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Conservation

Conservation means the intelligent use of resources. In that sense, this study deals with a conservation problem: how, when, and where to harvest the biological resources of the sea. There are many misconceptions about conservation. Amateurs tend to be particularly opinionated on this subject and often succeed in influencing governmental action, sometimes to bad effect. In this chapter I try to show that conservation of fishery resources is a complex, highly technical subject, better left to experts. Fishery research to provide knowledge which is to be the basis of legislation is most appropriately conducted by government conservation agencies. In recent years, such research has been expanding in scope and spreading throughout the world. Government fishery research necessarily concentrates on the relation between intensity of fishing and abundance of fishery stocks. However, fluctuating environment also affects abundance, but in ways which are yet far from understood. There is a need to expand fundamental research about environments from a biological point of view. Much of this should be undertaken by the research laboratories of universities and of private institutions. Meanwhile, study of the philosophy of fishery conservation, of the conservation of fisheries in relation to that of other resources and to human affairs in general, has been much neglected. This chapter suggests how this gap might be filled.

One of the most direct approaches to expanding the use of marine food resources is to start new fisheries on virgin stocks that have the capacity of sustaining large yields. We know of a number of these in various parts of the world. However, there are usually reasons why they are virgin: they are too remote from markets; consumers are unfamiliar with them; fishermen have no means of catching them; or fishermen are not aware of their value or of their existence. To overcome these obstacles, someone must do some commercial developmental work. That requires capital for boats, equipment, operations, and the expenses of establishing markets and market facilities. However, before many investors would be willing to risk much money in a new fishing enterprise, they would ask what they could expect to get out of it. To give them intelligent a priori advice, it would be necessary to have answers to questions such as the following: Where are the prospective fishing grounds located in relation to port, market, and distribution facilities and to refueling bases? How large are those grounds? What are their boundaries? How abundant are the fishery stocks in the area? How are the stocks distributed in terms of pounds per acre and pounds per unit of human work required in the harvesting? These are the obvious questions which are fairly readily answered from the results of explorations; they are taken up elsewhere in this study. This chapter deals with other questions which are equally important, perhaps more so, but which take much more time and research to answer, and which are usually neglected until sometime after fisheries have become well established and the supply has begun to waver.

How do the stocks shift seasonally? Are they really quite independent and virgin, or are they seasonal migrants from distant grounds which are fished elsewhere in intervening seasons? How much variation is there in availability of the stocks? Is the abundance likely to hold up under a fishery? How large an annual harvest can the stocks sustain, on the average?

The most baffling complex of problems with which all people engaged in fishery industries must contend concerns instability of the supply. This is not necessarily a new condition resulting from the intense mechanical exploitation of the modern age, but in large measure is a characteristic of many, perhaps of all, animals and plants, including those which are not exploited, as well as those which are. The histories of all the great fisheries as far back as records go are studded with sporadic famines and gluts of varying duration. Among the pelagic fisheries there are more than a few instances of stocks disappearing almost completely from fishing areas and remaining absent for many years. How much is fishing responsible for these vagaries? To what extent can fishing be controlled to prevent them? All great fisheries eventually come to a point where they must face these questions with their governments. Hence, we had better consider them in relation to any proposed expansion of the use of fishery resources. They are questions which are associated with the idea of conservation; they are leading topics in the programs of governmental conservation agencies.

Conservation is a great cause of the twentieth century. It was impelled by the tensions of crowded populations and by the experience of people who actually watched some virgin resources become despoiled for want of proper management. The popular use of the word in this sense is new, but the sentiment back of it is timeless, as evidenced by references to fishery problems scattered through ancient writings. These have a familiar ring. Dipping at random into a few likely books, I find that the Sumerians of 4,000 years ago provided for fishing rights and closed areas, and they had fishery inspectors. The Chinese of the Chou Dynasty (about 1000 B.C.) engaged fish wardens, issued licenses, and imposed closed seasons to protect spawning fish. In 1676, the Netherlanders passed a law to prevent exhaustion of their coastal waters. This regulated the size of meshes in nets and prohibited trawl-nets. The first of these provisions was adopted because small meshes destroy fry; the second because trawls kill spawn as well as the fodder on which young fish live. Even then this was not a new idea in Europe; the English had similar laws in the fourteenth century.

Thus it was not people of our time or our country who discovered husbandry of natural resources. Americans merely rediscovered it for themselves. They had lost it for a while during the settlement of the new world when nature seemed boundless. But then eventually symptoms that the land was being spoiled restored awareness of the need for providence. In a long settled country, the awareness comes naturally. People know from experience, if not instinctively, that resources have limits. It is the most obvious logic that unless enough seed is left after each harvest to provide for reproduction of a stock, the stock will dwindle away. Hence, people tend to apply this line of reasoning to aquatic animals, often preventing thereby the taking of full harvests.

The knowledge of how much is sufficient seed to maintain sea-fishery populations does not come by reasoning alone, however. It comes only by scientific study and experiment. Nevertheless, there never has been any lack of opinions on the subject. The commonest of these is that fishing must be restricted so that people "won't take too much." "We can't go on this way" is a frequent cry of fishermen while they proceed with their harvests. The most popular of all opinions about fishery conservation is that fishing must not be carried on at all during spawning seasons, or if that is not feasible, that the spawning females at least must be protected.

> . . . of the great quantities [of tunny] which enter the Mediterranean to spawn, some are caught by the fishermen after spawning, but the great majority before fulfilling that function. How then can we conclude that the cause of this diminution is not owing to the action of men?

That was written in 1888. People usually believe that immature fish must be protected so that they can have the chance to reproduce; and the largest, most aged specimens must be protected too, because they produce great quantities of spawn. Spare the mothers, the young, and the aged.

Other ideas are of fairly recent origin, for example that nets are harmful compared with hook and line, that purse seines are worse than other kinds of nets, that commercial fishing is more destructive than angling, that fish should be used only for human food, and that manufacture into fish flour should be discouraged because it uses dangerously large quantities of raw material. Most of such ideas have emerged full blown because they seem reasonable. It stands to reason that catching too many fish reduces the numbers of spawners, and that the amount of spawn is proportional to the size of broods. If fish have grown scarce, that *must* be because the number of spawners has been depleted; ergo, the process can be reversed by building up the spawning stock. This doctrine of the inviolability of spawn has always been the principal ingredient of popular opinions about the use of fishery resources, and is the basis of much fishery conservation legislation. It is a perfectly reasonable idea. For sea fisheries, however, it has one serious flaw: it is not often clearly borne out by experience, for the volume of spawn is only one of many factors influencing the abundance of a generation, and is rarely the dominating one.

Yet in most maritime countries, the books are studded with fishery conservation laws—closed periods, closed areas, bag limits, size limits, prohibition against certain kinds of gear, against commercial fishing, and all sorts of other restrictive devices largely intended to protect or build up the spawning stocks. Many of these laws are derived from preconceptions rather than from knowledge; they may have little bearing on scientific husbandry and can do more to obstruct than to further true conservation.

I propose now to discuss briefly some principles to show that scientific fishery conservation must be backed by a considerable body of very special information, and that is not a job for amateurs. Instead, in this field, an amateur can innocently, and with a sense of great righteousness, do harm about as easily as good.

Disregarding economic considerations, the harvest of fishery stocks should be permitted up to their "maximum sustained productivity." This is the ideal of scientific conservation: full utilization for the benefit of mankind, not restriction for the benefit of fish. The judgments which must be made to achieve this ideal must be based not on intuition, but rather on knowledge of the biology of the fishery populations.

Fishery biology, which is concerned with the development of this knowledge, is a relatively new field of science, hardly more than seventy years old, still in the process of evolution. It is carried on as a governmental function by nations having important fishery industries, and is gradually building toward a sound basis for scientific direction of fisheries. Fishery biologists have devoted a great deal of study to the effects of exploitation on abundance of fishery stocks and to the causes of variations in the size of year broods. Over the last seventy years, a mass of vital statistics has accumulated on a few heavily fished species in various parts of the world. From these statistics and from experience in regulating fisheries the following pattern is emerging.

Under primeval conditions, with no fishing by man, a stock of fish produces an enormously excessive quantity of eggs. A high proportion of the hatch dies from natural causes such as predation, disease, climatic and hydrographic disasters, and starvation. When man joins the constellation of influences by starting a fishery, he enters into competition with the other—the "natural"—causes of mortality, and the course of his fishery is determined in large measure by the success of this competition.

A young, growing fishery gradually, or often rather quickly, reduces the accumulated stock, and therefore the number of spawners and the production of eggs. But this does not necessarily result in any diminution of the number of young surviving to fishable size. It may even have a beneficial effect analogous to that which results from thinning, relieving the severity of competition both among the young and between the young and the adults. Thus a higher proportion of fish survives the infant stages under a moderate fishery than under primeval conditions. The word moderate, however, requires definition. It means not extreme—not too little and not too much. At one extreme, is the primeval stock, living under a regime of no fishing and composed of a large accumulation of old fish, which by taking up space and food and by cannibalism make conditions unhealthy for their own young, so that the surviving broods are relatively small. At the opposite extreme is a stock reduced to the vanishing point, with few spawners left, producing few eggs and, therefore, small broods. Between these two extremes of population abundance is a point of maximum efficiency of spawning, wherein the number of infants surviving to young fishhood is limited least by competition among their own kind and not at all by the quantity of spawn produced. In this range of abundance, year broods tend to be larger than at the extremes. However, judging from empirical data published in literature, these relations are far from regular, for varying environmental conditions also exert great influence on the survival of young fish. Consequently there are enough records of large broods issuing from the extremes of population abundance and of small ones issuing from the means to discourage generalizations on the matter.

In reducing the accumulation of big old fish, the new intense fishery shifts the mass of the stock toward the young fast growers. In the early days of the American haddock fishery, for example, specimens ten years old were common; whereas, within fifteen years, few were surviving beyond the age of six. Although this effect often arouses people to fear that a stock is on its way to extinction, such fears are groundless. As a matter of fact, from the viewpoint of resource use, big old fish are uneconomical, because they use their environment uneconomically. A few very crude estimates will illustrate the point.

A group of 100 sea bass which are each 20 years old weighs about 3,600 pounds. During the course of a year, 10 of them, say, die from natural causes, and 25, weighing altogether about 910 pounds, are caught by fishermen. At the end of the year, the 65 survivors, having grown in weight by about a pound each, weigh near to 2,400 pounds. Thus, through natural and fishing mortality, this group of bass has decreased in volume and value by a third. It has consumed 30,000–40,000 pounds of food during the year, of which only about 1 per cent has been used for building flesh, the rest having gone into body maintenance.

The same amount of food could support instead 1,700 sea bass, initially weighing 1,700 pounds, in their fourth year of life. During the year, around 170 (10 per cent), say, would die from natural causes. To get the same weight of harvest as the 20-year-old stock yielded in our model (i.e., 910 pounds) would require catching 520 fish. At the end of the year, the 1,010 survivors would weigh about 2,525 pounds. In spite of the depletion in numbers, therefore, the stock has increased in volume and value by 48.5 per cent. Of the food which this group of bass consumed, about 25 per cent went into building flesh, about 75 per cent into body maintenance.[1] Thus in our model, the fast growing younger fish (which predominate in a harvested stock) are shown to use their food more efficiently than the slow growing older fish such as are common in a primeval stock. That is to say, they have used a higher proportion of it for building flesh (25 per cent compared with 1 per cent) and a lower proportion for maintaining existence. The stock has yielded (in this hypothetical example) the same crop, 910 pounds, and it has improved in value by 48.5 per cent, whereas the older stock has depreciated in value by 33.3 per cent.

True, the older fish are more fecund than the younger, the 20-year-old stock of our model producing 225 million eggs, the fourth year stock only 55 million eggs.[2] Yet, judging from actual experience with fisheries on which records have been accurately kept, the population of younger fish in our model will be able to sustain itself unless the fishing rate exceeds the replacement rate.

This model gives a very rough idea of the kind of considerations that must go into managing a fishery resource.

Fish that have passed their period of youthful growth continue to grow, but too slowly to keep pace with an intense fishery. Consequently, the accumulation of big old fish that a new fishery finds is inevitably cropped off and cannot be replaced unless the rate of fishing is adjusted for that purpose. At first the annual catch increases, as more and more men enter the fishery, until it reaches a peak. Then the catch and the catch per fisherman decline sharply, as the old fish are removed, until the stock reaches a level where replacement by growth and new broods normally balance the annual cropping by the fishery and by natural causes of mortality.

In the last twenty years or so, biologists have given a great deal of attention to the dynamics of fishery populations, that is, to the inter-responses of rates of birth, growth, and death. This is at the heart of governmental biological research about marine fishery resources. The fundamental concept behind the mathematical models which are commonly used in these studies is that the rate of decrease in numbers with time is equal to a constant factor (the total mortality rate) times the numbers present at that time. We start with some large population. Under the pressure of fishing and natural causes of mortality the population decreases rapidly at first because the numbers present are large; as time goes on, the rate of decrease diminishes as the numbers left in the population diminish.

This is the familiar idea of compound interest—but in reverse. We learn from the compound interest formula that if we start with some small sum and keep compounding at very short intervals of time, the amount increases more and more rapidly. At the end of a number of years, say ten, we may have a sum many times larger than we started with. If we think of this final sum after ten years as our initial population and then work the compound interest formula backwards, the situation is analogous to the decline of a population. It proceeds rapidly at first, becoming slower and slower as the population gets smaller.

Mathematically, biologists express these relationships in the form of a differential equation:

$$dN/dt = -kN \qquad (1)$$

which simply states that the rate of change of the population (dN/dt) with time (t) is equal to a constant factor (k) times the population (N) present at that time.

In a fish population, one usually considers N as the number of fish of some stated age present at a given time, say 10,000 one-year old fish at the beginning of 1952. This number will decrease year by year until the last fish is captured or dies. In our Equation (1), therefore, k will be negative because our original population is always decreasing.

If there is no emigration, the only ways in which fish may be removed from the population are by fishing and by natural death. Our k, therefore, consists of two independent processes, fishing and natural mortality. Let us call the coefficients of these F and M respectively. Substituting F and M for k, we may write Equation (1) as follows:

$$dN/dt = -(F + M)N \qquad (2)$$

Integration of Equation (2) gives a conveniently usable form of the relationship:

$$N_t = N_o e^{-(F+M)t} \qquad (3)$$

where N_t is the number present at any time, t, and N_o is the number present at the beginning, which we take as $t = 0$.

Further development of Equation (3) is essential to a realistic treatment of population dynamics. A few rather simple mathematical manipulations convert Equation (3) to an equation expressing the yield in numbers at stated rates of fishing and natural mortality. Knowing the rate of growth and the relation between length, weight, and age of the fish, the fundamental equation can be written so as to give the yield in weight. In more complex models, one may introduce adjustments to allow for variations in growth which depend on density, and to allow for variations in natural mortality rate, thus simulating the actual conditions the biologist finds in investigating a population.

In this manner, given precise enough knowledge of rates of births, deaths, and growth under various fishing rates, it is theoretically possible to adjust fishing so as to get the most profitable average annual yield that a resource can afford. What the phrase "most profitable" means is a matter for people who set economic and sociological policies to define. It might mean most pounds of fish, lowest cost of fishing, highest prices of fish, most fish of certain specified sizes. It might mean highest catch per fisherman or highest income per fisherman. But whatever human interests prevail in defining the desirable, it is theoretically possible, given enough of the right kind of information, to achieve it, within the limits of the properties of the resource.

Thus some fisheries could theoretically increase their harvests by as much as 50 per cent—the haddock fishery of Georges Bank, for example, could probably do that—by scientific adjustment of the fishing rate. This may be accomplished in a variety of ways, depending on the kind of fishery and the habits of the fish. For example, it could be accomplished by setting a minimal size at which fish may be caught, or by prohibiting fishing in nursery areas, or by setting catch quotas.

The prediction of how a fishery stock would respond to a given level of fishing intensity results from theoretical synthesis of data. However, theory is one thing, fact another. The theory must be tested by regulating the fishery experimentally and observing constantly the response of the stock. On the basis of this response, the theory can be revised if necessary and the regulation adjusted accordingly. Since regulation is ordinarily a responsibility of government, the research required as a basis for it is better conducted as a function of government than of private research institutions or universities.

The scientific staffs of government conservation agencies characteristically must concentrate their researches on a few most important species and neglect the rest. This is necessitated by the small amount of money appropriated for fishery research; that is, it is small in relation to the magnitude of the job. Disregarding such practical considerations, I shall in later chapters argue a case against this focusing of fishery research on individual species out of context of their environmental systems, against giving too much attention to the effect of fishing on the stocks, and against too complacently assuming that natural conditions which affect adult fish stocks remain constant from year to year. Pertinent though these arguments may be, certain things must be learned about each species, no matter how the fishery for that species is to be managed, whether by judgment or by science, whether the course of the management is to be static or dynamic, whether it is to be species by species, each without regard to the other, or in accord with action of ecological principles, or whether the management is to be directed by government or by the fishing industries themselves.

The first problem to solve in any fishery investigation is the identification and definition of the stocks being fished. A stock remains genetically distinct because of a variety of barriers which may be geographic or biological, or both. Thus two stocks of one species may be kept apart by a continent, by a water mass having a repelling temperature, or by a submarine canyon; or they may intermingle freely part of the year and separate during the spawning season. A stock thus isolated may have distinctive habits, fecundity, growth rate, longevity, resistance to disease, and response to fishing pressure. If so it must be dealt with separately in any conservation action.

For each stock the following need to be studied:

The geographic distribution throughout the year
The abundance
The growth rate
The migratory habits, age by age
The spawning habits, spawning season, and fecundity
The relation between fishing rates and productivity
The mechanisms by which fluctuations in the environment affect natural mortality and distribution of infants and older ages
The features of the environment which affect distribution and habits

Because every circumstance in the lives of marine organisms is affected by external conditions; because the conditions for life in every part of the sea undergo continual changes; because while some of these changes are transitory, others extend over decades or even centuries—for many such reasons, fishery studies on the topics listed above can never end. True, these studies will change their character as information and the knowledge of principles accumulate. True, too, research about a fishery species might in the course of years progress so far that rather simple routine observations carried on by technicians might be enough to provide a strong basis for rational direction of the fishery. So far, however, marine fishery scientists have not yet reached that point for any species. In fact, they have opened up more problems, and more difficult ones at that. This does not mean that fishery biologists are impractical ivory tower residents, as some of their critics often charge, but that they are in the midst of the slow process of developing their science. Because of the nature of their subject, they are forced to feel their way blindly, revising their judgments as fast as they improve their perception of the shapes of facts. Different biologists, groping independently, sometimes reach quite different conclusions concern-ing the nature of these shapes, and dispute about their differences of interpretation. This is only further evidence that the science of fisheries is one in the making.

Meanwhile fishery research is continually enlarging its scope everywhere. Countries where such work had been going on for many years have lately been providing funds to increase the number of species and the areas studied by their governmental agencies and to expand research staffs and facilities. Other countries that had previously not shown interest in the subject have been establishing marine laboratories and sending students abroad to learn techniques of fishery research. The following commissions and councils have been organized to study problems of intergovernmental interest: Indo-Pacific Fisheries Council (16 nations); Inter-American Tropical Tuna Commission (3 nations); International Commission for the Northwest Atlantic Fisheries (10 nations); International Council for the Exploration of the Sea (13 nations); International North Pacific Fisheries Commission (3 nations); International Pacific Halibut Commission (2 nations); International Pacific Salmon Fisheries Commission (2 nations); International Whaling Commission (17 nations); Atlantic States Marine Fisheries Commission (15 states); Gulf States Marine Fisheries Commission (5 states); Pacific States Marine Fisheries Commission (3 states). It can hardly be said, therefore, that fishery research has been languishing for want of public interest and financial support.

It would be presumptuous to specify any technique or particular line of research which could with certainty speed the achievement of useful results. As in any kind of research institution the production fluctuates in quality and quantity, and it varies in these respects geographically. Even so, taking all things into account, it progresses about as fast as can reasonably be expected.

I have argued that fishery research is best carried on by governments and that it must be carried on along certain lines as listed above. It must be directed toward assembling certain information about the more valuable of the commercially important species. Doing just that much takes all the funds, facilities, and staffs which governments make available, leaving almost nothing for studying species which seem to be unimportant. This includes many commercially worthless but biologically enormously effective predators and competitors, and also all the myriad organisms of the food pyramid including the plants of the phytoplankton. Nowhere are there sufficient funds and talent available to cope with the problems of analyzing the tangle of interrelations among the species of that vast complex or of determining how the physical environment affects the existence of fishery stocks. In short, adequate provision is not made for studying marine environments as such. Consequently, there are only vague concepts of the biologically significant properties and actions of environments. In spite of all the talk about marine ecology and biological oceanography the amount of work done in those fields is negligible in relation to the magnitude of the subject, and in comparison with the effort put into fishery biology and physical oceanography. At the same time fishery biologists on the one hand and physical oceanographers on the other—the two groups now dominating marine research—have not yet found (perhaps not really sought) the kind of questions that would lead toward understanding the role of environments as media for living organisms. Formulating those questions is in itself a research problem.

The study of the environments of the sea is perhaps the widest gap in marine research programs, in which teams of scientists well educated both in biology and in physical oceanography and therefore able to straddle both fields should be engaged. Because such research appears to be remote from practical application, it is hard to justify for the scientific programs of government fishery conservation agencies. On the other hand, it fits without question into the functions of universities and oceanographic laboratories. In general, with a very few notable exceptions, however, such institutions have not concentrated much attention on the subject. How this condition might be corrected will be discussed in following chapters.

Perhaps in the long run greater increase in the harvest of the sea will come from scientific conservation (i.e., control of fishing to produce maximum sustained yields) than from development of new fisheries. However, scientific conservation requires not only information about the animals and plants of the sea. It also requires a willingness on the part of the general public, and especially of interested groups such as fishermen and men in political office, to accept and use this information intelligently as it is acquired. Very little provision is made to encourage this attitude through education. Here I mean education, not propaganda; classroom teaching, book learning, not sporadic television programs interspersing commercial advertising.

The principle that conservation-is-desirable hardly needs to be fostered any more than that honesty-is-the-best-policy. It is already pretty well accepted. The issues of conservation, however, are something else again. People in general, and that sometimes includes government officials, have very fuzzy notions as to just what conservation means. They are hardly aware of the fact that every conservation action requires choosing among several conflicting but often equally appealing human needs. The choice is often made in response to specious sentiment or to the pressure of interested groups rather than according to the judicious consideration of principles and all the needs of the public as a whole.

As is generally true of government centers, the office of a fishery conservation agency is hardly a place for quiet contemplation. Letters come in daily by the hundreds asking for information, demanding courses of action, seeking or giving advice, complaining about conditions here and there. They must all be answered politely and fully—"My dear Mr. Blank: In reply to your interesting letter . . ." Even more insistent is the telephone, and visitors, who come singly and in delegations to pay duty calls, to chat—"Have you a minute?"—or to influence decisions with plausible arguments. Meetings, designated with various degrees of dignity as conferences, hearings, conventions, or convocations, are almost daily occurrences. The demand for appearances, speeches, reports, articles, or formal opinions which comes in a never abating flood must be met affirmatively. All effort to be thoughtful and judicious is confounded by crosscurrents of dogmatically and often authoritatively represented opposing interests advocating or condemning, pushing or pulling, praising or disapproving, accusing or defending.

Of course this is the life of any man in public office. Public officials working in the commoner fields of government like law, economics and political science are probably much more subject to conflicting pressures. But in the background of their learning is a great philosophical literature. This is full of controversy, to be sure, as would be true of any literature on human affairs. What is important about it is that it has grown and matured in the objective atmosphere of scholarly centers. All universities have faculties who devote themselves to teaching and thinking and writing in these fields. They have nothing comparable for conservation in spite of the fact that this is likely to become one of the most pressing subjects of concern in human affairs.

Most of the literature bearing on fishery conservation reports the results of biological research required as a basis for regulation of fisheries or for predicting catches under given circumstances. It covers such topics as life history, migratory habits, rates of birth, growth and death, relative abundance, optimum catch, and recommendations for regulations of fisheries. In the main, this scientific literature has considerable vitality, contributing vigorously to the growth of knowledge. This cannot be said of the literature about conservation as a subject in itself or about conservation of fishery resources as it relates to the conservation of other resources, and as it fits into the whole complex of human problems. Such literature as there is on this subject is appallingly thin and perfunctory stuff. Most of it advances no new thought at all; it merely repeats what has been said before, using uncritically the same examples to support the same arguments over and over.

This state of affairs results largely from the fact that the bulk of the literature is produced by government administrators to order, on short notice—"I need a speech for Friday." How can anything objective and philosophical be thought through under such pressure? In some colleges where fishery science is taught, the professors are in no better position than government men, because they are themselves deeply engaged in governmental work through contracts. In fact they are worse off because they are continually driven by the need of acquiring more contracts to replace those that are nearing conclusion. So they have no more time to think about the larger questions of conservation than do their colleagues in government. Some of the general literature which attempts to deal with the large questions is produced by college professors who are familiar with soil technology or geology or forestry, but who are not authoritative on fishery resources. They make up for this lack by reading and paraphrasing government pamphlets or by inviting government specialists to write the chapter on fishes for their texts. The results usually have the dreary quality of potboilers.

There are a few first-class colleges where conservation study centers have been started in recent years. An authority on fishery problems should be added to the staff of at least one of these centers. He should be a man of broad education who has had successful experience in dealing with conservation problems and who has demonstrated ability to think critically and creatively about the subject. He would direct the education of people planning careers in various aspects of fishery conservation, including biological research and the administration of fishery agencies. What he would do besides would depend, of course, on his interests and background. He might devote himself wholly to collating information on changes in fishery resources in various parts of the world. He might study such problems as these: What national policies on the use of fishery resources should be fostered? How much should a government spend on fishery research? What directions should government-sponsored research take? How should government conservation agencies be organized to carry out their functions most effectively? What are the choices in conservation actions? What should be the basis of those choices?