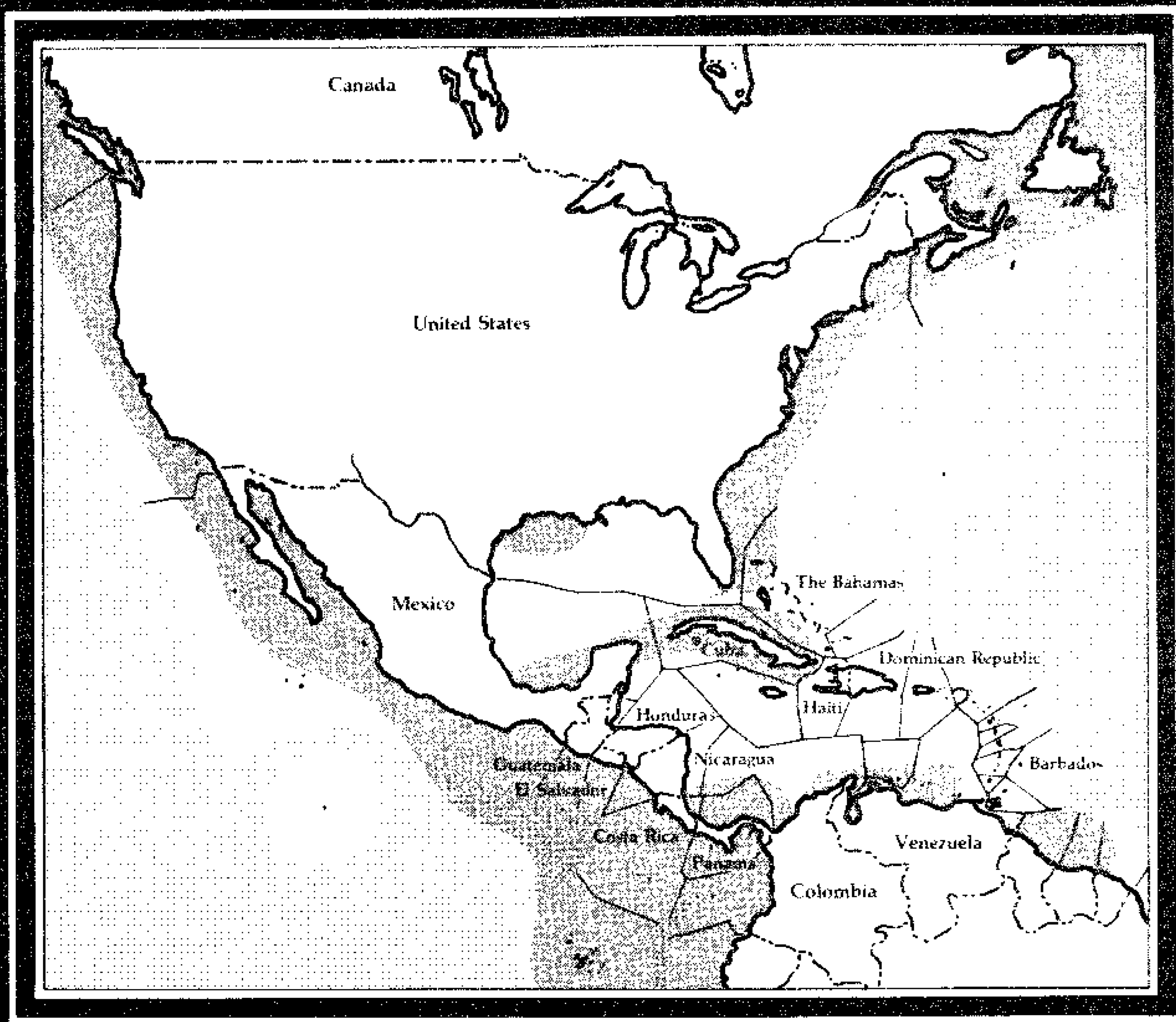
Toward Future Fisheries Management:



Some New Concepts For The 1980s

University of Wisconsin Sea Grant Institute

Toward Future Fisheries Management:
Some New Concepts For The 1980s

Proceedings of a Great Lakes Fisheries Meeting
at the University of Wisconsin-Madison
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University of Wisconsin Sea Grant Institute
Communications Office
1800 University Avenue
Madison WI 53706

Phone: (608) 263-3259

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LEGEND TO COVER MAP

Dark-shaded areas represent major fishing grounds (where phytoplankton production exceeds 250 milligrams of carbon per square meter per day). Unshaded areas of the oceans and international boundary lines extended offshore indicate the effect of a 200-nautical-mile economic zone.

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PREFACE

The papers reprinted and abstracted in this collection on the future of fisheries management were originally presented at a conference on the Great Lakes fisheries held January 14-16, 1981, at Madison, Wis. The meeting, organized and hosted by the University of Wisconsin Sea Grant Institute, was designed to bring together fishery biologists and resource managers from throughout the region to discuss the present and future status of Great Lakes fisheries.

One conference session focused on future fisheries management policies and addressed the specific question: What does management need from fisheries science? The papers reprinted here all revolve around that theme. The abstracts that follow are representative of the other themes and topics covered at the conference. While they were generated by an interest in better managing the Great Lakes fisheries at the regional level, their message is national, even global, in nature. The management of the world's fisheries, in light of the extended coastal jurisdictions of nations, requires that there be a rethinking of priorities and a fresh look at technology and science as they apply to solving fisheries problems.

At the same time, this collection of papers is being used by the Ocean Policy Committee of the National Academy of Sciences as a working paper to assist them and their Fisheries Task Force in generating scientific advice pertinent to the Fishery Conservation and Management Act and the Law of the Sea Convention. Sea Grant Programs around the country are also vitally interested and involved in these larger national issues of fishery management, so it seems appropriate for the U.W. Sea Grant Institute to publish these proceedings.

Efforts to explore this area of fisheries management and the ideas expressed in these papers are by no means unique. In the March 1981 issue of BioScience, there was a fine series of articles written by distinguished scholars that covered the issues involved in future management of the world's fisheries.

Nevertheless, we hope that this collection of papers and the abstracts that follow them will help to stimulate more thinking on this subject and help to focus the attention of fishery biologists and managers on the challenges that they will face in the years to come.

THE DIRECTIONS OF FISHERY SCIENCE

John Magnuson
Director, Laboratory of Limnology
University of Wisconsin-Madison
Madison, Wis

It is a time of scarce financial resources for the management of fisheries, of demands to provide more and more precise predictions of various management alternatives over larger regions of the globe, of the need to weigh biological management criteria against economic, political and social criteria. In this management milieu, there are many new needs in the critical relationship between fishery management and science. Some of these needs are addressed in the following papers.

Managers, for example, are asking scientists new questions with broader implications, and they are calling on a broader range of talents to help with the fisheries management task, as Ron Poff's paper reveals. We have moved past the point of managing these resources from a strictly biological point of view.

Also, when it comes to what constitutes optimum use of a fishery resource, our opinions have clearly changed, as Henry Regier points out in his paper. We are not just talking about maximum sustainable yields but also optimum yields, and Regier addresses some of the elements that need to be considered in looking at that optimum. The search to clearly specify the components of optimum use continues.

Economists have a rather clear definition of economic efficiency, but we recognize that fisheries policy and management, in practice, often do not take these economic factors into account. While a lot of "lip service" is paid to economics as a criterion for management, decisions are frequently based on other criteria instead, while little attention is given to the economic elements of fishery management decisions.

There are also new ideas that can be applied to the biological aspects of fishery management and these are exemplified in Larry Crowder's paper on cybernetics and fishery management. Are we in control of the resource? Can true control of our interaction with fish populations and communities ever be achieved? These are questions that Crowder explores.

If scientific fisheries management is to be achieved, Robert Edwards makes a strong case for the need for a new supporting cast. His rationale for a fisheries "architect" or biological engineer -- or "common sense quantifier," as Regier refers to it -- should stimulate introspection in our field.

In light of these papers and the fisheries management climate they reflect, I have a personal comment to offer. I have become concerned for the future of fishery science; by that, I mean concerned for the future development of new ideas and new levels of understanding related to the ecological basis for fishery science.

It is easy to picture a scenario in which more financial resources for fishery science go toward the application of our present technology to more stocks over larger portions of the globe, leaving fewer dollars and people to advance the science to higher levels. It is possible that in such a situation, our science will stagnate and we will leave to the next generation of those who apply fishery science the same technology we have available today.

Most of the ideas presented in these papers are relevant to this concern. The fishery "architect" to whom Edwards refers is the person who would apply fisheries science. This application should include economic efficiency as an integral part of the scheme. How precise a prediction will be then becomes a question of how expensive it will be to make the prediction more precise. Precise enough will have to replace any pseudoscientific idea of as precise as possible. The choice between a simple or complex model -- its data demands, the number of fish or environmental variables measured -- becomes a decision based on the interplay between the costs and benefits of the prediction's precision. If little thought is given to this concern, we may have few financial resources left to allocate to the advancement of our science.

The development of a fishery architect also puts new demands on those who remain in research. It will not be sufficient to grind out the numbers on another stock in another year and make yet another prediction; that is not research, that is technology. Research becomes the acquisition and testing of new knowledge, new questions, new concepts, new realism, new generality, new technique. How much of the present-day fishery science is applying the old, as opposed to seeking the new? I would bet only a small portion is involved in seeking the new.

In the search for the new, a thirst for simplicity should have as high a priority as a thirst for understanding complexities. The new technology will need inexpensive, suitably precise predictions. Are these now state-of-the-art? If so, I fear that they are not widely applied.

A number of the ideas and concepts in these papers are new, or are at least new applications of old ideas that are now crossing disciplines. To me, they point out the importance of the search for the new for all of those who are involved in the scientific aspects of fishery management.

WHAT DOES FISHERY MANAGEMENT NEED FROM SCIENCE?

Ron Poff
Staff Specialist, Great Lakes Commercial Fisheries
Wisconsin Department of Natural Resources
Madison, Wis.

What do we, as fisheries managers, need from science? Maybe sociologists, economists, attorneys and communicators, who are concerned for the fish community and the many people who enjoy the resource, can help answer our questions. This constitutes a departure from what might be expected when one asks, "What do we need from fishery science?" The departure is intentional, since others speaking on this subject are sure to address what they need of fisheries scientists. Instead, I came up with a list of questions for which I felt there were no ready answers. These are questions we are frequently asked in discussions with the public. There are some people, especially program administrators, who feel that it's important to have answers to these questions and that these benefits or costs are things to be considered when programs compete for funds.

One concern of sport and commercial fishermen is the comparative values placed on the sport fishery, the commercial fishery and the charter fishery. How valuable is the fishery in economic terms, and what terms are used? Do you talk about the purchase price of the fish as if you were to buy fish in the market? Do you talk about participation costs? What does it cost you to participate in that fishery, and is that a positive or negative part of this economic value? How about the spinoff that's involved in all of the various types of fisheries -- the jobs that are created. How much of the money that you assign as a value to a fishery is actually new, and how much is just money that's reallocated? Somebody thought I was nuts the day I said, "We're probably just taking people out of the bowling alleys over at Sheboygan and putting them down on the breakwater." Maybe I was. Is it jobs or dollars or something less tangible that you use when you talk about the economic value of the sport fishery. I know that we've got economists out there who think they've got the answers, but I haven't been able to get those answers for these fisheries yet in a suitable form.

What are the social values attached to the fishery? Several years ago, I attended a meeting in Houston that dealt with Optimum Sustained Yield, and a sociologist spoke about the social value of the fishery in Gloucester. The sociologists were more interested in maintaining the integrity of the Portuguese fishing community there than in maintaining the integrity of the ground fish fishery. But there is a social value. How do you measure those social values? Who should do it? Certainly not a fisheries scientist. What are the social values? There's social value in relaxation and catching fish.

To be a fisherman: that's a social value. Some people think it's great just to be involved with some aspect of the environment. There are aesthetic attributes of the environment, and in fishing you become aware of these: that's a social value. Someone recently talked about transitional values. I interpreted that to mean they were simply talking about the change of scene and its value to people who are stuck in an office or who are putting sheet metal screws in cars five days a week. These people get out on a lake and it's a tremendously exhilarating change of scene to them. It's a time for thought when you're fishing.

In commercial fisheries, fishing is a tradition. That's got to be a strong social value: how do you measure that? It's a regional tradition, as in Door County, Wisconsin; a tradition all over the Great Lakes area. It's also a binding force in communities built upon a long, strong history of commercial fisheries. They can say, "Hey, we're a fishing community!" -- and it means they have strong ties with each other. There's also a sense of accomplishment in catching fish and feeling that you are providing for others, and that's probably a social value too. Enough about social values.

Then you try to tie economic and social values together, and people talk about socioeconomic values. They relate them to biological values, and there's where we get into this whole business of Maximum Sustained Yield and its relation to Optimum Sustained Yield, and various people's definitions of these terms. Maximum Sustained Yield is basically what you're harvesting at the maximum rate of population growth. When you try to optimize yield, you get into some prescribed definitions in the federal laws. Optimum Sustained Yield is that quantity of fish that will provide the greatest benefit, with particular reference to food production and recreational opportunities. That amount is prescribed on the basis of Maximum Sustainable Yield modified by relevant economic, social and ecological factors. That's the legal definition on the saltwater coasts. It may not be our definition of what Optimum Sustainable Yield is on the Great Lakes. At the Houston meeting, a clearly acceptable definition of Optimum Sustainable Yield successfully evaded the discussants.

Under this area of socioeconomic vs. biological values and how you address their relationships, we have several client groups that have to be involved in the decision-making process. The question is: Should their roles be expanded? Wisconsin has commercial fishing boards -- client groups with limited rule-making authority over Lakes Michigan and Superior. In this instance, we have expanded the role of the harvesting group, and industry has become part of the management scheme. Perhaps there are other client groups who should play more important roles as well. We have advisory bodies; maybe their roles should be strengthened.

The administrative process has generated a lot of questions and created problems in and of itself that we need help with. These relate to the failure of the regulatory authority to react to fish resource changes in time to ensure that public interests are best served. We state in our policy that we will institute a resource management program that will react to the dynamic changes in the fish stocks. Yet if we want to change an administrative rule in Wisconsin today, it's going to take us nine months to do it unless we can convince people that the change is essential to the preservation of public health, safety or welfare. That's too long. In some of our fisheries, a whole year-class will be recruited to the fishery and exploited beyond acceptable levels in less than one year. In some instances, it may have been the only strong year-class in the last few years. So the time frame is wrong. Here's where we might ask the legal profession for help. Is there another way we can approach the changing of regulations governing resource harvests? Are there other processes besides rule-making available to us? Is it possible to draft a method for changing the quota on one of our critical species, which might involve making a simple calculation from a formula published right in the rules? I envision a procedure whereby fish stock strength indices collected through the winter are incorporated into a formula that would then be used to generate the new quota for the subsequent fishing year, thereby avoiding the whole long process of going through hearings. The formula would perhaps be promulgated through the rule-making process.

There's another area, too, where we need help, and we're getting some of it -- whether we like it or not, we're getting it. Who has rights and privileges to use the fishery resource? Why do they have them? Well, certainly in Wisconsin, the Lake Superior Chippewas have rights to the resource, and they retained them in treaty negotiations more than a century ago. What are those rights? That's another thing subject to interpretation. Who has been granted privileges out there? Most of us have been granted privileges by the people of the state, through its government, to go out there and harvest some part of the resource. We buy a license to do this. That's a privilege and clearly not a right in the same sense as the rights retained by Native Americans. Perhaps the differences between rights and privileges need clarification.

Every time we write a rule governing a fishery, somebody says, "You can't do that. That's unconstitutional." Are the constitutional challenges being adequately met? We need some help to be sure we're staying on the right track as far as those kinds of challenges go if we are to weather future challenges to our constitutional authority.

There's another area where we need help. We have, in managing a resource as large as the Great Lakes, interstate as well as international commitments. It's not just Wisconsin's lake. There's a boundary line out there in the middle and if you step across it with your load of fish, the Michigan authorities will chase you, and if you come back to our side, the Wisconsin authorities will chase you. The fishery is an interstate resource on Lake Michigan, and an international resource on Lake Superior. We should consider what more we can do as far as informal and formal agreements. How far do such agreements go toward solving some of our resource management problems? We should look at compacts between states as a management tool. In some areas we have used reciprocity as a tool in managing resources, or at least in managing the people who use the resources. There's more room to explore on this avenue for getting the job done.

We should also ask the communicators for some help, because another question is, "Are our clients being adequately informed on the status of the fish resources and of the fisheries?" Do they know enough about the biology of the fish species out there to be informed when they hear something from us, or are they confused? Are they really aware of how exploitation affects the stocks? I suspect they're not as informed as they should be, because we still have people who are firmly convinced that exploitation doesn't affect the stocks at all, that everything is cyclic and they can do as they damn well please out there: "Stocks will assuredly be depleted, but they'll recover sooner or later." Do these people really know on what we base our decisions or what is important to the decision-makers? We receive input at our public hearings and informational meetings, and a lot of it is flack -- meaningless input. Do the participants know how we make our decisions?

Now, what purpose will the answers to all these questions serve? They'll permit us to reflect client concerns in our management programs. They'll assist us in patterning new policies: policies must be rewritten as public interests and attitudes change. The answers should also aid us in designing and implementing new rules. And in the long run, they might allow us to move from the crisis management in which we presently find ourselves to strategic management programs. I'm confident that in Wisconsin we're about to enter a period of planned management, directed by sound policy and reflecting strong public influence.

OPTIMUM USE FISHERIES MANAGEMENT

Henry A. Regier
Institute for Environmental Studies
University of Toronto
Toronto, Canada

The term "optimum use," as a general objective or goal in renewable resource management, came to be used with increasing frequency as the 1970s progressed. Some proponents may have perceived it as an amalgam of a number of more specific goals. "Conservation" served such a role for much of the present century; as a slogan it is apparently foundering under the dead weight of too many accretions of subgoals and innumerable connotations, with some inconsistencies within the set.

Terms like "conservation" and "optimum use" are like multifaceted, evolving semantic complexes (see Rothschild and Roales 1979). They are often used to specify broad policy goals of somewhat heterogeneous elements. They can be used as political slogans, and certainly "conservation" has long been used in this way. Some politicians have linked "conservationism" with "conservativism." During 1980-81 the government of Ontario, dominated by the Progressive Conservative Party, used the sequence "Preserve it, Conserve it!" in official advertisements. Opposition politicians scorned all statements that no subliminal connection was intended.

"Optimum use" is an amalgam of concepts that have been derived from various sources:

-- It usually involves a ranked order of a specified limited number of uses that can be jointly accommodated, as opposed to haphazard use by an indeterminate number of users (open-ended multipurpose use) or to unregulated single-purpose use (by some powerful vested interests).
-- It is usually oriented toward a goal specified more or less explicitly in socioeconomic as well as biophysical terms.
-- Sometimes the mathematics of optimization are applied directly to specify goals or programs to achieve them; then "optimum" is used in place of "best," because the latter word is likely to be perceived as more value-loaded than the former.
-- A new, emerging coalition of interests may adopt optimum as a slogan for a rather eclectic mix of connotations, perhaps, but not necessarily like those above.

In practice, as applied to North American fisheries management, "optimum use" incorporates at least several of the narrower, more conventional concepts listed near the top of Table 1. It tends to assign high value to "sensitive uses" of natural systems. Specifically which terms in Table 1 are incorporated into "optimum use," and how the elements are then arranged in order of practical importance, seems to vary from jurisdiction to jurisdiction and from time to time. It also varies depending on the perspective of different interests within a particular jurisdiction and time period.

TABLE 1

Fourteen Political Options Related to Aquatic Ecosystems

1. Preservation of wild nature in a primeval state.
2. Restoration or renovation of despoiled features of nature to the original primeval state.
3. Rehabilitation of the more desirable wild features of despoiled nature, but not of some undesirable features.
4. Melioration or enhancement of the existing ecosystem by infusing desirable new ecological features that were not present in the primeval state.
5. Conservation or optimization of one or more human uses of the ecosystem, with each use practiced in an ecologically sensitive way.
6. Mitigation of undesired impacts of conventional human practices on ecosystems.
7. Reclamation by redirecting major natural processes for human use, such as dewatering a wetland.
8. Commercialization by organizing natural features and products for sale.
9. Urbanization by imposing modern human settlements upon some space in the ecosystem.
10. Industrialization by siting major enterprises, inevitably having ecological impacts, in the ecosystem.
11. Palliation by using other scarce resources ostensibly to protect nature, but only by token or ineffective means.
12. Externalization of useless or harmful byproducts of human activities to be diluted, inactivated or assimilated by the natural parts of the ecosystem.
13. Degradation by utterly ignoring or willfully despoiling wild nature.
14. Abiotization or sterilization by creating a nonnatural development that might consist entirely of nonliving or "abiotic" structures of concrete, glass, steel, plastic and similar man-made materials.

Source: Regier et al. 1980.

Most of the concepts/slogans in Table 1 have been addressed by "quantifiers" whose mission is to generate uniquely definitive advice to decision-makers. They presuppose that numerical information is better, or at least more convincing, than nonnumerical. To effect a degree of closure on difficult problems sufficient to permit the elaboration of quantitative formulae, simplifying assumptions are apparently always necessary. The assumptions may relate to features of a problem that are dismissed as extraneous, to abstractions of relationships retained in the problem studied, or to approximate techniques for doing complicated calculations. Sometimes the simplification verges on gross oversimplification, and then a very credulous manager is needed if the attempt at quantification is not to be dismissed as unrealistic.

For many quantifiers, the mathematical abstractions seem far more real than what busy managers perceive to be real within the hurly-burly of their everyday lives. It is only the occasional manager who fails to decline a role that would require him to remold ecological and socioeconomic behaviors to make them fit the mathematical abstractions. Politicians are even less tractable in this respect than most managers. The abstractors, at least the more perceptive among them, may feel confused and hurt.

Nevertheless, Common Sense Quantifiers (CSQs) have their places within the expert services available to managers. CSQs take a middle road between the everyday reality of the practical managers and the idealistic reality of the quantitative theorists (see Edwards 1981). It is as CSQs that we proceed here with the discussion of "optimum use."

We expect that some concept of "optimum use" will have some general currency in North America for the next decade or two, at least with respect to renewable resources management, both of the resource biota and their natural habitats. The concept will likely:

-- focus on "sensitive uses" as related to human ingestion, recreation and environmental consensus;
-- relate primarily to larger issues (goals, objectives, strategies) rather than to particular local events;
-- remain fairly complex operationally;
-- differ in emphases between jurisdictions;
-- evolve through time within jurisdictions according to changes in political parties in power;
-- provide scope for a wide variety of compromises and tradeoffs in practical application; and always
-- evade rational closure (i.e., it will remain open-ended).

The more complicated forms of quantification will continue to be perceived as providing interesting and challenging opportunities to learn and practice analytical skills. Only seldom will the more complex quantifications be accorded enough recognition to permit them to specify optimum measures that will actually be implemented in full in the world of the manager. This does not upset the CSQs, who may operate on the conviction that some intermediate level of quantification is usually "optimal." Perhaps this is as it should be. Democratic societies, and perhaps all other societies, have never attached overriding significance to quantitative measures on important matters, in spite of the trivializing propensities of today's popular media, which engender a kind of mass conditioning with respect to a variety of simplistic statistical indices. The more effective politicians and managers are those who know how to cope with the exigencies of fluctuating indices as well as with the oscillating public opinion percentages, whether these are causally interrelated or not.

Some years ago, Wilson C. MacKenzie of Canada's Department of Fisheries and Oceans examined a series of official and quasi-official documents to search out expressions of goals and principles that underlay Canadian fisheries policies then in place (MacKenzie 1974, cited in Loftus et al. 1978 with a brief summary). An economist, MacKenzie had long been a senior policy advisor within the Canadian fishery department and thus was well qualified to recognize concepts that had influenced the policies in practice.

Table 2 contains a summary of MacKenzie's list, except for the entries identified with asterisks. They all seem relevant to society's interests in aquatic ecosystems. The one entry in his list under "environmental harmony" still retained a strongly commercial bias. Naturalistic, romantic, aesthetic or other "environmentalist" goals were not part of the motivation of Canada's federal fisheries practices at the time; this has been emphasized by A.W.H. Needler (1979), long-time deputy minister of fisheries who left in the early 1970s.

Similarly, MacKenzie's list contained no direct reference to a goal on primary allocation of some fishery resources to the trade or domestic fisheries of Canada's native peoples, though this was clearly practiced in many locales. Recent events have emphasized the increasing significance of such a goal, both in Canada and the U.S.

Economists and ecologists have each elaborated somewhat different kinds of concepts and techniques in their study of man/nature interactions. They can be sorted into sets associated with the three major perspectives sketched in Table 2 (see Figure 1).

The correspondence sketched in Figure 1 between particular discipline foci and policy options is not intended to imply anything more than a strong bias. In practice, there is almost inevitably overlap among the goals. Also, the disciplinary tools have some flexibility in that they may be applied, perhaps secondarily, to issues related to the other goals. But a strong one-to-one bias does exist.

So what, then, is "optimum use"? Basically, optimum use, as a goal related to the allocation of "rights to use," is what the dominant political forces determine it should be in particular locales and in particular time periods. In Canada and the U.S., the following generalities seem to apply with respect to the primary relevance of particular policy goals and their associated disciplinary tools:

-- The larger, mostly offshore marine food and industrial fisheries are managed primarily by the policy of "material well-being."
-- Smaller, nearshore marine and freshwater food fisheries as well as most recreational fisheries, both marine and freshwater, and also the native peoples' fisheries are all primarily addressed through the goal of "cultural opportunity," which also involves maintaining ecosystems in a productive state.

TABLE 2

Goals for Canada's Fisheries
Assembled by Mackenzie

I. Environmental Harmony

A. Conservation and enhancement of the harvestable productivity of aquatic (freshwater and marine) ecosystems.
B. Preservation of all taxa endemic to an ecosystem or region.*
C. Preservation of representative ecosystems in a state as close to the primeval as practicable.*

II. Material Well-Being

A. Sustained growth in regional economies.
B. Rising returns to production factors (capital labor and enterprise) and equitable distribution of same.
C. Increased employment opportunities (quantity and quality).
D. Economic stability (including trade and monetary affairs).

III. Cultural Opportunity

A. Provision of opportunities for recreation and personal development (including education and physical and mental health).
B. Allocation of priority of harvest to native people and/or remote communities in some locales.
C. Maintenance of security and freedom (minimum social disruption).
D. Advancement of international peace and progress (national obligations to the world community).

*Not part of Mackenzie's list.

Source: Loftus et al. 1978.

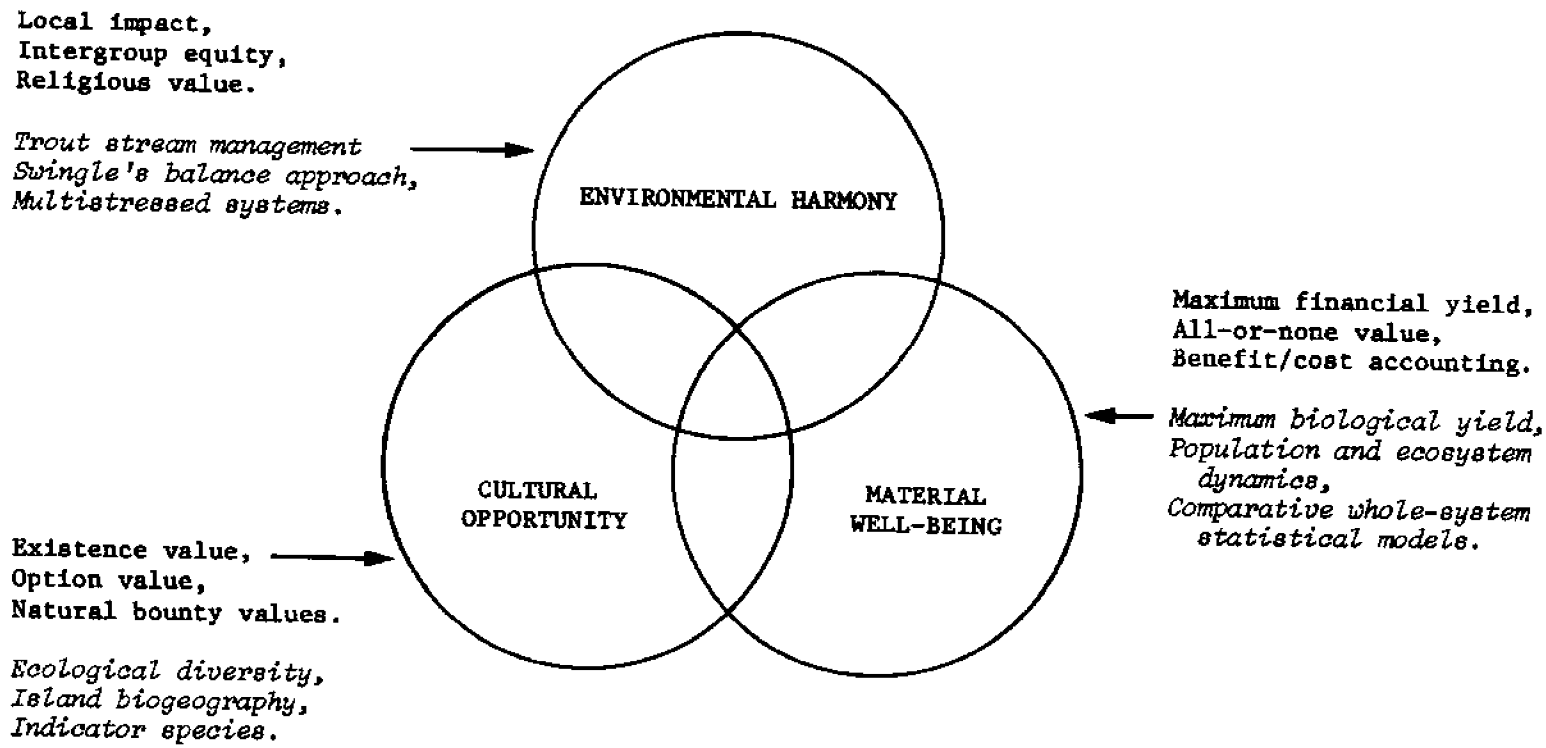

FIGURE 1. Three major policy goals, as elaborated in Table 2, showing some overlap in practice. Bracketed terms refer to economic approaches and ecological approaches (italics) as applied in management initiatives focused primarily on the relevant particular policy goal. (See also Talhelm et al. 1980 for further discussion on economic approaches.)

— Endangered species and fish of parks, especially wilderness parks, are likely to be managed according to the goal of "environmental harmony." Also, as in Ontario, the management agency may have set preservation of the resource as a first priority for all fisheries management options.

There are occasions and locales where political, economic, ecological and sociological realities might overlap to bring all of these considerations to bear. An example would be when, for cultural purposes, native people kill a few individuals of a particular rare species that has great potential application for enhancement that would benefit native, recreational and commercial fisheries. If in such situations the political process has not succeeded in specifying some priority allocation among these goals and their associated vested interests, then there is nothing much that disciplinary experts can do to resolve the conflict. The different tools of economics and ecology are all strongly biased. None of them fully transcends the basic differences between the policy goals.

But the interdisciplinary eclectic pragmatist, qua CSQ, needn't collapse in despair if the politicians have not yet managed a political resolution. The pragmatist can elaborate alternative scenarios. Then, with the judicious application of Common Sense Quantification and some simulation, light can be shed on the relative merits of the various scenarios. Such an approach might help clarify the issue for the politicians, with the result that a basic resolution, if only temporary, is achieved. This more definitive, balanced study can be undertaken using the conceptual and methodological tools appropriate to the policy priorities.

Scientific study and practical management of fisheries -- and presumably of other fields of renewable resources and the natural environment — have long been dominated by one-tool experts. Different fisheries in different locales are dominated by different kinds of one-tool experts. A consequence is that there is relatively little communication and understanding among experts on marine industrial fisheries, experts on freshwater recreational fisheries and experts on threatened species in parks.

Such parochialism is no longer tolerable, at least in situations where the political process seeks to achieve some form of optimum use with an allocation of rights to common resources among a number of interest groups that are motivated toward quite different goals. Here, interdisciplinary electicism is necessary both to help analyze some options for the politicians and, subsequently, to manage so as to achieve a specific resolution as agreed upon by the politicians.

In the process of investing the term "optimum use" with this mix of ideas, the political process has again challenged experts with new and broader demands. But experts are generally rather conservative. So it is predictable that a decade will have to pass before a majority of the then-contemporary experts will know what to do to approximate "optimum use." In the meantime, there will be some noise and confusion, generated in part by the one-tool experts.

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CYBERNETICS AND FISHERY MANAGEMENT: WHAT MUST WE KNOW TO RIGOROUSLY CONTROL FISH COMMUNITIES?

Larry B. Crowder
Laboratory of Limnology/Department of Zoology
University of Wisconsin-Madison

We have reached an era of limits. It is apparent with respect to both fish yields and fisheries management. The world fish catch seems to have leveled off, and though we are managing to increase the catch by stocking fish in some freshwater systems, such as the Great Lakes, we know that sooner or later there is an upper limit to what we can catch. As we try to be more and more precise in management to increase yields without incurring some excessive risk — of stocks collapsing, for example -- the information requirements from science, as well as social, economic and political sources, will increase very rapidly. In other words, how precisely we wish to "steer" a particular fishery system is going to dictate how much information we need to manage the system within acceptable performance boundaries. It may very well come around the other way. The limited resources available to acquire information may constrain how precisely we can manage, how detailed a control job we can do.

We often find ourselves in a mire of competing "wants" regarding fishery resources. The academic scientist often wants to know everything there is to know about the system. We all, as biologists, have some curiosity about the system, so new questions and exciting new observations constantly arise. The resource manager wants -- and needs, perhaps -- to pare down from knowing everything one could know about a particular fishery system to knowing those factors that are important to managing the system. The public usually wants results in terms of increased fishing opportunity at the lowest possible cost. Public curiosity about how biological systems work is often limited, based on the cost they are asked to pay for research. In a time of limits, we are in the position of having to separate or clarify the difference between wants and needs. That puts academic scientists and managers, in particular, in the position of having to limit inquiry from all that we would <u>like</u> to know, to what we actually <u>need</u> to know.

Systems control theory and related approaches probably constitute the most intricate approach to the management of complex dynamic systems. If, for example, engineers are launching a rocket, they monitor how far it is going off the planned trajectory and make small corrections to keep it on course. Insect pest managers have also used control theory to manage insect population "trajectories" (Tummala 1976). In fisheries management, we are probably a long way from carefully "steering" a fishery system, but control theory is an interesting approach, at least in the sense that it clarifies where we are likely to run into trouble as we try to fine-tune our management approaches.

So the question is: What kind of information would it take to manage a fishery system in the way an engineer would try to design and manage any complex dynamic system? I have chosen the Lake Michigan fish community as an example of a system that we are currently attempting to control (Fig. 1).

Essentially, the system is described by a collection of dynamic "state" variables; in the case of Lake Michigan fishes, these might be numbers, abundance, distribution or species-specific toxic chemical loads. These

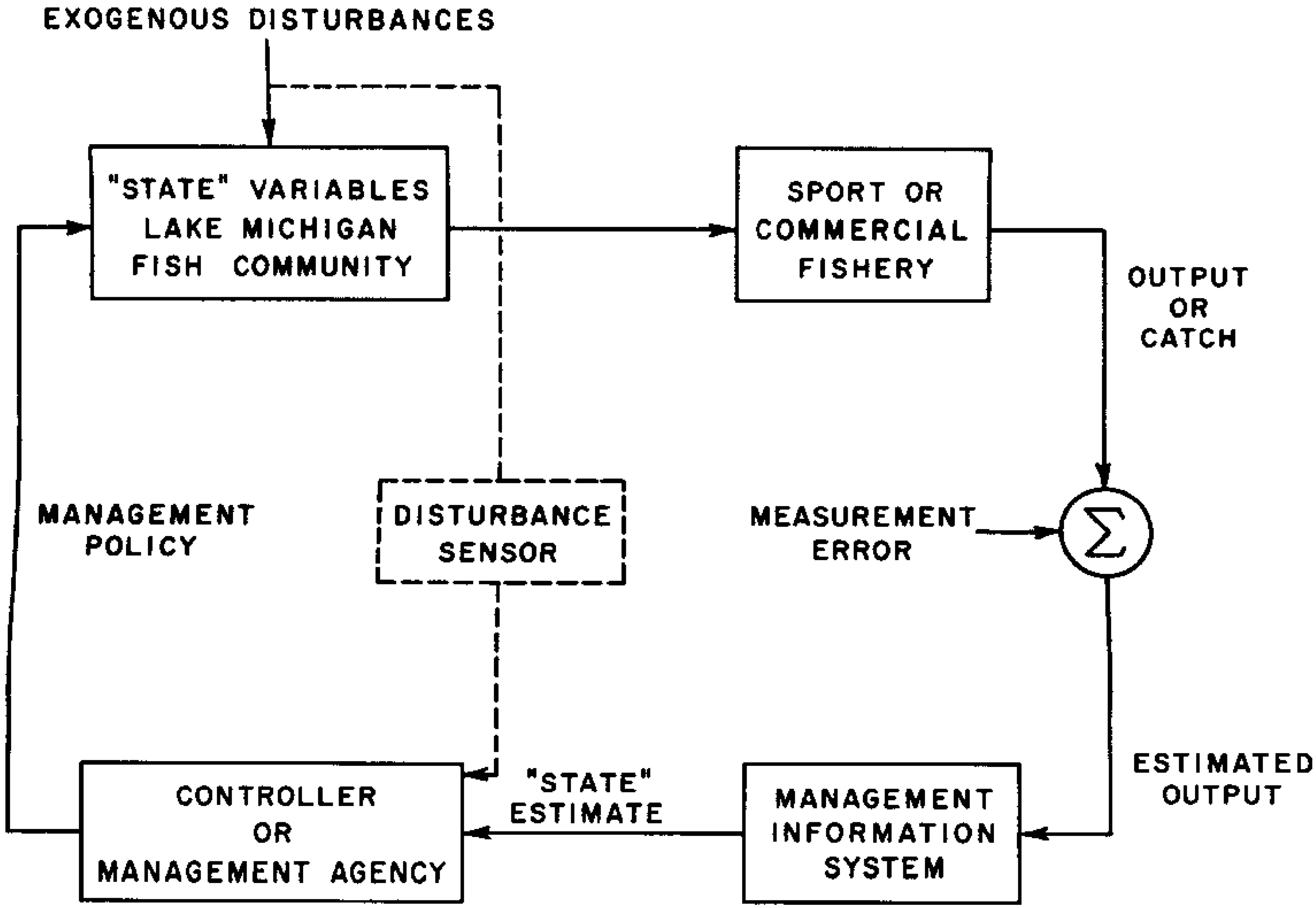

Fig 1. FISHERY SYSTEM CONTROL STRUCTURE

variables may be described by their state, which changes over time and which is influenced by management policies and exogenous disturbances. Exogenous disturbances come from outside the system and may affect Lake Michigan fish population sizes or abundances. Uncontrollable environmental variables, such as weather, are often considered exogenous factors. Part of what we consider disturbance is ignorance -- if we knew exactly how climate influenced fish populations, we could build that into our model, monitor the weather and reduce the effects of exogenous disturbances or stochastic effects on our predictions. Essentially, the sport or commercial fishery, or sometimes assessment fisheries, monitor the state of the system. They monitor the abundances of fishes or the population sizes and state output estimates in terms of catch per unit effort. Within some measurement error, that kind of estimated system output is then fed into a management information system that uses the data to infer how the system is functioning relative to desired performance criteria. This assessment then influences what kinds of policies issue from the controller or management agency. Basically, it is a simple feedback control system.

Based on systems control theory, there exists a set of constraints or limitations for this kind of control scheme. First of all, the controlled system must be modeled mathematically with reasonable accuracy. Fortunately for engineers, their systems are based on well-known physical principles and so are simple enough to develop an accurate mathematical model. We are still far from modeling the Lake Michigan fish community very accurately. A second factor is that policy inputs must be connected to the state variables; that is, managers can put their hands on the right "knobs" to effect changes in the system state. In many fishery systems, it looks like we are able to do that. This is especially true in Lake Michigan, where most of the top predators are currently stocked and lamprey are subject to chemical controls. Control theorists also assume that the system operates with random disturbances that affect the state -- we certainly have a lot of those, a lot of unknowns.

The fourth criterion is that the desired performance of the overall system, including the control system, can be stated mathematically as a set of consistent specifications or goals. We are making some progress toward getting some goals unified for the Great Lakes ecosystem (GLFC 1980). If we were in the unfortunate situation of each manager having goals for the same system that are not consistent, then it would be very difficult to agree on any desired performance criteria. Control theory also assumes a rational control-design procedure that leads from system specifications to a control policy (i.e., that we have some good management theories and experience on which to base our policy decisions).

Finally, control theory assumes that the control policy can be realized in terms of "real time" operations -- that this kind of control system or, for that matter, any kind of feedback control system can only be stable if the time lag that it takes for the controller or manager to estimate changes in a state and implement some appropriate management policy is shorter than the time dynamics of the system itself. Fishery scientists are in trouble with this assumption. Any number of reasons exist for long time lags in getting management policy changed, one of which is an institutional problem: it takes a long time to change laws. If the management or the control system has generally longer time dynamics than the system does, the control essentially gets out of phase with the system dynamics. It is like driving a car on an icy road with a three-minute time delay in the steering wheel: you're just never going to stay on track.

Within this context, what kinds of problems are there with implementing this sort of model and control system? How far are we from developing models of the Lake Michigan fish community? In terms of our understanding of biology, some of the constraints are as follows. First, recruitment relationships: Are there any stock-recruitment relationships for managed Lake Michigan fishes? Can we predict next year's alewife population from a stock assessment of this year's alewife population? We can probably agree on "no" as the answer to these questions. Further, how does recruitment relate to exogenous factors? Can we relate alewife year-class strength to climate or to water temperature or to some other variable in a way that will allow us to predict changes in alewife abundance?

A second biological constraint is the problem of spatial and temporal dynamics. Lake Michigan is obviously a very large system, and it is naive to manage that whole large system as if it is a point system. There are all kinds of spatial discontinuities, and except for some seasonal effects, I think it is fair to say that spatial and temporal dynamics are not very well known. In spatially and temporally dynamic systems, the mean of certain state variables or the mean of certain output variables may not be as important as the variance. If there is a very wide variance on the predicted alewife population size and we are interested in avoiding risks of a stock collapse, then the variance turns out to be a key element. Sensitivity analyses of models would help us determine which variables to monitor closely.

In Lake Michigan, we have experienced a series of invasions of exotic species. Species interactions, and particularly interactions resulting from exotics, have been a great source of surprise to us in the history of the Lake Michigan system. The first of these surprises is age-class interactions, which relate to my first concern — recruitment relationsips. We do not know how larger size-classes of planktivores may affect recruits or larval fishes. Second, we know little regarding competitive effects among species of planktivores, for example. We observe changes in relative fish abundance or distribution without really understanding what the underlying mechanisms are. Competition or predation or some unknown mechanism may alter system state variables, and we can't hope to predict these dynamics unless we can understand the processes that cause the observed changes.

Obviously, predation may have a profound effect on the Lake Michigan forage fishes. Don Stewart (1980) examined the increasing stocking rates of salmonid predators and, using a bioenergetics model for predator growth and consumption, asked the question, "Are we getting close to some carrying capacity for salmonid predators, or are we far from that yet?" The answer tells us whether we have a management problem or not. In other words, the information we need and how careful we must be are a function of how far we are from some limit. Stewart's analysis suggests that salmonid predators may be cropping a substantial portion of the alewife forage base.

The introduction of exotic species — the lamprey and alewife, for example -- are essentially stochastic events that would completely change the form of any model that we may have created. They may drive the system to a completely different stable point -- a completely different community composition. So species introductions are very likely to cause unanticipated changes.

Clearly, to develop a fish community model for Lake Michigan we would need more information on the ecological physiology and behavior of the organisms. In general, we need to know a whole lot more than we do now to minimize surprises. But so far, managers and scientists around the lake have done a really remarkable job responding to surprises and mitigating against damages. A tremendous alewife problem was turned into a tremendous salmonid sport fishery.

It is appearent that a very important component of this controller design is agreement on goals. The Great Lakes Fishery Commission has recently published a proposal for a "Joint Strategic Plan for Management of Great Lakes Fisheries." It will be interesting to see how we put this proposal into a tactical framework: How do we state those goals in more explicit form for a particular case? That will be the test of whether or not we can do it well.

Obviously, I have limited myself to just biological components. Management of these systems is going to have to encompass a larger ecosystem perspective, including such factors as climate, air pollution and water quality. It will also require a substantial input from user groups -- the social, political and economic aspects of the management process.

I also want to give an example of what may be an important time lag in the Lake Michigan salmonid predator-prey system (Stewart 1980). A bioenergetics model was used to estimate the impact of coho and chinook salmon and lake trout on the alewife population. Given information on the temperatures of water these fish occupy and the fish's growth rates, one can back-calculate from physiological equations how much food they had to eat to grow in the observed fashion. Then the diet shifts that occur as these fish grow can be factored in for an estimate of how many alewives they are eating.

If we were using an on-line control system, we would have to monitor alewife population size and adjust our stocking policies to follow alewife population increases or declines. If the alewife population increases, we are not in a whole lot of trouble because we can always stock more predators next year. But if the alewives should decline rapidly for any reason, we would have a serious time-lag problem. From the time we could detect an alewife population crash, there are long time lags before we could do anything about it. For example, the major influence of these salmonid predators on the alewife population comes, for coho, chinook and lake trout, two, three and five years, respectively, after we have already stocked them. In other words, salmonid predators we stock in Lake Michigan now are going to have their major effect on the forage base several years from now. In addition to that, we have a significant time lag to even assess whether the alewife populations have declined or increased. So it is difficult to determine if the alewife population is outside desired limits. Even when we find out, it may be too late to do much about it except mitigate against damages.

The recent suggestions from Carl Walters regarding "active" adaptive management (Holling 1978) are intriguing. This sort of management is experimental and allows us to learn something about the system behavior. In fact, active adaptive management may be the only way to test certain management hypotheses (Walters et al. 1980). However, if we have a management system working smoothly, there is a tendency not to take risks, not to "play with" an economically important system.

If active adaptive management is difficult to justify because of the risks, then I would consider two alternatives. The first is to attempt to model these systems mathematically and perform the perturbations on the models. In other words, if we cannot do the experiment in the field, we should at least try it out on models that are reasonable. Second, we are not exploiting passive experiments that are going on in Lake Michigan to the fullest. With every management action we take and with every natural fluctuation in the populations, we have experiments going on. They may not have all the appropriate controls, but I think there are things we can learn from them. Given the limits on what we can know -- based on finances and manpower and so on -- our most important job is to concentrate on asking the right questions.

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THE EXCLUDED MIDDLE: THE NEED FOR A NEW PARADIGM

Robert L. Edwards
Director, Northeast Fisheries Center
National Marine Fisheries Center
Woods Hole, Mass.

History will record that during the period from 1960 to 1980, marine fisheries went through an incredible and short-lived series of changes. A rapidly growing population, the need for protein foodstuffs, less-than-responsible toutings of the ocean's potential, cheap energy, and difficulty developing substantive international protocols in the ocean -- all this and more led to a rapid expansion of distant-water fisheries, grievous over-exploitation of fisheries and finally the present regime in which national purviews have been extended into the ocean beyond the traditional three-mile limit.

Those of you who follow the ups and downs of the Law of the Sea Conference (LOS) know that this activity, begun in the middle sixties, still remains to be consummated. It seems the fisheries issues are largely resolved if only because most countries of the world jumped the gun and extended their jurisdictions years ago. The LOS Conference and the activities associated with it have provided fertile discussion ground for lawyers and students of ocean law and policy for more than a decade. I feel even this activity will diminish considerably with or without agreement in the near future, just as have the distant-water fleets.

Of far greater interest to me than all the painfully obvious symptoms of "entropy," as Jeremy Rifkin[1] would say, is the dilemma posed to the marine fishery biologist who finds his traditional role and his credibility challenged. Most of your are aware that the marine fishery biologist has been under intense fire in the northeastern U.S. during the last four years. For those of us involved, it has seemed a little like early Salem revisited. The challenge is most serious in more democratic societies, but nonetheless exists everywhere. In fact, it's been occurring everywhere that "science" has been perceived to directly have an impact on man.

The problems that I am talking about, of course, can be generalized: they are those dealing with the allocation of resources. In general, the emotional content of the rhetoric has been directly related to the severity of management impacts upon the local citizenry. It is not easy to accept limits and make allocation decisions. What escapes most people is the universality of disenchantment with technical advisors of all descriptions. Thus the same ire and irrationality that exist on both sides in the U.S. can be found in South Africa, the North Sea, the Philippines, Japan and Central America.

My purpose today is not to dissect these problems. This is not a lesson in the comparative anatomy of fishery management problems. I am more interested in the management process as a living phenomenon and in its continued well being.

Accordingly, I will be addressing two interrelated scientific problems that bear on the viability of the marine fishery management process as it serves the purpose of a nation. The two problems are: (1) difficulties in the technology (information) transfer process and (2) misunderstanding the diverse roles of the scientist. Incidentally, I use the term scientist in reference to all technically trained people, be they biologists, economists or sociologists. I refer to anyone charged with the responsibility for assembling facts and figures and assaying them objectively to provide useful information to those who must make decisions for society. To show that the problems are universal, I will illustrate the issues with some European examples. The issues or questions are no different in scope than those observed in the United States or anywhere else.

The 200-mile extension -- whether viewed as an extension of the economic zone or a territorial sea -- had a severe impact on the European community of nations. Traditionally, the International Council for the Exploration of the Seas (ICES) provided needed scientific advice to the nations or commissions involved. Before the extension, all the countries involved carried out their managerial functions under the aegis of the Northeast Fisheries Advisory Commission (NEFAC). But the extension of jurisdiction made NEFAC ambiguous -- in part because of the resulting regionalization of fishery interests and control. Depending on your point of view, NEFAC may in fact be what is needed today. In any event, there are now, for example, the Baltic Sea Fisheries Commission and the European Economic Community, both of which are actively involved in fishery management. However, ICES remains the prime source of scientific advice.

The enhanced parochialism of the new fishery situation quickly brought to the surface a pervasive, subliminal unhappiness with "scientists " -- in this instance, the fisheries biologists of ICES. But the ICES is a mature community, and its reaction was to establish a forum for dialogue between scientists and managers. The first dialogue meeting was held in Copenhagen in May 1980. Following this "breaking of the ice," ICES President Dr. Gotthilf Hempel encouraged customers to comment upon ICES' advice presented in the 1980 report of the Advisory Committee for Fishery Management (ACFM). These responses were used as the basis for the next dialogue meeting in October 1980. There were many responses to Hempel's request. I appended one of them, a letter from Mr. J. Hertoft of the Danish Ministry of Fisheries to this paper (with his permission). The following quotes illustrate the flavor of the letter:

> "Is the data base available and are the methods used for assessment of fish stocks sufficiently reliable to ensure that the estimated catch predictions, and hence the TACs* based thereon, will lead to the 'agreed' objectives?...Is there any background for computation of TACs without reliable landing statistics? Has a fishery policy using TACs any future at all? Can TACs be replaced by some other management tool?
>
> "What are the objectives of the regulations introduced for the different fish stocks, and who is setting these objectives?...It cannot be a task for the scientists to recommend precautionary TACs. In doing so, they make purely political decisions with no scientific background."

*TAC stands for Total Allowable Catch.

The information transfer problem is often expressed as the need for a popular, even a comic book, version of an assessment report. This is not a laughing matter. Today's is a complex technical society. It is overburdened with data on everything affecting our lifestyles and more besides. Somehow, technologists seem to be held primarily responsible for the communication failures. Undeniably, they are inadvertently at fault for exacerbating the problem and are even directly responsible for it in some cases. Much of this is due to the fact that there are many scientific roles, and these different roles are not clearly recognized.

In the strict sense, a scientist is someone searching for new knowledge. His/her work and discoveries are tested, verbally or in the literature, against those of colleagues. It is, purely and simply, a competition of ideas. As such, the competition is vulnerable to the full range of human virtues and foibles.

Every scientist wishes for peer respect and wishes to survive in his or her chosen field of work. For the "hard core" research scientist, the goal is to move ahead the frontier of science. Introducing this level of scientific interaction into the process of making a social decision frequently serves only to decrease the probability of arriving at a reasonable decision for that particular time and place. It generally frustrates the nonscientist and enhances the impression that scientists are arrogant and unresponsive to the needs of society and that they are trying to dictate society's objectives.

My grandfather on my father's side was the chief engineer for the American Bridge Company many years ago. One of his projects was the George Washington Bridge. It was his responsibility to implement a socioeconomic decision to bridge the Hudson River. He had a responsibility not unlike that of a staff member of a fishery management council or a member of a fisheries ministry charged with establishing fishery management protocols. My grandfather concerned himself with delivery schedules, quality control, safety and other such things associated with building the bridge. He was not, in this role, a scientist; he was the man who implemented the decision to bridge the Hudson River.

The bridge was designed by a firm of architects. Designing bridges and buildings often starts with in a competition among architects to see who will come up with a cost-effective, aesthetically pleasing solution to a carefully defined need.

Is the architect a counterpart of the scientist? An architect may be an artist, but is not a scientist. Architects are constrained to design structures that meet specific needs. They work within the generally agreed upon "state of the art" when it comes to the qualities of building materials and an understanding of design constraints as they relate to such things as loading, response to environment and energy efficiency.

The "research" is done in engineering handbooks and trade publications. The "scientific" work took place earlier in the laboratory (e.g., National Bureau of Standards), in private industry (e.g., companies that tested and documented the characteristics of the materials they produce) and in the university (e.g., design studies, development of new materials).

One assumes that the architect is sure that every component part recommended has been appropriately tested and that data exists for its breaking strength, modulus of bending, aging characteristics, temperature responses and so forth. Each of these attributes is documented somewhere, using standard statistical procedures. It is understood that the architect did not do any of this work but assumed responsibility at the point at which he recommended new combinations of materials and new design solutions. Society understands the architect's role fairly well and, as a consequence, the scientist in this mix is seldom visible and his advice is not sought.

Although invisible, the scientist is there in the sense that the architect's craft depends upon data developed and presented in handbooks, technical papers, seminars and textbooks. Much of this material is presented and analyzed in exactly the same manner as is biological or economic data. The same statistical procedures are used to provide estimates of confidence (precision) and the same problem exists when it comes to dealing with the aspect referred to as accuracy. Since safety is so obvious a factor of concern -- falling bridges are not desirable -- the designer pays attention to the probability of materials not living up to the "average" expectation and builds in appropriate safety factors. As it turns out, many of the failures that do occur are usually related to a lack of quality control at the factory or to construction shortcuts, rather than to a failure to build in the appropriate safety factor. Building in this safety factor is an accepted procedure and is defended, if necessary, by the designer, not by the scientist in the National Bureau of Standards.

The architect is hired for his skill and judgement; he is hired to convert technical data into a product uniquely designed to meet society's needs.

In passing, it is worth noting that the data available to a bridge designer has been developed under ideal circumstances, relatively speaking. Fisheries data doesn't come as easily. The data will never be as precise and will never be amenable to repeated testing because it is always changing. Nonetheless, the average value estimated for any particular situation (given that it is accurate) has an equal probability of being right or wrong whether it is the breaking strength of a cable or an estimate of stock size. In a difficult fishery allocation situation, building in an appropriate safety factor for biological data requires the judgment of a Solomon.

Face-to-face exchanges between decision-makers and scientists often create intractable communication problems. To communicate data, the technologist is obliged to trivialize it -- by that, I mean to present a multidimensional situation two-dimensionally. This type of presentation is often too arcane and is resented for that reason. As soon as it is recognized by his audience as a gross simplification, the scientist is accused of "talking down to us."

The architect serves as a technology transfer mechanism -- what I refer to in fisheries as the "excluded middle." That role, or paradigm, hasn't yet taken form in our fishery management activities. It requires a background and training as sophisticated as that of the architect. Unfortunately, there is as yet no clearly established reward structure for such individuals. The function is beginning to take shape in the fishery management councils and in ICES with respect to the ACFM (Advisory Committee for Fishery Management). Universities are also beginning to perceive this need and are moving to define such a paradigm; later it will be possible to develop an appropriate curriculum.

To date, this function has been served by putting fishery scientists into these "architectural" positions. Lacking a clear perception of this new role, these individuals tend either to continue in the mode of a fishery scientist, or to serve the public interest as they see it, usually making the mistaken assumption that their particular expertise is relevant. Under these circumstances, they will recommend such things as total allowable catches without specifying the rationale or having stated objectives from decision-makers. Thus, the ACFM and various other technical advisors are seen as providing advice "for the greatest good, for the greatest number, for the greatest length of time." At times, they are seen as adopting an arrogant definition of the public interest — that is, "what men would choose if they saw clearly, thought rationally, and acted disinterestedly and benevolently."[2]

Such generally accepted definitions of the public interest imply that clear and unambiguous goals exist for society. Everyone knows they do not:

- Fishery biologists concern themselves with "maximum sustainable yields," multispecies models, overfishing, etc.

- Economists talk about "net social benefit" and tend to extrapolate their studies to indicate limited entry as the only solution to fishery problems.

- The consumer wants quality food at minimal cost.

- The businessman wants his profit.

- The fisherman wants his freedom — and so on.

Clearly there are few, if any, generally accepted concurrent goals for society.

We need to put the scientist back in the role of being a scientist. He or she should be concerned with improving stock size estimates, understanding stock recruitment relationships and improving the ability to project population changes far into the future. The scientist should be neutral and make no value judgments. Scientists are not necessarily any more objective than anyone else. Value judgments are often the bases of social decisions and are expressed at polling places, public meetings and legislative sessions. As one cynic said, "Man is characterized by his ability to be objective about everything but himself."

Under the present circumstances, advisory committees and individual technical advisors that serve as an interface between scientists and society at large have two options.

The first is to try and reflect society's needs when they provide advice. This is not only impractical, but also intrudes upon the purview of other properly constituted institutions to deal with such problems. It suggests that those individuals or committees can fully appreciate and represent all points of view. At one point during the ICES dialogue meeting, one of the ministers remarked that he very much wanted to know what a particular biologist thought as a biologist, not as a person. This made the point rather well.

The second option is to restrict the purview of technical advisors and committees. The very first restriction would be that they behave strictly in a neutral manner and only go beyond a simple, straightforward description of the state (economic, biologic, etc.) of any particular fishery resource and its social ambiance when explicit goals or objectives have been stated by the appropriate decision-maker.

If you agree, then we have no option but to establish a new role -- that of the fishery management engineer (architect), or Common Sense Quantifier (CSQ), as Henry Regier would say.[3] It should be emphasized over and over again that such advisors must have a clear statement of needs before they can carry out their activities. Establishing such a position does not solve the problem if the needs are not clearly defined.

I have presented these ideas to several groups and in every instance have been asked certain questions. I will comment briefly upon the topics addressed.

Not surprisingly, I have been asked to define the role of the federal scientist. Scientists range in roles from those who study a particular subject because it interests them (whether or not they have support from anyone) to those who carry out programs that are totally defined in advance by someone else. For the most part, our work within the National Fisheries Service is at that latter end of the spectrum. We are responsible for carrying out work relevant to particular situations in which there is a need to either make a decision, or provide advice to the public. Scientists in this mode are constrained to be somewhat conservative in their approach. As much as possible they need to avoid getting into the "competition of ideas." The advice they provide must be recognized as being based on generally agreed-upon scientific principles. It can't be so far out or process-oriented that it is perceived as irrelevant or "nice to know," as one administrator put it. This tends to put the government scientist in a difficult position. He or she is expected to maintain credibility by engaging in hard-core research and, at the same time, work full-time on the more mundane, less imaginative, strictly operational kinds of research that are deemed necessary.

There is no simple explanation of why technical people are so often resented. Remember the statement I mentioned earlier, where someone remarked that he wanted to know what a particular biologist thought as a biologist, not as a person. Contained in that comment is the implication that the biologist has some control of events as a consequence of what he says. The most articulate statement concerning control was made by Professor John McKnight in an article he wrote on the The Medicalization of Politics.[4] I have quoted part of this article below. To put it into our frame of reference in this paper, substitute the word "biology" for "medicine" as you read it.

"Viewed in these terms, the essential function of medicine is the medicalization of politics through the propagation of a therapeutic ideology. This ideology, stripped of its mystifying symbols, is a simple triadic credo: (1) the basic problem is you, (2) the resolution of your problem is my professional control and (3) my control is your help. The essence of the medical ideology is its capacity to hide control behind the magic cloak of therapeutic help. The power of this mystification is so great that the therapeutic ideology is being adopted and adapted by other interests that recognize that their control mechanisms are dangerously overt. Thus, medicine is the paradigm for modernized domination. Indeed, its cultural hegemony is so potent that the very meaning of politics is being redefined.

"Politics is interactive — the debate of citizens regarding purpose, value and power. But medicalized politics is unilateral -- the decision of the 'helpers' on behalf of the 'helped'...

"Politics is the act of reallocating power. Medicalized politics mystifies the controlling interests so that their power is no longer an issue and the central political question becomes one of increasing the opportunity to be controlled....

"A political society, peopled by citizens, will certainly find a need for a limited, valuable craft called medicine. That legitimate craft will be the result of whatever remains of modern medicine when our people have healed themselves by rediscovering their citizenship."

This is a delightful and articulate way to express the problem. Obviously there is a lot of good faith on both sides of the issue. In most instances, I am sure that the quotes overstate the seriousness of the problem. Nonetheless, the natural tendency for technically trained people to accept power and to use it according to their own perspective is a significant part of the problem.

To some degree, the role of the "architect" in the fisheries area has existed in the form of consultants hired for their expertise, much as the architect is hired. However, there are very few of these individuals. More often than not, their services are sought by fishing interests in other countries. To a limited degree, the role also exists in the private sector. I question whether the need is sufficiently great in our country to support very many of these individuals or enterprises, but it is certainly one solution to the problem.

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APPENDIX A: Text of a Letter from J. Hertoft to G. Hempel, President of the International Council for the Exploration of the Seas.

Denmark

26th September, 1980

Dr. G. Hempel
International Council for the Exploration of the Seas (ICES)

Dear Professor Hempel,

In your letter of 29 August 1980 you ask "customers" to draw attention to questions, which they would wish ICES to deal with in the next ACFM Report and to suggest any further improvement, which they think could be made in the Council's procedure for providing advice.

We are all aware of the fact that the advice given by ICES on fisheries management and the way this advice is used by the administrations is far from satisfactory as a basis for present and further fisheries policy.

Therefore we would like to suggest that the following questions be discussed at the meeting:

1. Is the data base available and are the methods used for assessment of fish stocks sufficiently reliable to ensure that the estimated catch predictions, and hence the TACs based there on, will lead to the "agreed" objectives?

   A. Fishery statistics in several countries are rapidly deteriorating because landings are not reported, or more often are reported as originating from a different area or as being of a different species. Basically, the state of affairs is brought about by a quotation system with its implicit invitation to cheating. Is there any background for computation of TACs without reliable landing statistics? Has a fishery policy using TACs any future at all? Can TACs be replaced by some other management tool?

   B. In recent years there have been a number of "embarrassing" revisions of recently-decided TACs. Is this due to the fact that early estimates of year-class strength are much more difficult than they appear to be from the ACFM reports. When doing catch prediction the scientists have to estimate the present (or recent) fishery mortality rates. Is ACFM confident that the methods used for this are so accurate that they allow for recommendations often appearing as a single figure TAC?

2. What are the objectives of the regulations introduced for the different fish stocks, and who is setting these objectives?

There seem to be three causes for introducing a TAC of a fish stock as a means of fishery regulations.

A. To prevent the stock from going extinct and, of course, to bring it back, if it is already going extinct. Under single-species management it is an indisputable goal to bring a depleted stock up again. Indisputable, because losses to other fisheries caused by the necessary management measures (mixed fisheries problems) and the conflicts thereby created are often deliberately neglected. This, obviously, should not be so.

B. To shift the stock size from one steady (or reasonably steady) level to another in order to increase total catch and/or the catch per haul. The ACFM has been taking for granted that this is politically desirable, an attitude already criticized at the previous dialogue meeting. Alternatives are apparently not much discussed.

C. As a precaution against a development whose direction is not known. In the absence of data to assess a fish stock the ACFM has sometimes recommended a precautionary TAC computed as the average catch over the last few years. In other words, it is recommended to stop further development of the fishery. There may be legal reasons for adopting TACs in order to prevent, for instance, certain nations who are not allotted quota, to take part in the fishery. However, it cannot be a task for the scientists to recommend precautionary TACs. In doing so, they make pure political decisions with no scientific background.

D. ICES continues to give advice based on single stock assessment. The fact that effort exerted on one species causes mortality on other species too, and the problem, whether developing and maintaining large stocks of predatory fishes is actually in the interest of the fisheries was never tackled by ACFM. Then administrators are still facing the illusion that each species can be managed as if other species did not exist.

3. How can the problems mentioned under items 1 and 2 be tackled?

There is no straightforward answer to this question. However, it is of utmost importance that the problems are recognized. One way to ensure that this is done may be to ask ACFM for a full specification of the basis of each TAC, which is stated in its report. (An example of a possible "questionnaire" to ACFM is appended).

If such a procedure is introduced the work load of the scientists will once more be increased. This, however, may lead to a better understanding of the shortcomings in the advice that ICES provides for 80-100 fish stocks and hence lead to considerations of how to put research work needed in order of priority.

Yours Sincerely,

J. Hertoft
Danish Ministry of Fisheries
Denmark, Copenhagen

Questionnaire to ACFM:
Proposed specification of background information in relation to TACs.

To be given for each stock

1. The political objectives on which the TAC is based

2. Evaluation of the data base

   (a) Source of errors
   (b) Magnitude of errors
   (c) Their consequences for the estimation of TAC

3. Insufficiency of the methodology

   (a) Source of errors
   (b) Magnitude of errors
   (c) Their consequences for the estimation of TAC

4. Estimated TAC

5. Summary of ACFM's judgment of the validity of its advice

6. Future research needed

SELECTED ABSTRACTS FROM OTHER PAPERS DELIVERED AT THE GREAT LAKES FISHERIES MEETING AT THE UNIVERSITY OF WISCONSIN-MADISON JAN. 14-16, 1981

U.S. FISH AND WILDLIFE SERVICE PROGRAMS IN THE GREAT LAKES

The Service Management Plan was approved in June 1980 and is the principal planning document through which the Fish and Wildlife Service communicates its purposes, goals and policies to other agencies and the public. The primary mission of the service is to "provide the federal leadership to conserve, protect and enhance fish and wildlife and their habitats for the continuing benefit of people."

The FWS shall strongly support the continuation of the traditional role of the states in the responsibility for and the management of fish and wildlife, with the exception of FWS lands, which are a responsibility.

Indian tribal governments have primary and traditional responsbility for the management of fish and wildlife on reservations, and also have authority to regulate tribal members in exercising off-reservation treaty rights. FWS has trust responsibility to assist tribes.

The FWS has identified 78 "Important Resource Problems" nationwide. Acid rain ranks 10th on that list, and 11th is freshwater fishes and fish habitat -- the Great Lakes.

FWS objectives for the Great Lakes are to participate in the development of the Strategic Great Lakes Fishery Management Plan, control sea lamprey populations to no more than 10% of their 1958-60 level, increase annual hatchery production to a predetermined level of lake trout as required by the Great Lakes Fishery Management Plan, and increase lake trout populations in Lakes Huron, Michigan, Ontario and Superior until naturally produced trout comprise 50% of the populations.

Hatcheries in Michigan (Jordan River, Pendills Creek and Hiawatha Forest) produced nearly 9 million lake trout in FY80, one-third of which were stocked on off-shore sites. We will have the capability to increase off-shore stocking to 50% in 1981. The Iron River National Fish Hatchery in Wisconsin is under construction and will provide an additional 3.5 million lake trout for stocking in the Great Lakes beginning in 1983.

The Genoa, Wis., Hatchery Biologist's Laboratory is instrumental in maintaining the Great Lakes Fish Disease Control Policy through a multi-agency effort involving federal, state and private hatcheries. The FWS intends to remain a strong supporter of the Disease Control Policy and is now in the process of developing cooperative agreements with all concerned states.

John W. Quam
Assistant Area Manger-Fisheries
U.S. Fish and Wildlife Service
St. Paul, Minnesota

PROGRESS AND PROBLEMS RELATED TO THE GREAT LAKES FISHERIES - MINNESOTA

The State of Minnesota has in its boundaries only 4 percent of the Great Lakes water area, but this includes 2 million acres of Lake Superior, a rocky, precipitous basin perimeter considered to be one of the state's most unique resources. Local fish species are typical of the cold, oligotrophic nature of these waters and have provided a fishery that in recent years has suffered from many of the same problems occurring throughout Lake Superior.

The more noteworthy problems are centered around the rehabilitation of the lake trout and lake herring fish populations. In the case of the lake trout, the apparent relationship between heavy stocking rates and survival of juveniles has shown that a buffer from sea lamprey predation must protect the juveniles to obtain survival. Fry stocking of lake herring is being attempted to restore this population, yet the relationship between the herring and rainbow smelt is not well understood. In either case, our goal is to attain self-sustaining populations of such a size as to support a significant fishery. A steelhead population supplemented by chinook salmon is the goal of our state's sportfish management planning.

It is hoped that present research will provide an improved strain of Lake Superior lake trout for brood stock, as well as better strains of steelhead trout for the sport fishery. A creel census is underway to assess the sport fishery harvest, but there is need to determine the economic value of the sport fishery. Similar information is needed for the commercial fishery. The relative worth of this renewable resource is sorely needed to give proper perspective to the fisheries of the Great Lakes in view of the continuous threats to their existence.

From the state management viewpoint, Sea Grant research and extension can assist in many areas where such expertise is lacking or inadequate. To avoid unnecessary duplication and promote complementary work, joint planning and cooperative studies cannot be overemphasized. Research and other data has been collected on the Great Lakes for over 30 years, and any new studies must be planned on the basis of available information.

The fisheries agency clientele, the commercial and sport fishermen, can also benefit from extension educational services. States are normally deficient in such services, which include clinics, publications and current advisories that benefit fishermen, whether anglers or netters.

Minnesota can benefit from these services and others that may be available from the academic community. For example, we need to map and classify the bottom shoals of Lake Superior to identify potential spawning reefs for lake trout. Perhaps there are tools of the trade that will now produce such maps and skilled personnel to provide such data. Identification of fry two years after stocking is sorely needed by biologists attempting to evaluate the success of fry stocking.

Fisheries resource managers depend heavily on management-oriented research and generally invest a significant amount of their budget toward that end. We turn to research biologists for solutions to biological problems and place our confidence in their approach to deal with each. For this reason, it is imperative that other researchers dealing with fish management problems work closely with these individuals.

Finally, the geopolitical problems facing Great Lakes fishery managers may pose a new venture in the form of post-educational training of fisheries workers. Strategic planning, involving interjurisdictional approaches to deailing with lake-wide fisheries issues, are presenting new challenges, a newer dimension of fish management.

Jerry Keuhn
Chief of Fisheries
Minnesota Department of Natural Resources
St. Paul, Minnesota

NEW YORK GREAT LAKES FISHERIES MANAGEMENT POLICY

New York's Great Lakes fisheries management policy is to develop the best possible sport fishery to meet public, economic and recreational needs and develop a controlled commercial fishery compatible with the sport fishery. Program justification is based on the tremendous economic potential of the sport fishery ($100 million estimate), recreational benefits and associated public support for environmental improvements.

Only three of the 50 states have more surface freshwater than New York, thanks to our Great Lakes' holdings (75% of our supply). Historically, state and federal fisheries agencies and the public have mostly ignored the tremendous fisheries potential of these waters until recently. Meanwhile, other users -- such as navigation, power, chemical, steel and other industrial interests -- have changed, degraded or destroyed much of our original aquatic resource base, due primarily to lack of public recognition of the importance of the Great Lakes. Today the most serious challenge facing Great Lakes resource managers is stopping environmental conditions. Other, more specific problems are the need for continued sea lamprey control, adequate stocking, public access, adequate private enterprise support facilities, funding for necessary research and other activities to meet those needs, and above all, continued public and legislative support for the program.

Since 1968, tremendous progress has been made in recognizing, resolving or addressing the above problems. New York probably has one of the most intensive contaminant surveillance and restrictive pollution control programs in the country. We have led the fight against winter navigation and other industrial uses of the Great Lakes that haven't proven to be environmentally acceptable. We have pushed for recognition of the ecosystem approach to lakewide/basinwide Great Lakes fisheries management now accepted by the Great Lakes Fishery Commission and the International Joint Commission. We have fully participated in the development of a Stategic Great Lakes Fishery Management Plan, which provides a lakewide/basinwide planning process that coordinates environmental and fisheries management on an ecosystem scope. We now have one of the finest developing salmonid sport fisheries in the world, supported by a new Salmon River Hatchery with a 250,000-pound production capacity and federal lake trout stocking. In cooperation with the Great Lakes Fishery Commission, U.S. Fish and Wildlife Service, Canadian Department of Fisheries and Oceans, the Ontario Ministry of Natural Resources, the Pennsylvania Fish Commission and others, we have developed lakewide sea lamprey control, a lake trout rehabilitation program and a forage fish stock assessment program. Finally, through Federal Aid Dingell Johnson and Anadromous Fish research funding, we have been able to carry out the practical research necessary to develop our successful Great Lakes fisheries program. Most recently, emphasis has been placed on intensive management of warm/coolwater species such as walleye, smallmouth and largemouth bass, northern pike, muskellunge and yellow perch, particularly in Lake Erie and the St. Lawrence River. Restructuring of our commercial and sport fisheries regulations is underway, based on information derived from that research.

Above all, through exceptional cooperation from New York's Great Lakes Sea Grant staff, we have enlisted the many publics such as sportsmen's groups, businessmen, legislators (including the newly formed Great Lakes Counties' Legislative Fishery Advisory Boards) to obtain full public support for our fisheries program. This has been essential in attacking the contaminant problem, particularly in Lake Ontario. Our present policy is to continue the development of our Great Lakes sport fishery simultaneously with a full effort by all concerned to resolve the contaminant problem. Since 1968, we have been very successful in spite of the above problems in developing a Great Lakes sport and compatible commercial fishery in our Great Lakes waters that is one of the best in the world. We expect it to continue to improve in the next decade.

William A. Pearce, Supervisor
Great Lakes Fisheries Section
New York State Department of Environmental Conservation
Albany, New York

WHAT DO SPORT FISHERMEN WANT FROM THE GREAT LAKES FISHERY?

1. Maintain a management program that will provide the opportunity for reasonably satisfactory catches by sport fishermen. There should be a mix of species that provides a long season, with fish available both to shore and boat fishermen. More fish should be available where the fishing pressure is heaviest.

2. Continue to improve communications between those responsible for management of the fisheries and sport fishermen. Participation in meetings -- such as the present one sponsored by UW Sea Grant -- should be encouraged. Sport fishermen are eager for information about present and future programs related to their favorite form of recreation. Keep in mind, always, that effective communication is a two-way street.

3. More recognition of the economic value of the sport fishing industry. The market value of the catch does not reflect the true economic value of the sport fishery. We believe it is a reasonable estimate that more than one million sport fishermen on Lake Michigan spend $350 million annually for their favorite family recreation.

4. More recognition of the social and human values of sport fishing. The need to find satisfying family recreation closer to home is becoming more urgent as the fuel crunch increases. Great Lakes sport fishing is within easy reach of some 40 million persons in the Midwest.

5. Better interstate and interagency cooperation. With the proliferation of current budget-trimming trends for government agencies, it is imperative to derive the maximum efficiency from funds that are available. If one state or agency can produce coho salmon (or some other desirable stocking species) at a lower cost, other states should consider purchasing stock from this tate, if possible. Better coordination of research could lead to greater cost-efficiency through avoiding duplicated effort.

6. More involvement of sport fishermen in fishery management. There appears to be a lack of representation of sport fishermen on the various boards and advisory groups related to management of the Great Lakes fishery. While not fishing for profit, sport fishermen are vitally concerned with the future of the Great Lakes for the welfare of present and future generations.

7. Better law enforcement. Violations of fishing regulations -- by sport or commercial fishermen -- are harmful to the management of the fishery and an affront to law-abiding citizens. There will never be enough law enforcement officers to patrol the waters of the Great Lakes adequately to apprehend violaters, so public support should be enlisted. Michigan's RAP program (Report All Poachers), for instance, seems to be producing desired results.

Eldon Robbins
Great Lakes Sport Fishing Council
Milwaukee, Wisconsin

PUBLIC POLICY CONSIDERATIONS IN FISHERY MANAGEMENT

In his talk, Virgil Norton focused on some of the public policy issues related to fishery research and management. He said that in some cases fishery research has been "sold" or justified on its immediate applicability to fishery management needs, but this has been misleading. In most cases, scientists are not able to answer the questions that contribute to short-term decision-making of the kind done by the regional fishery councils. "Let's not argue for [multispecies] models on the basis of how they contribute to immediate fishery management decision-making," said Norton, "but on the basis of how they contribute to scientific knowledge in general." He said that scientists shouldn't get caught in the "tidal wave" of tying every piece of research to current management questions, or they will lose out in the long run. They have to be more concerned about public policy.

In looking at public policy related to fishery management, Norton said that we have to consider what we expect our management approaches to yield. Many have argued for government action to ensure economic efficiency, he said, but government involvement is not always the best answer. The government may be going overboard in terms of regulation. Regulations may protect obsolete practices or inefficient production. And, he added, each new regulation imposes costs in terms of information needs or enforcement. Also, many regulations deal with resource distribution questions, Norton said, and fishery managers shouldn't be solely involved in income distribution.

Norton added that fishery managers have to come up with rational management programs -- ones that go beyond simple questions of dollars and cents. "If we are not going to attain or strive to attain economic efficiency," he said, "what other objective can we justify? To me, it seems to be conservation, in the sense of preservation. Our function, then, is no longer economic efficiency but management to avoid eliminating a species." In conclusion, Norton asked the question, "Are we going to develop an effective management system to attain economic efficiency?" If not, he said, fishery managers should assume an entirely different public role, and that's to press for preservation of our fisheries resources.

Virgil Norton
Dept. of Agricultural and Resource Economics
University of Maryland
College Park, Maryland

FISHERY PROBLEMS AND PROGRESS: WISCONSIN SEA GRANT ADVISORY SERVICE PERSPECTIVE

The problems confronting the Wisconsin fishery stem from three main sources and can be classified as falling into the following general categories:

1. Disruption of the Great Lakes ecosystem.
2. Fish population dynamics (fish stock fluctuations).
3. Pollution and microcontaminant levels in the aquatic environment.

Each of the above problem classification areas has a direct effect upon recreational and commercial fishing in the Great Lakes and have become the focal point for UW Sea Grant Advisory Service programming.

Ecosystem modification has resulted from processes such as harbor dredging, filling marshlands, excessive silting and other types of encroachment on the aquatic environment brought about by significant changes in the Great Lakes ecosystem. This has led to losses of spawning and nursery habitat for fish in many areas within the system. These situations have helped cause and maintain the present imbalance in the fish population.

Although a great deal of controversy surrounds the proposed explanations for why fish populations fluctuate, the fluctuation of fish stocks are a threat to the stability of the commercial fishing industry and a cause for conern among recreational fishermen. Since commercial fishing depends upon a limited number of species, any decrease in the number of commercially harvested species puts undue financial stress upon the commercial segment of the industry. Likewise, poor catch rates for recreational species results in reduced participation by angler and reduced revenues for the recreation-dependent segment of the industry. As part of the UW Sea Grant Advisory Services program, attempts have been made to educate both recreational and commercial fishermen about procedures that would increase the benefits from fish harvested. This includes short courses on fish handling and processing, publications on fish technology and preparation procedures, and the use of radio to inform the general public about fish and fish use.

At present, the problem that poses the greatest threat to the Great Lakes fishing industries is that of microcontaminants. In spite of all the work that has been done in this area, little has been accomplished with respect to alleviating the pressure on the fishery. Given the present state of the art, it looks as if little can be done other than to let nature take its course.

David A. Stuiber
Department of Food Science
University of Wisconsin-Madison

PROGRESS AND PROBLEMS:
OHIO SEA GRANT ADVISORY SERVICES

The Ohio Sea Grant Advisory Services was formed in September 1978. The first agent, Frederic L. Snyder, started in October with a prime responsibility of working with sport and commercial fishermen. Materials relating to fish handling and preparation have been prepared for each audience. However, due to the huge number of sport fishermen (700,000), utilizing Ohio's portion of Lake Erie, the agent was forced to spend a great deal of time with that group. Fortunately, a research project to develop markets for underutilized species was running concurrently and allowed Ohio Sea Grant to interact effectively with commercial fishermen. In November 1980, following completion of the marketing research effort, a second Sea Grant agent, David O. Kelch, started work. One of Dave's major areas of emphasis is to continue Sea Grant's fisheries marketing objective in an Advisory Service mode by working as a catalyst between commercial fishermen and retailers and consumers.

Recently, Ohio Sea Grant has begun to work with aquaculturists within Ohio and has hired a third agent, Frank Lichtkoppler, to start in Febraury 1981. Frank's primary responsibility is erosion and shore process; however, he has an aquaculture background from Auburn University and will be called upon to assist in this area. His presence will complete our initial objectives in that all components of the fishery can now be addressed.

The completion of the agent selection process has been one of our major successes. However, almost equally important has been our link with the Ohio Cooperative Extension Service, which through its county home economists has allowed Sea Grant to increase utilization of seafood products by educating homemakers on cleaning, cooking and preservation techniques.

Our one major disappointment has been the inability to develop a large, profitable market for freshwater drum.

In summary, we are most pleased with our educational and advisory service efforts and capabilities as they relate to Lake Erie's fisheries. We are continuing to work toward greater cooperation with the U.S. Fish and Wildlife Service and the Ohio Department of Natural Resources.

Dr. Jeffrey M. Reutter
Sea Grant Advisory Services
Ohio State University-Columbus

INDIAN FISHERIES CONSERVATION AND RESEARCH

The various treaties between the U.S. Government and the many Indian tribes of the Great Lakes region established these tribes as individual sovereignties. As a result, the traditional Indian attitudes toward hunting and fishing continued through the years. Tribal members fished and hunted however and whenever they desired, with little regard for the resource. This presented no problems as long as the traditional nets, boats and weapons were used. However, when modern equipment became available and adopted, the impacts on the resources began to show.

The following comments apply only to the 10 Wisconsin reservations under the jurisdication of the Bureau of Indian Affairs' Great Lakes Agency in Ashland, Wis.

Several Wisconsin tribes recognized the need for establishing controls on the harvest of fish and game but were hampered by the lack of trained personnel, funding and most of all, strong opposition from tribal members. Within the past three years, federal funds have been allocated to six tribes for establishing conservation codes, civil court systems and conservation law enforcement programs. In addition, the Red Cliff tribe now employs a professional fisheries biologist for conducting research on trout, walleye and whitefish populations in Lake Superior.

The two Wisconsin tribes located on Lake Superior have trained tribal wardens to enforc conservation codes that apply to both members and outsiders. Red Cliff, using data collected by their fisheries biologist, sets limits and seasons for trout and whitefish, and requires tagging of trout caught by tribal commercial fishermen. The Bad River has closed the Kakagon Sloughs at the mouth of Bad River to the taking of walleyes by any means during the spawning season. The exception is that the Bad River Fish Hatchery is permitted to set nets for the collection of spawn.

While keeping a low profile, Indian conservation law enforcement and fisheries research programs are beginning to benefit the Wisconsin portion of Lake Superior's fisheries. We encourage continued cooperation and improved working relations between all tribes and the various federal and state agencies involved in conservation activities.

Charles A. McCuddy
Natural Resources Specialist
Great Lakes Agency
Bureau of Indian Affairs
U.S. Department of Interior
Ashland, Wisconsin

QUOTA WALLEYE MANAGEMENT IN WESTERN LAKE ERIE

The western Lake Erie walleye population has changed drastically in the last 40 years. There was an acute decline in the late 1950s, then an equally acute resurgence in the 1970s.

Beginning in 1966, Ohio undertook steps to reduce commercial net mortality of walleye and related species. All gill netting was stopped in western Lake Erie during that year. Shortly thereafter, a sport bag-limit of 10 walleye was established. A few years later, all commercial netting in six biologically important zones in western and central Lake Erie was prohibited. The mercury crisis in the early 1970s partially preempted and complicated the evaluation of these earlier strategies. In 1972, all Ohio commercial walleye harvest was stopped by Wildlife Order. Beginning in 1973, the Great Lakes Fishery Commission provided a forum for the development of international quota management. Ohio strongly endorsed this management strategy by passing quota legislation in 1974.

The Ohio commercial walleye harvest ban remains in effect today. A sport bag-limit of six was adopted in 1980. Quota management, however, has not been legally adopted in Ohio because the total allowable harvest is not as high as the performance of the fisheries and stock density and distribution suggest they should be. The quota concept has produced a positive effect on western Lake Erie walleye. It only remains that this effect is expanded to include related species, thus providing "collective quota management" for a fish community wherein all agency philosophies and priorities could be accommodated with minimum biological loss to all affected species.

Russell L. Scholl
Assistant Chief
Division of Wildlife
Ohio Department of Natural Resources
Columbus, Ohio

A FORECAST FOR TOXIC CHEMICAL LEVELS IN LAKE MICHIGAN FISH

Trends in the levels of DDT and PCBs in Lake Michigan fish provide a basis for projecting the response — measured as the contaminant concentration in fish — to a change in contaminant input to the lake. Data on the rate of decline of th DDT-group pesticides in Coho salmon in Lake Michigan indicates the residence time for DDT in the water column is about 1.75 years. Transport to Coho via pelagic and benthic food chains corresponds to about 80% and 20%, respectively, of the Coho body burden of total DDT prior to the ban on DDT use. Transport of PCBs and DDT are expected to be similar. Consequently, reduction of the input of PCBs and similar chemicals into the Great Lakes should result in a fairly rapid and large decrease in the concentrations present in the fish. A mass balance for PCBs in Lake Michigan indicates loss occurs mainly by sedimentation and burial. Atmospheric input is an important souce. The importance of tributary input and direct discharge are uncertain.

David E. Armstrong
Department of Civil and Environmental Engineering
University of Wisconsin-Madison

DIFFERENCES AMONG FISHES IN ACCUMULATION OF PCBS:
A MODELING APPROACH

Food habits, thermal preference and life history traits of fish influence their accumulation of microcontaminants such as PCBs. From known thermal history and observed growth data, a bioenergetics model of fish growth computes food consumed and oxygen respired for several species of Lake Michigan fishes and estimates of PCBs accumulated via trophic and direct uptake pathways. For large salmonids in Lake Michigan, diet and growth efficiency differences combine to produce differences in rates of PCB accumulation. Adult alewives, which contain relatively high levels of PCBs, are the major source of PCBs for Lake Michigan salmonids. For fish of given age, variation in weight may account for a 10%-20% difference in expected PCB concentration; but for lake trout of equivalent weight, age may account for 500% difference in expected PCB concentration. For fish of equivalent age and weight, life history differences can account for 200% (lake trout vs. coho salmon) and diet differences up to 400% (alewife diet vs. smelt diet). We present results that predict how a substitution of other forage fish for alewives in salmonid diets would reduce by more than 50% the amount of PCB accumulated by the several salmonid piscivores. Extrapolating the current rate of reduction of PCB in forage fishes yields modeling forecasts for PCB concentrations in lake trout: A 2-3 kilogram, five-year-old fish should have 5 ppm PCB in 1983 and 2 ppm PCB in 1990.

J.E. Breck and J.F. Kitchell
Laboratory of Limnology
University of Wisconsin-Madison

FORAGE FISHES AND THEIR SALMONID PREDATORS IN LAKE MICHIGAN: PAST, PRESENT AND POSSIBILITIES

Alewife and rainbow smelt dominate the planktivorous fish fauna of Lake Michigan and are now the primary food of lake trout and introduced salmonids. Fluctuations in the abundance of alewives and smelt have been a concern due to the effect on native species and because of their present role as forage species. Each has been implicated as an important contributor in the local reduction or extinction of important native species. Mechanisms for these interactions include competition for food and predation on fish eggs and larvae.

Bioenergetic modeling simulations of alewife consumption by stocked salmonids suggests that as much as one-third of the annual alewife production is consumed in some years. Increasing stocking rates of salmonids in Lake Michigan yield a predator-prey system in which the predator numerical response is relatively independent of prey dynamics. This suggests possible declines in alewife production, changes in major forage available to predators and perhaps destabilization of the current predator-prey system.

Donald J. Stewart*, James F. Kitchell and Larry B. Crowder
Laboratory of Limnology/Department of Zoology
University of Wisconsin-Madison

*Present Address: Fish Division, Department of Zoology, Field Museum of Natural History, Chicago, IL 60605

AQUACULTURE POLICY AND PLANNING IN THE GREAT LAKES REGION

A five-year effort by the aquaculture industry and administrative and legislative branches of the federal government has resulted in recent enactment of the National Aquaculture Act of 1980 (Public Law 96-369; September 26, 1980). The act's primary function is to provide for policy planning and coordination of federal activities in matters related to aquaculture. The act established an interagency "Joint Subcommittee on Aquaculture" through the Office of Science and Technology Policy; names the departments of Agriculture, Commerce and Interior as lead agencies in directing the federal effort in aquaculture, and mandates the development of a "National Aquaculture Plan," plus assessments of the economic and regulatory constraints on aquaculture. Appropriations totaling $50 million for the three lead agencies for 1981-83 were authorized by the act, but it appears that these funds will actually be included in the federal budget over the next few years in light of the Reagan Administration's announced spending cutbacks. Federal planning to date has emphasized the need for state, regional and local participation in policy development, research and funding. In response to this, the Great Lakes Sea Grant Network is attempting to formulate a preliminary plan for aquaculture development in the Great Lakes region. Participation by state and regional agencies, the land grant college system and the private sector will be essential to this effort.

Terrence B. Kayes
Assistant Director
Aquaculture Research Laboratory
University of Wisconsin-Madison

CAN NEW TECHNOLOGIES PRODUCE A SAFE, USABLE PRODUCT?

Most people familiar with the Great Lakes are aware of the many problems that affect the Great Lakes system. One such problem is environmental pollution. Although there are numerous forms of pollution, the form which has caused the greatest difficulty for the fishery (both recreational and commercial) is the presence of chlorinated hydrocarbon compounds, which are absorbed by and accumulate in fish.

Most of the chlorinated hydrocarbon compounds currently found in fish have been classified as potentially hazardous, and tolerance levels have been established to protect consumers against overexposure to these materials. Technologists have addressed the problem of chlorinated hydrocarbon residues in fish, hoping to find or develop both inexpensive and effective methods that could be used during fish processing to totally remove or drastically reduce the contaminant levels in the fishery product. To date, no effective method has been found that will meet the desired objective of reducing the contaminant level and continue to produce integrity.

If the principal objective is simply to produce a safe, usable human food product, the technology existing today could accomplish that goal. Processing procedures involving fish flesh extraction with isopropyl alcohol will effectively remove chlorinated hydrocarbon compounds with the lipid from the fish flesh, leaving an odorless, flavorless, flour-like product high in protein but having the physical properties of sand. Such a product could be used to enrich food products of low protein value, but the cost of production and available markets for it make the process prohibitive.

Another and more plausible approach to using the chlorinated hydrocarbon-contaminated resource is the conversion of the fish into industrial fishery products, such as fish meal and fish oil. By modifying the existing fish meal processes, it should be possible to produce a final product that would meet established guideline levels for chlorinated hydrocarbon residues in such products. Through the use of fish meal and oil as animal feed ingredients, the human food requirement would be indirectly met with the other food products were consumed.

David A. Stuiber
Department of Food Science
University of Wisconsin-Madison

Reports Concerning the Great Lakes Fisheries.
by the Univerisity of Wisconsin Sea Grant

Fish Spawning Grounds in Wisconsin Waters of the Great Lakes, Catherine E. Coberly and Ross M. Horrall. 43 pp. University of Wisconsin Sea Grant Institute. August 1980. $1.00.

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The Lake Michigan Angler: A Wisconsin Profile. Karl C. Samples and Richard C. Bishop. 59 pp. University of Wisconsin Sea Grant Institute. June 1981. $1.00.

The Fish of Lake Michigan. Warren Downs. 32 pp. University of Wisconsin Sea Grant Institute. 1974. 50¢

The Fish of Lake Superior. Warren Downs. 36 pp. University of Wisconsin Sea Grant Institute. 1974. 50¢

The Technology of Perch Aquaculture. John Quigley and Richard Soderberg. 42 pp. University of Wisconsin Sea Grant Institute. 1977.

For copies of these reports, contact:

University of Wisconsin Sea Grant Institute
Communications Office
1800 University Avenue
Madison WI 53706

Phone: (608) 263-3259