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The Problem

Some time ago, The Conservation Foundation, an organization devoted to the proper use of natural resources for the welfare of mankind, asked me to explore the following question:

What scientific researches, apart from those which are in progress, would contribute significantly toward learning how to enlarge the yield of food from the sea in answer to human needs?

Back of this question are these assumptions: (1) We have not yet learned how to exploit the food resources of the sea fully; (2) scientific research will show the way; (3) there are gaps in present research programs which need filling. What are those gaps? This chapter begins by discussing the world food problem. Populations in various parts of the world are suffering from ills caused by protein deficiency. Much more protein food of animal origin is needed than is now being produced, and still more will be needed in the future. The sea evidently does have untapped food resources, but we do not know how extensive they are, nor how to exploit some of them; nor have we explored fully all of their possible uses. This ignorance limits exploitation of the sea's food resources but so also do factors in the fields of economics and sociology.

A great deal of research about the sea and its resources is going on in many parts of the world. Most of this is conducted by governments, and for the most part it is concerned with established fisheries and is aimed directly at practical application. Applied sea fishery research is given considerable attention. It is in the realm of pure or fundamental research that the most important gaps occur and where augmented support is most needed. This book will explore those gaps.

People living today know more about the conditions of their fellow men than was possible in any previous generation. Those who cannot read may study the photographs in the picture magazines and newspapers that now find their way into the remotest places, or they may hear about life in other countries as broadcast by radio, or even behold it on the cinema or television screen, for these things have spread everywhere. The most important agent for bringing men together has been the airplane. Twenty years ago a trip abroad would have been a great undertaking, even an impossibility, for many of us who now can almost casually visit the middle of Africa or India and be back home in a week. We put down on an airstrip near a village that a short while ago may hardly have known that such people as we or such a life as ours existed. Now they know. And we in turn know about them. We know of the wretched lives that other men must endure, and they must suspect from the glimpses they have had that such a life may not be necessary. This was probably the most significant consequence of the last war, when soldiers of many countries traveled all about the world—plain, simple men who might have thought themselves poor in their private lives, but who found themselves supremely wealthy with their lavish supplies of chocolate sweets and tins of beef. How can the well-fed ever be complacent again? How can the starved ones possibly accept their lot?

Among the questions that emerged from the war, one aroused the most widespread interest and seemed the most baffling. Is it necessary that the majority of people in the world—the *majority*—should never have enough to eat?

This problem has troubled political scientists and economists for a long time but never before has it been the subject of such a "movement" as is now underway. Since World War II the Food and Agriculture Organization of the United Nations has been born and has spread its work widely. An impressive body of literature has appeared to document the present situation, which can be described simply thus: Human populations are growing tremendously; in some regions they have far outstripped their food supply. Starvation—food deficiency of one kind or another—is widespread throughout the world. No country is quite free of it, not even the United States, and in some countries it is a chronic public ill. It is a problem that cannot be solved simply by shipping excess supplies from the richer to the poorer regions. There is not enough excess for that, and if there were there would not be the means to pay for it. In what ways, then, can needy peoples magnify their food supplies by their own efforts?

This is one of the most perplexing problems of our time. It occupies the attention of authorities in many different fields, and they reach conclusions which are often conflicting. Their disagreement is a measure of the difficulty of the problem and a sign that they have not yet found a solution. Indeed, perhaps none can be found. Some authorities conclude, after weighing all possible means of increasing food production, that the situation is hopeless. Only wholesale birth control can solve the problem, and the barriers to that seem insuperable. Other authorities feel more optimistic. Technological improvement in the use of our planet, they say, can add enormously to food production. This, coupled with the fact that birth rate levels off as standards of living improve, should eventually bring food supply and populations into a more satisfactory balance than they are at present.

This opinion is bolstered by the fact that agriculturists are improving the use of the land, and they are working constantly by many different lines of research to improve it still further. For example, by selective breeding they develop strains of plants and animals that have desirable qualities such as disease resistance and fast growth; by the scientific blending of feeds they reduce the cost of raising cattle and poultry; by the proper use of fertilizers they increase the productivity of soils. They have made spectacular progress in developing poisons for destroying insect pests.

Yet even with the benefits of agricultural science, production is still not enough to satisfy world needs. Some other source of very large quantities of food, especially of animal protein food, must be found. Where? Many food economists have pointed to the sea as the most likely place. This idea seems logical. The sea occupies 71 per cent of the earth's surface. Not only is it broad (139 million square miles) but it is deep (about 2⅓ miles on the average). Anyone who has looked through a well-illustrated natural history book knows that the sea is filled with wondrously rich fauna and flora composed of galaxies of strange forms. Drifting at the surface or in layers at intermediate depths are vast meadows of minute plants and swarms of small and large animals grazing upon them and preying upon each other. On the bottom are fields of all kinds of sedentary creatures feeding on the rain of disintegrating plant and animal bodies that falls from above. Chemists have analyzed enough of these strange organisms to know that many of them have about the same food values as fishes, shrimps, oysters, and clams.

The species of animals and plants in the sea number hundreds of thousands. There are 20,000 species of fishes alone. People who earn their living from the sea fisheries know they use only a part of

what they catch or could catch. North Atlantic fishermen who seek haddock or cod throw away vast amounts of other species. Argentine fishermen are well aware of shoals of pilchard off the coast of Patagonia, but have developed no important fishery for them. Many similar examples come to mind—hake off the west coast of North America, cod in the Bering Sea, tunas and herring off West Africa, sardines in the Indian Ocean, and many kinds of invertebrates in all seas. These are all rich in nutrients. They seem to be abundant. They are not queer-looking monstrosities but commonplace kinds of animals that are easily recognized as edible. Many of them occur close to areas where people are suffering from protein starvation. Fishermen also take enough specimens of odd things to know there is much which their nets and hooks miss, which might have value if caught in sufficient quantities.

We know from experience that certain parts of the sea are extremely fertile. Some regions which are heavily fished yield large quantities of food. Such are the fishing grounds of the North Atlantic and North Pacific Oceans, where 19 million tons are produced annually, or about 78 per cent of the world's total. These are not the only rich grounds. There are other regions which might yield comparable quantities if they were fished as intensively. Some of these have hardly been touched. Thus untapped food resources do exist in the sea; there are regions and species which are not fished to capacity, and others which are not fished at all.

Since there is a human need and since there are supplies, why not use them? There may not be enough to satisfy all the protein requirements, but what there is ought to go a long way. Why not open up this untapped world of the sea and use those of its resources which we now neglect? What stops us?

A complex of obstacles stops us. It appears that the ocean is being exploited about as much as economic and social conditions and technological knowledge will permit. As many men engage in marine industries as are willing to. Fishermen use methods they know will work and catch as many pounds as they can sell at prices which will induce them to persist in so dangerous and uncomfortable an occupation as fishing. They take all the kinds of marine animals and plants that their markets will accept. They preserve their catches as well as they know how, but only as much as will keep for foreseeable uses. They ship as much into the interior regions of their countries as transportation facilities and economic conditions permit. As many people as have money to buy fishery products do so as often as they want them in preference to something else. As many men now invest as much capital in marine industries as

they will risk against the uncertain supply of raw materials and the heavy operating costs involved in working with marine environments.

These general principles apply everywhere but in differing ways. Moreover, we must reckon with many sorts of geographic variations. The fertility of the sea varies over a wide range. The distances between rich areas and good port facilities and good markets vary. The length of the period during which weather is favorable enough for work at sea varies. The capacity of the fishery resources to withstand intense exploitation varies. The conditions of men who have access to the sea—their culture, economy, politics, physical well-being, education, enterprise, wealth—vary. The tastes of people vary from one place to another, as well as willingness to try unfamiliar foods.

Thus, to meet human food needs by increasing exploitation of the sea requires attacking all sorts of problems in a number of different fields—in economics, sociology, anthropology, education, as well as biology, oceanography, and technology.

If the human problems can be solved—and they are being attacked by such organizations as F.A.O.—a large amount of sea food will be needed. Merely to keep the present per capita consumption in step with the growing population will necessitate increasing production of sea food over the next fifty years by about 8.5 million tons. To include the entire population of the world (i.e., the proportion which is now starving), the increase during that period would have to be something of the order of 50 million tons.

Such an amount cannot come simply by expanding present fisheries. Species of vertebrates and invertebrates which are now neglected would have to be utilized, new fishing grounds exploited, new methods of fishing invented, and perhaps a new philosophy of exploiting the sea would have to be developed. At this point we do not know how to accomplish all of these things. We do not know all the species of sea animals or all their possible uses. We do not know all the fishing grounds or how to reach or catch certain species which we believe to be abundant. We have measures of abundance for only a few of the more intensively exploited species and for none of the unexploited ones. Thus a wall of ignorance about the sea fishery resources would impede our exploiting them, quite apart from the human problems.

In judging possible yields to be derived from the sea, people often assert that fishery is analogous to agriculture. There is an important difference, however. An agriculturist manipulates the environment. He fertilizes, tills, weeds, eliminates animal pests, and

fights diseases. He selects particular species for cultivation and within those species particular strains which have desirable qualities. A farmer can do all that; a fisherman cannot. A fisherman generally uses the marine environments only as hunting grounds, accepting conditions as he finds them. Sea farming is practiced in a few places, but for the most part it is primitive compared with land farming. There is no marine environment of which we have much more than rudimentary knowledge about the properties which are essential to sea life. We know nothing about the genetics of any marine species and therefore cannot engage in selective breeding. We know next to nothing about the diseases of marine organisms. Save in a few special cases, we do not know how to rear marine animals on a commercial scale. No one has yet learned fundamental causes of fluctuations in abundance and occurrence of marine organisms. A few transitory correlations have been found, but no causes. There is the problem. We are too ignorant of the sea and its resources to know how to intervene to the degree possible in farming. We cannot do what agriculturists do; we cannot manipulate the environment. Nor will we until we have acquired a great deal more knowledge than we now have.

This is not to say that the sea and its food resources are neglected subjects of study. Actually, more effort is going into fishery and oceanographic research than ever before. Many governmental and international agencies are working diligently all over the world to stimulate new industries, particularly fisheries, and to determine the most profitable rates of exploitation. They carry on all sorts of activities—biological, oceanographic, and technological studies, governmental regulation for conservation, exploratory fishing, technical assistance to necessitous countries, advertising and educational campaigns, and so forth. In reading the journals about fisheries no one can fail to be greatly impressed by the multiplicity of activities directed toward improvement of fishing industries and toward the full, rational use of the sea's food resources.

In general, these programs are directed toward practical goals. Altogether, people engaged in them are coping with a tremendous job. The phrase "vast ocean" gives no inkling of how vast it really is. Exploration of only a small area of the sea requires more money for operating ships than is ever available for the purpose. The task of inducing an underdeveloped country to fish and eat fish takes more trained personnel than existing organizations can ever spare. The problems of increasing the use of ocean resources far exceed the means of attacking them. Fishery research-and-development programs are concentrated in only a few areas, so that very great

stretches of fertile sea remain almost completely unexplored, and many underdeveloped places are without fishery aid programs. Present effort might be added to or multiplied and still leave large geographic gaps. One simple way to attack our problem would be to fill in some of those gaps by starting new programs in regions that are now neglected, and by contributing to existing programs that are now inadequately supported. However, that would be to ignore gaps of another sort.

Most of the questions which existing programs pursue are tied closely to the known, and researchers are obligated to practical application. For example: How are known kinds of fishes distributed in unexplored regions? How can fishing by known methods be expanded? How can known techniques of fishing and technologies of handling fishery products be improved? How can they be adapted to local conditions? How can rates of fishing the known exploited resources be controlled to produce optimal yields? How do the abundance and availability of fishery organisms relate to known properties of the environment? How can people use or manipulate the *known* to their advantage?

By far the largest part of present marine biological research is concerned with questions of this sort and is conducted almost wholly under governmental direction. These are not the only questions that government fishery agencies study—governmental research deals with a great diversity of problems—but they are dominating questions. In general, the research conducted to answer them is limited in the extent to which it deepens or broadens our understanding of the marine environment, and it does not arouse the interest of scientists whose preference it is to carry on fundamental research.

Most of the financial and moral support goes for these purposes, to achieve ends which can be easily foreseen. On the other hand, negligible support goes for probing the unknown, for simply enlarging knowledge of the marine environments and the life which they contain, and for doing this without the obligation of showing an eventual application. It is in this kind of undirected research that principles of wide application are most likely to be discovered and from which the now undreamed-of treasures of knowledge are most likely to emerge. There is an evident gap which marine research institutions are neglecting. Scientists often call this kind of research "fundamental" or "basic," in contrast to "applied."

Fundamental research is the wellspring of a science. Nevertheless, it is difficult to define because it does not have clear-cut boundaries. And however it may be defined, it is often difficult to defend.

It is not, as some people imagine, aimless pottering. I doubt that a good scientist indulges in such a whimsy except for relaxation. Fundamental research is generally aimed toward the discovery of natural laws, that is, principles which underlie great processes. It is closely akin to a fine art. It grows at its own pace, depends heavily on logic, respects intuition, is rarely fruitful when pushed or nagged. It is the kind of work that a man is driven to do by inner necessity because he is passionately interested in the doing of it, without thought of an ultimate application.

The most highly developed sciences, chemistry and physics, are founded on systems of principles. These were discovered through fundamental research that was impelled only by a desire to understand mysteries of nature and carried on with no predetermination to produce a mechanical age. Yet not one of the marvels of today—automobile, diesel engine, airplane, radio, electric light, telephone, synthetic chemicals, or atomic force—would have been possible without prior knowledge in such fields as mechanics, light, heat, sound, electricity, and behavior of molecules, which had emerged from seemingly impractical studies in laboratories over the course of two centuries. These principles give chemists and physicists the necessary tools for thinking ahead, for predicting, and hence for inventing.

Presumably populations of living organisms in the sea also react predictably under given circumstances, but we have yet to resolve the multiple parts of the controlling circumstances. Of course the materials that physicists and chemists work with are superbly regular in their properties. Molecules respond to law with nice precision, always in the same way under given circumstances. Principles which underlie the behavior, the abundance, the very existence of wild plants and animals, particularly those that live out of sight in the depths of the sea, are exceedingly elusive, much more difficult to discover than laws of matter and energy. The most obvious lack in marine research programs is the pursuit of principles.