Centennial Lecture IV: The Historical Development of Fishery Science and Management

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Fisheries are human activities, and before discussing them I should note that I shall use the word fish to include all of the living aquatic resource organisms that are harvested by the fisheries. Also, I define fishery science as a public-service profession that includes management activities, and not just as the pursuit of scientific knowledge about the fisheries.

I propose to examine the history of fishery science and management with emphasis on the socioeconomic aspects, in addition to the biological or ecological aspects of the resources with which many of us are familiar. I do so especially because we have three kinds of fisheries, around which fishery science has developed, which differ radically in their social dimensions. These are 1) recreational fisheries, 2) commercial fisheries, and 3) fish farming.

In the first kind, when any resident of northern America goes angling in public waters, he or she usually buys a state license and pays a substantial Federal tax (10 percent) on the equipment used. The license fees for the rights to fish and the special taxes pay for most, if not all, of the public costs of management and enhancement.

Second, when any resident of northern America goes commercial fishing in public waters to catch perhaps a thousand times as many fish as the angler, he or she pays only modest "taxes" for license or landing fees on a per-fish basis, which pays very little of the public costs for research on and management of the commercial fishery resources. In addition, the commercial fishermen are heavily subsidized by both Canadian and U.S. governments, as well as much of the rest of the world, through low-cost loans, special advisory services, and unemployment insurance.

Third, when any farmer in northern America grows fish, he or she may have to obtain some special permits, but will usually operate in waters that are completely controlled by lease or ownership, and will have exclusive rights to the organisms.

Fishery scientists serve all three kinds of fisheries with similar biological studies. However, these fisheries have very different socioeconomic situations which, I believe, deserve greater understanding and attention from fishery scientists.

The difference in public costs between recreational and commercial fisheries is surprising because 1) there are more than 200 times as many anglers in northern America as commercial fishermen, and 2) the overall economic value of the recreational fisheries, with all of their supporting activities, is much greater than the value of the commercial fisheries. One might expect that general revenues rather than special revenues would be used for an activity popular among about 20 percent of our people, and that special services to less than 1 percent of our people would require some special taxes on them. But no, the commercial activity of a few is deemed important enough to require continuing transfer payments from the rest of the people; whereas, the recreation for many largely pays its own way.

After recognition of these anomalies and the difficulties of managing a resource of the commons, it is perhaps less surprising that the research on and management of the recreational fisheries is a conservation, social, economic, and political success story; whereas, the research on and the management of the commercial fisheries just may be a conservation and a social success, but it is potentially, in many circumstances, an economic and political disaster.

This situation is not unique to northern America, even though the recreational fisheries are as well developed in few other countries. The commercial fisheries (in the developed countries of the world) are almost all in a similar situation, and the subsistence or commercial fisheries of the lesser developed countries, which have had such high hopes with the new Law of the Sea, are moving rapidly in the same disastrous direction. In fact, the subsistence and the small-scale commercial fisheries, which have sustained village people for centuries, are really endangered. To afflict them with our modern development practices is a prelude to social disaster.

My assignment from the organizers of this Celebration is to review the development of fishery science and management. I shall try to do so with emphasis on the major steps that have resulted in the present situation, with the hope that we shall arrive at a clearer understanding of what lies ahead.

This would be an impossible task, had I not the benefit of several excellent histories, and I should first pay tribute to the authors and editors. They include

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Paul Galtsoff, who wrote the story of this laboratory (Galtsoff, 1962); Norman Benson, who edited the compendium on "A Century of Fisheries in North America" (Benson, 1970); Arthur Went, who prepared the history of the first 70 years of ICES, the International Council for the Exploration of the Sea (Went, 1972); Kenneth Johnstone, who wrote the history of the Fisheries Research Board of Canada (Johnstone, 1977); and Albert Koers of the Netherlands, who detailed the history of regional fishery organizations (Koers, 1973). They all deserve our thanks for their painstaking scholarship.

I shall not attempt a chronology of the long tug-of-war between fishery science and fishing experience; rather, I shall describe a series of epochs, five of them, that I think illustrate the successive steps in the application of science to management and the problems that have arisen. My interpretations will be based on my own biases, and I hope they will be more enlightening than controversial.

Epoch I—Basic Research: Through the 1940's

Basic research began, in North America as well as in northern Europe, in the middle of the last century, and was stimulated by the age-old role of fisheries in society. The fisheries of eastern North America had been the magnet that attracted daring seamen from Scandinavia and southwestern Europe nearly a millenium ago and remained as one of the primary resources for the people of eastern North America until after the establishment of this laboratory. They were vital to the early settlers because they provided profitable employment and winter food before the settlers could be sustained by farming. This kind of role is not unlike the roles of the fisheries in many of the lesser developed countries in recent times.

By the middle of the nineteenth century some of the fishery resources had already declined by alarming amounts, as they had in the Northeast Atlantic, where the causes were hotly disputed. Trout culture had started as a business, both in Europe and North America, and it was suggested that declining wild resources could be restored by stocking. But many people felt that more facts were needed, so Congress authorized creation of the U.S. Commission on Fish and Fisheries in 1871. Spencer F. Baird was appointed Commissioner, and he returned to Woods Hole annually, during the summers, to work in the area with which he had become familiar during earlier vacations.

His appointment set the course of fishery studies in the United States for many years. He was a zoologist and naturalist who pursued biological studies of the fishery animals with great zeal, and who encouraged many nongovernmental scientists (some from Europe and Canada) to use the U.S. and Marine Biological Laboratory (MBL) facilities that had become available at Woods Hole. For about 50 years, this station was the summer center for marine biology in eastern North America.

The beginnings of fishery research in the United States were part of the growing concern about the environment and the public support of research to achieve conservation. The American Fish Culturist's Association was formed in 1870, and it, significantly, named Baird as well as Samuel Wilmot (who later became the Superintendent of Fish Breeding in Canada in 1876) as honorary members in 1872. This Association broadened its mission in 1884 with a change of name to the American Fisheries Society.

More general support for conservation research came when, in 1873, the American Association for the Advancement of Science (AAAS) urged application of research to forestry problems and the reformation of forest management policy. The AAAS also supported the formation of the U.S. Geological Survey in 1879 and the U.S. Biological Survey of the Department of Agriculture in 1885, the same time the fishery buildings were constructed here in Woods Hole, Mass. Soon after, in 1895, a major voice for conservation appeared, one of our leading sportsmen's magazines, *Field and Stream*.

The research that began here at Woods Hole under Baird's stimulus was mainly biology or oceanography. It provided an essential background of biological and environmental understanding, but it was not nearly adequate for the public decisions required in fishery management. The authority that Baird received was of the broadest kind, "to prosecute investigations and inquiries . . .with the view of ascertaining whether any and what diminution in the number of food-fishes of the coast and lakes of the United States has taken place; and, if so to what causes the same is due; and also, whether any and what protective, prohibitory, or precautionary measures should be adopted. . ." (Galtsoff, 1962: 9). Baird began to describe the New England fisheries, the oceanography, and the organisms in the waters. He, his colleagues, and visiting scientists at the MBL, included oceanographic, biological, ecological, parasitological, and other studies in what was predominantly a descriptive approach.

The scientists who came pursued their own specialities more or less in isolation while the Commission pursued descriptions of the fisheries. This became the mode of research at Woods Hole for the several decades before the Woods Hole Oceanographic Institution (WHOI) was formed in the 1930's. The emphasis in much of this research was of the narrowest kind—as it had to be: I am in no way critical of the basic research; we must continue it, but we must recognize the surroundings and the nature of the activities that make it viable. The scientists gradually extended the frontiers of knowledge step by step. They set the national pattern of fishery research for the first two-thirds or so of the century that we are commemorating.

A similar pattern became established in Europe after the formation of ICES. The Kristiania Conference in 1901 endorsed scientific inquiry as the basis for a rational exploitation of the sea, and laid down rather precise plans for hydrographical and biological work. This brought together several countries to the inaugural meeting of ICES in 1902 (Went, 1972:10-22).

Canada also, during the same period, established a Board of Management of the Marine Biological Station in 1898 for a laboratory on a barge in the Gulf of St. Lawrence (Johnstone, 1977). This was followed by the Go Home Bay sta-

tion in Georgian Bay in 1901 and permanent stations in New Brunswick and British Columbia in 1908. The Biological Board of Canada was established in 1912.

Subsequently, an attempt was made to establish a North American organization similar to ICES, with the formation of a North American Council on Fishery Investigation by Canada, Newfoundland, and the United States in 1920. However, this Council was discontinued in 1938.

Few fishery laboratories were established before the 1920's. They emerged as the limnological and aquatic biological laboratories gradually incorporated fishery studies. In addition, a few laboratories began to study salmonid culture, notably the problems of nutrition and disease. Still later, fishery technological laboratories concerned with the handling of the products, were organized, mostly after World War II.

All of this research, the basic research, and the attempts to deal with the ongoing and urgent social, economic, and political problems of the fisheries had established a dichotomy between the researchers and the managers of the fisheries. The researchers had to approach the scientific problems one by one, whereas the managers faced the overall challenges of making decisions about a complex human activity with the help of a few facts about the fisheries. The researchers had time and isolation; the managers had deadlines for decisions in a political arena.

The closure of the dichotomy has been long and difficult. I think there is a major lesson for us in this if we look at the problems we have had in closing this dichotomy, in satisfying the needs of the researcher, and at the same time trying to satisfy the concerned public. An illustration is the research on and management of the Pacific halibut fishery; a program that we regard as a foundation of modern marine fishery management (Bell, 1981). After alarms about overfishing during World War I, a treaty was negotiated between Canada and the United States in 1918, which failed to be ratified. The first treaty to be ratified was the 1923 Convention which permitted research and specified a winter closed season, a provision objectional to the Washington State legislature, which had requested legislative review of any conservation measures. The authority of the Halibut Commission was gradually extended to additional convervation measures in revised conventions of 1930 and 1937, but it was not until the Convention of 1953, 35 years after the first attempt at a treaty that the political differences were resolved to the point of granting reasonably complete authority for the conservation measures. This was possible only because the Commission and its research staff had worked very closely with all parts of the fishery, clearly established public confidence in its basis for decisions, and gained a special political decision. It was of course responsible to the Governments of Canada and the United States, but it also generated strong political support for its independence from the national fishery agencies. In essence, it gained confidence the old-fashioned way—it earned it.

This epoch, from 1885 to about 1950, was a period of slowly increasing research, but the findings had very little effect on fishery management. Conservation was fundamentally a political issue (Smith, 1966). The freshwater regulations were based on common sense, avoiding waste, protecting young animals so they could grow, protecting breeding animals so they could reproduce, and spreading the catches through the prevention of any excessive ingenuity in the use of nets. When the fish became scarce, waters were stocked from hatcheries (as this station did for so many years). The marine fishery regulations, on the other hand, were very few, and there was little regulation of marine fisheries in this country, aside from inshore shellfisheries and perhaps the inshore herring fishery of New England, until recent years. What regulations there were, were largely designed to promote orderly marketing and orderly fishing, not really for the purpose of conservation in the usual sense that we think of it.

A major step toward application of science to the U.S. freshwater fishery management began during the 1930's in the Tennessee Valley Authority (TVA). The TVA plans included a strong emphasis on all outdoor recreation, especially fishing. As the reservoirs were filled, it started fishery and environmental research programs with the objective of trying to improve recreation.

This dichotomy between fishery research and management persisted for many decades, and its residue, even today, arises from both the climate required for scientific work, and the development of public confidence in the science. The scientists must focus on parts of complex problems if they are to advance their knowledge, yet they must contribute effectively to the regular cycle of decisions (for which they never have enough scientific evidence) if they are to develop the confidence of the public. The scientific focus is mostly long-term, yet the need for decisions recurs in short-term cycles.

Epoch II—Emergence of a Profession: The 1950's

The profession of fishery science began to emerge in the 1950's. The experience with the Halibut Commission and the confidence that had been gained helped, but still left this broad problem—how to get at the management. I would like to read a quotation from one of our most perceptive fishery managers.

"The fishery administrator starts his functioning with a background of a vast, unorganized ignorance, illuminated by occasional flashes of traditional legend, hearsay, inference, assumption, guesswork, and praise be, an increasing backlog of scientific theory and fact coupled with the experience gained from trial and error. The administrator, having no firmly fixed starting point of fact, must then chart some sort of course in the hope of arriving at the only definite landmark in his harassed existence—that represented by a stable, sound, productive fishery. This part of the job, nevertheless, might be considered relatively simple, calling for nothing more than a system of Spartan, conservative restraints and restrictions upon the taking of fish. By always leaning over backward in regulating, giving the resource the benefit of the doubt, he might come up with reasonable assurance of protecting the resource, except that the eco-

nomic survival of thousands of individuals, hundreds of communities, and dozens of counties, may be affected by the administrative action taken" (James, 1951).

The dry wit of Milton C. James, who for many years was the Assistant Director for Fisheries of the U.S. Fish and Wildlife Service, is as pertinent today as it was in 1950 when he made that statement at the Gulf and Caribbean Fisheries Conference.

Despite such understanding of fishery management by a few people, the major impetus for the application of science to marine fisheries really came from political problems and I'd identify them as follows:

First was the Japanese excellence in fishing before World War II. At that time Japan had the largest fish catch of any nation, and had developed the best equipment and organizations for distant-water fishing of any nation. They demonstrated their ability with "invasions" of Bristol Bay, Alaska, in 1936 and 1937, which set off a continuing alarm about Japanese fishing off North America that was only slightly muted during World War II. Within a few weeks after the Japanese surrender in 1945, and with the resurgent pressure to protect Pacific salmon and halibut, President Harry S. Truman issued his famous proclamation which stated ". . .The United States regards it as proper to establish conservation zones in those areas of the high seas contiguous to the coasts of the United States, wherein fishing activities have been or in the future may be developed and maintained on a substantial scale." This action gave priority to conservation needs and clearly inferred that conservation would be shared, that other nations would not be excluded from the fisheries, and that the regulatory measures would be open to negotiation (Johnston, 1965). This really formed the basis for the many fishery treaties which soon followed.

The impetus in freshwater fishery management in the United States came with the mounting concern over the freshwater fishery resources that resulted in a major increase in Federal funding through the Dingell-Johnson Act of 1950. Much of this money (from a 10 percent excise tax on angling gear) immediately went into research programs in each of the states.

The special concepts of fishery science as a separate part of the aquatic sciences had been gradually building since the landmark paper by Baranov (1918), with the work of European scientists associated with ICES, the work of W. F. Thompson on halibut and Fraser River salmon, and with the work of freshwater scientists in northern America associated with the Biological Board of Canada, the Tennessee Valley Authority, the States of California, Michigan, New York, and Washington, and the U.S. Bureau of Fisheries, among others.

The scientific concepts had been established, but public acceptance of a science-based fishery management was very slow. It clearly intruded on established political and legislative prerogatives. An example of the difficult transition occurred in the management of the Alaskan salmon resources. There the salmon production reached a peak of about 200,000 metric tons annually in the middle 1930's and then steadily declined to about half that level by 1945. The Federal management had no acceptable explanation so the salmon industry asked the University of Washington and W. F. Thompson for help. He organized the Fisheries Research Institute and started a progam of research on the salmon management problems—not just salmon biology. He discovered that the existing regulatory system had permitted decimation of a large proportion of the several thousand spawning units, while allowing excess escapement from many of those remaining. The FRI developed vastly improved methods of estimating escapement and survival of the young salmon, which resulted in better forecasts of the returning runs and better regulatory control of the fishing. The Federal government continued its basic research on salmon biology, with no attention to research on the management system, until after a radical reorganization of the Alaskan office of the U.S. Fish and Wildlife Service in 1955, but then it was too late. The residents of the Territory of Alaska voted overwhelmingly for statehood in 1958, many of them because of their perception of a failure of Federal fishery management. The new State of Alaska took over the regulation of the fishery in 1960, continued to refine its regulations (assisted by some favorable weather conditions), and production recently returned to its peak level of about 200,000 metric tons.

After World War II, fishery conservation treaties proliferated, and all of them depended on fishery science. Prior to the War, only the halibut and sockeye salmon conventions between Canada and the United States had had a significant reliance on scientific research. But afterward came a radical revision of the earlier whaling treaties in the Whaling Convention of 1946, the Northwest Atlantic Fisheries Convention of 1949, the Inter-American Tropical Tuna Convention of 1950, the International North Pacific Fisheries Convention of 1953, the Great Lakes Fisheries Convention of 1954, and eventually others affecting northern America (Johnston, 1965). These attempts to solve specific problems gave rise to the United Nations meetings in 1955 in Rome and in 1958 Geneva that advanced the efforts to change the ancient Law of the Sea.

In the Northeast Atlantic, the political problems were much more complex, and they still are. Attempts had been made to reach agreement on conservation conventions since 1882. ICES had been coordinating the ocean sciences since 1902, but a viable agreement on conservation was not reached until ratification of the Northeast Atlantic Fisheries Convention in 1964.

The failure of the one Federal fishery management program in Alaska and the new Federal responsibilities for fishery management under the numerous treaties after 1945 led to a major reorganization with the adoption of the Fish and Wildlife Act of 1956 that established the Bureau of Commercial Fisheries in the Fish and Wildlife Service. The Bureau brought the Federal research much closer to the management responsibilities.

The state activities in marine fishery management of the United States were limited to the fisheries within 3 miles of the coast and badly coordinated. So, Congress authorized the Atlantic, Gulf, Pacific, and Great Lakes states to form compacts for coordination of marine

fishery management in various years between 1942 and 1968.

In addition to the national actions to base marine fishery management on science, the states and provinces of northern America followed a similar course with respect to domestic fishery management. Funding for much of the research in the United States came from the Federal Aid in Sportfish Restoration Act of 1950 (the Dingell-Johnson Act) which earmarked funds from an excise tax on fishing tackle. Scientific investigative activities became a routine part of most freshwater fishery management in Canada and the United States.

Fishery science was accepted worldwide through the activities of the Fishery Department of the Food and Agriculture Organization of the United Nations after the Conference of FAO authorized the creation of regional fishery bodies in 1959 (Koers, 1973). Several regional committees or commissions were subsequently established which emphasized applied research and integrated scientific investigation with fishery development.

Thus, fishery science came out of academe and became another public-service profession similar to the science-based professions of medicine, architecture, and engineering. The fishery scientists were asked not only for their scientific findings but also for their advice on a course of action.

The profession began to develop a conscience about its integrity, and took major steps toward reinforcing public confidence. The American Institute of Fishery Research Biologists was incorporated in 1956 to advance the application of science to the use of fishery resources and to maintain high professional standards. This action was soon followed by the larger program of certification of fishery scientists by the American Fisheries Society.

The profession grew rapidly in employment as laws required a scientific basis for management, and as the public expected ever more from the scientists. Membership in the American Fisheries Society was 1,147 in 1950, of which about three-fourths were probably fishery scientists. Now membership in the Society is approaching 7,000, whereas a directory of North American fishery scientists lists about 8,100. Employment once predominantly in government fishery agencies in 1950, has spread rapidly to other agencies and to the private sector.

The problems faced by fishery scientists have proliferated. Whereas the early challenges were predominantly in fish culture and government fishery regulation, fishery scientists are now called on to deal with aquatic environmental problems, operation of fish businesses, processing and packaging of fish, and fishery development.

Epoch III—Rejection of Science: The 1960's

The promise of conservation implied in the new laws concerning fisheries, as well as other environmental issues, was not enough. Our consumption of all resources came to be seen as excessive, and leading to disaster in the long-term (Galbraith, 1958). Others pointed out the failure of governments to deal with resource issues in a comprehensive way (White, 1958). Both government and science became suspect.

A major contributor to the change in public perceptions, however, was a biologist and editor who was employed by the U.S. Fish and Wildlife Service from 1936 to 1952 (and who made at least one cruise from Woods Hole on board the *Albatross III*). Rachel Carson, who had written so emotionally about the sea, turned her attention to the impact of pesticides on the environment with her book "Silent Spring" published in 1962. The use of chemicals came to be seen by many people as the result of the application of science to control and abuse our environment.

The distrust was exacerbated by the inability of scientists to predict the ecological effects with the assurance that people demanded. The interactions of the organisms, with each other and with their environment, were discovered to be extremely complex, and we still recognize their great complexity. Some of the chemicals had effects in quantities so minute as to be difficult even to detect. Governments were seen to be unresponsive to the public will as they tried unpersuasively to find compromises between use and abuse of the environment.

The conservation movement based on "wise use" became the environmental protection movement based on avoidance of use and preservation of the environment. Value judgements about the environment came to be dominant factors in new laws.

One of the most significant steps toward environmental management came in the United States with the National Environmental Policy Act (NEPA) of 1969. This required that all policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with it, and that all Federal Agencies shall—

"(A) utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment;

"(B) identify and develop methods and procedures. . .which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical considerations; . . ."

The Act also required preparation of a detailed Environmental Impact Statement (EIS) for all Federal actions, including fishery regulations. In addition, the Act touched the roots of environmental policy in other countries as it stimulated similar laws, and as its provisions were vigorously promoted by the United Nations Environmental Program.

Other U.S. Acts that directly affected the fisheries include the Endangered Species Act of 1969 and the Marine Mammal Protection Act of 1972. These gave a higher priority to a public sense of value in rare species and marine mammals than to economic considerations or any concept of use by individuals.

A manifestation of special environmental values in the recreational fisheries is the movement to preserve "wild" stocks of salmon, trout, and other species. Wild may be interpreted to mean stocks unsullied by hatchery fish, but in

some circumstances, "wild" fishing in wilderness-type surroundings has been advocated even though the fish are stocked from hatcheries.

One of the consequences of the environmental movement was to regard solution of environmental problems as entirely a political action. An example was the approach of the Sierra Club (Mitchell and Stallings, 1970). That "Handbook for Environment Activists" includes statements about the need to restructure society in a conservation revolution, and the need to deal with a system of suppression and oppression. It gave no recognition to the long history of the development of professional environmental sciences, or even to the use of science in solving society's environmental problems.

Nor have some leading academic ecologists recognized professional conservation science. In two comprehensive "ecology" texts (Ehrlich et al., 1977; Moran et al., 1980) there is no recognition of the conservation movement as we know it; rather, it is portrayed as a fight to save endangered species, to prevent oil drilling, to save whales, to save energy, and to reach other broad political goals. They convey no sense of the use of science in order to attain specific environmental objectives, as steps toward long-term goals. They make no mention of a century during which forest, wildlife, soil, water, agriculture, ocean, atmospheric, fishery, and other professional environmental sciences have developed in hundreds of departments in leading universities, nor how scientists in these disciplines contribute daily to civilized problem solving. They merely advocate a general environmental political movement.

The ecologists are, however, beginning to stress the need for understanding and managing the combination of natural and socioeconomic systems, but it is not clear that they have reached the point of using cost-benefit analysis or widely adopted a problem-solving approach in a social milieu (Barrett, 1985; Risser, 1985).

Epoch IV—The Great Transition: The 1970's

The new fishery treaties and the new environmental laws that became effective during the 1950's and 1960's were enough to change greatly the practice of fishery science, but an even greater stimulus for change came in the 1970's. The long struggle to develop a new international Law of the Sea (LOS), begun in the 1950's, continued with desultory and inconclusive negotiations during the 1960's and early 1970's, and was finally agreed upon in early 1974. Although this concept was not officially ratified until 1982, somewhat more than 100 countries agreed with the concept, and immediately thereafter many of them declared 200-mile economic zones, especially to control fisheries and any seabed resources off their coasts.

Perhaps it was a quirk of fate that at this same time, in the early 1970's, the expansion era of the world's fisheries ended. Since the late 1940's, after the fishing fleets recovered from the impact of World War II, fishery production had been increasing at a rate close to 7 percent annually, or doubling every decade. Then, about 1970, the rate suddenly decreased. Now, fishing production is slowly increasing, perhaps at a rate of about 1 percent annually; but, certainly the great era of expansion—of rewards for an industry able to invest in superb long-range ships, find new resources, and get them to market, is over. It is quite clear that there are no more significant opportunities in the conventional ocean fishery resources (Troadec[1]). A few coastal countries have some major resources within their 200-mile zone and may be relatively fortunate.

Canada is one of the countries with exceptional fishery resources off its coasts, but by 1980, it had failed to develop policies that would control the coastal unemployment, or coastal employment, and overcome the resistance to modernization of the traditional fisheries in eastern Canada. In western Canada they have had similar problems with gross overinvestment, especially in the salmonid fishery (Copes, 1980).

[1]Troadec, J. P. 1985. The mutation of world fisheries: Its effects on management priorities and practices. Unpubl. manuscr. submitted to Workshop on World Fisheries Management and Development; University of Washington, Seattle, 7-11 July, 1985.

Many of the smaller nations, and segments of the fishing industries in northern America, expected great benefits from the movement of controls by their governments out to 200 miles. The prevailing view in the United States was that fishery regulation was for the foreigners, not for us; we want to get out there and catch all of those fish.

But the profitability of the common fisheries vanishes as fishermen expect more, fish harder, and invest more when the resource will sustain no more production. We are close to that stage now, although some of the production off Alaska might be directed toward more domestic fisheries. But even so, any benefits will have a short term effect. Fishermen expect government to protect their way of life, and this is a very deep-rooted public tradition. A large portion of the public admire fishermen and are all in favor of protecting traditional fisheries; they have a very powerful political position.

What I have described is not a phenomenon unique to North America, I have also mentioned problems in other countries. Here are a few examples extracted from the Country Experience Papers submitted to the FAO Conference on Fisheries Management and Development in 1984.

Norway: The state supports about half of the income of the fishing industry, and the state support has stimulated increased participation in fishing and complicated the corrective efforts.

Portugal: The fishing industry faces one of the worst times in its history. Nationalization of large enterprises in 1974 decreased their productivity.

Spain: Coastal fishing capacity is excessive. Extensive subsidies are provided to the fleet.

Canada: Investment in fishing approximately doubled during the 1970's. The majority of fishing enterprises are incapable of generating a revenue surplus or even an adequate income. Major financial crisis by 1981. Government correction is paralyzed by prospects of more unemployment. [The increased employment, even though supported in large part by government subsidy, is regarded as beneficial because of the dependence

of many coastal communities on the fisheries (Doubleday et al.[2])].

Malaysia: There is overcapitalization in both the private and public sectors, far too many artisanal fishermen and severe overfishing.

Japan: Production is sustained in part by a fortunate increase in local sardine stocks. Most fisheries have limited entry and, in many, the numbers of licensees have been reduced. (They have an interesting system of reducing the number of licenses. They pay the fishermen who give up their licenses, but they also charge the fishermen who remain more for their licenses, in effect, making them pay for their share.)

Peru: The industry is in a major crisis with overinvestment in both fish meal and fish canning.

A summary of 26 papers submitted to the FAO conference (Cleveland, 1985) presents the general view that countries benefited from control or, in many cases, elimination of foreign fishing within their 200-mile zones. However, it did not address the domestic social and economic problems that commonly followed because of the overoptimism and overcapitalization in many countries.

The end of the expansion era of the world's commercial fisheries has stimulated other changes that are certain to cause a long-term economic and social impact. The most important of these, in my judgement, is the consequence of development of the technical and organizational skills by the large businesses that have participated in the expansion. An illustration of the economic strength of such businesses appeared in a report on the Japanese fish companies during the middle 1960's (FNI, 1968).

At that time, four large companies in Japan accounted for about 63 percent of Japanese catches, or about 8 percent of the world catch. Also, that 63 percent was a greater quantity of fish than the entire production of the United States and Canada combined. Those four companies with their economic power, became leaders in world competition through their organizations, and marketing on a world scale. They now dominate a large part of the world fish business and remain powerful competitors in any kind of business. I would further note that three of those Japanese fish companies are currently listed, and I believe are the only fish companies so listed, in the Fortune 500 list of the largest industrial corporations outside of the United States. These companies have a major impact on their government's policies, and it must be so recognized as we deal with them. We cannot just exercise crude political pressures without expecting vigorous economic pressures in return.

The end of the expansion era has also brought an increase in the price of fish, relative to other foods, with the consequence that fish used as subsistence food for poor coastal communities became shifted to city markets or into international trade. This, of course, has been accompanied by complete changes in the handling, processing, and distribution systems.

With the markets for fish expanding faster than the supply, there has been an increased incentive to farm fish. Fish farming has been increasing at a rate of about 7 percent annually. In other words, it has doubled in production in the past 10 years. The quality is easy to control, and large successful farms in many countries involve sophisticated financing, technical, and management practices.

In addition to the profound changes in the commercial fisheries, the recreational fisheries are expanding rapidly in the developed countries—i.e., a doubling in the numbers of anglers since 1955 in the United States. Here there are more than 200 anglers for each commercial fisherman. They are also expanding in the lesser developed countries with the influx of tourists.

The management of these recreational fisheries, compared with that of the commercial fisheries, has been remarkably successful. Most freshwater stocks in northern America, and many other developed countries, were allocated long ago to recreational fishermen, and recently a few saltwater stocks have been reserved for angler use. New fishing waters have been added as reservoirs have been constructed. Research on the stocks, the regulatory systems, and the enhancement potential has been well supported since the 1950's, and has resulted in a steady increase in knowledge pertinent to management. The findings have been made known to the anglers through their clubs and advisory groups, and have resulted in steady improvement of the management (Grover, 1980; Radonski and Martin, 1985).

A major complicating factor is change in aquatic environments. We abuse the water more and more, and I would note that the fishery agencies are frequently at the forefront of the aquatic environmental problems because the fish are perceived to be indices of the quality of water, and people think that if the fish survive well, the water is likely to be relatively good. The fishery scientists also have greatly broadened their needs to become sensitive to the problems of water use, which is at least as political a problem as the use of the fisheries.

So after a great transition in the fisheries and our fishery science, some roles of fishery science remain the same. Despite the surge in fishery research and the increasing public confidence in fishery scientists, the solution of problems always includes consideration of an unstable mixture of scientific facts and value judgments. To go back to Milt James again, we remind ourselves that "The fishery administrator starts his functioning with a background of a vast unorganized ignorance." We must keep in mind that the administrator always has to be dealing with the future and with predictions less accurate than everyone desires.

Epoch V—Greater Challenges: The 1980's and Beyond

How can our history guide our judgment of our future? I propose to take a speculative look ahead by describing the driving forces in the fisheries that influence policy and suggesting an approach to what I regard as the most urgent problems. I think the principal forces are the demand for fish relative to the size of the resources, the commercial interests

[2]Doubleday, W. G., et al. 1985. The impact of extended fisheries jurisdiction in the Northwest Atlantic. Unpubl. manuscr. submitted to Workshop on World Fisheries Management and Development, University of Washington, Seatlle, 7-11 July 1985.

in the resources, both in recreational and commercial fisheries, and the special values held by the public about the resources—the noneconomic, nonquantifiable values.

The potential production from the wild resources is unquestionably less than the demand for recreation and food. This was discovered long ago in the fresh waters of the world, where a large proportion of the production was allocated by law to recreational fishermen, or by custom and law to poor artisanal fishermen. But now we have demolished the premise in the old "Law of the Sea" that the ocean fisheries were unlimited. They, too, are limited, and our production is close to that limit[3].

The recent growth in wild fish production is less than the rate of growth of the world population even with relatively optimistic analyses (Wise, 1984), and a higher proportion of the products is continuing to go into distant markets, rather than being sold fresh in nearby markets. The price of fish relative to other foods is increasing, so we have a continuing shift away from the traditional fisheries.

Fish farming is spreading, and I expect this is going to be the growth sector. As was mentioned this morning, the opportunities for fish pathologists, fish veterinarians if you will, is growing very rapidly, and will be essential to the development of fish farming. I make special mention of commercial fish farming. This is already much larger in the United States than public fish farming which produces fish to be stocked. Probably less than 5 percent of the U.S. production is currently produced in public hatcheries for stocking purposes; the balance of more than 95 percent is produced directly for markets.

Outdoor recreation is certainly continuing to grow very rapidly in the developed countries, and spreading quickly to the less developed countries. This includes recreational fishing and the large commercial interests supported by it—fishing tackle, recreational boats and highway vehicles, and the hotel and restaurant businesses near good fishing.

With a shortage of wild stocks in most places for both food and recreation, one issue is "How well can we conserve them in the sense of maintaining an optimum yield?" This depends on our scientific knowledge of the resources gained through research and monitoring, and on acceptance of controls on the fishing by the fishermen—which depends at least partly on the public perception of our reliability.

Our research, although pursued with great vigor as we try to deal with these mounting problems, comes up against some relatively intractable problems about circumstances that we find exceedingly difficult to predict. One of the problems is the extreme variability in the interspecies relationships; the relationships between, for example, large larval stages of a commercial species and its predators, or between adults and their food organisms, between competitors, as well as between predators and prey (Valiela, 1984). I'm quite pessimistic about the early solution of many of the problems after a recent paper in *Science* which dealt with the very simple ecological situation of trying to change the acidity of a small Canadian lake (Schindler et al., 1985). The conclusion was that even with just trying to change one factor, they could not predict the sequence of changes in the biological populations in that small lake.

Another equally difficult problem is understanding the genetic evolution in populations under selective fishing (and all fishing is more or less selective), and with changing environmental impacts and interspecies relationships. Such changes operate on a time scale of decades, and again we have barely gotten acquainted with the kinds of problems we are likely to have in this area.

Certainly, if we try to base our fishery management on rapidly increasing research, I fear that we are going to have a rebellion on the part of people who finance that research. We are not likely to have early results for the very difficult problems that we face to enhance management in the near future. That doesn't mean we shouldn't try, and I think our great challenge here, for the science, is to find the balance between pursuing these long-term problems, with good science, and satisfying our public that we are managing the fisheries as well as possible.

Even if we learn how to make better predictions through better and more research, these will be expensive. When added to the substantial costs of monitoring the fisheries, negotiating regulations, and enforcement, the total may be prohibitive. Already the costs of many ocean fishery management programs in the United States and Canada are running from about one-fourth to as much as fully equal to the first sale value of the fish caught.

The conventional ecological or economic research, moreover, appears likely to have little impact on the pervasive problem of overinvestment in the commercial fisheries. Solution of this problem requires political action on the part of the people concerned to develop a wholly new policy in most countries of the world. The people concerned are those in the fish businesses at all levels from fishing through processing and marketing plus the public at large because of the substantial transfer payments required to sustain not only the management of the commercial fisheries, but the operations as well.

Such transfer payments in the commercial fisheries contrast strongly with the relative absence of such payments in the recreational fisheries, even though the latter support large commercial interests. This situation appears to have arisen in our policy-making process because of the difference between business and conservation interests.

I mention the relative absence of transfer payments supporting recreational fisheries because our political scientists point out, conclusively, that business has a privileged role in policy making as it contributes social and economic benefits (Lindblom, 1980). I think some of our past difficulties have arisen because of failure to communicate adequately with the businesses, or perhaps among the business people, the government policy makers, and the scientists. Commercial fishing creates employment

[3]There are some exceptions in terms of Antarctic krill or the mesopelagic fishes, but these would be anything except traditional fisheries. They would involve only a few companies with very large financial backing and technological expertise to manage wholly new technology in catching, marketing, and processing.

and supports numerous coastal communities in northern America. Access to the resources is regarded as a basic right that commercial fishermen can exercise, and the economic plight of the traditional fishermen generates sympathetic government assistance, frequently because there is no other employment opportunity in such communities. The conservation objectives of commercial fisheries management have been achieved largely by a reduction in the efficiency of the fishermen, and the resulting costs of this inefficiency to the fishermen and their communities are borne by government through subsidies. This happens in spite of the fact that commercial fishermen make up less than 1 percent of the electorate in northern America.

The recreational fishermen, on the other hand, have a special role because of the public appreciation of outdoor recreation, and of a clean environment that goes with it, and recognize that those must be conserved or preserved. The reduction in efficiency of fishing required to spread the catch among the recreational fishermen does not create a commensurate decrease in the enjoyment, which conceivably may even be maintained with no catch at all by requiring fish to be released alive.

The recreational fisheries help to support a large commercial service business which is seldom adversely affected by the fishery management. Such businesses also support the ideal of conservation and the principle of open access to fishing. They have no reason to claim government help if management restricts the catches. In fact, they would probably object if the management did not spread the catches among all who wanted to fish. The more people who want to fish, the more there are who will buy equipment, meals, lodging, boats, or whatever. Since about 20 percent of the population goes fishing for fun, these fishermen have a very large influence on our fishery policy.

The public has had a long experience, 30 years or more, of steadily increasing confidence in the recreational fishery management. On the other hand, most of our commercial fisheries in the salt waters, except for a few under international treaties, have not been regulated. We have not established that give and take, that degree of mutual understanding among science, business, and government, that I think we must have in the long term for commercial fishery regulation.

This contrast between the management policies of recreational and commercial fisheries provides my closing argument. Restrictions on recreational fishing that divide the allowable catch among all who want to fish are accepted because they satisfy the public ideals of equal access and fairness in the interests of conservation. Restrictions on commercial fishing which divide the catch among all who want to fish satisfy the public ideals of equal access and fairness but conflict directly with the business needs of the fishermen.

Recreational fishery regulations have been devised over several decades to fit the ideals. Future commercial fishery regulations must compromise the ideal of open access for commercial purposes. The ancient ideal of open access fits the use of the public resources for personal food or fun, as long as a perception of fairness is maintained and conservation is achieved, but not their use for profit.

In the sense that the commercial fisheries are a human activity, we have never managed them as a business activity except by subsidizing the consequences of government interference. Subsidies were seldom necessary during the great expansion era of fishing during the 1950's and 1960's, and unfortunately, that era left the visions of great profits that might be realized after nations had authority to control their fisheries out to 200 miles.

Now we need a new commercial fishery management policy in most of the oceanic fisheries of the world. How to achieve this has been debated extensively, (recently in Frady, 1985) and I do not propose to get into the thicket of a detailed discussion. I suggest that a new policy must be based on a widespread public acceptance of a change in public rights in fish as a resource of the commons. The public must agree that fishing can be pursued by anyone as a source of personal food or fun, but fishing for profit cannot. The pragmatic reason is simply that governments are in the fish business as the owner of limited resources, and by allowing unlimited opportunities to establish private businesses, governments are preventing each business from managing properly a fundamental function of any business—matching the investment to the expected return.

That business function could be achieved if the rights in the resources were known over time enough to plan and recover investments. Therefore, the rights should be owned, be transferable, and be divisable, so that sale or purchase of them would let a fishing business become efficient (Pearse, 1981).

Our research and our debate over how to achieve such a change in policy needs a change in direction. All of the scholarly analyses that limited entry is essential are being immediately rejected by the fishing industry, and we are not going to accomplish much unless we find out how to deal with the immediate problems of the business that is involved. Perhaps the approach that might work is one of making it clear that the fishermen who remain in business will have a substantial cost for a license and then making a substantial payment to those who agree to give up the business.

I don't believe that commercial fishermen are going to give up as long as the government continues to subsidize them. They can play the government subsidies on one hand and the management on the other, and are continuing to do so. Every commercial trade publication, commercial fishery trade publication, contains the essence of this contradiction in the complaints about limited entry on the one hand and the ineptitude of the management councils, on the other hand. That publication is sustained by all of the advertisements for bigger vessels, faster vessels, new equipment, better nets, and better ways to go fishing. Here is the nutshell of the conflict.

Perhaps the next step for the economists is to elucidate the entire public costs that are involved in this, the continuing transfer payments, and most importantly, that there is no indication of an end to the transfer payments. There

is no way that these big, new fleets operating out of New England, which have doubled and tripled in capacity, are going to be indefinitely operated unless there are continuing subsidies, even with protection against imports.

So much for some of the current challenges. I am sure that fishery scientists will meet them as we have the previous challenges. We have had a glorious century in which we have matured as a public service profession. We have developed our sciences, our professional values, our social awareness, and an educational philosophy. We have enriched and permanently changed the political process of fishery management. More importantly, we are changing with society, and we will continue to serve it professionally.

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