sexually transmitted disease is a factor in the decline in sea lion populations through reproductive failure.

Andrea Hunter confirmed that the basic metabolic rates of marine mammals are similar to those of terrestrial animals of the same weight. She has developed relationships that can be used to assess the amount of prey consumed by species of marine mammals whose metabolism has not been studied.

Northern fur seals have also been hit by a mysterious decline in Alaska; their populations have halved since 1950. MMRU and NPUMMRC studies have shown that, like the Steller sea lions, northern fur seals are smaller today than in the past.

Eastern Pacific harbour seals have increased greatly in numbers in British Columbia since their protection from commercial hunting began 30 years ago. Theresa Burg showed that populations can be grouped into distinct northern and southern groups. The results suggest that the Pacific Ocean was colonized twice from the Atlantic Ocean during the past million years, with the first colonists now reduced to a small portion of the harbour seals on southern Vancouver Island. The harbour seals have become a threat to out-migrating salmon smolts, at least in the Puntledge River in BC, where the seals group under bridges at night in spring

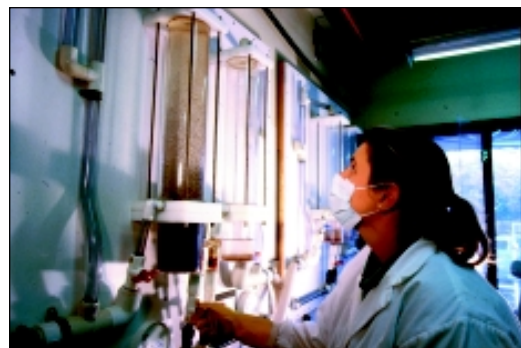


*Russ Andrews of the Marine Mammal Research Unit glueing a satellite tracking tag onto the fur of an anaesthetized female Steller sea lion.*



*Harbour seals.*

*Technician working at an elutriator used to wash scats and extract bones from fecal samples to determine seals' and sea lions' diet.*







Three whale watching vessels in Johnstone Strait, BC, observing a single killer whale in the centre of the group.

and form an almost continuous gauntlet. In a study by Harald Yurk at MMRU, an acoustic harassment device proved very efficient at preventing smolt predation by the seals.

Killer whales became experimental animals in the wild for the first time when Robert Williams investigated the effect of whale watching vessels on their behaviour. The present guideline for boats to move parallel to the whales at a minimum of 100 metres was found to be sound - whale path predictability decreased as boats came closer, although no changes were noted in mean dive time or surface behaviour. In another first, vocal patterns of killer whales were shown by Volker Deecke to be modifiable behavioural traits that are transmitted through learning; discrete vocal traditions are maintained by separate groups in the same area, implying selective copying that may function in kin recognition or mate choice. Kristin Kaschner has been exploring the use of smart 'pingers' to reduce cetacean bycatch in commercial fisheries. The pingers, whose sounds can deter the cetaceans, are selectively activated by the animals' vocalizing at a critical distance from the net.

Historic whaling records from British Columbia were used by Edward Gregr to develop generalized linear models to predict the habitats of several species of whales. Six independent variables were: depth, slope, depth class, sea surface temperature, salinity, and time. Results supported anecdotal suggestions that some species previously spent extended periods in coastal waters of the province.

## AMPHIBIANS

William Neill and students have been using endangered salamanders as indicator species to determine the impact of land use on the underlying biological components of stream and lake ecosystems, with a focus on the consequences for invertebrates (zooplankton and insects), fish, and particularly, amphibians that consume them. The effects of logging and silviculture practices in near-stream habitats on the production and composition of aquatic ecosystems have been investigated in co-operative research with the BC Ministry of Forests, to examine the impact on downstream sedimentation and thus on amphibian survival and growth. Some 120 headwater streams were surveyed throughout the Lower Mainland forests and on northern Vancouver Island.

Such land use in natural and anthropogenically altered landscapes results in both direct and indirect effects on the biodiversity that supports fish and amphibian com-

Pacific Giant Salamander in the Chilliwack Valley, BC.



munity composition and production. Direct effects include changes in inputs of the nutrients that underwrite the productivity of aquatic systems; modification of hydrologic regimes, resulting in erosion and sedimentation; and disruption of the physical structure of streams, lakes and adjacent riparian wetlands. Indirect effects include disruption of food web structure and dynamics as a result of direct negative and positive effects on selected species, habitats and water quality. Understanding these human disturbances of aquatic environments and their organisms is essential to developing meaningful, cost-effective management strategies. Understanding these effects is also essential in long term maintenance of the biodiversity of aquatic ecosystems. This research has both a British Columbia and an international focus. There are numerous case studies within the province from which more general theoretical and applied lessons can be drawn.

Close working relationships with the Fisheries Branch and Wildlife Branch of the BC Ministry of Environment, Lands and Parks, with additional support from the Skagit Environmental Endowment Committee and World Wildlife Fund Canada, have supported projects to establish baseline compositions and distributions of stream invertebrates and endangered amphibians, particularly the Pacific giant salamander. Most of the work has been done in the Chilliwack River Valley, which is subject to clearcut logging. Also, the activity patterns of more than 70 salamanders were followed by radiotelemetry over a three-year period. Further, populations of larval salamanders are being monitored and their behaviour under various habitat conditions investigated by experimental manipulation.

Nutrient enhancement studies have been conducted in streams whose fish production had been severely reduced by earlier logging. Further, with support from NSERC and the Fisheries Research and Development Section in the Centre, the effects of lake nutrient enrichment on fish composition and abundance have been investigated. Some positive effects of fertilizers had been obtained in the production of more and stronger fish. William Neill's laboratory has also studied the structural and functional changes in aquatic food webs that result from manipulations in fish composition and abundance. Mesocosms were used to isolate the effects of fertilizers, contaminants, etc. on productivity of both aerobic and anaerobic pathways in freshwater ecosystems. [ECOPATH](#) is now being used as a tool in these investigations.

Other aquatic biodiversity related research has included investigations of the introduction of exotic fish species in National Parks in the US, and in midwestern recreational fisheries lakes, in collaboration with the US National Parks Service and several state natural resource departments.

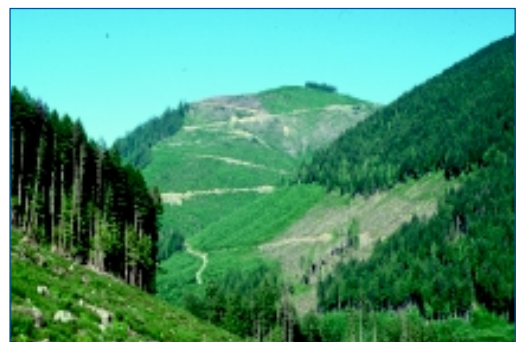


*Tailed frog, Chilliwack Valley, BC.*



*ABOVE: Clearcut without a buffer beside a stream in the Chilliwack Valley.*

*BELOW: Research in the Chilliwack Valley is examining the effects of extensive logging on Pacific giant salamander and tailed frog habitat.*





North arm of Kootenay Lake, BC, looking south from near Kaslo.

This tugboat and barge are used to distribute up to 900 tons of fertilizer, containing the nutrients phosphorus and nitrogen. Liquid fertilizer is added to Kootenay Lake each year to replace nutrients trapped behind dams upstream to aid the ongoing health of fish species.



## LAKE FERTILIZATION

Experimental fertilization was conducted on Kootenay Lake, BC, from 1992 to 1997 to compensate for nutrients lost behind hydroelectric dams upstream of the lake, which decreased plankton densities and caused dramatic decline in kokanee (landlocked sockeye) salmon stocks. Lisa Thompson and Carl Walters studied the effect of fertilization on zooplankton and salmon. A simulation model of the lake suggested that increased zooplankton production resulting from fertilization might be shunted into increased abundance of *Mysis relicta*, an exotic crustacean that competes with kokanee, and that nutrient additions might actually hasten the kokanee decline. Surprisingly, *M. relicta* abundance decreased during the experiment, while kokanee abundance increased four-fold, the hoped-for result of the fertilization. It was thought that high surface water turnover rates due to melting snow increased *M. relicta* mortality. Caution should be exercised in extrapolating the results to other large lakes where fish populations have been affected by hydroelectric dams or competition from exotic species. Nutrient additions may not reach the desired target species unless the responses of exotic competitors are suppressed by physical factors operating independently of the dynamics of the food web. But the project was a warning that nature has plenty of surprises in store and not to believe the predictions of all models!

## AFRICAN LAKES

Very large lakes, often ephemeral in geological time, hold a fascination for fisheries scientists because the limits of geography, nutrients and fishery catches may be reached quite quickly. These finite limits mean that great lakes can provide natural microcosm experiments that may tell us what to expect, eventually, in the deceptively boundless ocean. In fact, using North American or European great lakes as 'test beds' is hopeless, as they were altered irreversibly over a hundred years ago, so that management is a continual battle of mitigation. But most African Great Lakes, which are important suppliers of fish protein to humans, have had little interference and continue not only to offer fascinating insights into evolution, but are also instructive in setting the balance between conservation and fisheries issues.

A major book reviewing species changes in African lakes was published in 1995 (*The Impact of Species Changes in African Lakes*), edited by Tony Pitcher and Paul Hart, and containing 23 peer-reviewed papers by over 30 leading authors. In the past 90 years, major changes have occurred in fish faunas; in Lake Victoria these include what has been called the largest mass extinction to occur in modern





times. Some changes have been caused by increasing fishing, but others are due to exotic fish species introduced to create new fisheries. The aim of the book was to evaluate the impact of these species changes on the natural and human communities of the lakes. The book concentrates on introductions of Nile perch to Lake Victoria, the freshwater sardine to the human-made Lake Kariba, and on changes to Lake Malawi caused by fisheries. Other lakes, such as Tanganyika, Turkana, Kivu, Kyoga, Naivasha, and the human-made Lake Itzhi-tezhi, are included for comparison. Comparisons between the introduction of planktivores and piscivores, and between natural and man-made lakes, were used to gain deeper understanding. Throughout, equal emphasis is given to both human and ecological costs and benefits of the species changes.



*Each evening, artisanal fishers sell their catch of small cichlids on the beaches around Lake Malawi.*

Research on African Lakes has continued at the Fisheries Centre. Morris Mtsambiwa and Tony Pitcher worked on recruitment to the fishery for introduced sardines in Lake Kariba, Zimbabwe. Juvenile fish were aged using rings formed each day in the otolith bones and so cohorts of young fish recruiting to the fishery could be followed month by month. Although recruitment peaked during the austral spring, results proved that spawning occurs throughout the year, so that the sardine fishery is very productive at over 6 tonnes per year per square kilometre. Seasonal and annual fluctuations are closely driven by the nutrient load of the Zambezi River. The research included novel methods for partitioning offshore migration from mortality in small fish.



*Semi-commercial trawl on Lake Malawi.*

Tony Pitcher, Alida Bundy and William Neill devised an empirical model that provides approximations of likely fishery yields for introduced species, given primary production, fish yield and other factors from a lake where the fish is already established. James Njiru drew up basic population parameters, and estimated fishery yields, for 'dagaa', a small carp-family fish that occupies the zooplankton-eating 'sardine' niche in Lake Victoria, and which exploded in numbers at about the same time as the Nile perch when a small freshwater prawn also exploded in biomass. Edward Nsiku, using [RAPFISH](#) and [ECOPATH](#), worked on the fisheries of Lake Malawi.

*Trawl catch on Lake Malawi is sorted into plankton-eating and herbivorous cichlids, catfish and few cyprinids. Over 30 years, this fishery has caused large changes in species composition.*

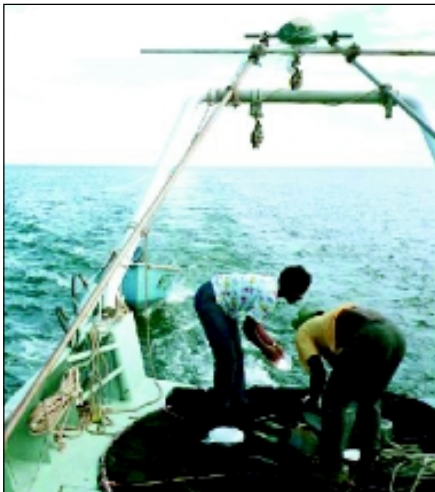
In 1998 Tony Pitcher, working with John Craig from ICLARM, led a workshop at Lake Nasser (a book, ***Sustainable Fish Production in Lake Nasser: Ecological Basis and Management Policy***, edited by John Craig, was published in 2000) in co-operation with a dedicated but under-resourced team from a local research laboratory, the Fishery Management Center of the High Dam Lake Development Authority, and social scientists from Cairo and FAO. Lake Nasser, human-made by damming the river Nile at a site deeply-imbued with ancient history at Aswan, has brought dramatic costs and benefits to Egypt. The dam generates huge amounts of cheap electricity and there



are plans to use lake water to irrigate desert valleys for the burgeoning human population. Lake Nasser fisheries may produce about 20,000 tonnes per year (catch data is very uncertain), but might produce a lot more if well managed. The pros and cons of introducing sardines were discussed by an expert from Zimbabwe, Brain Marshall. On the debit side, the Nile no longer floods uncontrollably meaning that fertilizers have to be used to the first time in 5000 years in the Nile delta; a 30,000-tonnes-a-year delta fishery for sardines has vanished; and Lake Nasser is silting up ten times faster than expected, giving it only 100 more years of life. The project sets forth a research and action strategy to address these issues.

## FISH BIODIVERSITY

Documentation of species is a pre-requisite for efforts towards their conservation. An increasingly accepted way of bringing together the scattered records that comprise our knowledge of the world's fish fauna is the **FISHBASE** project (see Box next page). This database seeks to document all the world's fish species - estimated at over 26,000. The Fisheries Centre has become actively involved in this massive undertaking. Daniel Pauly has contributed much to the structure of **FISHBASE**, especially in the display and analysis of vital fish statistics (growth, mortality, food and oxygen consumption). He mediated contracts from the BC Fisheries Branch through the Fisheries Centre to **FISHBASE**, which enabled thorough coverage of the fish of British Columbia, including all fish records in the UBC Zoology Museum. **FISHBASE** is now widely used at the Centre by graduate students, several of whom also have contributed photographs and/or data.



*Freshwater sardines were introduced from Lake Tanganyika to the human-made Lake Kariba in the 1960s. They now form the basis of an important food fishery.*

*ABOVE: Fisheries Centre graduate student Morris Mtsambiwa (now a conservation officer in Zimbabwe) sampling juvenile sardines in Lake Kariba.*

*RIGHT: Sardine fishing vessel - sardines are attracted at night with mercury vapour lamps, then scooped up with a 20m-diameter winch-operated lift net.*



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The report has been written and edited by Jay Maclean, David Barker, Melanie Power and Tony Pitcher. The material has been edited and approved by Fisheries Centre members. References have been copy edited by Chuck Hollingworth. PageMaker layout by Melanie Power has also been edited by this team.

Photographs have been collated by Maria Morlin, and some new ones taken. Photographs were kindly supplied by: Aque Atanacio, Peter Auster, Catharine Blackstock, David Briggs, Rik Buckworth, Alida Bundy, Villy Christensen, Sean Cox, Nick Didlick, Graeme Ellis, Katia Freire, Andrew Grimm, Pam Hall, Julie Hawkins, Jan Heggnes, Lee Hulbert, Ernest Keeley (salmon photos), Uwe Kils (<http://krill.rutgers.edu>), Kompas Online, Roger Krohn, Bob Lessard (cover photo), Steve Mackinson, Jay Maclean, Steve Martell, Brent Matsuda, Richard Maunsey, Lisa Mike, MSCUA (University of Washington Libraries), Maria Morlin, Paul Nicklin, NOAA (National Marine Fisheries Service), Thomas A. Okey, Daniel Pauly, Murray Pearson, Tony Pitcher, Val Pitcher-Gray, Melanie Power, David Preikshot, Callum Roberts, Snorri Snorrason, Manuel Solis, Ulli Steltzer, Ann Tautz, The Exxon Valdez Oil Spill Trustee Council, Lisa Thompson, Andrew Trites, UBC Photos, Reg Watson, Dirk Zeller. For more information on photographs, contact: the Fisheries Centre ([office@fisheries.ubc.ca](mailto:office@fisheries.ubc.ca)).

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### FISHBASE

FISHBASE is a relational database on fish species of the world. Now in its sixth annual release, it contains information on almost all the world's species, and is available as a CD-ROM as well as online ([www.fishbase.org](http://www.fishbase.org)). The database contains information from published material on all aspects of the biology of each species and gives for each datum the source reference. The relational aspect of this encyclopaedia allows the user to determine - and discover - relationships



among data sets and between them and environmental parameters. This feature enables users to look at resources as well as individual species and to focus on the fundamental scientific concepts and what they mean in terms of interacting species and their environment.

FISHBASE provides trophic levels of species where available from literature or diet, information of importance to aquatic ecosystem research. In the absence of direct information, trophic levels are estimated from similar

species, scaled for size. A new interface for FISHBASE that allows direct input to fledgling ECOPATH models is under development.

FISHBASE was developed by a team from the International Center for Living Aquatic Resources Management, headed by Dr Rainer Froese, with Daniel Pauly as scientific advisor. The European Union has been a major source of funding for FISHBASE, and many other donors and individuals have also contributed to its development.

Since 2000, FISHBASE has been run by a consortium of seven institutions (four European museums and other research institutes, FAO, ICLARM, and the UBC Fisheries Centre).





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Denuta Dolecki  
Jackie Hancox  
Karl Mallory (1995-1998)  
Gail Wada  
Laura Williams  
Arliss Winship  
Mandy Wong (Co-op Student)

### **Sea Around Us Project Newsletter Editor**

Melanie Power (1999-present)

### **Secretaries**

Jessica Chen (2000-present)  
Maureen White (1999-present)  
Donna Shanley (1999)  
Sonia Hanlon Thomson (1994-1995)

### **Webmasters**

James Hrynshyn (Marine Mammal Research Unit, August 2000-present)  
Amy Poon (2000-present)  
Felimon Gayanilo (1999-present)  
Marcelo Vasconcellos (1997-1999)  
Leo Yu (1995-1997)

## ADJUNCT PROFESSORS

**Dr Robert C. Brown**  
Simon Fraser University  
Fisheries geography

**Dr Villy Christensen**  
DANIDA/ICLARM  
Ecosystems and Fisheries

**Dr Anthony Davis**  
St Francis Xavier University  
Fisheries Anthropology

**Dr Edward Donaldson**  
DFO, West Vancouver  
Aquaculture

**Dr John K. B. Ford**  
Vancouver Aquarium  
Marine Mammals

**Dr Martin A. Hall**  
IATTC, La Jolla  
Fisheries and Ecosystems

**Dr Douglas E. Hay**  
DFO, Nanaimo  
Pelagic fisheries

**Dr Michael A. Henderson**  
DFO, Vancouver  
Fisheries Policy

**Dr John Hoenig**  
DFO, St. John's  
Assessment Methodology

**Dr Charles Hollingworth**  
University of North Wales, Bangor  
Scientific Writing

**Dr Glen S. Jamieson**  
DFO, Nanaimo  
Invertebrate Fisheries

## International Advisory Council

Dr John F. Caddy  
FAO, Rome, Italy

Dr Rognvaldur Hanneson  
Bergen, Norway

Dr David Policansky, *Chair*  
Washington, DC, USA

Dr Meryl Williams  
ICLARM, Penang, Malaysia

Dr Kevern Cochrane  
FAO, Rome, Italy

Dr James Kitchell  
University of Wisconsin-Madison, USA

Dr Keith Sainsbury  
CSIRO, Hobart, Australia



**Dr Gunnar P. Knapp**  
University of Anchorage  
Fisheries Economics

**Dr Jack Knetsch**  
Simon Fraser University  
Resource Economics

**Dr Rosemary Ommer**  
University of Calgary  
Fisheries Sociology/History

**Dr Randall Peterman**  
Simon Fraser University  
Fisheries Management

**Dr Laura Richards**  
DFO, Nanaimo  
Fisheries Assessment

**Dr Stephen C. Riley**  
Idaho Fish and Game, Boise  
Salmonid Habitats

**Dr Gary D. Sharp**  
NOAA, Monterey  
Fisheries Oceanography

**Dr John Spence**  
BC Science Council  
Industry and Fisheries

**Dr Max Stocker**  
DFO, Nanaimo  
Fisheries Assessment

**Dr John G. Stockner**  
DFO, West Vancouver  
Food Chain Dynamics

**Dr Arthur Tautz**  
BC Fisheries Research Branch  
Fisheries Policy

**Dr Amanda Vincent**  
McGill University, Montreal  
Fisheries Conservation

**Dr Daniel M. Ware**  
DFO, Nanaimo  
Pelagic Fisheries Models

**Dr Jane C. Watson**  
Malaspina University College,  
Nanaimo  
Marine Mammals

**Dr Martin Weinstein**  
Comox  
Human Ecology

## POST-DOCTORAL RESEARCHERS

**Dr Ramón Bonfil (Mexico)**  
Groundfish Assessment Project  
1996-1997  
Supervisor: Dr Tony Pitcher

**Dr Tony Courtney (Australia)**  
Evaluation of Hong Kong Fisheries  
1996-1997  
Supervisor: Dr Tony Pitcher

**Dr Sylvie Guénette (Canada)**  
Sea Around Us Project  
1999-present  
Supervisor: Dr Daniel Pauly

**Dr Sheila Heymans (Namibia)**  
Back to the Future Models  
2000-present  
Supervisor: Dr Tony Pitcher

**Dr Scott Hinch (Canada)**  
Energetics of upstream migration in  
sockeye salmon  
1993-1994  
Supervisor: Dr Michael Healey

**Durrell Kaplan (USA)**  
Sea lion model population  
1997-1998  
Supervisor: Dr Andrew Trites

**Dr Jonathon Money (Canada)**  
Marine Mammal Data Analysis  
Supervisor: Dr Andrew Trites

**Dr Nicola Novarini (Italy)**  
1997  
Supervisor: Dr Bill Neill

**Dr Peter Rand (USA)**  
Energetics of ocean migration in  
sockeye salmon  
1994-1996  
Supervisor: Dr Michael Healey

**Dr John Richardson**  
1993  
Supervisor: Dr Bill Neill

**Dr Dave Rosen (Canada)**  
Steller sea lion energetics  
1995-1998  
Supervisor: Dr Andrew Trites

**Dr Lore Ruttan (USA)**  
Sea Around Us Project  
1999-2000  
Supervisor: Dr Daniel Pauly

**Dr James Scandol (Australia)**  
Spatial models for salmon movement  
Supervisors: Dr Michael Healey and  
Dr Carl Walters

**Dr Keith Thomson (Canada)**  
Spatial models for salmon movement  
Supervisors: Dr Michael Healey and  
Carl Walters

**Dr Dom Tollit (UK)**  
Improving estimation methods of  
population and diet of Steller sea  
lions  
2000-present  
Supervisor: Dr Andrew Trites

**Dr Reg Watson (Australia)**  
Evaluation of Hong Kong Fisheries  
1997-1998  
Supervisor: Dr Tony Pitcher

**Dr Peter Watts (Canada)**  
Steller sea lion energetics  
1993-1995  
Supervisor: Dr Andrew Trites

**Dr Dirk Zeller (Australia)**  
Sea Around Us Project  
1999-present  
Supervisor: Dr Daniel Pauly

## LONG-TERM VISITORS

**Dr Jackie Alder (Australia)**  
Edith Cowan University, Perth

**Frank Asche (Norway)**  
Institute for Economics, Bergen

**Dr Luis Calderon Aguilera  
(Mexico)**  
CICESE, Ensenada

**Dr Villy Christensen (Philip-  
pines)**  
ICLARM, Manila

**William Cheung (Hong Kong)**  
University of Hong Kong





**Dr Paolo Domenici (France)**  
Centre National de la Recherche  
Scientifique

**Dr Kurt Fausch (USA)**  
Boulder, Colorado

**Maria Gasalla (Brazil)**  
Fisheries Institute, Santos

**Neil Gribble (Australia)**  
Northern Fisheries Centre, Brisbane

**Jan Hagenes (Norway)**  
University of Bergen

**Dr Paul Hart (UK)**  
University of Leicester

**Lorenz Hauser (Austria)**  
University of Swansea

**Dr John Hunter (Australia)**  
CSIRO

**Narriman Jiddawi (Tanzania)**  
Institute of Marine Science

**Yeongha Jung (Korea)**  
Pukyong National University

**Toshio Katsukawa (Japan)**  
Ocean Research Institute, Tokyo

**Dr Chistopher Luecke (USA)**  
Utah State University

**Dr Kjartan Magnusson (Ice-  
land)**  
University of Reykjavik

**Julie Martin (Australia)**  
Department of Fisheries, Darwin

**Dr Kevin McLoughlin (Aus-  
tralia)**  
Bur. Resource Serv., Canberra

**Dr Leif Nøttestad (Norway)**  
University of Bergen

**Dr David Ramm (Australia)**  
Department of Fisheries, Darwin

**Dr Rashid Sumaila (Norway  
and Nigeria)**  
Institute for Economics, Bergen

**Cindy Rejwan (Canada)**  
University of Calgary

**Ling Tong (China)**  
Yellow Sea Fisheries Res. Inst.,  
Qingdao

## CURRENT GRADUATE STUDENTS

**Alisdair Beattie (Canada)**  
MSc RMES (start 1997)  
Project: Optimal size and placement  
of marine protected areas  
Supervisor: Dr Daniel Pauly

**Emma Bredeesen (Canada)**  
MSc Zoology (start 2000)  
Project: Marine Mammals in the  
Antarctic Ecosystem  
Supervisor: Dr Andrew Trites

**Rik Buckworth (Australia)**  
PhD Zoology (start 1996)  
Project: Dynamics of tropical line  
fisheries  
Supervisor: Dr Carl Walters

**Olivier Cheneval (Canada)**  
MSc Zoology (start 1999)  
Project: Steller sea lions predator-  
prey relationships  
Supervisor: Dr Andrew Trites

**Andrea Coombs (Canada)**  
MSc RMES (start 2000)  
Project: Ecosystems  
Supervisors: Dr Daniel Pauly and Dr  
Andrew Trites

**Raychelle Danielle (USA)**  
MSc Zoology (start 2000)  
Project: Molting of Steller sea lions  
Supervisor: Dr Andrew Trites

**Carolyn Donnelly (Canada)**  
MSc Zoology (start 1999)  
Project: Comparative nutrition  
values of Steller sea lion prey species  
Supervisor: Dr Andrew Trites

**Katia Freire (Brazil)**  
PhD RMES (start 2000)  
Project: Analysis of northeastern  
Brazilian fisheries  
Supervisor: Dr Daniel Pauly

**Vincent Gillett (Belize)**  
PhD RMES (start 1995)  
Project: Policies and politics: an  
approach to integrated fisheries  
management  
Supervisors: Dr Daniel Pauly and Dr  
Ralph Matthews

**Anna Hall (Canada)**  
MSc Zoology (start 2000)  
Project: Porpoises  
Supervisor: Dr Andrew Trites

**Paul Higgins (Canada)**  
PhD RMES  
Project: Experimental management  
of water releases from British  
Columbia hydro dams  
Supervisor: Dr Carl Walters

**Leonardo Huato (Mexico)**  
PhD Zoology (start 1991)  
Project: Spatial movement models  
for salmon  
Supervisor: Dr Carl Walters

**Andrea Hunter (Canada)**  
MSc Zoology (start 1999)  
Project: Computer modelling of  
marine mammal feeding rates  
Supervisors: Dr Daniel Pauly and Dr  
Andrew Trites

**Kristin Kaschner (Germany)**  
PhD (start 1998)  
Project: Modelling of global marine  
mammal food consumption  
Supervisors: Dr Daniel Pauly and Dr  
Andrew Trites

**Aran Kay (Canada)**  
MSc RMES (start 1999)  
Project: *Mysis relicta* and kokanee  
salmon in Okanagan Lake, BC  
Supervisor: Dr Daniel Pauly

**Alison Keple (Canada)**  
MSc Zoology (start 1999)  
Project: Marine mammal population  
surveys in the Strait of Georgia  
Supervisors: Dr Andrew Trites and  
Dr John Ford

**Steven Martell (Canada)**  
PhD Zoology (start 1999)  
Project: Shrimp fisheries and  
ecosystem impacts of benthic trawl  
fisheries  
Supervisor: Dr Carl Walters



## **Miguel Martinez (Mexico)**

PhD Zoology (start 2000)  
Project: Ecosystem-based analysis of bycatch in the Mexican tuna fishery  
Supervisor: Dr Tony Pitcher

## **Jan McPhee (Canada)**

MSc Zoology (start 1997)  
Project: Heart rate as an indicator of metabolic rate in captive Steller sea lions  
Supervisor: Dr Andrew Trites

## **Elizabeth Mohammed (Trinidad and Tobago)**

PhD RMES (start 1998)  
Project: Reconstructing the South-eastern Caribbean Ecosystem: Applications for Assessment and Management  
Supervisor: Dr Daniel Pauly

## **Nathaniel Newlands (Canada)**

PhD RMES (start 1997)  
Project: Biomass estimation using a schooling model for Atlantic bluefin tuna in the Gulf of Maine  
Supervisor: Dr Tony Pitcher

## **Amy Poon (Canada)**

MSc RMES (start 1999)  
Project: Impact of Ghost Fishing: A Tentative Global Estimate  
Supervisor: Dr Daniel Pauly

## **Melanie Power (Canada)**

PhD RMES (start 1997)  
Ethics and Policy in Canadian Fisheries: A Rapfish Analysis  
Supervisor: Dr Tony Pitcher

## **Dave Preikshot (Canada)**

PhD Zoology (start 2000)  
Project: Fish biodiversity in large marine ecosystems  
Supervisor: Dr Daniel Pauly

## **Yvette Rizzo (Malta)**

PhD RMES (start 2000)  
Project: The central Mediterranean: functioning of a large marine ecosystem  
Supervisor: Dr Daniel Pauly

## **Teresa Ryan (Canada and USA)**

PhD RMES (start 1999)  
Project: Herring, eulachon and Aboriginal peoples in the Hecate Strait, BC  
Supervisor: Dr Tony Pitcher

## **Dorothee Schreiber (USA)**

PhD RMES (start 2000)  
Project: Halibut, groundfish and fishing communities in Hecate Strait, BC  
Supervisor: Dr Tony Pitcher

## **Richard Stanford (UK)**

MSc RMES (start 2000)  
Project: Fisheries ecosystem in the English Channel  
Supervisor: Dr Tony Pitcher

## **Stephen Watkinson (Canada)**

MSc RMES (start 1998)  
Project: Salmon carcasses - Nature's nitrogen pill  
Supervisor: Dr Daniel Pauly

## **Harald Yurk (Germany)**

MSc Zoology (start 1996)  
Project: The evolutionary history of resident killer whale clans in the northeastern Pacific, using vocal dialects  
Supervisors: Dr Andrew Trites and Dr John Ford

## COMPLETED THESES\*

## **Beatrix Beisner (Canada)**

PhD Zoology (2000)  
Title: Response of plankton community structure to temporal heterogeneity and productivity  
Supervisor: Dr William Neill  
Current Position: Post-Doctoral Fellow, University of Wisconsin-Madison

## **Ross Claytor (Canada)**

PhD Zoology (2000)  
Title: Fishery Acoustic Indices for Assessing Atlantic Herring Populations  
Supervisor: Dr Carl Walters  
Current Position: DFO, Halifax

## **Sean Cox (Canada)**

PhD Zoology (2000)  
Title: Angling quality, effort response, and exploitation in recreational fisheries: field and modeling studies on British Columbia rainbow trout (*Onchorhynchus mykiss*) lakes  
Supervisor: Dr Carl Walters  
Current Position: Post-Doctoral Fellow, University of Wisconsin-Madison

## **Edward Gregr (Canada)**

MSc Zoology (2000)  
Title: An analysis of historic (1908-1967) whaling records from British Columbia, Canada  
Supervisor: Dr Andrew Trites  
Current Position: Consultant, Facet Decision Systems Inc.

## **Sylvie Guénette (Canada)**

PhD RMES (2000)  
Title: Marine reserves for the Northern cod  
Supervisor: Dr Tony Pitcher  
Current Position: Post-Doctoral Fellow, Fisheries Centre

## **Trevor Hutton (South Africa)**

Zoology (2000)  
Title: Fisheries management policy in South Africa: An evaluation of alternative management strategies for the hake and linefish fisheries  
Supervisor: Dr Tony Pitcher  
Current Position: Post-Doctoral Researcher, CEFAS, Lowestoft, UK

## **Maria Morlin (Canada)**

Zoology (2000)  
Title: A comparison of land use and coho salmon abundance in the Georgia basin, British Columbia  
Supervisor: Dr Carl Walters  
Current Position: PhD Student, Fisheries Centre

## **Dave Preikshot (Canada)**

MSc Zoology (2000)  
Title: An Interdisciplinary assessment of tropical small-scale fisheries using multivariate statistics  
Supervisor: Daniel Pauly  
Current Position: PhD Student, Fisheries Centre

\* Thesis abstracts are available online at [www.fisheries.ubc.ca](http://www.fisheries.ubc.ca).



**Silvia Salas (Mexico)**

PhD RMES (2000)  
Title: Fishing Strategies of Small-Scale Fishers and their Implications for Fishery Management  
Supervisor: Dr Tony Pitcher  
Current Position: Post-Doctoral Fellow, St. Mary's University, Halifax

**Dorothee Schreiber (USA)**

MSc Zoology (2000)  
Title: Body size, food availability and seasonal rotifer community structure in Deer Lake, British Columbia  
Supervisor: Dr William Neill  
Current Position: PhD Student, Fisheries Centre

**Marcelo Vasconcellos (Brazil)**

PhD RMES (2000)  
Title: Ecosystem Impacts of fishing forage fishes: An Analysis of Harvest Strategies for the Brazilian Sardine  
Supervisor: Dr Tony Pitcher  
Current Position: Post-Doctoral Fellow, University of Rio Grande, Brazil

**Laura Vidal (Mexico)**

MSc Zoology (2000)  
Title: Exploring the Gulf of Mexico as a large marine ecosystem through a stratified spatial model  
Supervisor: Dr Daniel Pauly  
Current Position: PhD student, CINVESTAV, Merida, Mexico

**Arliss Winship (Canada)**

MSc Zoology (2000)  
Title: Growth and bioenergetic models for Steller sea lions (*Eumetopias jubatus*) in Alaska  
Supervisor: Dr Andrew Trites  
Current Position: Research Technician, UBC

**Robert Ahrens (Canada)**

MSc Zoology (1999)  
Title: Heritable risk sensitive foraging in juvenile fish: Potential implications for the dynamics of harvested populations  
Supervisor: Dr Carl Walters

**Jessica Bratty (Canada)**

MSc RMES (1999)  
Title: The winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) in interior British Columbia streams  
Supervisor: Dr Carl Walters

**Eny A. Buchary (Indonesia)**

MSc RMES (1999)  
Title: Evaluating the effect of the 1980 trawl ban in the Java Sea, Indonesia: an ecosystem-based approach  
Supervisor: Dr Daniel Pauly  
Current Position: Research Associate, Fisheries Centre

**Janelle Curtis (Canada)**

MSc Zoology (1999)  
Title: The Impacts of Forest Harvest on the Persistence and Colonisation Potential of Pacific Giant Salamanders (*Dicamptodon tenebrosus*) in British Columbia  
Supervisors: Dr William Neill and Dr E. Taylor  
Current Position: PhD Student, McGill University

**Johanne Dalsgaard (Denmark)**

MSc RMES (1999)  
Title: Modeling the trophic transfer of beta radioactivity in the marine food web of Enewetak atoll, Micronesia  
Supervisor: Dr Daniel Pauly  
Current Position: PhD Student, Copenhagen

**Heather Ferguson (UK)**

MSc Zoology (1999)  
Title: Demography, dispersal and colonisation of larvae of Pacific giant salamanders (*Dicamptodon tenebrosus*, Good) at the northern extent of their range  
Supervisor: Dr William Neill  
Current Position: PhD Student, University of Edinburgh

**Steven Mackinson (UK)**

PhD RMES (1999)  
Title: Integrating Knowledge to Predict Spatial Dynamics of Herring Shoals Using an Expert System  
Supervisor: Dr Tony Pitcher  
Current Position: Post-Doctoral Researcher, CEFAS, Lowestoft, UK

**Steven Martell (Canada)**

MSc Zoology (1999)  
Title: Reconstructing lingcod biomass in Georgia Strait and the effect of marine reserves on lingcod populations in Howe Sound  
Supervisor: Dr Carl Walters  
Current Position: PhD Student, Fisheries Centre

**Linda Milette (Canada)**

MSc Zoology (1999)  
Title: Behaviour of lactating Steller sea lions (*Eumetopias jubatus*) during breeding season: a comparison between a declining and stable population in Alaska  
Supervisor: Dr Andrew Trites  
Current Position: Teacher, BC

**Edward Nsiku (Malawi)**

MSc RMES (1999)  
Title: Changes in the fisheries of Lake Malawi, 1976-1996: Ecosystem-based analysis  
Supervisor: Dr Daniel Pauly  
Current Position: Fisheries Officer, Malawi

**Chantal Ouimet (Canada)**

PhD Zoology (1999)  
Title: Test of alternative domains of attraction in the dynamics of a fishless oligotrophic lake  
Supervisor: Dr Carl Walters  
Current Position: Post-doctoral Fellow, University of Alberta

**Lisa Thompson (Canada)**

PhD Zoology (1999)  
Title: Abundance and production of zooplankton and kokanee salmon (*Oncorhynchus nerka*) in Kootenay Lake, British Columbia during artificial fertilization  
Supervisor: Dr Carl Walters  
Current Position: Post-Doctoral Fellow, Santa Barbara, California

**S. Scott Wallace (Canada)**

PhD RMES (1999)  
Title: Fisheries Impacts on Marine Ecosystems and Biological Diversity: The Role for Marine Protected Areas in British Columbia  
Supervisor: Dr Daniel Pauly  
Current Position: Staff, Bamfield Marine Station





## **Rob Williams (Canada)**

MSc Zoology (1999)  
Title: Behavioural responses of killer whales to whale-watching: opportunistic observations and experimental approaches  
Supervisor: Dr Andrew Trites  
Current Position: PhD Student, St. Andrew's, Scotland

## **Chantelle Bozynski (Canada)**

MSc Zoology (1998)  
Title: Interactions between growth, sex, reproduction, and activity levels in control and fast-growing strains of Nile tilapia (*Oreochromis niloticus*)  
Supervisors: Dr Daniel Pauly and Dr Robin Liley  
Current Position: Student of Veterinary Medicine

## **Ratana Chuenpagdee (Thailand)**

PhD RMES (1998)  
Title: Scales of Relative Importance and Damage Schedules: A Non-Monetary Valuation Approach for Natural Resource Management  
Supervisor: Dr Daniel Pauly  
Current Position: Assistant Professor, Virginia Institute of Marine Science

## **Volker Deecke (Austria)**

MSc Zoology (1998)  
Title: Stability and change of killer whale (*Orcinus orca*) dialects  
Supervisors: Dr Andrew Trites and Dr John Ford  
Current Position: PhD Student, St. Andrew's, Scotland

## **Donald Demarchi**

MSc Zoology (1998)  
Title: A Spatial Simulation Model for Evaluating the Response of Rare and Endangered Species to Conservation Strategies and Forest Practices: A Case Study on the Northern Spotted Owl  
Supervisor: Dr Carl Walters

## **Barbara Johnston (Canada)**

MSc Zoology (1998)  
Title: Terrestrial Pacific Giant Salamanders (*Dicamptodon tenebrosus* Good) - Natural history and their responses to forest practices  
Supervisor: Dr William Neill

## **Dale Kolody**

PhD Oceanography (1998)  
Title: Analysis of Fraser River sockeye salmon coastal migration route variation using Bayesian estimation methods and individual-based modelling  
Supervisor: Dr Michael Healey

## **Gerald Oliver (Canada)**

MSc Zoology (1998)  
Title: Benthic algal and insect responses to nutrient enrichment of an in-stream mesocosm  
Supervisor: Dr William Neill  
Current Position: Fisheries Consultant, Cranbrook, BC

## **Ulrich Reinhardt (Germany)**

PhD Zoology (1998)  
Title: The role of body size in the habitat choice and foraging behaviour of juvenile coho salmon under predation risk  
Supervisor: Dr Michael Healey

## **Jordan Rosenfeld (Canada)**

PhD Zoology (1998)  
Title: The effect of fish predation on benthic community structure in streams  
Supervisor: Dr William Neill  
Current Position: Research Biologist, BC Ministry of Fisheries

## **Chris Schell (Canada)**

MSc Zoology (1998)  
Title: The response of periphyton chlorophyll *a* and invertebrate drift to the end of nutrient enrichment  
Supervisor: Dr William Neill  
Current Position: Environmental Consultant, Smithers, BC

## **Hreidar Valtýsson (Iceland)**

MSc Zoology (1998)  
Title: An assessment of Icelandic flatfish stocks  
Supervisor: Dr Carl Walters  
Current Position: Assistant Professor, University of Akureyri, Iceland

## **Alida Bundy (UK)**

PhD RMES (1997)  
Title: Assessment and management of multispecies multigear fisheries: a case study from San Miguel Bay, the Philippines  
Supervisor: Dr Daniel Pauly  
Current Position: Post-Doctoral Researcher, DFO, Halifax

## **Maura MacInnis (Canada)**

MSc Zoology (1997)  
Title: Grazer control of bacterial abundance in a freshwater pond community  
Supervisor: Dr William Neill  
Current Position: Technical writer, Toronto

## **Boyd Porter (USA)**

MSc Zoology (1997)  
Title: Winter ecology of steller sea lions (*Eumetopias jubatus*) in Alaska  
Supervisor: Dr Andrew Trites  
Current Position: Biologist, Alaska Department of Fish and Game, Ketchikan

## **Angela Prince**

MSc Zoology (1997)  
Title: The movement and competitive behaviours of male coho salmon (*Oncorhynchus kisutch*) reproductive tactics  
Supervisor: Dr Michael Healey

## **Laura Rempel (Canada)**

MSc Zoology (1997)  
Title: Habitat variation due to seasonal flooding of the lower Fraser river and the influence on the macroinvertebrate community  
Supervisor: Dr Michael Healey  
Current Position: PhD Student (Geography), UBC

## **Judson M. Venier (USA)**

MSc Zoology (1997)  
Title: Seasonal ecosystem models of the Looe Key National Marine Sanctuary, Florida  
Supervisor: Dr Daniel Pauly  
Current Position: Consultant, Toronto



**Ramón Bonfil (Mexico)**

PhD RMES (1996)  
Title: Elasmobranch fisheries: status, assessment and management  
Supervisor: Dr Tony Pitcher  
Current Position: Visiting Researcher, FAO, Rome

**Theresa Burg (Canada)**

MSc Zoology (1996)  
Title: Genetic analysis of eastern Pacific seals (*Phoca vitulina richardsi*) from British Columbia and parts of Alaska using mitochondrial DNA and microsatellites  
Supervisor: Dr Andrew Trites  
Current Position: Post-doctoral Fellow, University of Colorado

**R. Scott Cope**

MSc Zoology (1996)  
Title: Responses of sockeye salmon (*Oncorhynchus nerka*) embryos to intragravel incubation in selected streams within the Stuart-Takla watershed  
Supervisor: Dr Carl Walters

**Guillermo Giannico (Argentina)**

PhD RMES (1996)  
Title: Juvenile coho salmon habitat utilization and distribution in a suburban watershed: the Salmon River (Langley, BC)  
Supervisor: Dr Michael Healey

**Scot Mountain**

MSc Zoology (1996)  
Title: An investigation of a potential carrying capacity of coho and chinook salmon in the Georgia Strait  
Supervisor: Dr Carl Walters

**Morris Mtsambiwa (Zimbabwe)**

PhD RMES (1996)  
Title: Some management aspects of pre-recruitment ecology of the freshwater sardine *Limnothrissa miodon* in Lake Kariba  
Supervisor: Dr Tony Pitcher  
Current Position: Senior Officer, Zimbabwe Parks and Wildlife Department

**Simon Hemphill (Kenya)**

Visiting PhD Student (University of Wales) (1995)  
Title: The Ecology and Exploitation of Yellowfin Tuna, *Thunnus albacares* (Bonnaterre 1788) in the Pemba Channel, Kenya  
Supervisor: Dr Tony Pitcher  
Current Position: Director, Sea Adventures Ltd. Sport Fishing Company, Kenya

**James Njiru (Kenya)**

MSc (Ag) (Kenya) (1995)  
Title: Use of otoliths to assess age and mortality rates in the Lake Victoria pelagic cyprinid fishery  
Supervisor: Dr Tony Pitcher  
Current Position: Fisheries Research Officer, KMFRI, Kenya

**Gabriel Antonius Wagey (Indonesia)**

MSc Oceanography (1995)  
Title: The influence of surface currents on the dispersal of coho salmon (*Oncorhynchus kisutch*) from the Strait of Georgia  
Supervisor: Dr Michael Healey  
Current Position: PhD student, Oceanography, UBC

**Joseph De Gisi (USA)**

MSc Zoology (1994)  
Title: Year class strength and catchability of mountain lake brook trout  
Supervisor: Dr Carl Walters  
Current Position: Environmental Consultant, Smithers, BC

**Joel Sawada (Canada)**

MSc Zoology (1994)  
Title: An examination of differential survival in downstream migrating coho salmon smolts  
Supervisor: Dr Carl Walters  
Current Position: Biologist, BC Ministry of Fisheries



# FISHERIES CENTRE RESEARCH REPORTS

## ANNEX 2

**Commercial Whaling: the Issues Reconsidered**

1993. 1(1). 36 pages. Edited by T.J. Pitcher and R. Chuenpagdee.

**Decision Making by Commercial Fishermen**

1993. 1(2). 75 pages. Edited by T.J. Pitcher and R. Chuenpagdee.

**Bycatches in Fisheries and Their Impact on the Ecosystem**

1994. 2(1). 86 pages. Edited by T.J. Pitcher and R. Chuenpagdee.

**Graduate Student Symposium on Fish Population Dynamics and Management**

1995. 3(2). 33 pages. Edited by A. Bundy and E.A. Babcock.

**Harvesting Krill: Ecological Impact, Assessment, Products and Markets**

1995. 3(3). 82 pages. Edited by T.J. Pitcher and R. Chuenpagdee.

**Mass-Balance Models of the North-Eastern Pacific Ecosystems**

1996. 4(1). 131 pages. Edited by D. Pauly and V. Christensen with assistance of N. Haggan.

**Reinventing Fisheries Management**

1996. 4(2). 84 pages. Edited by T.J. Pitcher.

**The Design and Monitoring of Marine Reserves**

1997. 5(1). 47 pages. Edited by T.J. Pitcher.

**Assessment of Hong Kong's Inshore Fishery Resources**

1998. 6(1). 148 pages. Edited by T.J. Pitcher, R. Watson, A. Courtney and D. Pauly.

**Use of Ecopath with Ecosim to Evaluate Strategies for Sustainable Exploitation of Multi-Species Resources**

1998. 6(2). 49 pages. Edited by D. Pauly with assistance of G. Weingartner.

**Graduate Symposium on Fish Population Dynamics and Management**

1998. 6(3). 40 pages. Edited by M. Vasconcellos and D. Preikshot.

**Trophic Mass-Balance Model of Alaska's Prince William Sound Ecosystem**

1998. 6(4). 143 pages. Edited by T. Okey and D. Pauly.  
(Note: Second Edition printed in 1999, Volume 7(4).)

**Back to the Future: reconstructing the Strait of Georgia Ecosystem**

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**Distant Water Fleets: An Ecological, Economic and Social Assessment**

1998. 6(6). 111 pages. Edited by P. Bonfil, G. Munro, U. Sumaila, H. Valtysson, M. Wright, T.J. Pitcher, D. Preikshot, N. Haggan and D. Pauly.

**Ecosystem Change and the Decline of Marine Mammals in the Eastern Bering Sea**

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**Evaluating the Benefits of Recreational Fisheries**

1999. 7(2). 169 pages. Edited by T.J. Pitcher.

**Back to the Future: Reconstructing the Hecate Strait Ecosystem**

1999. 7(3). 65 pages. Edited by N. Haggan and A. Beattie with assistance of D. Pauly.

**A Trophic Mass-Balance Model of Alaska's Prince William Sound Ecosystem for the Post-Spill Period 1994-1996. 2nd Edition**

1999. 7(4). 137 pages. Edited by T.A. Okey and D. Pauly.

**Marine Protected Areas with an Emphasis on Local Communities and Indigenous Peoples: a review**

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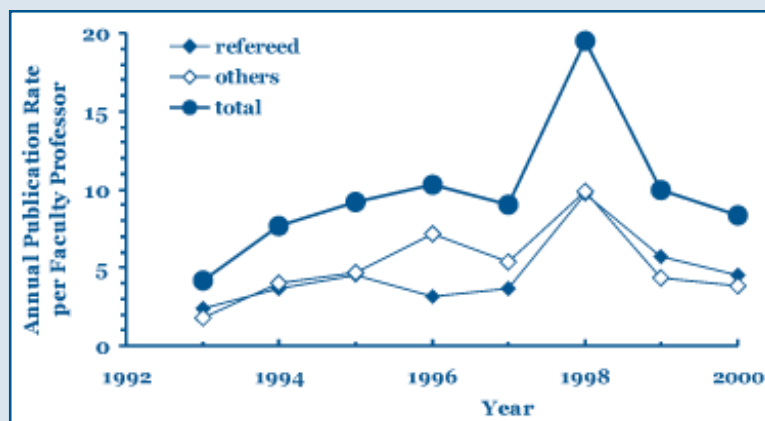




# PUBLICATIONS BY MEMBERS

## ANNEX 3

This annex is divided into two sections: papers in journals, books and edited volumes that have been peer reviewed, and other published contributions that have not been through this process. The editing of contributions which have themselves been peer reviewed is included in this latter section.



The graph shows that the Fisheries Centre's publication rate has grown since 1993 and is currently averaging about one publication every week, and about 4.5 peer-reviewed publications per Faculty member per year. Moreover, according to ISI, the average citation rate among the Faculty members in the Fisheries Centre is over 50 citations per year.

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## 1993

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# CONFERENCES AND WORKSHOPS

## **Training Course on Ecopath with Ecosim**

November, 2000: University of British Columbia, Vancouver, Canada.

## **Back to the Future Ecosystem Modelling Workshop - East Coast. MCRI Project**

September 29-30, 2000: St. John's, Newfoundland, Canada.

## **Back to the Future Ecosystem Modelling Workshop - West Coast. MCRI Project**

September 11-12, 2000: Vancouver, British Columbia, Canada.

## **FAO Workshop in the Use of Ecosystem Models to Investigate Strategies for Capture Fisheries**

July 17-20, 2000: University of British Columbia, Vancouver, Canada.

## **International Conference on the Economics of Marine Protected Areas**

July 6-7, 2000: University of British Columbia, Vancouver, Canada.

## **“Sea Around Us Project” Methodology Review Workshop**

April 30-May 6, 2000: Dunsmuir Lodge, Victoria, Canada.

## **International Conference on Evaluating the Benefits of Recreational Fishing**

June 1-4, 1999: University of British Columbia, Vancouver, Canada.

## **FAO Workshop on the Use of Ecosim to Evaluate Strategies for the Sustainable Exploitation of Multispecies Resources**

March 25-28, 1998: FAO, Rome, Italy.

## **An Ethical Analysis of Fisheries: Canadians and Fish Stocks, East and West**

October, 1998: Queen Charlotte City, Haida Gwaii, Canada.

## **The Use of Ecosim to Evaluate Strategies for the Sustainable Exploitation of Multispecies Resources**

March 25-27, 1998: University of British Columbia, Vancouver, Canada.

## **Strait of Georgia Ecosystem Reconstruction Workshop**

November 21-22, 1997: University of British Columbia, Vancouver, Canada.

## **An Ethical Analysis of Fisheries: Canadians and Fish Stocks, East and West**

November, 1997: University of British Columbia, Vancouver, Canada.

November, 1997: St. John's, Newfoundland, Canada.

September, 1997: Dunsmuir Lodge, Victoria, Canada.

## **The Spatial Structure of Herring Stocks and its Impacts on the Assessment of Herring Fisheries**

September 15-16, 1997: University of British Columbia, Vancouver, Canada.

## **Design and Monitoring of Marine Reserves Workshop**

February 28, 1997: University of British Columbia, Vancouver, Canada.

## **The Third Fisheries Graduate Student Symposium**

March 21-23, 1997: University of British Columbia, Vancouver, Canada.

## **International Symposium - Reinventing Fisheries Management**

February 20-24, 1996: University of British Columbia, Vancouver, Canada.

## **Harvesting Krill: Ecological Impact, Assessment, Products and Markets**

November 14-16, 1995: University of British Columbia, Vancouver, Canada.

## **First Graduate Student Symposium on Fish Population Dynamics and Management**

April 22-23, 1995: University of British Columbia, Vancouver, Canada.

## **Impact of Changes in North Pacific Oceanographic Regimes on Coastal Fisheries**

March 2-3, 1995: University of British Columbia, Vancouver, Canada.

## **Bycatches in Fisheries and their Impact on the Ecosystem**

October 13-14, 1994: University of British Columbia, Vancouver, Canada.

## **Decision-making by Commercial Fishermen: A Missing Component in Fisheries Management?**

November 25-26, 1993: University of British Columbia, Vancouver, Canada.

## **Workshop in Management Procedures for Commercial Whaling**

June 11, 1993: University of British Columbia, Vancouver, Canada.

## ANNEX 4





# SEMINARS

## 2000

**Lore Ruttan (Fisheries Centre, UBC)**

Information sharing among Pacific Hake fishermen: fact or fancy?

**Steve Martell (Fisheries Centre, UBC)**

Incorporating seasonality into ecosystem models: introducing ECOPATH SC.

**Mark Trevorrow (Institute of Oceanographical Sciences, DFO, Sidney)**

Trial of new side-looking fisheries sonars in the Southern Strait of Georgia.

**Pat Slaney (BC Ministry of Fisheries)**

Watershed restoration: from theory to practice.

**Charles Menzies (Department of Anthropology, UBC)**

The nexus of misfortune and conflict: the management of British Columbia's Coho salmon crisis.

**Pamela Mace (NMFS, USA)**

Larkin Lecture Discussion: MSY reborn - but with a new identity: is it necessary, is it sufficient?

**Amy Poon (Fisheries Centre, UBC)**

Fish Tales: Interactions between Science and Literature.

**Aran Kay (Fisheries Centre, UBC)**

An Ecopath model of Okanagan Lake - Searching for a solution to the MYSID crisis.

**Anne Hollowed (NMFS, USA)**

Measuring the influence of climate variability and predation mortality on single-species stock assessment advice.

**Ken Ashley (BC Ministry of Fisheries)**

Update on the Kootenay Lake Fertilization Experiment.

**Olivier Cheneval (Marine Mammal Research Unit, UBC)**

Foraging behaviour of juvenile Steller sea lions feeding on Pacific herring and Walleye pollock.

**Mike Pearson (Resource Management and Environmental Studies, UBC)**

Protecting endangered fish on private land in British Columbia: A case study of the Salish sucker and Nooksack dace.

**Dirk Zeller (Fisheries Centre, UBC)**

MPAs and coral reef fisheries: 'Spillover' - does it exist or is it even relevant?

**Jackie Alder (Fisheries Centre, UBC)**

Coastal Zone Management in 3D: a new institutional model.

**Maria Morlin (Fisheries Centre, UBC)**

"One fish, two fish, no fish TO fish" - Land Use and Coho Salmon in the Georgia Basin.

**Evelyn Pinkerton (School of Resource and Environmental Management, Simon Fraser University)**

The Ideal Fisheries Management Agency: what could it look like?

**Roland Pitcher (CSIRO Marine, Australia)**

Seabed Biodiversity and Habitat Mapping.

**Bruce Ward (BC Ministry of Fisheries)**

Declivity Reversal in Steelhead Trout: Fisheries Research on Ecosystem Rehabilitation at the Keogh River.

**Sheila Heymans (Fisheries Centre, UBC)**

Ecopath and Network Analysis of the Northern Benguela Ecosystem, Namibia.

**Ed Gregr (FACET Inc.)**

Addressing Complex Issues Relating to Spatial Analysis.

**Miles G. Richardson (Chief Commissioner of the BC Treaty Commission)**

The B.C. Treaty Process, Interim Measures and Fisheries.

**Doug DeMaster (NMFS, USA)**

Contrasts in Management or are they?: Problems in Managing Cook Inlet Beluga Whales and Eastern North Pacific Gray Whales.

**David Fluharty (School of Marine Affairs, University of Washington, USA)**

Implementation of the Sustainable Fisheries Act/Ecosystem-Based Fisheries Management.

**Sonia Rodríguez Ruiz (Biología Marina, Universidad de Alicante, Spain)**

Influence of Trawling in the Diet of Fishes of *Posidonia oceanica* Meadows in the Western Mediterranean.

**Sylvie Guénette (Fisheries Centre, UBC)**

An Ecopath model of the Azores Archipelago.

**James Ianelli (NMFS, USA)**

Examples of Fisheries Conservation Management in the North Pacific.

**Susan Allen (Oceanography, UBC)**

The Influence of Topography on Coastal Flows and Some Impacts on Zooplankton and Fish Distributions.

## 1999

**Glen Jamieson (DFO)**

Management Principles of Marine Reserves applied on Spatially-Structured Stocks.

**Russ Jones (Haida Fisheries Program)**

First Nations' ocean interests and marine protected areas.

# ANNEX 5





**Dave Rosen (Marine Mammal Unit, UBC)**

Can captive studies benefit wild steller sea lions?

**Bill Collins (Quester Tangent Corporation)**

Use of acoustic seabed classification for seabed habitat.

**John Meech (Department of Mining and Mineral Process Engineering, UBC)**

Fuzzy logic expert systems for consultative and real-time applications.

**Eric Tamm (Coastal Community Network)**

Community and Fisheries Sustainability: Linking ecosystem health to socio-economic wellbeing of fishing-dependent communities.

**Kristin Kaschner (Marine Mammal Unit, UBC)**

Increasing the efficiency of 'pingers' to reduce cetacean bycatch in commercial fisheries.

**Alasdair Beattie (Fisheries Centre, UBC)**

Trawl discards and seabirds in British Columbia: a free lunch for all?

**Sean Cox (Fisheries Centre, UBC)**

Regional-scale modelling of BC's small lake rainbow trout fishery: implication for regulations and development.

**Trevor Hutton (Fisheries Centre, UBC)**

Co-operative versus non-cooperative management of shared linefish stocks in South Africa: an assessment of alternative management strategies for Geelbek (*Atractoscion aequidens*).

**Silvia Salas (Fisheries Centre, UBC)**

Decision making by fishers and fishing strategies analysis.

**Laura Vidal (Fisheries Centre, UBC)**

Source and fate of bycatch in the Gulf of Mexico.

**Terry Glavin (Transmontanus)**

Pacific Fisheries Research Conservation Council.

**Kevern Cochrane (FAO, Rome, Italy)**

Larkin Lecture Discussion.

**Andrew Trites (Marine Mammal Research Unit)**

Steller sea lions: why have they declined?

**Elizabeth Mohammed (Fisheries Centre, UBC)**

Marine Fisheries in Eastern Caribbean.

**Stephen Watkinson (Fisheries Centre, UBC)**

Salmon carcasses: nutrient pills for the province.

**Sigal Balshine-Eam (Israel)**

Parental care evolution in the cichlid fisheries of Lake Kinneret and Lake Tanganyika.

**Steve Kennelly (Fisheries Research Institute, NSW, Australia)**

A successful protocol used to solve by-catch problems: examples from prawn-trawling and tuna purse-seining.

**Neil A Gribble (Northern Fisheries Centre, Australia)**

A spatially explicit multi-competitor coexistence model of penaeid (shrimp) distribution on the Australian Great Barrier Reef.

**Ratana 'Ying' Chuenpagdee (Fisheries Centre, UBC)**

Coastal zone management: state-of-the-art?

**Scott Akenhead, Peter Lawson and Ian Williams (Facet Decision Systems Inc., National Marine Fisheries Service, I.V. Williams Consulting)**

Fisheries planning and management in large ecosystems, with prototypes for Pacific salmon management.

**Reg Watson (Fisheries Centre, UBC)**

Enhancing trawl fisheries management through simulation: the Simsys approach.

**Steven Mackinson (Fisheries Centre, UBC)**

A new approach to the analysis of stock-recruitment relationships: "model-free estimation" using fuzzy logic.

**Paul Fanning (DFO)**

Workable governance in Caribbean fisheries.

**Molly Lutcavage (New England Aquarium, Boston, USA)**

Tracking North Atlantic Bluefin Tuna: Integration of Meso and Macroscale Technologies.

**Julie Martin (Northern Territory Fisheries, Australia)**

The use of mangroves and their resources by fish in Darwin Harbour.

**Dominique Pelletier and S. Mahévas (IFREMER, France)**

Developing a computer-based simulation model to explore spatial and seasonal management measures in a mixed fishery.

**Rosemary Ommers (Memorial University of Newfoundland)**

Just fish - ethics and issues in marine fisheries management.

**Neil A Gribble (Northern Fisheries Centre, Australia)**

Application of VMS to fisheries stock assessment.

**Jordan Rosenfeld (BC Ministry of Fisheries)**

Habitat associations of juvenile cutthroat trout: implications for forestry management.



**William Cheung (University of Hong Kong)**

History of the fishing industry and fishery resources in Hong Kong in the 20th century.

**Melanie Power (Fisheries Centre, UBC)**

A comparative, multidisciplinary evaluation of Canadian fisheries, East and West, using the Rapfish method.

**Mary Gregory (Resource Management and Environmental Studies, UBC)**

An application of auction theory to licence retirement.

**Mike Healey (Fisheries Centre, UBC)**

Bioenergetics of salmon migration and spawning: running on empty.

## 1998

**Ray Hilborn (University of Washington)**

Do hatcheries increase marine fish production: a case study of Prince William Sound Alaska.

**Scott Hinch (Forestry, UBC)**

Swimming behaviour, energy depletion, and risk of en route mortality in river migrating adult salmon.

**Randall Peterman (Simon Fraser University)**

Spatial and temporal patterns of covariation in survival rates, growth rates, and age at maturity of sockeye salmon.

**Steve Mackinson (Fisheries Centre, UBC)**

Expert systems and BC herring fishery.

**Marcelo Vasconcellos (Fisheries Centre, UBC)**

Harvest control of schooling fish stocks under oceanographic regimes.

**Daniel Pauly (Fisheries Centre, UBC)**

Fisheries impact on marine ecosystems.

**Mike Thoms (Department of History, UBC)**

Trout in Space.

**Edward Nsiku (Fisheries Centre, UBC)**

Management approaches to Lake Malawi.

**Hreidar Valtýsson (Fisheries Centre, UBC)**

Assessment of Icelandic flatfish stock.

**Nathaniel Newlands (Fisheries Centre, UBC)**

The role of shoaling behaviour in the spatial dynamics of stock collapse in fisheries.

**Nigel Haggan (Fisheries Centre, UBC)**

Aboriginal program: Opening the Doors

**Rashid Sumaila (Fisheries Centre, UBC, and Chr. Michelsen Institute, Norway)**

Game theory: basic concepts and application to fisheries management.

**Daniel Pauly (Fisheries Centre, UBC): Special FAO Workshop**

Ecological modelling with Ecosim.

**Catherine Stewart (Greenpeace), John Radosevic (United Fishermen and Allied Workers' Union), Tom Bird (Sport Fishing Institute of British Columbia), Arnie Narcisse (BC Aboriginal Fishing Commission), Rashid Sumaila (Fisheries Centre, UBC)**

Special Series - Debate on Pacific Salmon.

**Nathaniel Newlands and Steve Mackinson (Fisheries Centre, UBC)**

Using heuristics to model the structure and distribution of herring shoals.

**David Ellis (The Fish for Life Foundation)**

The Georgia Strait herring issue: an alternative view.

**Rashid Sumaila (Fisheries Centre, UBC)**

Markets and the fishing down marine foodwebs phenomenon.

**Ana Parma (International Pacific Halibut Commission, USA)**

Decadal changes in growth and recruitment of Pacific halibut and their effects on stock assessment.

**Duncan Stacey**

The Knight Inlet native oolachon fishery on the Klinaklini River, past and present.

**Rick Brodeur (NMFS, USA)**

The role of pre-recruit pollock in the Bering Sea and North Pacific ecosystems.

**Amanda Vincent (McGill University).**

Project Seahorse.

**Sylvie Guénette (Fisheries Centre, UBC)**

The potential of marine reserves for the conservation of northern cod in Newfoundland.

**Vincent Gillett (Fisheries Centre, UBC)**

Institutionalising Marine Protected Areas.

## 1997

**Ole Arve Misund (Institute of Marine Research, Norway)**

Mapping distribution, abundance and migration behaviour of schooling fish by underwater acoustics.

# ANNEX 5



**Paul Leblond (Fisheries Resource Conservation Council)**

To open or not to re-open: background to the Fisheries Resources Conservation Council's recommendations on Atlantic groundfish.

**Luis E. Calderone (Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, Mexico)**

Is the shrimp fishery of the Gulf of California collapsing?

**Leif Nøttestad (University of Bergen, Norway)**

Herring school dynamics, including their interaction with whales.

**Reg Watson (Fisheries Dept., Perth, Western Australia)**

Prawn fisheries in Western Australia.

**Rashid Sumaila (Chr. Michelsen Institute and Fisheries Centre, UBC)**

Do marine reserves make bioeconomic sense?

**Carl Walters (Fisheries Centre, UBC)**

Northern prawn fishery in Western Australia.

**Norm Hall (Fisheries Dept., Perth, Western Australia)**

Rock lobster fisheries in Western Australia.

**Laura Richards (DFO)**

British Columbia groundfish fisheries and the precautionary approach.

**Bernard Walrut (Fisheries Centre, UBC)**

Aspects of domestication and property in fish in the law.

**Steve Martell (Fisheries Centre, UBC)**

Lingcod reproduction and demographics in Howe Sound.

## 1996

**Pierre Magnan (Université du Québec à Trois-Rivières)**

The impact of white sucker introductions on brook trout population.

**Tony Davis (St. Francis Xavier University)**

Common to whom? Social justice and fisheries management.

**Peter Bayley (Oregon State University, USA)**

Understanding river-floodplain ecosystems: why are they so productive?

**Wendell Koning (Fisheries Branch, Ministry of Environment, Land and Parks)**

Experimental fertilisation of oligotrophic streams in British Columbia.

**Rainer Froese (ICLARM, Philippines)**

The biodiversity problem and the power of relational databases.

**Graham Forrester (University of California, Los Angeles, USA)**

Recruitment and the population ecology of reef fishes: revising the supply-side ecology paradigm.

**Kevin McLoughlin (Department of Primary Industries and Energy, Australia)**

Australia's southern shark fishery.

## 1995

**Rosemary Ommer (Institute of Social and Economic Research, Memorial University of Newfoundland)**

Sustainable communities of fish and fishers? Memorial University Eco-Research Project.

**Steve MacDonald (DFO)**

Recent fisheries/forestry interaction.

**James Scandol (Fisheries Centre, UBC)**

Dynamics of sockeye salmon populations.

**John Sproul (Fisheries Centre, UBC)**

Japanese halibut management.

**Tony Pitcher (Fisheries Centre, UBC)**

The impact of pelagic fish behaviour on fisheries.

**Michael Henderson (DFO)**

Management and assessment of sockeye and chinook salmon in British Columbia in 1995.

**Terry Quinn, II (University of Alaska, USA)**

Determination of sustained yield in Alaska's recreational fisheries.

**Laura Richards (DFO)**

Uncertainty in fisheries management: a case study of British Columbia rockfish.

**Louis Botsford (University of California, Davis, USA)**

The dynamics of meroplanktonic metapopulations.

**Narriman Jiddawi (University of Dar es Salaam, Zanzibar, Tanzania)**

Stock assessment of Indian mackerel.

**Enric Cortes (Mote Marine Laboratory, Florida, USA)**

Demographic modelling as a tool in assessment and management of shark stocks.

**Carlos Moreno (Universidad Austral de Chile, Chile)**

Ecological consequence of shellfish gathering at the rocky shores in Chile.

**Francis Juanes (University of Massachusetts, Amherst, USA)**

Comparing early life history strategies of bluefish: a global approach.

**Fisheries Centre Debate**

Biodiversity of fisheries products must be sacrificed if fisheries are to meet demand in the 21st century.



## 1994

**Daniel Pauly (ICLARM, Philippines)**

Towards a unified theory of fish growth and mortality.

**Martin Hall (Inter-American Tropical Tuna Commission, California, USA)**

An ecological view of the tuna-dolphin problem in the eastern tropical Pacific Ocean.

**Andrew Trites (Marine Mammal Research Unit, UBC)**

The decline of Steller's Sea Lions and the development of commercial fisheries in the Gulf of Alaska.

**Michael Healey (Director, Westwater Research Centre, UBC)**

Environmental assessment of the Old Man River dam.

**Eric Parkinson (British Columbia Ministry of Environment, Lands and Parks)**

Making management decisions on small lakes: manipulation and models.

**Keith Thomson (Fisheries Centre, UBC)**

Do ocean currents affect the return migration of sockeye salmon?

**Timothy McDaniels (Westwater Research Centre and School of Community and Regional Planning, UBC)**

Co-operative fisheries management involving First Nations in British Columbia: an adaptive approach to strategy design.

**David Ramm (Department of Primary Industry and Fisheries, Darwin, NT, Australia)**

Fisheries and recent research on the effects of herding in groundfish.

**Dana Schmidt (Alaska Dept. of Fish and Game, USA)**

Implications of overescapement of sockeye salmon on harvest and enhancement strategies (Legacy of the *Exxon Valdez*?).

**Francis Christy (IMARIBA, Washington, DC, USA)**

Global Fisheries Development and Management Requirements.

**Milo Adkinson (School of Resource and Environmental Management, SFU)**

Setting escapement goals using both historical abundance and habitat features: important details of a Bayesian approach.

**Chris Luecke (Dept. of Fisheries and Wildlife, Utah State University, USA)**

Utah Lake management strategies to assist with the recovery of endangered sockeye salmon in Idaho.

**Royann Petrell (Bio-Resource Engineering, UBC)**

Reducing seed wastage on salmon farms.

**Robert Newbury**

Rivers and the art of stream restoration.

**Gordon Munro (Department of Economics, UBC)**

The management of high-sea fisheries resources.

**Richard Ferrero (NMFS, USA)**

Growth and reproduction of small cetaceans: results of life history investigations on dolphins taken in high seas liftnets.

## 1993

**Laura Richards (DFO)**

Management of British Columbia groundfish problems with multispecies fisheries data.

**Robert Scheibling (Dalhousie University)**

Of sea urchins, seaweeds and chance: cyclic alterations of community state in the rocky subtidal zone off Nova Scotia.

**Kjartan Magnusson (University of Iceland)**

Cod-capelin interactions in Icelandic waters.

**Scott Hinch (Oceanography Dept. and Westwater Research Centre, UBC)**

Littoral fish communities in central Ontario: patterns and processes.

**Lance Lesack (SFU)**

Biogeochemistry of lakes in the central Amazon floodplain and in the MacKenzie Delta: analogue ecosystems representative of climatic extremes.

**John Stockner (DFO)**

Contrasting food webs in coastal and interior British Columbia lakes: impacts on sockeye salmon production.

**Brian Riddell (DFO)**

Chinook management issues and the Pacific Salmon Treaty.

# ANNEX 5







# GRADUATE COURSES

The following 3-credit courses are currently run by the Fisheries Centre:

**Fish 500 Issues in Fisheries Research: Seminars**  
**Fish 501 Issues in Fisheries Research: Freshwater**  
**Fish 502 Issues in Fisheries Research: Marine**  
**Fish 503 Issues in Fisheries Research: Policy**  
**Fish 504 Quantitative Analysis of Fisheries I**  
**Fish 505 Quantitative Analysis of Fisheries II**  
**Fish 506 Critical Issues in Fisheries Development**

Several of the above courses are comprised of modules. Different modules are run each year depending on our partners, visitors, and workshops in the Centre.

## ANNEX 6





# EDITORIAL POSITIONS

## MICHAEL HEALEY

*Estuaries*. Associate Editor (1993-1995).

*Transactions of the American Fisheries Society*. Associate editor (1998-1999).

## DANIEL PAULY

*Fish and Fisheries*. Associate Editor (2000-present).

*Marine and Freshwater Research* (Formerly *Australian journal of marine and freshwater research*). (1997-present).

*African journal of tropical hydrobiology and fisheries*. Editorial Board (1995-present).

*Boletim Instituto Portugues de Investigacao Maritima*. Editorial Board (1995-present).

*Reviews in Fish Biology and Fisheries*. Editorial Board (1993-2000).

*FishByte* Section of NAGA, the ICLARM Quarterly. Editor (January 1992-December 1996).

*Asian Fisheries Science*. Editorial board Member (1987-1993).

*Journal of Applied Ichthyology*. Subject Editor for Fisheries in Developing Countries (1985-1994).

## TONY PITCHER

*Fish and Fisheries*. Quarterly journal, Blackwell Science. Founding Editor (1999-present).

*Fish and Aquatic Resources Book Series*. Blackwell Science. Founding Editor (8 volumes, 1999-present).

*Boreal Ecosystems*. Editorial Board (1996-present).

*Reviews in Fish Biology and Fisheries*. Quarterly journal, Kluwer Academic (formerly Chapman and Hall). Founding Editor (1988-1999).

*Fish and Fisheries Book Series*. Kluwer Academic (formerly Chapman and Hall). Series Editor (24 volumes, 1988-1999).

## CARL WALTERS

*Environmental Management*. Associate Editor (1995-present).

*Canadian Journal of Fisheries and Aquatic Science*. Editorial Board (1986-present).

*Environmental Software*. Associate Editor (1986-present).

*Northwest Environmental Journal*. Associate Editor (1985-1993).

*Journal of Applied Mathematics and Computation*. Associate Editor (1982-present).

*Conservation Ecology*. Editorial Board.

*Ecosystems*. Editorial Board.

# ANNEX 7







# PROFESSIONAL ACTIVITIES

## MICHAEL HEALEY

1998-1999: President of CCFFR 1999, and member program committee for Coastal Zone Canada 98  
1995-1999: Member, science advisory committee to Yukon Energy Corp regarding environmental effects of Aishihik Lake hydro-electric project  
1995: Expert Witness, DFO, Nechako River Flow Agreement, British Columbia Utilities Commission  
1995: Specialist Consultant, Task Force on Missing Salmon  
1993-1995: Royal Society Evaluation of Aquatic Science in Canada (Chair)  
1992-1995: Special Advisor at various meetings on conservation of Central Valley chinook, California  
Member of the science advisory committee to the Northern River Basins Study, Canada/Alberta/NWT (Canada water act funded study of the Peace, Athabasca and Slave Rivers)

## WILLIAM NEILL

1994-1996: Consultant. B.C. Ministry of Environment, Lands & Parks, Wildlife Branch  
1995: Review Panel, US National Park Service, Crater Lake National Monument: a critique of 10 years' research and an assessment of plans for future research  
1993-1995: Consultant, US National Park Service, North Cascades National Park: fish introductions to high alpine lakes  
Member of Governing Council, Ecological Society of America  
Member of Research Commission for National Parks, US National Parks Service

## DANIEL PAULY

1995-present: American Fisheries Society  
1996-1999: Working Group 105 on "The Impact on Fisheries Harvest on the Stability and diversity of Marine Ecosystems" of the Scientific Committee on Oceanic Research  
1995-1998: Scientific Adviser of International Foundation for Science  
1995-1998: Committee on Ecosystem Management for Sustainable Marine Fisheries, (U.S.) National Research Council (Washington, D.C.)  
1988-1997: British Sub-Aqua Club/Philippine Sub-Aqua Club  
1987-1997: Network of Tropical Aquaculture Scientists  
1986-1997: Common Property Resource Network  
1982-1997: Network of Tropical Fisheries Scientists  
1982-1994: Deutsche Gesellschaft für Meeresforschung  
1988-1993: Scientific Adviser of Asian Fisheries Society Research Fellowship Award Scheme  
1984-1993: Asian Fisheries Society

## TONY PITCHER

1999-present: Board of Directors. Institute for Pacific Ocean Science and Technology, Vancouver, BC  
1999-present: Max Plank Institute Advisory Board, Ploen, Germany  
1995-1997: Board of Directors. Vancouver Public Aquarium  
1995-1996: Board of Directors. Sustainable Ocean Resources Society, Vancouver, BC  
1994-1996: Project Leader, COFRI Fish Stock Assessment Group, BC  
1994: Evaluation Panel for South Africa's new interdisciplinary research programme in fisheries and marine science (SANCOR)  
1994: Evaluation Panel for fisheries research programme at ICLARM, Manila, Philippines  
1993-present: Honorary Professor, University of Concepcion, Chile  
1993-1994: Consultant on African Lakes, MRAG Ltd., London, UK

## ANDREW TRITES

Advisory Member of Animal Management Committee at Vancouver Aquarium  
Advisory Member of Research and Conservation Committee at Vancouver Aquarium  
Chair of Marine Mammal Species Specialist Group at COSEWIC (Committee on the Status of Endangered Wildlife in Canada)  
Co-chair of Biennial Conference Program Committee at Society for Marine Mammalogy

## CARL WALTERS

2000-2001: Mote Marine Laboratory Eminent Scholar  
Founding Director of the Chinook Foundation  
Founding Director of the Save the Salmon Foundation  
Member of the Pacific Fisheries Resource Conservation Council, BC  
Fellowship Bureau of Resource Science, NT, Australia

## ANNEX 8





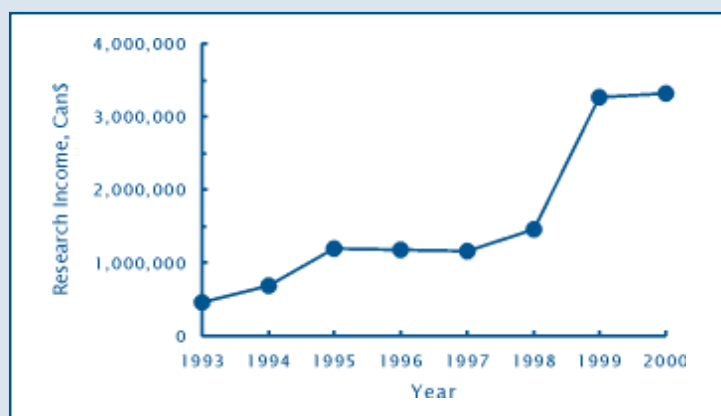
# RESEARCH SUPPORT INCOME

## Funding from UBC (1999-2000)

Salaries:	\$368,110
Operating costs:	\$18,545

**External research funding:** \$3,258,242

## External research funding by year:



## ANNEX 9

## Infrastructure grants\*:

1995 :	\$150,000	(UBC)
2000:	\$12.7 million	(CFI, KDF, UBC)

\*Project finances are as declared to the Fisheries Centre.







# ACTIVITIES WITH RESEARCH PARTNERS

The Fisheries Centre has signed a number of formal Memoranda of Understanding (MOUs) with Research Institutes in eight countries, with the aim of building solid foundations for on-going partnership in research. This Annex provides a list of activities that have taken place under each of these MOUs. Other research partnerships are mentioned in the list of research projects detailed in Annex 11.

## AUSTRALIA

**The Fisheries Division**, Department of Primary Industry and Fisheries, Northern Territory of Australia. (DPIF: Mr Darryl L. Grey), Harbour View Plaza, McMinn and Bennett Streets, Darwin, Australia.

*Graduate Student:* Rik Buckworth (Dr Carl Walters) 1997-2000.

*DPIF Visitors to FC:* Julie Martin (Ecosystem modelling courses: 1999 and 2000); Dr David Ramm (sabbatical: 1993-1994).

*FC Visitors to DPIF:* Dr Tony Pitcher (1996, 1998); Dr Carl Walters (1997, 2000).

## CANADA

**The North-West Maritime Institute**. (NWMI: George Hays), 130 First Avenue West, Prince Rupert, British Columbia BC, Canada V8J 1A8.

*Joint Workshop:* Modelling the Hecate Strait ecosystem: Back to the Future (1998), (Nigel Haggan).

**British Columbia Aboriginal Fisheries Commission, and UBC First Nations House of Learning.** (Three-way MOU)

Accelerated enrolment of Aboriginal graduate students.

*Joint Workshops:* Back to the Future projects in the Georgia and Hecate Straits, BC

## CHILE

**Oceanography Department**. (UDEC: Dr Renato Quinones), University of Concepcion, Chile.

*UDEC visits to FC:* Luis Duarte (2000).

*FC visits to UDEC:* Dr Tony Pitcher (graduate courses: 1996 and 2000); Eny Buchary (2000).

*Joint Project:* Ecosystem modelling of Antarctic krill fisheries (Drs Tony Pitcher and Tarsicio Antezana: 2000-present).

## INDONESIA

**Center for Coastal and Marine Resource Studies**, Bogor Agricultural University, Bogor, Indonesia

*CCMRS visits to FC:* Dr Akhmad Fauzi (2000 and 2001), Dr Rokhmin Dahuri (1999)

*FC visits to CCMRS:* Dr Tony Pitcher (1998 and 1999); Eny Buchary (1999); Nigel Haggan (1998 and 1999).

*Collaborative research:* on rapid appraisal of Indonesian fisheries.

## ITALY

**Food and Agriculture Organization of the United Nations** (FAO). Rome, Italy.

*FAO Visitors to FC:* Dr Kevern Cochrane (1999, 2000); Dr Richard Grainger (1999, 2000).

*FC visitors to FAO:* Dr Tony Pitcher (1998, 1999); Dr Reg Watson (2000).

**International FishBase Consortium**. Rome, Italy (2000-present).

*Attendance of Dr Pauly at Committee Meetings of Consortium* (2000).

## MEXICO

**Centro Interdisciplinario de Ciencias Marinas**, Instituto Politecnico Nacional, Mexico. (CICIMAR: Mr Victor Manuel Gomez Muñoz), La Paz, Baja California Sur, Mexico.

*Graduate student:* Leonardo Huato (1993-2000).

*CICIMAR visits to FC:* Dr Francisco Arreguin-Sanchez (1996, 2000).

*Joint Workshops:* Ecosystem modelling (Drs Villy Christensen, Daniel Pauly and Francisco Arreguin-Sanchez: 1996); ecosystem modelling (Drs Carl Walters and Francisco Arreguin-Sanchez: 1998).

## NORWAY

**The Chr. Michelsen Institute**. (CMI: Dr Gunnar M. Sorbo), Fantoftvegen 38, 5036 Fantoft, Bergen, Norway.

*CMI visits to FC:* Dr Rashid Sumaila (1994 - 1999); Dr Frank Asche (1993).

**The Institute for Marine Research**. (IMR: Dr Ole Arve Misund), Bergen, Norway.

*IMR visits to FC:* Dr Ole Arve Misund, graduate course: 1996; Dr Leif Nøttestad (1997, 1999).

*FC visits to IMR:* Dr Tony Pitcher (graduate course: 1994; cruises: 1994, 1996). Dr Sylvie Guénette (cruises: 1996, 1997); Dr Stephen Mackinson (cruises: 1996, 1997); Taja Lee (cruise: 1996); Dr Villy Christensen (2000); Dr Dirk Zeller (2000).

*Joint Project:* Schooling dynamics of herring in the Norwegian Sea (1994-present).

# ANNEX 10



## PHILIPPINES

**The International Center for Living Aquatic Resources Management.** (ICLARM: Dr. Meryl J. Williams), Bloomingdale Building, Salcedo Street, Legaspi Village, Makati, Metro Manila, Philippines (from 2001 in Penang, Malaysia).

*ICLARM visits to FC:* Dr Villy Christensen (1997 - 1999); Dr Meryl Williams (1996); Dr Rainer Froese (1997, 1999); Dr John Munro (2000).

*FC visits to ICLARM:* Dr Daniel Pauly (annually 1994-2000).

*Joint Projects:* Fishbase in British Columbia (Drs Daniel Pauly and Rainer Froese: 1996); Sea Around Us database: Drs Reg Watson and Rainer Froese : 1999, 2000).

## PORTUGAL

**The Department of Oceanography and Fisheries.** University of the Azores, (DOP: Dr Ricardo Serrão Santos), Horta, Faial, Azores, Portugal, PT-9901-862.

*DOP visits to FC:* Telmo Morato Gomez (2000).

*FC visits to DOP:* Dr Tony Pitcher (2000, 2001); Dr Sylvie Guénette (1999, 2000).

## SWEDEN

**The Centre for Fish and Wildlife Research.** Swedish University of Agricultural Sciences, Umeå, Sweden (CFW: Dr Lars-Ove Eriksson).

*CFW visits to FC:* Dr Lars-Ove Eriksson (1998).

*FC visits to CFW:* Dr Tony Pitcher (2000).



# RESEARCH PROJECTS

## NIGEL HAGGAN

Back to the Future in the Hecate Strait: traditional and aboriginal knowledge for the model reconstruction of past marine ecosystems. Haida and Tsimshian Nations/DFO/UBC. 1998.

## MICHAEL HEALEY

Ecological risk associated with aquaculture development in BC (with M. Power, Waterloo). Aquanet: NSERC-NCE. 2000-2006.

Effects of flow and temperature on upstream migration and spawning of sockeye and pink salmon. NSERC Equipment Grant. 2000-2001.

Roles of science in the development and evolution of fishery management policy. SSHRC. 1999-2002.

Effects of flow and temperature on energetics of upstream migration and spawning in salmon. NSERC Strategic Grant. 1998-2002.

Energetics of reproduction in Pacific Salmon. NSERC Research Grant. 1997-2001.

Habitat requirements and conservation of Salish sucker and Nooksack dace. Habitat Conservation Fund: BC Fisheries. 1999-2000.

Techniques for evaluating the quality of coastal habitats for fishes. Burrard Inlet Environmental Action Plan. 1998-2000.

Science and learning in the evolution of fishery management in New England (with T. Hennessey, URI). US Sea Grant Program. 1995-1998.

Energetic costs of upstream migration and spawning in sockeye salmon. DFO. 1995-1997.

Roles of science in developing resource management policy. Council for International Exchange of Scholars (Fulbright). 1995-1996.

Analysis of contaminant data for Fraser River fishes. Fraser River Action Plan. 1995-1996.

Prospects for sustainability in the lower Fraser basin ecosystem. Tri-Council Eco-Research Grant (with 25 other faculty). 1993-1996.

Biophysical controls on salmon migration and production in the North Pacific ocean (with P. Leblond and C. Walters). NSERC Strategic Grant. 1993-1996.

Energetics of upstream migration in Early Stuart sockeye (with Scott Hinch). DFO Subvention Grant. 1991-1995.

## WILLIAM NEILL

Recovery of Pacific giant salamander populations threatened by clear-cut logging. Endangered Species Recovery Fund: World Wildlife Fund Canada. 1996-2001.

Persistence of threatened Pacific giant salamander populations under forest harvesting in the Chilliwack River Valley. Forest Renewal BC Research Grant. 1996-2001.

Pacific giant salamander - Impact and recovery from forestry operations. BC Ministry of Environment. Habitat Conservation Trust Fund. 1994-2001.

Dynamics of zooplankton and phytoplankton in pulsed nutrient regimes. NSERC Research Grant. 1993-2001.

Activity patterns of adult Pacific giant salamanders, *Dicamptodon tenebrosus*, with respect to habitat and season. BC Ministry of Environment, Lands and Parks. 1994-1997.

Distribution of the Pacific giant salamander, *Dicamptodon tenebrosus*, in the Skagit watershed of BC. Skagit Environmental Endowment Committee/BC Ministry of Environment. 1994-1995.

Community structure of woodland streams with special reference to forest age and logging. BC Ministry of Environment: Wildlife Branch. 1993-1994.

## DANIEL PAULY

Modelling the dynamics of mysids in Lake Okanagan. BC Ministry of the Environment. 2000-2001.

The Rivers Inlet ecosystem. David Suzuki Foundation. 1999-2000.

Spatial modelling of marine protected areas in the Hecate Strait. David Suzuki Foundation. 1999-2000.

The Sea Around Us. Analysis of the impact of fisheries on marine ecosystems. Pew Charitable Trusts. 1999-2003.

A mass-balance model of trophic fluxes in Prince William Sound. Exxon Valdez Trust. 1998-2001.

FishBase: a database for fish biodiversity. ICLARM. 1995-2000.

Trophic flows in the oceans. NSERC Research Grant. 1998-2001.

Impact of distant water fleets (with T. Pitcher). World Wildlife Fund International, London. 1998-1999.

## ANNEX 11





FishBase as an electronic encyclopaedia of BC fishes. BC Ministry of Environment. 1995-1996.

International workshop on Modelling North Pacific ecosystems. DFO/UBC. 1995.

Ecosystem and Biodiversity research. UBC/NSERC New Faculty Start-up Grant. 1994-1995.

## TONY PITCHER

Back to the Future in Newfoundland and Hecate Strait: goals and policy for the restoration of aquatic ecosystems and fisheries. Coasts under Stress, SSHRC/NSERC MCRI Grant. 2000-2003.

Spatial modelling of the Hong Kong ecosystem with prediction of the impacts of artificial reefs and marine protected areas in Hong Kong. ERM Hong Kong Ltd. 2000-2001.

International centre for fisheries research, infrastructure of the UBC Fisheries Centre. BC Ministry of Fisheries/ MELP/Watershed Restoration Program. 1993-2001 .

Journal publication support. Blackwell Science (formerly Chapman and Hall, Kluwer Academic). 1993-2001.

Development of a multidisciplinary rapid appraisal technique. Rapfish. FAO, Rome. 1999-2001.

Schooling dynamics and biomass estimation in Atlantic bluefin tuna. New England Aquarium, Boston. 1998-2001.

Shoaling behaviour, ecosystems and the resilience of fisheries: role, diagnostics and management. NSERC Research Grant. 1996-2001.

Multispecies ecosystem modelling workshops. FAO, Rome. 1998-2000.

Just fish: ethics in Canadian fisheries east and west. SSHRC Strategic Grant/UBC Research Development Fund. 1997-2000.

Ecosystem simulation for predicting the impact of artificial reef deployment in Hong Kong. ERM Hong Kong Ltd. 1998-1999.

Impact of distant water fleets (with D. Pauly). World Wildlife Fund International, London. 1998-1999.

Back to the Future in the Strait of Georgia: interdisciplinary input to the model reconstruction of past ecosystems. Peter Wall Institute of Advanced Studies. 1998-1999.

Fisheries assessment in Zanzibar. LGL Ltd., Toronto. 1997-1999.

Schooling dynamics of Atlantic herring in the wild: research cruises on the *G.O. Sars*. Institute of Marine Research, Bergen: in-kind contribution. 1994-1998.

Schooling dynamics of Pacific herring in the wild: research cruises. DFO: in-kind contribution. 1994-1998.

Development of invertebrate fisheries. DFO. 1997-1998.

Assessment of fishery resources in Hong Kong's marine ecosystem. ERM Hong Kong Ltd. 1997-1998.

Ecosystem modelling of the Eastern Scotian Shelf. DFO. 1997-1998.

Assessment of the status of groundfish stocks exploited by the BC trawl fleet. BC Groundfish Research and Conservation Society. 1996-1998.

International workshop on the design and monitoring of marine reserves. COFRI. 1997.

Logical decision analysis among stakeholders in the Skeena watershed. DFO. 1996-1997.

Watershed restoration database project. BC Ministry of Environment. 1995-1996.

Watershed restoration training. MELP. 1995-1996.

A biodiversity server for BC. BC Ministry of Environment. Fisheries Branch. 1995-1996.

Watershed Restoration Program - Monitoring and Evaluation Design Workshop. BC Ministry of Environment. 1994-1995.

Bangladesh fisheries research. French Embassy. 1994-1995.

Common Ground Project. DFO/UBC. 1993-1996.

Salmonid Enhancement Project evaluation workshop. DFO. 1993-1995.

Management of schooling fishes. UBC/NSERC New Faculty start-up grant. 1993-1994.

Fisheries Centre start-up grant. BC Ministry of Advanced Education. 1991-1994.

## RASHID SUMAILA

International workshop on the economics of marine protected areas. Chr. Michelson Institute, Bergen. 2000.



## ANDREW TRITES

Steller sea lion studies. Vancouver Aquarium Marine Science Centre: in-kind contribution. 1996-2001.

Marine mammal research. NSERC Research Grant. 1999-2001.

Steller sea lion studies. North Pacific Marine Science Foundation. 1995-2001.

An investigation of the relationships between marine mammals and oceanographic parameters in BC coastal waters. DFO. 1997-2000.

Boat-whale interaction. Private Donation. 1997-2000.

The causes of the Steller sea lion decline in the North Pacific. North Pacific Marine Science Foundation (NOAA). 1997-2001.

Upgrade of marine mammal information systems. DFO. 1998-1999.

Ecopath ecosystem model of the Eastern Bering Sea. Packard Foundation. 1997.

Reducing the mortality of salmonids by harbour seals on the Puntledge River. DFO. 1996-1997.

Water chiller package for bioenergetic studies of marine mammals and sea birds. North Pacific Marine Science Foundation (NOAA). 1997.

Behavioural studies of Steller sea lion winter and summer haul-out sites in Alaska. North Pacific Marine Science Foundation (NFWF). 1997-1999.

Killer whale-vessel interactions in Robson Bight ecological reserve. BC Parks. 1995-1994.

Pinniped swim mill. Alaska Science and Tech. Foundation equipment grant. 1994-1996.

Population diversity and structure of harbour seals in BC using DNA analysis. DFO/NSERC Science Subvention Program. 1994-1996.

Solving the puzzle of the disappearing sea lions. Partners in Science Awareness Grant. 1995.

Behavioural ecology and diet of Steller sea lions. North Pacific Marine Science Foundation. 1994-1995.

Care of Steller sea lions. North Pacific Marine Science Foundation. 1994-1995.

Bioenergetics of Steller sea lions. North Pacific Marine Science Foundation. 1992-1994.

## CARL WALTERS

Development of Ecosim system modelling software. Sea Around Us project. 1999-2004.

Grand Canyon ecosystem modelling and monitoring. 1996-present.

Stock assessment review and advisory programme. Northern Territory Fisheries Department, Australia. 1994-present.

Design of adaptive management strategies for managing exploited fish populations. NSERC Research Grant. 1993-2001.

Recreational fisheries in BC lakes. 1993-2000.

A strategic plan for Canada's freshwater sport fisheries. NSERC Strategic Grant. 1995-2000.

Cross-scale phenomena. NCE Sustainable Forest Management. 1995-1999.

Kootenay Lake fertilization. Columbia Basin Fish and Wildlife Compensation Program. 1996-1997.

Zooplankton, mysis and kokanee analysis for Kootenay Lake. BC Ministry of Environment. 1993-1997.

Modelling system for evaluating endangered species policies. Forest Renewal BC Research Grant. 1994-1995.

West coast Fisheries: Fish on the Line Review. The David Suzuki Foundation. 1994-1995.

Small lakes modelling. BC Ministry of Environment, Fisheries Branch. 1993-1994.

Estimation of the carrying capacity of the Georgia Strait for chinook and coho salmon using bio-energetic models. DFO/NSERC Joint Science Subvention Program. 1993-1994.

Model of Lake Kariba. ODA Species Changes in African Lakes Project. 1993.

# ANNEX 11





# ABBREVIATIONS

**CFI**

Canada Foundation for Innovation

**CSIRO**

Commonwealth Scientific and Industrial Research Organisation

**DANIDA**

Danish International Development

**DFO**

Department of Fisheries and Oceans Canada

**FAO**

Food and Agriculture Organization of the United Nations

**FNHL**

First Nations House of Learning (UBC)

**IARE**

Institute of Animal Resource Ecology

**IATTC**

Inter-American Tropical Tuna Commission

**ICLARM**

International Center for Living Aquatic Resources Management

**IPOST**

Institute of Pacific Ocean Science and Technology

**IRE**

Institute for Resources and Environment

**KDF**

Knowledge Development Fund, British Columbia Government

**MCRI**

Major Collaborative Research Initiative

**MMRU**

Marine Mammal Research Unit

**NMML**

National Marine Mammal Laboratory (US)

**NOAA**

National Oceanic and Atmospheric Administration (US)

**NPUMMRC**

North Pacific Universities Marine Mammal Research Consortium

**NSERC**

Natural Science and Engineering Research Council (Canada)

**RMES**

Resource Management and Environmental Studies

**SCARP**

School of Community and Regional Planning

**SDRI**

Sustainable Development Research Institute

**SSHRC**

Social Science and Humanities Research Council (Canada)

**UFAWU**

United Fishermen and Allied Workers' Union

**WWF**

World Wildlife Fund for Nature

## ANNEX 12







*BACK COVER (CLOCKWISE FROM TOP LEFT):*

*Diverse set of fish for sale in an Indonesian market.*

*Steller sea lion rookery.*

*Coho salmon (Oncorhynchus kisutch), a fishery that has collapsed in British Columbia.*

*Artisanal fishing vessel with attached Rumpon (fish attraction devices) in Ambon, Indonesia.*

*Jaring lempar, or cast net, is a common artisinal gear in most inshore waters in western Indonesia, in particular in shallow inshore waters, such as river estuaries.*

*Yellow tail rockfish (Sebastes flavidus) off the north-east coast of Vancouver Island, a species that has been lost in some areas of British Columbia.*

*Fisheries Centre students being given a tour of the Steveston commercial fishing harbour by the United Fishermen and Allied Workers' Union.*

*Moored in Darwin is Australia's northern prawn trawler fleet, one of Australia's largest commercial fisheries.*

