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Northeast Fishery Management Task Force

Overview Document of the Northeast Fishery Management Task Force, Phase I

Richard C. Hennemuth[1], Brian J. Rothschild[2], Lee G. Anderson[3], and William A. Lund, Jr.[4]

[1] *Woods Hole Laboratory, National Marine Fisheries Service, Woods Hole, MA 02543*
[2] *Chesapeake Biological Laboratory, Univ. of Maryland, Box 38, Solomons, MD 20688*
[3] *Coll. of Marine Studies, Univ. of Delaware, Robinson Hall, Newark, DE 19711*
[4] *Marine Research Laboratory, Univ. of Connecticut, Box 278, Noank, CT 06340*

U.S. DEPARTMENT OF COMMERCE
Philip M. Klutznick, Secretary
National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator
National Marine Fisheries Service
Terry L. Leitzell, Assistant Administrator for Fisheries

Northeast Fisheries Center
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PREFACE

This document is the result of studies originating within the Northeast Fishery Management Task Force. The Task Force, organized in 1979 by the New England and Mid-Atlantic Fishery Management Councils and funded by the NMFS, seeks to promote discussion and dialogue on the major issues of fishery management and to explore the effects of various fishery management alternatives.

Composed of representatives from the fishing industry, Regional Fishery Management Councils, federal and state agencies, academic institutions, and general public, the Task Force will operate in three phases. The first phase will assemble background information for identifying and analyzing management options. The second phase will examine this background information to determine the data requirements, regulatory measures, administrative procedures, and enforcement methods associated with each management option. The third phase will critically review the various options for application to specific fisheries, particularly the Atlantic demersal finfish fishery.

This document is one of eight developed under Phase I operations. It was issued in March 1980 as a separate publication, but is being reissued in the *NOAA Technical Memorandum NMFS-F/NEC* series, as are the seven other Phase I documents, since it lays the groundwork for them.

Jon A. Gibson, Coordinator
NOAA Technical Memorandum NMFS-F/NEC series

TABLE OF CONTENTS

BACKGROUND

The waters off the northeastern coast of the United States support some of the richest fisheries in the world. Establishment of the 200 mile limit in 1976 under the Fisheries Conservation and Management Act for the first time gave the U.S. and its fishing industry the opportunity to ensure that these fisheries yield the greatest possible benefit to the public and the industry that serves it, not merely in the short run, but for the future. The Northeast Fisheries Management Task Force was organized in 1979 to provide a forum for discussion of the major issues which management, government, and industry must resolve. The Task Force is made up of representatives from the fishing industry, from the academic sphere, and from the Regional Fisheries Management Councils. Its job will be to address the range of alternatives available, to assess the benefits to be expected from each, to translate these alternatives into specific objectives, and to show, by way of example, how the alternatives might apply to particular fisheries.

The idea of management is not new. Local rules, for example, on the taking of anadromous spawning fish such as alewives . . . rules that set catch limits at so many barrels per householder or that restrict fishing to alternate days of the week . . . are virtually as old as the colonial settlement of America.

But management can be controversial. This is not surprising, since it may bring into focus conflicts between short-term benefits to those who use the fishery resources, and benefits to accrue in the future. If the problems were as simple, say, as the problem that confronts a farmer: the balance between the quantity and value of crop yields versus the costs of land, working that land, and maintaining its fertility, any conflicts might be readily resolved. But fishery management is not that simple. The resource, unlike the farmer's, is common property. Yields are difficult to determine. The populations of fishes that yield the "crop" move from place to place intermingling with other populations so that the consequences of different fishing practices become difficult to evaluate. The effect of a rise or fall in numbers of one species upon the numbers of another, that is the interaction between populations, must also be considered. These are technical problems addressed mainly by fishery biologists and managers.

At bottom, management is addressed to social and economic goals which may or may not be served by such traditional approaches as maintaining maximum yields of various species over many years. These economic aspects may include price-maintenance, distribution of benefits among various localities and classes of fishermen, consumer prices, and yield of critically-needed protein (this last is of course less crucial in the northeastern U.S. than in some other countries). Most modern fisheries are capital-intensive; natural fluctuations in fish populations, let alone those brought on by misjudgment of the fishing pressure those populations can sustain, can be disastrous for those who invest in these fisheries and for the future climate in which they can prosper.

Perceptions of management's effectiveness have often been negative: "the regulatory regime is confusing"; "statistics and stock assessment are inadequate"; "enforcement is perfunctory". The Task Force has undertaken to address these problems and to improve communications between fisheries scientists and managers, and members of the fishing industry. Its work has been divided into three phases.

The first phase, which is covered in the present report, was carried out by eight working groups, each concerned with a different major aspect of fishery management. The groups included members of the fishing industry, the Management Councils, state and federal governments, and universities. Phase I was generally concerned with assembling background information for identification and analysis of management options.

In the second phase, to follow later, management options potentially applicable to fishery management in the Northeast will be identified. Data requirements, regulatory measures, administration, and enforcement methods will be examined in relation to management alternatives.

Finally, in Phase III, the options developed in Phase II will be critically reviewed with respect to actual fisheries, in particular the Northeast demersal finfishery. Government agencies, the Councils, and the public will participate, so that all concerned may better understand the management rationale.

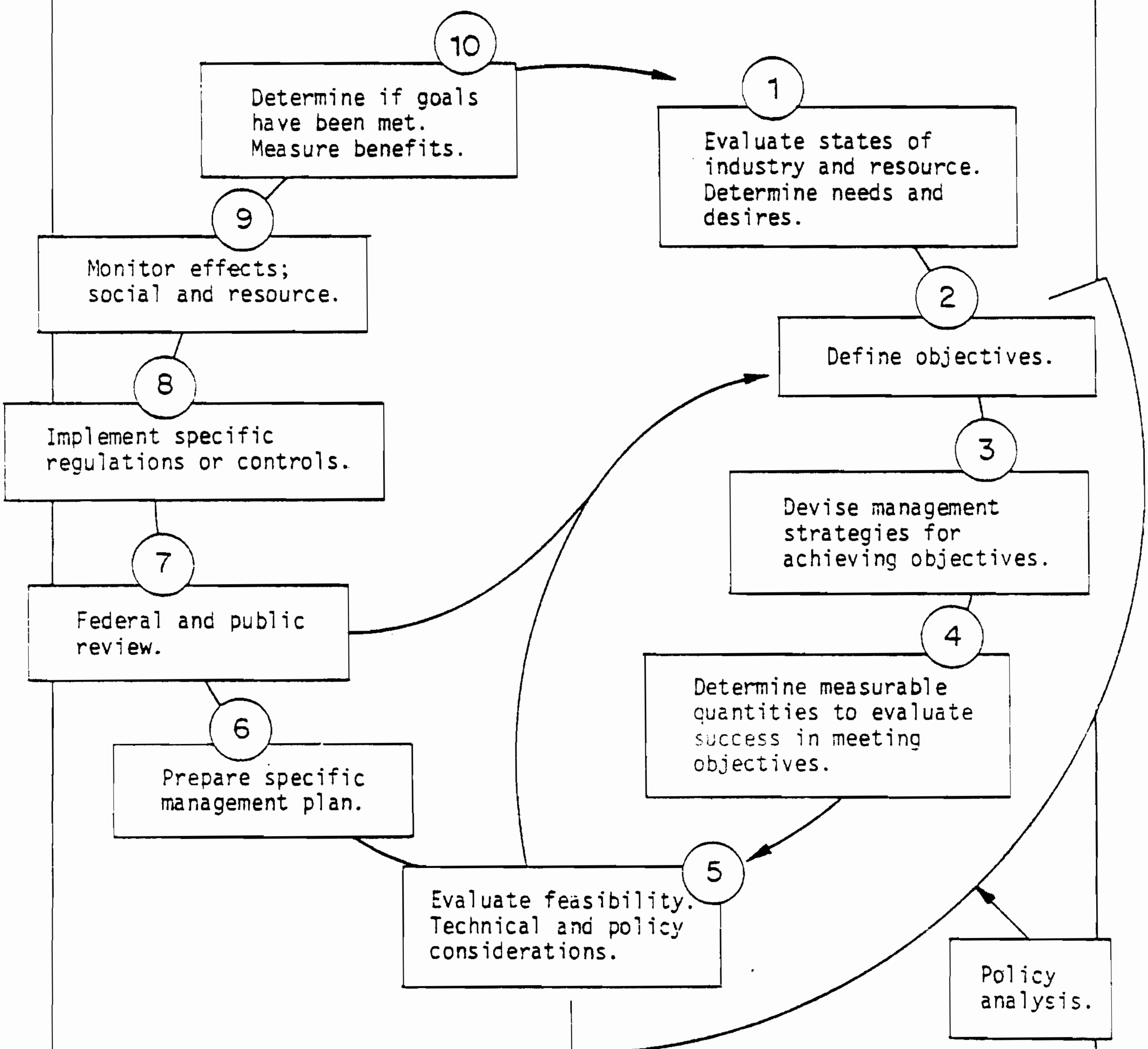
In the pages that follow, we will first describe the process of management. Next we will take up its objectives and the social, ecological, and technical environments in which these objectives are to be achieved. We then discuss the methods of management, and finally, the types of benefits which are sought from the process.

THE MANAGEMENT PROCESS

Management should be viewed as a comprehensive process or system. Often, in practice, what is considered to be management is only a fragment of the process we discuss here. Enforcement, for example, or stock assessment might be emphasized, while the context in which these elements can have an effect is more or less ignored. Regulation and management are not equivalent; regulation is one of the tools available to management, but a system of management might be devised in which regulation plays no part.

The workings of the proposed management process are diagrammed in Figure 1. It may be seen as a continuous cycle by which the present state of affairs is described; objectives are established together with a plan for achieving them and reviewing them by those concerned:

THE FISHFRIES MANAGEMENT PROCESS



the necessary data for monitoring effects and benefits of management are gathered; and the success of the program is judged preparatory to revising it.

Management is in a real sense experimental. Lessons are learned from the process and incorporated in the form of revisions. The whole cycle need not run its course for this to happen, as the "feedback" arrows at various points in the diagram show. The quality of management decisions depends on the information available, and on decision-making skill. Because information is often lacking, incomplete, or questionable, such skill is crucial. While uncertainties about the natural or social environment will always be with us,uncertainties arising from vaguely-articulated management processes can and should be identified and rooted out.

The iterative or "feedback" process of management may lead to changes in objectives if, for example, they were formulated incorrectly in the first place, or if the social purposes they were originally intended to serve should change. Changing objectives because an existing management approach does not achieve them is quite a different matter, since this undermines the structure of rational decision.

Obviously, testing each potentially useful management option by means of the iterative, experimental process is impractical. Alternatives may be tested by modelling or "bench" analysis, which, though it may be imperfect, will help to sort out the best option to try in practice. Such analysis would be brought to bear on the earlier steps (2 through 6) illustrated in Figure 1.

MANAGEMENT OBJECTIVES

The management process (see Figure 1) starts by describing the present state of fishery resources and the industry that exploits them, and then, in social, economic, and biological terms, determines future objectives. How these objectives are defined is crucial to the management process. To be useful, objectives must be clearly stated, practically attainable, of *measurable* benefit, and based upon an understanding of all aspects of the problem they address, rather than fragments of the problem.

Experience teaches us that the way in which management objectives have been framed in the past may make them difficult to translate into action. Often, they are stated in excessively general terms: "maximize social welfare", for example, or "catch all underutilized species in U.S. waters". Such statements may be unarguable as general goals, but they need to be supplemented by more specific subobjectives whose attainment can be measured with data and techniques that are either at hand or practically obtainable.

In setting subobjectives, however, one must keep the broader purpose in mind. Objectives which focus only on part of a problem must be linked together in a comprehensive approach, to reduce the risk of achieving one goal by unwittingly defeating others. In a multi-species fishery, for example, management concentrating upon one or two principal species and ignoring the complex of species making up the by-catch may indeed approach optimal catch levels for the species selected but in so doing reduce catches for the fishery as a whole to suboptimal levels.

Fully as important as defining the objectives themselves is specifying the process for attaining them. For instance, regulating a fishery to achieve "optimal stock size" is of little use as an objective if optimal stock size cannot be established, or indeed, if stock size cannot be measured at all with sufficient precision. Specific objectives require specific information from the ecological and socio-economic environments for assessing the impact of the management system. Objectives should be framed in terms of definable events and measurable benefits, recognizing that severe mismatches may exist between time-spans of social and ecological processes, the latter commonly being slower. This implies a nested set of objectives and subobjectives with opportunity for feedback in the process, as indicated in Figure 1.

The problem of defining objectives and the pathways for achieving them raises a number of issues which are discussed in turn below:

Reactive vs. predictive management. When cause and effect are fully understood, management can be predictive, a state of affairs that is only rarely completely achievable in practice. Where the choice of objectives, the nature of benefits, or the consequences of intervention are uncertain, or the ecological responses of the resources imperfectly known, management may have to be more or less reactive, incorporating what is learned in the process of management in revisions of technique and perhaps in redefinitions of objectives, when experience shows the original definition to have been unsatisfactory. This "feedback" approach will be particularly necessary when objectives are long-term, or when techniques are untried. Reactive management is not necessarily "unplanned"; provision for reactive steps can be part of the planning. The greater the uncertainty in the system, the more reactive must be the management approach taken, with a proportionately greater need for timely monitoring of events. It is important that changes observed which lead to "course corrections" be evident not only to the managers but also to those affected by the management policy.

Objectives implicit in the choice of method. A given objective may be approached by a variety of methods, each of which may facilitate, or frustrate, achievement of some other objectives in ways which may or may not be foreseen. For example, "limited entry" might be aimed at reducing fishing effort, but in choosing this method, one implies that the social or economic consequences of employing it are also objectives of the plan. Identifying any "hidden" or implicit objectives in a spectrum of alternative methods will help in choosing among those methods. The distinction between methods and objectives must at all times be borne in mind; a method is a means of achieving an objective, which should be clearly articulated; it is not an end in itself.

Biological objectives. Maintaining a resource in some particular state may be set forth as a management objective, but this often begs the question of why such a state is desirable. There are certainly biological constraints on objectives. However, the purposes of management are social, and objectives of management, assuming they are realistic in ecological terms, should be established with reference to the social consequences they are intended to produce.

Public and private objectives. The Fishery Conservation and Management Act sets forth objectives which are desirable as a matter of national policy, but not necessarily from the individual fisherman's, businessman's, or community's perspective. The Regional Fishery Management Councils must reconcile any conflict.

The Act's first purpose, to establish a fishery conservation zone under U.S. control, has been achieved (except for some uncertainties about U.S. and Canadian jurisdictions); domestic objectives take precedence over foreign objectives.

A system of conservation and domestic management, a second purpose of the Act, has also been started, by establishing the Regional Fishery Management Councils, but "conservation and management", which are stated as joint goals, have not so far been given equal weight by the public and its legislatures. Conservation (i.e. prevention of "overfishing and depletion") has been initially emphasized as a separate and overriding objective, whereas management is addressed to optimum yield and domestic fishery development, to which ends conservation may be directed.

Integration of public objectives with private objectives (the diverse desires of individuals, firms, local communities and other organizations may, of course, also conflict among themselves) will often require trial-and-error. Even the interests declared by individuals may generate multiple, conflicting objectives. Common interests and those which are peculiar to specific individuals or groups must be sorted out. The latter may be served by appropriate selection of management units and expressed in terms of a series of subobjectives tailored to individual needs which nevertheless are consistent with a long-term, common goal.

Overfishing and depletion are nebulous terms if their "prevention" is considered outside of the context of optimum yield. A depleted stock is sometimes defined as one which has fallen below the maximum point on yield or stock-recruitment curves. However, the observed variability in productivity of fish stocks is often too large to apply the underlying theoretical models on which such definitions are based. Overfishing, therefore, would better be evaluated in terms of management, that is, social, objectives. If it is seen that a population, in the course of pursuing such objectives, is becoming unacceptably low (in the national sense), then the objectives should be revised, since it is probably possible to fish a stock to the point that it will no longer support a continuing fishery.

Full utilization is an FCMA objective which implies that any surplus in excess of domestic capacity may be allocated to foreign fishermen, if public and domestic management objectives are thereby served. At issue are questions of competition between domestic and foreign fishermen, availability of stocks that might be jointly fished, and interspecific relationships between stocks that might be independently fished by foreign and domestic fleets. Since one objective of the Act is domestic fishery development, economic interactions and direct resource competition must be taken into account. If predictions of the effects of foreign fishing are imprecise (for instance, due to competition), a reactive mode of management may be best.

Starting point for management. In principle, objectives can be developed without regard to present practices, but as a practical matter, these practices and their relation to the current state of the resources will influence the approach to be taken, particularly for the shorter term. There is often strong pressure for maintaining the *status quo,* particularly if management has not yet been much developed. Management might start with rather general objectives which minimize disruption of traditional practices, reserving those that require more stringent regulation for later, if these should be required. Setting general objectives need not imply a lack of purpose. For example, objectives addressed to the resource as a whole rather than to individual species or stocks of fish might prove to be more beneficial than a species- or stock-specific approach.

THE MANAGEMENT ENVIRONMENT

Fisheries are based on a natural resource. The ecology of this resource is only to a limited extent alterable by human intervention, and the consequences of such intervention may be difficult to foresee or to control. Management, then, must first of all collaborate with the natural workings of the environment. Management's purposes are social. It is the social environment which determines which goals are desirable, and the most acceptable ways of achieving them. Finally, management is limited by the techniques available for its purposes. These topics are explored further below.

The Ecological Basis of Fisheries

Intelligent fishery management requires an understanding of the relationships between the living and non-living elements of the natural environment, and the impact of fishing upon them. Ecology is the study of such relationships.

Ecologists may focus upon individual organisms, populations of organisms, or the relationships between populations. Since the health of a fishery depends upon whole populations of animals rather than individuals, the ecology of populations and the interaction between them is emphasized for purposes of fishery management.

Populations . . . many individuals of the same species living and reproducing among themselves in a definable space . . . have at any moment certain attributes which are of fundamental importance to fisheries science and management: birth rate, death rate, growth rate, and age (or size) distribution (that is, the population will have a characteristic percentage of its members in each of several age or size categories; this may change markedly with time).

The classical growth model. According to this model, a population of animals finding itself in an environment where food and living-space are ample will increase slowly at first, then more rapidly as the many surviving young grow to reproduce themselves, much as capital invested at compound interest grows as the interest is added to the principal.

Unlike invested capital, however, the animal population, according to this model, eventually will cease growing as its size becomes balanced with the supply of food, space, or some other factor necessary to support it. It has reached its "equilibrium density".

Growth of this sort is called density-dependent. The population size at this point reflects the "carrying capacity" of the environment for that particular species at that particular time. (Population growth is not always limited by density-dependent factors however; sometimes alteration of the physical environment or intrusion of a competing species better-adapted to the environment will bring it to a halt; these are density-independent factors).

The density-dependent growth model underlies one of the traditional concepts of fishery management. If we were able to remove from a population a tonnage of fish each year equal to the natural annual increase, the population abundance would remain the same. Moreover, if that "parent" population were of a size where annual increase was most rapid (that is, not at the early stage of expansion, described above, or approaching the tapering-off point), the amount that could be cropped would be at its greatest, the so-called "maximum sustainable yield".

Regrettably from the point of view of practical management this model does not describe what often happens in nature. It assumes that the numbers of young added to a population are proportional to the numbers of adults, while practical experience with most fish populations has shown this to be untrue. Many major fisheries either began or were expanded on the strength of one or two good year-classes which supported these fisheries for a number of years; additions to the population were not directly proportional to the numbers of spawning adults (though the quantity and quality of the spawning stock is one among several important factors in year-class success).

System dynamics. What is wrong, then, with the simple model underlying the concept of maximum sustainable yield? In general, it is deficient in that it treats the population's environment as fixed, whereas in fact natural environments are dynamic, that is to say, in a state of constant flux. Quantity and quality of food varies with time, and food requirements may be quite different for different life-stages. Moreover, genetically unrelated populations do not exist in a vacuum but interact with one another: positively, as when increases in a prey population favors its predator, or negatively, when two predators compete for limited numbers of prey. The relationships between species may be exceedingly complex. Animals which are prey at one life stage may become predators at another, while competition can be quite indirect. Such relationships may be quite difficult to decipher, and even more so to predict.

The interactions among organisms in a natural assemblage influence the growth rates and abundance in a dynamic fashion. If a population is not fished, all growth is ultimately balanced by natural mortality (although owing to the dynamic interactions, this does not insure that populations will be stable in size). When fishing starts, there are greater removals from the population than additions. Though these removals may to some extent be offset by increased survival and growth among the remaining fishes, they my be so extensive that a new balance is established between fishing mortality and recruitment; a point may even be reached where fishing is no longer economical.

Recruitment is the process by which new individuals are added to the exploitable portion of a population; it is influenced by the processes of spawning, hatching, growth, and survival, and in turn recruitment influences population density and fishing success. Prior knowledge of expected recruitment is desirable for management. Three approaches may be taken to predict it.

1. A historical type of predictive model is based on observed relative strengths of past year classes. The frequency of occurrence of various year-class sizes in the past are plotted, and the probability of future year-class sizes predicted, assuming that future conditions will be the same as in the past and that they will influence year-class success in the same way.

2. The prerecruit portion of the population may be sampled by special surveys or from fishermen's records to provide prerecruit indices. Relative strengths of prerecruit year classes may be compared, and the number of prerecruits in past year classes may be related to the number of fish subsequently recruited. This method provides year-to-year information to the manager.

3. By developing a basic knowledge of the environmental and population factors which determine successful year classes, a more reliable means of prediction could be formulated. This method (like prerecruit indices) might permit prediction of year-class strength before recruitment is completed, and at the same time furnish insight into long-term trends. Far more knowledge of the ecology of fish populations is needed for this method to become feasible.

While estimates of future recruitment are essential for any management plan whose objectives are based on population size, attempting to influence recruitment by manipulating population size is an uncertain endeavor, since the effect of spawning upon recruitment is itself uncertain. It is particularly difficult to adjust plans to compensate for year-to-year changes in recruitment for short-lived species such as squid; the time for reacting to observed recruitment is simply too short.

Multi-species approaches. In view of the dynamic interactions in nature, a single-species approach to management is inadequate, particularly for multi-species fisheries, or fisheries where the by-catch is significant.

To avoid the deficiencies of a single-species approach, management might address itself to the productivity and harvest potential of an entire ecosystem, since the ecosystem in the long run has greater stability than any of its components. However, to be practical, management must recognize the social fact that some species are more desirable than others, and in some measure direct the fisheries to certain species. This suggests a multi-species scheme of management: individual species, groups of species, or particular fisheries (defined by area or gear) would be regulated to control the relative balance of the species mix.

The Social Basis of Fisheries Management

Fish stocks are managed not for their own sake but to achieve social objectives, and this takes place in a social context. Exploitation for short-run advantage at this expense of future generations is obviously irresponsible, so time is an important dimension in management planning; if maximum social benefit over time is set as a goal, the survival of the fish stocks is assured. But the success of management is to be measured, finally, in social terms.

A clear statement of social objectives must precede formulation of a management strategy, but this is difficult because the perception of what is beneficial may vary from fishery to fishery, and from one social group or region to another.

The first consequence of a particular management option and the means used to implement it is upon the composition of the fleet for a given fishery and the fishing methods used. These, in turn, may affect:

- the number of fish caught and the cost-effectiveness of catching them.
- distribution of income and employment among geographic areas, social groups, large and small firms, vessel types, etc.
- efficiency and income in the processing and marketing sectors.
- cultural life and community structure in the areas concerned.
- international balance of trade and, depending on the level of foreign participation in a fishery, international relations.

Different management options can affect such aspects of social well-being in different and sometimes conflicting ways. It will be necessary, therefore, to rank the good and bad potential consequences of various options, and to secure some consensus on which are most important. Where conflicts exist, they must be directly addressed in setting management objectives.

There is a social basis to fishery management, but also a social context consisting of the participants in management and fishing and the social institutions in which they operate. To make the distinction more clear, consider Figure 1, in which a technical plan is devised, and then subjected to various processes of review. It may be that, abstractly speaking, a single administrative authority would be most effective for a particular fishery. In the existing social context, however, this may be impractical; given the existing body of law and the responsibilities and interests of governmental, trade, environmental, and consumer groups, all may have to be accommodated if management is to succeed. In particular, to be well-understood are the internal workings of the Coast Guard and the Departments of Commerce and State and the relations between them, for they are responsible for approving, implementing, and enforcing management plans.

The individuals whose industry is being managed have a most urgent interest in the process and their cooperative response can be crucial to success. For example, if management dictates a closed fishing season, fishermen may observe this season but react by building bigger boats, with the unfortunate result (demonstrated from past experience) that the catch and its cost increase.

Clearly, the needs and possible reactions of the industry must be contemplated in choosing management options, and the industry must realize that its needs are being considered. This points toward maximum public participation in the management process.

As a practical matter, the needs and desires of all concerned cannot always be met; their reactions should be anticipated and the consequences of these reactions weighed in advance. For example, if a certain management option is likely to lead to litigation, the question should be asked, is the objective worth the trouble and expense of defending it?

The social basis of management is implicit in the concept of "optimum yield". When judging what that optimum might be, biological and technical facts-of-life must be given full weight, but managers must always have before them the principle that management is intended to serve social ends.

The Technical Basis of Management

The technology available to the fishing industry and to those charged with enforcing management plans must be considered in developing those plans. Technical practicality is one aspect; another is cost.

Fixed or passive gears, for example, may favor development of a self-regulating fishery, providing a practical means of achieving a fixed exploitation rate, but such gears may be too costly in present circumstances for certain species or fishing grounds.

Other gears may be cost-effective in the short run, but may adversely alter the environment or cause excessive damage to the prerecruit stock.

Processing and marketing may be limiting factors as well. In New England, the danger of declining catches resulting from increasing capacity of the fleet might be in some measure offset by developing fisheries for unexploited species, but this makes it essential to include processors and marketers in the management program, and to give them technical assistance in preparing and selling the catch.

Enforcement may be constrained by the physical dimensions of the area under surveillance. For some types of regulation such as effort limitation by fishing days, remote sensing or telemetry, or perhaps satellite surveillance, may offer solutions.

The ability technically to monitor the effects of management on both the stocks and the social sector may greatly affect assessments of management's value. Improvements are needed both in hardware (sampling tools) and in statistical and survey design.

METHODS OF MANAGEMENT

Management Units

The Fishery Conservation and Management Act of 1976 states that "to the extent practicable, an individual stock of fish shall be managed as a unit throughout its range and interrelated stocks of fish shall be managed as a unit or in close coordination". How these units are defined is of fundamental practical importance to successful management. For example, a single management unit encompassing the entire east coast might be justifiable on genetic grounds for certain migratory species, but a regulation based on such a unit could prove to be inappropriate for particular regions of the coast for a number of biological, social, or economic reasons. On the other hand, a multiplicity of small management units could become impossible to coordinate. Some middle ground is indicated.

Management units are defined by the nature and distribution of the resources themselves, by social and economic factors, and by fishery technology.

The fishery resources to be found in the U.S. Fishery Conservation Zone off the New England and Middle Atlantic states contain some 200 species, but are dominated by perhaps two dozen species of finfish and mollusks which form the basis of the commercial catch.

Basic biological knowledge about these species: their seasonal and geographical distribution, identification of separate stocks, their reproductive patterns, and their ecological response to their environment, including interactions with other species, is fundamental to the definition of management units.

But a knowledge of how they are caught and marketed is essential as well. A few of the species mentioned are the targets of a pelagic fishery (pelagic trawl and purse seine) in which, by and large, only the species sought is captured. Most species, however, are taken on or near the bottom by otter trawl; this gear, though it selects more or less for the size of fish caught, does not select for species, resulting in a by-catch of non-target species which may be substantial. In fact, the annual landings of certain species, including many commercially important ones, may be predominantly, or almost entirely, as by-catch.

Preoccupation with "target" species of a fishery, without due attention to the effect of management on the fishes composing the by-catch, could lead to unplanned-for, and possibly adverse, effects on the condition of the by-catch stocks.

There is another kind of interaction between species at the harvesting level. Fishermen switch their effort from species to species seasonally and according to abundance and price, in order to maximize their profits. Managers must be alert to the effect that regulatory measures directed at one species may have upon this seasonal switching by fishermen and upon their annual income.

The economic interactions between species can be traced further, to the marketplace. The fisherman's price for one species may depend directly on the landings of another, and where markets are regional in nature, the fish need not be landed in the same port or nearby ports. For example, sea-scallop prices may be affected by landings throughout the New England and Mid-Atlantic regions, by imports, and by the price of such competitive species as lobsters. It follows that the perspective of management must be wide enough to include the multi-species nature of fisheries throughout a region.

The geographic distribution, and in many cases the migratory habits, of fish stocks, and the economic interactions between species at the harvesting and marketing levels, point towards broad definitions of management units. Management units defined in biological and economic terms can be expected to cut across existing jurisdictional boundaries. For management to succeed, jurisdictions must cooperate.

To sum up, management units must:

1. comprehend seasonal and geographical distribution of the fishery resources.

2. address the multiple species nature of most New England and Mid-Atlantic fisheries in terms of the by-catch, which makes up a substantial part of total landings, and in terms of the seasonal pattern of switching from one species to another in many fleets, a pattern which has evolved to generate maximum returns from resources whose abundance varies over the year.

3. transcend, where necessary, jurisdictional boundaries, incorporating institutional agreements to insure effective implementation.

Regulatory Measures

Fishery management is intended to increase social benefits from the resource. Thus, choice of management techniques requires clear statements of social objectives. Each technique must be weighed against its alternatives (including the alternative of doing nothing) in terms of a number of biological, social, and economic criteria, to determine how the underlying social objectives might best be served. The criteria for judging alternative techniques are described briefly as follows:

1. **Control of fishing mortality.** When fish stocks decrease to low levels from intense fishing mortality, additional effort is required to maintain catches, which may lead to economic waste. An efficient fishery implies control of fishing mortality.

2. **Biological impacts other than control of fishing mortality.** Techniques may affect specific components of the resource, such as small fish, spawners, or fish of a particular species, with implications for recruitment and future yields, or the availability of a given species to a particular user group.

3. **Relation to the natural functioning of the fishery system.** System productivity is ultimately traceable to such natural factors as radiation from the sun. The influence of management practices on large natural systems, and on the socio-economic environment in which the fisheries take place, is limited. Recognizing this, techniques should be chosen which enhance the operation of these mechanisms rather than interfering with it.

4. **Relation to harvesting efficiency.** Efficiency of a fishery may be expressed in several ways: proportion of potential productivity actually used, cost per unit of catch, income per unit of catch, catch per unit of energy expended, etc. The efficiency measure used depends on the objective of the plan and must be appropriate to it.

5. **Historical precedence for the technique.** Success may depend on the credibility of the approach among those affected: past perceived success or failure of a particular method must be considered (though in no way should this preclude new techniques).

6. **Costs of enforcement and administration.** Calculation of net benefits must include costs of administration and enforcement, and these costs must be justified in terms of potential returns.

7. **Impact on non-target components of a system.** Objectives of management are often specific for a particular species, user-group, or processing segment of the industry. Impact on other system components must be considered to avoid unwanted consequences (for example, on existing, flexible patterns of response to changes in resource abundance or price).

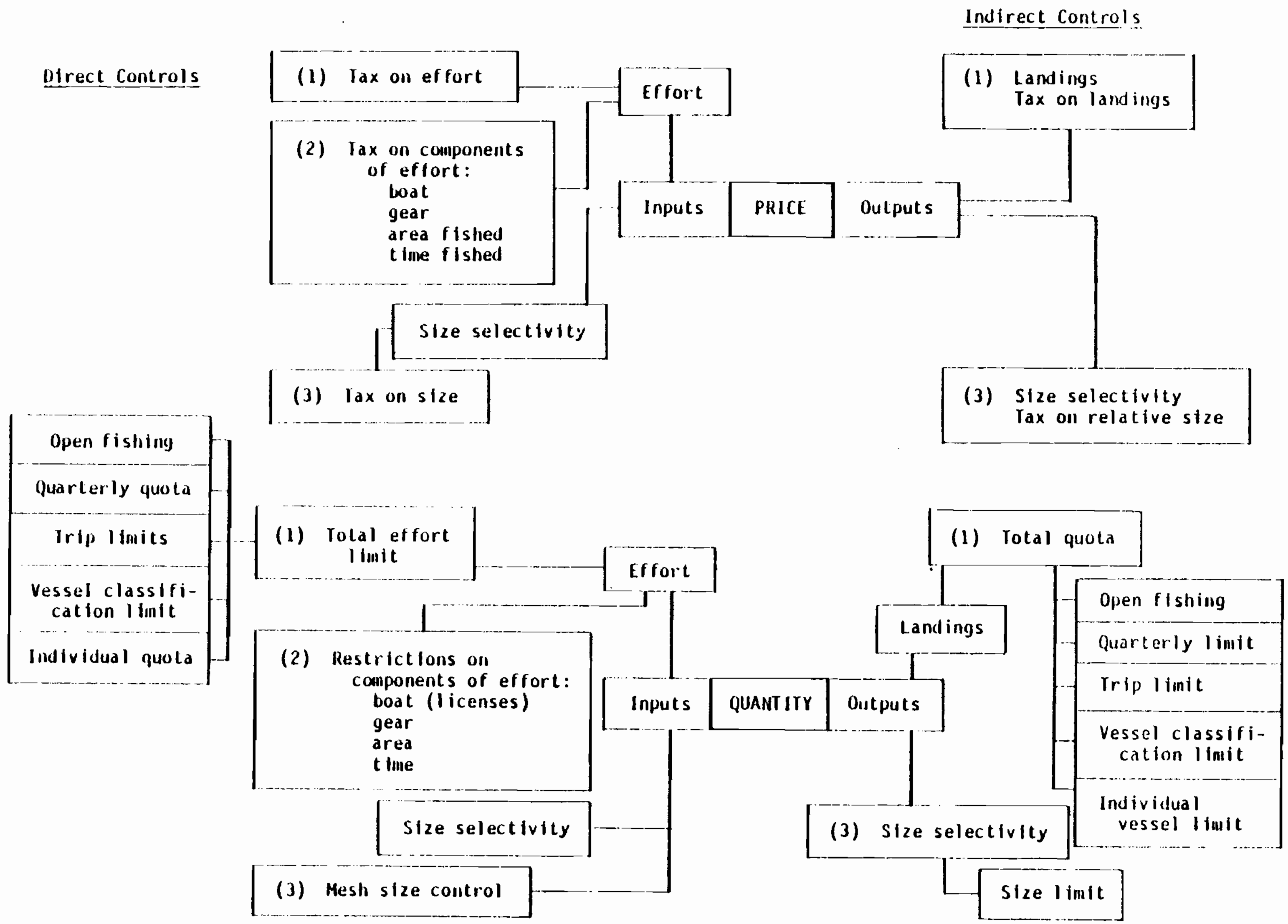
8. **Impact on distribution of benefits.** In an unregulated fishery, distribution of benefits evolves naturally, some groups benefiting more than others. Management techniques may affect this natural distribution in desirable or unwanted ways.

9. **Relation of a technique to its scientific basis.** The impact of a management technique is usually assessed by scientific means. The cost and feasibility of such assessment varies between techniques. Further, the "robustness" of the scientific basis, that is to say, its ability to yield useful results despite imperfections in the method or the data, varies also.

The fishing industry (like any industry) has an *input* side and an *output* side. In the fishery, inputs are defined in terms of effort (number of boats, area fished, time spent fishing, power of the gear). Outputs are defined by landings. The input and output sides of the fishery are represented diagrammatically in Figure 2, on the left and right respectively. The input side has a direct effect on fishing mortality, and from this, any measures that are aimed at the harvesting sector itself may be considered "direct" regulations in terms of their effect on fishing mortality. Direct regulations are classified as "active" or "passive"; the former are concerned with total catch or effort, while the latter restrict the location and time of fishing, type of gear used, and the size-selectivity of the catch. The distinction between active and passive is important because the effects of passive regulation, in the absence of direct controls on catch or effort, cannot be explicitly estimated; without catch and/or effort limits, mortality is theoretically unbounded.

Measures aimed at the output side of the industry are classified as "indirect"; such measures seek to affect the behavior of the harvesting sector (and hence fishing mor-

CLASSIFICATION OF REGULATORY MEASURES



tality itself) by manipulations in the social and economic (that is to say, shore-based) spheres.

In the upper portion of Figure 2, controls on inputs and outputs (i.e. direct and indirect controls) are in terms of price, in the lower portion in terms of quantities caught or landed.

There are two ways in which price controls may be applied to inputs (effort). First, if a useful measure of effort (e.g. ton-days) can be established, a unit tax can be levied in terms of such a measure. Alternatively, where such a measure does not exist, one or more components of effort can be taxed (taxes on gear or fishing time, for example). If different sizes of fish can be selectively caught, a tax can be devised to discourage taking of small fish. A tax on small-meshed nets would serve this purpose.

Turning to price controls on outputs, taxes on landings, which may or may not be scaled to different sizes of fish, can modify fishing activity and fishing mortality in roughly the same manner as a direct tax on effort, assuming that there are not discards at sea (i.e. that land ings are equivalent to the catch). The treatment and control of discards may be critical to the effectiveness of many of the alternative management techniques; measures that do not minimize discards will probably prove relatively ineffective, but the problem of discards will not easily be overcome because of their low value at the dock.

Direct controls on quantities caught are an alternative to taxes in attacking the problem of effort limitation. Total effort may be limited if a suitable measure of effort can be defined. Lacking such a measure, components of effort can be controlled in ways analogous to the application of price controls described above. Size-selectivity can be influenced by mesh-size regulations (though there are technical and biological constraints).

Indirect quantitative controls on effort (that is, controls applied on the output side) consist of some form of landing quota. Such quotas can have a size-selective structure.

Some general observations can be made on the classification shown in Figure 2.

1. Output controls (price and quantity) control the amount and size of fish actually landed; input controls affect the amount and size of the catch via the amount and type of fishing activity.

2. Controls designated as item "1" in the diagram are theoretically interchangeable, if landings are completely determined by effort. In such cases, if a tax could be devised to achieve a certain level of effort, an analogous tax on landings could produce the same result, or a catch restriction could be substituted for an effort restriction. In practice, unfortunately, it is difficult to relate raw effort to catch, with the result that the different approaches vary widely in effectiveness.

3. Restrictions on components of effort (item "2" on the input side of the diagram) are not reflected on the output side; there is no way to control landings produced by particular components of effort. Limits on total effort (item "1") on the input side are absolute, but limitations based on components of effort become so only if all components are included in the regulatory scheme. If only a few components are controlled, fishermen may increase the other components of effort to compensate, if it is profitable to do so.

4. Restrictions on size-selectivity may be used independently of restrictions on effort or landings but this will not control total effort in a precise manner. However, if size-selective controls are effective, mortality of smaller fish which results from a given level of effort will be limited. Both size and mortality must be controlled to achieve maximum yield per recruit.

5. All of the management techniques shown in the diagram are associated with implicit income distribution patterns. In the absence of controls, the patterns evolve from the nature of the fish stock and the characteristics of the fleet exploiting it. This will again become the case if controls are simply in the form of total effort restrictions, or total landings quotas. The "natural" distribution of benefits, however, may be altered by resort to the techniques listed at the extreme right and left of the diagram. By using quarterly quotas, trip limits, vessel classification limits, or individual vessel quotas or effort allotments, certain groups within the fleet may be assured of a share in the catch that they might not otherwise get, or the catch may be distributed more evenly over the year. To achieve the overall objectives of management, the various techniques for redistributing benefits must be used in a context of total effort or total quota limitations.

6. Fishery management techniques may be judged by their ability to achieve desired levels of fishing mortality or size-selectivity, and by the relative harvesting efficiency that results from their applications. General conclusions about the various approaches listed in the diagram are difficult to draw. Quotas are designed to produce a given catch level; whether they also produce target levels of fishing mortality depends on changes in size of the fish population. Effort limits, on the other hand, depend on determining accurately the relationship between effort and fishing mortality and on reducing effort effectively when necessary. For financial controls to be effective, one must know the relationship between amount of tax and the resulting restriction on effort or landings. This may be difficult to predict in a multi-species fishery where various species compete in the marketplace.

7. More definite conclusions may be stated about the influence of management techniques upon the cost of harvest. Four such techniques lead to minimal cost. These are: taxes on landings, taxes on effort, a total quota with individual vessel allotments, and a total effort limit with individual effort allotments. Other

techniques either directly or indirectly cause harvesting costs to be greater than necessary.

Timing, Monitoring, and Enforcement

Timing: Under the requirements of the Fishery Conservation and Management Act, and associated statutes, it takes a minimum of 250 days to process a fishery management plan, or a major amendment to such a plan, following its submission by a Fishery Management Council. The plans must be reviewed each year, and usually, to date, the plans cover one year. Amendments are required to extend the plans into subsequent years, and generally, since these amendments involve quotas and optimum yields, they are considered major amendments. The result is that Councils must prepare such amendments before the effects of the plan currently in force can be known.

Multi-year plans and "framework" plans are alternatives to the one year plan. Multi-year plans establish management regimes, including target quotas, that remain in effect for periods of time that may or may not be specified. Framework plans establish criteria for various changes, including quotas, by regulation rather than amendment. Framework plans take only 95 days, not 250, for amendment, but they have a disadvantage from the Council's point of view: under these plans, Councils may recommend changes, but may not make them directly. Thus they delegate some of their authority to the National Marine Fisheries Service.

Because of this, the Councils must be careful, in setting up framework plans, to limit the role of the National Marine Fisheries Service; the NMFS should be allowed to react to various anticipated conditions in the fishery, but it should not be allowed to initiate actions without the full public participation which is intrinsic to the function of the Councils. Such participation is essential in securing the cooperation of the fishing industry.

Present experience with the Fishery Conservation and Management Act indicates that flexibility in the development, amendment, and implementation of management plans must be increased if these plans are to be responsive to the dynamic nature of the fisheries. Plans must be responsive to changing stocks and fishery conditions and to unforeseen consequences of the management plans themselves. Excessive flexibility, however, constant tinkering with a given management regime, is to be guarded against; a regime should be applied long enough for its effects to be evaluated. Experience with existing plans suggests that the limits within which flexible response may be allowed should be more rigorously defined than they have been to date.

Phasing of fishery management plans to conform with traditional or evolving seasonal patterns in the fishery may be beneficial, though a difficulty may arise in reallocating resources in cases where both foreign and domestic fleets are involved and their respective seasons differ.

Monitoring: Assessing the effectiveness of a management plan depends on a regular flow of accurate biological, economic, and social data and an orderly system for interpreting those data. Much of the information which is of direct use to the Councils has been systematically accumulated over many years, but as their work proceeds, additional requirements have become plain. The list of these requirements is quite long, and need not be reviewed here.[1]

Two points should be brought out, however. The first is that the Councils are bound by certain time constraints, such as legislated hearing and review schedules, and the organization of management plans in terms of fishing years, which may not fit conveniently the existing schedules of data gathering and analysis of such agencies as the National Marine Fisheries Service. In order for the Councils to have information when they need it, it is necessary for them to project their requirements well in advance, to permit the suppliers of data to schedule their work accordingly.

The second point concerns required reporting by fishermen and processors. Councils should keep changes in these reporting procedures to a minimum, recognizing that the quality of data supplied will probably decrease as the complexity and scope of reporting requirements increases. The quality of reports from these sectors almost certainly will reflect their satisfaction with the management process.

Enforcement: Fishery management plans have been developed, approved, and implemented more rapidly than the enforcement programs necessary to support them, and frequently with little regard for the resources available for enforcement or the cost-benefit aspects of enforcement. Enforcement agencies have not always allocated their resources to fit the requirements of the management plans. In choosing methods of control, those that are more or less self-enforcing should be given the closest attention.

It is essential that fishermen and processors perceive enforcement to be regularly carried out, violations resulting in certain penalties. A fixed schedule of penalties (similar to those applied in motor vehicle cases) which increase with repeated offenses may serve as a deterrent, since consequences of conviction will be known beforehand. Such a plan, moreover, may expedite the legal process. This approach has been recommended by the Mid-Atlantic Council for the surf clam and ocean quahog fisheries; if successful, it may serve as a model for other fisheries.

[1] A comprehensive inventory of available and recommended data will be found in an Appendix to the present document: *Economic and Biological Data Needs for Fisheries Management with Particular Reference to the New England and Mid-Atlantic Areas.*

BENEFITS

Fisheries management is intended to improve social (including economic) benefits to those involved directly and indirectly in the fishing industry, and to those who consume its product. These benefits are measured by various indices of change. Because there is a cost associated with management, and because management programs which result in improved benefits for one sector may do so to some extent at the expense of another sector, it is *net* benefit which must be weighed before undertaking a management scheme. Due to uncertainties inherent in the process, opportunities for feedback which may lead to revisions or even abandonment of a management approach, must be built into the program.

Management may affect social well-being in ways that are not contemplated in the objectives set forth. Positive effects are of course welcome; unforeseen negative effects become a cost of management. Obviously, every effort should be made to anticipate all consequences of a comprehensive management program, keeping surprises, whether pleasant or otherwise, to a minimum.

Both the magnitude of net benefits, and their distribution (who gets the benefits and who bears the cost) must be addressed in framing the objectives.

The nature of benefits to be expected from a particular management plan will vary with its objectives. Generally, though, they will accrue to one or more of the following groups:

1. **Commercial harvesters.** Benefits for this group usually are measured in terms of profit, but may include such social aspects as economic security and way of life.

2. **Recreational harvesters.** The benefit might be measured by the number of days fished. The value of each day can vary, but depends partly on the number and type of fish caught, which can be influenced by management.

3. **Processors.** Benefits are measured in terms of profits and employment. Economic security and way of life may also be factors.

4. **Consumers.** Benefits take the form of increased supplies, lower prices, and better quality of the product. Increases in harvesting efficiency may make a surplus of economic inputs available for production of new fishery products or for other economic sectors.

Some of the indices for measuring benefits are discussed in Appendices to this document. Social benefits include many hard-to-quantify elements, such as way of life, community structure, or work satisfaction of processors and harvesters. Some related index is usually employed. The point to be made here is that indices must be developed and data gathered so that management's effectiveness can be objectively judged. It should be recognized, however, that many types of benefits cannot presently be measured very well (an approach based on uncertainty theory may prove useful here) so that changes in management based on measured benefits should be made cautiously.

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