

towing a float with wire mesh bottom under the end of the conveyor, deep enough that water cushions the impact of falling material.

This method of sampling requires that rate of travel of the conveyor belt exceed rate of linear progress of the dredge, and that these rates remain constant for a short time before and during the sampling. The dredge must, of course, travel in a straight line, a requirement which is easily met by steering so that the rail of the boat is kept a constant distance from the vertically-driven pole. If the rail is not essentially parallel to the keel-line of the boat, a "false rail" can be used as a reference plane.

Inasmuch as the dredge when carefully operated is virtually 100 per cent efficient, highly quantitative samples are obtainable by the method described. No other gear of which we have knowledge has equal utility in shoal-water surveys of commercial shellfish or in studies of distribution, abundance, and ecologic relationships of the littoral macro-benthos. To view the panorama of bottom communities passing on the conveyor belt is a unique and rewarding experience, one that challenges the biologist to make greater and better use of this remarkable machine, the Maryland clam dredge.

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The Biological and Economic Problems in Marine Fisheries Management¹

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IN THE NORTHWEST we have, in spite of the Japanese, tended to view our fisheries management problems as of sole concern to ourselves and possibly Canada. Our complacency has recently been rudely shaken by the appearance of Russian trawlers off Alaska's coast.

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Although not much publicized, especially as to the activities of the scientists, the International North Pacific Fisheries Commission is itself evidence of the growing international flavor of the management of our high seas fisheries. This has been further emphasized by the Geneva conference on the Law of the Sea called by the United Nations in the spring of 1958.

Whether we like it or not the management of our high seas fisheries cannot be viewed as a matter of our concern alone. The nations of the world have declared their interest in all high seas fisheries and this interest may be expected to affect our entire approach to problems of management of these fisheries. An examination of recent events in which the international aspects of high seas fisheries management have been discussed is therefore appropriate.

The Geneva Conference on Laws of the Sea

The 1958 Geneva conference of the United Nations on the Law of the Sea climaxed a number of years of study by representatives of member states to develop a code of law for the sea. The results of this conference were expressed in four proposed treaties covering various aspects of maritime law, which are now being considered for approval by the different nations. If approved, they will constitute a code of law which will govern the activities of man on the seas and incidentally will be the basis for fisheries regulations beyond territorial limits.

Since they represent a series of compromises the provisions of the treaties are not very specific on many points. For example, the breadth of the territorial seas is defined in Article 6 of the proposed convention on the "Territorial Sea and Contiguous Zone" (Document A/Conf. 13/L.52) as follows: "The outer limit of the territorial sea is the line every point of which is at a distance from the nearest point of the baseline equal to the breadth of the territorial sea." Apparently no agreement could be reached as to whether the territorial limits should be three miles or two hundred miles in breadth. Since the United States has advocated three miles for some years, we cannot expect these limits to be extended much farther out to sea in the near future, although a suggestion of six miles for territorial limits, plus an additional six miles for the limits of exclusive rights for fisheries, is rumored to have been proposed and to have received considerable support.²

The effect of any reasonable territorial limit upon fisheries regulation may be appreciated by consideration of other provisions regarding fisheries which are included in Article 2 of the Convention of the High Seas (Document A/Conf. 13/L.53). This article provides as follows: "The high seas being open to all nations, no State may validly purport to subject any part of them to its sovereignty. Freedom of the high seas is exercised under the conditions laid down by these articles and by the other rules of international law. It comprises, *inter alia*, both for coastal and non-coastal States:

1. Freedom of navigation;
2. Freedom of fishing;
3. Freedom to lay submarine cables and pipelines;
4. Freedom to fly over the high seas.

"These freedoms, and others which are recognized by the general principles of international law, shall be exercised by all States with reasonable regard to the interests of other States in their exercise of the freedom of the high seas."

²This proposal was rejected at the second U. N. Conference on the law of the sea held in April, 1960, so that territorial limits remain a subject of controversy.

Fisheries conservation is covered more extensively in the "Convention on Fishing and Conservation of the Living Resources of the High Seas" (Document A/Conf. 13/L.54). This proposal again insures the right of all nations to fish the high seas, "subject (a) to their treaty obligations, (b) to the interests and rights of coastal states as provided for in this Convention, and (c) to the provisions" . . . of this convention. Later articles provide that states participating in a fishery shall agree to conserve it, or if they cannot agree the matter is to be submitted to arbitration. This assumes that at least one of them wants to conserve it.

The rights of coastal states are defined in Articles 6 and 7 of this same proposed treaty. These recognize the special interests of a coastal state in maintaining the productivity of fisheries off its coast. They declare the right of a coastal state to take part on an equal footing in research and in regulation of its coastal fisheries, regardless of whether it participates in those fisheries, and also the right to initiate conservation regulations to protect those fisheries. It is important to note that the proposed treaty states that these measures are to be valid for other states only if the following requirements are fulfilled: (a) that there is a need for urgent application of conservation measures in the light of the existing knowledge of the fishery; (b) that such measures do not discriminate in form or in fact against foreign fishermen.

These conditions are also to govern the deliberations of any special commission set up, as provided in the convention, to arbitrate disputes concerning fisheries conservation. There is no mention of the principle of abstention in any of the proposed treaties, although the principle was proposed by the committee on fisheries and missed approval by only a narrow margin of votes. The conference also rejected the resolution adopted by the committee on High Seas Fishing and Conservation of Living Resources, (A/Conf. 13/L.21 Annex), which "commended the abstention procedure to States for utilization where appropriate . . ."

Several conclusions may be drawn from the results of this conference.

The treaties formulated by this conference represent the results of careful study by the International Law Commission, appointed by the United Nations for this purpose. They include all points of international law of the sea upon which the nations of the world could agree at the time of the convention, and therefore may be viewed as the future basic law of the sea whether or not the treaties are accepted formally by all nations. These treaties should be of special interest to fisheries conservationists as well as to the fishing industry.

The right of any nation in the world to share in any fisheries up to the present 3-mile limit which we currently claim is recognized by most nations in the world. It is well for us to realize this means that if we do not develop our fisheries, others will certainly develop them. They can also promulgate regulations for these fisheries if necessary, and if their regulations are based upon appropriate scientific findings they will probably be recognized internationally.

Only those who participated in the conference will know what was behind the choice of words used to formulate these proposed laws to govern fishing on the high seas. Since I am not a lawyer I cannot say how they might be interpreted in court or by any arbitrators who might some day be appointed under these regulations to settle disputes that may arise over these fisheries. Viewing them as a fisheries biologist they seem to recognize only the possible need for regulation without stating why such regulation might be needed "urgently."

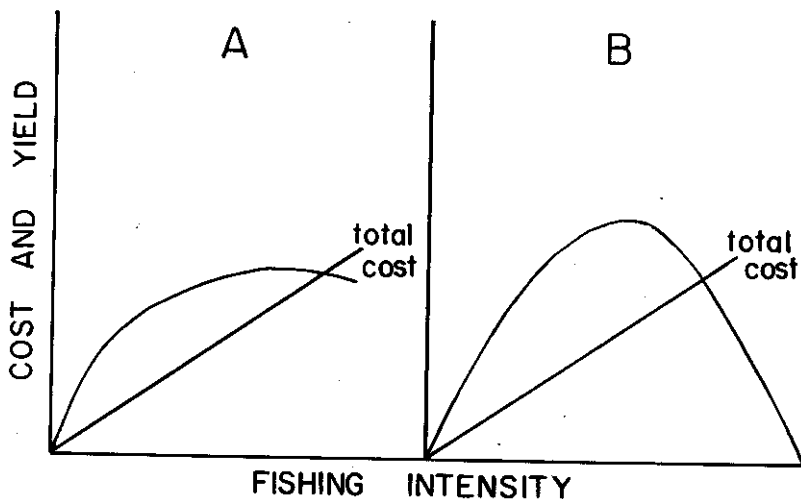
All of the background statements and documents upon which this agreement is based are specific on this point, however, and recognize that the "Principal objective of conservation of the living resources of the seas is to obtain the optimum sustainable yield so as to secure a maximum supply of food and other marine products." (Paragraph 18 Section II, Rept. Int. Tech. Conf. Cons. Advisory Res. Sea UNA/Conf., 10/5 Rev. 2, July, 1955.) This is called elsewhere the "maximum sustainable yield" (UN 392 A/CN. 4/Ser. A/1956).

The discussions which were developed at the Conference on the Biological and Economic Aspects of Fisheries Management, held at the University of Washington in February, 1959, indicate that this objective should be qualified by economic considerations. Moreover according to Beverton and Holt (1957) the existence of a unique maximum sustainable yield may be doubtful. These authors have developed a theory of the reaction of a stock of fish to a fishery, which results in the yield rising continuously and asymptotically as the fishing intensity is increased and as the minimum size or age limit of fish taken is raised.

Figure A must be viewed as 3 dimensional and the relationship has been given the name of the eumetric fishing curve. This may be contrasted with Figure B the curve drawn by Schaefer (1959) which indicates that total yield will decrease from some maximum as the fishing intensity is increased without limit.

In either case, however, the authors indicate that as the fishing intensity increases the total cost of landing the fish must increase. The simplest possible concept is that this increase will follow a straight line. Eventually the cost curve and the yield or value curve intersect and the net profit or "rent" from fishing disappears at this point.

If the theory of eumetric fishing is valid, there will be no maximum level of total yield that is unique for the fish population in question. There is a maximum net economic yield however which may be defined as that level of fishing and of the minimum size limit at which the eumetric curve lies farthest above the



FIGURES A AND B. Relationship of sustainable catch and total cost to fishing intensity. Curve A is eumetric fishing curve.

total cost curve. Under constant conditions of production of fish (growth, natural mortality, etc.) and with a constant relationship of cost to fishing intensity this point may be defined, provided sufficient information is available concerning the biology of the fish population, the relationship of the fishery to the population, and the economics of the fishery.

The "eumetric fishing curve" derived by Beverton and Holt requires extrapolation far beyond any population levels that have been observed and includes imperfect approximations of the effects of great increases in population density which do not correspond with conditions encountered so far in dense populations of fish. It is difficult therefore to acknowledge its validity, and Schaefer's approximation seems to correspond more nearly with present knowledge of fish as well as other types of populations. According to this theory the yield will finally decrease as fishing intensity F (Figure B) is increased so that the intersection of cost and value curves occurs at a much lower level of fishing than it would in Beverton and Holt's model. As long as the cost curve has a positive slope the level of maximum economic yield will occur at a fishing intensity lower than that which will produce maximum yield.

It is apparent then, whichever of these two theories is accepted, that maximum economic yield will always occur at a fishing intensity below that at which maximum yield can be obtained (this is at $F = \infty$ in Beverton and Holt's theory). Moreover as the cost per unit of fishing effort increases, i.e., the steeper the cost curve rises, the point of maximum economic yield will lie farther to the left of the level of maximum biological yield. The biological and economic maxima will lie closer together as the cost per unit of fishing decreases. They will only coincide if costs are zero.

Let us examine the relationship this theory has to the methods of handling high seas fisheries proposed by the UN conference cited above. It is necessary to combine these proposals with currently accepted methods of regulation as enforced by the International Halibut or Salmon Commissions, by the Fish and Wildlife Service or by the various States. These regulations generally limit total catch but do not limit the number of boats or the number of separate units of gear which may be used to take that catch, although several attempts to accomplish this purpose have been made, for example in Chesapeake Bay and in Alaska. In other words accepted conservation regulations are aimed at attaining the "maximum sustainable yield" however that may be defined. Under these circumstances, with no limit on amount of gear which may be applied, the number of active units of effort utilized to capture a limited total yield will be increased until the net income or profit is reduced to that level where the number of fishermen leaving the fishery for easier or more profitable pursuits will be balanced by the number of new ones entering, or amount of gear leaving equals amount entering. We will assume that the total yield or catch, and the manner in which it is taken, are regulated "properly" so as to obtain the maximum sustainable yield. We can assume that with regulation for the sole purpose of obtaining the greatest yield in weight of fish, (if the level of maximum yield can be found) and the catch fixed at that point by law, the cost curve will rise vertically as the number of boats and amount of gear increases until the point of intersection of cost and value curves will lie at the point of maximum catch.

Whether or not this situation is satisfactory economically, it corresponds with conditions as they exist at present.

What would happen then if fishermen of another nation decided to enter this fishery? Under the treaties proposed by the Geneva Conference, the best that could be hoped for would be that the new entry would conform with established catch limits and with regulations set up by those already regulating the fishery for taking that catch and would even conclude a special treaty binding themselves to follow those regulations in perpetuity! In the meantime, however, the number of fishing boats as well as units of gear in use has been increased beyond the stable level that has provided only the minimum "opportunity returns" which had kept the original fleet stabilized. The original fleet, therefore, would face the necessity of either reducing its size by eliminating fishermen, boats, and gear from the fishery, or of accepting a reduced income. Since we originally supposed that the fishery was stable at a point where net income was just sufficient to attract the same numbers of fishermen into the fleet as were leaving for more lucrative or easier pursuits, we could assume that a decrease in net income, such as would result from the entrance of another nation's fishermen into the fishery, would cause a reduction in the number of fishermen, in the number of boats and in the amount of gear operated by the original nation. These fishermen would then be forced out of their chosen trade and would have to find employment elsewhere. Meanwhile, the catch formerly available directly to the original country would either be directed elsewhere or would have to be purchased from foreign fishermen. Aside from implications regarding foreign trade balances or food supplies, if the original fleet was operating at a level of maximum efficiency, nothing will have been gained by the world as a whole from the substitution of one group of fishermen for another; and in the case of some states which are economically vitally dependent upon their fisheries, such a displacement of fishermen would result in unnecessary hardship. Certainly nothing has been added to the world's supply of food.

The case described above is a very special one which probably the halibut fishery of the northeastern Pacific alone approximates. It is instructive to examine the effects of entrance of a new nation possessing a more efficient fleet, i.e., lower cost per unit of fishing effort, into an unregulated fishery. Unless the original and less efficient fleet were protected by tariffs or subsidies, the more efficient one should have no trouble in capturing the fishery, just as a more efficient type of gear will supplant a less efficient one unless the latter is artificially protected by regulation, as is presently true in the Alaska salmon fishery.

Many other possible situations may be described for which examples could be found in the world's fisheries, but time does not permit examination of more of them here. The burden of all such conceivable sets of events would seem to be that in unregulated fisheries under proposed international law the more efficient fleet would supplant the less efficient one by reducing the level of abundance and catch to levels at which the latter could no longer survive. In the case of regulated fisheries, under existing management practices, assuming the catch is stabilized at the maximum a stock of fish is capable of producing, nothing will be gained economically nor will any additional food be produced by the entrance of another nation into such a fishery, provided the original fishing fleet is operating at or near maximum efficiency. No consideration has been given here to any claims the original fishermen may feel they have to a fishery which they have conserved and developed to its level of maximum yield.

Effect of Regulation to Obtain Maximum Economic Yield

If our concepts of fisheries management should be altered to permit substitution of the objective of maximum economic yield for maximum biological yield, it is at once apparent that the proposed international law for high seas fishing is completely inadequate. In fact, it is inadequate for any type of conservation since, theoretically, any nation desirous of entering a regulated fishery could force its way in by obscuring true issues or refusing to recognize the validity of any case that might be presented in the interests of conservation. Marine fisheries biology is so complex and until the last few years has been supported by acceptable data only in a few specific cases. As a result definite answers to many important questions have not yet been found. Decisions concerning the need for conservation are easily confused even by sincere biologists who, because of complicated situations, can arrive at widely opposite conclusions from the same data. The situation would be greatly complicated by an attempt to maximize the economic yield. This could only be achieved by complete regulation of the number of boats, as well as the number of units of gear which are permitted to enter the fishery. It must even be assumed that regulations would have to be designed to force, or at least encourage, continued modernization of techniques to maintain efficiency and minimum costs.

Such control would be comparable with that exercised through ownership and could not be accomplished if anyone who might wish could inject a new fleet of boats into such a fishery. Successful economic control could only be accomplished under an arrangement which would reserve all rights in a fishery to those operating it.

How this is to be done within existing concepts of fish conservation is an unsolved mystery with clues to possible solutions furnished, for example, by accepted methods of handling public grazing lands by the U. S. Forest Service, but with the added complication of location of the high seas fisheries in a sort of no man's land. The scope of the problem would be reduced to manageable proportion by international acceptance of the principle of abstention as the basis for handling high seas fisheries conservation.

The principle of abstention was first formulated in the "International Convention for the High Seas Fisheries of the North Pacific Ocean," a treaty between Canada, Japan and the United States, signed in Tokyo in 1952.

The principle provides in brief that if any nation has developed and conserved a fishery it has certain rights to that fishery. These rights are retained as long as it can show that its use of the fishery is scientifically controlled, and that it is obtaining the maximum yield the stock is capable of producing. The joker in this deck is the requirement that to obtain abstention, at present, the nation in possession must prove to the satisfaction of any other country which might wish to enter the fishery that the fishery complies in all the respects with the requirements for abstention. It would seem as though some more objective way of reaching such a decision could be provided than that of pitting one nation against another in this manner. Perhaps the method of arbitration proposed by the fisheries committee at the Geneva Convention would provide objectivity.

At the various meetings of the International Law Commission the abstention principle was refined and finally presented in a form only slightly altered from that provided in the International North Pacific Fisheries Treaty. Since it was rejected by the Geneva conference, it would seem that we are discussing a lost

cause except for the North Pacific treaty. But the margin of loss at Geneva was small, and it still appears to be the most logical solution to the still unsolved problems of conservation of high seas fisheries.

At present, it is looked upon solely as a method of insuring continued conservation of fisheries. It may be viewed literally as a sort of reward to a nation and its fishermen for a competent job of fisheries management. By implication this recognizes the economic value of a fleet and its equipment, but is still a far cry from recognizing the development of maximum economic yield as a valid objective of fisheries management. Acceptance of this objective by all nations presents a number of complications that seem to make it improbable that we shall soon see it established on an international scale.

Whatever develops in the law of the high seas as it pertains to fishing, and to fish conservation, a common thread of thought may be followed through all of the proposals, including those that came out of the Geneva conference. This states firmly that the management of the high seas fisheries is going to be based upon scientific research of a quality acceptable to all nations. The high standards that must be met are evident in the deliberations of the International North Pacific Fisheries Commission and in the discussions of the participating scientists. The Commission is charged with determining whether various stocks of fish can comply with the requirements for abstention. Scientific justifications have been subjected to the searching criticism of the most competent fisheries biologists available to the three participating nations. The similarity of requirements for regulation by Coastal states, or others of high seas fisheries provided in the fisheries regulations proposed by the United Nations, indicates that in the future any such regulations will be subjected to similar scrutiny.

It appears that fisheries biology has come of age and that the responsibility for formulating programs of management of high seas fisheries will in the future fall on the biologists' shoulders. It is only sensible that this should be true.

A recent suggestion that we face the need to divide the ocean into zones, which will be reserved for certain nations to exploit may be a view of the future. This is not a matter that can be proposed lightly as may be concluded from the unforeseen difficulties that have haunted our Pacific tuna fisheries ever since the so-called Truman Doctrine of conservation zones was proclaimed in September 1945. Possibly the claims of several South American countries to territorial limits of 200 miles would have developed alone, but these claims were stimulated to an unknown degree by the proclamation.

Finally conservation to be effective must deal with whole stocks of fish and conservation boundaries which ignore the biological boundaries of such stocks will be futile.

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