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Report of a Colloquium on the Multispecies Fisheries Problem, June 1976

EDMUND S. HOBSON and WILLIAM H. LENARZ

INTRODUCTION

Historically, most fisheries have been managed as if populations of fishes are independent, even though many fisheries take more than one species together, often without distinguishing among them. There is concern that to manage effectively we must know how exploited populations interact with each other, with other elements of the environment, and with the fishery (and ultimately society) itself. This requires good data on each of the many species affected by the fishery, including those caught incidentally, and those seriously affected indirectly through biological relations with exploited species. Despite the general concern, however, efforts toward solution of what has been called the multispecies problem have been diffuse and uncoordinated. In fact, there is little evidence of a generally recognized broad concept, perhaps because so many variations of the problem exist.

To better define the multispecies problem, a colloquium was held at the Southwest Fisheries Center, Tiburon Laboratory, in June 1976. Under the sponsorship of the National Marine Fisheries Service, NOAA, this colloquium brought together investigators that represented a broad range of interests in fisheries biology and economics (Table 1). It was quickly recognized, however, that comprehensive solutions to multispecies problems transcend these fields to include political science, sociology, and the physical sciences. Thus, although the colloquium limited itself to topics that reflected the expertise of the attendees, it is emphasized that these topics are segments of a larger system that must be fully examined before final answers are attained.

The major components of the multispecies problem have long been recognized, but understanding their complexities has become possible only with recent advances in refined field techniques, computers, and quantitative fisheries research. Five interacting components can be identified within the system: management objectives, regulations, fleet or fishermen, exploited fish stocks, and ecosystems. The complexity of the interactions within this system, including areas within the expertise of the included research disciplines, is enormous (Fig. 1). This complexity is increased many fold by the continuously changing natures of the components. Therefore, even though the colloquium limited its attention to economics and fisheries biology, it faced a major challenge.

Table 1.—Participants in the Multispecies Colloquium.

Norman J. Abramson	National Marine Fisheries Service, NOAA, Southwest Fisheries Center, Tiburon, Calif.
Peter B. Adams	National Marine Fisheries Service, NOAA, Southwest Fisheries Center, Tiburon, Calif.
Robin Allen	Inter-American Tropical Tuna Commission, La Jolla, Calif.
William W. Fox, Jr.	National Marine Fisheries Service, NOAA, Southwest Fisheries Center, La Jolla, Calif.
Edmund S. Hobson	National Marine Fisheries Service, Southwest Fisheries Center, Tiburon, Calif.
William H. Lenarz	National Marine Fisheries Service, NOAA, Southwest Fisheries Center, Tiburon, Calif.
Loh Lee Low	National Marine Fisheries Service, NOAA, Northwest and Alaska Fisheries Center, Seattle, Wash.
Roy Mendelssohn	School of Forestry & Environmental Studies, Yale University, New Haven, Conn.
Virgil Norton	Department of Resource Economics, University of Rhode Island, Kingston, R.I.
Patric K. Tomlinson	Inter-American Tropical Tuna Commission, La Jolla, Calif.
Albert V. Tyler	Department of Fisheries & Wildlife, Oregon State University, Newport, Oreg.
Carl J. Walters	Institute of Animal Resource Ecology, University of Brirish Columbia, Vancouver, B.C.
Norman Wilimovsky	Institute of Animal Resource Ecology, University of British Columbia, Vancouver, B.C.

The colloquium concentrated on identifying the types of research that could be expected to best benefit fisheries management, and immediately recognized that sound research programs would be unlikely without stable management objectives. Because management objectives determine the information needed, and thus research plans, changes in these objectives, amplified by the many interactions among the system's components (Fig. 1), could be profoundly disruptive.

IDENTIFYING RESEARCH AREAS

Before proceeding, the colloquium examined the relations among certain

Edmund S. Hobson and William H. Lenarz are with the Southwest Fisheries Center Tiburon Laboratory, National Marine Fisheries Service, NOAA, 3150 Paradise Drive, Tiburon, CA 94920.

critical variables that characterize the diverse fisheries to be managed. A 3 × 3 matrix was constructed to do this (Fig. 2).

As illustrated by the matrix, the various fisheries can be assigned to one of the following categories: 1) a single-species fishery where only one species is taken in significant numbers, 2) a multiple-species fishery, where two or more species taken in significant number lack important interactions among them, and, 3) a multiple-species fishery where two or more species taken in significant number interact in important ways.

As further illustrated by the matrix, these fisheries can also be characterized by the types of gear used: 1) fisheries using specialized gear that takes a single species, 2) fisheries using flexible gear to take a species mix that can be altered during a given deployment, and 3) fisheries using inflexible gear to take a species mix thought to be unalterable.

It was recognized by members of the colloquium that these categories are artificial, and that the cells in the matrix are in reality points on continua. Also, it was recognized that few, if any, fisheries are characterized by any single point on the matrix. Furthermore, most fisheries can be expected to evolve under a wide range of varying pressures (economical, sociological, political, biological, and technological) that would change their positions on the matrix over time. Nevertheless, although the positions of most fisheries on the matrix are changeable rather than fixed, their characteristics at a given time center around specific points.

Further elaboration of the matrix (Fig. 3) shows the relationships among degree of management control, difficulty of determining sustainable yield, and the numbers of management options—all under the various combinations of biological and technological considerations defined above. Let us consider how the matrix might be used in planning research of management strategy. By examining the relationships shown, we can predict that a single-species fishery using specialized gear offers many management options

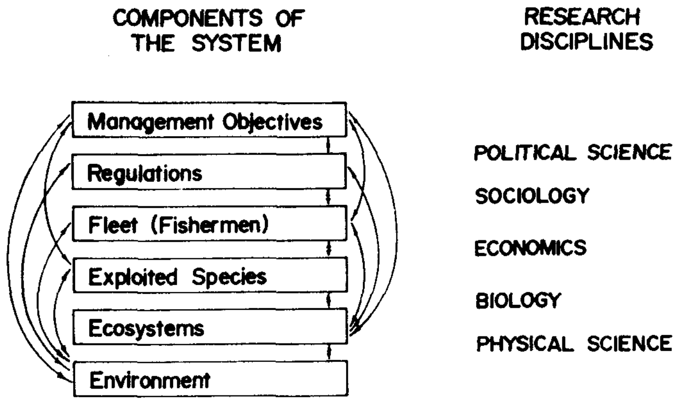

Figure 1.—Major components of the multispecies fishery problem.

FISHERY TARGET

	SINGLE SPECIES	MULTIPLE SPECIES w/o interactions	MULTIPLE SPECIES w/ interactions
Specialized Gear			
Flexible Gear			
Inflexible Gear			

Figure 2.—Variables that characterize a fishery. Terms listed in the column at the left refer to the gear used.

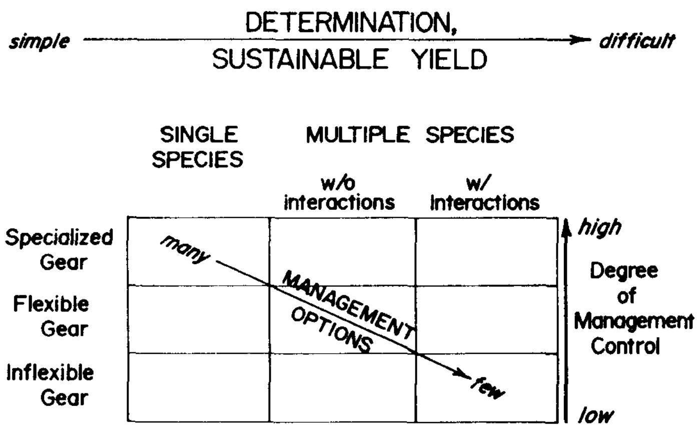

Figure 3.—Relationships among variables of a fishery.

and a high degree of management control. Under these circumstances it is relatively easy to determine sustainable yields and then implement management control if necessary—a highly desirable characteristic for management. Many fisheries, however, use what is in practice inflexible gear to take multiple species that interact significantly. Here, with few management options, and low degree of management control, the situation is unfavorable from management's point of view. Under these circumstances, management may wish to encourage more flexible fishing practices that permit greater selectivity in the catch, that is, introduce specialized methods that limit the catch to the target species. Unfortunately the fishing industry may resist these efforts through fear of increased cost or lost revenue. The histories of the International Commission for the Northwest Atlantic Fisheries and the International Pacific Halibut Commission include disputes over this issue. The fisheries involved exploit complexes of bottom and midwater fishes, and traditionally used methods and gear that took many incidental species. This resulted in dangerous stresses on species of relatively low abundance but of considerable importance to Canadian and U.S. fishermen. Some representatives of the fishery claimed the gear was inflexible, and the incidental catches unavoidable (perhaps to avoid management control). But Commission scientists, determining the gear was in fact flexible, introduced certain practices that relieved the pressures on the vulnerable species. They had, in effect, moved the position of the fishery on the matrix from row 3 to row 2 (Fig. 3), thus increasing the level of management control. Thus we see how examining the relationships illustrated by the matrix can provide insight and serve as a tool in planning research and management strategies where complex multispecies problems exist.

GENERAL NEEDS IN SOLVING MULTISPECIES PROBLEMS

Solving multispecies problems establishes research needs not unlike those that have shaped traditional single-species problems. The much greater complexities of the multispecies problems, however, require far more refined and sensitive methods and equipment. These needs can be arranged among five categories:

1) More effective data management systems.
2) More refined modeling techniques.
3) More accurate monitoring of existing fisheries.
4) More biological information on marine organisms (including species presently unexploited), with emphasis on biological interactions.
5) More emphasis on socioeconomic aspects of the problem.

Elaborating on each of these, in order:

1) Historically, data collected in some fisheries programs have been underutilized because more data have been collected than even a quantitatively trained biologist can handle. Increased use of computerized data management systems and consultation with data management specialists would allow more efficient storage and retrieval of the volume of data needed to solve multispecies problems.
2) Modeling has yet to fill its anticipated role as a major tool in solving management problems. To date, computer simulation models have generally suffered from poor structure and incomplete analysis, so that much of the behavior of the models remains unknown. In particular, optimization techniques should be more widely applied to better define those characteristics of the model that the modeler wishes to emphasize. What is needed, then, is further development and more systematic application of existing techniques, as well as the development of new techniques.
3) Monitoring fisheries. Characteristics of the catch (species, age, size) of most fisheries are poorly known, particularly where a large fishery is exploited by international fleets. Without this basic information we cannot effectively apply elementary procedures to assess even single-species stocks. Obviously, then, the more complex procedures needed to solve multispecies problems cannot be implemented with data presently available. More effective monitoring of the catch is a basic need.
4) To manage our marine resources effectively we must better understand the biology of marine organisms. It is especially important to understand the important interactions among the various organisms in the ecosystem, as only then can we hope to predict what the ultimate effects of a given management decision will be.

   In defining priorities for research there has been a tendency to ignore species currently unexploited by the commercial and sport fisheries. The following considerations point to some dangers in this course:
   a) The important, often critical, biological relations of most, if not all, species valued by fishermen are poorly understood or unknown, and at least many involve species currently unfished.
   b) Among the species currently unfished are opportunities for new fisheries that would reduce pressures now concentrated on the relatively few target species.
   c) Relative values change with time, and species without commercial value today may be highly valued in the future (including many forms now taken incidentally with a target species, but discarded because of low market value).
   d) To be effective, management programs must be designed with a long-range view. A

program locked into just a few currently favored species is soon likely to become obsolete.

e) Responsibilities for managing marine resources extend beyond those species currently of direct importance to the commercial and sport fishing industries.

5) Socioeconomic problems may overshadow all other concerns of management and yet traditionally these areas have received relatively little attention. Although in many instances socioeconomic problems lie beyond the influence of management, they should be identified and anticipated in management tactics.

Where the goals of management are merely preservation of a fishery, socioeconomic concerns have little impact; however, when management objectives expand beyond preservation, as often is the case, socioeconomic considerations generally are involved, and a relatively complex system of interacting influences must be evaluated. For example, when the concern is that of a specific fishery, economic considerations may impact on the system at several levels: 1) final demand (i.e., market prices), 2) production costs, and 3) harvesting effort. It is necessary to integrate biological information with the economic considerations at each of these levels, and a major problem is to identify the type of biological information needed in each case. The above is true of a single-species fishery as well as for a multispecies fishery, but for the latter the task becomes far more complex.

SUGGESTED RESEARCH

The kinds of research needed to solve multispecies problems can be arranged in three major categories according to the time required for their completion: 1) Short-term research projects are based on existing data (a) to provide approximations or "educated guesses" that respond to immediate needs, or (b) to provide guidelines for subsequent research; 2) moderate-term research projects usually involve collecting substantial amounts of new data and last 2 to 5 years, with a clearly defined termination date from the outset; and 3) long-term research programs usually involve collecting substantial amounts of new data that will influence the ultimate course of the research; such programs have an indefinite termination date, and generally last more than 5 years.

Recognizing these major categories, the group identified meaningful research topics that probe important multispecies problems. These topics are outlined below.

Short-Term Research

Synthesis of Existing Knowledge on Diversity and Stability of Disturbed Communities

In exploiting a species, or combinations of species, there is danger of reducing the diversity within certain marine communities. Although this may or may not be an undesirable situation, the impact of such a development remains unknown. Management should know if reduced diversity might lead to instability among valuable stocks, or if its options in future management decisions are being severely limited. Although answers will require moderate or long-term research programs, a preliminary step could be the synthesizing of existing knowledge on the relation between diversity and stability in disturbed communities.

Determination of Existing Fleet Capabilities

Management must be able to estimate the pressures that a fleet can exert in response to situations that could possibly follow management decisions. This is often difficult because many uncontrollable variables, most of them economic, influence the number of vessels active at any given time. The potential of the fleet must nevertheless be estimated because management efforts that increase catch per effort are likely to increase effort.

Immediate Stock Assessment

Extended jurisdiction responsibilities have created an urgent need for approximations of existing catch and effort records. These can only be based on existing catch and effort records, the literature, and conventional analytical techniques.

Identifying Whether a Multispecies Problem Exists

With simulation modeling, a short-term effort could compare the consequence of managing several exploited species as if they were one with the results of a more complex treatment of the individual species. This should provide insight into the need for extensive research on individual species and species interactions.

Preliminary Study of Program Design

Often the course, or even the feasibility, of a long-term effort cannot be determined without a preliminary study that considers program design and other factors. These studies can be considered independent projects, and should be more widely used to reduce the possibility of commitment to fruitless long-range research.

Moderate-Term Research

Surveys

Management requires understanding, and to understand an ecosystem one must know its biological and environmental components. Two types of surveys are needed: a) comprehensive surveys without bias toward species of current economic importance, and b) surveys assessing the status of species important to the fishing industry. The former type is more complex and would take a larger effort, but both could be completed in two to three years. The conclusions that can be drawn from each of these two types of surveys are different, and this distinction must be recognized by management.

Standardization of Fishing Effort

Fisheries that exploit more than one species with flexible gear present the need to partition effort among the species in order to estimate population abundance indices. Current methods of estimating population abundance require detailed records of catch and effort by time, area, species and mode of fishing. Data collection and/or data management systems must often be improved if this methodology is to be used.

Fleet Behavior Analysis

Behavior of fleets that use flexible gear to fish two or more species, shifting from one to another under differing circumstances, is difficult to predict, and this complicates management of the exploited species. Study of this behavior is needed. A monitoring program could compile the following data for each exploited species: catch per effort, value of catch, cost of effort, and catch limits. These data, considered with the cost of shifting from one species to another, could be analyzed with standard analytical procedures, such as linear programming. Intelligent interpretation of the results should permit predicting how the fleet is likely to react to management actions and other perturbations of the system.

Feasibility of Nonspecific Sampling

If preliminary study has indicated that it is unnecessary to consider individual species in a particular multispecies fishery (see previous section on Identifying Whether a Multispecies Problem Exists), an aggregation of species in the landings of that fishery might be sampled for age and size composition without identifying the component species. The results could then be compared with a statistical analysis of the same parameters from similar landings where the component species are separated and considered separately. From this comparison we may determine whether needed statistics can be compiled from landings where species are not separated. Possibly we can identify assemblages of species that respond as a unit to fishing pressures in a way that is consistent and repeated under measured applications of fishing effort.

Long-Term Research

Simulation Modeling

There is a need for imaginative and relatively simple models of biological communities. These must, however, incorporate a sound understanding of the biological interactions within these communities. This understanding has been lacking in the many attempts that have been made to model such communities, so it is not surprising that these attempts have failed. Although a model must be simple to have practical value in management, this does not mean the studies upon which it is based can be simple; to the contrary, simplicity in the model will come only with thorough study of the modeled situation.

Experimental Management Programs

Often it is difficult to evaluate the impact of management actions on the fishery owing to the inevitable effect of many uncontrolled variables. Consequently, it is desirable to conduct long-range experimental fishing programs that would test the effect of important management actions under controlled conditions. Among other requirements, such a program would need preserves where the experiments could be undertaken without interference from other fishing. Possible experiments include testing the impact on the populations of various modifications of fishing gear, size or catch limits, closed seasons, etc. In all such experiments, there should be sufficient time following actual manipulations of the system to monitor long-range effects.

Community Engineering

The construction of artificial reefs is one of the few areas where we have successfully influenced environmental change. Such reefs enhance sport fishing, and also permit study of disturbed communities. In addition to bettering the design of future artificial reefs, such studies will aid in predicting the impact of disturbances created by man, and also increase our understanding of natural reef communities.

Defining Communities

An important step toward meeting management goals is defining the communities of animals that include the exploited species. The concept of species assemblages (see section on Feasibility of Nonspecific Sampling) may be useful for management purposes as it may be possible to treat naturally occurring groups of animals as single species.

Stability of Ecosystems

One current theory suggests that stable ecosystems result from a particular combination of species in fixed proportions, and that such ecosystems become unstable if any one of its components is significantly disturbed. This theory should be further tested because, if true, fishing has far more impact on the ecosystem than has been assumed. Experiments with perturbed systems, such as artificial reefs and experimental management programs, could be designed with this test in mind.

Trophic Relationships

Many of the research programs suggested above indicate need to understand species interactions, and most, if not all, important interactions relate to feeding. Comprehensive understanding of trophic relationships within a community of animals is required to understand that community, and also provides valuable, often needed, background for other research.

CONCLUSION

To manage our fisheries effectively, we must develop long-range plans with stable objectives that recognize the need to understand the important interactions among resource species, other elements of the environment, the fishery, and, ultimately, society itself. To do this we need more effective data management systems and analytical techniques,more biological information, with emphasis on interspecific or intercommunity interactions, and more emphasis on socioeconomic aspects of the problem. Needed research ranges from short-term projects of fixed length, to long-term programs of indefinite length.

FUTURE MEETING

The colloquium closed with the participants unanimous in acknowledging the need for a future meeting. There was satisfaction in what had been accomplished, but recognition that it was just a beginning. Most important, it was recognized that the expressed views had been limited to those of fishery biologists and economists. The future meeting should include other viewpoints that are part of the multispecies problem, especially the views of physical scientists, political scientists, and sociologists.

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