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The world's production from the aquatic environment, excluding whales, doubled in the decade between 1952 and 1962, from 22 million metric tons to 45 million metric tons and in the period from 1962 to the present, from 45 million metric tons to about 70 million metric tons. The most rapid growth during this period occurred in the landing of sardine-like fishes, most of which were processed as fish meal and oil, and in the tunas, flat-fish, and squid. Freshwater fish, excluding those of mainland China, accounted for about 3.25 million metric tons of the 1952 aquatic production, growing only slightly to the present. An increasing proportion of the catch is being taken in lower trophic levels. Whatever rate of conversion one adopts, species at lower trophic levels produce a greater amount of protein than do their predators. To utilize these species, we must bring into production species not now harvested in large quantities or at all. For this, we will need an imaginative partnership between harvesting technology and food technology. In managing high seas resources for continual harvest, the problems of international jurisdiction must be considered. Also, international and national arrangements for research and research institutions must develop programs sufficiently broad to encompass the biological, oceanographic, atmospheric, behavioral, and social scientific programs posed by our use of the oceans in increasingly varied and conflicting ways.

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PROSPECTS OF THE WORLD'S FISHERY RESOURCES WITH EMPHASIS ON THE WESTERN HEMISPHERE

Lucian M. Sprague
September 1970

This paper is respectfully dedicated to Dr. Wilbert M. Chapman, who was to have presented a paper at this Symposium.

Much of the material was stimulated by his writing and draws heavily upon his voluminous correspondence and publications for inspiration.

PROSPECTS OF THE WORLD'S FISHERY RESOURCES WITH EMPHASIS ON THE WESTERN HEMISPHERE *

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INTRODUCTION

The world's production from the aquatic environment, excluding whales, doubled in the decade between 1952 and 1962, from 22 million metric tons to 45 million metric tons and in the period from 1962 to the present, from 45 million metric tons to about 70 million metric tons. The most rapid growth during this nearly two-decade period occured in the landing of sardine-like fishes, most of which were processed as fish meal and oil, and in the tunas, flat-fish, and squid. Freshwater fishes, excluding those of mainland China, accounted for about 3.25 million metric tons of the 1952 aquatic production, growing only slightly to the present. The value to the fishermen of the living aquatic resources on a global basis, taking as an average price, $100 a metric ton, was a little more than 7.0 billion U.S. dollars. One might multiply by 3 or 4 to get the overall value of these products to the economy. In any case, the fish harvest is very valuable, worth more than twice all the other resources presently taken from the sea (Chapman, 1970). It is not realistic to expect the rate of growth in fisheries harvest, an average of 6% per year in the last two decades, to continue for an indefinite length of time. We can, however,

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estimate the limits within which we might expect growth to take place and highlight the principal problems to be expected. According to Chapman (1970), there is reasonable expectation that supply and demand will create a global harvest of living resources of a little less than 100 million tons by 1975, 175 million tons by 1985, and a little more than 400 million tons by the year 2000. These estimates are thought by many to be somewhat on the high side.

MAJOR TRENDS

An examination of the pattern of growth of the fisheries in the past two decades reveals a number of trends. The most important is the increasing proportion of the catch being taken in lower trophic levels. This trend bears very strongly on the estimates of the limits within which we might expect growth to take place. A number of authors, Chapman (1967), (1970), Ryther (1969), Schaefer (1965), and Graham and Edwards (1962), have given fairly divergent estimates of the total limits of potential fishery growth. Actually, Schaefer's estimate of 200 million metric tons per year and Chapman's much greater estimates of 1-2 billion tons per year, are essentially similar. Schaefer confined his estimate to animals of upper 2-3 trophic levels, principally the table-grade food fishes, tuna, halibut, salmon, bass, etc., while Chapman included in his estimate very large numbers of animals at a trophic level of harvest 1.5 times above that of primary production of fishes such as redcrab, krill, anchovies, smelts, sand lances, etc.; both make the estimates of Graham and Edwards (1962) and Ryther (1969) seem entirely too conservative.

Whatever limits one wishes to place on these numbers, the basic outlines of future fishery harvest seem clear considering the pattern of growth of the past two decades. Furthermore, we can predict the problems in the development of the future marine products industry from the kinds of problems which have emerged in the past two decades.

THE RESOURCES

Whatever rate of conversion one adopts, species at lower trophic levels produce a greater amount of protein than do their predators. Nearly 40% of the present marine fishery catch consists of herring-like fishes. Some of these feed almost entirely on phytoplankton and others, on a mixture of phytoplankton and small zooplankton.This level of harvest corresponds on the average to about 1½ steps above the phytoplankton.

Indirectly converting a fairly substantial amount of the total production of phytoplankton into nutritional products for human use, will depend upon bringing into production species not now harvested in large quantities or at all, and upon man serving as a predator at trophic levels increasingly close to the level of primary production. For this, we need an imaginative partnership between harvesting technology and food technology. We will have to use products not now recognized as common foods as components of palatable and inexpensive formulated foods. These new food products would probably contain ingredients from diverse plant and animal sources, and marine protein could be the most important animal protein source.

Depending upon the trophic level at which the future harvest is taken, the limit of future production apparently lies between 4 and 40 times the 1965 harvest of 50 million metric tons.

A number of species in great demand are already being harvested at levels approximating a maximum sustainable yield, and some have been harvested at levels beyond their sustainable yield. In some of these cases, serious management problems exist. Among these are the whales, the Pacific sardine, and to a lesser extent the Pacific and Atlantic salmon, halibut, the North Atlantic cod, haddock, and yellowtail flounder, the yellowfin tuna in the Eastern Tropical Pacific, and some stocks of shrimp and lobsters, the mackerels and mackerel-like fishes of Southeast Asia, numerous coastal species near the Philippines, and of increasing concern, at least from the catch per effort point of view, if not maximum sustainable yeild, the world-wide long line tuna and billfish catches. However, in the areas of most of these fisheries, there are other species which could be harvested by known methods, but which are not now being harvested at all or are only beginning to be harvested. Notable among these are the 4.5 to 5.6 million tons of anchovies in the waters adjacent to the state of California and similar large stocks near Patagonia. Other unexploited species are the thread herring of the Gulf of Mexico and Pacific off Central America; sardenella off Central West Africa, the Arabian and Oman Seas, and northwest Australia; the Arctic capelin; and substantial quantities of hake off the coast of North America and Latin America; very large but unknown amounts of squid, and very large amounts of small invertebrates or krill in Antarctica, which are estimated by Kasahara (1967) to be capable of a sustainable yield on the order of 100 million tons per year. If we go one step higher in the trophic levels, there are very large numbers of small jacks, scad mackerels, the Indian mackerels, saury, and so on. The world-wide harvest of this particular group of fishes has grown surprisingly slowly in the last decade. At the so-called apex predator level, substantial resources of valuable species are yet unfished for technological reasons. Rothschild (1965) estimated that about 50-100 thousand tons of a single species of tuna, the skipjack, could be harvested in the open oceans of the Eastern Central Pacific and much more if the pelagic potentials of the Central, Western Pacific, South Pacific, and Indian Ocean were added.

The fishing efforts of the eastern European countries, particularly the USSR and Poland, off the coast of the United States between 1960 and 1970, illustrates the probable future pattern of fisheries exploration and harvest. In the Georges Bank region, off the coast of North America, between 1960 and 1961, the USSR and Poland recorded no catches of mackerel, herring, and red hake, and only small quantities of cod and haddock. By 1969-1970, however, the USSR was harvesting 380,000 metric tons of these species, and Poland and other eastern European countries were harvesting approximately 150,000 tons. The western European nations joined this fishery in 1962, and Canada and the western European nations by 1968 were harvesting 187,000 tons of these species. In addition, in 1964, the USSR developed a new fishery in the region roughly between Rhode Island and North Carolina, which increased the catches of the USSR and Poland from 0 in 1963 to a total of 127,000 tons in 1968-1970. These catches were composed mostly of red hake and mackerel.

The USSR has exhibited an interest in the Antarctic krill as a potential fishery, and has been fielding an increasingly large fleet to the Antarctic for krill and other species. In the year 1966-1967, the USSR took approximately 600,000 metric tons of Patagonian hake before Argentina extended its territorial limits to 200 miles.

These efforts of the USSR and other developed countries like Japan, indicate a trend toward somewhat lower trophic levels of harvest, the harvest of several species from one general region, and a national policy to explore and fish wherever substantial quantities of fish may be found. Some developing countries recognizing opportunities to improve their foreign exchange position (possibly with unfavorable internal operating costs) are making strong bids to enter the world's distant water fisheries. Taiwan, Ghana, South Korea, and on a more local but increasing scale, Israel, United Arab Republic, Ceylon, Thailand and Singapore are moving into distant water fisheries within the framework of their individual national economic development policies.

The present production of fish from fresh and brackish water is reported to be about 3.5 to 4 million tons, exclusive of the production of Red China. Harvesting fish from these environments has been going on for 3,000 to 5,000 years with very little real advances in either the art or science. The advances in practice that have occurred, have depended upon a transference of agricultural methods, such as the use of pesticides to control predacious insects, rather than on specific scientific research directed toward increases in production. The research which has been carried out is confined to a small cross section of potentially valuable species and the needs for broadly based research in nutrition, disease, breeding, and reproductive physiology are great.

Prospects for a dramatic increase in world production of fish from land-bound or land-related environments, such as rivers, lakes, managed farm ponds, and the coastal estuarine areas of the world in sufficient quantities to offset the losses of oceanic production are not particularly bright. This is in part true because such efforts have been and will remain largely a way of converting less expensive fish into lesser amounts of more expensive fish. Indeed, recent developments in world agriculture seem to limit these prospects. Pesticides and herbicides used in connection with the production of rice and the harvesting of more than one crop a year from the same paddy, has already begun to sharply limit the mixed cropping of fish and rice which has been practiced in Southeast Asia for many years. Pesticide levels in paddy run-off waters can reach levels high enough to destroy the present and potential fishery production expected from many freshwater areas and estuaries downstream of large rice production areas.

Optimistically, a four-fold increase in production of fish from fresh and brackish waters presently in use and a two and a half-fold increase in areas cultivated is not unrealistic over the next two or three decades. The resulting ten-fold increase, however, is expected to have its greatest impact on luxury foods such as salmon, oysters, and shrimp; and on fish eaten locally where high production costs are offset by the low transportation and processing costs. At present levels of harvest, pond fishery products appear to be at least as expensive as tuna - at $125-$210 per ton, exvessel, one of the world's more expensive fish. In some cases, prices range as high as $5000 a ton for pond-cultured shrimp, in comparison with the $8-$55 per ton paid for anchovies and similar species reduced to meal or canned in containers that often far exceed the price of the fish inside them. The need to increase pond fishery production exists, but the needs are regional, local, and reasonably easy to identify.

LEGAL, POLITICAL, AND INSTITUTIONAL CONSIDERATIONS

Because the harvest of fishery resources is carried out in both waters of national and international jurisdiction, and because most fisheries are harvested as a property of common use, and further, because our attempts to formulate international law regarding fishery matters are relatvely recent, among the most serious problems in connection with managing high seas resources for continual harvest are those of international jurisdiction.

These questions have been reviewed extensively by others: Chapman (1967) (1970), Schaefer (1965), Christy and Scott (1965). Recently, Christy (1970) has called attention to the difficulties of separating jurisdiction over the bed of the sea from the superjacent waters, and the lack of real appreciation outside the specialist community of the real importance from an economic point of view of the seas' fisheries resources.

Discussing the reopening of discussions of the 1958 Geneva Conventions on the Law of the Sea, Christy states:

> "And yet, in spite of the economic and political importance, fishery problems are being dragged in by the back door, to face decisions by diplomats who, for the most part, lack the requisite interest and competence to solve such problems. It is because of this that it seems timely and useful to raise a few points that might be considered by those who are (presumably) preparing themselves for the new conferences on the law of the sea. 1) The problems of fisheries, because of both the centuries of use and the recent, dramatic changes in the enterprise, are inordinately complex. However, the issues have not been precisely described and the alternative resolutions have scarcely been formulated. 2) The overemphasis on the seabed may lead to short term damages to the world's interest in fisheries. 3) The character of today's decision-making arena is far different from that of 1958. The fishery diplomats will not be participating in a club of fishery states, but in the context of a global interest in the wealth of the seas, in a split between developed and developing states, and in the fears of a United States-Soviet Union condominium. 4) There is increasing awareness that the patterns of distribution among nations of the sea's wealth in fisheries is becoming more and more non-inclusive in nature, and that the opportunities for sharing are more restricted. 5) These non-inclusive patterns of distribution are supported by customary and conventional law. Non-inclusive access to (though not distribution of) wealth is required for efficiency in production. If there is to be more inclusive sharing of wealth, then there is need for totally new institutions and law."

As the world population grows over the next several decades, two quite different factors are bound to increase the demand for aquatic protein very sharply: 1) the increase in the number of people whose income is rising, and whose demands for better diet are rising as fast as, or faster, than their incomes; and 2) an increase in the numbers of persons suffering from protein deficiency diseases because of an imbalance in the distribution of income and food.

Countries faced with large numbers of such persons will in the face of political pressure, adopt new policies, but not necessarily unselfish ones, to alleviate one or both problems.

As more and more fish populations are subject to harvest, the need for effective management based on scientific knowledge (some kinds of which we do not now have) will sharply increase. A continuation of the rapid growth of high-seas fisheries between 1950 and 1970 into the next two decades, will make management problems more difficult, and increasingly serious economic and political problems can be expected to arise.

At present, the most intractable management problems are posed by the whale fisheries of the Antarctic, the salmon and halibut fisheries of the North Pacific, the plaice fishery of the North Sea, and in the last few years, the yellowfin tuna fisheries of the Eastern Tropical Pacific, and the world-wide long-line tuna fisheries (Chapman, 1967).

So far, management of the high seas fisheries has been entirely confined to regulating the total tonnage of valuable species and/or their size and age at capture by what are called "stock assessment methods". Control of the commercial marine fisheries has been directed primarily toward providing the greatest yield of a single species without taking into account interactions with the environment and other harvestable populations. For example, the California sardine fishery was not managed effectively because the fundamental relationships between the sardine and its associated planktotrophic neighbor, the California anchovy, were not understood until too late.

On balance, it seems unlikely to me that single species fisheries can achieve total yields which approach a four-fold or greater increase in total catch unless other fisheries like the krill or squid fisheries develop very rapidly. However, as human population pressures are converted into fishery pressures, multi-species fisheries, like the Russian and Japanese trawl fisheries of the North Pacific, are becoming more common and eventually will account for the bulk of fishery production. Such fisheries magnify the already extremely difficult scientific and political problems of management.

It is not possible to forecast exactly the way in which world fisheries will develop and the biological consequences of this development. It is abundantly evident however, that biological, oceanographic, economic and behavioral science studies adequate for understanding some of the various cause and effect relationships involved are needed to understand the ever increasing large scale multi-species fisheries. There are, at present, no single-species high seas fisheries for which the needed kind of reasonable understanding exists, much less multi-species fisheries.

Possibly for two fisheries, the depleted California sardine and the fisheries of the North Sea, there is enough multi-disciplinary information now available to define the outlines of the problem, to illustrate the complexity involved, and to point the way for future studies.

During the last two decades, a great deal has been learned at both the national and international levels about the oceans and their resources, efficient and modern ways of harvesting these resources, locating the resources, and identifying their range of distribution. This knowledge, however, needs to be augmented and used as the basis of a rational management agreement between nations to prepetuate the living resources upon which social and industrial growth depends.

A small group of individuals have called attention to the need for examining the harvest of marine resources in the light of economic data. Recently, increasing attention has been called to the need to involve coastal populations more deeply in the economic growth that results from the harvest of natural resources.

It seems to me that if better management arrangements are not made, hopefully, on the basis of mutually acceptable scientific evidence, then the potential of the world's oceans will not be made available to individual nations or to mankind, and much of the potential resource could be wasted.

While such international agreements are important, so too are national policies for the economic management of fisheries resources, aimed at preventing overcapitalization, the curse of many of the world's historically valuable fisheries.

In the United States, it has recently been recognized that ocean policy and its implementation must be brought together by the reorganization of the federal-civilian departments for ocean science into the National Oceanographic and Atmospheric Agency.

Similar thinking and organization seems called for at the international level if we are to implement the various kinds of research management now so badly needed.

Other urgent uses for the oceans such as transportation, mineral development, petroleum development, the disposal of chemical or thermal wastes, increasingly point to the need for a United Nations agency with broader functions than those of the Intergovernmental Oceanographic Commission or through those of the FAO Department of Fisheries.

While recognizing the membership of the USSR in UNESCO, the IOC parent organization and the close cooperation that exists in the sphere of fisheries between the FAO and the USSR, as only two examples, there is need, in the long term, for an ocean policy framework compatible with the needs of the whole international community which has the active membership of the world's most populous countries, both developed and developing, including, again for example, mainland China.

In some ways, the problems of managing the fisheries in the coastal zone appear to be less complex than managing high-seas commercial fisheries, because they are wholly within the jurisdiction of a single state, but the problems are in fact no less difficult. Alternative and competing uses, involving both living resources and other uses of the ocean, must be balanced without detriment to the environment, often in the face of concerted economic or political pressure.

On the one hand, the waters must be managed for the needs of better commercial fisheries and recreation. On the other hand, the coastal zone is increasingly being used for the disposal of domestic and industrial wastes, which in some cases are extremely harmful to the living resources.

Within this coastal zone, the sea floor provides petroleum, minerals, and other useful products which when exploited may directly or indirectly modify the environment of the living resources. The problem is to reconcile these various uses of the marginal sea, and where this is not possible, to acquire sufficient knowledge to provide a basis for decision among the incompatible uses. Despite our considerable scientific knowledge, our understanding of the impact on the ecology of the various uses to which we would put our coastal zone is abysmally small.

International and national arrangements for research and research institutions must develop programs sufficiently broad to encompass the biological, oceanographic, atmospheric, behavioral, and social science programs posed by our use of the oceans in increasingly varied and conflicting ways.

In the last two decades, and particularly in the last decade, major patterns of interaction of the ocean and atmosphere have been recognized; in some cases, tentatively identified with the pattern of movement, occurrence and abundance of major fishery populations. It is probably within our technical ability to understand both large scale and small scale atmospheric, oceanographic, biological, and economic relationships together with the ways in which the animals react to their environments. We need such understanding as a guide to the formation of agreements on rational use of living resources and to minimize the sort of man-made inbalance of marine species which has occurred in the case of the whales and the Pacific sardine.

Such studies will require a multi-disciplinary approach of almost unprecedented proportions, but, the by-products could include insight into tropical hurricane formation, increased understanding of terrestrial world-wide weather patterns, and a deeper understanding of the consequences - ecological, social, and economic - of our activities in regard to the world's valuable populations of marine animals. Hopefully, application of the results of such studies through increasingly equitable management agreements will insure a sustained harvest of edible protein from the oceans for as long as it is needed by our planet's human population.

LITERATURE CITED:

Chapman, W. M., 1967. The State of Ocean Use Management. FAO Fisheries Report No. 46, Suppl. No. 1, FAO, Rome.

Chapman, W. M., 1970. Some Problems and Prospects for the Harvest of Living Marine Resources to the Year 2000. Prepared for meeting at UNITAR, Feb., 1970.

Christy, F. T., Jr., and A. Scott, 1965. The Common Wealth in Fisheries. John Hopkins Press, Baltimore, Maryland.

Christy, F. T., Jr., 1970. Fisheries and the New Conventions on the Law of the Sea. San Diego Law Review - Law of the Seas, Volume 7, No. 3, July

Graham, H. W., and R. L. Edwards, 1962. Fish and Nutrition, Fishing News, London, pp. 3-8.

Kasahara, H., 1967. Food Production From the Ocean. Conference on Law, Organization, and Security in the Uses of the Ocean. Ohio State University, 1:1-43.

Rothschild, B. J., 1965. Preliminary Assessment of the Yield Potential of the Skipjack Tuna in the Central Pacific Ocean. Proceedings, Governor's Conference on Central Pacific Fishery Resources, edited by T.A.Manar, Honolulu

Ryther, J. H., 1969. Photosynthesis and Fish Production in the Sea. Science, Volume 166, pp. 72-76.

Schaefer, M. B., 1965. The Potential Harvest of the Sea. Trans. American Fish. Soc., Volume 94, No. 2, pp.123-128.