SPC/Fisheries/Tech.10 (HQ) 13th May, 1968

SOUTH PACIFIC COMMISSION

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THIRD TECHNICAL MEETING ON FISHERIES

KOROR, PALAU TRUST TERRITORY OF THE PACIFIC ISLANDS

(JUNE 3 - JUNE 11, 1968)

THE CONCEPT OF A REEF AND LAGOON FISHERIES INSTITUTE

by

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In the region within the purview of the South Pacific Commission lie some of the largest and best-developed coral reef and lagoon environments in the world. The potential economic value of the coral reef and lagoon environments is as yet largely unknown. Some evidence exists suggesting that, although the standing crop of fishes associated with coral reefs and lagoon situations may be rather high in an undisturbed and unutilized state, such stocks are readily reduced by moderate fishing pressures. The evidence supporting this is suggestive at best.

For many of the islands within the area of the South Pacific Commission's responsibility, human populations are increasing rapidly and the pressure of human needs on the available resources is growing at even a higher rate than that of population growth by reason of the desire for a higher standard of living. Considering the enormous area of the ocean in this region as compared to the tiny area of land, the thought has long been held that the living resources of the sea itself could be a source of food and/or income of great potential.

The living resources of the sea in this region occur in three very different marine communities : the most important and the largest is the oceanic community which includes tunas, spearfishes and other creatures of the open tropical ocean; the next community is that of the coral reefs and lagoons which are part of the structure of many islands in this region; and the third, the benthic organisms associated with the submerged flanks of the islands and offshore banks. Some day a fourth marine community may become important in this region. This is the mesopelagic community which lies below oceanic waters and is presently little known or little fished. As mentioned, the fish stocks of the oceanic environment are by far the greatest in magnitude of the three discussed. In some respects they are also the best known. The reason for this ari. latter situation is that fisheries on a very large scale have been in existence for these stocks for many years throughout the open tropical oceans of the world. Frysland average Levelad

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The techniques for taking and handling oceanic tunas are evolving and are efficient and complex. For example, some of the newest refrigeration equipment used on Japanese high-sea long-line vessels freezes fish at a temperature of 40° below 0, a low enough temperature to apparently hold the fish in a state close enough to that of fresh fish to be accepted as such on the Tokyo market. Purse seining methods for the schooling tunas are becoming more efficient. The markets in which the catch of these long-range vessels are sold do accept the whole spectrum of fishes taken at, of course, various and appropriate prices. Independent and island-based fisheries for these species of high-sea fishes may be difficult to establish with the competition of the foreign high-sea fisheries. However, it is possible that foreign vessels could be based at island ports and this kind of development has gone forward, notably at American Samoa and on a trans-shipment basis at a number of other ports. While shoreside processing facilities based on deliveries by a foreign fishing fleet may provide substantial local income, the local income to be derived through freezing and trans-shipment is much less.

However, apart from the questions of how best the peoples in the region of the South Pacific Commission's area of jurisdiction can profit from foreign fishing fleets operating in this region, there is a question of the research needed to both conserve and best utilize the stocks of high-sea fisheries in this region. It is difficult to argue that the cost of such a research program should be charged against the residents of the region, either as a matter of bookkeeping or directly. The obvious benefits of such a program would go to those nationals whose vessels are engaged in the high-sea fisheries, the processing and sale thereof, and obviously the cost of such a program should be against their accounts. In any case, the island peoples should have an equal opportunity to enter the oceanic fisheries if they wished to do so.

However, since island peoples currently derive little benefit from the exploitation of the oceanic fisheries, research programs for their benefit should not be directed towards the problems of these fisheries but towards those fishery problems which are most likely to directly concern them. The fishery resources which lie within certain distance from shore may not be legally exploited by foreign fishermen. These resources, then, may be developed for the benefit of the people of the region without the direct competition or interference by foreign fishermen. They hold, therefore, the possibility of being developed in ways that best meet the needs of these residents and what it is practical for them to do. An institute for the reef and lagoon fisheries would be concerned with some of the fisheries within territorial waters.

The objective of such an institute would be to undertake programs to maximize the sustained yield of the reef and lagoon fisheries for the residents of the region. The attainment of this objective would involve a broad spectrum of studies which, depending upon the intensity of use, would differ in emphasis.

The pattern of development and research concerning these resources may be conveniently considered at three levels of intensity of usage. The first, which I shall call low-intensity usage, would involve no dundamental change in the eco-system and would constitute a cropping of a naturally occurring surplus of fishes and the level of cropping should not exceed that of the sustainable yields. If one wished to increase production beyond this point to one I shall call a moderate degree of intensity of use, some modification of the natural eco-system may be required. One could suggest, for example, the elimination of predators of the more useful species by fishing for them as well as

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for those normally taken and/or possibly the elimination of competitors, that is, species with similar food habits but of little value for food. The third stage, which would constitute high intensity, may require the substitution of a simplified eco-system with the elimination of the greater part of the diversity of organisms commonly associated with coral reefs. This would represent a fish farming stage and would involve the culture of selected organisms. It might involve the use of a lagoon as a very large fish pond in which selected environmental and biological factors are manipulated to maximize yields.

Each level of intensity of use would involve three important problem areas: (1) those relating to the biology and ecology of the reef and lagoon biota, (2) those relating to technological and engineering requirements for the efficient harvesting and management of the reef and lagoon resources, and (3) those relating to the socio-economic and the institutional aspects of the management and patterns of usage of the reef and lagoon resources.

The Biological Programs. These need to be based on an understanding of the unique nature of the coral reef and lagoon eco-systems. The coral reef, both in terms of biomass and species diversity, appears to be an oasis in an ocean desert. Levels of gross primary productivity of coral reefs have been measured and between 15 to 25 grams of carbon may be fixed through photosynthetic processes per square meter of surface per day. These rates for the adjacent open ocean would be about 0.5 grams of carbon per square meter per day or less. The rates of carbon fixation between the coral reefs and the adjacent open ocean is thus as much as 50 times greater on the reef. The coral reef appears to be among one of the most productive of marine environments but in contrast tropical ocean waters, especially in areas near the center of the great gyral currents, are among the least productive. Since the waters of the ocean commonly break upon and often freely flow across reef areas, what mechanism permits this great difference in the rate of production of organic material to exist? Photosynthetic process requires three elements in order to function : first, of course, are the plants themselves, the photosynthetic machinery; next is the radiant energy from the sun which is the source of power for the photosynthetic process; and third, a number of chemical compounds, the inorganic nutrient salts which provide the raw material. Aside from trace elements, in most marine environments the two compounds which are likely to be limiting are phosphates and nitrates. There is evidence that the energy of the sun is not limiting in a shallow-water tropical marine environment.

The question is, then, what is the source of the large supply of nutrients that appear to be available for the photosynthetic organisms of the reefs? The answer may be critical as far as the possibility of obtaining high levels of yield from reef and lagoon fisheries is concerned.

The far greater productivity of a reef and lagoon as compared to the adjacent open ocean may be the result of several factors. One may be the efficiency of the zooxanthellae-coral relationship in the conservation of mutrient salts. Another may lie in the recycling of mutrients within the reef eco-system in addition to the short-link food chains such as that existing between zooxanthellae and the corals. A third may lie in a more efficient removal of mutrient salts from the sea water than is true for the phytoplankton. The removal of mutrient salts by phytoplankton cells depends to a great extent upon diffusion rates, whereas the removal of these salts by fixed algae depends to a great extent upon turbulence and the movement of the water itself. The basic question that must be answered before one can move with any great degree of competence in the direction of attempting large-scale exploitation of reef

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and lagoon fisheries is what fraction of nutrients are recycled through one mechanism or another and what fraction is taken directly from the sea. The sustainable limits of productivity of the reef eco-system will be set by the rate of nutrient imports and exports and this may be essentially independent of the recycling rate. If the reef and lagoon eco-system is exploited to the degree that recycled nutrients are lost, rates of production must decline and the biomass also. The segregation of nutrient sources into those originating from water coming through the reef and lagoon eco-system from the open sea and those which are a part of a nutrient pool that is being constantly reused does present certain difficulties; it is also a problem that has not yet been tackled to any serious degree by scientists. Its solution is essential in the development of a rational program for the use of reef and lagoon fishery resources.

I have mentioned some of the biological problems, that is, the problems relating to the reef as a homogeneous community or series of communities. Important questions here concern the nutrient budget and the food webs of the various species of organisms of the reef and lagoon communities. In addition to these problems, there are those associated with the life history patterns and population dynamics of the various species which may be the object of fisheries and their competitors and predators. A characteristic of the greater majority of species found in the reef and lagoon environments is the existence of a pelagic larval stage during which the organism in question spends more or less time as a member of the planktonic biota in the open sea. This situation has a crucial bearing upon recruitment and upon the nature of certain problems which must be solved if it is desired to use the species in question for aquaculture.

relate to the nature of the reef and lagoon fisheries and the patterns of usage for the catch. These problems are likely to be diverse and to be difficult to outline in detail now. However, lacking successful solutions for many of them, the whole concept will fail.

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Perhaps even more critical are the group of problems I have called socio-economic and institutional problems. Patterns of use of reef and lagoon resources, whether private or public, and of regulation, will be determined not only by what is efficient but by what people who have a share in these resources feel is proper. The efficient practices may run counter to acceptable practices and in turn result in uneconomic operations which do not succeed for this reason.

Mention has been made of certain major problems and problem areas which a Reef and Lagoon Fisheries Institute would be expected to attempt to solve. These have been presented in rather general terms and it might be enlightening to consider some of the specific programs that such an Institute would need to undertake. These will be considered in the order in which the major problem areas were presented, that is, the biological problems, the technological and engineering problems, and finally, the socio-economic and institutional problems. The following discussion is in no sens exhaustive, rather it is suggestive of the nature general of problems that will require resolution.

An initial program as far as any given region lagoon area is concerned is to find out the nature of the existing fisheries, the species of fish taken by these fisheries, their relative desirability, their yields and the effects of the fisheries for them on the stocks. This, of course, requires the establishment of a statistical system of sorts concerned with the fish catch.

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Such a system where fishing is largely of a subsistence nature might be based on periodic interviews of individual fisherman and counts of the number of active fishermen at selected times and might best be accomplished by spocially trained indigenes or at least persons competent in the local language.

Another program which must be considered for each important species of fish separately is the pattern of recruitment of young fish to the fishery, the magnitude of recruitment and the magnitude of suitable environment for this species. In this case, questions which must be answered relate to the adequacy of recruitment, that is, do enough youngfish enter the adult environments to replace those harvested by a fishery or is the limiting factor rather the carrying capacity of the environment itself. If the carrying capacity of the environment be limiting, the young recruits may be subjected to a high mortality before they are actually the objects of a fishery. There appears to be great fluctuation in this situation for some species and the recruits are often the objects of an independent short-term seasonal fishery.

The nature of food webs and the magnitude of food resources entering these webs for different trophic levels needs to be elucidated. The life history patterns in general for the more useful species need to be known, and since a great many of them have a pelagic larval stage for those species which may be considered as subjects for aquaculture, techniques for rearing them through all life history stages will need to be developed.

For technological and engineering developments, one obvious set of programs relates to various harvesting techniques and to improving the efficiency of these techniques, that is, to increase the yields per fishermanman-day. There may be problems of preservation and processing of the catch unless it be consumed fresh and locally in its entirety. Then there may be other problems relating to distribution and marketing. Developmental programs may be required for both groups of problems.

In the socio-economic and institutional problem areas an obvious program relates to the profitability of the fisheries. The relationship among the value of the catch, costs of boats and equipment needed, and the fishing effort required to take the catch will all determine the standard of living of the fishermen. An important question relating to the one just mentioned is the control of entry to the fisheries. If unlimited entry is permitted it may be impossible to obtain any significant margin of profitability or more than a minimal standard of living for the fishermen, simply because a limited stock of fish may be harvested by an increasing number of fishermen until the point is reached where no individual fisherman profits from his fishing. In any case, if the stocks are limited and sustainable yields are an objective of management, it may be necessary to establish quotas or to assign fishing grounds or to use some other technique to bring fishing effort and magnitude of available stocks of fish in harmonious agreement. Should it be desirable to develop aquaculture, it may also be desirable to assign oxclusive rights to reef or lagoon areas. Some sort of a monopoly is required even though it be quite limited and restricted if only to insure that harvesting is done when the organisms being cultivated are of appropriate age and size and are not cropped off too soon. The socio-economic and institutional problems are, of course, not to be solved by operational or economic analyses that indicate the most effective arrangements alone. There must be general agreement by those affected by changes and the public generally also. Involved

are political decisions of a nature that no institute can make, but if the operational and economic consequences of various alternative decisions can be compared, the decision selected may be on an informed basis at least.

Since, for the most part, reefs and lagoons have their own character and their own peculiarities and the Institute would of necessity develop general approaches to many of these problems, it is likely that in detail the general approaches would have to be adapted to accommodate the differences among physical situations and also among the habits and customs of the people.

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