A Preliminary Report on International Fisheries Management Research (1971)

Pages
63

Size
8.5 x 10

ISBN
0309346118

Working Group on International Fisheries Management; Committee on International Marine Science Affairs Policy; Ocean Affairs Board; National Research Council

A PRELIMINARY REPORT

ON

INTERNATIONAL FISHERIES MANAGEMENT RESEARCH

Report of the Working Group

on

International Fisheries Management

of the

Committee on International Marine Science Affairs Policy

(IMSAP)

of the

Ocean Affairs Board

National Academy of Science - National Research Council

May 1971

Preface

As its first step toward assistance in development of improved international fisheries management, the Committee on International Marine Science Affairs Policy convened a working group to attempt to formulate an agenda of research needs in this field. The working group met for three days in Seattle, March 19-21, 1971, and produced the rough draft of a report. It has been revised by the undersigned using suggestions of various members of the working group. There was general agreement in the group on the major propositions contained in the report, but individual members obviously might differ on details of wording and emphasis.

It is hoped that the report and the annexes may prove useful to potential investigators. Questions or observations on the contents are welcome.

William T. Burke

Chairman, IMSAP

Table of Contents

raised by unilateral claims, bilateral or multilateral agreements, or international conventions concerning fisheries have an effect on and are affected by the distribution of values.

The framing of the question - "who gets what" - however, is not without its difficulties. The characterization of the "who" can be expressed in several ways. It might include the present fishing states, coastal states with fishery resources off their coasts, all states in the world community, states members of the UN, or those states that will have a significant influence on decisions - whether by themselves or in blocs.

The "what" can also be characterized in several ways. In one respect, it might simply be numbers or tons of fish. Or it could be much broader. If it includes economic costs, there are questions as to whose criteria are to be used. It could include other values derived from fisheries that do not pertain directly to the economic benefit of the yield but to other benefits such as the use of the fishery to maintain or enlarge employment opportunities or to provide domestic sources of protein, etc. And even beyond this, there may be non-fishery benefits whose distribution would be affected by fishery decisions. These might include the use of the ocean for mining, waste disposal, or military purposes.

These latter elements complicate the fundamental question of allocation and they must be kept in mind. They are valuable clues in identifying issues that are likely to be raised at the next Law of the Sea Conference (hereinafter referred to as LOS-73) and beyond - and in determining the significance of the issues.

II. Immediate Approaches

Although it is clear that the questions of allocation are central to reaching agreement on improved international fishery management, it is not at all clear how, and in what way, these questions will be formulated at the future LOS-73. The issues that appear to be important today may undergo considerable change in the next year or two because of rapidly changing events taking place in international fisheries and in other aspects of marine affairs. It is, therefore, difficult to identify the kinds of information that will be useful to the conferees and it is difficult to prepare an agenda for research.

The working group believes that these problems are of such importance that the immediate first step should be to get expert forecasts of future developments and issues important for future international arrangements. At the same time, the working group believes that it would be valuable and useful to have an immediate effort made to collocate basic information on the current status of world fisheries. These two specific and urgent recommendations are elaborated in the following paragraphs.

(A) A Forecast of Events

The LOS-73 is intended to be a milestone in creating international legal arrangements for numerous ocean activities. It is generally realized that the far-reaching importance of LOS-73 warrants careful planning and preparation. Consideration of planning for this conference from the standpoint of fisheries specifically gives rise to a large number of problem situations, many of which are inter-related and exhibit considerable variability in scope. The working group has listed some of these in this report and more are contained in attached documents. It is difficult to determine in the relatively short time that is available how much effort should be applied to each problem, when studies should be completed, and whether, in fact, significant elements have been omitted from consideration.

Insofar as LOS-73 is concerned, we cannot now be certain that the conference will be held - nor do we now know when it will convene if it does. We cannot know whether the conference will in fact be the medium where important decisions are made or whether these decisions will be made before or after the conference but independent of it. If we can anticipate the nature of the stage upon which LOS-73 will be set and also have better notions of the total context of ocean activity over the next 10-15 years, we can better judge how much effort to expend on each proposed study area and arrive at an appropriate time phasing for their conduct. The answers to these questions are not simply derived, and cannot be characterized as black or white; the answers to such questions are judgmental.

There are techniques for investigating these questions of judgment and these involve the use of experts to assay, primarily, the future. If we could assay the dynamics of legal arrangements in the ocean for the next 10-15 years, including LOS-73 as a major milepost along the road, we could then be better able to allocate our efforts to those studies that might provide the most important contribution to the conference and to succeeding events.

The first task in this approach is the identification of the individuals who are experts. These might include persons who are not normally considered expert in ocean or fisheries policy issues nor involved with them. The need is for informed persons who are successful in forecasting events such as LOS-73. The questions asked of the experts must be carefully considered and prepared. The questions, however, will very likely involve the prediction of the issues that might be raised at LOS-73; the kinds of decisions that might be made at LOS-73 (including failure to reach agreement on certain issues); the future impact of these decisions; the probable evolution of ocean legal arrangements in the years following LOS-73; the formation of blocs and bloc viewpoints at LOS-73 and later; the impact of various sorts of information on the conference and thereafter; and what other elements external of our ordinary considerations might be important, such as general US-Soviet relations, the emergence of Communist China into the ocean scene, the evolution of a seabed regime, and so forth.

The procedure used to elicit expert opinions would be to ask the experts to write scenarios of future legal arrangements in the ocean, specifically including LOS-73 as part of this future and covering such topics as mentioned above. These scenarios would then be examined, compared, and collated. They may then be referred to the various authors for further consideration. The completed scenarios will, if properly done, provide an "expert" view of the unfolding future, including LOS-73, and with this projection we should be better able to allocate our effort and delimit the scope of the studies in terms of the most relevant problems.

(B) Current Status of World Fisheries - An Overview

Another first step in the development of a research agenda directed to meeting the information needs of the impending conference and the formulation of a long-term research program, is the establishment of a benchmark of the current status of the world's fisheries. In our view, the concept of a benchmark goes considerably beyond an enumeration of what is. It involves the development of a method of articulating in a simple format the current status of fishing activity throughout the world. An appropriate analogy is the construction of both a balance sheet and a profit and loss statement for the world's fisheries. The objective of creating this format is two-fold:

a) to permit all decision makers to visualize, in common terms, the current status of the fisheries and in so doing to obtain a preliminary view of problems and imbalances.

b) to permit projections of current activity so the decisionmakers can see the implication of current trends and how various courses of action will influence these trends.

In this activity two things must be borne in mind.

i) at the present time no such overview of the world's fisheries exists and it is needed both in order to plan and to formulate the proper definition of the problems and the research required to throw light on these problems.

ii) the initial cut at the overview will be a first approximation.

But as individual studies of specific cases are completed they could easily be incorporated into the accounting framework developed for evaluation of the current status of the fisheries. Accordingly the accuracy and coverage of the overview will be improved and extended as the research agenda unfolds. There will be a continuous interaction between the evaluation of the current and estimated future status of the fisheries and the underlying research.

Item "b" above will permit a continuous evaluation of priorities and constitute part of the raw material out of which scenarios required for planning may be written more specifically. The development of the accounting framework requires inclusion of analysis of the following topics: (It is important to emphasize that the following outline is just suggestive. As the work proceeds the emphasis will shift, problems not currently visualized will be uncovered, and the framework will have to be adjusted to allow for these developments. A purpose of the recommended exercise of forecasting events is to lay a base for improving on this outline.)

(B) Current Status of the Fisheries

1. Major fish stocks

a) Current level of exploitation relative to estimated maximum sustainable yield.

b) Identification of those currently exploiting the stock.

c) Location of the exploitation relative to coastal state.

d) Description of unexploited stocks.

2. Technology

a) The technology utilized to harvest the stock.

b) The rate of change (development) of the technology and the evaluation of the implications of the change for the stock; existing utilization of capital and labor, etc.

3. Economic considerations

a) Primary markets where stocks are sold, secondary markets, and processing centers.

b) Economic efficiency of the process of exploitation; the existence, if any, of redundant capacity; the economic gains from efficient exploitation.

4. Political and social problems

a) Distribution of benefits.

b) Arrangements for limiting exploitation.

c) Perception of interests in living marine resources.

d) Constraints within which national officials must act in international negotiations.

5. Projections of

a) The projection of items 1-4 above are the basis of five, ten and fifteen year time horizons.

The working group concluded, although not unanimously, that the above study might be helpful if executed immediately and that it might be done as a first approximation in a three-month period by one or two knowledgeable investigators. Much of the data exists but it needs to be collected in a more useful form.

III. Explanation of Schematic Outline

Several purposes are intended to be served by the schematic outline. First, it presents in summary form the range of studies we now believe to be useful and suggests their inter-relationship. Second, it emphasizes studies of various specific situations from the results of which it might be possible to derive some general principles important for improved management (depicted by the arrow linking boxes B and C). Third, it indicates that such general principles will very likely have to be applied in specific situations by negotiations between concerned states (depicted by the arrow linking Boxes C and A). Fourth, and finally, the central focus of all studies should be upon the allocation problem and this is shown by the arrows linking each category of inquiry to "allocation".

(A) Specific Case Studies

Box A lists a number of specific or local case studies deemed useful. These case studies fall into four classes:

1. Specific Stocks
   - a. Shrimp, global (peneaid)
   - b. Tuna, global
   - c. Tuna, E. Trop. Pacific
   - d. Anadromous
   - e. N. Pacific Crab
   - f. Whales
2. Specific Fishery Regions
   - a. S.E. Asia
   - b. West Africa
   - c. Indian Ocean
   - d. N. Pacific Trawl
3. Fishery Activities of Individual Countries
   - a. USSR Distant Water Fishery
   - b. Japan Distant Water Fishery
   - c. Selected LDC
4. Analysis of Common Factors
   - a. Collective Impact of fishery limits
   - b. Preferential rights
   - c. Aggregate capacity, fleet mobility
   - d. Entry conditions
   - e. Pollution
   - f. Labor supply
   - g. Research capability

b) the adoption of a fisheries limit at LOS-73, the limit adopted being 12, 18, 24, 50, 120, 200, 300, 400, 500 miles; 200, 1000, 2500 meters; or in terms of categories of living resources;

c) categories of resources that might be defined so as to provide systems for managing living resources, e.g., anadromous species, sedentary species, coastal species, high seas pelagic species;

d) the adoption of one or another of the above limits for various regions of the world;

e) the adoption of specific fishing limits for coastal control, coupled with one or another international regime for areas or stocks outside such limits. Alternative international systems need to be specified and evaluated;

f) continuation and evolution of existing international fishery commissions in light of the above arrangements.

In examining implications it is important that any legal regime or arrangement be regarded as transitory or in an evolutionary state. This follows from the natural uncertainties of ocean utilization and the dynamics inherent in technological change. In these circumstances the implications of any given arrangement will be changing and it is important to prepare the way for adjustment of legal relationships to accommodate shifts in the underlying biological, technical, economic, and political conditions.

(B) The various phases of specific case studies are represented in the box labelled B. The following provides some specifications and illustrations of the studies subsumed under the various categories there designated.

STOCK

The major need is for studies which investigate the dynamics of the stock(s) under study. This would include such characteristics as extent and distribution of the stock(s), and other factors necessary to estimate potential yields under different management strategies.

EFFORT

A number of studies are useful in terms of effort expended to harvest fish. These include: 1) Effort in terms of fishing mortality generated on the stock(s) under study. 2) Physical characteristics of effort such as fleet capacities, gear types, versatility and mobility. 3) Other features such as labor requirements, capital investments, operating costs, and projected technological innovations.

MARKETS

The reference here is to studies of demand for living marine resource commodities by individual states and groups of states. Projections of a fairly refined nature should be made for the next decade; somewhat less refined projections would be useful over the next two to three decades. These studies should attempt to provide price and income elasticities and cross price elasticities both among fishery products and between these products and other forms of animal protein. The effects on demand of information on mercury and other substances in fish should be studies.

Projects pertinent to market analyses include those of the Japanese, Russian and other distant water fishing industries, and studies of marine protein concentrate and its use.

Another study would be an evaluation of recreational fishing of stocks that are international in character -- primarily salmon, tuna, and billfish. Inquiry should include projections of demand for this type of fishing over the next decade and some indications of the particular stock that will be of direct or indirect importance to both sports and commercial fishermen.

LEGAL INSTITUTIONS

(1) Existing Arrangements

Studies should be made of the considerable variety of existing arrangements pertaining to use rates and to allocation. Illustrations include the experience of the International Whaling Commission and the allocation arrangements developed outside that body. Others include detailed examination of the structure and functioning of the numerous international fishery commissions, particularly in order to analyze these activities for light they might shed on improvement in future management.

States employ a variety of less formal means than fishery commissions for management and studies should be made of those arrangements. Particular attention should be devoted to the pattern of bilateral arrangements that are now employed in many parts of the world.

Other existing arrangements include, for example, allocations by general treaties such as the provisions in the Shelf Convention affecting living resources of the shelf. A study might attempt to arrive at a uniform and widely accepted definition of such resources in terms of their physical characteristics, distribution, harvesting techniques, and economic values of stocks.

(2) Criteria and Objectives for Future Arrangements and Alternative Possibilities and Consequences

A most critical aspect of the general allocation problem is to determine the objectives for the future and inquiries to clarify these objectives are essential. Traditional objectives include supplying protein, creating savings and earnings in foreign exchange, diffusion of wealth, increasing employment and so on. Analysis should involve investigation of the nature of these objectives and an attempt to anticipate appropriate objectives for the future. In addition a need is to construct criteria by which to judge the alternative approaches to the objectives that are most relevant and effective. These criteria might involve, for example, questions of capital budgeting, time horizons, and the valuation of resources.

An important task is to evaluate the alternative decisions listed above (p.7-8) in terms of these objectives and criteria.

POLITICAL, ECONOMIC, AND OTHER EXOGENOUS FACTORS

There are three general types of exogenous factors which warrant research with respect to international fisheries arrangements. A first involves other uses of the sea, such as mining or military uses. States emphasizing their interests in these activities might look upon fisheries jurisdictional problems in terms of possible tradeoffs for concessions in what they consider more important marine-related interests. Assessment of these possibilities could be a valuable contribution to sound fishery management.

A second area for research concerns the problem of interest perception. The question is how policy-makers in various parts of the world envision their national interests in the ocean, including the potential for fisheries development and management.

A third category of factors concerns the effects of general relations between or among individual states in terms of manifestations for fisheries decisions. Inquiry into these factors is important not only in terms of long-term considerations, such as ideological differences, but also short-run developments that may bear on particular decisions at particular times.

The above rather brief account of potentially useful studies is obviously not exhaustive. Further indication of possible inquiries and of research approaches is contained in Annexes 1-4.

INDEX

1. GEOGRAPHIC DISTRIBUTION OF FISH STOCKS

I. Substance: The study would provide a series of maps showing the location and distribution of fish stocks of present (and foreseeable future) value to man. A stock would be defined in terms of the requirement for unified management. The definition might be narrow in some cases (e.g., Georges Bank Haddock); broad in others (e.g., salmon of NW American streams); or, in certain instances, cover inter-related stocks (e.g., California sardines and anchovies). The maps would show distribution through all political boundaries and would cover all areas where the stock is currently fished or susceptible to fishing with new techniques.

II. Relevance: The study would be helpful in identifying location of fish stocks relative to alternative political boundaries. It would show those stocks that might be completely enclosed within the limits of a single coastal state; within the limits of a few coastal states; or within and without coastal state limits; using various sets of limits in terms of both depth and distance.

III. Feasibility: The information is presently available in satisfactory status for only a few species. In these cases, maps might be done quite easily or might already be available and should be brought together. In other cases, the information may have been gathered but may have to be made available and processed. And in many cases, there may not be satisfactory information. In these cases, a study of the cost of getting such information would be useful. It is reported that USFS is currently doing a mapping of the distribution of fish stocks.

IV. Costs: Where information is available the costs would be small. Where information has been gathered but has not been released or processed, the economic costs would be small but there may be difficulties in political terms. In these cases where the information does not exist, a study of the costs of getting it should be undertaken.

V. Auspices for Study: The study might best be done under the auspices of FAO through cooperation with international fishery commissions and individual states.

2. MODELS OF BIOLOGICAL YIELD FUNCTIONS

I. Substance: Several researchers have proposed and are investigating theoretical models of biological yield functions. There are apparently significant differences in approach and in results of the research (viz. Carlson/Waugh/Bell and Schaefer models). Further improvements and refinements of the models are of great importance over the long run. However, in the short run (between now and the new LOS) it would be desirable to evaluate the models presently available and to determine those that will be most helpful in providing rough estimates of yields and in evaluating, in rough terms, the effects of alternative regulatory mechanisms.

II. Relevance: It would be useful, insofar as possible, to reduce disagreements over the amounts of fish that can be taken from a particular stock, region, or globally. It would be useful to have some common approach to the determination of yields, even though that approach might not have the accuracy that can be anticipated from future refinements in model building. This would be of value

not only in facilitating agreement on estimates of potential yields but also in providing a uniform basis for evaluating alternative regulatory devices.

III. Feasibility: While it might not be too difficult to bring together the various researchers in the US, USSR, and elsewhere, it may be difficult to get agreement on uniform approaches and models.

IV. Costs: Costs would include those of holding several meetings and the services of a coordinator.

V. Auspices: BCF (NMFS) did something similar with respect to demand models and might do the same for yield functions.

3. DEFINITION OF SEDENTARY FISHERIES

I. Substance: The study would attempt to arrive at a uniform and widely acceptable definition of sedentary fisheries. This would require an analysis of the physical characteristics, distribution, harvesting techniques, and economic values of stocks.

II. Relevance: Creeping jurisdiction.

III. Feasibility: Information would be difficult, agreement even more so. US and USSR are already preparing lists which would be valuable.

IV. Costs: Time of an economist, scientist, and fishery technologist plus international workshop.

V. Auspices: FAO.

4. OUTPUT PROJECTIONS BY STOCKS

I. Substance: This study (or series of studies) would provide estimates of present yields, potential yields, and projections of catch over the next decade. It should be done for stocks of present and possible future international use. Stocks that are entirely intra-national might also be studied, but under lower priorities. The estimates of present and potential yields would be derived primarily from biological data, while the estimated projections of output should include economic analyses of the conditions of demand and supply.

II. Relevance: These estimates would be of much value in providing some indications of the wealth of the seas and of its distribution. The studies should cover as many stocks as possible, preferably undertaken under some ordering of priorities with respect to importance in economic and conflict terms. The studies should be undertaken in cooperation with the mapping activities depicting the Geographic Distribution of Fish Stocks.

III. Feasibility: This work has already been done, in part, by FAO (the Indicative World Plan) and by the U. S. Fisheries Service (Bell, et. al., "The Future of the World's Fishery Resources," in draft). It is also available, in terms of present and potential yields, for a large number of particular stocks. There are, however, differences in approaches and results and it is likely that further (and significant) refinements are possible. It is particularly important to review, evaluate, and refine the economic projections.

IV. Costs: This could be extremely costly, depending upon the amount of biological data that would need to be gathered and the degree of refinement of economic projections that might be desirable. One approach might be to convene an international meeting of biologists and economists to review data, seek agreement on approaches, and determine needs for information.

V. Auspices: A meeting of experts might be done under the auspices of the FAO or other U.N. agency. Individual stock studies could be done under a variety of auspices.

5. DISTRIBUTION OF FISHERIES WEALTH

I. Substance: This study would examine the distribution of catch by states, would identify trends, and project patterns of distribution into the future. It should seek to distinguish between catches made within narrow limits, within extended limits, and beyond extended limits. And it might make distinctions between low and high unit value species. It should also seek to evaluate the ways in which states may benefit from fisheries through other means than catching; viz., overseas investments, processing plants, licensing of foreign effort. Some indications of how distribution patterns might be affected by different limits and international arrangements should be attempted.

II. Relevance: Some indications of alternative patterns of distribution in the future is clearly important to decisions on limits and arrangements.

III. Feasibility: Several of the suggested studies would be helpful -- geographic distribution, distant-water industries of various states. FAO catch statistics would be of help. More refined analyses would be difficult on a comprehensive basis but might be feasible as case studies and in general terms.

IV. Costs: Salaries of several scholars.

V. Auspices: Non-governmental agencies with cooperation of governments.

6. ALTERNATIVE REGULATORY TECHNIQUES

I. Substance: These studies would examine the various regulatory techniques that are employed now and that might be employed in the future. The techniques would include total quotas, national quotas, licensing schemes, taxes, gear restrictions, closed seasons, closed areas, and all other possibilities. Analysis would be with respect to particular kinds of stocks and situations, empirical and simulated. The techniques would be tested against the various goals and values that are sought by states. They would also be evaluated in terms of the economic, social, and political transaction costs required to put them into effect.

II. Relevance: Manifest.

III. Feasibility: A large number of studies has already been done and more are in process. These should be elaborated and refined, particularly with respect to transaction costs and in terms of various goals and values. They should be brought together within a common framework. One limiting factor is the paucity of sociologists and political scientists who are competent in fisheries.

IV. Costs: This would depend upon the depth of the analyses.

V. Auspices: Studies might be done by individuals and groups in both governmental and non-governmental agencies. A common presentation might be under the auspices of FAO.

7. LABOR SUPPLY - COASTAL FISHING

I. Substance: This study would attempt to provide some indications of the characteristics of coastal fishing labor supply at present and over the next decade. It should provide estimates of numbers employed, full and part-time; costs; and some indications of alternative employment opportunities and degree of labor mobility. This should be done for both the states that already have significant coastal fishing and those that are anticipating significant fishing in the future. Presumably, some information has already been acquired in a number of areas through foreign and international aid programs. It would be useful to bring such information together.

A second part of the study should also be attempted, at a general theoretical level and/or with respect to certain significant states. This would attempt to provide information on the sociological and political significance of coastal fishermen.

II. Relevance: Employment opportunities for fishing are a major factor of influence on coastal state positions with respect to limits and preferential rights.

III. Feasibility: It would not be difficult to define economic characteristics in many situations, although refinement of the information may be desirable. In other cases, the statistics may be inadequate and require major efforts. Sociological and political aspects of fishing as an opportunity for employment would be considerably more difficult. Perhaps a few case studies would be sufficient.

IV. Costs: The costs for the economic part would depend upon amount of information presently available and the degree to which refinement would be necessary. Costs for the sociological and political aspects would be prohibitive if undertaken for a large number of states. A few case studies might be possible, but would still be costly because of the lack of scholars and data.

V. Auspices: Economic part might be handled by or through cooperation of FAO, UNDP, World Bank, ILO, etc. The case studies by individuals.

8. LABOR SUPPLY - DISTANT-WATER FISHING

I. Substance: This study would analyze the conditions and characteristics of labor supply for distant-water fishing efforts. It would seek to determine the trends and make projections of costs and difficulties. The most important present and potential distant-water states would be included in the study. It would examine the technological innovations that might reduce labor requirements and costs. It would examine techniques for using local labor. And it would examine increased services, decreased time on grounds, and other means by which labor difficulties could be alleviated. The study should attempt comparison among states to determine where comparative advantages might lie in the future.

II. Relevance: The study would help determine how, and to what extent, increasing labor costs and difficulties will affect distant-water fishing states. The analyses of distant-water fishing industries of individual states, that are suggested elsewhere, would provide information for, but not duplicate, this study, since this study would be primarily concerned with comparisons among the states.

III. Feasibility: The study could be done most easily after completion of studies of the individual states. But because such studies might not be available for some time, it would be desirable to

undertake a comparative analysis before completion of the others. Such an approach would be feasible but difficult.

IV. Costs: This would depend upon the number of states covered and the depth of the analysis. Satisfactory results might be obtained by several working meetings of fishery technologists, economists, and country experts.

V. Auspices: Preferably an international body as coordinator and convenor of meetings.

9. INVESTMENT IN VESSELS AND GEAR

I. Substance: An extremely large number of studies could be done on fishing vessels and gear. Only a few of these, however, would be of particular importance for the decisions at LOS, and it is these that should be given priority. They should focus on the characteristics of vessels and gear over the next decade and, perhaps, beyond. They should be largely comparative in nature, attempting to determine how and where different states will be involved. The studies should provide some indications of total investment by states; of the mobility of vessels between areas and between species; of the effectiveness of the vessels; and of the costs and subsidies involved. It would be particularly helpful to determine trends in national and international aid and development programs.

II. Relevance: The studies should be helpful in shedding light on two kinds of issues. One would be in anticipating the location and severity of congestion and conflict that might occur in the future. And the other would be in the provision of guidelines to development programs so that redundancy in effort and conflict might be reduced.

III. Feasibility: Some of the information would result from studies of individual states and other suggested studies. Some is already available (e.g., several NMFS papers, OECD monograph on Fishery Policies and Economies, FAO Fishery Investment Conference). These might be brought together and evaluated without too much difficulty. Additional studies would be difficult because of the inadequacy of economic information on capital costs. (The studies might help to stimulate the development of better statistical series.)

IV. Costs: This would depend upon how much information is presently available. An exploratory study would be very helpful and probably could be done by an economist working with experts at various centers. This might produce a questionnaire or a survey guide that could be used in rounding out the information.

V. Auspices: If it goes by means of exploratory study and questionnaire, it might be done under the auspices of FAO or perhaps UNDP or World Bank.

10. TECHNOLOGICAL INNOVATIONS

I. Substance: These studies would focus on the kinds of innovations; (a) that are likely to be economically feasible in the next decade and (b) that may be economically feasible in the next three decades. Emphasis should be placed primarily on those innovations that may have significant effects on international uses. For example, studies of cultivation techniques for high unit value species for the luxury market would be relatively less important than studies of innovations in remote sensing of herring or tuna schools. The studies should deal with those innovations that are likely to increase pressure on limited stocks, and also on those that might release pressure. The former would include studies of attracting devices, remote sensing techniques, and other techniques that might be used on conventional stocks. The latter might include developments affecting presently "underutilized" stocks -- processing of protein concentrates, nets for taking western Pacific tuna, deep water trawling.

II. Relevance: It is conceivable that there may be technological innovations on the horizon that could "revolutionize" the fishing industry -- or parts of it. It is likely that there are innovations that will have a significant effect on particular international arrangements. Remote sending by satellites or aircraft of tuna schools might increase congestion in the already highly over-capitalized yellow fin tuna fishery of the IATTC. Questions are raised as to who should pay for the innovations, who should share in the information, and how to rationalize the effort.

III. Feasibility: There is probably sufficient information of a technical and scientific nature (viz. FAO Conference on Fish-Finding, Canadian Conference on Automation). The information, however, needs careful economic evaluation (as in the Norton study on "Search Efficiency -- Tuna"). It also should be focused as suggested in Paragraph I, above. Some information should be available from the suggested studies of individual states and on investment in fisheries and gear. In addition, a study getting under way at Brookings on the relationship between innovations and U. S. foreign policy might have some useful inputs.

IV. Auspices: FAO, possibly IOC, or through academic institutions.

V. Costs: If there is sufficient technical and scientific information, the work might be handled by an economist working for 1-2 years in cooperation with various research centers.

11. MARINE PROTEIN CONCENTRATES

I. Substance: The study would project the future demand for marine protein concentrate. This might be done on different assumptions as to price, processing, packaging, distribution, and consumer preferences. It would also evaluate the effect on supplies of fish stocks that are presently utilized and that are presently under-utilized.

II. Relevance: If consumption of a marine protein concentrate should become significant, it could have a marked effect on both the supplies of fish and the institutional arrangements for fisheries management.

III. Feasibility: Some studies have already been done or are under way (viz., by Keil at M.I.T., the Protein Advisory Group of the U.N., AID, etc.). The NAS Committee on Marine Protein Resources is considering convening an international, inter-disciplinary conference which could be the means for getting the study done.

IV. Costs: Those of a conference of 30-40 experts plus some support for papers.

V. Auspices: The NAS Committee.

12. DEMAND PROJECTIONS BY STATES

I. Substance: These studies would focus on individual states and groups of states and seek to determine the nature and magnitude of their demands for living marine resource commodities. They would attempt projections of a fairly refined nature over the next decade and of somewhat less refined nature over the following two or three decades. They should attempt to provide price and income elasticities and cross price elasticities both among fishery products and between fishery products and other forms of animal protein. There should also be a study of the degree to which demand may be affected by information on mercury and other substances in fish.

The studies proposed here overlap with others that are suggested and with some already completed. The most important one that is already completed is that of Bell, et. al., for the U. S. Fisheries Service, "The Future of the World's Fishery Resources." This study should be reviewed carefully to determine whether or not further refinements might produce differences that would be significant for those who will be making the decisions.

Other proposed studies with which these would overlap include the studies proposed for Soviet, Japanese, and other distant-water fishing industries, and the study on marine protein concentrate.

II. Relevance: Obvious.

III. Feasibility: With a few exceptions (Japan and the North Atlantic states) there would be difficulties in getting adequate statistics on patterns of demand. It would be desirable to have some sociological inputs to provide some indications as to how demand patterns might be changed or are likely to change -- and these would also be quite difficult.

IV. Costs: These would depend upon the degree to which it would be desirable to refine USFS estimates and the degree to which satisfactory information is produced from other studies.

V. Auspices: A review and evaluation of USFS and FAO studies might be done by an international team under the auspices of FAO. Further refinement, if desirable, might be done under the same auspices. Studies of demand by individual states might be handled by the states.

13. RECREATIONAL MARINE FISHING PROJECTIONS OF VALUE & DEMAND

I. Substance: The study should attempt an evaluation of recreational fishing of stocks that are international in character -- primarily salmon, tuna, and billfish. It should also project the demand for such fishing over the next decade and some indications of the particular stocks that will be of either direct, or indirect importance to both sports and commercial fishermen.

II. Relevance: Conflicts between commercial and sports fishermen over stocks within international marine waters are already evident. Sports fishermen generally have significant political influence. As the demand for sports fishing increases and as the conflicts become more significant, it can be expected that the sports fishermen will attempt to play a major role in decisions. It would be useful to have some background information on the use of sports fisheries over the next decade in order to anticipate the location and severity of conflicts that might occur. It would also be useful to attempt an evaluation of sports fishing in order to help provide a basis for regulatory measures (including pay-offs, perhaps) that would facilitate resolution conflicts.

III. Feasibility: Aside from the ordinary difficulties in getting the statistics, there is an additional problem in the pricing and evaluation of recreational resources.

IV. Cost: Principal investigator, consultants, and travel.

V. Auspices: The principal investigator should be an economist familiar with the economics of recreational fisheries. The study could probably best be done in a university or research institution, and in the U. S. since, in addition to salmon, billfish should be included.

14. THE SOVIET DISTANT-WATER FISHING INDUSTRY

I. Substance: The study would provide a projection of Soviet distant-water fishing activities over the next decade. It would include an economic analysis of the demand for fishery products and an analysis of the non-economic factors that may affect demand. It would analyze the conditions of supply. This would include a study of labor characteristics, costs, and trends. And it would include a study of investment in vessels. The latter aspect would include classification (insofar as possible) of vessels by fishing effectiveness and by likely kind and location of fishing effort. An examination of Soviet research interests and gear developments would also be valuable.

II. Relevance: The study would be designed to provide background information that would permit projections of the location and intensity of future Soviet fishing. It would help in providing some indications of the accommodations that might be sought by the Soviets in bilateral negotiations and international conventions.

III. Feasibility: Access to adequate information on Soviet fishing activities and interests might be difficult. It is believed, however, that there is enough information to provide a basis for reasonably accurate estimates and indications of future intensity, kind, and location of Soviet fishing effort.

IV. Costs: The costs would include the salary of a principal investigator plus consultant fees and travel.

V. Auspices: The study should be done under the auspices of private institution, either within or outside the U. S. It might best be done by an expert in Soviet economics cooperating closely with experts in fisheries.

15. THE JAPANESE DISTANT-WATER FISHING INDUSTRY

(This would be similar in most respects to the proposal for a study of the Soviet fishing industry. However, in addition to studies of supply characteristics, it would be necessary to examine Japanese investments in foreign fishing industries. Feasibility would be greater in view of greater availability of information.)

16. THE DISTANT-WATER FISHING INDUSTRIES OF OTHER STATES

(Studies similar to those for the Soviets and Japan should be done for other states. Criteria for the selection of states to be studied should include: the relative importance of the industry to the state's economy and to world fishing effort; the significance of the industry with respect to the potential for conflict;

the influence of the state in the process of making international decisions. Some possibilities might include Spain, South Korea, Taiwan, Brazil, and Poland.)

17. FISHERY ISSUES

I. Substance: This study -- or series of studies at various intervals -- would seek to identify and describe the different international fishery issues. It would characterize the significance of the issues and the interests that would be affected. It would also deal with how these issues might be perceived by different states and what blocs might be formed with respect to them. The relationship of fishery issues to other ocean issues should also be examined.

II. Relevance: Between now and the new LOS, the kind and character of fishery issues may be subject to frequent change. Anticipation of these changes would be useful.

III. Feasibility: Anticipation of the issues would not be difficult. The analysis of them would be helped by other suggested studies.

IV. Costs: Occasional support of scholars.

V. Auspices: FAO and non-governmental groups.

18. CLARIFICATION OF FISHERY GOALS

I. Substance: The studies would seek to identify and evaluate the various items of value (economic and non-economic) that are sought by states from international marine fisheries. They would define differences between states and particularly between states with different cultural and political backgrounds. The values would include (but not be limited to): economic income (as measured from different wage/price structures); employment opportunities; protein supplies; national security; psychological satisfactions (freedom and independence of fishing, conservation *per se*); nationalistic pride; anti-foreign sentiments; etc. The studies would attempt to determine how states perceive their interests and provide some basis for evaluating reality of perceptions.

II. Relevance: The identification and evaluation of goals would help participants at LOS develop a more common understanding of issues.

III. Feasibility: Some of the individual state studies that are suggested may bear information of value for these studies. Studies might be done by analyzing groups of states or through the case approach.

IV. Costs: Salaries of several scholars.

V. Auspices: Probably best done by non-governmental agencies.

19. TRENDS IN INTERNATIONAL FISHERY ARRANGEMENTS

I. Substance: This study (or perhaps, series of studies) would focus on the recent developments in fishery arrangements and seek to anticipate how these might operate in the future. It would examine the National Quota (Historic Rights) kinds of agreements; the coastal state preferential rights approach; abstention agreements; and the unilateral extensions of exclusive limits. The studies would examine how the arrangements and unilateral claims work; their stability; their effect on distribution of fisheries wealth; and their ability to meet desirable goals. They would examine how decisions are made and how effective the arrangements are in dealing with problems of management, research, allocation of rights and resources, and enforcement. They would attempt to determine the kinds of arrangements that might be operating by the time of the new LOS, and that might be operating beyond that under different assumptions of agreements.

II. Relevance: The studies should provide LOS conferees with an accurate appraisal of the ability of present arrangements to meet future needs and with some indications of general principles that might be acceptable.

III. Feasibility: Other suggested studies on fishery goals and arrangements will relate closely to these studies. The difficulties of getting these studies done lie, in part, in the shortage of competent and knowledgeable scholars and, in part, in the problem of getting access to relevant information. Some related studies have already been done (e.g., FAO series) and others are actively under way (e.g., Burke Project).

IV. Costs: The salaries of competent scholars.

V. Auspices: The studies might best be done outside of public agencies but with their cooperation.

20. INTERNATIONAL DEVELOPMENT PROGRAMS

I. Substance: This study would examine the activities of international development and foreign aid programs and their effect on fishery activities of states. It would seek to determine ways in which the programs might ameliorate conflicts and ways in which programs might be coordinated to achieve mutually beneficial effects. Criteria for evaluating projects should be analyzed and refined.

II. Relevance: In areas where supplies are limited, development programs might lead to excess intensity of effort and to conflict.

III. Feasibility; Information should be readily available for most international and national programs.

IV. Costs: Salary of a scholar.

V. Auspices: Non-governmental.

21. ALTERNATIVES FOR FUTURE FISHERY ARRANGEMENTS

I. Substance: These studies would suggest and analyze possible fishery arrangements for the future. They would discuss the functions to be fulfilled -- research, management, regulation, allocation of rights, enforcement, and arbitration. And they would explore ways in which the functions might be fulfilled and the costs and difficulties that would be associated and that would occur in adoption. Studies should be done of specific situations and with respect to general principles. They would cover ad hoc bilateral agreements, multilateral arrangements, regional commissions, and international commissions or authorities. Criteria for evaluating the arrangements should be developed. Different limits and degrees of exclusive rights might be assumed.

II. Relevance: Manifest.

III. Feasibility: A number of studies, some suggested and others as well, would relate to this area. Several papers have already been done and others are in process (viz., COMSER report and present USFS study on institutional impediments). Additional studies can be done individually or through multi-disciplinary groups. At some point it might be useful to have a conference allowing for presentation and discussion of alternatives.

IV. Costs: Salaries of scholars, expenses of conference.

V. Auspices: Both governmental and non-governmental groups.

22. INTERNATIONAL MANAGEMENT OF TUNA

I. Substance: This study would analyze demand and supply conditions for tuna over the next several decades. It would determine the location of stocks, particularly with respect to various national limits. It would examine and evaluate present international arrangements and trends. And it would suggest and evaluate different

alternatives arrangements for the future, including, but not limited to, regional commissions, unilateral controls, and international authorities. It would also examine different regulatory devices such as quotas, national quotas, taxes, entry controls, etc.

II. Relevance: Tuna stocks are already a source of conflict. They are more international in character than most other stocks both because of their occurrence and because of vessel mobility.

III. Feasibility: Several studies have already been done in this area (e.g., Frederick Bell on world investment in tuna, Jack Kask on a global tuna authority, some studies in Japan, and others). Further elaboration and refinement would be possible and desirable. This could relate to some of other suggested studies on international arrangements and regulatory devices.

IV. Costs: Assuming that the data are satisfactory, costs would not be great.

V. Auspices: Governmental and non-governmental agencies.

23. INTERNATIONAL MANAGEMENT OF WHALES

(This study would be similar in most respects to the suggested study for international management of tuna.)

24. INTERNATIONAL MANAGEMENT OF SALMON

[This study would be similar in most respects to the suggested study on tuna management. But in addition, it would have to take account of the anadromous characteristic of salmon, possibilities for cultivation, and, in particular, the recreational as well as commercial use. It would also relate to the suggested study on sports and commercial fishing.]

25. INTERNATIONAL MANAGEMENT OF OTHER STOCKS

[In addition to whales, tuna, and salmon, it would be desirable to examine the trends and alternatives for international (or multilateral) management of many other stocks; e.g., North Atlantic cod and haddock, North Sea herring.]

26. 200 MILE EXCLUSIVE LIMITS - MANAGEMENT EFFECTS

I. Substance: This study would examine the consequences of a 200 miles zone of exclusive fishing limits. The consequences would be examined in terms of management (another study would examine consequences for the distribution of fisheries wealth). It would deal with stocks that are fully enclosed within the limits of two or more states and those that fall both within and outside of such limits. Certain representative examples might be selected for detailed analysis -- viz., anchoveta off Chile and Peru, North Sea herring, pilchard and anchovy off West Africa, cod and haddock on Grand Banks. The study would examine management techniques that might be adopted; how access might shared or opened; the provision and costs of research and enforcement; and the problems of different national values, subsidies, and markets.

II. Relevance: A realistic appraisal of problems and benefits of extended fishing zones would be helpful.

III. Feasibility: This would depend upon the degree of analysis and on the need for data that is not presently available. Some general thinking on the subject would be quite feasible and of value.

IV. Costs: Dependent upon the degree of detail.

V. Auspices: Might best be handled by scholars outside of government agencies.

27. 200 MILE EXCLUSIVE LIMITS - DISTRIBUTIVE EFFECTS

I. Substance: This study would be based partly upon the suggested study of the geographic distribution of fish stocks. It would, in addition, attempt an economic evaluation of the stocks taking account of differences in wage/price structures, subsidies, etc. It would also examine how states and groups of states might utilize the wealth contained. Where a particular stock is enclosed within the limits of two or more states there would be questions as to the criteria and means for allocating shares among the states, and there would be questions as to how rents might be derived from leasing, taxing, or licensing foreign vessels. The proposal for sharing of access within the fishery zones of the European Community would be of interest.

II. Relevance: The studies of distributive and management effects of 200 mile zones should be compared to studies of preferential rights zones.

III. Feasibility: Comprehensive analyses of all stocks would be extremely difficult, but a few case studies and some general analysis would be feasible and of value.

IV. Costs: Dependent upon number of studies and details of analysis.

V. Auspices: Non-governmental agencies.

28. PREFERENTIAL RIGHTS

I. Substance: This study would examine the concept of preferential (or special) rights of coastal states. It would analyze the situations in which such rights have been employed and the trends for future arrangements. It would examine the implications for management of stocks and for distribution of fisheries wealth. It would seek to evaluate, for example, the gains and losses experienced by parties to the ad hoc bilateral agreements off the coasts of North America. And it would explore the stability of such arrangements and the kinds of pressures that might be exerted to break them. In management terms, it would examine the inter-relationships between agreements, between different states and different stocks. And it would seek to anticipate the long-run outcome of a system of preferential rights.

II. Relevance: The study would be compared with the suggested studies of 200 mile zones and should shed some light on the acceptability of these among other, alternatives.

III. Feasibility: Might be limited by the difficulty of getting information, but speculative pieces would be of value.

IV. Costs: Those of a few scholars.

V. Auspices: Non-governmental agencies.

29. MEANS USED IN CONFLICT SITUATIONS

I. Substance: This study would focus on the areas of conflict and the means by which states have sought to achieve their objectives. It would evaluate the severity of the conflicts and the importance of the objectives to the states. It would examine the kinds and effects of the different sanctions and forces that were employed. It would analyze the formation of blocs and their significance in reaching resolution.

A second part of the study would seek to determine the means that might be used in future conflict situations.

II. Relevance: The study would be helpful in anticipating the severity of future conflicts and how sanctions and forces might be employed.

III. Feasibility: It would be difficult to obtain access to information for detailed analyses, but there may be sufficient information for a general approach. Some of the other suggested studies would be helpful.

IV. Costs: Salaries of scholars.

V. Auspices: Non-governmental.

30. FISHERY BLOCS

I. Substance: This study would seek to determine how states are likely to align themselves with respect to various issues. It would analyze how states perceive their interests and the similarity or contrast of their interests. It would identify the bases for the formation of blocs, the strength of the blocs, and how blocs on fishery issues would relate to blocs on other issues.

II. Relevance: Manifest.

III. Feasibility: This study might be done at various intervals by various observors.

IV. Costs: Not great.

V. Auspices: It can be assumed that various governments will be making such studies. It would be desirable to have such studies done outside of government as well.

ATLAS OF WORLD FISHERIES

Lewis M. Alexander

The problem of international regulation of fisheries, in addition to its biological, economic, and legal dimensions, has also geographic implications, in that whatever processes take place or are contemplated have a geographic locus or pattern of movement on the earth's surface. The geographic distribution of such processes is important both in terms of conceptualization on the part of decision-makers (who often plan in terms of abstractions rather than of real-life conditions) and of the possible interactions which can take place between the processes or activities in question and other attributes of the area in which they occur. Depiction of these processes in an Atlas of World Fisheries would appear to be a useful enterprise.

The purpose of such an Atlas would be (1) to bring together in cartographic form a variety of types of data which can be compared with one another graphically in order to analyze forms of interaction, and (2) to suggest new lines of data gathering and research which could be meaningful to an understanding of international fisheries problems.

It is intended that the Atlas be as flexible as possible in terms both of changing conditions and of contemporary data. Once the initial format for data compilation and display are completed, the individual maps would be computer-produced and could be updated as new information becomes available. The Atlas would be in a form permitting easy replacement of individual sheets. A tentative table of contents would be as follows:

ATLAS OF WORLD FISHERIES

I. The Resource Base for Fisheries

- A. The extent of continental shelves; regions of upwelling, and of converging ocean currents
- B. Major commercial fishing grounds, by species and estimated potentials
- C. Unexploited or underexploited stocks
- D. Migration patterns of principal pelagic species

II. Fisheries Exploitation

- A. Major commercial grounds
  - 1. by volume of catch and estimated MSY of species
  - 2. in terms of nationals fishing, distribution of effort, and principal species caught by national fleets
    - a. changes over time* in composition of national effort

*"over time": possibly the ten-year period, 1960-1970

3. in value of catch; total and by species

III. National Fishing Efforts

A. Major fishing nations

1. in terms of volume and value of total catch; distribution between inshore and distant-water fisheries

a. changes over time in volume, value, and distribution

2. major areas fished by each nation

a. importance of areas to total national catch

b. importance of national effort to total catch of the areas

B. Principal fishing ports in terms of volume, value, and species

1. changes over time in volume, value, and species

C. Distribution of national catch into fresh and processed products

1. changes over time in the distribution

D. National and local dependence on fisheries

1. countries with strong economic dependence on fisheries

a. changes over time in degrees of dependence

2. coastal communities with strong dependence on fisheries

IV. International Trade in Fisheries Products

A. Major exporting and importing countries by value, volume, and products

1. changes in national demand for fish and fish products

2. changes over time in direction and volume of trade

V. National Fisheries Restrictions

A. National claims to exclusive fisheries jurisdiction or preferential rights

1. special claims to conservation zones

2. variations in permission to non-nationals to fish in exclusive areas

3. changes over time in fisheries claims

B. Effects of national claims on fisheries exploitation

1. changes over time in volume and species of catch following the imposition of restrictions

C. Bilateral and multilateral fisheries arrangements

1. nations and types of arrangements involved

2. effects of such arrangements on fisheries exploitation

VI. International Fisheries Organizations

A. Distribution and geographical extent of international arrangements

B. Types of activities of the organizations.

Efforts of various types have been and are being made in fisheries mapping programs. As part of the early planning for an Atlas of World Fisheries an inventory should be made of such programs, and plans formulated for cooperation where possible with these efforts.

A contribution of the geography profession would be in the planning and execution of maps and graphs, including evaluation of data in terms of its suitability for mapping, and suggestions of forms of cartographic representation.

Our fishery problems are complex, and examination of any relatively small aspect of these problems is likely to result in strategies which benefit only those aspects of the systems which happen to be examined. Optimization in the narrow sense may not create the best strategy for the entire system. To avoid such limited strategies, NORFISH will focus on the "big picture" of North Pacific fisheries--NORFISH will be a comprehensive study of the exploitation of the living resources of the North Pacific Ocean and also, in a lesser way, of the fishery resources that affect the fisheries of the North Pacific. We will, for example, also study the nonfishery resources or products such as soybean meal (an important trade-off product for fishmeal) that may affect fishery resources of the North Pacific. Emphasis in this study will be placed on developing a systems approach to forecasting the dynamics of the resources, the industries, the market trends, the international regimes, and the way each of these interacts with the other.

The necessity for such a program essentially stems from the fluidly dynamic status of fisheries in the North Pacific. The changing nature of the fisheries is reflected in the phenomenal developments that have taken place in the exploitation of the living resources of the North Pacific since the end of World War II. Since that time, all nations have greatly intensified fishing activities in their coastal waters. Japan and the U.S.S.R. started sending large fleets to distant waters to exploit hitherto unused stocks. South Korea joined later. Large fisheries, developed principally after the war, include those of saury and squid in the western Pacific; various flounders, pollock, rockfishes, herring, shrimps, king crab, and tanner crab in the Bering Sea; rockfishes, flounders, king crab, shrimps, and hake in the Gulf of Alaska and waters further southward; tunas across the ocean; as well as some whale stocks. In addition, saury and anchovy stocks off the United States coast may be developed soon. Many resources in Asian coastal waters have been fully developed or overfished.

Technological improvements and the employment of factoryships and motherships have made fishing extremely mobile and dynamic. Emphasis has shifted from one stock of fish to another. The level of maximum exploitation often has been reached within a few years after the initiation of exploitation, reflecting the obsolescence of traditional management concepts based on the long-term development of a fishery.

International arrangements have become extremely complex. A number of treaties and international agreements have been concluded among nations bordering the North Pacific, but new problems keep arising. A new Law of the Sea Conference is just before us, so the next decade may witness drastic changes in the international arrangements among the fishing nations of the region and their

relative strength vis-a-vis fishery negotiations. Domestic institutions may also be modified substantially.

The rapid economic growth of Japan is changing her position in the North Pacific. Demand for both high quality fish and low-cost products, such as fishmeal and surimi, is growing fast, and labor shortage remains acute. Fish exports are decreasing with increasing imports from Korea, U.S.S.R., Formosa, Alaska, and Canada. The shortage of animal protein has reached a point where the production of petroleum protein on an industrial scale is being seriously considered.

It is no longer possible to make a meaningful analysis of the situation in the North Pacific and project this analysis into the future without considering all major factors affecting the exploitation of its resources--biological, technological, economic, and political. The region must be studied as a whole. Within one season, hundreds of large vessels may move from one area to another or from one stock to another. A large fishery may develop quickly in a new area as a result of the depletion of a stock in some other area, either from fishing or environmental changes. Markets for a new species or product may expand rapidly from fishing activity in a remote area. Only through a coordinated approach can we identify opportunities for U. S. fisheries.

Long-range Objectives:

The long-range objectives of the NORFISH program include:

1. Definition of a plan for conservation and utilization of the fishery resources of the North Pacific Ocean.

2. Definition of the ways in which the U. S. fishing industry can use best the fishery resources of the North Pacific.

3. Identification of constraints which impede such use and provision of plans to reduce or eliminate the constraints and implement high level utilization.

4. Location of new investment opportunities and identification of existing investments which could be used to stimulate growth of U.S. fisheries.

Approaching these objectives, even at an early stage in our studies, will:

1. Provide a scientific basis for management of living resources of the North Pacific Ocean that takes into account biological, economic, and political factors affecting the resources.

2. Make available to the U.S. fishing industry, in one package, reliable information on the status of resources, market trends, changes in the international regime, and other factors affecting the industry.

3. Provide a basis for advice to the U.S. government and to industry on international policies for resource use as well as

on possible changes in domestic institutions that might be required to strengthen the position of the industry.

4. Provide faculty and graduate students at the University of Washington with opportunities to be involved in nationally and internationally significant problems of exploiting living resources of the sea.

Formulation of these objectives was based on discussions with people in the fishing industry about ways in which a Sea Grant program could assist the industry. These study areas constitute the long-range framework of our program: 1) the resources, 2) the North Pacific data system, 3) the industries, 4) the market trends, 5) the international regime, 6) a fishing information system, 7) non-traditional population dynamics, 8) ocean engineering, 9) oceanfish interactions, 10) allocation, 11) salmon management, 12) tuna management, 13) modelling, and 14) interfaces with other studies.

1. Resources: This section of the study will catalog resources that are presently exploited. Data sources will be identified; time-space distributions will be described; interactive computer routines will be developed to search for particular resource-density configurations in time and space; and generalized production models will be fitted where appropriate. In addition, current trends in effort, catch, and catch-per-unit-of-effort will be examined to predict future trends. The study will also predict possible exploitation patterns for unexploited fishes.

Data on major resources will be collected, stored, and analyzed. Availability and accuracy of data differ from area to area; therefore detailed analysis can be made of some resources while only a superficial review is possible for many others. Generally, however, the present study will go beyond what has been done under the FAO Indicative World Plan, the main purpose of which was to arrive at a rough estimate of the potential of each area of the world ocean.

The history of exploitation of major resources will be studied in detail. Available statistical data will be collected and stored as much as practicable. This part of the study will be subdivided, somewhat arbitrarily, as follows: China Seas demersal resources; pelagic resources around Japan, South Korea, and southern East China Sea; offshore resources in temperate and subtropical zones; sub-Arctic demersal resources; sub-Arctic pelagic resources; temperate pelagic resources in the eastern Pacific; inshore resources; marine mammals; and oceanographic characteristics of areas in which major resources are found.

2. North Pacific Data System: Certain minimal data are required to monitor exploitation studies of stocks. In recent

years, stock exploitation has intensified rapidly; therefore it is necessary to acquire, rapidly, catch and effort statistics from the nations that fish the North Pacific. In this section of the study we will examine existing data exchange systems such as those used by FAO, ICHF, INPFC, and other organizations and determine the feasibility and the requirements for implementation of a North Pacific fish stock monitoring network.

3. Industries: Fishing industries of the nations that exploit North Pacific resources differ from each other historically, structurally, and institutionally. This study will analyze the fishing industries of the following nations in order to discover their effects on resources of the North Pacific: United States, Canada, Japan, U.S.S.R., South Korea, Formosa, Mainland China, and North Korea.

4. Market Trends: For selected important species, the flow of products will be followed starting from the fishing grounds. Wherever possible, values added at each level of processing and marketing will be estimated. Changes between past and anticipated trends will be studied. International movements of fishery products are becoming more and more active in the North Pacific, particularly with increasing importation by Japan. (Such movements already have substantial effects on the fishing industries of different nations in this region.) Despite total landings amounting to 8.7 million metric tons in 1968, Japan is expected to have an increasing shortage of fishery products which will have to be met by imports.

5. International Regime: Various arrangements have been made between different nations in this region, and several international fishery commissions are in operation. Extensive negotiations are carried out between different nations almost continuously. The present study will evaluate the effectiveness of these arrangements not only from the point of view of conservation but also on the basis of other considerations, such as minimizing international disputes, allocation of catches, development of new resources, and problems of new entry.

Some major changes may take place in the regime of the sea on a worldwide basis in the next few years. General trends will be toward extension of national jurisdiction over the seabed as well as superjacent water. Possible effects of such changes on the fisheries of this region will be studied.

6. Fishery Information System: Most fisheries are prosecuted without the benefit of rapid information flow among the fishermen, the processors, and the management agency. In this section of our study, we plan to examine probable configurations for a fishing information system and determine the nature of feasible information systems. Such an information system might entail the fishery vessels

reporting their catch by radio to a central processing system. On the basis of catch histories and management algorithms the central processing system could "tell" the boat where to fish next. Also, such a system could predict catch arrivals and thus enable processors to adjust workloads accordingly.

Concurrently, the non-traditional population dynamics theory (see this heading) will be used to develop real-time or quasi-real-time population management strategies which will monitor the fishing strategy section of the processing system. These studies would constitute a planning document for the development of actual fishing information systems.

7. Non-Traditional Population Dynamics: Traditional dynamics, largely based on a few simple exponential-type models and more or less dependent on steady state systems, are not entirely responsive to the needs of contemporary fishing problems. In order to find techniques that are suitable for these problems, we will develop study papers which examine the feasibility of models in what we call non-traditional fishing dynamics. These involve 1) decisional models, 2) pulse fishing models, 3) sub-area management, and 4) mixed species techniques.

8. Ocean Engineering: We are not emphasizing this area in our program. We must, however, call attention to certain ocean engineering problems which will be considered as integral parts of other segments of our investigation or will have to be considered during later phases of our studies. These include 1) gear, 2) vessel and gear modularity, 3) acoustics, and 4) presentation.

9. Ocean-Fish Interactions: Despite efforts to correlate the abundance of fish with features of the ocean environment, the practicability of these "forecasts" often is lacking. In general, we do not know what variables in the ocean should be measured, on what scales, and on what space-time dimension. Furthermore, we do not know whether the conventional space-time dimensions are the appropriate dimensions or whether we should be measuring velocities or accelerations of the variables or simply, as is usually done, their absolute values.

Of further consideration is the stock and recruitment problem, which is fundamental to almost any management advice and yet is one of the least understood problems in fishery biology. While theoretical models are at least available to describe the relation between the abundance of the stock and the abundance of the resulting recruits, little is known about the all-important variability (the variability often obscures any underlying relation that might, in fact, obtain) in the stock and recruitment relation. Moreover, much of this variability may owe to techniques of measurement. There have been no critical reviews of these problems suggesting the important areas in stock and recruitment problems

that need to be examined. We propose, in this study, to review and synthesize the literature on ocean-fish interactions and ocean environment-recruitment interactions and outline the questions which require solution in our fisheries. The exact nature of this review will depend on the deliberations of the stock and recruitment conference which will be held at the University of Aarhus in the summer of 1971.

10. Allocation: Conservation of resources of the North Pacific can be considered as the optimel time-rate of resource utilization. Thus, to conserve these resources, we must allocate them to intervals in time as well as to the various nations and the firms within the nations. The allocation problem is essentially an economic problem which requires data from many other phases in this study. The solution of this complex economic problem requires considerable information allocative constraints which result, in a large part, from jurisdictional considerations both in terms of our present understanding and in terms of future changes in the jurisdictional situation.

In this part of our study, then, we will map out economic-legal strategies which will provide advice to our government on the best strategies in this area to produce a maximal utilization of the resources of the North Pacific.

11. Salmon Management: The salmon fishery is one of the most important fisheries in the North Pacific. The Bristol Bay run of red salmon has, in a good year, a value of $100 million when packed and shipped to Seattle. Yet the management of these runs does not take advantage of modern technology. We propose to investigate the feasibility of a salmon management system for Bristol Bay. This study emanates from the requirements developed by our linear programming model of run allocation in the Naknek-Kvichak system. The concept involves placement of acoustic sensors in the estuaries and utilizing these sensors to monitor the run and escapement. Information from the sensors would be processed at a central location, and this information would be used to direct and systematize biologists' observations and to provide management recommendations.

Another concept involves the prediction of the run of red salmon to Bristol Bay. Fisheries Research Institute has made forecasts based on estimates of abundance of salmon on their migratory route, one year before return, for a number of years. These estimates of abundance could be made more efficient because the presently used purse-seining techniques permit only three or four sets to be made each day. Therefore, we have developed a concept of a high seas trap which would monitor salmon continuously. We have already begun experiments which would use acoustic devices to monitor the passage of salmon in the trap.

12. Tuna Management: Tuna fisheries constitute an extremely valuable resource. The albacore, for example, generally considered to be the most valuable species of tuna for canning purposes, is of particular importance to the Pacific Northwest. Yet the albacore is a single population in the North Pacific migrating among the North American summer surface fishery, the Japanese spring live bait fishery, the Japanese winter longline fishery, and the multinational equatorial longline fisheries. Despite the cosmopolitan nature of the albacore, there is a tendency to view the dynamics of the albacore just on the basis of events that are observed in the North American fishery. In our studies of the tuna fisheries, we will concentrate on the dynamics of the albacore as they relate to the several fisheries in the Pacific.

13. Modeling: We envision a large amount of modeling to be incorporated in our studies. The majority of the modeling will be accomplished during intermediate phases of the study by which time we plan on completing the stages which will contribute to defining and formulating the kinds of models that need to be built.

14. Interfaces with Other Studies: There are many resource oriented programs being conducted at the University of Washington. For example, Dr. James Crutchfield of the Department of Economics is leading a study, sponsored by the National Marine Fisheries Service, on institutional problems. A principal objective in our studies will be to maintain communication between these programs and NORFISH. To implement this communication we are budgeting funds to conduct each year two NORFISH colloquia in which University of Washington participants and invited participants can exchange views.

Procedures for 1971 and 1972:

The procedure for 1971 and 1972 is essentially one of systems development. The long-range goals are both ambitious and general. We feel that it is important to formulate our problem in broad, general terms so as to avoid the risk of ignoring all meaningful factors. In addition to developing our system for implementing the utilization of the North Pacific resources, we hope to accomplish the following within the first two years of the project:

1. Documentation and time-space mapping of resources with plans for development of a computer atlas which can be interrogated to determine or estimate abundance and trends in abundance of important resources on any dimension in a manner similar to that developed by Stommel for oceanographic data.

2. Consideration of international fishery agreements pertinent to data exchange to determine whether existing agreements on data exchange can be implemented.

3. A background paper on the adequacy of existing population dynamics and the relation of these dynamics to fishing information systems and to criterion for management, in general.

4. A study on the allocation of resources.

5. A critical review of ocean-fish interactions emphasizing the needs, design, and feasibility criteria for future studies.

6. A paper which integrates the problems, market trends, the international situation, and the status of the resources in the North Pacific.

7. Development, through extension, of high degree of communication with the fishing industry.

Quantitative Science Paper No. 19*/

PREREQUISITES FOR THE APPLICATION OF A SYSTEMS ANALYSIS APPROACH TO RESEARCH AND MANAGEMENT OF AQUATIC RESOURCES

BY

Brian J. Rothschild

CENTER FOR QUANTITATIVE SCIENCE
IN FORESTRY, FISHERIES AND WILDLIFE

University of Washington
Seattle, Washington 98105

March 1971

*A series prepared under the general sponsorship of the Quantitative Ecology and Natural Resource Management Program supported by Ford Foundation Grant Number 68-183.

/Draft prepared for Sixth Session of Advisory Committee on Marine Resource Research (ACMRR) Rome 10-17, March 1971.

INTRODUCTION

The purpose of this paper is to provide a short draft background document for the sixth session of the Advisory Committee on Marine Resource Research (ACMRR) to be held in Rome, 10-17 March, 1971, on the prerequisites for the application of a systems analysis approach to research and management of aquatic resources. The paper is intended to introduce the subject of systems analysis and its relation to fishery research and management. It is a brief extension of an earlier paper "A Systems View of Fishery Management with Some Notes on the Tuna Fisheries" which is in press as a FAO Technical Report and will be referred to in this paper as the "reference paper".

The discipline of systems analysis has its roots in the development of operations research (Morse, 1970) and is a methodology for providing advice to decision makers on complex problems which usually involve policy. It is, therefore, no accident that the continued development of systems analysis appears to parallel the continually increasing urgency with which we need to solve the complex problems of our contemporaneous world. In these complex problems the systems analyst endeavors to use systems methodology to ask the "right questions".

The same sort of complex problems, amenable to systems analysis, are quite abundant in fisheries. For example we have:

- Poorly developed criteria for national and international temporal and spatial allocation of stocks
- The open-access problem
- Many overfished stocks
- Little understanding of the stock and recruitment problem
- Poorly developed theory on multiple species fisheries and the effects of exploitation of one species on the exploitation of others
- Many ineffective fishery management procedures and concepts
- Fleets capable of exerting tremendous amounts of fishing intensity
- A need to develop theoretical and rational bases for jurisdiction
- Misallocation of stock complexes in the time stream
- A need for the fishing community as a whole to participate in rational management and to be held accountable for mismanagement, overfishing, and irrelevant research

- A need to improve our understanding of the ways in which fisheries can contribute to the economic development of the developing nations
- A limited understanding of ocean-fish interaction as testified to by the limited success predicting fish abundance and distribution from environmental data
- A need to ensure planning for fishery development and management, particularly in the developing countries vis-a-vis UNDP funding
- A need to develop both biological and economic theory for treating short term fluctuations. Most available theory depends upon "on-the-average" behavior. Incentives for more efficient stock utilization require predictions of what will happen "next year".
- The lack of efficient information systems for the storage and retrieval of catch, effort and other fishery data.

Actually, the examples in the above list point collectively to the problem of the management of our fisheries stocks. We assert that systems analysis can place appropriate weight to each of these problems and make an important contribution to the development of fishery management in its broadest context. This paper will provide background for the application of systems analysis to these sort of problems.

In our discussion of systems analysis, it is important to recognize that the systems analysis that we will discuss is a particular methodology. It is not necessarily related, for example, to control-system theory, to computer systems or to the study of ecosystems. Its orientation is considerably different than other methodologies, such as the scientific method or operations research. The scientific method, for example, has always been philosophically (Copi, 1953) oriented toward seeking, but never attaining, ultimate truth whereas operations research is basically a collection of mathematical techniques (such as mathematical programming, simulation, inventory theory, and queing theory) which are useful for the solution of relatively well defined problems. Because the sponsor of the systems analysis needs advice to make timely decisions he frequently cannot afford the luxury of a scientific investigation or the solution of the wrong operations research problem.

In order to apply systems analysis to fishery management it is necessary to appreciate the systems methodology. In the following section I have outlined some of the concepts of the systems methodology. Following this, there is a discussion of a few of the specialized techniques that systems analysts use. The background and the methodology then provides a substrate for describing further prerequisites for initiating analysis of fishery management or continuing the analysis that was begun in, for

example, the reference paper. An Appendix contains some remarks that refer to other areas in aquatic sciences where systems analysis might be implemented.

SYSTEMS METHODOLOGY

This section presents a collection of ideas and concepts relevant to the systems methodology.

The first concept involves the description of a system (cf Churchman, 1968). A system is a collection of interactive entities among which flow information or material. Because the real world is extremely complex, the analyst must obtain simplified, but not necessarily simple views of the flow of information or material among the components of the system. This necessity generates systems which are, of course, abstractions of the real world and thus are artifices of the imagination. The cleverness, success or failure, of an analyst can be measured in the degree to which his abstractions of real-world systems contribute toward the efficiency of the analysis.

In addition to being an artifice of the imagination each system has further properties that include its inputs, its outputs, its resources, its environment, and its management mechanisms. The resources of the system are those entities that are modifiable by the system whereas the system environment (not to be confused with the term "environment" in ecology) consists of those entities that are, with respect to the system, fixed constraints; these fixed constraints are unmodifiable by the system. For example, one fishing system might consist of a fleet of 10 boats which are considered to be fixed in number and 30 fishermen which must be allocated three to a boat. In this instance both the boats and the fishermen constitute part of the environment. An alternative system might consist of 10 fixed boats, and 30 fishermen that can be allocated 0,...,30 per boat. For this alternative system, the boats are still in the environment, but the fishermen have become part of the resources of the system. We can see that even with fixed number of people and equipment we can arrive at, even in this simple example, many alternative systems (many analyses tend to be deficient because they form a rigid boundary between the resources and the environment of the system). A final property that we should discuss is the way the system is managed, that is, how are decisions made in the system. These decisions can be made by people as in the conventional view of management or by machines or man-machine in the cybernetic view. Even if we are not engaged in systems analysis per se, should we not be able to identify these properties of the system that we are dealing with. Are we muddling, if we cannot identify the properties?

Thus given a problem situation we can see that its solution rests in attaining certain objectives which can be attained by the construction of alternative systems, each having inputs,

outputs, resources, environment(s), and management. The analysis attempts to identify all possible alternative systems which might achieve the objectives and then choose that alternative system or set of alternative systems that will enable the transmission of appropriate advice to the decision makers. How should the alternative systems be chosen? In a systematic way, naturally. A systematic way of choosing among alternatives is outline in Quade. I have modified his approach and have outlined it in Figure 1. It is not possible to go into details of Figure 1 in this short paper. It is important, however, to distinguish a few particularly important aspects of the essence of systems analysis which appears in Figure 1. The first is that the analysis is iterative by nature, that is to say, if the interpretation is unsatisfactory, the analysis cycle is reinitiated at the formulation stage. Instead of time phasing a one year project to reach the interpretation stage at the end of a year, we would, using a system approach, perhaps schedule, for the same problem several during the year. We might want to sketch an entire problem from the formulation to the interpretation in a matter of months, thus making several passes during the year. It is clear then that in systems analysis we treat our objectives as a variable. This is only reasonable because after we make our first iteration, we know more about the problem than before the first iteration and therefore shouldn't we expect our view of the problem to change with additional information? Again, we are not only attempting to solve the problem as it is initially posed; we are also attempting to simultaneously determine if we are asking the right question.

A second feature of Figure 1 that bears emphasis is the segment on criteria. A criterion is a test that we apply to a set of alternatives to adjudge which alternative is, in some sense, best. It is important to distinguish criteria from objectives which are missions that are to be accomplished. The substance of many analyses lies in the definition and reasonableness of criteria. I have discussed the nature of criteria in the reference paper mentioned and pointed out the need to develop economically-related proximal criteria for fishery management.

Many analyses have the weakest link in the criteria which are used. There are a variety of common criterion errors. The cost-benefit ratio, for example, only makes sense in a non-approximate sense in the unlikely situation in which the costs and benefits are a straight line passing through the origin. Another misuse of ratios is the following (see Mckean, 1964): we have two alternative research cruises, Cruise A and Cruise B. Cruise A will yield, all other things being equal, 1,000 temperate observations (benefits) for $2,000 (costs), but Cruise B will yield 2,000 observations for $3,000. The benefit-cost of A is 1/2 and of B is 2/3. Thus, in terms of benefit-cost, the system B is better than A. But is this an appropriate criterion? A better criterion for judging between A and B might be to ask the question of whether it makes sense to pay $1,000 for 1,000 additional observations. Another criterion related

problem which may challenge the intuition is the casting of priorities (see Hitch and Mckean, 1960). We are frequently asked to rank activities in some sort of order and we attack the first ranked activity first. The vagueness of uncautious use of priorities can be seen by being given a list of desirable items; for example, a new car, a typewriter, and a pair of shoelaces. Many people would assign priorities to these items in the order that they are given. If, however, we mention in considering this shopping list that we have a budget of only $50, the priorities will instantly be reordered. Cost is frequently not included in setting priorities. A final example of the cirterion problem is the MSY criterion that has been and is commonly being used in fisheries, but is generally recognized to be a rather poor criterion. An example of the economic deficiencies in the MSY model have been rather clearly elucidated by Waggener (1967). An example is shown in Figure 2.

Thus the development of criteria is an extremely important part of systems analysis. While this activity should not dominate a study, it should be an important component, particularly in an area such as the applied aquatic science, where the criterion problem has been given so little thought.

In addition to the concepts outlined in Figure 1 there are several others that need to be emphasized, even in a brief discussion. The first of these is the concept of suboptimization. We can view a system as a series of hierarchies. As an example, consider the food problem in country x. The analyst will try to contribute to the solution of a particular food problem in country x by breaking the problem into component parts. One component might be a fish sector and another might be an agriculture sector. Attempts to optimize either the fish or the agriculture sector are called suboptimization. Suboptimization can be dangerous if the suboptimalities are not consonant with optimality in the entire system. If we were to optimize the fish sector we could conceivably allocate considerable emphasis to meal production which might not be consonant with the solution of the food problem. On one hand, it is almost always necessary to suboptimize to make a problem manageable. On the other hand, the dangers of suboptimization must be avoided by making sure that the suboptimization provides optima that are constant with the main goals and objectives of the system. Many "solutions" to fishery problems are clearly suboptimal. The dange of suboptimization can be greatly reduced by taking - at least initially - as broad a view of the problem as is practicable.

Another concept involves the problem of overdetermined criteria. These are criteria that are set at levels that are too high to be of operational use. For example a fishery research organization might want to promote the fullest use of stocks while minimizing all conflicts associated with the harvesting or processing of stocks. Is this even possible and what information

does a statement such as this convey to the employees and the constituents of the organization? This is clearly an example of overdeterminism; more proximal criteria need to be developed. A further example of overdetermined criteria may be various economic criteria such as attainment of economic efficiency. Advice on economic efficiency is frequently difficult to interpret operationally, because the advice, in itself, does not tell the fishermen, for example, how to be economically efficient. A set of operational criteria needs to be developed which are consonant with the higher level criteria of efficiency.

Finally, two components should be included in most of the alternative systems that could be conceived in passing through the process outlined in Figure 1. These are implementation and communication. There is little use in a system analysis that does not include plans for communicating and implementing the analysis. In fact, many analyses are quite successful in one sense and failures in a more important sense. The success lies in their solution of the technical problems, but their failure lies in not planning implementation. A considerable portion of analysis, then, should be devoted to developing explicit plans for the implementation and communication of the system.

SPECIAL TECHNIQUES

A variety of special techniques have become associated with the systems methodology over the years. While it is not entirely necessary to be entirely familiar with these techniques it is useful to be cognizant of them when contemplating system analysis. Knowledge of these techniques enables the analyst to appreciate the kinds of solutions that are possible for the questions posed. A certainly nonexhaustive list would include organization; technological forecasting; business decision theory; inter-personal communications; and computer methods.

With respect to optimization techniques, these can be found in any textbook on operations research. In addition to the well known techniques of optimization of simple "nice" functions that everyone learns in calculus the reader will find various mathematical programming techniques for optimization of constrained objective functions. The reader will also find in most of these texts the bases for inventory and queing theory. All of these have applications in fisheries ranging from fleet scheduling and management to research design.

The subject of technological forecasting is, as Bright says, an attempt to "assay the future". Systems analysis because of its philosophy places heavy emphasis upon understanding the future rather than describing the status quo. The subject of technological forecasting is difficult and fraught with incommensurables. Nevertheless, there is much about fishery technology that can be forecast. For example, if we take a 10-year planning horizon, what

changes do we expect to see in jurisdiction, in vessel design, in fish detection, in fleet strategy, in refrigeration, etc.

Business decision theory is taken here to include the techniques that are used to make business decisions. This includes such concepts as, for example, capital budgeting; the allocation of capital among investment projects where the capital could be fishing vessels and the projects could be fisheries and determining the present value of various investment schemes. The subject of program budgeting should also be mentioned to emphasize the need for fisheries work to concentrate upon programs rather than activities.

Interpersonal communication theory is, of course, a very large subject, but at least one aspect of this theory is particularly important to fisheries work and this deals with the use of experts (see Quade, 1968a). Who are the experts and what makes an individual an expert? How can we best utilize the knowledge and intuition of experts? One technique that appears pertinent is the delphi method which was developed to obtain an opinion from a group of experts. The conventional approach is to have a meeting or a conference of experts and ask for an opinion or advice. The advice that will emanate from the meeting will most likely be colored by the most dominant personalities in the group - it may not be the best advice and it certainly does not represent an accurate view of what the group is thinking.

The delphi method attempts to avoid this difficulty by developing a questionnaire on the pertinent subject. This questionnaire is sent to the experts and an individual is assigned to monitor and sort out the opinions; he then uses the responses to generate another questionnaire which is sent to the same group. The process continues until the opinions of the group are stabilized. The delphi method clearly involves a lot of work, especially since it forces the "meeting" sponsor to carefully identify and formulate the problem and objectives. The delphi method in many instances can be quite cost effective.

Finally, I wanted to especially mention the broad range of computer techniques that would be used in a system study or could be used in fisheries. These computer techniques may be grouped into three categories. The first involves "canned" programs; the second involves special computer techniques; and the third is simulation. With respect to canned programs, there are two sorts. The first involves collections of canned programs such as, for example, the UCLA BIMD series or the IBM scientific subroutine package. These permit the user to conduct a wide variety of sorting, statistical, and mathematical procedures. There is a need to develop familiarization with these programs and techniques for using them. Just for one example it is possible to compute computationally complex fishing power ANOVA's with exceptional east using BIMD X64 generalized ANOVA procedure. In addition to promoting a familiarization with these techniques we also, almost

needless to say, need to provide the opportunity for computing to those who may not have ready access to computers. This might, depending on cost-effectiveness, be done by mail or telephone link. Actually, some computations might not be undertaken without computer facilities. The second type of canned program is the program designed especially for computing particular fishery problems such as estimating growth parameters, mortality rates, etc. A library needs to be established for these programs and their use should be facilitated by providing some sort of long-distance service and consultation.

Some special computer techniques that warrant special mention are information systems which I have discussed briefly in the reference paper and display techniques. The handling of fishery data in an efficient way obviously requires an information system. Display in the very broad sense can be taken to mean computer graphics as well as CRT display. We are currently experimenting with developing a fishery system for the North Pacific Ocean which we are calling NORFISH. One of the NORFISH systems will link an information system with a simulation model. We are hoping that the system will permit users who are not generally familiar with the details of computer technology to communicate with the system and ask a large variety of "what if" questions, which will be answered in part with both CRT display and graphic output. The third group of techniques involves simulating modelling. While this sort of modelling can be done, for simple situations, "on the back of envelope", more complex situations will involve computer oriented models. In addition to writing simulation programs in one of the more traditional languages there are several simulation languages such as GPSS, DYNAMO, and SIMULA. SIMULA is particularly interesting; it is ALGOL based and presents fantastic opportunities for logic and set manipulation. One of the fundamental tasks of the system analyst is to predict the future and as fisheries science proceeds more and more into taking a system view, the simulation techniques will play an important role in predicting the future.

THE PREREQUISITES

The first prerequisite for the application of a system analysis approach to research and management of aquatic resources is obviously to identify the problem situations. I have attempted to do this in the introduction. Are these reasonable and are there others that should be considered? Perhaps of these, the one that is most important is fishery management in the broad sense.

The second step is to briefly indicate our present status with repsect to proceeding toward a solution of the various problems. How fast are we progressing? Is the problem being attached in an efficient and systematic way? Is there a better way? The systems analyst would certainly advocate the use of his discipline.

The third step is to apply the systems methodology to the problem in question. I have begun to do this in the reference paper for fishery management. The problem situations outlined all need careful formulation. The application of the methodology will generate certain questions, many of which can be answered by application of the specialized techniques. Implementation will require setting specific dates for completion of additional phases, such as information search, criteria development, etc.

In conclusion, then, the world is undergoing a technological revolution. This technological revolution is characterized by a fantastic development of "hardware". This development has accelerated our everyday problems. The development of our skills to handle, manage, and control technology, our "software", has lagged behind hardware development. The hardware-software lag or gap generated the development of techniques to handle the complex problems. Many of these techniques are subsumed under system analysis. The hardware-software gap in the aquatic sciences is also quite noticeable although not produced by nearly as extensive hardware development or other areas. There is no doubt that this gap in aquatic sciences can also be reduced by the application of systems analysis.

APPENDIX

In addition to the problems of fisheries management there are other areas in aquatic science that are both amenable to systems analysis and most likely to produce material increases in our understanding of the very complex questions that each entails. This understanding is quite necessary to make resource decisions from a base of rationality rather than a base of pressure. Needless to way, the wise use of resources depends on the continuing and dynamic strengthening of the information required to make decisions. Some of the other aquatic-science problems amenable to systems analysis include:

(1) The problem of national and regional development. Fish are a valuable resource to developing countries. What is the best approach for using wealth generated by fish in the development process? How should the government(s) allocate their development effort: marine fish, mariculture, agriculture, industry, etc.?

(2) Management of management. Just as systems analysis should be developing systems for analyzing systems, managers should be developing management skills. What is the best way to motivate people in aquatic sciences and to increase technical and interpersonal expertise? How are decisions made and who makes the decisions?

(3) Pollution is everywhere. It has been existent for centuries. Its noxiousness over the time-space frame is simply a matter of degree. Although there are some systems analyses in the pollution area, these are relatively few. Are we asking the right questions about pollution? To what extent are our pollution oriented activities involved in describing the status quo or would it be more preferable to study the criteria by which we adjudge the various social questions that impinge upon the pollution problem? Are we building an effective decision and policy framework for dealing with pollution or man's modification of the environment?

(4) Our studies of ecosystem have largely been involved in describing the inter-relations among the various components. The systems analyst might question, among other things, the extent to which ecosystem study concerns itself with the dynamics of the ecosystem.

(5) Oceanography is a subject that generates tremendous amounts of data and the analyst would want to examine the cost-effectiveness of obtaining these and the extent to which modern information-system theory is utilized in the storage and processing of these data. In addition the analyst might ask to what extent is our total effort in fisheries oceanography related to empirical tests and to what extent is it applied to obtaining an understanding of the cause and effect relations between the numerical and spatial distributions of fish in the oceans? The prediction of numerical and spatial distribution of fish in the oceans depends to a large extent on understanding these cause and effect relations.

REFERENCES

1. Churchman, C. W. 1968. The Systems Approach. Dell Publ. Co., 243 pp.

2. Copi, I. M. 1953. Introduction to Logic. Macmillan, New York, 472 pp.

3. Hitch, C. J. and R. McKean. 1960. Economics for Defense in the Nuclear Age. Harvard Univ. Press.

4. McKean, R. N. 1964. Criteria, In Quade, E. S., Editor, Analysis for Military Decisions. Rand Corporation R-387-PR. 382 pp.

5. Morse, P. M. 1970. The History and Development of Operations Research, In Kellehez, G. J., Editor, The Challenge to Systems Analysis. Operations Research Society of America. Vol. 20:21-28.

6. Quade, E. S. 1968. Principles and Procedures of Systems Analysis, In Quade, E. S. and W. I. Boucher, Editors, Systems Analysis and Policy Planning. American Elsevier Publ. Co., New York, 453 pp.

7. Quade, E. S. 1968a. When Quantitative Models are Inadequate, In Quade, E. S. and W. I. Boucher, Editors, Systems Analysis and Policy Planning. American Elsevier Publ. Co., New York, 453 pp.

8. Waggener, T. R. 1969. Some Economic Implications of Sustained Yield as a Forest Regulation Model. Institute of Forest Products, College of Forest Resources, University of Washington Contribution 6, 22 pp.

*Giulio Pontecorvo	Graduate School of Business Columbia University New York, New York
Brian Rothschild	Professor of Fisheries College of Fisheries, University of Washington
Bernard Skud	Director of Investigations International Pacific Halibut Fisheries Commission, Seattle, Washington
*Lowell Wakefield	President, Wakefield Fisheries Wakefield, Alaska
**Robert Warren	Associate Professor of Political Science University of Washington
**Edward Wenk, Jr.	Professor of Engineering and Public Affairs University of Washington

Members of Working Group Unable to Attend:

*S. V. Ciriacy-Wantrup	Professor of Agricultural Economics, University of California Berkeley, California
*John L. McHugh	Professor, Marine Science Research Center,State University of New York Stonybrook, New York
*Edward L. Miles	Associate Professor, Graduate School of International Studies, University of Denver Denver, Colorado

*Members of IMSAP

**Attended during part of meeting