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Decision Making by Commercial Fishermen

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Decision Making by Commercial Fishermen

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DIRECTOR'S FOREWORD

Academic fishery researchers, fisheries graduate students, government fishery scientists, fisheries consultants, and a large contingent of commercial fishermen gathered at the UBC Fisheries Centre from November 25th and 26th, 1994, in order to discuss the impact of decision making by commercial fisherman on fisheries management. Participants came from British Columbia, Washington and Alaska. The workshop was organised by Dr Paul Hart, from Leicester University, United Kingdom, while he was on sabbatical leave at the UBC Fisheries Centre. This workshop is designed to focus on the impact of commercial fishermen's decisions about how and when to fish and to set out the basis of a greater understanding of this key area.

Decision making by commercial fishermen constitutes the second of a series of open workshops sponsored by the new UBC Fisheries Centre. The workshop series aims to focus on broad multidisciplinary problems in fisheries management, provides an synoptic overview of the foundations and themes of current research, and attempts to identify profitable ways forward. Edited reports of the workshops are published in *Fisheries Centre Research Reports* and are distributed to all participants and to selected international fisheries libraries. Further copies are available on request.

Fishery management has failed conspicuously to halt or reverse the depletion of fish stocks world-wide. This is a paradox, given the sophisticated nature of modern fishery mathematics that can explicitly take account of risk and uncertainty in fishery data and forecasts.

What factors have brought about this failure of fishery management? Inappropriate ecological models and poor use of data may be a technical cause, but a more fundamental problem is that fishermen's interests are not explicitly included in the evaluation of responses to new policies. There has been a general failure to acknowledge that fishers take decisions based on their assessment of likely rewards. An extreme example is that fishermen may decide to act illegally if risk of detection is small.

Decisions taken on a short, medium and long time-horizons can impact the fish resource in different ways. Many immediate economic pressures force fishermen to take a short-term view of stock depletion. In contrast, fishery scientists are traditionally trained to take the long-term of view of steady-state sustainable yields. Evidently, these two different perspectives are fated to be on a collision course.

Commercial fisheries are often constrained by a legal framework or by regulations that are not congruent with the fisherman's perception of the world. Not only have fishermen rarely been consulted about their views of the balance between conservation and catches, but their legitimate concerns are generally treated dismissively. Furthermore, fishermen may have a detailed and accurate knowledge of the current status of the resource that forms their livelihood, but this knowledge has seldom been used in forming assessments. I hope that this report will contribute to our insight of this field.

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

ORGANIZER'S INTRODUCTION

Each person at this workshop will come with a different perspective on decision making by fishermen. My view has dictated how the programme was defined. This short introduction is designed to make my approach clear. Alternative views will emerge as the discussion proceeds.

The least emotive way to explain my perspective is through an example unrelated to fishing. I am a car and a bicycle owner. Each day as I leave the house for work, I have a choice; should I travel by car or by bicycle? The decision I make is determined (not necessarily consciously) by weighing up and comparing the costs and benefits of driving the car and of cycling. If I take the car it might be quicker. It will keep me warm and dry and it is less effort. The journey will cost me something, the main immediate cost being gas and wear and tear on the car. Travelling by bike will have egligible monetary cost, but will entail physical exertion and I might get cold or wet. The bicycle will have the benefit of taking me directly to the door and will provide some exercises. How these two alternatives are judged would be affected also by my age and state of health; if I'm old and overweight the cost-benefit analysis would be looked at differently than if I am 25 and in training for the marathon.

What has been described so far are the immediate costs and befits of driving the car and of cycling. It is these that determine the course of individual action. You are all aware that there are other costs and benefits of the two modes of transport that could be detailed. For every tank of gas used by a car, three times the weight of carbon dioxide is produced. Obtaining the gas to fuel the car has entailed environmental degradation in some far off place which might have a multitude of knock on effects (Exxon Valdez and so on). At a more personal level, years of driving instead of cycling, coupled with a chronic inability to resist just one more helping of that delicious desert, will result in an overweight and unfit body that copes less well with the ravages of old age. If you had chosen cycling as a long term alternative, then advancing years will bring arthritic knees and wrists although these might be outweighed by a better level of cardiovascular fitness more able to cope with advancing age.

Most of us decide by evaluating short term costs and benefits, yet our actions carry hidden costs and benefits which only become apparent after a longer span of time. Smog in large cities has increased with increasing car use. Given that a causal link between car use and smog has been established, how can individual behaviour be influenced to reduce the atmospheric degradation? In Santiago, Chile, smitten by smog, an effort was made to reduce traffic by decreeing that private cars with a registration number ending in an even number would drive on alternate days, and those with an odd last number would use the days in between. For those who can afford it, this restriction is no problem, just buy two cars, one with an even last number and one with an odd last number. To guarantee a reduction in traffic, and to remove the chance for cheating, the authorities would have to introduce regulations that change immediate costs and benefits of using the car. Paying a hefty toll as soon as you join the road might be one (impossible to enforce) possibility.

Decision making by fishermen is no different from decision making by the traveller; short term costs and benefits determine actions that have long term results. Fishery managers see the long term effects (as do the fishermen of course) and, like the Santiago city council, introduce regulations that do not change the short term costs and benefits of fishing. The fishermen, driven by the need to earn his bread and to service the loan on his boat, will be forced to devalue the future in favour of the present. When regulations interfere with that process, in the way in which the car regulations in Santiago attempted to stop people using their cars on alternate days, the fishermen will be forced to find ways of getting round the regulations. Fishermen from Scotland catching haddock in the North Sea have been forced to continue catching fish after they have filled their quotas and sell the catch in secret at sea. If they didn't continue fishing, they would face financial ruin.

This workshop provides an opportunity to go someway towards identifying the immediate costs and benefits that determine the decisions fishermen make. We also need to establish the goals the fisherman have in mind when he evaluates costs and benefits. Is the only goal the maximization of profit or is the goal complicated by less definable factors such as relishing life at sea, enjoying the freedom of being your own boss and many other subjective factors that are hard to quantify.

My concluding point relates to how the information we need is to be obtained. The temptation is to assume that interviewing fishermen will give us all the answers. Interviews will provide insights into how the fishermen perceive their activities, but they cannot give the whole answer. Fishermen are not all-knowing and all-seeing. Each captain sees the world from his bridge alone and cannot know where all the other boats are and how the fish are distributed in space and time. Surveys by third parties can fill these gaps. In addition, interviews do not give the whole picture because no human being is ever entirely clear about why they do what they do. We get good at creating hypotheses (stories) to justify what we do, but how often do we test these hypotheses? An outside observer can create hypotheses about decision making and then test them with experiment or further observation.

Fishermen, governments and the general public hope for good resource management. A critical task is identifying what managers should manipulate in a fishery to achieve the good management. I hope this workshop will contribute towards identifying goals and costs or benefits that can be manipulated in a way that achieves sustainability and keeps fishermen employed.

Paul J.B. Hart
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Possible Decisions

At sea

- Leave port or not?
- Which area to head for?
- Set net or continue searching/steaming?
- Haul net or leave in?
- Keep undersized fish or discard?
- Set net in same area or move?
- Is quota caught?
- Should excess fish be kept and sold at sea?
- Is hold full?
- Which port should fish be landed in?

On land

- Should I buy another vessel?
- Do I need a more advanced sonar?
- Would a more powerful engine be useful?
- Is my net big enough?

SUMMARY OF THE DISCUSSION SESSIONS DURING THE WORKSHOP ON 'DECISION MAKING BY COMMERCIAL FISHERMEN'

Paul J.B. Hart, Department of Zoology, University of Leicester, University Road, Leicester LE1 7RH, U.K.

At the start of the introductory session, Paul Hart outlined his view of decision making. During this session the idea was to list the decisions that fishermen take. Fishermen are concentrating on short term decisions whilst managers have the long term view. The two approaches do not agree on goals (decision criteria/currency). A session by Martin Esseen, who had been invited to attend but could not come, had planned to talk about the moment to moment decisions that commercial fishermen take.

The central idea behind the workshop was that a better understanding of the decisions fishermen take would improve the chances of managers designing control methods that would be less open to circumvention by the fishermen. The topic was clearly discussed as long ago as 1979 by Wilen (1979, *J Fish Res Bd Canada*, 36: 855-858). He pointed out that simple models of exploited populations assume that the system is a single input (effort) single output (fish) system. Wilen corrects this view, pointing out that effort is a multidimensional concept. If managers want to devise successful control measures, they need to be able to predict the outcome of proposed controls. The problems with this are threefold and are

1. Is it necessarily true that a multiple input fishery will use too much of all dimensions of effort, or just some?

2. If one component of effort is regulated, how will fishermen combine all other dimensions? Will the industry simply dissipate rents by expanding these other components?

3. What sorts of policies are likely to be the most effective in regulating fisheries where production techniques are highly flexible?

Wilen goes on to say that 'For the most part, these questions have not been satisfactorily addressed in any literature yet. Crucial to answering these questions is the nature of the individual fishermen's behaviour, i.e. what motivates his choice of input configurations when he builds a new vessel or modifies an existing one'.

The fishermen at the workshop disagreed with Paul Hart's analysis and argued that fishermen are intensely interested in the long term perspective. They want to remain in fishing and they want their sons to follow on. Later, they did concede that once they have begun to fish, they became highly competitive and were out to catch as big a share as possible of the available fish. It was evident from this discussion that to the owner-operators present, the long term view did concern them. However, the current management and fishing structures makes it hard for them to give voice to their thoughts. When discussing with management, the fishermen have to extract as much fish as possible. When fishing, the fishermen have to grab as much as they can because if one individual doesn't get the fish someone else will.

The three main layers of decision making that influence a fishery are depicted in Figure 1. The original programme was to have concentrated on the lower level, but the discussion dwelt mostly on the second. Most of the prepared talks provided examples of how decision making by fishermen could be studied and accounted for.

It became evident during the course of this discussion that management councils should be devised which encourage cooperation between the separate factions. There is a need for people in the management process to realise that if they cheat they will be disadvantaged. There is a need for long term personal relationships between managers and fishermen to make cooperation more likely. The concentration of managers into large impersonal institutions ,makes it unlikely that such personal interactions can occur. (Wilen (1979) mentions the Prisoner's Dilemma model as a useful way of thinking about the evolution of cooperation between fishermen competing for access to the resource on the fishing grounds). Although we did not consider possible structures that would achieve cooperative behaviour, the subject seems one well worth developing. Of course groups with continuous membership of the same people, could lead to a cosy partitioning of the resource without recognising the long term consequences of the actions taken. A mechanism would be required to keep group members aware of their goal, perhaps by a separation of powers. A management council would propose measures that would then be acted upon by a management executive. Each would have some sort of veto right over the actions of the other.

Software that might facilitate agreement was described by Scott Akenhead. He outlined the process that is usually used in management as one lacking a vital dimension, the view of the different stakeholders. Without this dimension, the decision making process might consider a number of hypotheses about how the fishery was behaving. Each hypothesis would have a number of indices that would measure the desirability of the hypothesis. However, what is necessary is to realise that each stakeholder will evaluate differently, the significance of each index so making it very difficult for a group to come to an agreement. The essential group structure is to have all stakeholders together in the discussions so that each may see the complete picture. This is preferred to present structures where interested parties usually meet in pairs, so always leaving other stakeholders out and giving them a chance to feel that agreements are being made behind their backs. Akenhead demonstrated software that makes it possible for a group of stakeholders to examine as they talk, the implications of each of their proposals.

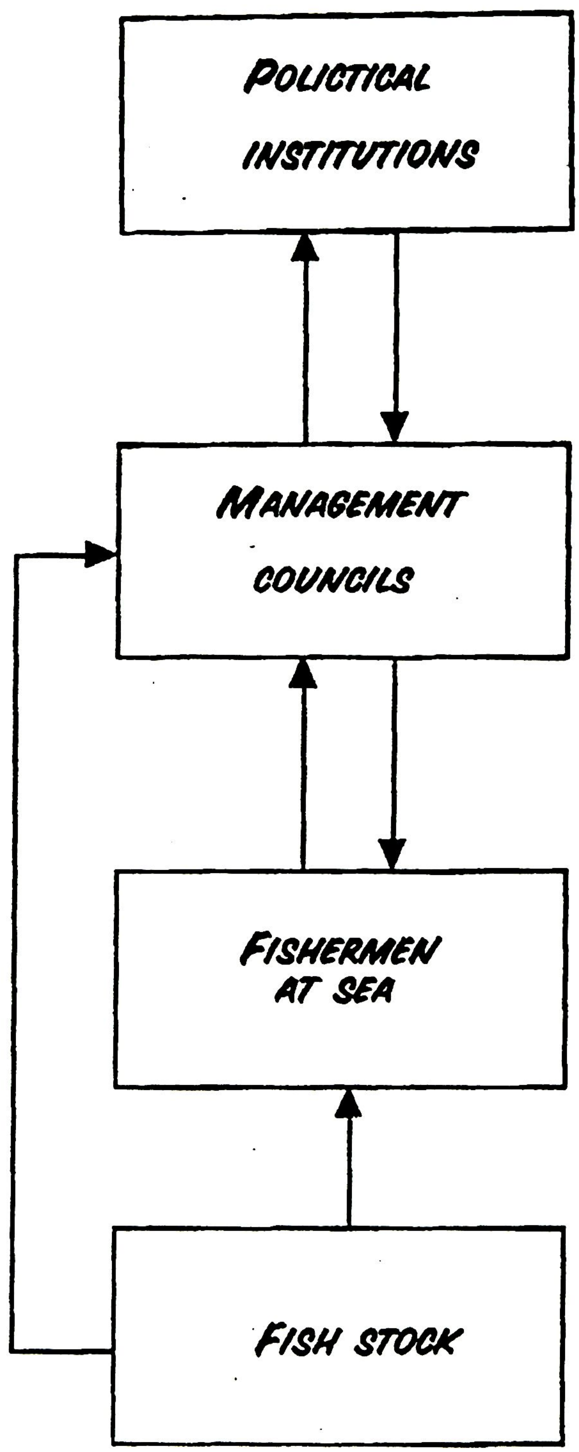
There was discussion after John Sproule's talk about the use of log books. The wider significance related to the need for information in the management process. Good information is essential if managers and fishermen are to make the best use of a fish resource.

Later comments showed that fishermen also rely heavily on information to decide where to go when they leave port. They speak with others on the radio and then decide where to go on the basis of which fishermen are where. They use their knowledge of the skill of other fishermen to judge what to do. These comments were not expanded and were made at the very end of the workshop during Paul Hart's summing up.

The discussion was extensive and the present summary has only been able to select the main points to mention. It must be said that the workshop concentrated on management decisions rather than the decisions of fishermen whilst at sea. This sidelined the main thrust of the talks which concentrated on the intended theme. This occurred because of the personal interests of the commercial fishermen who attended and who were clearly concerned to better arrive at a better system for catch allocation and for setting quotas.

It became clear early on that commercial fishermen are not much interested in their own decision making. There is still much room for research in this. More data is required on fishermen's decisions and it is essential that the fishermen and managers are persuaded that the topic of this workshop can contribute significantly to better management practices.

LEVELS OF DECISION MAKING IN FISHERIES



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CONTRIBUTED PAPERS

CATCHING HORSE MACKEREL OFF CHILE: THE INFLUENCE OF SCHOOL BEHAVIOUR AND OTHER FISHERMEN

Paul J.B. Hart, Department of Zoology, University of Leicester, University Road, Leicester LE1 7RH, U.K.

The horse mackerel (*Trachurus murphyi*) fishery off the south central region of Chile takes about 2 to 3 million tons a year. Most of the catch is reduced to meal with only a few percent being canned or processed to surimi. The fishery is carried out by large purse seiners the biggest of which can take up to 60,000 tons a year. In the winter the fishery takes place at night whilst fish are caught during the day in summer. Late autumn to early winter (February - June) is the peak period for catches.

During 11 voyages on two purse-seiners in March and April, the size of catch and time spent searching per vessel was related to the behaviour of the jack mackerel schools. Radar data were used to define groups of fishing vessels and to follow their movements over time. Most of the fleet fished either within or around other vessels only leaving to return to port to off load their catch. Groups broke up during the day but often reformed at night.

Groups moved offshore at a mean speed of 2 nautical miles per hour. Groups lasting up to three nights meandered away from the coast, the fleet possibly following fish that are feeding on productive zones caused by upwelling. Time spent at sea by purse-seiners was employed either **cruising** or **searching**. Cruising ships travelled in a straight line and cruising was associated with deeper (65m on average) and larger schools. When schools became more numerous and shallow, skippers began searching, during which they slowed down and changed course frequently (see Figure 1). Searching tended to be more persistent outside fishing groups. A search could end with either a set of the net or none. The net was set when schools were at a mean of 37m deep compared with 56m when no set was made. Abandoned search was more likely outside a fishing group and in groups with few vessels. Setting the net and hauling it again had a high opportunity cost absorbing on average 1.8h.

During the search period, and before the net was set, the jack mackerel schools tended to coalesce and move deeper in the water column. Some sets failed to catch fish and this usually occurred when the schools were deeper than during a successful set. Unsuccessful sets were also associated with larger groups of fish. Catch per unit search time was highest in the centre of a fishing group where searching was less. The highest amount of time spent searching was in the inner margin of the group. Searching then fell away as vessels moved away from the core of the collection of vessels. Decision points in the fishing cycle are shown in the Figure.

The grouping behaviour of fishing vessels is possibly a response to the highly unpredictable occurrence of fish schools. Individual searching of areas of possible upwelling, where fish are most likely to be found, is thought to be unproductive. If a searched area has no fish then steaming time to the next potential fishing area could be long and expensive. The quickest and surest way to find fishable aggregations is to locate other ships. Fishing in groups incurs a cost of interference, but this is outweighed by the benefit of finding fish quickly.

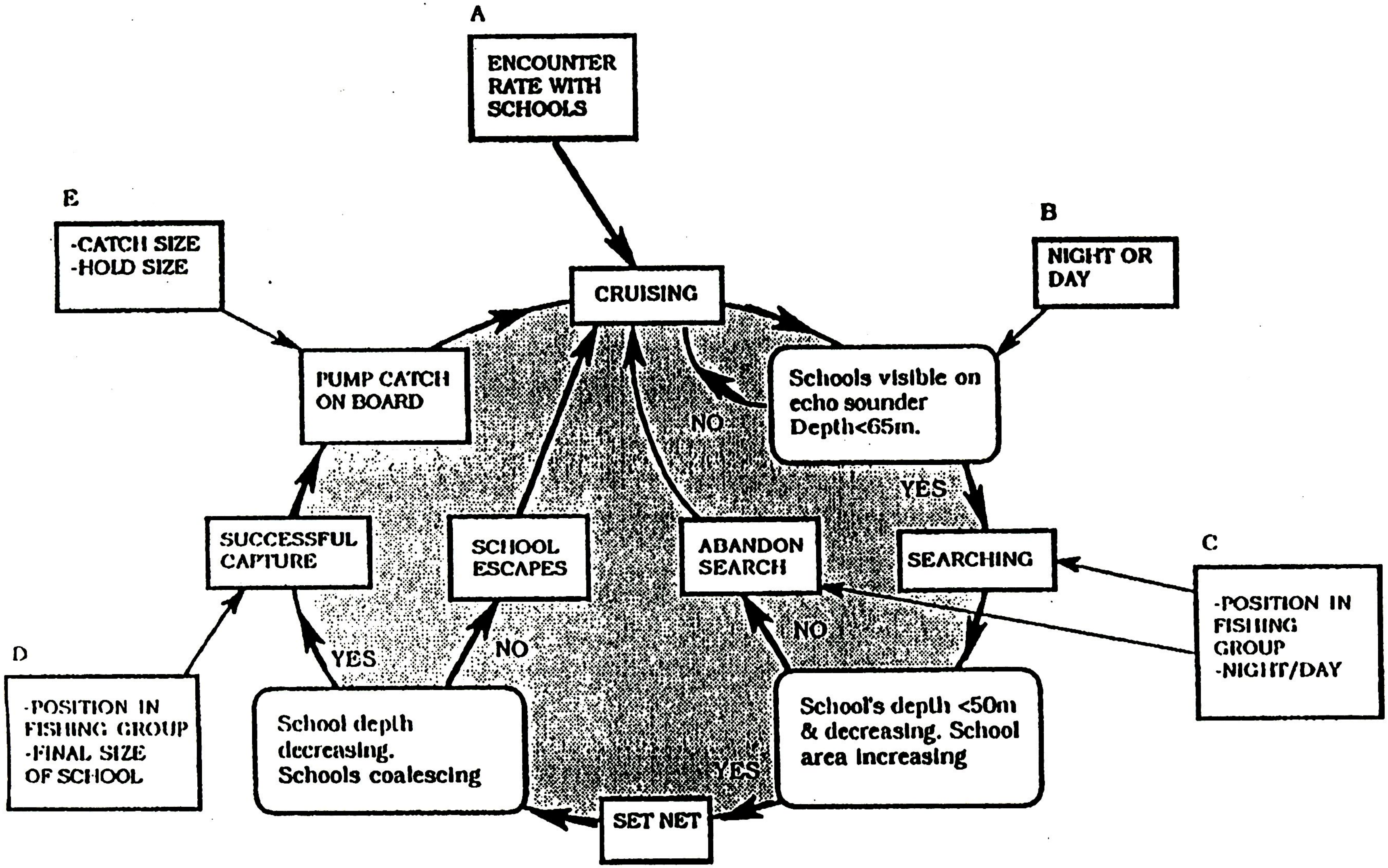

Figure 1. The cycle of decisions and activities during purse-seining with an indication of the factors that later the decisions that skippers make. The values of variables such as school depth have been derived from this study.

THE OCEAN, THE FISH, AND THE FISHERMEN: OBSERVATIONS ON THE SALMON TROLL FISHERY OFF THE WEST COAST OF VANCOUVER ISLAND

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The ocean over the continental shelf off the west coast of Vancouver Island is characterized in summer by a complex interaction of directional currents and wind driven upwelling. The predominantly NW winds during summer push surface waters south along the outer continental shelf to create a southward flowing shelf break current. Over the inner continental shelf surface waters flow north driven by the buoyancy of low salinity water flowing out of Juan de Fuca Strait and Vancouver Island inlets. Upwelling occurs in the turbulent zone between these two currents. West of the entrance of Juan de Fuca Strait is an upwelling gyre (the Juan de Fuca eddy). The continental shelf bathymetry north of Barkley Sound is fairly simple with depth contours parallel to the coast. From Barkley Sound south, however, the bathymetry is convoluted with complex banks and depressions. In this region currents over the continental shelf are weaker and less directional than further north.

This oceanic region is an important nursery area for chinook and coho salmon and a migratory route for sockeye, chum, and pink salmon returning to the Fraser River and Vancouver Island streams. It is one of the richest salmon fishing areas in North America. The predominant fishery is a mobile hook and line (or "troll") fishery of 800-1000 vessels that harvests all five species of Pacific salmon in varying numbers but with coho, chinook and sockeye being the most important species.

The salmon have a patchy distribution in both time and space. Spatial patchiness, we believe, reflects the topography and oceanography of the continental shelf. Chinook tend to be concentrated in the region from Barkley Sound south with particular concentrations associated with the 100 m depth contour at several specific locations on the shelf. For example, Swiftsure Bank is a location where we frequently encountered high density of chinook. We do not know what causes these concentrations of chinook salmon. We speculated that they are associated with concentrations of their food. The association with bottom topography may reflect the tendency to reside nearer the bottom than other species. Coho tend to be concentrated in the turbulence mixing zone between the coastal and the outer continental shelf currents. Again we believe that coho are responding to ocean circulation events that concentrate their food organisms near the surface. We were able to examine one concentration of coho in detail and found that it was associated with a localized upwelling within the turbulent mixing zone. Sockeye and pink salmon also appear to use the interface between the coastal and outer shelf currents as a migration corridor, but we know less about their behaviour.

Temporal patchiness reflects primarily life stage dependent migrations of the species. Chinook and coho are present off the west coast of Vancouver Island throughout the year. Sockeye, pink and chum are present primarily during the summer and autumn, while on their return migration from the open ocean to spawning rivers along the coast.

Fishermen respond to the patchy distribution of salmon by adopting different distributions seasonally. Historically, during April through June when only chinook salmon were open for harvest, the fleet was concentrated in the area from Barkley Sound south with dense patches of vessels on the 100 m depth contour. From July until September the fleet was concentrated along the zone between the coastal current and the outer shelf current. Most of the fishermen have formed into loose information sharing coalitions consisting of up to 20 vessels. Information on where salmon are located is disseminated among all fishermen very quickly and they are able to respond rapidly to any change in fish distribution. As a consequence, the average catch rate of individual vessels is not related to the density of vessels in any particular location. The fishermen, as predators of salmon, appear to conform to the ideal free distribution model of predator-prey interactions.

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FISHING TACTICS IN A TWO SPECIES FISHERIES MODEL

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ABSTRACT

The selections for fishing location largely determine the species mix and value of a fisherman's catch. Because of travel costs, these choices also determine the profitability of a fishing trip. This study develops a simple theoretical model for the selection of fishing locations by a fisherman faced with two co-occurring species whose density varies with distance from port. The fisherman is constrained by a fixed trip length, and the species can have different catchability coefficients, handling times, and prices. The model is used to determine the profit-maximizing fishing tactics (the fishing locations and time spent at each location), and, when one of the species cannot be sold because of price or trip limits, to explore theconditions that generate deliberate bycatch and discarding.

INTRODUCTION

Fisheries scientists spend considerable time and money studying fish, and very little time studying fishermen. And yet in fisheries management it is the fishermen that are regulated, the fish stocks are affected indirectly, if at all. If management policies are to be effective, then managers must be able to anticipate how fishermen will respond to regulations. In the short run, the primary response available to fishermen is their choice of fishing location. In choosing where to fish a skipper considers not only the catch that he is likely to make at different fishing spots, but also the costs that arise from fishing there. In this study I have two objectives: (1) to develop a general modeling framework for examining the behavior of fishermen, and (2) to analyze the specific contention that the discard problem in the trawl fisheries in the Pacific Northwest is due to the restrictive trips limits under which the fishermen must operate.

Trip limits are a management device used by the Pacific Fishery Management Council to slow the pace of certain fisheries along the U.S. Pacific coast and thereby extend the fishing season through the entire year (Pacific Fishery Management Council 1993). When a boat makes a tow that causes its cumulative catch to exceed the trip limit, then the excess fish must be discarded. Fishermen claim that trip limits are wasteful and result in significant amounts of discarded fish. For example, an empirical study by Pikitch et al. (1988) estimated that about 16% of the catch of widow rockfish was discarded at sea.

A MODEL FOR FISHING LOCATION CHOICE

For simplicity in this exercise I collapse space to a single dimension, distance from port (d), and consider the actions of a fishing vessel operating exclusively from this port. Assume that there are two species of fish, A and B, whose biomass densities are normally distributed with distance from port. The equation describing the density of species A at location d is given by

$$(1)\quad D_A = \frac{Biomass_A}{\sigma_A * \sqrt{(2*\pi)}} * \exp[\frac{-(d-\mu_A)^2}{2*\sigma_A^2}]$$

The parameter $Biomass_A$ is the total stock biomass of species A, parameter μ_A controls the location of the peak biomass density of A, and σ_A controls whether A is widely or narrowly spread. A similar equation describes the density of species B.

While a boat is fishing, catches are assumed to accumulate in proportion to the fish densities (D_A and D_B) and the time spent deploying the gear (tF). Because the fish densities vary with d, the distance from port, the catches also depend on d. The equations describing the catches (C) of species A and B are given by

$$(2)\quad C_A = q_A * D_A * tF$$

and

$$C_B = q_B * D_B * tF$$

The parameters q_A and q_B are the "catchability coefficients" for species A and B. They measure the fishing power of the fishing vessel and gear for A and B. When the fish densities are both unity, q_A and q_B determine the catch per hour of A and B.

Assume that each fish caught requires time for handling and processing and that no further catching can occur while the fish are being handled. The amount of time required for handling and processing (tH) varies with the size of the catch and is given by

$$(3)\quad tH = h_A * C_A + h_B * C_B$$

Parameters h_A and h_B control how much time the fishermen must spend handling and processing unit quantities of A and B.

The flow of gross revenue to the skipper is given by

$$(4)\quad R = (1-S) * (p_A * C_A + p_B * C_B)$$

where S is the fraction of the landed catch that the crew receive as their share, and p_A and p_B are the unit prices for A and B. When catches are large and trip limits are binding, then the gross revenue flow is restricted to the value of the trip limits.

The total duration of a fishing trip (T) is assumed to be fixed. It is comprised of time spent steaming to and from the grounds (tS), time spent searching for fish and working the gear (tF), and time spent handling the catch (tH);

$$(5)\quad T = tS + tF + tH$$

The steaming time is determined by the fishing location (d) and the vessel's speed (V),

$$(6)\quad tS = 2*d \,/\, V$$

The time available for fishing is completely determined by the fishing location,

$$tF=T-tS-tH,$$

$$(7)\quad tF=\frac{T-2*d/V}{1+h_A*q_A*D_A+h_B*q_B*D_B}$$

The skipper's choice of where to fish determines the steaming time and the catch rates, which in turn fix the time for fishing and handling. The skipper's gross revenue flow (eq.4) can now be written as a function of d.

To determine what fishing location results in the maximum profit flow requires one to know how costs vary with fishing location. During a fishing trip costs (K) accrue for fuel (kE), labor (kL), and other miscellaneous (kM) cash expenditures,

$$K=kE+kL+kM$$

$$(8)\quad K=pE*(uS*tS+uF*tF+uH*tH)+W*T$$

pE is the unit price for fuel, and uS, uF, and uH are the rates of fuel use while steaming, fishing, and handling; W is the wage rate (if any) for the crew plus some minimum wage that the skipper requires as compensation for his services. These operating costs do not include any "fixed costs", costs which accrue even if the vessel remains at the dock, such as insurance, license fees, and interest payments. For simplicity assume that uH =0. The skipper's cost flow (eq.8) can now been written as a function of d.

Given values for the parameters and the assumption that fishermen operate to maximize their profits, this model can be used to explore how a fisherman's choice of fishing location varies with changes in the characteristics of the fishery, such as the separation between species A and B, the technical characteristics of the vessel and gear, or the management regulations.

AN EXTENSION TO THE MODEL

The model above assumed that the skipper selects only one fishing location during a trip. However, when trip limits apply, the best fishing strategy might be to fish at more than one location; e.g., fish at one site to catch the limit of species A and then fish elsewhere and finish the trip with catches of species B. One can use the following approach to investigate whether fishing at two locations could produce greater profits than fishing at the best single location.

Let d_1 denote the first fishing location and let tF_1 denote the time spent fishing there. Because the total trip duration is fixed, feasible locations for a second fishing site (d_2) and the time available for fishing there (tF_2) are limited by the skipper's choice for d_1 and tF_1. Sites closer to port than the first are always feasible because they require no additional steaming time beyond what was required to reach the first site. However, sites that are further from port require additional steaming time; d_2 must therefore satisfy the following constraint,

If the second site is feasible, then the time

$$(9)\quad 2*(d_2-d_1)/V < T-(2*d/V+tF_1+tH_1)$$

available for fishing there is given by

$$(10)\quad tF_2=T-tS-tF_1-tHU_1-tH_2$$

The skipper's revenue and cost flows can be written as functions of d_1, tF_1, and d_2. Give the skipper's choice for d_1 and tF_1, it is possible to determine the choice for d_2 that will result in the largest profit flow per trip.

SOME RESULTS

The figure illustrates results from the model for a situation in which the two species are almost completely coincident. In this case it is impossible to catch species A without also catching some of B. The results shown are for the simpler model in which fishing occurs at only one site during a trip. The middle panel on the left shows how revenues per trip (the solid line) and costs per trip (the dashed line) vary with distance from port (on the horizontal axis). The vertical dotted line represents the optimum distance from port, the location that produces the maximum flow of profits. The lower panel on the left depicts the catches per trip resulting at each location. The catch of A is represented by the solid line and the catch of B is represented by the dashed line. At the optimum fishing location the catch is comprised of a mix of A and B. For the panels on the left the trip limits are sufficiently large that the catches never exceed the limits.

For the two panels on the right there is a binding trip limit on the landings of species A. This trip limit has no effect on the catches of A and B at any given location (compare the two lower panels), but the catch of species A that exceeds the trip limit must be discarded at sea. As a consequence, the revenue curve becomes distorted and the optimum fishing location shifts slightly further from port, as shown in the middle panel.

In the example shown in the figure fishing at the optimum location yields a substantial catch of species A of which about 40% is discarded because of the trip limit. When there is greater separation between the two species, however, the same trip limit can have a very different effect. In this case the trip limit can make it unprofitable to fish on species A, with the result that fishing occurs where A is absent and fishing results in little or no discarding.

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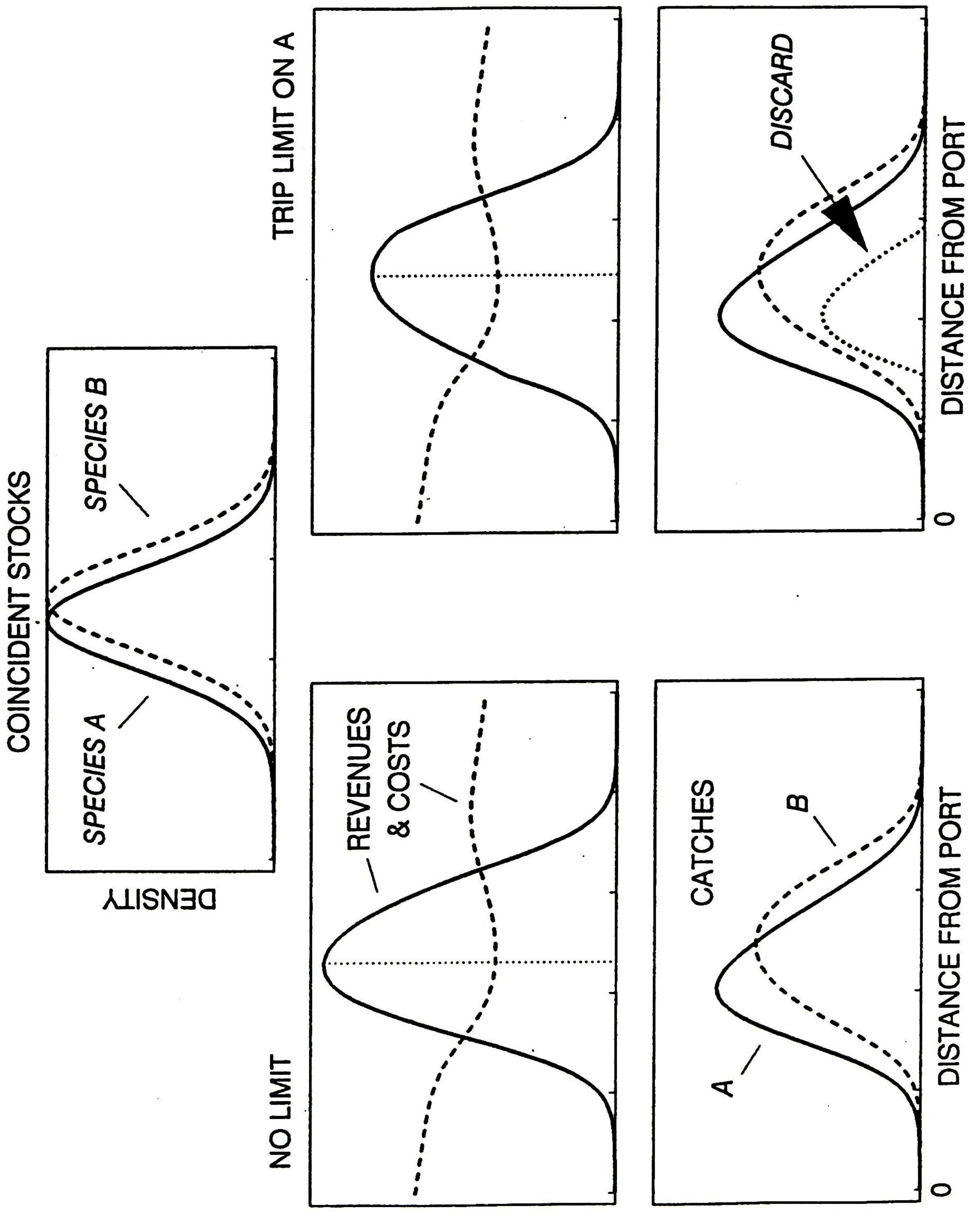
COINCIDENT STOCKS
SPECIES A
SPECIES B
DENSITY
NO LIMIT
REVENUES
& COSTS
CATCHES
A
B
0
DISTANCE FROM PORT
TRIP LIMIT ON A
DISCARD
0
DISTANCE FROM PORT

DECISION MAKING BY B.C. COMMERCIAL SALMON FISHERMEN

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Twenty five years ago B.C. salmon fishermen thought government rules and regulations interfered with their freedom to make decisions. Compared to today the interference was minimal. Net fisheries lasted seven or eight months a year with two to four days of fishing per week. The troll season was open for more than 200 days. There were no catch quotas, fishermen could use troll, seine or gillnet gear if they wished, and could retain whatever species and bycatch that came aboard. Recreational and aboriginal fisheries had minimal impact on commercial fisheries management. Consequently fishermen had a multitude of choices to make on when they fished, where they fished, how they fished, and what they fished for. They had lots of decisions to make.

In the 1990's it is a different story. Fisheries management has become extremely complex with a multitude of different objectives that often seem incompatible, and the government is making many of the decisions that fishermen used to.

a) Conservation is the first priority of the Department of Fisheries and Oceans (DFO). It always has been, but there were far fewer conservation problems in the past and consequently less restrictions on fishermen. Recent concerns for weak stocks has resulted in area closures, catch quotas, and much less fishing time.

b) Aboriginal fisheries obligations are the second highest priority. In 1992 the Government of Canada announced a seven year Aboriginal Fisheries Strategy. This plan makes it very clear that aboriginal needs come first and that commercial troll, gillnet, and seine fisheries shall be curtailed if necessary to deliver aboriginal allocations.

c) Pacific Salmon Treaty obligations are the third priority. This treaty between Canada and the United States was signed in 1985 to address a number of conservation and equity issues. It has provided significant benefits to Canada from increased catches of Fraser River sockeye, but it has resulted in further restrictions for commercial fishermen as conservation and allocation commitments are addressed. For example, the treaty resulted in chinook and coho catch ceilings for the troll fleet on the West Coast of Vancouver Island, and time and area restrictions are used to limit the catch.

d) Further down the priority list is allocation between recreational and commercial fishermen, and allocation within the commercial sector between trollers, gillnetters, and seiners.

In 1969, to address the problem of "too many boats chasing too few fish" the government introduced licence limitation to the salmon fleet. This reduced the number of boats but it did nothing to reduce the catching power of the fleet. In the 1970's when fishing was very profitable, money was reinvested in bigger and better boats, the seine fleet was allowed to grow by converting troll and gillnet licences to seine licences (TABLE I), and the overall result was a modern fleet of salmon vessels that catches more fish in far less time than the larger pre-1969 fleet.

Previous stability in catch shares between troll, gillnet and seine fleets collapsed, as seine and troll catches went up at the expense of the gillnetters. Gillnetters demanded a fair share of the catch and eventually in 1985 the commercial sector made its first agreements on allocation between the three gear types. DFO is tasked with delivering these allocations and in doing so has put further restrictions on fishermen in order to meet these goals.

Today's highly efficient fleets harvest all of the salmon allocated to them in less than half the time of the past. The troll season is from July 1 to mid or late September. Seine fisheries often don't start until mid July or later and may be finished by the end of September or early October. This highly efficient fleet some years gets to fish for 10 weeks or less. Fishing areas have been reduced and gear restrictions implemented to reduce fleet efficiency.

Fishermen who used to be able to keep everything they caught are prohibited from retaining species other than salmon unless they have bought expensive additional licences e.g. halibut. They also have catch limitations on all five species of salmon as a result of conservation concerns and Pacific Salmon Treaty and domestic allocations.

Naturally fishermen have not liked most of the changes and the effect on their livelihoods and way of life. In response to the objections and concerns of fishermen and fish processors, DFO has over the years developed an extensive advisory process to get input from the industry into fishing plans (TABLE II). In general although there are many positive results from the advisory process, fishermen have not had as much influence as they expected on the conduct of their fisheries. For example most would like their fishing season to start earlier than it does, but DFO invariably rejects such advice because it would affect some other user group's allocation even if there are no conservation concerns.

Commercial fishermen have an opportunity, through the advisory process to provide advice on fishing plans, but because their advice seldom takes into account the needs and goals of other gear types and user groups DFO frequently can't accept it. The result is a lot of disgruntled fishermen. In order for them to have more decision-making power for their fisheries, there has to be a process that brings user groups together so that everyones needs and objectives are understood and addressed together.

TABLE I: Number of seines and troll/gillnet licenses in 1968 and 1993.

	SEINE	TROLL/GILLNET	TOTAL
1968 fleet size	369	5737	6106
1993 fleet size	533	3850	4383

TABLE II: DFO Advisory committees

ADVISORY COMMITTEES

Commercial Fishing Industry Council

Queen Charlotte Advisory Board

North Coast Advisory Board

Central Coast Advisory Board

Outside Troll Advisory Committee

South Coast Advisory Committee

Inside Troll Advisory Committee

Fraser River Advisory Committee

FISHERMEN'S BEHAVIOUR IN RESPONSE TO MANAGEMENT: A CASE STUDY OF HAWAII'S LOBSTER FISHERY

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During the early 1980's, Hawaii's commercial lobster trap fishery experienced significant increases in fishing activity resulting from the arrival of large high capacity vessels and their crews from the "mainland" of the United States of America (US). Between 1979 to 1986, commercial Spiny Lobster landings in Hawaii rose from 45 tons to 243 tons. During this same time period the value of these landings grew from US$320 thousand to over US$ 4 million.[1]

In response to this dramatic growth, a Fishery Management Plan for stocks of Spiny Lobster, ***Penulirus marginatus***, in the Northwestern Hawaiian Islands (NWHI) came into effect in 1983. This management was initiated by the Western Pacific Regional Fisheries Management Council (WPFMC or Council). The WPFMC has management authority for fisheries within the 200-mile Exclusive Economic Zones (EEZ) around western Pacific states and territories of the US. This authority was established under the US Federal Government's 1976 Magnuson Fisheries Conservation and Management Act.

Given the dramatic rise in fishing pressure on Hawaiian lobster stocks, WPFMC contracted the University of Hawaii's Agricultural and Resource Economics Department to conduct economic analyses of various aspects of this fishery. The research included evaluating effort limiting management strategies. Presented here is a description of this changing fishery during its early management period as well as a partial review of results from those evaluations with specific reference to fishermen's response to regulations.

Hawaii's lobster fishery remains, as it was then, an open-access fishery. At the time, limited entry was considered to reduce fishing pressure on sensitive stocks. Other effort limiting regulations besides license restrictions were considered. These included establishing constraints on the legal number of fishing trips and/or traps carried per trip. However, data gathering was need to provide the bases for future regulation decisions. Therefore, the Council's first lobster regulations called for permit requirements and maintaining daily catch reports. The regulations placed no limit on the number of permits allowed in the fishery. The National Marine Fisheries Service carried out the logistics of issuing permits and collecting catch reports. As a result, annual reports on the fishery were produced by NMFS and presented to the Council.

Within a few years after coming under regulation by WPFMC in 1983, Hawaii's NWHI commercial lobster fishery rapidly matured. Fleet size significantly expanded from 11 to over 50 permit holding boats from 1983 to 1985. (At times, however, less than have were active participants. This suggests some permit holders were merely speculators concerned with the future possibility of limited access regulation.) During this time the number of trips to the NWHI fishing grounds more than tripled (Fig. 1). The average distance for one of these trips nearly doubled from 776 miles to nearly 1,300 miles[2]. The intensity of fishing activity also expanded as vessels and equipment were modified to carry more traps and fishermen became more skilled in setting and hauling gear. For example, in terms of traps hauled per day, fishing effort tripled for the average vessel from 228 to 661 trap-hauls per fishing day between 1983 to 1987[3]. Also over this time period the species composition of this principally Spiny Lobster oriented fishery expanded to include the Common Slipper Lobster (*Sycllarides squammosus*) and the Ridgeback Slipper Lobster (*Scyllarides haanii*). Total Slipper Lobster harvest grew from just 10% of NWHI lobster catch in 1983 to nearly 50% in 1986[4]. The principal force behind these rapid adjustments in behaviour of fishermen was economic in nature.

Economic incentive drove the growth of this industry. Lobster prices in the United States were high, and getting higher. This was influenced by the steady decline in production through the 1970's from one of America's traditional lobster producing regions; the South Atlantic[5]. Lobster demand was also spurred on by growth in the US economy during the 1980's. Personal consumption of luxury goods, such as lobster, increased with a rise in expendable income. These factors made lobster fishing in Hawaii an attractive option and encouraged migration of fishermen and their vessels from outside the State.

Trends in both the market and the fishery itself collectively motivated profit maximizing fishermen to modify processing aspects of their lobster harvesting activity. In Hawaii, between 1984 and 1987, average ex-vessel prices for Spiny Lobster nearly doubled rising from US$7.23 to US$13.06. Average prices for Slipper Lobster more than doubled during this period increasing from US$4.92 to US$10.64[6]. Those prices reflected a shift away from local live lobster markets to distant markets in major out-of-state cities that were frozen product oriented. A market shift toward frozen lobster complimented a growing logistical problem in this fishery. Increasingly long travel-time to NWHI fishing grounds created constraints associated with maintaining a quality live product. Operators responded to those unique fishery and market conditions by shifting to at-sea processing of frozen tails. Such vessel conversion was common in the fishery during that time. To receive high economic returns fishermen recognized the need to provide a well packaged pre-processed frozen lobster tail product, and modified their behaviour to meet those changing demands.

This review considers an economic model of how financially motivated fishermen would respond to two types of management regulations. Both of these forms of fisheries management would fall in the general category of direct effort control. The two stratagem discussed here are: 1) limiting the number of boats, i.e. licensing; and 2) gear restrictions, i.e. trap and trip limits. The general categories of regulation, and their economic implications on the fishery as a whole, are discussed using these specific examples. A simple model shows the economic effects on the fishery resulting from fishermen responding to constraints on their operation's efficiency (gear restriction) and to restricted access into a fishery (license limitation). Each of these are represented in Figure 2a and 2b, respectively.

The model converts a simple biological sustainable yield curve to a sustainable revenue curve by multiplying catch volume by a constant price. As a result, fishing effort per boat (Trap-hauls for example) for all vessels in the fishery can therefore be summed to correspond fishing effort (E) to total gross revenue (TR) earned by the fleet. To keep the model simple, the total cost (TC) "curve" for the fishery as a whole is considered linear.

Beyond a certain level of activity, the model links an inverse relationship between the industry's total fishing effort and its profitability. Industry profits can simply be measured as the difference between total revenue and total cost at any given level of effort. An open-access fishery experiences new entrance of other fishermen who perceive that profitability as being greater than the cost of converting and transporting their vessel. Fishing effort of these new entrants adds to the total. As this influx continues, the industry moves along its cost curve until eventually overall total cost of the fishery equals total revenue. Economic incentive no longer exist and effort expansion discontinues. This level of fishing effort is represented in Figure 2a by E_0 where industry profits equal zero. This model describes the case in Hawaii where it was estimated that in spite of fishery-wide total revenue equalling US$ 5.9 million in 1986, all commercial NWHI lobster fishermen as a group were on average barely breaking even financially[7].

The Council and NMFS cooperated to consider effort limiting management options that would both protect future NWHI lobster stock productivity as well as fishermen long-term economic well-being. Given their dock-side enforceability, trap and trip regulations were considered an attractive option for Hawaii's lobster fishery. Such management regulations limiting the number of traps fished or trips taken per season would impose inefficiencies on the operator. Using the economic model, this translates into an increased average cost of fishing effort. The total cost curve slope therefore becomes steeper. Such an industry total cost curve (TC_1) is depicted in Figure 2a. The initial effect would be a reduced level of total fishing effort due to some fishermen withdrawing their boats from this fishery. Vessels with higher average costs at low levels of effort would be the first economically motivated operations to exit the fishery. However, boats capable of economic viability at this reduced level of fishing effort (E_1) sought by management, would remain in the fishery and others at least as efficient would actually enter until the industry again just broke-even (E_2). Therefore, in the absence of limiting the number of vessels allowed to fish, resource oriented objectives such as conservation or production may be realized, yet fishery participants would be no better off financially.

Next, limiting the number of vessels allowed to operate in the fishery is considered. Figure 2b shows the lobster fishery at the economic breaking even point when fishing effort is E_0. Assume managers limit the number of licensed boats in order to reach fishing effort E_1. The objective is to achieve a higher level of harvest quantity or sustainable revenue (R_1), as well as improve the fishery's total profits (Profits I @ E_1). Profits I are the sum of those accrued by each participating operator. While not graphically displayed here, higher catch rates resulting from lower effort levels creates an economic incentive for individual operators to increase their vessels harvesting capacity. This collective expansion of fishing effort beyond E_1 raises the industry-wide cost per unit effort as depicted by TC_1. If sufficient physical limitations existed for the fleet, effort expansion would be bound. Such physical constraints might include sufficiently few licensed boats, individual vessel size, horsepower, and fuel and storage capacity. As an example, total effort might reach its limit at E_2. The result would be positive industry profits, yet reduced from I to II. However, the argument has be made that, in the absence of constraining factors, the expansion of individual fishing effort could collectively be sufficient to again reduce industry profits to zero (E_3)[8]. The model suggests that to insure economic profitability for the fishery as a whole as well as for individual fishermen, limited entry schemes must be complimented with additional effort constraining regulations.

To summarize, profit is among the leading motivators influencing behaviour of commercial fishermen. Individuals respond to regulation by modifying fishing effort in such a manner that is perceived to improve financial return on their activity; even if only in the short-run. When fishing under a management framework that does not create conditions where all fishermen utilizing a particular resource consider themselves as having a vested interest in its future productivity, competition focused on short-term gains will dominate and activity will lean toward over exploitation. To avoid this all too common result, fishermen and managers must work together in order to devise regulations that foster both biological sustainability for the resource and long-run economic viability for the industry and its fishermen.

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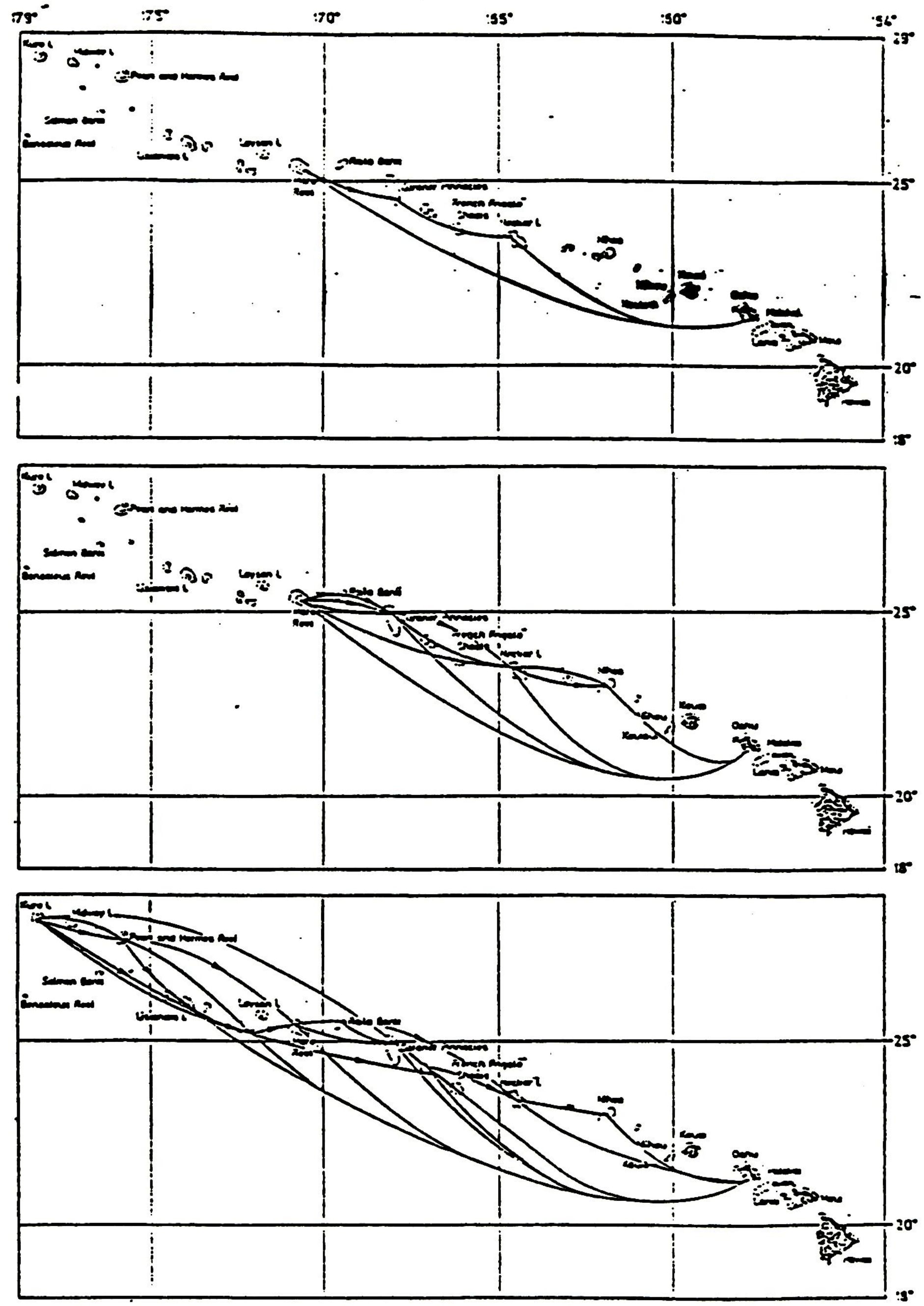
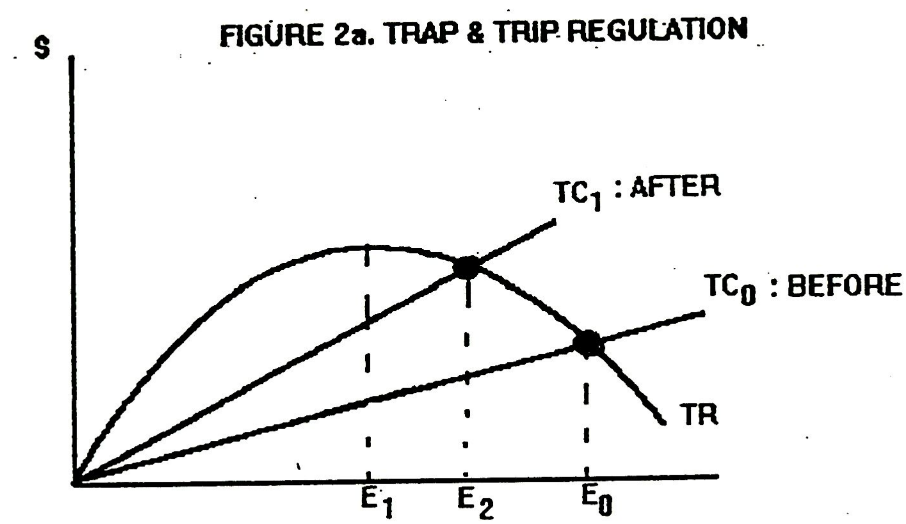


1983 19 TRIPS
3 AREAS

1984 33 TRIPS
6 AREAS

1985 62 TRIPS
14 AREAS

Figure 1. Expansion of Lobster Fishing Activities in the Northwest Hawaiian Islands. (Source: Gates, P. & K. Samples. 1986.)



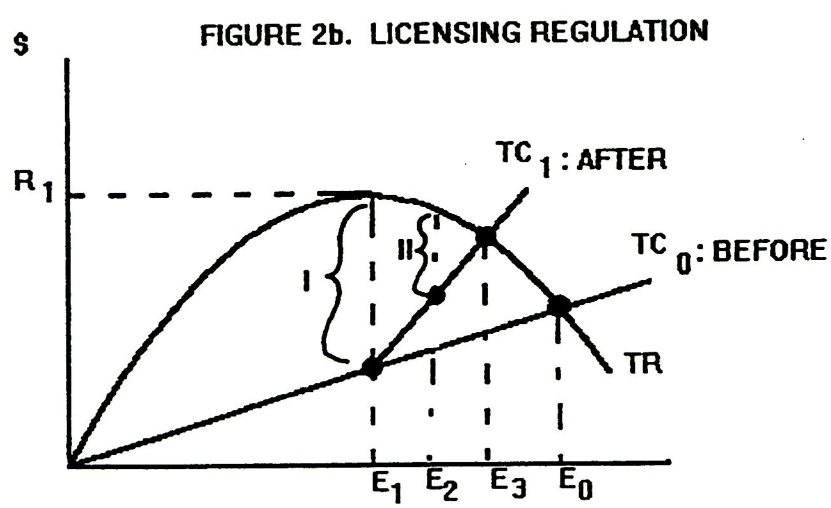


Figure 2. Economic Model Presenting Fishery Regulation Effects of Trap and Trip Limits (Fig.2a.) and Licensing (Fig. 2b).

REDUCING UNCERTAINTY THROUGH TECHNOLOGICAL INNOVATION.

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The development of innovative technologies for providing new information to fishing Captains for improved efficiency of harvesting fish at sea proceeds at a rapid pace. The Captain of a fishing vessel is required to continually make decisions relating to the safety of his vessel and catching fish (Figure 1). Regulatory factors (e.g. shipping, environmental, and fishing regulations) and environmental factors (e.g. navigation, weather, tides and currents, ice, and sea state) affect the safety of his vessel and crew. Socio-economic factors (e.g. company policy and budget, health and welfare of the crew, engineering, and maintenance) and bio-physical factors (e.g. distribution and abundance of targeted and non-targeted species, fishing gear, water depth and temperature) affect his harvesting operations. Much and varied information is acquired on the bridge of a modern fishing vessel (e.g. Figure 2). The fishing Captain is not necessarily approaching information-overload, but his time on the bridge and the fishing deck is valuable and is not readily re-allocated without proven or perceived benefits to the safety of his vessel and his ability to efficiently catch fish.

A brief case study is examined to illustrate some considerations for implementing new technologies on fishing vessels, specifically the provision of operational fisheries oceanography products (oceanographic information used for finding commercially viable concentrations of targeted fish species).

Seaconsult Limited (St. John's, NF), with assistance from Fisheries Products International Limited (FPI) and Fisheries and Oceans Canada (Northwest Atlantic Fisheries Centre), tested a prototype Temperature-Directed Fisheries Service for demersal fish on the east coast of Newfoundland and Labrador in 1989. A ship-board and land-based hardware/software system was developed to provide FPI's offshore trawlers with real-time, sea-bottom temperature maps to assist in their search for commercially-viable concentrations of Atlantic cod, American plaice and yellowtail flounder.

The objective was to provide the Trawler Manager and Captains with oceanographic information to aid in the decision-making process for finding concentrations of target species and minimizing by-catch of non target species. The intent was to provide near real-time temperature/depth maps (with synopses of ocean temperature regimes and their changes) for fishermen to use, in conjunction with their own experience and new information about temperature and depth preferences of fish. No scientist involved intended to tell fishermen where to go the find fish. Considerations used to develop the ship-board and land-based system included: 1) the timely acquisition and transmission of quality sea-bottom temperature data from trawl net sensors to the shore-based analysis facility, 2) a user-friendly ship-based system requiring little or none of the Captain's time to operate (the system developed had to be turned on when the vessel put to sea and turned off when it tied up), 3) the timely delivery of useful products to the Captain while at sea, and 4) the ability of Captains to interpret these products to the benefit of his fishing operations.

A three-month test of this service with the ship-board system installed on three trawlers clearly demonstrated the potential benefits of this new real-time information to the Trawler Manager (at the corporate level); the trawler Captains were polite, interested, but (not surprisingly) did not use the new information. Insufficient knowledge was provided for them to interpret the oceanographic products, and insufficient time was available to prove the concept and justify travelling hundreds of kilometres to "hypothesized" concentrations of fish on the basis of this new information alone. In hindsight, for this fisheries oceanographic service to be operationally implemented (prior to the collapse of the east coast fishery), a longer prototype evaluation program would have been required to place the utility of this new information in context with that proven to be of use to the trawler Captains.

Valuable perspectives were obtained on how new and innovative technologies (specifically operational fisheries oceanography services) might be introduced. Fishing Captains require a reliable, cost-effective service. The ultimate evaluation of such a service is whether or not fishermen will pay for it; if fishermen will not pay, then the service is not required! (Although the cost of development and evaluation of an operational fisheries oceanographic service should not necessarily be the responsibility of fishermen.) Only when there are no fish in the nets would this service be required, and the delivery schedule would be dictated by the movement of fish (migration and responses to biotic and abiotic water properties) and fishermen (fishing plan and fisheries openings). The requirement for real-time data is a non-trivial issue that may necessitate the installation of dedicated data communications on the vessel (for the timely acquisition of real-time data, its transmission to shore, and the reception of data products from land-based analysis facilities). This requirement would be determined by the space and time scales of fish and fishermen's movements.

An operational fisheries oceanographic service would involve a troïka of participants: fishermen, government, and university/industry consultants. The government would provide funding for developing and testing a prototype service, provide test fisheries, survey, and catch data, and would oversee the management of "new" data acquired from fishermen. The benefits to government would include the development of new jobs and improved fisheries management and research capabilities (with the acquisition of new and larger volumes of fisheries and oceanographic data). Fishermen would provide new (and potentially numerous) observation platforms for the acquisition of near real-time data (while the harvesting operation is underway or with test fishing outside conventional fishing times and zones). Fishermen would immediately benefit from improved harvesting efficiency with new information available for their decision making. Consultants, working (funded) on behalf of government and/or fishermen, would manage the new and large volumes of data, quality control the data provided to government managers and scientists, and provide operational products to fishermen.

An additional and important consideration is the propriety of environmental and catch data obtained by different groups of fishermen. User-specific data products could be provided, or the sources of information could be protected. It may be possible that the benefits to all fishermen would be greater when the data are non-proprietary, but this would depend on the competitive nature of the fishery involved.

The primary requirement for implementing new technologies within the fishing community (regardless of who provides the concept and motivates its development - consultants, government, or fishermen) is free and open-minded communication between all parties. This requirement obvious! The legitimate, self-serving interests of all these participants to make a living at the profession of their choice, however, is not so readily recognized and frequently impedes introduction of innovative technologies to the possible detriment of improving the efficient, long term utilization of our fisheries resources.

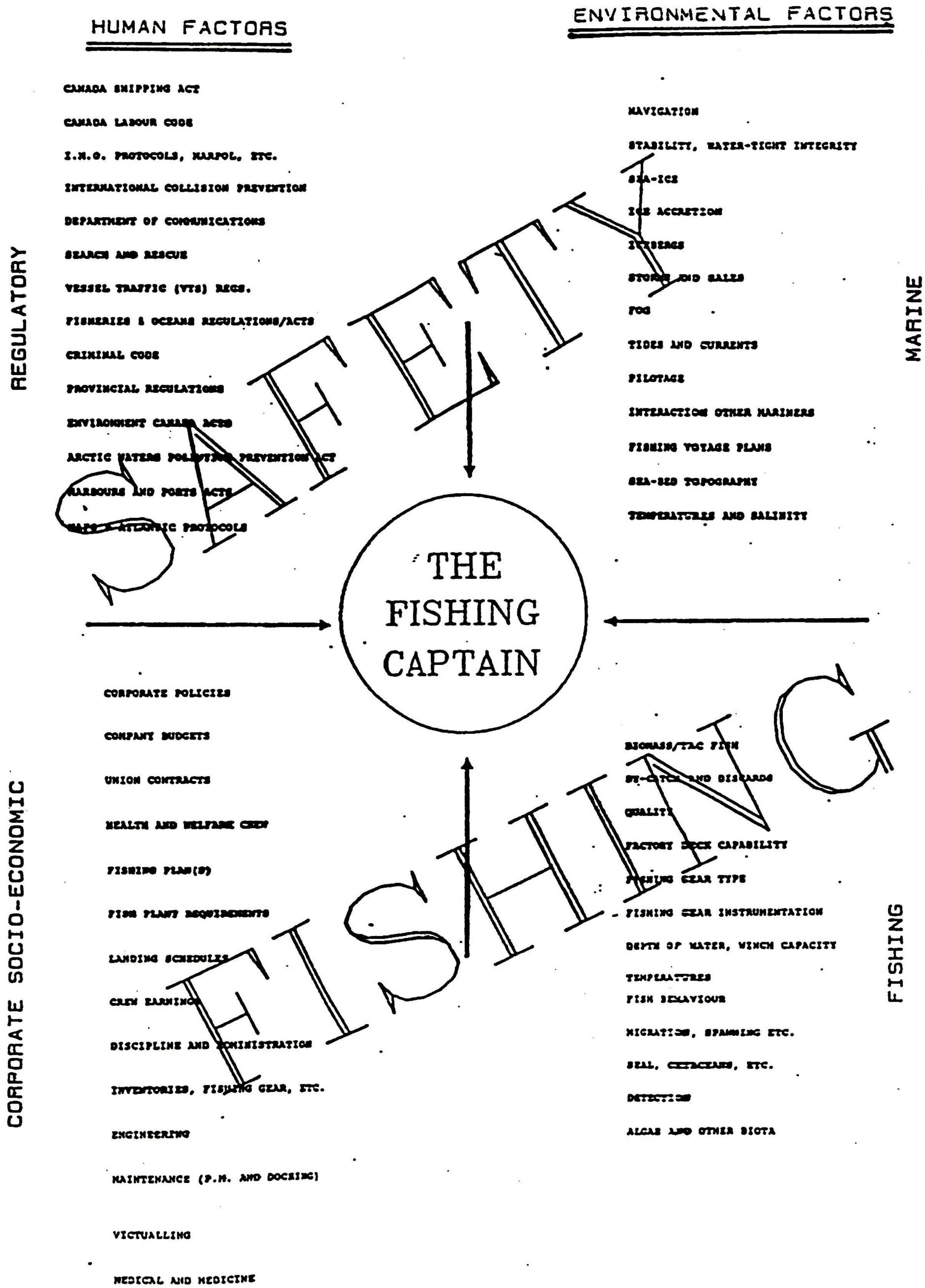

Figure 1. Factors affecting the decision making of an Atlantic Canadian trawler Captain, circa 1989 (provided by Captain Mike Hogan)

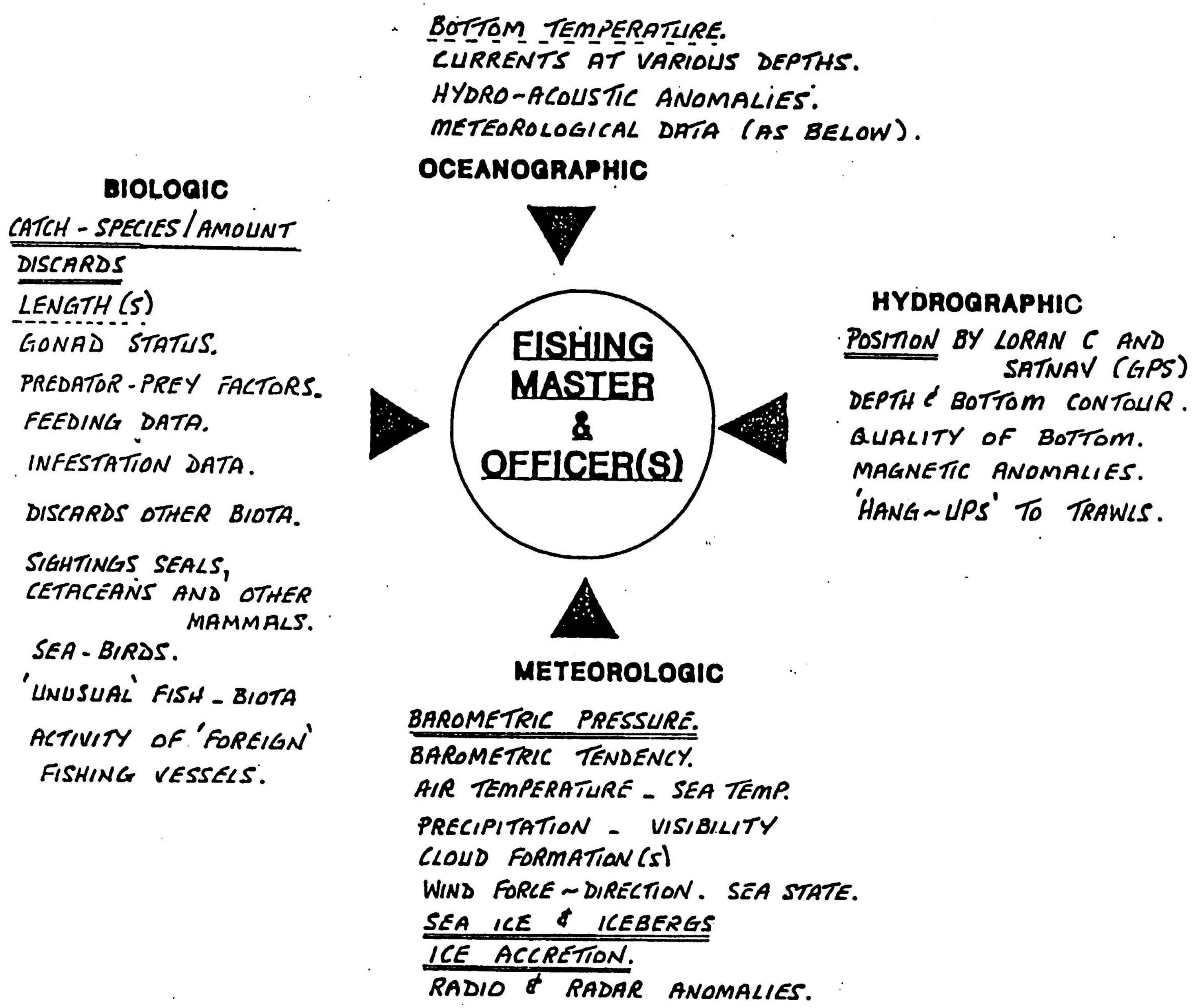

Figure 2. Data acquired by an Atlantic Canadian trawler Captain (circa 1989). Retained data are underlined (provided by Captain Mike Hogan)

IMPORTANCE OF EFFORT RESPONSE PREDICTIONS IN POLICY DESIGN AND ASSESSMENT.

Carl J. Walters, Fisheries Centre, University of British Columbia, 2204 Main mall, Vancouver, B.C. V6T 1Z4.

Analysis of fishing effort dynamics has historically concentated on long term changes associated with investment, with a key concern being overcapitalization. Models for long term dynamics seldom attempt to capture the very rapid dynamic changes in effort associated with day-to-day operational decisions on when and where to fish. But good predictions about these rapid changes are critical to the design of "inseason" regulatory systems for achieving long term objectives. In sport fisheries, rapid changes can negate or even reverse the intended effects of regulations such as minimum size limits, and can cause unintented side effects in stocking programs. In fisheries stock assessment, changes in spatial distribution of fishing effort make it very risky to use catch-per-effort data as an index of trends in stock size. Three case examples are used to illustrate these issues.

In Rivers Inlet, B.C., inseason management of sockeye salmon harvest involves a series of weekly fishery openings, where the openings are planned each year using a model for how the sockeye run passes through the fishing area. This planning model is critically sensitive to assumptions about how many vessels will choose to enter the fishing area each week, and how these vessels will distribute themselves along the migration pathway through the fishing area. If biologists underestimate fishing effort and exploitation rate early in the season, they are forced a few weeks later to make painful and controversial closures or risk overharvesting. If they overestimate effort, they can allow longer openings later but these openings are exhausting for fishermen and create problems of reduced fish quality and interception of other salmon species.

Trout fisheries in the B.C. interior are managed largely by varying stocking rates and a few regulations such as minimum size limits. Fishing effort appears to respond in a logarithmic way to increasing abundance through stocking, and this response makes it very difficult to establish and maintain quality (large fish size) fishing in any lake.

We are currently developing software at UBC for mapping changes in the spatial distribution of commercial fishing effort and catch rates, for use in the design of surveys that use a combination of commercial fishing and research survey data to provide better indices of stock trend. This software combines judgemental information provided by fishermen about where they historically found fish and would expect to see fish now, with logbook and survey data. We hope to link these information sources using spatial statistics methods to provide year-by-year maps of how fish distributions have changed during development of such fisheries as black cod off the B.C. coast. A particular appeal of this software system is that it provides not only a computer data interface, but also a "people interface" where fishermen and biologists can come together to discuss and share specific information for stock assessment, thus making the stock assessment process a truly collaborative and cooperative effort.

FISHERIES CENTRE WORKSHOP SERIES

The Fisheries Centre organizes workshops concerning fisheries-related topics and issues of current interest. We aim at developing the knowledge and tools required to study particular problems arising in fisheries. Also, we focus on enhancing understanding of natural ecosystem.

Our workshops are designed to be as practical as possible. Thus they usually include some practical work and/or model development, as well as presentation of papers and/or talks by experts in the field. The workshops have an informal format and are held in small groups to generate discussion and to provide a comfortable working environment.

The report from each workshop is edited and published in the Fisheries Centre Research Report series which is distributed among various institutions and organizations and available on request. Outputs from the workshops are formulated into plans for future research in each area.

We welcome participants from around the world, and from all fisheries institutions/organizations, including the private sector. Graduate students are particularly encouraged to attend and participate in our workshops.

In general, all the workshops in this series are held at the Fisheries Centre on the UBC campus. However, FC resources and personnel have experience in tailoring workshops to suit particular interests and can be held elsewhere.

FC Workshops 1993

Commercial Whaling - The Issue Reconsidered (*Fisheries Centre Research Reports 1993, Volume 1, Number 1)*

Decision Making by Commercial Fishermen: a missing component in fisheries management? (*Fisheries Centre Research Reports 1993, Volume 1,Number 2)*

FC Workshops 1994-1995

FC Workshop # 1

Bycatches in Fisheries and Their Impact on the Ecosystem

A two-day practical workshop, aiming at evaluation of the impact of targeted fisheries on non-targeted components of the ecosystem, and the trade-offs that may have to be considered in mitigating this impact.

Date: **October 13-14, 1994**

FC Workshop # 2

Impact of Changes in North Pacific Oceanographic Regimes on Coastal Fisheries

This two-day workshop will review the impacts of changes in the dynamic ocean environment on fisheries along the Pacific coast of North America, and will discuss how bio-physical models may be used to understand and quantify these impacts.

Tentative date: **February or March 1995**

FC Workshop # 3

Catchability Estimates in Marine Fisheries

A two-day practical workshop focused on variation in catchability and its consequences in fisheries.

Tentative date: **October or November 1995**

FC Workshop # 4 (*tentative)*

Oolichan Fisheries

If you would like to know more about our activities, or to receive additional copies of Fisheries Centre Research Reports, please write to:

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