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THE ECONOMIC AND SCIENTIFIC BASIS OF THE PRINCIPLE OF ABSTENTION

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CONTENTS

Introduction

1. In response to a request by the Secretariat of the United Nations, the following report is presented covering the Economic and Scientific Basis of the Principle of Abstention. Preparation of this report has required reference to a number of different articles. These are listed alphabetically by authors as a bibliography at the end of the paper and are referred to at appropriate places by the author's name followed by the year in which the article was published. The principal references have been the *Papers presented at the International Technical Conference on the Conservation of the Living Resources of the Sea*[1] and the report[2] of that Conference held at Rome in 1955 which together present an excellent summary of the basic problems of world fisheries today. It seems essential however in dealing with a matter of such importance as the abstention principle that the original sources of information upon which the principle must be based should also be listed.

2. Examination of the literature, as far as it has been possible for me to pursue the subject, indicates that no work has been published which could be construed as furnishing an economic basis for abstention. An informal conference of representative economists from Canada and the United States of America and fisheries biologists held at the School of Fisheries, University of Washington, on 15 May 1957 was completely concerned with reconciling differences in the basic thinking of the two groups with regard to the development of methods of conservation which would permit a more economic operation of fishing fleets within the limits of restrictions required to conserve a fishery and to maintain it at its level of maximum sustained yield. The economic basis presented below is founded primarily upon my personal views, and is restricted by an apparent lack of work on this subject by economists. Several brief references in the International Law Commission's report covering the work of its eighth session[3], in the report of the Rome Conference and in the papers presented at that Conference are insufficient in my mind to provide an economic basis for the principle of abstention. At present, therefore, it is my opinion that the principle of abstention should be developed solely upon the so-called "scientific basis", which is that of conservation of our marine resources and the production of the maximum amount of food from the sea. A short summary of the economic factors mentioned at various times in connexion with the abstention principle is included for reference.

I. THE PRINCIPLE OF ABSTENTION

3. 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 full text of the treaty is reproduced in the United States Department of State publication, *Treaties and Other International Acts Series* No. 2786, dated 9 May 1952. The pertinent part of article IV is reproduced below for ease of reference.

"1. (b) With regard to any stock of fish which the Commission determines reasonably satisfies all the following

* This paper was prepared at the request of the Secretariat of the United Nations but should not be considered as a statement of the views of the Secretariat.

[1] United Nations Publication, Sales No.: 1956.II.B.1.

[2] United Nations Publication, Sales No.: 1955.II.B.2.

[3] *Official Records of the General Assembly, Eleventh Session, Supplement No. 9* (A/3159).

conditions, a recommendation shall be made as provided for in Article III, Section 1 (b):

"(i) Evidence based upon scientific research indicates that more intensive exploitation of the stock will not provide a substantial increase in yield which can be sustained year after year;

"(ii) The exploitation of the stock is limited or otherwise regulated through legal measures by each Party which is substantially engaged in its exploitation, for the purpose of maintaining or increasing its maximum sustained productivity; such limitations and regulations being in accordance with conservation programmes based upon scientific research; and

"(iii) The stock is the subject of extensive scientific study designed to discover whether the stock is being fully utilized and the conditions necessary for maintaining its maximum sustained productivity."

4. The principle of abstention was first placed before the International Law Commission in the report of the International Technical Conference on the Conservation of the Living Resources of the Sea at Rome (para. 61) as a special case of the problems created by new entrants into a fishery under conservation management.

"61. A special case exists where countries, through research, regulation of their own fishermen and other activities, have restored or developed or maintained stocks of fish so that their productivity is being maintained and utilized at levels reasonably approximating their maximum sustainable productivity, and where the continuance of this level of productivity depends upon such sustained research and regulation. Under these conditions, the participation of additional States in the exploitation of the resource will yield no increase in food to mankind, but will threaten the success of the conservation programme. Where opportunities exist for a country or countries to develop or restore the productivity of resources, and where such development or restoration by the harvesting State or States is necessary to maintain the productivity of resources, conditions should be made favourable for such action."

5. In paragraph 62 of the same report the provisions of the International North Pacific Convention, under which abstention may be justified, are paraphrased as follows:

"62. *Existing procedures.* The International North Pacific Fishery Commission provides a method for handling the special case mentioned above. It was recognized that new entrants in such fisheries threatened the continued success of the conservation programme. Under these circumstances the State or States not participating in fishing the stocks in question agreed to abstain from such fishing when the Commission determines that the stock reasonably satisfies all the following conditions:

"(*a*) Evidence based upon scientific research indicates that more extensive exploitation of the stock will not provide a substantial increase in yield;

"(*b*) The exploitation of the stock is limited or otherwise regulated for conservation purposes by each party substantially engaging in its exploitation; and

"(*c*) The stock is the subject of extensive scientific study designed to discover whether it is being fully utilized, and what conditions are necessary for maintaining its maximum sustained productivity.

"The Convention provides that, when these conditions are satisfied, the States which have not engaged in substantial exploitation of the stock will be recommended to abstain from fishing such stock, while the States engaged in substantial exploitation will continue to carry out the necessary conservation measures. Meanwhile, the abstaining States may participate in fishing other stocks of fish in the same area."

6. Comparison of section (a) as stated above with Article IV, section 1 (b) (i) of the International North Pacific Treaty indicates the omission in section (a) above of the last words in the corresponding section of the treaty "which can be sustained year after year." While the last three words are redundant if it is specified that the increase in yield must be sustained, this omission would defeat the purpose of the paragraph (a) as will be shown below.

7. The comments by Canada on article 31 of the provisional articles concerning the regime of the high seas [4] repeat paragraphs 61 and 62 of the report of the Rome Conference including the omission noted above in paragraph (a).

8. The provisions of the International North Pacific Treaty were designed to fit specific problems faced by Canada, Japan and the United States of America in the North Pacific Ocean. A more general proposal was framed by the United States of America in its comments on the provisional articles concerning the régime of the high seas [5] which rephrases the problem of abstention and the requirements for application of the principle. The United States proposal was restated more clearly in the presentation made by Mr. Edmonds at the 356th meeting of the International Law Commission on 30 May 1956 [6] which outlined the following text for part of article 27.

"3. Where, within reasonable limits, the maximum sustainable yield under current conditions of any stock of fish is already being obtained and the maintenance and further development of such yield is dependent on the conservation programme, including research, development and conservation being carried on by the State or States whose nationals are substantially fishing such stock, States not so fishing or which have not done so within a reasonable period of time, excepting the coastal State adjacent to the waters in which this stock is found, shall abstain from fishing such stock. In the event of disagreement as to whether a particular stock meets the above qualifications for abstention, the matter shall be referred for arbitration as provided in article 31.

"4. The arbitral commission shall reach its decision and make its recommendations under paragraph 3 of this article on the basis of the following criteria:

"(*a*) Whether by reasonably adequate scientific investigation it may be determined that certain conservation measures will make possible the maximum sustainable yield;

"(*b*) Whether the stock is under reasonable regulation and control for the purpose of making possible the maximum sustainable yield, and whether such yield is dependent upon the programme of regulation and control; and

"(*c*) Whether the stock is, within reasonable limits, under such exploitation that an increase in the amount of fishing will not reasonably be expected to result in any substantial increase in the sustainable yield."

9. The commentary on article 53 in the report of the eighth session of the International Law Commission (A/3159, p. 35) is a composite of all of these proposals; paragraphs (*a*) through (*d*) of section 4 and section 5 of this commentary are set forth below:

[4] *Yearbook of the International Law Commission 1956* vol. II (A/CN.4/SER.A/1956/Add.1), p. 42.

[5] *Ibid.*, p. 91.

[6] *Ibid.*, vol. I (A/CN.4/SER.A/1956), p. 122-123.

"4. The report of the Rome Conference also described a procedure now in operation which provides a method for handling this special case. This procedure, under the designation 'principle of abstention', was proposed by certain Governments for inclusion in the Commission's fishery articles. This proposal provided that:

"(a) When States have created, built up, or restored productive resources through the expenditure of time, effort and money on research and management, and through restraints on their own fishermen, and

"(b) The continuing and increasing productivity of these resources is the result of and dependent on such action by the participating States, and

"(c) Where the resources are being so fully utilized that an increase in the amount of fishing would not result in any substantial increase in the sustainable yield, then:

"(d) States not fishing the resources in recent years, except for the coastal State, should be required to abstain from fishing these stocks as long as these conditions are fulfilled.

"(5) The Commission recognized that both this proposal, the purpose of which was to encourage the building up or restoration of the productivity of resources, and the proposals of some other Governments, based on the concept of vital economic necessity, may reflect problems and interests which deserve recognition in international law. However, lacking the necessary competence in the scientific and economic domains to study these exceptional situations adequately, the Commission, while drawing attention to the problem, refrained from making any concrete proposal."

10. Comment on the significance of variations in phraseology of the different proposals requires an understanding of the scientific basis of fisheries conservation and the clarification of terms used. The scientific basis of fisheries conservation is in fact the scientific basis of the principle of abstention.

Definition of a stock

11. The principle of abstention in all the proposed versions is applied to "stocks of fish". The terms "stock" and "population" are considered by Schaefer (1955) * to be synonymous and are defined by him as a homogeneous group of members of the same species occupying a continuous environment, interbreeding freely within that environment and reacting as a unit to changes in population size whatever the cause of such changes may be. In the report of the Rome Conference (para. 21) stocks are defined by inference as "independent or semi-independent populations, which constitute the natural biological units of the resource to be dealt with by a conservation programme." (International Technical Conference - Rome, 1955). In the practical application of conservation and in establishing the principle of abstention the term "stock" must be interpreted according to local conditions. These conditions may be defined by the nature of a fishery, by the relationships between the environment and the species of fish exploited, or by the relationships between different species of fish all of which are taken by a single type of gear or which may be taken by several different types of gear which operate as a series of fisheries on all the species together.

12. In the herring fisheries of the North Atlantic Ocean and of the Northeast Pacific the fishery is for all practical purposes confined to a single species. The same is true of the cod fishery of the North Atlantic, the halibut fishery of the Northeastern Pacific, the king crab fishery of the North Pacific, and many others although all of these fisheries undoubtedly operate on a number of separate stocks. The choice of species to be taken is entirely in the hands of the fishermen and in general the only species taken is the one sought and for which the gear is best adapted. In these fisheries the strict definition of stocks given above, which applies only to a particular group of members of a single species, would apply.

13. On the other hand, in many other fisheries several species are unavoidably taken in a single type of gear operated in a single locality. While some choice may be exercised by the fishermen in the depth at which the gear is operated, or in season or area of operation, practical considerations of management make it impossible to separate the species in designing a management programme. Examples of such a fishery would be the bottom trawl fisheries in the North Sea or in any locality, where all fish living on or close to the sea floor in the path of the trawl, and which are too large to escape through the trawl's mesh, will be at least represented in the catch. The fishermen can obtain catches that are predominantly of one species in some areas, and the more skilful ones can in some places take almost pure catches of a desirable fish, but normally the catches are mixed and management must recognize this mixture of species. Under such circumstances the stock may be defined as a combination of species that forms a fairly distinct population unit which reacts as a whole to changes in population size of all species.

14. In other cases where one species is very much more important than all others taken, in both value and volume of catch, management necessarily may be aimed primarily at the conservation of that one species. Two examples of such a fishery are the salmon fishery of Bristol Bay in which all five species of Pacific salmon are taken but which is dominated by the single species of red salmon (*Oncorhynchus nerka*). The salmon fisheries of the Fraser River also include all five species of Pacific salmon but are dominated by the large stocks of sockeye salmon (*Oncorhynchus nerka*) and pink salmon (*Oncorhynchus gorbuscha*).

15. The salmon fisheries in the boundary waters of the United States and Canada which exploit principally the different species of salmon that spawn in the Fraser River also exemplify the case of many types of gear fishing for several species but all of which comprise a single fishery. The two most abundant species as noted above are the sockeye and pink salmon. These are taken by purse seines, traps (on the southern end of Vancouver Island only), gill nets, and reef nets as they migrate through the Strait of Juan de Fuca, through the San Juan Islands, Strait of Georgia and finally into the Fraser River. While the larger runs of the two species are somewhat separated in time of appearance in the fishery, the most practical method of regulation is by restricting the time of fishing (aside from restrictions imposed on gill net mesh size) to permit desired escapement.

* All references indicated with an * are to be found in the Bibliography annexed to this document.

16. In multi-species fisheries, stocks have to be defined on the basis of units of all the more important species. This is justified since in most cases all of these species react in somewhat the same manner as a stock composed of a single species. In this case, all of the species involved would have to occupy the same type of environment (as in bottom fishes) or would have to be of closely related species (as in the salmon fisheries).

17. A primary requisite for management of a fishery is that the stock, whatever its nature, be capable of clear definition. That is, it must be possible to establish the geographical limits of the area occupied by a particular stock. To be effective these geographical limits must be defined whether or not the fishery covers the entire range of the stock. During particular seasons, or periods of the life history of a species, migrations of the stock may take it out of range of the fishermen who seek it. This is true of the salmon stocks of the Pacific Coast of North America. The American net fisheries for these species are restricted to a particular part of the salmon life history since the fish spend much of their life in the Pacific Ocean far out of range of the United States and Canadian fishing vessels which by law are required to operate only along the eastern Pacific shores. In general the salmon only move into this restricted range of the fishermen as they reach maturity and full growth and begin final migration to their spawning streams.

18. Application of the principle of abstention to a stock of fish implies that the stock is capable of conservation management and it was recognized by the International Technical Conference at Rome that the basic unit for conservation management is the population or stock. It may be presumed that neither conservation regulations nor the principle of abstention would be effective if applied to only parts of stocks of fish. This would happen only if such stocks had not been defined geographically, or were incapable of definition at present, such as tuna stocks which, like the albacore, apparently range over wide reaches of the oceans.

II. Scientific basis of fisheries conservation

19. The scientific basis of fisheries conservation is covered in some detail in the *Papers presented at the International Technical Conference on the Conservation of the Living Resources of the Sea* (see Michael Graham, pp. 1 and 56, M. B. Schaefer, pp. 14 and 194) but will be summarized briefly here. The theory upon which this principle is founded was developed during the last forty years. Beginning with Baranov (1918) *, these principles were further elaborated and extended by Hjort, Jahn and Ottestad (1933) *, E. S. Russell (1942) *, Graham (1935) *, Thompson and Bell (1934) *, Ricker (1944) *, Schaefer (1954 a and 1954 b) *, and Beverton and Holt (1956) * and many others. The comparatively recent development of these principles is associated with the growth of fisheries technology during the last thirty years which has developed such efficient fishing techniques that their effect on the stocks of fish is unmistakable in some fisheries. Significant proportions of some fish populations are now harvested and, when not controlled, fishing has resulted in reducing the size of some of those populations so far as to make their harvest uneconomical. The cost of capturing and landing fish at the low levels of abundance which have resulted has in some cases been found to be greater than the value of the fish (see Thompson and Freeman (1930) *, Thompson, Dunlop and Bell (1931) *, and Thompson and Bell (1934) *).

20. The science of fisheries biology has shown that this type of exploitation of our fishery resources is not only uneconomical but is also wasteful since it prevents these same stocks of fish from producing as much as they can if they are utilized in accordance with their productive capacities.

21. As will be noted in the simple example to be developed below, a fishery may grow and expand for many years without experiencing either full development or depletion. It is well recognized that the growth of a fishery requires a diminution in size of population which is usually shown by a decrease in the average catch per unit of fishing effort. But this decline does not indicate that the stock has been depressed below its level of maximum yield.

The theory of fishing and the productive capacity of a stock of fish

22. The scientific basis of the principle of abstention is identical with the theory of fishing and its relationship to the productive capacity of a stock of fish. It is shown by Schaefer (1955, page 34, equation (1)) * that in its simplest terms the productive capacity of a stock of fish is determined by the balance which exists between the rates of growth, reproduction (recruitment), natural loss and fishing.

Growth rate

23. While the growth rate is limited by the genetic structure of any species, it has been found to be less in crowded populations where the amount of food produced by the environment is not sufficient to meet the full needs of the population (Alm, 1946) *. As the population is thinned by fishing, growth increases (Anderson, 1938) * until it reaches the maximum of which the species is capable in that environment.

Rate of natural mortality

24. Thinning a population by fishing also reduces the rate of natural loss or mortality. This rate will be at its maximum in a virgin population and will fall as the number of old fish is reduced and as the population becomes composed of a larger proportion of young vigorous, rapidly growing individuals. As noted by Schuck (1949) *, the rate of natural loss may be very low in commercial sizes of fish which are subjected to an intensive fishery.

Rate of recruitment

25. The rate of reproduction or recruitment is affected by the density as well as by the size of the population. With the environment crowded to its full capacity, little room remains to support large numbers of young fish and, even though the numbers of eggs

produced may be great in such a population, the number of young fish which usually survive under such conditions is relatively small. In addition, the number of eggs produced by marine fishes, in general, is closely related to size so that slow-growing females mature at a later age and, because of their smaller size at any age, will produce fewer eggs than younger, faster-growing females in a population of reduced magnitude. The rate of reproduction in an efficiently fished population will, therefore, be greater because of the greater number of eggs produced by individual females which grow faster and mature younger than in a crowded population and, above all, because the survival rate of the young will also increase as more room becomes available for them.

Natural fluctuations

26. It is recognized that variations in the complex environment of fishes will result in variations in all three of the above factors (growth, natural mortality and rate of reproduction), particularly in the numbers of young fish which survive to adult sizes (Hjort, 1926, and Tait, 1955) *. These variations are recognized as "natural fluctuations" in population size and are usually expressed in the population itself as variations in the relative number of survivors produced during different spawning years. A particularly favourable year may give rise to an abundant year class of fish which in biological terms may become a "dominant year class" because it is present in larger numbers than both the older and younger year classes, often for a period of some years (Hjort, 1926) *.

27. In the most highly developed fisheries, the fishery takes such a large proportion of the stock that its effect is of much more importance than the natural fluctuations.

Changes in a fish population caused by a fishery

28. The response of a fish population to the development of a fishery can be measured by the total amount of the catch each year, by the changes in amount of fish caught per standardized unit of fishing effort, and by correlated biological changes in the population itself. Most obvious among the biological changes are the number of fish of different ages that are taken in the catches. Beginning with a virgin fishery which has not been previously fished, the following changes may be expected over a period of years during which the total amount of fishing is gradually increased: The total catch will increase for a time; the catch per unit of fishing gear will decrease steadily as the number of units fished is increased; the relative numbers of older and larger fish in the catch will decrease steadily; with some variations to be expected if dominant year classes are present and if the species has a short life and only a few year classes are present at one time. As indicated above, these changes will be modified by the combined effects of the increase in growth rate and rate of survival of young and the decrease in rate of natural loss.

Increased productivity during early development of a fishery

29. A fishery will reduce the size of the population existing on a fishing bank. During its early development, the removal of old and diseased fish, the reduction in competition for space and for food, and the reduction of the average age of the population will actually increase the productive capacity of the population. This productive capacity of the stock determines the weight of fish produced each year in excess of that which is required to maintain the stock at a constant size. In a virgin population which supports no fishery, there is no excess, since the weight of fish produced is just sufficient to replace natural losses. However, as the stock size is reduced and the productive capacity increases as described above, this excess weight will increase as growth increases and natural losses decrease.

Overfishing causes a decrease in productivity

30. If the intensity of fishing, or, in other words, the total amount of gear run in the area occupied by our stock continues to increase each year, we can expect that eventually a point will be reached where the genetic potential for growth of the species will have been fully expressed and no further increase in growth rate will result from additional thinning of the stock. In addition, the capacity of the environment for producing food will not be used to its fullest if the stock becomes so small that all of the food is not utilized. If the natural losses are also reduced to zero or near zero on fish of commercial sizes, even though the production of young is maintained, the population will have passed its point of maximum productivity. Further increase of fishing will remove fish at smaller and smaller sizes, will prevent their full development through growth, and will then result in a decrease in the total catch. Thus, if a fishery which had been stabilized at its level of maximum productivity were then subjected to a greater amount of fishing, the total catch would fall to a lower level. Moreover, the amount of fall would be directly related to the increase in amount of fishing.

Illustration of the theory of fishing using a theoretical model of a stock

31. These relationships are illustrated by the hypothetical population and fishery shown in table I and figure 1. This model is constructed after a pattern similar to that used by Graham (1955). But Graham's model merely shows that, under the assumed circumstances, less fishing will yield a greater catch. The present one is designed to illustrate the full cycle of development of a fishery in a very simple and diagrammatic manner from a low fishing mortality rate of 10 per cent to a condition of overfishing. This model also illustrates the benefit to be derived from adjusting the amount of fishing to the stock's productive capacity.

Basic rates used for the model

32. Because of the lack of precise data on any one fishery concerning the exact interactions of all of the various rates, the model described below is a composite of information taken from several publications dealing with different species. The growth rate (average weight at each age) is that of the California sardine (Clark,

1928 and Phillips, 1948) *; the natural mortality of 30 per cent at the lowest fishing intensity corresponds with an estimate made by Thompson and Bell * for halibut in Western Alaska. The decrease in natural mortality agrees roughly with Schuck's work * which indicates that natural mortality is very low in commercial sizes of haddock on Georges Bank off the eastern coast of the United States, in a population being fished at a rate of roughly 50 per cent per year. No change is made in number of fish in the youngest age class (rate of recruitment) at different levels of abundance nor is the rate of growth altered. This would reduce the relative increase in productivity of the stock that would occur because of increased growth rate in the early stages of the developing fishery and would also slow down the rate of decline at higher rates of fishing, because, except for species which mature at a very young age, the spawning stock would be greatly reduced at the highest fishing levels and recruitment could be expected to decrease.

33. With these limitations, the model illustrates clearly the events that can be expected to occur within a population at different levels of exploitation by a fishery. It shows the condition of the stock in terms of the relative numbers of each age of fish which survive under each set of conditions as well as the total catch, catch per unit of gear, and the relative number of units of gear that would be fished.

34. The situation illustrated in each column in table I and shown by each set of points in figure 1 is commonly known as a "condition of stability". In other words, when a stock of fish is exploited at the same level of fishing intensity year after year, it will become stabilized in size, catch, catch per unit of effort, and number of fish in each group if environment is relatively constant and natural fluctuations relatively small. Again, for simplicity, we have assumed environmental effects and recruitment to be constant. The length of time required for a stock to become stabilized at a new level of fishing will, in general, correspond to the number of ages of fish that will be represented in the catch at the new level of fishing. If we were to assume that fishing and other factors were altered suddenly between the different levels shown in table I, we could expect the conditions shown in each column to have become stabilized only after the passage of a period of years corresponding to the number of ages represented in each column. For example, if the rates of mortality were suddenly changed from $F = 10\%$, $N = 30\%$ (columns 2 and 3), to the conditions shown in columns 4 and 5, a total of sixteen years would be required before the total catch, catch per unit of effort, and relative numbers of fish at each age would be as shown in columns 4 and 5. If the change were to the condition shown in column 10, the change would require only six years to have its full effect. Therefore if a fishery had changed, over a period of years, to assume exactly the different rates of fishing shown in table I and figure 1, and if the changes in population size had brought about the changes indicated in natural mortality, neither the total catch nor catch per unit of effort would have followed the exact course indicated on figure 1. The values shown in each column would be approached gradually through a series of changes similar to those shown in table II and figure 2.

Manner of operation of various mortality rates

35. These various rates of mortality act in the same manner as ordinary rates of compound interest, and table I corresponds in general nature to the tables computed by insurance companies to determine rates of survival and death in human populations. Computation of the catch uses the same principles and requires the use of exponential rates to determine what portion of the total deaths (deaths caused by both natural and fishing losses) will appear in the catch. These processes are discussed in detail in Thompson and Bell *, Graham (1936) *, Baranov (1918) *, and Ricker (1944) * and will not be dealt with further here.

Changes in the numbers of fish of each age in the stock

36. The most striking change that may be noted in table I in the populations (P) and the catch (C) are the numbers of fish in the different ages that appear in both the population and catch. These may be seen in columns 3 to 20 in table I. In a stock that has a natural mortality rate of 30 per cent but is fished at a rate of only 10 per cent per year, eighteen different age classes are represented in the population and in the fishery as is shown in columns 2 and 3. As the natural mortality rate decreases and the rate of fishing increases, the total number of age classes represented in both the catch and the population decreases until, at a rate of 50 per cent fishing with no natural mortality, only twelve age classes are represented in the stock. If the fishing mortality is raised to 80 per cent, the number of age classes present in the stock and in the catch is reduced to six. In a very intensive fishery, the fish are caught before they can grow very old so that the stock is comprised entirely of very young fish.

37. The effect of this change in the relative numbers of fish of different ages is shown in the total catch that appears at the bottom of each column in the table and is also illustrated in figure 1. As the intensity of fishing increases, the total catch increases from approximately 45,000 units at a fishing level of 10 per cent to a total catch of 165,000 units at a rate of fishing of 50 per cent. At still higher levels of fishing, however, the effects of the rapid decline in numbers of older fish in the population begin to appear so that the total catch declines at fishing rates above 50 per cent.

38. In this particular model, therefore, the maximum yield in the total weight of fish caught occurs somewhere in the neighbourhood of a fishing rate of 50 per cent. The model illustrates that at levels below 50 per cent an increase in the rate of fishing will result in an increase in yield, and this increased yield can be maintained year after year indefinitely as long as the rate of fishing is not increased beyond the rate of about 50 per cent per year. However, a stock that conforms in all respects to this model, and for which the rate of fishing has been established at a level of at least 50 per cent per year, will produce a smaller catch if the rate of fishing is increased beyond 50 per cent.

Changes in the average catch per unit of fishing effort

39. It has been shown by Baranov (1918) * and others that the rate of fishing — that is, the number of

units of gear that are run per unit of time in a particular area occupied by a stock of fish — will be proportional to the exponential rate of fishing. Thus, in the model, the relative amount of fishing, that is the relative numbers of units of gear that would be fished each year, would correspond to an exponential rate of fishing that can be calculated from the logarithms of the annual rates indicated at the head of each column by methods given by Baranov. Dividing these figures for number of units of gear into the total catch taken at each level of fishing gives the average catch per unit of effort. This again has been shown to be directly proportional to the average stock present in any fishing season (Beverton and Holt (1956) *). This average catch per unit, as is shown in each column in table I and also in figure 1, decreases uniformly from the high point which corresponds to the lowest rate of fishing to a minimum which corresponds to the highest rate of fishing. In other words, the total weight of fish present on the banks decreases uniformly as the intensity of fishing increases. The intensity of fishing or number of units of gear fished is represented by the line of figure 1 labelled "effort".

Comparison of total yield, catch per unit of effort and effort expended

40. The different values assumed by total catch and catch per unit of effort at different levels of fishing are the result of all the complex factors which act upon the stock. In the model, the fishery was assumed to be the principal variable. This is true in many fisheries. Even in those fisheries where natural changes may be of great importance, changes in rate of fishing would have the same effect on rates of mortality, catch and stock, although an increase in importance of natural changes could superimpose fluctuations upon those caused by the fishery and might result in random changes that would have no relationship to changes in fishing. This would tend to obscure the effects of fishing on the stock and would increase the difficulty of measuring those effects but would not necessarily make such measurement impossible.

41. The important relationship is seen in the existence of a level of fishing at which the yield of the stock is a maximum. Below that level of fishing the yield increases with more fishing and above that level the yield decreases as the amount of fishing increases.

42. The course of events is also reversible. If a fishery has become stabilized at a high level of effort corresponding in our model to a fishing rate greater than 50 per cent per year, the total catch can be increased by the expenditure of less effort. This apparent paradox has been illustrated by the regulation of the Pacific halibut fishery (Dunlop, 1955) *.

43. If the effort is reduced sufficiently in the model to lower the rate of fishing below 50 per cent per year the total yield will then decrease. On the contrary if the fishing effort is held constant at any level, the stock will become adjusted to that level of fishing and after a period of time the catch will become constant and remain constant as long as the yield is held constant. If it is desired to increase the yield from a fishery that has been stabilized at a population level below that which corresponds to its maximum level of productivity (i.e., above 50 per cent annual fishing rate in the model) it would be necessary to take less than the sustainable yield at the current stock level. For example, in table I the sustainable catch at the 70 per cent level of fishing is 131,308 units per year. To increase the productive level of this stock it would be necessary to take less than 131,308 units for several years. The excess weight produced by the stock would be added to the population and would result in a larger population with a larger potential yield. This is just a different way of saying that the rate of fishing would have to be reduced to increase the yield in this stock which was being fished at a rate of 70 per cent per year.

Effects of heavier fishing on the production of spawn

44. While the above relationships are most important in understanding the effects of different amounts of fishing upon a stock, it may be of interest to digress for a moment and to consider the resulting changes in the numbers of fish of different ages which will be represented in the stock when it is stabilized at different fishing intensities. It may be seen in table I that the largest number of age classes is found at the lowest rate of fishing and the smallest number at the highest rate of fishing. The increase in weight of catch from the lowest fishing rate to that of 50 per cent per year is associated with an increase in the numbers of fish caught. However, at rates above 50 per cent the total weight caught decreases in spite of the capture of the same number of fish at all levels of fishing. There is no need to discuss these rather complex relationships further except to note that the greatest change in numbers of fish is in the older age classes which are responsible for the production of spawn.

45. The change that occurs in weight of fish in the stock is great because the larger, older fish which weigh more, feel the full effect of any change in fishing throughout their life span. A change in rate of fishing has a cumulative effect with increasing age. This fact takes on greater significance as the number of age classes represented in population increases and as the age at which maturity is attained and eggs are first produced increases. Thus, the female halibut of the Northeast Pacific first matures at an age of eight years. Since they are first taken in the fishery at about four years of age, an increase in mortality rate would be effective for at least four years before the females begin to produce eggs. The egg-producing capacity of this species increases in proportion to their weight and roughly in proportion to the cube of their length. Thus, Thompson and Bell * calculated that an increase of from 20 per cent to 40 per cent in fishing rate would result in decreasing the weight of halibut older than eight years of age in the population, the age of first maturity, to about 15 per cent of their total weight at the lower rate of fishing. In the example shown in table II, the increase of fishing rate from 50 per cent per year to 70 per cent per year completely eliminates the fish above age seven. The number of eggs and young produced each year would be in proportion to the total weight of the older fish in the population.

46. The reduction in amount of spawn produced at higher levels of fishing may not be important if survival

rates are high in young fish or if the amount of spawn produced, even by small numbers of spawners, is sufficient to provide the number of young required. It can accelerate the decline in size of population and hence the decline in total catch at high levels of fishing if the production of spawn is lowered sufficiently to affect recruitment. This may be seen in various salmon fisheries and was apparently approached in one group of halibut stocks (Thompson and Van Cleve, 1937) *.

Effect of a sudden change in rate of fishing; the temporary increase in total yield

47. The relationship illustrated in table II and figure 2 are the basis for the provision in the International Convention for the High Seas Fisheries of the North Pacific Ocean (article IV, section 1 (*b*) (i)) that: "Evidence based upon scientific research indicates that more intensive exploitation of the stock will not provide a substantial increase in yield which can be sustained year after year." The last phrase was omitted in the report of the Rome Conference (para. 38, sentence (*a*)); but this phrase forms an essential part of this concept. This is illustrated by the changes that would take place in total catch if a fishery, stabilized at the level shown in columns 10 and 11, were suddenly subjected to an increase in fishing that would raise the fishing mortality rate of 70 per cent (columns 14 and 15). These changes are shown in table II and figure 2. The first year after the rate of fishing is increased from 50 per cent per year to 70 per cent per year, the total catch is about 1,500 units or 9 per cent higher than before although the catch per unit of effort falls to about 50 per cent of its value before the change. The changes that take place in the catch per unit of effort measure the changes occurring in the average total weight of stock present on the banks during each fishing season following the change in the rate of fishing and these values fall steadily as soon as the rate of fishing is increased. But at any level of fishing, a sudden increase of fishing intensity will be followed by an increase in total catch. This increase is because of the capture of fish which otherwise would have formed a part of residual population remaining on the banks after fishing is completed. It furnishes evidence that the population is being reduced in size.

48. If the increase in fishing rate is between fishing levels below those which result in the maximum sustained yield, a permanent increase can be expected. If fishing is already at or above the level of maximum sustained yield, an increase in fishing rate will result in only a temporary increase in total yield. This increase will be followed by a decline in yield to a level lower than was obtained at the lower rate of fishing.

The relation of conservation to abstention

49. It may be inferred from the above discussion that the definition of the level of maximum sustained yield or of the relationship between yield and amount of fishing for any stock would require a profound knowledge of the biology of the stock as well as of the characteristics of the fishery to which that stock is subjected. Application of this knowledge in an effective management programme would certainly involve restraints on the fishermen to control the rate of fishing if the productivity of the resource required rebuilding or if it were desired to stabilize the stock at any level of yield. This would require a programme of research and management using the most modern techniques of fisheries biology and would involve the expenditure of a great deal of effort, time and money to acquire the necessary data, perform the required analyses, and to design, put into effect and establish adequate checks on the management programme of almost any stock of marine fish (A/3159, p. 35, commentary to article 53, para. 4 (*a*)).

50. There is some question whether absolute proof could be established that "the continuing and increasing productivity of these resources is the result of and dependent on such action by the participating states", (A/3159, p. 35, commentary to article 53, para. 4 (*b*)). This proof is not required in the North Pacific Convention. In the latter it is only required to prove by scientific research that more intensive exploitation of the stock will not result in a substantial increase in the sustained yield and that the fishery is being regulated through legal measures, etc. and that such regulations are based upon scientific research. The abstention requirements referred to in the International Law Commission report are therefore much more stringent than are those provided in the treaty.

51. If proof should be available that the productivity and condition of the stock is a result of the programme of research and management, it would in most cases only become clear after some years of regulation of the fishery. One exception would be found in proof of the effect of the management of salmon stocks. The result of restricting salmon fishing may be immediately evident in the number of spawning fish which are permitted to escape the fishery. Lack of regulation can prevent the escapement of any salmon or of too few fish to maintain the stock. On the other hand, many years of careful study would probably be required to prove the relationship for a stock of slowly growing fish like the halibut which may have as many as twenty or more age classes represented in the catch.

52. It is evident from the discussion above that, if sufficient data were available to determine the relationship of the yield to stock size and intensity or amount of fishing, it could be established whether the "resources are being so fully utilized that an increase in the amount of fishing would not result in any substantial increase in the sustainable yield" (A/3159, p. 35, commentary to article 53, para. 4 (*c*)). To qualify for abstention under this requirement the fishery would have to be stabilized at or above the level of maximum sustained yield. In the model this would correspond to a fishing rate of 50 per cent or more per year. Under this condition as noted above an increase in the amount of fishing would cause a decline in the sustained yield after a temporary increase in catch.

Application of the model to the principle of abstention

53. Let us consider the hypothetical case of a stock of fish which has been exploited for many years by one or two States. The fishery, we will assume, has passed through the normal history of rapid development to a

state of over-fishing so that the catch as well as the yield per unit of effort has declined. The States involved had then undertaken an extensive programme of biological investigation of the stock which proved that the reason for the decline in production had been excessive fishing. Following this discovery, let us say that the States had agreed upon a programme of regulation based upon the results of their research programme which provided for the limitation of fishing through such devices as limitation of the total catch that could be taken each year, prohibiting the use of destructive fishing gear, prohibiting the capture of undersized fish, and the closure of spawning grounds, spawning seasons, and nursery areas to fishing, etc. As a result of these regulations which were carefully monitored by an extensive and continuing research programme, the stock was rebuilt and stabilized at a level which was producing the maximum yield of which the stock was capable. The stock would comply, therefore, in all respects with the requirements of abstention, the research programme fulfilling in general the requirements set up by Schaefer (1955) *.

54. If now, another State should desire to share in the fishery and should begin fishing this stock which historically had been conserved and maintained by the original fishing States through the expenditure of large amounts of money and much effort on research and by restrictions imposed on their fishermen, there is little doubt that the entire conservation programme would be in danger and the continued productivity of the stock would be imperilled.

55. If the abstention principle were applied, however, the new State would refrain from taking the species under regulation but would be free to exploit other species in the same area which did not fulfil the requirements of abstention. The original fishermen would continue to obtain the maximum yield which the stock in question was capable of producing. In addition, any new fishermen could produce additional food from the other species available on the same fishing grounds. The world's food supply would be increased, and the fishermen of all participants would be benefited. A good example of such a situation is found in Bristol Bay where the Japanese and Canadians abstain from fishing salmon which are taken by fishermen of the United States, but, on the other hand, the Japanese participate in the fishery for king crab (*Paralithodes camtschatica*).

III. The economic basis of the abstention principle

56. Many purely economic reasons are considered to be sufficient reason for controlling fisheries. Where markets are limited a sudden influx of fish can cause a glut. Continuation of unrestricted fishing will cause a collapse of price to fishermen and may result in the waste of fish. Many conservation systems prohibit the wilful waste of fish and to prevent such waste the catch may be limited. More often the industry itself may limit the amount of fish they will purchase from fishermen or if they own the boats and gear will limit the catch the fishermen may take.

57. In addition, the price of fish is usually related to the size of the fish taken in the catch. Limits may be placed by the buyers and by fishermen on the numbers of small fish that may be landed because of the higher cost of handling the small fish and because of the smaller price they command in the market. This is similar to other closures that may be imposed by the industry or by conservation agencies to prevent the capture of fish during seasons or in areas where their condition is unsuitable for marketing. This would apply to closed seasons for the Dungeness crab of the Eastern Pacific (*Cancer magister*) during periods of the year when large numbers of them shed their carapace, and the quality of the meat becomes too poor to market.

58. Closures may also be imposed to prevent losses incurred through dangerous conditions during stormy periods of the year. These also relieve the industry from the expense of maintaining crews to handle small amounts of fish that may be brought in by more venturesome fishermen. These small amounts cannot be handled or marketed economically, but if one dealer continues to handle fresh fish during a period of reduced landings, all of his competitors will be forced to do likewise to prevent loss of market outlets. This was probably the original reason for the imposition of a winter closed season on the Pacific halibut in the provisions of the original treaty between the United States of America and Canada on this species (see paragraph 86 below).

59. There are also many economic ramifications of any programme of conservation. For example, in some cases if no programme of conservation were instituted an entire industry can suffer economic extinction. Moreover, stabilization of the catch of any species of fish at a certain level will have widespread ramifications in the stabilization of the fishery that depends upon that species, as well as upon the entire processing and marketing organization that places the product in the hands of the consuming public. Promotion of the most efficient utilization of a fishery would fall into this class. The most efficient utilization of a fishery infers full utilization of boats and gear to obtain a catch that will bring the largest return on the investment in time and gear to the most fishermen. Many complicated problems are involved in determining the desirable level at which any fishery should be stabilized to bring about this result. One of the greatest sources of trouble would, of course, be the variations with time, in ratio of cost of operations to value of catch. In addition, economic levels vary in different countries, and some States are faced with the need of providing work for the most men even though at a low income level. Others are more concerned with the more efficient use of manpower through use of as much mechanical equipment as possible.

60. It appears to be impossible at the present time to cover all, or even a significant part, of the possible variations in these situations in general provisions that would permit the use of this criterion as a basis for abstention. The present state of knowledge in the field of fisheries economics is summarized by Crutchfield (1956) *.

61. It is difficult to visualize how such situations could be used as a basis for the principle of abstention

and it is my personal view that attempts to found this principle on such a basis would lead only to confusion. Economic conditions vary widely from one State to another and a condition of glut in a fishery of one State might be relieved by the participation of another. The same may be said for the other economic reasons for regulation mentioned above.

Vital economic necessity

62. The only purely economic reason which, in the writer's opinion, might justify application of the principle of abstention is that of vital economic necessity, an example of which is described by Paul Hansen (1955) * in his report presented to the Rome Conference. The situation described by Paul Hansen indicates that the natives of Greenland are entirely dependent for the necessities of life on the fish and mammals living along the coast. Under the primitive and strenuous conditions of their life, the natives cannot compete with fishermen from other countries who invade the Greenland waters and their very existence would be threatened if the living resources of the sea, upon which they depend, were over-exploited.

63. A similar situation is described by Gilbert and O'Malley (1921) from a survey made of the Yukon River in Alaska in 1920 to investigate the possible relationship of the operation of a commercial cannery in the mouth of the Yukon River in 1919 and the failure of the natives inhabiting the Yukon drainage to obtain sufficient salmon for their winter needs in that year. Conditions for commercial fishing at the mouth were found to be less favourable in 1920 and the catch of salmon by the cannery and used for export from Alaska was much less than in 1919. The conclusion was reached that if the cannery had not operated on the Yukon in 1919 there would have been enough salmon to supply the needs of the natives. Moreover, it was found that the only reason there was sufficient fish in 1920 for both cannery and native use was because of a larger run and the smaller take by the cannery.

64. The place salmon play in the economy of the inhabitants is described vividly by the following excerpts from their report.

"Taking the river as a whole, a distinct hardship is imposed on whites and natives alike when the king salmon run is below normal.

"Unquestionably, however, the chum furnishes by far the larger share of the dried salmon. Along some stretches of the river almost complete dependence is placed on this species, locally known as the dog salmon and the 'silvers.' The higher grade of chums, known as 'silvers', form the staple dog food throughout the Yukon country. All traders handle them and may deal in from 5 to 50 tons in a year.

"The dependence of the native and white population on the salmon supply of the Yukon admits of no question in the minds of any who have acquaintance with the conditions of life in the great interior of Alaska. The natives have other sources of food, but the salmon form their main provision for the winter — their insurance against starvation when other sources of food fail them, as they not infrequently do. No one who inquires into the matter can doubt that if the supply of Yukon salmon should become seriously curtailed widespread suffering and death would in many seasons be visited on the natives.

"The whole scheme of things in the sparsely populated Yukon wilderness is predicated on the dog, and the use of the dog necessitates dried salmon.

"The dog is as essential in Alaska as is the horse in other regions, and the only acceptable dog feed is dried salmon. Various substitutes have been tried out when salmon could not be procured. They were used extensively by the 'dog-mushers' of 1919, when dried salmon often could not be had at any price. Fresh meat was used, and enormous numbers of caribou and moose were slaughtered for this purpose. But it is impossible to carry sufficient meat for many days, and the supply is precarious. Furthermore, the dogs do not thrive and work well on this diet. A diet of cereals and fat in some form was extensively used. Stocks of rice, flour, corn meal and bacon were heavily drawn on. Dogs traveled well on a ration of corn meal and bacon, but the expense was almost prohibitive, and there was the labor of cooking up each night in camp a meal for the dogs after the exhausting travel of the day with the temperature perhaps 50° below zero and a weary famished team waiting to be fed. Dried salmon forms a light condensed food which contains all the elements needed to keep a hard-working team in excellent condition, and it is always ready to be fed without preparation. There is no acceptable substitute, and there is not in Alaska any divergence of opinion on this subject. No single need in the interior of Alaska is more generally or more urgently felt than dried salmon for its various uses."

65. On the basis of their survey, Gilbert and O'Malley recommended that fishing for export from the area be prohibited on the Yukon and off its mouth. As a result of this recommendation and of annual surveys made since then by the United States Government, commercial fishing for export from Alaska has been restricted in the area of the Yukon River. During 1957, the commercial fishermen of the United States were limited to a catch of 65,000 king salmon in the Yukon River and to 6,000 kinds in the Kuskokwim River. It is estimated that in the same year the native fishermen took about 250,000 king salmon and about 1,000,000 chum salmon from the Yukon River alone for their personal use. This represents a total catch of between 15,000,000 and 16,000,000 pounds of fresh salmon from this river.

66. Still another situation is presented by Iceland, whose people are dependent upon the fisheries for their livelihood. As stated by the delegation of Iceland to the United Nations in the Sixth Committee [7]: "The coastal fishing grounds have always been the foundation of Iceland's economy and it can be said, without any hesitation, that without them the country would not be habitable." While Iceland recognizes the benefit to be derived from ensuring the maximum sustained yield from a stock, they are faced with a situation where the requirements of the coastal State and of the other States fishing in the coastal area are not satisfied by the maximum yield. Under such circumstances, they propose that the coastal State should have exclusive jurisdiction over the fisheries for a distance from the coast sufficient to meet their needs. Iceland also stated [8] that "there has to be a clear-cut distinction between two things, i.e. the conservation problem and the utilization problem. If there is a conflict of interests as to the latter, the coastal State should have priority up to a reasonable distance regardless of whether that area is called ter

[7] *Official Records of the General Assembly, Eleventh Session, Sixth Committee,* 494th meeting.

[8] *Ibid.*

ritorial sea, contiguous zone, superjacent waters of the continental shelf or something else."

67. Obviously, Iceland, in separating the problems of utilization and conservation and by holding for exclusive jurisdiction over a limited part of the continental shelf is not intending to deal with whole stocks of fish. Their problem presents conditions which differ from those covered by all forms of the proposed abstention principle since its solution involves exclusive use by the coastal State regardless of the length of time other States have participated in their fisheries.

68. There are probably very few isolated localities in which vital economic necessity would be as clearly evident as in the Greenland and Yukon River areas. Undoubtedly, the fisheries along such shores as the coast of India could be shown to be vitally necessary to the villages of fishermen that use them. The fisheries of Iceland present still another degree of economic importance to an entire nation. However, to meet the requirements of the proposed abstention principle, it would be necessary to question whether the dependent States or fishermen were fully utilizing the fish stocks or were only fishing a part of them. The same questions would then have to be answered, the same data collected, and the same problems solved as in establishing the scientific basis of abstention. It does not appear, therefore, that abstention as proposed could be justified upon a basis of vital economic necessity alone.

69. Other methods probably could be found which would be better suited to protect the interests of people who may be economically dependent upon fishing part or even all of a stock of fish but who could not necessarily comply with the requirements of full utilization and detailed knowledge of the biology of the stock and of its fishery. Some other method certainly should be used to cover problems involving exclusive jurisdiction over coastal fisheries when the coastal State continues to share any part of the stock with others, and where the interests of the coastal State take precedence over priorities of others in the exploitation of the stocks.

Examples of the application of the principle of abstention

70. A greater understanding of the principle of abstention may be gained from the history of the fisheries to which it has been applied. Consideration of all of the fisheries covered by the International Convention for the High Seas Fisheries of the North Pacific Ocean would require several volumes. Sufficient background should be provided by a brief description of two examples; the salmon fisheries of Bristol Bay and the halibut fishery of the Northeastern Pacific, both of which are well documented.

(*a*) *The salmon fisheries of Bristol Bay*

71. Bristol Bay is located to the north of the Alaska Peninsula and is the southeastern extremity of the Bering Sea. The name is usually applied to the area lying east of a line running north from Port Moller to Cape Newenham.

72. All five species of the Pacific salmon (genus *Oncorhynchus*) found on the Pacific Coast of North America are taken in Bristol Bay. These are the chum (*Oncorhynchus keta*), the coho (*Oncorhynchus kisutch*), pink (*Oncorhynchus gorbuscha*), king (*Oncorhynchus tschawytscha*), and red (*Oncorhynchus nerka*). The red salmon are by far the most important species, making up an average of about 95 per cent of all salmon taken in that area. As far as can be determined from published data, the relative importance of the other four species in the fishery is a measure of the varying sizes of the runs as they occur in the Bay.

Development of the fishery

73. The salmon has always been important in the diet of the natives of Alaska, but in 1880, about thirteen years after the purchase of Alaska from Russia by the United States, a commercial fishery was started on Bristol Bay for the purpose of salting salmon. The first cannery was established there in 1884. The ease of handling and marketing canned salmon and its acceptance by the public resulted in the steady growth of production from 400 cases packed in 1884 to 133,418 cases in 1891 (Moser, 1901) *. The increase in pack was more rapid after 1892 and reached a peak of over 25 million fish in 1917, of which almost 98 per cent was red salmon.

74. The numbers landed in succeeding years fluctuated widely, almost reaching the 1917 level in several years. The catch finally rose to another peak in 1938 when over 24.7 million red salmon were packed. Since 1938, the total catch of all species and especially of red salmon in Bristol Bay has shown a downward trend.

75. This decline in catch was not because of a decline in fishing effort or interest but has been associated with a decline in the size of the runs. It has also been due in part to a gradual restriction of the fishery by more strict regulations designed to provide an adequate escapement of adult fish to the spawning grounds. The regulations up to 1924 are outlined by Rich and Ball (1929) * and show that the first measures protecting adult salmon in Alaska were adopted by the United States Congress on 2 March 1889 and prohibited the erection of dams or other obstructions in salmon streams. The regulations increased in complexity and effectiveness each year from that time onward as the fishery became more intense throughout the territory of Alaska and as knowledge of the life history of the salmon and the relation of fishing practices to its conservation became clarified.

76. The method of approach to regulation was altered by the passage of the so-called White Act in 1924, which gave the Secretary of Commerce broad powers to limit the size and character of fishing gear, limit the catch, limit the time, means, methods and extent of fishing, and also required that not less than 50 per cent of all fish running into streams where counting stations were maintained must be allowed to pass through the fishery, enter the streams, and spawn. The provisions of this act gave more effective protection to the salmon than had been given previously.

77. The continued development of improved fishing techniques and increase in the amount of fishing gear

more than compensated for the growing restrictions of fishing and were at least partially responsible for the extreme variations in yield noted above as well as for the steady decline in size of the runs after 1938.

Entrance of the Japanese into Bristol Bay

78. During the early 1930's, the Japanese began fishing for king crab and trawling for bottom fish in the Bering Sea along the western boundary of Bristol Bay. The Japanese soon began to show interest in taking salmon as well and in 1936 began a research programme to investigate the salmon fisheries of Bristol Bay.

79. With a catch that seemed to be more variable each year, with rising costs of production and faced with continued increases in regulatory restrictions, the fishing industry of the United States objected strenuously to the entrance of a new group of fishermen into a fishery which they had previously fished alone and which they had developed. Moreover, in order to preserve the fishery they were sacrificing fishing time and fishing areas, and were submitting to many other restrictions to reduce the strain on the stocks. Feeling ran high, forcing the Governments of the United States and Japan to intervene (U.S. Department of State, 1954 a) * with the result that in 1938 the Japanese Government agreed informally not to fish or to "investigate" further the salmon fisheries of Bristol Bay (U.S. Department of State, 1954 b) *. There was at no time any question of the right of the Japanese to fish king crab or bottom fish in this area although United States fishermen had also participated in these fisheries to a limited extent; the protest against new fishermen was confined entirely to the salmon fisheries which had a long history of development and regulation, and had proven to be clearly limited in its potential productivity.

80. At the end of World War II, the Salmon Industry of Alaska viewed with concern the continued failure of increasing governmental restrictions on fishing in Bristol Bay to halt the decline in abundance of the species and in 1947 undertook to assess themselves to support a biological investigation of the Bristol Bay fisheries. Their objective was to supplement the work that had been in progress since the beginning of the fishery by the United States Government, to discover the causes of the decline in salmon stocks, and to assist in developing methods of rebuilding the stocks to their level of maximum productivity.

81. This programme has been performed by a group of scientists from the University of Washington, operating under a contract with the Alaska Salmon Industry. It has been supported by the canners of Bristol Bay who, each year, donate to the programme a certain amount of money for each case of salmon packed. These funds have supported a programme that is closely co-ordinated with the work of biologists of the United States Fish and Wildlife Service, and is now assisting in providing answers to many puzzling facets of salmon biology. It now appears that these two programmes will furnish a basis for the formulation of methods of regulation that will permit the rebuilding of the Bristol Bay salmon runs.

Life history of the salmon

82. The difficulties involved in accomplishing this end are directly related to the biology of the Pacific salmon. While the life history of the five American species varies in detail, they agree in that all species spawn in fresh water streams. The adults enter these streams from the sea and migrate varying distances upstream to lay their eggs and fertilize them in holes they dig in the gravelly stream beds. The eggs are covered over again by the digging activity primarily of the female salmon. After spawning, the adults of both sexes of all Pacific salmon invariably die. After a few weeks or months in the gravel, the young salmon hatch from the eggs; and, remaining in the gravel until the stored food is used up, they then work their way out of the gravel into the stream. In the case of coho, king and sockeye (as well as chum salmon in the Yukon River), the spawning locality may be hundreds or even several thousand miles from the sea. After different periods of time, the young salmon make their way back to the sea where they complete most of their growth and on maturity return to the same stream from which they arose as young, to complete the spawning act and die.

The relation of salmon life history to conservation

83. The important peculiarities of the Pacific salmon life history are that they spawn only once, that all species require access to fresh water to spawn and reproduce, and that individual runs or races of salmon move into specific areas or streams at certain times each year. This peculiar life history requires careful adjustment of fishing operations to permit the escapement of a part of each race. The proportion of each race that can be taken will vary but indiscriminate fishing in areas where races are not separated can result in the overfishing of certain races. To avoid this result, the United States fisheries officials have now undertaken to restrict Bristol Bay fisheries to areas where they have found that the races bound for the different rivers are almost completely isolated. Regulation of these unit fisheries is then formulated to permit escapement of the desired numbers of all segments of these runs. Canadian and United States net fishermen have been restricted by law to operate within coastal waters along the Pacific Coast of North America. While it has been found possible to capture commercial quantities of salmon on their feeding grounds on the high seas, these two Governments consider that effective conservation of salmon requires the control of fishing as far as possible on separate stocks so that sufficient escapement may be permitted from each one. This is found to be almost impossible when the fish are exploited by nets on the high seas where the stocks seem to intermingle widely.

84. Here then is a fishery that historically has been fished by one nation. It is particularly vulnerable to over-exploitation because the entire stock moves into streams for breeding purposes. As this migration passes into the accessible inshore waters and finally into the shallow streams it could easily be fished out by unrestricted fishing. As the fishery has developed and has demonstrated its effects upon the stocks of fish regulations have been developed, based upon biological

research, which are aimed at permitting the fullest use of the stocks commensurate with their productive capacities. During recent years, the industry itself has supported its own programme of biological research to assist the responsible government agency in solving the many difficult problems associated with stabilizing the fishery and stocks at the level of maximum sustained yield. As a matter of interest, the amounts spent by the United States Government during the last thirty years for management and research on Alaska salmon resources have been over $18,000,000. Since 1947, the Alaska Salmon Industry has provided more than $800,000 for the support of biological research on Bristol Bay stocks of salmon alone. Additional funds also have been spent by the industry for research on salmon stocks in other areas of Alaska.

(*b*) *The halibut fishery of the North-eastern Pacific*

85. The history of the halibut fishery of the west coast of the United States, Canada and Alaska was reviewed by Dunlop (1955) * at the International Technical Conference at Rome. He described how the fishery was developed by Canadian and United States fishermen beginning in 1888 when railroads were completed to West Coast ports permitting rapid shipment of fresh halibut to the large eastern United States and Canadian market centres.

86. The fishery developed rapidly as the technology of handling the product and of fishing was developed. By 1915, sufficient concern had arisen from the growing scarcity of halibut on more accessible banks along the coast of British Columbia to cause the Government of that province to sponsor a biological investigation to determine the cause. The final result of that investigation and of later developments in the fishery was a fisheries treaty between Canada and the United States of America which was concluded in 1923.

87. A commission was appointed by the two Governments to give effect to the treaty, and this commission undertook to sponsor a biological research programme of its own, beginning in 1924. The investigations that followed were supported equally by the Canadian and United States Governments and formed the basis for a new treaty, adopted in 1930, that gave the commission power to regulate the fishery. Another treaty in 1937 and still another in 1953 modified regulatory procedures as the investigations of the commission's staff developed a better foundation for management through an increasing understanding of the biology of the stocks. Each succeeding treaty has broadened the regulatory powers of the commission, enabling it, in each case, to adapt the regulations more closely to the peculiarities of the fishery and to mould the regulations into a pattern more closely in keeping with the biological needs of the stocks.

88. The results of this work are well known since these are the first and, as yet, only stocks of a marine species of fish that are regulated successfully on a sound basis of scientific research. The recovery of the halibut stocks from the low level of abundance reached in 1930 to three times that level off the coast of British Columbia and Southeastern Alaska, and to twice that level in the Gulf of Alaska, has been associated with a marked increase in the total catch. The improved regulations of 1954 which enabled the better use of all stocks on the banks raised the catch to 71.2 million pounds. This must be compared with the 44.2 million pounds produced by the full effort of the fishing fleet in 1931. The increase in abundance has been sufficient to permit taking this greater amount of fish with only a fraction of the effort required in 1931. This fraction was 50 per cent in Area 2 and 65 per cent in Area 3.

89. The variations of total catch and catch per unit of effort during the past decade indicate that the fishery is now just about at the level of maximum sustained yield. This cannot be stated definitely now because of deficiencies in our knowledge of the complex relationships between the stocks of fish, their environment and the fishery. The continuing studies of the commission, with observations of the results of management, should in themselves go far to measure these relationships, just as they furnished the first demonstration of the validity of the concepts of fisheries population dynamics elucidated by Baranov.

Significance of abstention in the halibut fishery

90. The important fact concerning this fishery is that it has been regulated for twenty-six years by an international commission which is operating under a treaty between the two countries which share in the fishery. These regulations, based upon detailed biological investigations, have been directly responsible for rebuilding this fishery from a depleted state which had resulted from a prior lack of regulation and lack of knowledge concerning the productive capacity of the stocks. These regulations have been successful because of sacrifices made by United States and Canadian fishermen. The two fleets, at any time since regulations have been imposed, have been capable of taking much more halibut than has been permitted by the commission. The efficient use of the halibut stocks, and the most efficient use of the world's fishing fleets, would seem to point to the application of the principle of abstention in this fishery where new, outside effort would not only lower the efficiency of the two fleets already operating on these stocks but could result in no increase in the production of fish.

91. It is of interest that since 1924 a total of over $2,500,000 has been appropriated by Canada and the United States for biological research and management of the halibut fishery.

IV. Summary

92. The scientific basis of the principle of abstention lies in the fundamental laws of fisheries population dynamics, according to which if a fishery is stabilized at its level of maximum yield, it will produce less fish if the intensity of fishing is increased. However, a sudden increase in fishing will result in a temporary rise in total catch while the stock is being reduced in size to a new low level.

93. The economic problems in the world's fisheries have not been investigated sufficiently to provide a sound basis for abstention on this ground except perhaps

in the restricted field of vital economic necessity. This would include only those fisheries which are essential for the support of a particular group of people. However, even this criterion would require evidence of complete utilization which in turn would involve the same information as the scientific basis of abstention. It appears that other and better methods might be found of protecting the rights of people in case of vital economic need.

94. In any application of the principle of abstention the stocks concerned must be clearly defined geographically. Sufficient data must have been gathered to prove the need for conservation, and research and management programmes must be in force which meet the most rigid requirements so far set for any conservation programmes. These requirements are that it must be possible to demonstrate that the regulations are responsible for stabilizing and restoring the stocks. Moreover, the research programme must establish the size of the maximum sustainable yield. The principle provides a simple solution of problems involving the most efficient use of fisheries, the production of the most food from the sea, and the establishment of conditions conducive to intelligent conservation and use of our natural marine resources.

95. As set forth in the report of the International Law Commission, it prohibits the whimsical exclusion of enterprising fishermen from under-exploited fisheries. It can actually stimulate a more intelligent approach to fisheries exploitation as well as management through the requirement of scientific proof of the validity of regulations, of the condition of the fishery, and of the geographic range as well as conditions of stocks of fish on which it is based, as well as requiring establishment of the level of maximum sustained yield for the stocks in question. With this stimulus, many fisheries research programmes now in progress would have to be examined more carefully for objectives, methods and scope. Many would have to be completely altered to fulfil the requirements outlined by the International Technical Conference in Rome. As a result, many fisheries which are now producing far below their potential because of lack of management or even because of mismanagement, could probably be brought back to a substantial level of production.

96. To a conservationist, it seems regrettable that all fisheries management programmes cannot be placed under the same requirements of practical accomplishment as are demanded of anyone requesting abstention for any fishery. It would raise the scientific level of most fisheries programmes and at the same time would impose a heavy penalty on improperly conceived, inadequately supported or poorly executed research or management programmes.

Annex

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TABLE I

Number of fish in the population (P) and numbers caught (C) from each age class in a population showing the average weights at each age given in column 1, with constant recruitment of 2000 at age 1.

The numbers shown correspond to values that could occur at each level of natural (N) and fishing (F) mortality after the population and fishery had become stabilized at that level.

		N = 30% F = 10%		N = 25% F = 20%		N = 20% F = 30%		N = 10% F = 40%		N = 0 F = 50%		N = 0 F = 60%		N = 0 F = 70%		N = 0 F = 75%		N = 0 F = 80%	
1 Wt.	2 Age	3 P	4 C	5 P	6 C	7 P	8 C	9 P	10 C	11 P	12 C	13 P	14 C	15 P	16 C	17 P	18 C	19 P	20 C
51	1	2000	169	2000	349	2000	541	2000	762	2000	1000	2000	1200	2000	1400	2000	1500	2000	1600
86	2	1260	106	1200	210	1120	303	1080	412	1000	500	800	480	600	420	500	375	400	320
122	3	794	67	720	126	627	170	583	222	500	250	320	192	180	126	125	94	80	64
151	4	500	42	432	75	351	95	315	120	250	125	128	77	54	38	31	23	16	13
163	5	315	26	259	45	197	53	170	65	125	62	51	31	16	11	8	6	3	2
174	6	198	17	156	27	110	30	92	35	62	31	20	12	5	4	2	2	1	1
189	7	125	11	93	16	62	17	50	19	31	16	8	5	1	1				
199	8	79	7	56	10	34	9	27	10	16	8	3	2						
205	9	50	4	33	6	19	5	14	5	8	4	1	1 (ages 9–10)						
208	10	31	3	20	3	11	3	8	3	4	2	1							
215	11	20	2	12	2	6	2	4		2	1								
220	12	12	1	7	1	3		2		1									
230	13	8	1	4		2		1	3 (ages 11–14)										
235	14	5		3		1	2 (ages 12–15)	1											
243	15	3		2	2 (ages 13–17)	1													
250	16	2	1 (ages 14–18)	1															
	17	1		1															
	18	1																	
Number caught			457		872		1230		1656		2000		2000		2000		2000		2000
Total weight caught		45,486		82,577		110,136		144,073		165,162		146,222		131,308		125,017		119,391	
Catch in weight/unit			431.7		370.1		308.8		282.0		238.3		159.6		109.1		90.2		74.2
Number of units of gear		105		223		357		511		693		916		1,204		1,386		1,609	

TABLE II

Changes occurring in total catch, catch per unit of effort, and in population following a change in rate of fishing.

The number of fish of each age which would occur in the population (P) and which would be taken in the catch (C) at different rates of fishing are shown in each column for each year after the sudden change in fishing rate.

Years following sudden change				1		2		3		4		5		6		7	
Annual fishing rate / Annual natural mortality		F = 50 N = 0		F = 70 N = 0													
1 Wt.	2 Age	3 P	4 C	5 P	6 C	7 P	8 C	9 P	10 C	11 P	12 C	13 P	14 C	15 P	16 C	17 P	18 C
51	1	2000	1000	2000	1400	2000	1400	2000	1400	2000	1400	2000	1400	2000	1400	2000	1400
86	2	1000	500	600	420	600	420	600	420	600	420	600	420	600	420	600	420
122	3	500	250	300	210	180	126	180	126	180	126	180	126	180	126	180	126
151	4	250	125	150	105	90	63	54	38	54	38	54	38	54	38	54	38
163	5	125	62	75	52	45	31	27	19	16	11	16	11	16	11	16	11
174	6	62	31	38	27	22	15	13	9	8	6	5	3	5	3	5	3
189	7	31	16	19	13	11	8	7	5	4	3	2	1	2	1	1	1
199	8	16	8	9	6	6	4	3	2	2	1	1	1	1	1		
205	9	8	4	5	3	3	2	2	1	1	1	1					
208	10	4	2	2	1	1	1	1	1	1							
215	11	2	1	1	1	1											
220	12	1		1													
Stock		3999		3200		2959		2887		2866		2859		2858		2856	
Number caught			2000		2237		2070		2020		2006		2000		2000		2000
Weight caught		165,162		166,653		142,994		134,841		132,438		131,333		131,333		131,134	
Catch/unit			238.3		138.4		118.8		112.0		110.0		109.1		109.1		108.9

FIGURE 1

Total catch, catch per unit of effort, and total amount of gear run at different rates of fishing in a model fishery

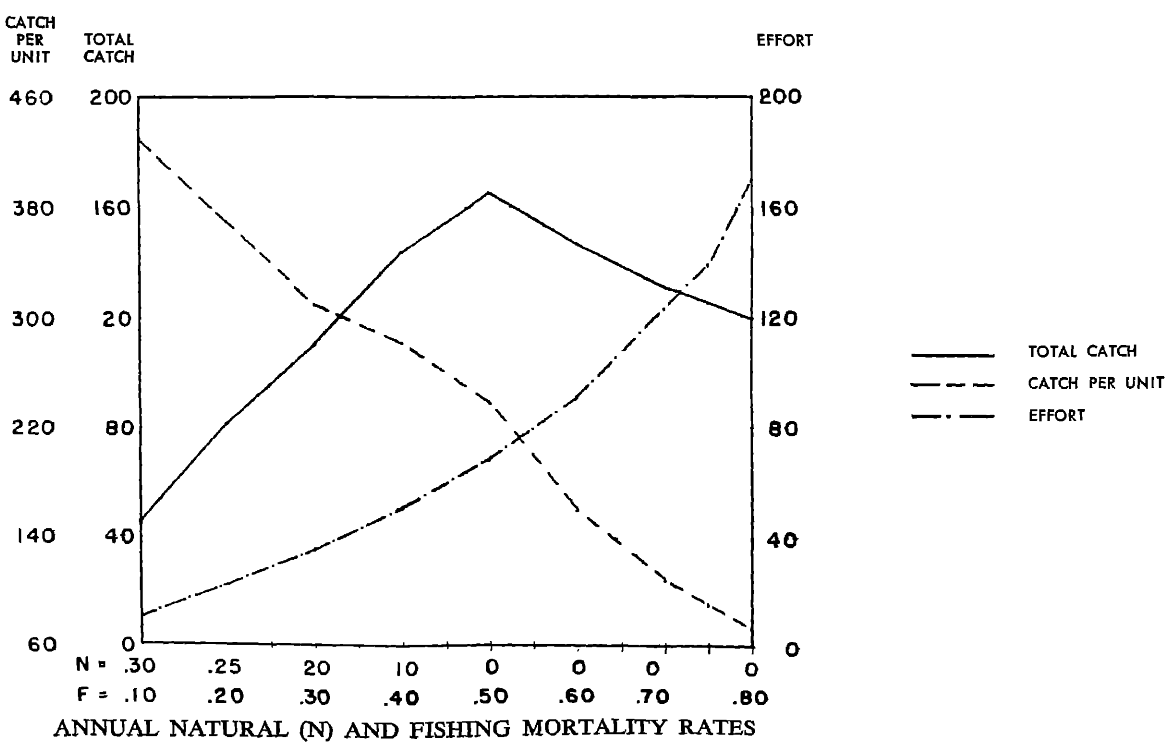

FIGURE 2

Changes that could be expected to occur in total catch, catch per unit of effort, and amount of gear run each year (effort) in the years immediately following a sudden change in the rate of fishing from 50 per cent per year to 70 per cent per year