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The Identity of Species

All research into marine biological resources depends on precise identification of species and populations. The science of classification, called taxonomy, is pursued primarily in research museums where collections of specimens are housed. During the last thirty years, taxonomy has been seriously neglected and museum work allowed to lapse for want of support. This chapter discusses the importance of taxonomy and urges that museums be given better financial support than they have been receiving.

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?

If we think about the sea itself and not about such human affairs as economics and sociology, there are four obvious general ways to attack this problem: Survey unexplored areas in search of new food resources; harvest and process animals and plants which are not now used; control rates of exploiting fishery stocks so as to get maximum harvests; farm sea plants and animals in inshore enclosures. With any of these approaches, it is necessary first to take into account certain elementary facts. These may seem absurdly obvious; nevertheless, they are neglected often enough in planning new fishery schemes that they had better be stated:

1. Among the hundreds of thousands of species of animals and plants that live in the sea, only a few are harvestable in commercially significant quantities and only a few are suitable for direct human use.
2. Each species of animal and plant has a particular geographic distribution which is delimited by conditions of environment.

3. The abundance of a stock of a species is greatly influenced by the abundance of species of prey, competitors, and predators. Man is one of the predators.
4. The rates at which average fishing harvests can be sustained at the most productive level are determined by rates of natural mortality, growth, and reproduction. These vary from one species to another and within a species from one population to another, depending to a considerable extent on conditions of the environment. They also vary from year to year.

Underlying each of these four statements is a concept of species as a unique biological entity. It is hardly possible to deal with food resources without in some way recognizing species. To give a very homely analogy: a farmer must distinguish crops from the weeds, the well-growing, disease-resistant strains from those which are less hardy, the vermin from the useful livestock. He kills noxious weeds and insects with specific herbicides and insecticides. He plants particular kinds of vegetables and fruits to meet local conditions of soil and climate. Such practices result from a tremendous amount of research about species.

Species are equally important to those concerned with exploitation of the sea, though in rather different ways. Fishermen must distinguish the species that are marketable from those that are not. They direct their operations according to the distribution of species. The point of reference for marine biological research programs is usually species. In exploring unknown grounds, people are interested in finding familiar species of fishes, say, sardines or tunas or cod. Research to improve pond culture methods is usually tied to one or two species that grow well in ponds, for example, milkfish and prawns. It is an actual or anticipated depletion of particular species that arouses demand for research programs to devise conservation measures; such programs are always focused on the species affected.

The most elementary fact that a fishery biologist must learn about each fishery stock—elementary in the sense not of being easiest, but of coming first—is the identity of the species. What is it that must be dealt with in designing a policy of intelligent fishing? That is the first question that must be answered. For example, snapper fisheries of the Atlantic coast of Central America harvest at least six species which overlap in distribution. How do fluctuations in abundance of one species relate to those of the others? How do their habits differ? In some places fishermen take mostly very small fish of ten inches or so. Do these belong to species of small size, or are they the young of larger fish upon which people elsewhere depend? Answers to these questions would have important bearing on the harvesting practices of the fishermen if they chose to fish scientifically for maximal yields.

Again, wherever people fish along the shores of tropical countries, they find large quantities of jacks (*Caranx*). It is tempting to conclude that in underfished places there must be the basis of a great potential fishery. But the fact is that there are many kinds of jacks which look so alike that experts have not yet been able to establish their identity. Yet they differ in many important ways. While some species are delicious, others are not very palatable, and still others are in some places occasionally poisonous and therefore never safe to eat. Moreover, the various species differ in distribution, in habits, and in vulnerability to fishing pressures. Any plans for developing fisheries in a virgin area would have to take these differences into account.

It is hard to say that any one of a system of lines of activity in a field such as marine biology is the fundamental one. Nevertheless, if one must be so designated, that which comes closest to qualifying is the identification and definition of species. A misconception common among scientists as well as the lay public is that this means naming plants and animals and keeping the names tidily catalogued. Actually, the names are important only as a convenience. Organisms could just as well be designated by call numbers, like books in a library. However, it does happen that by international agreement, zoologists and botanists use a system of Latin nomenclature. This simplifies scientific literature tremendously. But it is not the names that make species interesting, or the bottles of dead specimens of these species in museum collections, but the fact that they represent vital populations.

By definition, every species has a unique anatomy and physiology. This uniqueness limits the geographic distribution of a plant or animal species to only certain areas of the sea, and within those areas to certain habitats where chemical, physical, and biological conditions combine peculiarly to satisfy its specific requirements. The abundance and well-being of a species are maximal where the combination of environmental conditions is most favorable, and they diminish as the combination grows less favorable.

Few species are distributed continuously or are genetically homogeneous throughout their range. Rather, changes in their environment and in the constitution of their genes occurring in the long course of geological time, have divided most species into communal populations or "demes," as they are sometimes called, and given them various degrees of independence. A species is sometimes defined as a system of demes.

Communal populations within species differ from one another in features of anatomy, physiology, and behavior. They also have distinctive geographic ranges or ecological habitats, or both. The more important of them often behave almost like different species and are identifiable as something of lesser rank only because at certain geographic points or in certain anatomical and physiological features they merge with other similar populations, or, if completely separated geographically, cannot always be distinguished from them. These "almost-species" are called subspecies. In marine animals and plants, which, in general, have been studied less than terrestrial ones, subspecies have received little attention. Most marine subspecies are probably still unrecognized. What are now considered to be closely related but distinct species probably in many instances will prove to be subspecies when connecting links are found or recognized.

Subspecies themselves differ from one another in various ways. It is difficult to determine how to designate the degree of distinctness of these populations. Consequently, a great deal of study is necessary to understand the populational structure of almost any species.

Such study is important in the understanding of a fishery, for populations may differ from others in growth rate, in longevity, in productivity, in resistance to disease, in susceptibility to parasites, in migratory habits, in response to fishing, and in many subtle ways. Consequently, any plan to direct a fishery scientifically must take into account not merely the species, but the population as a unit of the species. Evaluation of abundance and of productivity must be by populations. People working to develop methods of fish farming must recognize differences between populations in seeking the best growing, hardiest strains of fish and shellfish. Control of fishing rates to produce maximum yields must be by populations. Fishing is a highly selective process, and may affect different communal populations of a species in different ways. Fishermen deliberately seek certain sizes of fish to satisfy their markets. They fish in certain depths to take advantage of the habits of their quarry which they know, and thus they may miss, or "select against," those of the same species which are adapted to a habitat of differing properties, as, for example, deeper water. Fishing gear often selects sizes of fish. Fish tend to school according to size; the distances which they migrate vary according to size; they are available only while they are passing through the areas where fishermen are working. Certain sizes may be available for longer periods than others. Thus there are many ways by which different sizes can be subject to fishing pressure. Populations differ in size characteristics. By various selection processes, a fishery may be favoring the survival of some populations and the reduction of others. Such undirected selective breeding might be advantageous, but it might equally well have dysgenic effect in the long run.

For all these reasons, it is essential to be able to distinguish populations and to know the relative influence of heredity and environment in maintaining their identity. Environment certainly has a greater immediate effect on the characteristics that identify populations than on those that identify species. Therefore, in our dimension of time, a species is so stable an entity that it must serve as a standard with which all its populations can be compared.

The study of species, their origin, phylogenetic relations, and geography, is the branch of biology called taxonomy. The tremendous impact of Darwin's *Origin of Species* on the intellectual life of the nineteenth century made this the dominating subject of biological research for about fifty years. The great idea which inspired biologists to redirect their interest was evolution. Because evolution gave meaning to classification and purpose to collecting, scientists constantly improved methods of catching animals, especially at sea, where any haul of a net might bring up enough new species for a publication. The most obvious way for philanthropists to contribute to science was to build a research museum, or at least to finance expeditions for collecting specimens. During this period some great museums were founded and they acquired great collections. For a long time, these museums were the center of activity in the field of biology. Their staffs made the most frequent contributions to biological literature. They got the lion's share of bright young students.

In its earliest stages, the study of species was concerned chiefly with comparative anatomy, embryology, and classification, these being the subjects which best demonstrated evolutionary relationship. In time, however, it opened up all sorts of other interesting subjects of inquiry such as comparative physiology, general physiology, experimental zoology, life history studies, and behavior. As biologists turned their attention to these topics, they abandoned the museum for the experimental laboratory or the open field. In doing so, they tended to lose sight of the importance to their work of the definition of species. Thus, between 1910 and 1920, "systematics" went out of fashion. A generation of biologists had found other subjects for enthusiasm, particularly mechanics of the life processes and physiology of the cell. Museums were no longer alive with activity. The rising scientists, at first indifferent to museums and their staffs, became slightly contemptuous. "He is only a natural history man" became a standard epithet. "What difference does it make what you call an animal?" biologists often asked, even while finding it necessary to have the subject animals of their researches identified.

Beginning about 1930, new ideas began to emerge in some fields of biology especially in population genetics, which led to a reexamination of taxonomy itself by forward-looking scientists, a movement which is leading taxonomy out of its dark age and giving it greater prominence. The "new systematics" as it is called, recognizes that all biological disciplines contribute to a knowledge of populations, and systematic problems are now being attacked from the sides of genetics, physiology, ecology, and immunology.

Unfortunately, studies of this sort deal only with one or a very few species. They progress slowly, and the very number of existing species precludes applying the new methods to more than a few of them. At the same time, the need for the kind of basic knowledge of many species provided by the museum specialist continues to grow, while funds for collection upkeep and for the necessary field and museum research diminish.

The great research collections, consisting of thousands to millions of specimens, are housed principally in two sorts of institutions—governmental museums, which often must cater to the general public in their exhibition halls, and university museums whose chief function is to house reference collections. The public museums, often supported by city governments, get funds for public education or entertainment, but little for upkeep of collections or for research. Universities generally support their museums wretchedly. They often do not replace curators who have retired. They may appropriate enough money to keep the specimen bottles filled with alcohol, but little more. In some places even that necessary job now depends on volunteer labor. Thus the continuity of the discipline which was the foundation of modern biology, the handing down from one generation to another of its tradition and skills, stands in danger of breaking up. A student who inclines toward taxonomy, as a few brave souls do, has at best a narrow choice of teachers. He can, of course, learn from books, but that is a poor substitute for the constant guidance of a living authority. For several groups of animals and plants there are but one or two living authorities; for some there are none at all.[1]

A museum collection, which is the basis for taxonomic research, is analogous to a research library. Its value is proportional to the amount of creative work that goes on about it. If a library reduced its staff to a part-time, nonprofessional caretaker, stopped buying new books, failed to catalog those that came in as gifts, and stood them about the floor in piles, it would become a dead place. That is what most natural history research museums are today. They are dead places. Some that are not dead are very quiet. Men of universities who are responsible for the intellectual life of their country should not allow such a situation to continue.

What would it take to restore a sick research museum to healthy life, that is, to the point where it would be a living, intellectual institution, with a constant flow of material and ideas, contributing discerningly to the growth of biological science? Compared with the research in fields of biology that are fashionable today, it need not cost very much. The principal needs are staff and money for travel. One man should not be expected to do all the curatorial work for a collection of world-wide scope, as well as carry on research about his subject of interest, make his own illustrations, do all the measuring and tabulating, teach students, and typewrite his own manuscripts. He needs a corps of assistants. No problem worth investigating can be solved by studying the anatomy of a few dozen pickled specimens. It should be carried into the field, over the entire range of species under study. The museum scientist should have sufficient travel allowance and time to permit this. He must have access to a number of disciplines besides anatomy, particularly genetics, physiology, biochemistry, animal behavior, and mathematics. However, skills in all these subjects will not be found combined in one man. Therefore, a well-balanced museum staff should include several people having among them a wide variety of backgrounds. They should have access to experimental facilities (perhaps in cooperating research institutions) and enough funds to make use of them.

From the point of view of fisheries industries, one of the most valuable functions that a museum staff can perform is the compilation and frequent publication of distributional charts. Since knowledge of distribution is constantly growing and since distribution is constantly changing in response to fluctuations of environment, this must be a continuing job. The almost complete lack of such charts is one of the most serious gaps in recorded knowledge of the sea. The charts that do exist—a few of them are reproduced in this book—contain inaccuracies that severely limit their usefulness.

A much-neglected line of research that is essential to a taxonomic laboratory is anatomy. The internal as well as external anatomy of all species of marine animals must be worked out and described in order to provide a solid basis for understanding their taxonomic position and identity. As it is, less than 2 per cent of the known species of marine animals and plants have been well described, and those mostly before 1900. The status of anatomy today is about as low as that of systematics. A university must support a professor of comparative anatomy of vertebrates since that subject is required for entrance to medical school. However, that is generally as far as the university can go. Any energy the professor has left after lecturing to hundreds of students weekly, he may give to research. One faculty member for teaching invertebrate zoology (including all the land forms) is about as much as can be spared for supporting work in invertebrate zoology in an average university. And museum curators have little opportunity for pure anatomical research. Thus progress is too slow to keep abreast of the needs of other branches of biology. And needs there are. The description of many species of fishes, for example, goes no further than external anatomy. Even studies of races are based only on such superficial features as head length, size of eye, and position of fins. In general, biologists cannot go much further in these studies because they simply do not know the internal anatomy well enough to recognize significant differences in the shape or position of the various organs. Not only taxonomists, but students of behavior and of physiology are handicapped in not having complete knowledge of anatomy.

Characteristics of the digestive system, for example, tell a good deal about the probable feeding habits of an animal. The presence or absence of sensory organs can provide the basis for designing experiments to learn how animals analyze their environment.

The groups that are most obviously pertinent to the problem of exploiting the sea are the marine mammals, fishes, mollusks, crustaceans and algae. But there are other groups of organisms. Are they to continue to be neglected because they seem commercially unimportant? What about the parasitic worms that infest fishes and mollusks? What about the invertebrate animals which are important links in the food chain? What about the starfishes, which are enemies of mollusks, and the pathogenic fungi which infect all sorts of marine animals? If it is true, as is often said, that species can be understood only in relation to their environment, then the ideal natural history museum must comprehend the whole gamut of animals and plants that occur in the sea, for they are all parts of environments in which fishes, mollusks, crustaceans, and algae live.

Where would these ideal natural history museums be placed? There are enough museums already existing so that it is neither necessary nor desirable to establish any new ones. In fact, there are regions where museums that are close together could be consolidated with considerable economic advantage to their supporting institutions. This would require some noble swallowing of pride, but it should be done wherever several mediocre, run-down collections could be combined to help make one good one. As a matter of fact, museum directors of a few institutions, in order to specialize, have already begun a movement to consolidate certain parts of collections by exchange. In any plan to strengthen museums, the highest priority should be given to those which already have great collections with type specimens and which are attached to universities having excellent scientific libraries. These, being close to scientists in fields other than biology, are in the best position to secure imaginative advice for attacking some of the more difficult problems of taxonomy. They are also in the best position to teach principles of taxonomy and the techniques of identification to students of general biology who will later become ecologists, biological oceanographers, fishery biologists, and conservationists.