

Small-scale fisheries in North America: research perspectives

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1. INTRODUCTION

This paper aims to provide a sense of past, present and future research activity dealing with small-scale fisheries in Canada and the United States. While this is necessarily a subjective account, hopefully it provides a reasonable overview of the debates and directions in fisheries research. The use of the term «small-scale» deserves specific comment, since this concept, so common in discussions of developing fisheries, is almost absent from the everyday fisheries language of North America. Hence a key component of this discussion, to be considered at the outset, involves examining what «small-scale» might mean in the North American context.

A few words about the focus and scope of this paper are in order. Since both Canada and the U.S. have developed an extensive fisheries research infrastructure, and have produced voluminous research work on fisheries, any review such as this must be somewhat selective. The reader will note a certain emphasis on salmon fisheries in the northeast Pacific together with groundfish and shellfish fisheries in the northwest Atlantic region; these fisheries have tended to attract the most research attention, and also happen to be most familiar to this writer. However, there is also reference herein to a range of other (primarily marine) fisheries, such as the Gulf of Mexico inshore shrimp fishery and native fisheries on the Arctic Ocean. While many North Americans are actively involved in studying small-scale fisheries elsewhere in the world, such research will be excluded from this discussion. Furthermore, research oriented towards large-scale/industrial fisheries in North America will be included only insofar as it also relates to small-scale fisheries.

The paper begins in section 2 with a discussion of the difficulties involved in defining small-scale fisheries. This is followed in section 3 by a review of fishery objectives, and an attempt to categorize current North American fisheries thinking within three broad «philosophical» paradigms.

There follows a series of reviews dealing with research work on small-scale fisheries in North America. As pointed out above, these are selective reviews, aimed at providing the flavour of work in each area rather than a

complete survey. In particular, although the role of research in the natural sciences receives attention, I have not attempted to survey in any detail the abundant work in this area. Section 4 deals with fisheries structure, including the harvesting and processing sectors, fishing communities, integrated models of the fishery system, and an overview of fishery case studies. In section 5, the focus is on dynamic aspects of fish populations, labour and capital, including consideration of stock assessment methods, fishery employment, and investment decisionmaking. Research on fishery management is considered in section 6; this work ranges from discussions of fishery conflicts and the need for management, to analyses of regulatory techniques such as limited entry, fishermen quotas, and co-management.

In section 7, the focus is on fishery researchers and the institutional framework for research. Finally, section 8 contains a discussion of multidisciplinary research in small-scale fisheries, together with comments on research priorities, current trends and future directions.

A multidisciplinary bibliography is provided at the end of the paper. While not an exhaustive list, the 150 references contained in the bibliography do provide a broad sampling of small-scale fisheries research work from across North America, and hopefully touch on most of the current research themes. There is an emphasis on books and journal articles, which tend to be widely available. Unfortunately, while government documents often contain some of the best fishery case studies, they are not easily obtained, or even uncovered - those referenced here are ones which happen to be known to the author. It should be noted that, since the purpose of the bibliography is to provide broad guidance to the literature, not all the material listed there is referred to in the text.

2. DEFINITIONAL DIFFICULTIES

2.1. What is a small-scale fishery?

One of the most difficult tasks in attempting to synthesize research work on «small-scale» fisheries lies in determining what exactly constitutes such a fishery. Given a particular piece of fisheries research, it is relatively easy to categorize the philosophical or disciplinary approach, but arguments can and do ensue over whether or not the subject of the paper is in fact a «small-scale» fishery. PANAYOTOU (1985, p.11) notes «it is not unusual to find that what is considered a small-scale fishery in one country would be classed as a large-scale fishery in another». This point is highly relevant in considering North American small-scale fisheries within a global context.

Certainly, some form of definition is important; as with scientific hypotheses, definitions tend to shape the way we view a subject. On the other hand, no definition is the ultimate truth; the concept of a «working definition» is more appropriate. In the case of small-scale fisheries, it is also absolutely essential that any working definition be multi-disciplinary in nature.

In this spirit, and hopefully applying common sense to the definitional question, this review will treat as «small-scale» those fisheries possessing at least some of the following characteristics:

- (i) the fishery constitutes an integral part of the (usually coastal) communities where fishermen live ;
- (ii) the participants are not only highly dependent on the fishery for their livelihood, but have few other job opportunities ;
- (iii) vessels are relatively small and individually-owned ;
- (iv) there is a greater reliance on labour than on capital in the fishery production process ;
- (v) in broad terms, net income levels are relatively low ;

- (vi) the participants do not view themselves as being part of an «industrial» fishery, and ;
- (vii) the fishery is viewed, at least by some, as «traditional» and possibly as technologically backward.

Such a list of characteristics can form the basis of a «scorecard» by which fisheries are classified; a small-scale fishery is then one satisfying a sufficient number of these properties. This can be compared with PANAYOTOU's (1985, p.11) broad depiction of small-scale fishermen as those «who, by virtue of their limited fishing range and a host of related socioeconomic characteristics, are confined to a narrow strip of land and sea around their community, faced with a limited set of options, if any, and intrinsically dependent on the local resources».

The social science concept of «marginalization» can also be useful in categorizing small-scale fisheries. Marginalized elements of society are those who, through membership in particular minority groups (eg. native peoples) and/or through their location (eg. in rural or remote areas), can be thought of as being on the periphery of the society. Within this context, small-scale fisheries are often marginal, and tend to be seen either as «industries ripe for modernization and calling out for rationalization» or as «people and communities threatened by economic forces beyond their control», depending on one's perspective. Discussions of policy towards small-scale fisheries tend to be battles of ideology, and, as shall be discussed in detail here, the battleground extends beyond the political arena to involve fishery researchers as well.

One final point should be made here, before turning to the specific case of North American small-scale fisheries. With respect to terminology, the term «small-scale» is sometimes used interchangeably with such concepts as «artisanal», «subsistence» and «inshore». But to what extent are these really synonyms? PANAYOTOU (1985, p.11) points out that «although there is no standard definition of small-scale fisheries, various classifications of fisheries do exist: small-scale versus large-scale, subsistence versus commercial, artisanal versus industrial, inshore (or municipal) versus offshore...».

In this framework of contrasting terms, the choice of language depends on what is important. The idea of «small-scale vs. large-scale» seems to place emphasis on the size of the fishermen's operation. On the other hand, if the rationale for fishing is the focus, the «subsistence vs. commercial» dichotomy may be more appropriate. If the style of production is of interest, we might look at «artisanal vs. industrial» conflicts, while if ties to fishing communities are crucial, an «inshore vs. offshore» concept could be best. While North American social scientists have emphasized a «traditional vs. modern» dichotomy in their studies of fisheries over the past two decades, recently they have come to question the previously accepted notion of the «traditional» North American fishing community (Y. BRETON, Laval University, pers. comm.). This point will be addressed in more detail below.

2.2. Small-scale fisheries in North America?

As pointed out above, the terms «small-scale» and «artisanal» are entirely absent from discussions of North American fisheries, except in the social science literature. Biologists do not use the terms, economists do not use such language, and most significantly, to my knowledge essentially no one in the North American fisheries bureaucracy refers to «their» fisheries in this way. Instead, reference is to «inshore» fisheries, or «small-boat» fisheries, or «native» (Indian) fisheries; these are the possible candidates for North American small-scale fisheries. To place North American fisheries within a global context, we need to translate the fishery language as best as possible, and to evaluate these fisheries with respect to the criteria listed above.

To the extent that the concept of «small-scale» focusses on concreté aspects of the fishery (such as vessel size), and contrasts in quantitative terms with the idea of «large-scale» fisheries, then in the North American context, the terms «inshore» and «small-boat» may be reasonable synonyms. On the other hand, in my view, the term «artisanal» means something more, involving such factors as fishermen's self-perception and style of production, as much as it

does on concrete aspects. We might ask whether the fishermen consider themselves to be «artisans» - in most North American cases, I think the answer would be no.

In Atlantic Canada, for example, we speak of a dichotomy between «inshore» and «offshore» fisheries, based on the distance from shore at which fishing takes place - the inshore fishery clearly involves smaller boats, more labour intensive operations, and more connections with coastal communities than does the offshore, and hence it is perhaps reasonable to speak of this as a «small-scale» fishery. However, inshore fishermen in many parts of Atlantic Canada are heavily capitalized and are more likely to consider themselves as businessmen than as «artisans». Depending on their geographical location and their access to specific fisheries, these fishermen can do quite well economically, in spite of being part of the «small-boat» fleet. Hence the size of the boat does not necessarily define the size of *per capita* incomes.

Overall, from a definitional point of view, it is reasonable to claim that small-scale fisheries do exist in North America. Yet it is also true that the clear dividing line which may well exist between small and large-scale in developing countries is not always so evident in North America. Indeed, discussion of small-scale or artisanal fisheries most often takes place in the context of fisheries in developing countries, while Canada and the United States are not usually considered to be in this category of nations. Thus one can ask whether it is really appropriate to use the same concept of «small-scale» in referring to North American fisheries.

Yet there is a great deal of geographical and developmental diversity within these «developed» nations. The fisheries in North America which might reasonably be categorized as «small-scale» tend to be (i) located in geographical regions which lie outside the mainstream social and economic centres, and/or (ii) involving participation principally by fishermen belonging to groups in society (eg. native peoples) that have been traditionally excluded from the centres of economic and political power. Thus such fisheries are often «marginal», and are located in parts of North America which, in relative terms, can indeed be called «developing regions».

2.3. The evolution of definitions

While the above features of small-scale fisheries do provide some guidance in determining which North American fisheries fall into this classification, a number of serious cautions are in order. From an economic and technological perspective, we can observe the capitalization of some North American small-scale fisheries to the point that one wonders whether they still fit the category.

In Nova Scotia, for example, a previously clear split between inshore and offshore fleets has been muddied by the development of a «midshore» fleet, comprised of intermediate-sized vessels operated by fishermen who in most cases had been part of the inshore fishery. This midshore fleet operates under inshore regulations but has the capability to fish in offshore areas. Is it enough that the boats in this fleet are small relative to offshore vessels, or are they qualitatively outside the small-scale classification? Certainly, they do not seem to constitute an «artisanal» fishery by any means.

From a social science perspective, definitions of small-scale fisheries are under review. This has been brought about particularly through research on (i) the historical evolution of what have been called «traditional» fisheries in North America, (ii) the importance of secondary fishing activities, and (iii) the social and political interconnectedness of different «categories of fishermen» (Y. BRETON, Laval University, pers. comm.).

On the first of these topics, which I find particularly intriguing, Breton points out that fisheries often referred to as «traditional» were actually established in the last century by «mercantile companies that evolved with large production units possessing most of the characteristics of commercial capitalism». The features that we think of as characterizing «traditional» fisheries (family work groups, customary fishing rights, etc.) only developed after the

departure of these large companies. BRETON notes that «we are now discovering the enormous range of differences (both at a temporal and spatial level) between small-scale fishing communities, and the necessity to conceive them by taking into account the various intensities with which capitalism developed in different areas».

3. RESEARCH PARADIGMS

The discussion here focusses on the links between fishery objectives and the paradigms adopted by fisheries researchers. Three representative paradigms are presented; it is argued that these correspond to the three principal classes of fishery objectives found in the literature.

3.1. Fishery objectives

One of the most amazing features of the North American fisheries literature is the lack of discussion of fishery objectives. What is the purpose of the fishery? This question is rarely asked, particularly in academic research. Perhaps it is a problem with discipline-based research; for example, economists know that any economic activity is there to generate monetary benefits, or possibly to maximize «consumers plus producers surplus», while social scientists know that the fishery is there to maintain fishing communities, and so on.

Yet there are in fact a wide variety of fishery objectives, a point clearly recognized in the management of developing fisheries. For example, LAWSON (1984) lists 14 common goals of fisheries development, such as increasing production, employment and fishermen's incomes, industry diversification, skills development, and the encouragement of both exports and production of food for domestic consumption. Most of these objectives are relevant in a North American context, apart from food production, which tends to be of little interest in fishery management discussions other than those dealing with native Indian «food fisheries».

Of course, the real challenge is not to list all possible objectives, but rather to prioritize the list. Naturally, this leads to considerable disagreement, usually between those with conflicting philosophies or ideologies. Indeed, this may well explain why researchers often assume objectives, rather than discuss them - messy arguments are thereby left to the policymakers to debate. Yet in reality, the choice of priority objectives must be made before any real analysis of suitable fishery management approaches are formulated. Efforts to determine what the various fishery users actually want, and to devise «objective functions» incorporating these goals, have been made in some fisheries (e.g. HILBORN and WALTERS, 1977).

In considering the choice amongst conflicting fishery goals, it is useful to summarize the list of possibilities. A report of the United Nations Food and Agriculture Organization (FAO, 1983) suggested that «objectives could be placed in three groups - maintaining the resources, economic performance, and equity (or social needs)». This useful classification leads to the consideration of three paradigms for small-scale fisheries, each emphasizing one of these objectives. These will be referred to here as the Conservation, Rationalization, and Social/Community paradigms, respectively. The paradigms correspond roughly to the historic approaches of biologists, economists and social scientists to fisheries research (although this is not to suggest that all researchers think alike in any one of these disciplines). Each paradigm will be discussed in detail below.

3.2. The Conservation paradigm

The discipline of biology has tended to dominate fisheries research in North America. The vast majority of fishery research activity within government fishery departments, as well as government-funded university research, is of a primarily biological nature. It is not surprising, therefore, that biologists have played a major part historically

in shaping fisheries research priorities. In particular, this has led to a focus on work aimed at protecting fish stocks - hence the Conservation paradigm.

By and large, it is felt, fishermen and consumers of fish will take care of their own interests, so that the primary duty of fishery management is to take care of the fish. Of course, this reflects not only a concern for fish stocks, but a recognition that future fishermen and future consumers will benefit from fish stock protection now. Such a paradigm has resulted in a substantial collection of biological research broadly aimed at ensuring that harvest levels do not exceed the sustainable capacity of the fish stocks.

With respect to fishery management, the Conservation paradigm can be seen as one of imposing direct controls on «the fleet» to restrict one or more of fishing location, fishing time, total effort, and total harvest. Within this paradigm, people play only a minor role - fishermen are simply components of «the fleet», which must be controlled in order to protect «the fish».

3.3. The Rationalization paradigm

An endless debate ensues in the field of economics over the balance between economic efficiency and distributive justice. The vast majority of economic research focusses entirely on the former - how to maximize the size of the «pie», representing net benefits from the fishery. Questions of distribution - how the pie is shared both now and in the future - tend to be considered beyond the ability of economists to «solve», and thus best avoided.

The Rationalization paradigm takes this approach, focusing on the maximization of economic efficiency, and usually assuming whatever is necessary for the «efficient solution» to represent a «social optimum». Indeed, society is assumed to pursue just one objective, the maximization of «rents» or economic surplus, representing net economic benefits over and above reasonable payments to labour and capital. As part of this paradigm, a fisherman is usually assumed to be not so much an individual as a profit-maximizing «firm», again pursuing a single objective. Fisheries that do not behave in an economically efficient manner need to be «rationalized»; in most cases this means a reduction in the number of fishermen.

Interestingly, this paradigm has also become popular in recent years amongst biologists and fishery managers (the majority of whom are biologists by background), as well as economists. One of the extraordinary changes in North American fishery thinking over the past two or three decades has been the emergence of economic theory and the idea of «rationalization» as an increasingly dominant force (see, for example, LARKIN, 1978).

3.4. The Social/Community paradigm

Where the Rationalization paradigm focusses on efficiency, the Social/Community paradigm concentrates on distribution. The economic language of rationalization deals in fishing firms and utilizes mathematical analytic tools wherever possible, while the Social/Community paradigm focusses on the people and communities involved in fishing, and relies more on descriptive (and sometimes statistical) methods. Indeed, the traditional Social/Community paradigm appears to be based on an underlying assumption that those in small-scale artisanal fisheries are downtrodden, marginalized people, who have been treated unfairly by society. This, of course, is in direct contrast to the fishing «firms» of the Rationalization paradigm.

Social science researchers, who seem to be the most frequent followers of the Social/Community paradigm, see clear changes in this approach over time. For example, MARCHAK (1984) notes that «Fishing has long attracted social scientists with a romantic streak in them. A considerable library of descriptive accounts of fishermen, fishing villages, the tasks and trials of fishing attest to that. But social scientists today are not reproducing these romantic

accounts.» She suggests that current sociological research on fisheries is more analytical than in the past, now emphasizing a so-called «political economy» approach. While this change is important from the perspective of research activity, it does not alter the fundamental nature of the Social/Community paradigm. MARCHAK (1984) reflects this paradigm in expressing her hope that recent sociological work on Canadian fisheries will «have some impact on ... the struggle now undertaken by the fishermen and processing workers».

4. RESEARCH ON FISHERY STRUCTURE

In this and the following two sections, we turn from philosophical issues to research reviews. The emphasis here is on research dealing with the state of small-scale fisheries; case studies of specific fisheries, the harvesting sector, the processing sector, fishing communities, and the fishery system as a whole.

4.1. The diverse nature of North American fisheries

As discussed above, there are certain aspects of a fishery, such as its situation in a «marginal» region or its labour-intensivity, that lead us to classify it in the «small-scale» category. Hence, we can expect some commonalities amongst small-scale fisheries in North America. However, there is also much diversity, particularly due to biological differences in the fish species being exploited and socioeconomic differences in the fishery environment.

As an example of biological differences affecting research emphases, contrast the lobster fisheries in New England and Atlantic Canada with the Native Indian salmon fisheries in the northwestern United States and British Columbia. The lobster fisheries, amongst the best-studied small-scale fisheries in North America, exploit a basically sedentary species, with relatively clear geographical delineations being possible between the fishing zones of neighbouring communities. Thus much research has focussed on the existence and possible expansion of self-regulation as a management tool in these fisheries. On the other hand, the Native salmon fisheries harvest highly migratory species, and thus conflict arises almost inescapably with larger-scale users. In this case, the emphasis has been on examining interactions between native and commercial fisheries, and dealing with the question of resource allocation.

The situation of the fishery within the broader economic and social picture also leads to varying research attention. In many cases, small-scale fishermen may be fishermen partly out of tradition and partly because there are few alternative employment opportunities in the local area (as for the Newfoundland inshore fishery, the Alaskan salmon fishery, and Native fisheries in the Arctic). In such cases, the social opportunity value of labour is low, and research tends to deal with issues of community attachment, labour mobility and economic development. On the other hand, if fisheries are closer to major markets (as is the case for the southwestern Nova Scotia fisheries and the Gulf of Mexico shrimp fishery), the fishery may be a much more lucrative activity and there may be a tendency towards increasing participation in the fishery, even in the face of more plentiful job alternatives. For such fisheries, an emphasis on management questions seems to be more common.

4.2. Case studies of small-scale fisheries in North America

Specific case studies carried out by fisheries researchers in North America tend to have a disciplinary focus; it is rare, for example, to find a study which pays equal attention to the biological, economic and social aspects of a fishery. Economic and social science works tend to treat the natural environment and the fish stocks as given, while studies of the bioeconomic system usually neglect social factors.

Reasonably comprehensive overviews can be found in various government and fishery agency reports, although unfortunately many of these are not widely distributed. Two of the best sources for reviews of Canada's Pacific and Atlantic fisheries are the reports of major government-commissioned studies carried out in the early 1980s by PEARSE (1982) and KIRBY (1983). While these studies are not focussed specifically on small-scale fisheries, they do deal with a wide variety of biological, economic, social, and management aspects of the fisheries. BASSO *et al.* (1986) present an interesting review of the fishermen, harvest levels, and management options in the Quebec snow crab fisheries, while BENNETT (1973) reviews native Indian salmon fishing on the Fraser River in British Columbia. In terms of United States case studies, the report of the United States Comptroller General (1976) contains a wealth of information about U.S. marine fisheries overall, and specific biological and economic data on many of the major fisheries. McHUGH (1983) provides brief outlines, as well as references to detailed work, on oyster, crab and menhaden fisheries on the mid-Atlantic coast.

Interestingly, useful summaries of many fisheries can also be found in research utilizing a quantitative modelling approach, such as the model of KRAUTHAMER *et al.* (1987), dealing with the Texas inshore shrimp fishery, and the papers in HALEY (1981) on Newfoundland, New England, and British Columbia fisheries. Such work aims to provide analytic tools for predicting the fishery's response to regulatory change, and tends to focus on essential features of the given fishery - we return to a discussion of these in part 4.5 below.

A wide variety of fishery case studies exist in the social sciences. Sociologically-based case studies include the work of ACHESON (1975) on the lobster fishery of Maine, MARIL's (1979) discussion of the Texas shrimp fishery, research on British Columbia fisheries collected in MARCHAK *et al.* (1987), and several papers in LAMSON and HANSON (1984) dealing with Atlantic Canadian fisheries such as those based on Newfoundland cod, groundfish in southwest Nova Scotia, and herring in the Bay of Fundy. Several studies focus on the impact of declines in the New England fisheries (BOERI and GIBSON, 1976 ; and DEWAR, 1983).

Anthropological case studies include examinations of Newfoundland fisheries in ANDERSEN and WADEL (1972), as well as many of the papers in ANDERSEN (1979); each of these books contains collections comparing related research on European fisheries in the North Atlantic. Important anthropological research has also been carried out on fisheries along the Atlantic seaboard of the United States by McCAY (1980) and by POLLNAC and POGGIE (1979).

Case studies with an economics flavour include a series of reports for the Economic Council of Canada (SCOTT and NEHER, 1981) dealing with the Pacific halibut fishery (CRUTCHFIELD, 1981), the Bay of Fundy herring fishery (CAMPBELL, 1981), and others. A great deal of research has been focussed on the Newfoundland inshore fishery, including work by COPES (1973, 1983), COPITHORNE (1981) and MUNRO (1980); each of these reviews the lengthy history of the Newfoundland inshore fishery and discusses economic policy options. Comprehensive socioeconomic case studies of two Massachusetts ports, New Bedford and Gloucester, have been completed by DOERINGER *et al.* (1986); these provide considerable insights into fishermen decisionmaking and the variety of labour processes arising in fishing communities, although they are focussed more on the offshore (larger-scale) component of the fishery. In the United States, an example of an economics-based case study is PROCHASKA's (1976) review of Florida's fisheries.

Finally, several fishery reviews take an ecological, technological and/or fishery management approach. For example, the papers in BENSON (1970) provide a broad overview of North American fish stocks and their management, largely from the perspective of biologist/managers. The fisheries discussed involve species ranging from the Pacific sardine and salmon, to a variety of stocks in the Great Lakes, to groundfish in the Atlantic, as well as oysters, clams, trout, herring and halibut. BROWNING (1974) gives an historical account of north Pacific fisheries, discussing the fish species, fishing fleets and fishing technology involved, including techniques of fish handling and processing. KUMPF (1977) adopts an inter-disciplinary approach in discussing the economic impact resulting from pollution in a wide variety of U.S. fisheries along the Atlantic coast and Gulf of Mexico. In so doing, he provides a great deal of information about each of these fisheries. A rather different approach is taken by McEvoy (1986), who reviews ecological and legal aspects of California fisheries, from 1850 to the present. He also provides a very extensive

bibliography including legal studies, historical accounts, and U.S. and California government documents dealing with fisheries in California and elsewhere.

4.3. Fish and fishermen

Understanding the harvesting sector of the fishery - the processes by which fishermen catch fish - is clearly essential to any study of small-scale fisheries. This has been an area in which fruitful collaboration between biologists, economists and technologists has been possible. From the biologist's perspective, the focus is often on the determinants of fishing mortality, i.e. calculation and/or prediction of the impact particular groups of fishermen have on the fish stocks. Economists place their emphasis on determining «production functions» - the relationship of harvest levels to the various inputs, such as labour, capital, and fish - and on studying «economically optimal» fishermen performance. Finally, the technologists deal with fish-fishermen interactions in terms of their concern with improving the efficiency of fish harvesting methods.

Considerable data is required for a suitable analysis of the harvesting sector, and the quality of data available in North American fisheries varies considerably. In Atlantic Canada, the federal government undertakes regular fishermen surveys to collect information on costs and earnings, as well as investment and capacity levels (e.g., DFO, 1984 ; 1988). Since these survey results contain no social content, social scientists in the region have traditionally undertaken surveys of their own (see, for example, APOSTLE *et al.* 1985).

In recent years, there has been an increasing realization by North American fisheries researchers that good fishery management requires not simply the setting and enforcing of regulations, but also the ability to predict fishermen response to these regulations. This in turn necessitates a reasonable understanding of fishermen behaviour (WILEN, 1979). To this end research efforts have included analyses of non-monetary benefits affecting fishermen decisions in the Alaska salmon fishery (KARPOFF, 1985), studies of fleet dynamics in the British Columbia salmon fishery (HILBORN and LEDBETTER, 1979), applications of behavioral models to the New England fishery (OPALUCH and BOCKSTAEEL, 1984). Research into the interaction between fishermen decisionmaking, fishery enforcement, and the regulatory framework have also been carried out (e.g. SUTINEN and ANDERSEN, 1985 ; MAZANY *et al.*, 1989).

4.4. Fishing communities and the processing sector

Land-based aspects of small-scale fisheries have received much less attention than those taking place at sea. However, some economic and social studies are available dealing with the processing sector and coastal fishery communities in several parts of North America. For example, on-shore aspects of the British Columbia fishery are discussed by PINKERTON (1987a) and GUPPY (1987), who focus on fishing-dependent communities and the processing sector, respectively. VAGNEUX (1984) considers the productivity and working conditions of processing plant workers in Quebec and elsewhere in Atlantic Canada.

The position of women in small-scale fishing communities, and particularly their work in fish processing plants. For example, LAMSON (1986) looks at women in Atlantic Canadian fish plants, while CONNELLY and MACDONALD (1983) and PORTER (1985) consider more broadly the role of women in coastal fishing communities.

4.5. Studies of the «fishery system»

As mentioned above, some very interesting research has been carried out on small-scale fisheries in North America using quantitative techniques of resource modelling, operations research, and computer simulation. The

idea of resource modelling is to develop a mathematical abstraction of the real-world fishery system which is simple enough to analyse, while maintaining intact all the key dynamics and interactions of the fishery. The resulting «model» can be used to predict future behaviour or to calculate the optimal performance under various conditions (e.g. CHARLES, 1989 ; CLARK, 1985).

The term «operations research» refers to the set of descriptive and optimization techniques which can be used in resource modelling to explore policy options and to determine desirable outcomes dependent on management objectives and system behaviour. See HALEY (1981) for a collection of research using these techniques. One of these methods, computer-aided simulation, is particularly useful in (i) providing a framework to study interactions amongst components of the fishery, and (ii) examining the effects of proposed management regimes on a variety of social, economic and biological indicators. Such an approach has also proven helpful in facilitating the process of consultations between government and fishermen (HOLLING, 1978).

While an in-depth understanding of modelling and operations research methods may well require knowledge of either mathematics or computer analysis, the results can be made easily available, especially since fisheries researchers and managers now have easy access to micro-computers. See KRAUTHAMER *et al.* (1987) for an impressive multidisciplinary model of the Texas inshore shrimp fishery.

5. RESEARCH ON FISHERY DYNAMICS

Perhaps more than any other component of society and the economy, fisheries are dominated by dynamic processes. In this section, the emphasis is on research dealing with dynamics of the fish, the fishing fleets, labour and capital in North American small-scale fisheries.

5.1. Fish and fleet dynamics

A key focus of biological research into North American fisheries has been the analysis of fish population dynamics, in an effort to understand the determinants of fish growth and to aid in the setting of biologically-sustainable harvest levels. This research has certainly involved study of basic biological aspects of the fish (such as size-at-age, intrinsic growth rates, and carrying capacities) but the work has become increasingly mathematical, with virtual population analysis, simulation modelling, time series analysis, and a variety of statistical techniques gaining widespread use (see, e.g., DFO, 1986 ; RICKER, 1958 ; STOCKER 1987).

Social science researchers have also paid great attention to fishery dynamics, focussing on the processes of change in fishing communities, and the extent to which such changes have been forced on these communities (e.g. ANDERSEN, 1979 ; McCAY, 1979 ; SPOEHR, 1980). Unlike the biological research outlined above, work on social dynamics has been more descriptive than it has quantitative or predictive in nature.

Economists lagged behind somewhat in addressing dynamic change in fisheries, likely because the economics toolkit lacked the means to solve messy problems of economic optimization over time. This changed in the early 1970's, with the application of mathematical approaches such as optimal control theory to problems in fisheries economics (CLARK, 1976). Now economists clearly recognize the crucial importance of dynamic processes in fisheries. Indeed it is sometimes suggested that the development of complex dynamic models has become so fashionable amongst academic fishery economists as to somewhat overwhelm policy discussions.

5.2. Labour dynamics

Labour in fisheries has received attention from a variety of standpoints. For example, several of the papers in CHAUMEL (1984) deal with labour in North American fisheries and processing plants, considering issues ranging

from productivity to workers' health. FERRIS and PLOURDE (1980, 1982) examine aspects of labour dynamics and unemployment in the small-scale fisheries of Newfoundland, while MARTIN (1986) addresses the effect of the social opportunity cost of labour on fisheries in Quebec. Two common themes in research work deal with fishermen's cooperatives as a form of organization in the fishery (e.g. McCAY, 1980), as well as the role and development of fishermen's unions (e.g. CLEMENT, 1984).

While fishery labour processes and questions of employment have been studied by both economists and social scientists in North America, there remains, I believe, considerable scope for multidisciplinary research in this area. In particular, there has been little success in developing predictive models of fishery labour dynamics (*cf.* the theoretical work of CHARLES, 1989). Empirical work in this area would seem to have significant value both in the formulation of long term fishery management plans and in overall regional development involving fishing communities.

5.3. Capital dynamics

There have been many studies of capital and investment dynamics in the small-scale (and larger-scale) fisheries of North America. This work comes from two rather different perspectives, those of economics and social science. On the one hand, as discussed above, the theory of fisheries economics assumes, as a central tenet, processes by which open-access common property fisheries become overcapitalized (GORDON, 1954). Hence, it is not surprising that considerable attention is devoted by economists to showing that fisheries in North America do indeed suffer from excess fishing capacity (e.g. FRASER, 1979, but compare TOWNSEND, 1985).

On the social science side, researchers looking at fishery capital tend to focus on the degree of capitalism in the fishery, and the evolution of capital over relatively long periods of time (see, e.g., SINCLAIR, 1986, and the papers in both MARCHAK *et al.*, 1987, and McCAY and ACHESON, 1987). The dynamics of investment tend not to attract much interest in this research, although factors inducing fishermen to invest (such as government regulations) are discussed.

Empirical research into investment dynamics has been carried out for Canadian fisheries by LANE (1988), with respect to trollers in the British Columbia salmon fishery, and by CHARLES *et al.* (1988) for the inshore fishery of Nova Scotia. The former is based on data collected by the Canadian government, and focusses on investment decision-making by fishermen. The latter utilizes data from the authors' survey of fishermen owning vessels of 35 to 65 feet in length, and emphasizes the interaction of investment, regulation and enforcement in the fishery. An example of fishery investment studies in the United States is that of TETTEY and GRIFFIN (1984), who examine investment patterns for American shrimp fisheries in the Gulf of Mexico, based on U.S. government data.

6. RESEARCH ON FISHERY MANAGEMENT

Research into fisheries management has likely received more attention than any other topic arising in North American fisheries. For one thing, these fisheries are heavily-managed on an international scale, and hence there are many cases to examine and much scope for criticism. Secondly, management affects fish stocks, fishing «firms» and fishing communities, thus being of interest to researchers in all disciplines. This section reviews research into the philosophy of fishery management, methods of management, and case studies of management in specific fisheries.

6.1. The Need for Management

Evidence from a variety of collapsed fisheries around the world, combined with theoretical fisheries research over the past four decades, have convinced the vast majority of North American fishermen, and fishery researchers,

of the need for management. This is particularly so in Canada, which has more of a tradition of government intervention, while in the United States stubborn hopes for «free enterprise fisheries» have faded in recent years with the collapse of several American fish stocks.

On the other hand, the need for, and desirability of, government regulation is not universally accepted as a basic premise of fisheries management. Options for management without government involvement will be discussed below. There also exists a few studies suggesting that perhaps some fisheries are best left in a relatively unmanaged state. In particular, TOWNSEND (1985) and SINCLAIR (1983) consider small-scale fisheries in New England and Newfoundland respectively, and question the use of regulatory means which limit participation in the fishery.

TOWNSEND examines the non-monetary benefits accruing from fishing and from the existence of open access to the fishery. He suggests that the «right to fish» is an important external benefit of the fishery; community stability is enhanced since fishing represents a base-line (fallback) occupation, providing local workers with some wage bargaining leverage.

SINCLAIR considers shrimp and cod fisheries in northwest Newfoundland, fisheries in which access has been limited through a licensing scheme. Like TOWNSEND, SINCLAIR is concerned with the disruption and resulting inequalities arising in fishing communities when some community members are denied access to the principal local industry. He suggests (p. 307) that «the economic objectives of licensing were partially achieved, but the social consequences...suggest limited-entry licensing is a flawed management strategy in isolated, fishery-dependent regions».

6.2. How to Manage

Even if there is a rough consensus on the need for management of North American small-scale fisheries, this is certainly not matched by a consensus on how to manage. While management objectives and directions certainly differ on the basis of conflicting ideology and fishery paradigms, an equally important dichotomy can be found between what might be called the «government intervention» and the «property rights» approaches. The former recognizes and accepts the traditional common property (and often open access) nature of fisheries in North America and elsewhere, arguing for strong central management to meet societal objectives. On the other hand, the property rights approach takes a more institutional viewpoint, advocating the creation of mechanisms by which fishermen will hold some form of property rights, and thus the fishery will avoid detrimental effects of an open access «rush for the fish».

6.3. Government Intervention

The interventionist approach has been dominant in North American fisheries. As described in section 3, fishery management in the past was principally in the hands of biologists, and the emphasis was on direct management measures to ensure fish stock conservation. Such tools as total allowable catches (TAC's), escapement targets, closed areas, closed seasons, and mesh size restrictions fall in this category.

More recently, HARDIN's (1968) «Tragedy of the Commons» has had an enormous effect on the thinking of fishery researchers. Left to their own devices, so the argument goes, fishermen will destroy any social benefits that a fishery could produce. This conclusion, based on the assumption that fishermen are individualistic and myopic profit-maximizers, has led to the widespread advocacy of measures to reduce the number of small-scale fishermen and to «rationalize» the fishery from an economic perspective. In Canada, for example, economic researchers have successfully imbedded the expression «too many fishermen chasing too few fish» into most fishery discussions. Of

course, this is partly due to the fact that such a concept also fits in with the Conservation paradigm of biologists and the management feasibility concerns of fishery managers.

Amongst fishery management techniques within the broad «interventionist» heading, the limited entry approach is perhaps the simplest and most popular in North American fisheries, typically used in combination with total allowable catches (e.g. in groundfish fisheries) or escapement targets (in salmon fisheries). Limited entry has also received the most research attention in North America (e.g. RETTIG and GINTER, 1978). Directly limiting the number of participants in a fishery essentially institutes a form of access rights, rather than property rights, and is now heavily criticized by fishery economists, since it does not necessarily avoid the over-capitalization caused by a «rush for the fish».

Economists prefer the idea of royalties or landings taxes, which in theory can induce «desirable» behaviour by fishermen, thus controlling the fishery at an economic optimum. This type of indirect regulation, although not altering the basic common property nature of most fisheries, has found popularity amongst economists, perhaps because taxes have been widely analysed in the general economics literature. Such royalties have been applied to foreign fleets fishing in North American waters, but they are virtually unknown within domestic North American fisheries, largely due to fishermen resistance.

Direct intervention to regulate North American fisheries is likely to continue, but few fishery researchers find such regulation as appealing as the idea of property rights. We turn now to this «hot topic» in North American fishery research.

6.4. Property rights

The concept of «common property» is well-established in discussions of fisheries and other natural resources (BERKES, 1985 ; CHARLES, 1988 ; CIRIACY-WANTRUP and BISHOP, 1975 ; HARDIN, 1968 ; MARCHAK *et al.*, 1987 ; McCAY and ACHESON, 1987 ; PEARSE, 1980 ; SCOTT and JOHNSON, 1985 ; WILSON, 1977). Of course, common property represents one form of property rights in which there is some form of social ownership of the resource, so that no one individual can control the overall exploitation of the resource. While the potential to over-exploit an unregulated common property fishery has been pointed out for decades (SCOTT, 1955), North American economists, social scientists, and even fishery biologists have recently become particularly enthralled with discussions of this topic.

Three approaches to the introduction of property rights into North American fisheries have been presented by researchers:

(1) a form of «sole ownership» (SCOTT, 1955), perhaps involving full property rights held by a government agency (KEEN, 1983) ;

(2) property rights allocated through a «market» or by the government to individual fishing entities (MOLONEY and PEARSE, 1979), or ;

(3) formalization of «informal» property rights already held *de facto* by fishing communities (ACHESON, 1975 ; BERKES, 1981 ; CHRISTY, 1982).

It is the latter two approaches which provide the focus of the debate amongst North American fishery researchers. Those who follow the Rationalization paradigm tend to favour a system of «individual transferable quotas» (ITQ), in which fishermen («firms») buy and sell the rights to harvest certain quotas of fish. This is seen as the ultimate solution to the open-access «rush for the fish», since it allows fishermen to choose their own level of operation, minimize their fishing costs, and maximize efficiency. To my knowledge, this system (which operates in New Zealand) has yet to be introduced in North America, although a system of non-transferable «enterprise allocations»

has found favour in the large-boat fishery for groundfish in Atlantic Canada. It appears that a quota system with some degree of transferability has just been introduced in the British Columbia geoduck fishery (The Fisherman, 1989).

On the other hand, under the Social/Community paradigm, research has focussed on showing how fisheries can be self-regulating (BERKES, 1981) or «co-managed» jointly by fishermen and government (KEARNEY, 1984 ; PINKERTON, 1987b ; 1989), if fishermen and fishing communities are brought fully into the management process. This research presents the argument that such management is more efficient than direct top-down intervention by government, since it shifts the management task to fishing communities, yet it avoids the social disruption that might be involved in establishing a market for individual fishermen quotas.

Fundamentally, then, the property rights debate comes down to a choice between instituting property rights through a market-oriented approach versus a community-based approach. Of course, neither of these is particularly prevalent in North American small-scale fisheries, where common property and direct government regulation predominate. Yet this fact has certainly not stopped fishery researchers from debating the issue.

6.5. Coping with conflict

Most North American small-scale fisheries are operating in a state of «full exploitation», with the allocation of harvest «shares» being as important as optimization of the total harvest itself. Not surprisingly, therefore, conflicts arise continually and the study of mechanisms for conflict resolution is a popular one amongst researchers. Most research in this area can be classified into two categories:

- (i) scientific analysis of the preferences held by each user group, and the development of suitable decision-making approaches (HEALEY, 1984 ; HILBORN and WALTERS, 1977), and ;
- (ii) social science research into alternative participatory decision mechanisms (BAILEY *et al.*, 1986 ; LAMSON and HANSON, 1984).

A third topic, involving social, economic, legal and criminological research on illegal fishing and fishery law enforcement, is receiving increased attention. While this topic has received relatively little attention in the theoretical literature, work in the area is being spurred on by the discovery (for example, in the Nova Scotia and Newfoundland groundfisheries) that illegal fishing and misreporting of catch levels have led to serious errors in stock assessments and subsequent management plans.

6.6. Fishery management case studies

A wide variety of fishery management examples have been discussed already earlier in this paper (e.g. section 4.2). At this point, the goal is simply to guide the reader to further references in the literature, dealing with broad management frameworks as well as management approaches in specific small-scale fisheries across North America.

With respect to overall management systems, the Fishery Conservation and Management Act of 1976 has formed a clear basis of fishery management in the United States. YOUNG (1982) reviews the successes and failures of this legislation from the perspectives of efficiency, equity, and noneconomic values. The Act led to the creation of eight Regional Fishery Management Councils across the U.S., involving state and federal marine scientists, academics, statisticians, and private researchers in a form of decentralized management. These innovative multidisciplinary councils are discussed by PETERSON and BOWMAN (1984), who note that Council duties include: the development of fishery management plans, the review of stock assessments and quota levels, the conduct of public hearings, and the establishment of any necessary scientific and statistical committees. In Canada, the broad framework for fishery management, including relevant legislation, is described by VANDERZWAAG (1983).

On the Atlantic coast of North America, RICHARDSON and GATES (1986) use a simulation model to examine management options, such as increases in minimum sizes and decreases in overall mortality, for the American lobster fishery. This work is unusual in that it examines both efficiency and distributional effects of regulatory changes. Also on the Atlantic coast, BUBIER and RIESER (1986) contrast Canadian and American management of groundfish fisheries in the transboundary Gulf of Maine / Georges Bank region, an area which has received considerable attention both before and after the World Court decision regarding the international boundary.

With respect to Arctic fisheries, LAMSON and VANDERZWAAG (1988) discuss the potential for joint U.S.-Canada management of Arctic marine resources, including the fish stocks exploited by native Inuit peoples. Papers in WESTERMEYER and SHUSTERICH (1984) also deal with Arctic fisheries and other natural resources, from a policy perspective.

On the Pacific coast, KASAHARA and BURKE (1973) provide a broad review of fisheries management approaches, while the book of GREGORY and BARNES (1939) is remarkable in showing that even a half-century ago, North Pacific fisheries were the subject of considerable multidisciplinary analysis. Other studies of fishery management in the Pacific include those of PEARSE (1982), dealing with fisheries in British Columbia, YOUNG (1983), focussing on Alaskan fisheries, and McEVOY (1986), on California's fisheries.

7. THE RESEARCH FRAMEWORK

To this point, we have considered the philosophical basis for fisheries research in North America, together with a spectrum of research results. This section presents a highly subjective view of the environment and infrastructure within which North American fisheries research takes place.

7.1. Research by governments

Both Canada and the United States have well-established government fisheries research centres. In Canada, these include the Pacific Biological Station on the west coast and the Freshwater Institute in central Canada, together with the Bedford Institute of Oceanography and the Northwest Atlantic Fisheries Centre in the east. United States facilities include the Southwest Fisheries Centre in California, the Southeast Fisheries Center in Florida, and the Woods Hole Oceanographic Institute in New England.

As noted previously, fishery research in North America has historically focussed on biological research with a conservation objective. These centres follow this pattern, focussing principally on scientific (biological and oceanographic) research, and usually undertaking basic research (e.g. on fish biology) as well as stock assessments which feed directly into the fishery management process.

Increasingly, however, the research bureaucracy has paid attention to studies (still biological in nature) dealing with improving the efficiency of the harvesting process and the quality of the end product. For example, research dealing with the salmon fisheries on Canada's Pacific coast and in the U.S. northwest has included (i) studies of fish behaviour, in an effort to predict the direction of migration and thus ensure full utilization of the stocks, (ii) studies of optimal harvesting in «mixed stock» fisheries, and (iii) work on the determinants of fish quality and of improved processing methods. This research reflects both the impact of economic thinking on research priorities, and the perceived requirement that research be «more relevant» to the fishing industry (rather than just the fish).

In Canada, a perpetual debate ensues within the Department of Fisheries and Oceans, and indeed within government research centres, over the desirable balance between «pure» and «targeted» biological research - the former

is risky, since it may or may not lead to improved benefits from the fishery, while the latter tends to be mundane and relatively unsatisfying for the scientists. It is possible to plot a changing climate for fishery research over time, varying back and forth between encouragement for basic research and pushes for «relevant» research. At present, fishery research centres, and the researchers themselves, try to achieve a careful balance - for example, promotion of scientists remains based on the production of publishable research, while project funding may well depend on the relevancy of the work. The bureaucratic structure of biological research in Canada reflects this dichotomy; researchers are part of a separate Biological Sciences Branch of DFO, but their research centres are also responsible for helping local fishery managers in stock assessments and the like.

In contrast to the considerable presence of biological and oceanographic facilities for governmental fisheries research, there are no such centres devoted to economic or social science aspects of fisheries research, and indeed existing centres usually exclude any work outside the natural sciences. Hence the amount of such research is very limited, and it is very «applied» in nature. For example, in Canada, economic studies are carried out in a different branch of the Department of Fisheries and Oceans (DFO) than are biological studies, and usually (although not always) such studies are undertaken to respond quickly (and politically) to a perceived problem. In this sense, economic research tends to be more targeted, and perhaps more «efficient», but it has not been particularly «pro-active».

The desirability of increasing the level of social science research carried out by government fisheries agencies in North America has often been pointed out, primarily by social scientists (ANDERSEN, 1978 ; FRICKE, 1985 ; LAMSON and READE, 1987). To my knowledge, there appears to be little interest in this on the part of those in the fishery agencies.

In both the United States and Canada, jurisdiction over most fisheries is held by the federal government (although this remains a contentious issue in Canada). Accordingly, the vast majority of governmental fisheries research takes place at the national level. In Canada, however, where the provinces maintain jurisdiction over aquaculture as well as land-based aspects of the fishing industry (such as processing), some work does take place at the provincial level, although to a much more limited degree. For example, the provinces of British Columbia, Quebec, Nova Scotia and Newfoundland all have their own fisheries departments, and research into such topics as the performance of the processing sector or aquaculture development can take place there.

7.2. Research by universities

North American universities are the principal sources of fishery research outside of government. While the quantity of biologically-oriented fishery research carried out in North American universities likely exceeds the quantity of social science research, universities nevertheless produce the vast majority of social science work, given the lack of attention to this area by governments. Not surprisingly, universities are home to many of the theoretical developments arising in North American fisheries research.

In the United States, university-based fisheries research and educational efforts since 1966 have been focussed on institutions selected by the government as «Sea Grant» universities (just as agricultural research is focussed at «land grant» universities.) In this way, the U.S. government has created «centres of excellence» in fishery research; the total number of such universities is 21 at present, with a further 8 institutions having major Sea Grant programs (KING, 1986).

As KING points out, «Sea Grant's strength is built upon its ability to promote interdisciplinary marine research, education and advisory activities responsive to both local and national needs». He notes further that «Sea Grant provides virtually the only research support for marine related subjects outside the traditional academic fields of biological, physical and chemical oceanography, and geology and geophysics». In fact, funding for the «targeted»

research under the Sea Grant program (e.g. \$16 millions in 1983) is much less than that provided by other branches of the government for more basic marine research (e.g. \$50 millions in 1983, provided for oceanographic research by the National Science Foundation). The variety of government funding for U.S. marine scientists is analysed in detail by SHANNON and PALMER (1986).

In Canada, government funding for university fishery research is on a more ad hoc basis. The Canadian government provides financial support for particularly relevant work directly through the Department of Fisheries and Oceans, in the form of «DFO Science Subvention Grants», although these funds are short-term in nature, and no attempt has been made to build long-term fishery research infrastructure, as in the U.S. Sea Grant universities. On the other hand, substantial generalpurpose operating grants are also available to many scientific researchers (including university faculty in the fisheries area) through the Natural Sciences and Engineering Research Council of Canada. Social scientists, however, obtain relatively limited support for specific research projects through the Social Sciences and Humanities Research Council of Canada.

7.3. Research by the fishing industry

A limited amount of research activity is carried out by participants in the fisheries of North America; this is largely done by large processing companies and by fishermen unions, and is most often accomplished through contracts with consultants or academics. For example, the large Canadian processors B.C. Packers and National Sea Products have each utilized consultants to analyse fish stock assessments performed by the federal government.

In some cases, however, union staffpersons are involved directly in research projects - the Maritime Fishermen's Union in Atlantic Canada and the United Fishermen and Allied Workers Union on Canada's Pacific coast are two such examples. The MFU represents inshore fishermen in the «small boat» fishery sector, and hence its research activity is focussed on assisting small-scale fishermen through studies of resource availability, inshore/offshore conflict, fishery development opportunities, and the like. The UFAWU focusses on the salmon fishery, drawing up their own «alternative» fishery management plans, based on research into predicted stock sizes and allocation patterns. Since the health of the environment is particularly important to the salmon fishery, the UFAWU also supports the «Suzuki Foundation», which undertakes investigations into potential salmon habitat degradation.

7.4. Participatory research?

The concept of participatory research - in which fishermen and others in the fishery sector are involved in determining research priorities and in carrying out the work - is certainly not well-established in North America. While fishermen's organizations often express the desire to participate, it is rare to achieve such involvement.

One interesting success story in this area involves a cooperative venture between the Canadian government (Department of Fisheries and Oceans) and the Maritime Fishermen's Union on Canada's Atlantic coast. This research program was jointly designed by fishermen and government to provide key biological information needed for improved management of the halibut fishery. In particular, the inshore-oriented MFU wishes to close halibut spawning grounds to large draggers, and needs the research results to support its case. Success of the program relies on small-scale fishermen voluntarily collecting biological samples from halibut they catch, and returning these to the federal government for analysis. (JOHN KEARNEY, Maritime Fishermen's Union, pers. comm.)

8. MULTIDISCIPLINARITY AND OTHER «TRENDS»

What does the future hold for North American fishery research? Given the vast quantity of research taking place in North America, this question should perhaps be the subject of major conferences and lengthy volumes, rather than a few paragraphs in this paper, but hopefully a few thoughts are in order. Before gazing at the future, it is useful to look briefly backwards.

8.1. Past research trends

Over the past several decades, North American researchers have succeeded in developing a wide spectrum of fishery theory. North American governments have used some of these theoretical tools in developing a sophisticated system of fishery management. Yet serious ecological, economic and social problems remain in many North American fisheries. This is undoubtedly due in part to failures at the political and institutional levels, but could it be that something has been lacking in the research itself?

Two possibilities come to mind. First, there has been a major focus on theoretical research in North America. This has certainly led to considerable advances in our understanding of how fish and fisheries function, but to what extent has this knowledge been applied to real-world fisheries? For example, two North American developments, RICKER's (1954) stock- recruitment models and CLARK's (1976) bio-economic models, are important theoretical contributions, with great potential for application. Yet relatively few applied fishery studies have resulted, while innumerable theoretical papers (some of them my own) have explored almost every conceivable aspect of these models. In a research environment where rewards are given for publication rather than relevancy, it is so much easier to publish theory than it is to undertake lengthy applied studies.

Secondly, there may well be an argument that all the discipline-based research output over the years has barely touched on the complex problems of a multi-faceted fishery. Is it really possible to follow the scientific method of reducing a fishery system to its basic elements and studying each of these separately? Of course, most fishery researchers have had this form of reductionist scientific training, and certainly such research is necessary, but somehow all the small details of the system are never added together to make a whole.

While the current climate for fishery research in North America may be discipline-based and theoretically-focussed, a number of research questions call out for a multidisciplinary approach. We turn now to a discussion of the barriers, the successes and the future potential for such research.

8.2. Multidisciplinary research ?

The need for fisheries research which crosses disciplinary boundaries is well-known. Since there is already an abundance of natural science research in fisheries, the push for multidisciplinary tends to involve the incorporation of social science research into fishery studies and policy formulation (e.g. ANDERSEN, 1978 ; FRICKE 1985 ; PRINGLE, 1985 ; VOILAND and DUTTWEILER, 1984).

Unfortunately, although the desire for multidisciplinary research may be expressed from time to time, there remains a variety of significant barriers to such research. Some of these are as follows:

(i) most researchers are trained principally in one discipline ;

(ii) young researchers, who may be more likely to have a multidisciplinary training, might well have difficulty in being accepted within the discipline-based environment of a university or government laboratory ;

(iii) if a researcher wishes to pursue multidisciplinary work, the number of suitable journals in which to publish the results is rather limited (although this situation is slowly changing) ;

(iv) multidisciplinary research, while undoubtedly challenging, may not be at the forefront of any one discipline, so that the researcher risks falling behind in their «home» field ;

(v) most fishery research bureaucracies either focus entirely on research in the natural sciences, or tend to separate researchers according to their discipline ;

(vi) if an interdisciplinary research team is assembled, either in a university or in government, the work may be hampered by language difficulties, until researchers learn to communicate without the comfort of their own discipline's jargon, and ;

(vii) perhaps most fundamentally, the vast majority of fishery researchers seem happiest and most comfortable within their own discipline. It could be a bit like travelling - seeing new (multidisciplinary) sights may be very pleasant for a short time, but it's nice to get home again.

As one who enjoys the figurative travelling of multi-disciplinary research, I must admit to some disappointment when I find that most fellow university academics are not particularly keen in this regard. On the other hand, there certainly are success stories, and maybe it is best to concentrate on these.

The most common form of multidisciplinary research is that which involves two disciplines. For example, the development of bio-economic modelling (CLARK, 1976, 1985) links biological ideas (particularly population dynamics) with economics (prices, costs, etc.) in a framework of mathematical modelling. This has led many economists and biologists to learn enough about the other discipline to be able to formulate integrated fishery models. Similarly, studies in fishery socio-economics (CHARLES, 1988) link together social concerns (such as work satisfaction, income distribution, and community welfare) with economic aspects (e.g. labour processes, social and opportunity costs). Recently, efforts have been made to examine fisheries in terms of the interaction of economic forces and social institutions (WILSON, 1982 ; WILSON, 1986).

While it is relatively rare for published research work to be based on more than two disciplines, see KRAUTHAMER *et al.* (1987) for an excellent counter-example involving a «sociobio-economic» fishery analysis. There are a few good examples of work involving a combination of biological, economic and social factors taking place within government fishery management agencies. In the U.S., for example, legislative requirements call for a multidisciplinary approach to fishery policy formulation (although FRICKE (1985) suggests that this requirement has yet to be fulfilled).

In Canada, the federal Department of Fisheries and Oceans has undertaken a number of multidisciplinary projects. A major Pacific coast initiative, the Salmonid Enhancement Program (SEP), was designed to increase overall salmon populations along the British Columbia coast, and has been evaluated on the basis of five «accounts» involving biological, economic and social indicators (see, for example, RANK, 1982). An interdisciplinary team with which I had an involvement aimed to analyse the set of fishery management proposals developed by PEARSE (1982) for the Pacific fisheries. This required the design of a predictive bio-economic model which also was capable of indicating distributional affects. The modelling approach utilized in that project has proven useful in other fishery situations (HOLLING, 1978). On Canada's Atlantic coast, efforts to expand interdisciplinary research have been made by both social scientists (ANDERSEN, 1978) and government biologists (MAHON, 1985), although these efforts have yet to break through the structural inertia in the research system.

In considering the scope of multidisciplinary research in North America, it is also useful to note the growth in educational programs which cross disciplinary lines. For example, the University of Washington has an interdisciplinary School of Fisheries, Simon Fraser University (British Columbia) offers a Masters in natural resource management, the University of Rhode Island and Memorial University of Newfoundland both have a variety of

fisheries and marine programs, Laval University (Quebec) now offers a new undergraduate fisheries degree, the Université du Québec at Rimouski offers a Masters in marine management, and both the latter institution and Dalhousie University (Nova Scotia) have government-funded Diploma programs in marine affairs, oriented towards students from developing nations. Hopefully, this expansion in multidisciplinary education can only help future prospects for similar scope in research.

8.3. Future Directions

There are many topics in North American small-scale fisheries which call out for a multidisciplinary research approach. At this point I will briefly mention three of these, all of which require the integration of economic, social, and institutional analyses:

(i) An improved understanding of fishermen behaviour and the nature of labour dynamics is important for long-term fishery planning. Managers need to know how fishermen will respond to new management initiatives, while planners need to determine the effects of changing fish stock abundances and changing economic conditions on fishing communities over time. To accomplish these goals, one must examine fisherman and community decision-making mechanisms (CHARLES, 1989 ; GASKILL *et al.*, 1986 ; McCAY, 1980 ; POLLNAC and LITTLEFIELD, 1983 ; WILEN, 1979). This in turn requires cooperation amongst social scientists, economists, technologists and biologists ;

(ii) The fishery production system involves the fish stock, the fishermen and the processing sector, as well as marketing and distribution activities. While analysis in all disciplines has focussed on the primary harvesting sector (fish dynamics, fleet economics, social interactions amongst fishermen, etc.), linkages amongst the various components of the fishery system need more attention. As BRETON (Laval University, pers. comm.) points out, studies of this macro-system require a multidisciplinary approach, since «disciplinary practitioners are becoming more aware of their limits when trying to grasp the overall components of the activity» ;

(iii) The important role of the fishery bureaucracy and its interaction with the fishing industry, needs more research attention. Recently, both social scientists and economists (e.g. ANDERSON, 1984 ; 1987) have focussed on the structure of management agencies and the dynamics of regulation in fishery systems. The regulatory component (including scientific research, management bureaucracy and the legislative framework) can be seen as fitting within a dynamic system alongside the fish, the fishing fleet, the fishermen and the fishing communities. To analyse this integrated system, one needs a combination of economic, social and political science methods. While biology is not at the centre of this, one also needs to understand the dynamics of the fish stocks in order to address fishermen and regulatory dynamics.

These examples provide but a few suggestions of research priorities for North American fisheries. Undoubtedly, it will prove difficult to institutionalize a multidisciplinary fisheries research approach. While the need is clear, the barriers are extensive. But looking on the positive side, there are enough researchers interested in multidisciplinary work that I have some confidence we will see much more such research in the future, even as we wait for fisheries institutions to catch up.

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