#45

WORKING PAPERS

THE ROCKEFELLER FOUNDATION

PERSPECTIVES ON AQUACULTURE

>HIGH SEAS FISHING

>NEAR-SHORE FISHERIES

>THE OCEANIC ISLANDS

>SMALL BOAT FISHING

>AQUACULTURE IN THE PACIFIC BASIN

>AN RF PROPOSAL

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AQUACULTURE

A Conference Held at

The Rockefeller Foundation

In October 1973, a small group of fisheries experts met at The Rockefeller Foundation. Present were specialists from the Foundation and representatives of other concerned organizations, including ten other private foundations, the U.S. Agency for International Development, the International Development Research Centre, the United Nations Development Programme, and the World Bank. The Conference on Living Aquatic Resources was organized to provide information on worldwide and regional needs in aquaculture and fisheries development, and to assist RF officials in organizing a program of support.

As a result of the meeting's recommendations, the Trustees of The Rockefeller Foundation, at their December meeting, approved a grant of $250,000 "for the organization and development of a coordinated research, training, and action program on living aquatic resources in the Pacific basin"--a modest, but important, step.

This Working Paper contains five papers presented to the conference as well as a proposal for an international center for living aquatic resources management.

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The Rockefeller Foundation

Rockefeller Foundation Conference

on

Living Aquatic Resources Management (Aquaculture)

October 2, 1973

Speakers

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High Seas Fishing

David H. Wallace

Since the turn of the century, the utilization of living resources in the oceans has increased very rapidly. During this seventy-year period, the yield of fish from the oceans has increased about fifteenfold. Today, the worldwide catch of fish and shellfish is about 70 million tons, and this is considered by many biologists to be approaching the amount that can be harvested safely from the sea. The current estimate of possible production from species that are immediately acceptable and available to the human population is between 100 and 150 million tons. While this amount of protein is relatively small in terms of the protein needs of the world, the contribution that fish have made over the years to human subsistence has been very great, and in some areas of the world, it has been far more important than milk or animal protein. Thus, I think we have to think of the fisheries as a key part of the basic food material of the world.

In the United States, we have a yearly consumption of fish and shellfish of about 11 pounds per capita. Yet, the total utilization of fishery products in the United States ranges from fifty to seventy pounds per capita because a large portion is industrial fishery products such as fishmeal and oil used as feed in animal husbandry. In other parts of the world, fresh fish are used directly as human food. There has been increasing demand for fish over the past several decades, and this has led to a major exploration and exploitation of the ocean's fish. In many cases and in many areas, nations were totally unprepared to deal with the consequences of this exploitation, which has led to considerable disruption, even among the developed countries, because they have been led into a condition of intense competition to catch the stocks that are available to them. In some cases, a drastic depletion of a stock has resulted. The haddock fishery off New England, which had been a traditional major fishery for the United States for many years, is a classic example of this. As a result of the intensive fishing that developed in the last decade, the haddock has now been depleted to the point where there is some question whether or not this stock can recover except

over a very long period of time.

Even as the fishing countries are striving to increase the catch from 70 million tons, the world community is facing difficult problems of maintaining stocks of certain fishes. Dr. Garrett Hardin called the problem facing world fishing "the tragedy of the commons." In essence, it suggests that in absence of effective control, each national entity operating under the current legal arrangements in the ocean is locked into a system that compels it to seek an increase in yield or harvest advantage over its competitors in an habitat that is limited. Fishing is the only food-producing system that relies on a hunting mode, exploits wild stocks, and harvests resources that are for the most part considered the common property of sovereign nations. These largely uncontrollable activities ultimately lead to the destruction of the resources and the industries that utilize them, because each nation is pursuing its own best interest in a society that today professes to believe in the freedom of the commons.

Freedom of the commons, as far as fishing is concerned, has been in existence always. In 1958, an attempt to deal with the problem of the commons--to develop some order in utilizing the resources of the sea--was made at an international "law of the sea" conference. At that time, most countries felt that the resources beyond the territorial limits of the countries were common property, and they have been operating with this attitude ever since. I believe that we must change our rationale if we are going to better utilize the resources of the sea. In some ways, we must get away from the idea of a common property resource, because what belongs to everybody belongs to nobody. In our efforts so far through international commissions of various kinds--and the United States is involved in nine such conventions--we generally have been unable to decide on the essential management components that are needed to preserve the stocks of fish at their highest level.

I don't believe that the solution is a technical one. What is really required is a change in philosophy. Over the last ten years, the countries that have made the greatest progress in developing world fishing capabilities are the U.S.S.R. and its satellites and Japan. The Japanese have become seekers of fish in order to meet their essential protein needs, and this has been the motivation also for the U.S.S.R.. With the development of their massive fleets to carry on pulse fishing, both countries have been able to greatly increase their production of fish from every part of the world. The total effort that has gone into fishing has brought about a substantial crisis in terms of maintaining the production itself. People once thought that the resources of the sea were infinite--that

they were limitless. Twenty-five years ago, there were some biologists who said that we could produce 500 million tons of fish from the sea. We now know that these estimates were erroneous and we must revise our thinking. But on the basis of these estimates, many countries were led to believe this potential existed and therefore organized their industries to take advantage of this big harvest. This is the situation we have today.

We are facing a critical need for protein in the world, and we must start to orient our thinking toward meeting this need. There have been numerous estimates indicating that by 1985 an excess of 100 million tons of fish and shellfish is required if the sea is going to make its proportionate contribution to human nutrition. It is obvious that insofar as world fishing is concerned, an increase of 30 million tons in that period of time is rather improbable. This leads us to the next step: how to accomplish this goal of increased fish production. It leads inevitably to the consideration of aquaculture as a method.

In the world at the present time, according to FAO statistics, there are some five million tons of living resources that are being produced through aquaculture. Of this amount, 3.7 million tons are fish, one million tons are molluscs, oysters, mussels, and others, and about 300,000 tons are seaweed and aquatic plants. There have been various estimates made of the potential increases in production from aquaculture, which have ranged from an increase of five to twenty times the five million tons that are currently being produced. If we can increase production five times in the next fifteen years through aquaculture, we would come close to meeting the increased need for protein from the sea. And if we can do this, then there is also every reason to believe that we can continue to increase our production so that by the year 2000 we may be able to produce from 40 to 50 million tons through this technique.

We talk about aquaculture as if it were something new. This is a great misconception. We also talk about aquaculture as if it were something that we know nothing about. That is also a misconception. For example, in China, aquaculture has been practiced for centuries and has been extremely successful. Some estimates indicate that 40 percent of the fish protein needs in China are now being met through aquaculture. The Japanese have been very successful in aquaculture, particularly with molluscs, and have traditionally cultivated oysters in a very sophisticated way, using the total water column from surface to bottom to grow the oysters. We have extensive information and experience in this method of culture.

We know a lot about the potential for aquaculture; now action is necessary. We are ready to do the things that are necessary to make major breakthroughs in

terms of production. As I said before, we have a great fund of knowledge. But there are many things that we need to know. We need to know how to produce the seed that is necessary to grow the organism. We need to know more about the nutrition of the organisms that we wish to cultivate. We need to be involved in genetics and selective breeding to improve the stocks in order to move from wild stocks to domesticated breeds. All of these things are already being done on some species. We need to move in the same kind of direction in terms of others. Through selective breeding, we now have something that is close to being domesticated stock. This is what we have to do, and we must get on with the job.

Near-Shore Fisheries

H. Burr Steinbach

I have been around some of the developing countries in biomedical work, and I've also been around the marine fisheries in a number of developing countries--Taiwan, the Philippines, Indonesia, and Puerto Rico--as well as the states of Maine and New York. There is an amazing similarity to the problems that one finds in each of these places.

These perambulations have given rise to a series of probably biased opinions. It might be said that developing countries, and especially island cultures, are endangered species and we ought to pay attention to their habits, cultures, and so forth at least on the level accorded to whales and alligators. There is a tendency of high-level technology to move laterally without much foresight. You end up with flush toilets and no plumbing. And last, in planning programs, it is more fun and more profitable if one thinks big and works small. It gets you down to the people level. So these are the biases that I have.

David Wallace has discussed the potentials of food from the sea with reference to high-seas fishing. The only thing that I would add is that high-seas fishing has nothing to do with near-shore fisheries and, furthermore, high-seas fishing tends to produce a product that goes through a convoluted path before it gets back to the people. You have the odd situation of island cultures that are surrounded with reefs full of fish while they eat canned mackerel packed in some distant city. I live in Cape Cod most of the time, and I go into the fish market and buy fish sticks made in Japan. I can afford to pay for it--developing country people cannot. High-seas fishing has both problems and successes and the technology is quite good. Nevertheless, the catch is essentially something that becomes part of a somewhat massive technological and capital-intensive operation that then depends for its ultimate output upon whether or not the peoples of the world can afford to enter that technological and capital camp. In a way, this aspect is one of the factors allowing the separation of fisheries into two categories. One type is involved with the world marketplace. The other category of fisheries has to do with a much more direct transfer of the protein product from the oceans to the

people who are going to eat it. I don't think I need dwell on small-boat fishing in this country. The technology is low compared to high-seas fishing. There was a meeting in New York State recently that was concerned with a New York Sea Grant proposal. One of the striking things discussed was that in Rhode Island the fishermen discovered that if a trawl is changed from its usual depressed oval shape to a more square shape, you get more fish. So New York is importing Rhode Island specialists to introduce a new trawl opening that works better. That comes under the heading of technology transfer. Another thing that fascinates me about high-seas fishing is that of the first five producers (of fish products), two of them, the United States and Japan, are the highest importers as well. My guess is that Peru, which is one of the highest producers, also ought to import much more, but I doubt that Peru's economy can afford it.

David Wallace, commenting on the nature of the high-seas fisheries, referred to "the tragedy of the commons." I think that it is equally true to say that our local fisheries in this country and probably in many other countries suffer from the Jeffersonian approach.

Jefferson said that if the country wasn't divided into states and the states divided into counties, such a division would have to be effected and each unit would run itself. If any one of you has looked into the difficulties of operating near-shore fisheries or of attempting to put into operation any sort of fish farming or aquaculture, you will have realized this Jeffersonian democracy principle is providing tremendous obstacles to getting things done in the marine area. One instance of such a local bind is that of the oysterman in the Chesapeake Bay area. Virginia oystermen can use only rakes and dredges. Maryland fishermen can use dredges, but only if they are pulled by sailboats. A few years ago Maryland fishermen were allowed to use outboard motors on Mondays and Tuesdays.

With respect to other means of getting fish from water, it is important to note that on a worldwide basis we really do know a lot about how to manage fish ponds, oyster strings, and, to a certain extent, other kinds of fisheries. World technology is really quite well-advanced, but it does tend to be a green-thumb or Luther Burbank approach. As with primitive farming before we had the science of agronomy and animal husbandry, we are now in the earlier stages where aquaculture is concerned. There have been many reports on the state-of-the-art of aquaculture. There are many reports that will tell you that you can increase production two orders of magnitude in the exploitable near-shore areas and land areas for use of aquaculture. So that by intensifying aquaculture, one could certainly raise protein production many times by at least an order of magnitude

or two. I remember one figure that interested me in Oceania. There are about 100 million acres that could be converted to either estuarine or in-shore aquaculture, which means that if you take the rule of thumb that for every hectare of managed fish operations you need one man, you end up with a substantial number of men that would be employed in such an increased operation.

The real charm of thinking about fishing that is closer to home, in-shore fisheries, aquaculture, and the like, relates to the objectives that one has in an operation such as this. The overall objective would certainly be to enhance the protein intake of the world. We do need more protein, and there seem to be limits in some areas of production. I doubt if the microbial degradation of hydrocarbons is going to solve protein problems. Oil companies sometimes tell me that they can take certain microbial forms and make good protein. Soybean protein is booming, but I suspect it has some limitations. It does seem that one of the best things to do is to get started on the primary objective of getting the protein into people who need it and who live near sources of protein. With that in mind, I think it is quite clear that if we have the ability to raise or farm fish or catch fish near shore, and if we have a lot of people who can do it, and if we had places where it could be done, then I think quite legitimately one can ask why it isn't being done. All components are at hand. What is holding things up? Here I can invoke an elementary analogy--the problem of three-body collision. When chemists are faced with a slow-reacting system, a catalyst is added.

How to catalyze the interaction of the various components of the system is one of our problems. We have the potential to do it. We have many places that need the increased production of locally related efforts, and I think we already have some demonstrations that a small catalytic element will indeed stimulate productivity. I saw one example in Taiwan. I was there at the time that the Foundation awarded a $50,000 grant in Taiwan for fish farming. I think I could trace a direct relationship between that grant and their ability to use the money innovatively, to work on the problem of spawning fish other than carp. The cooperation between the Taiwan group and the group in Hawaii in turn has led to the commercial raising of mullet. It all started with a little catalytic intervention into an area that has a strong background of aquaculture and near-shore fisheries.

There are a series of things that can be done. A lot of them have been outlined in reports. The standard report talks about the need for more money, the establishment of an office at the highest levels of government, the establishment of a management structure, and contains an economic flow chart. The report is accepted--and nothing happens. There is no follow-up.

One of the components that is needed to catalyze this sort of work is certainly an educational extension system. Some system that will have the same effect as that of the agricultural extension work originally started in the Midwest. This work is really necessary.

The slogan of needs for aquaculture, or for any other farming culture, is "seed, feed, and labor," and particularly the "seed" aspect. The development of a well-managed animal husbandry with a sound genetic base so that you can work out the strains that are best adapted to particular localities and particular areas is an absolute must and that, unfortunately, comes under the heading of basic scientific research, which is anathema to Congress at the moment. But such work needs to be done now. There must be studies on genetics and the early management of the fish. There certainly has to be a lot more known about the nutritional problem of raising the stocks when you get them, and we are in a rather primitive condition with respect to pest and disease management. However, we do understand the problems, and in some instances we know how to tackle them. Given our research capability and green-thumb skills, we must act as catalysts for getting the knowledge and people and places together. All this comes under the heading of educational extension and the development of an aquatic equivalent of agronomy and animal husbandry.

The Oceanic Islands

Alexander Spoehr

It is the firm belief of the group at this meeting, in looking at world needs for protein from the sea, that a major emphasis should be placed on getting fish and aquaculture products to people at the local and regional level. Industrialized fishing is not our main concern. Our main concern is rather to assist indigenous people to develop their own resources and capabilities to feed themselves in local and regional markets. My assignment is to review briefly some of the social and behavioral science components of the concepts that we have been discussing, and at the same time to introduce the Pacific as a promising program area. Within the Pacific area, furthermore, I am going to limit myself to the islands of Oceania, thereby simplifying a larger and more complex picture. It is true that island Southeast Asia also depends on the sea, but it is a more complex area than Oceania. I will confine my remarks to the Oceanic islands, consisting of Micronesia, Melanesia, and Polynesia, lying to the east of Southeast Asia but not including New Zealand or Hawaii. I first wish to say a few words about the historical background of the peoples and cultures of these Oceanic islands.

The first settlement of the Pacific outside of Southeast Asia was by hunter-gatherers, beginning about 30,000 B.C. at the height of the Pleistocene glacial period, when man more or less walked into New Guinea, Australia, and Tasmania. He was blocked from moving farther east for two reasons. The first is that he had no adequate water transport. The second is that to survive on the Pacific islands he also had to have domesticated food plants. When these requirements were met, about 2000 B.C., man moved into the Pacific island basin proper, probably from the islands of Southeast Asia. The settlement of Oceania was completed by about A.D. 500. There then emerged a series of island societies adapted to the sea from which they derived their protein and to the land from which they derived their carbohydrates from domesticated plants. With the impact of European colonialization during the eighteenth and nineteenth centuries, these islands' cultural and social systems became disrupted. There was initially a major decimation of

population and a dislocation of the traditional social and economic systems that these people had followed. Beginning with the twentieth century, however, the island population recovered at an amazing rate. There are today more people living in the Pacific islands than at the time of Captain Cook's initial discovery. Traditional cultures still survive in varying degrees, although they have been considerably altered. The picture today is one of rapid social change of an expanding population with a major need for protein sources.

There are certain trends of change in Oceania that are evident. These also tend to be common to Southeast Asia. I shall briefly outline them.

Growing out of the colonial period, a new geographic framework has emerged in Oceania. It consists of regions, forming new political units, the center of which is a port town, surrounded by an island hinterland. These port towns are well-known, Pago Pago, Papeete, and so on, and are focal points for sociocultural change. A second current trend is penetration of a money economy. It is still true that there are parts of New Guinea where this remains incomplete, but generally within the island area apart from New Guinea penetration is virtually complete. With this has grown a market-oriented economy. A third trend in the area is the acceptance of and commitment to the material civilization of industrialized countries. Transistor radios, sewing machines, tools, and cloth are not luxuries but essentials. Also, since World War II, tourism has made its appearance. The impact of this addition should not be taken lightly. It is the substitute for industrialization in much of this island area, and has led to a further growth of port towns. Concurrent with these changes, there also has emerged a series of rather distinctive migration patterns. One such pattern is the movement out of the islands into metropolitan countries such as New Zealand and the United States. More important, however, is the movement from the hinterland into the port towns, the regional centers. Finally, there is a third movement, one largely of technicians, from one region to another, such as Fijians working in the Solomons. In this picture of migration, the human populations of Oceania are trying to allocate their efforts into locales where they believe economic payoff is greatest. This is what, I think, largely underlies the migration patterns. It is important for us to recognize this factor if we wish to stimulate and to improve the utilization of sea resources.

Another trend is rising levels of formal education, which is linked to the emergence of new elite groups, whether these be in the professions, in politics, or to some degree in the economic sphere. There still remains a real need for technically trained personnel, partly due to the nature of the status system that

is operating. Finally, there is the emergence of a political conscience, leading to new states and developing polities.

In the light of these changes, the need for protein is today greater than ever before. In some parts of Oceania, traditional fisheries have virtually disappeared. I could take you to an island of the Loyalty group, with beautiful lagoons and gorgeous reefs, where the people no longer fish. They feel it more profitable to work in the towns. However, in other areas, fishing is still viable, and as a whole I have the feeling that Oceania has a resilient and resourceful population.

A second subject deals with how a social and behavioral scientist looks at the diffusion of technology, the way in which new ideas cross cultural boundaries. This is actually an old interest in social science, particularly in anthropology, geography, and agricultural economics. However, insofar as the social and behavioral scientist can state general propositions regarding those factors that control the acceptance or rejection of new technologies across cultural boundaries, I must admit that our knowledge is at a very elementary state. We are unable to propose such general propositions, due primarily to the inadequacies of our data base. Most of the information that is available consists of reconstructions after the event, rather than observations during the event. Observations during the event have indeed increased during the past 20 years, but our data base is still deficient. Nevertheless, it is possible for the social scientist to point to certain areas that must be considered in terms of the diffusion and transfer of technology. In the initiation of a program that involves such transfer, what things do you look at?

First, the most obvious one is the state of the existing technology in the society that is not the donor but the recipient. Barry Fisher will give you an example of the successful introduction into American Samoa and Ponape of a particular kind of fishing dory. It so happens that the Micronesians and the Polynesians have had in the past beautifully designed types of sailing craft, including the single outrigger sailing canoe. Nevertheless, this canoe is not adapted to present-day fishing. Yet, the people who received the new fishing dory were still fishermen. They could appreciate a good craft of new design. Their existing technology was receptive to the innovation.

A second area lies in what is called social structure. How are these recipient societies organized and what kinds of social groupings do they maintain that control and channel their life patterns? In many of these island societies, kinship is a central concern. Kinship-based descent groups remain important.

They are corporate groups with theoretically unlimited life and, furthermore, hold title to resources. Kinship is important in the organization of economic production as well as in the distribution of products. Another aspect of social structure is the character of social inequality, and of social stratification. It is in this area that one can discern the channels of authority and of leadership, which may relate to the acceptance of innovations.

A third important field is that of cultural values. I can give you a few examples. The first is that cultural values are reflected in attitudes toward work itself. Is work valued as a thing in itself--as a moral good? Or is it simply valued according to the goal to which work is directed? Europeans coming into the Oceanic islands tend to bring with them their own value system, and it is often difficult for them to understand that the islanders do not necessarily value work as the Europeans do. The islanders judge according to the objectives toward which work is directed. A second important factor in this realm of cultural values relates to the specific aspirations which individuals hold and which affect the choices and decisions they make. This becomes important, for example, in the character of entrepreneurship.

A fourth area relates to economic organization. Here I will mention three points. Throughout developing countries, one of the major problems is capital formation; how to assemble the kinds of capital appropriate for the new technologies that are being introduced. My own feeling is that, in Oceania, capital can indeed be found as long as we are not talking about capital-intensive, high-level technology. If we are concerned with a fish-protein technology appropriate to these societies, I believe capital can be developed collectively within the island groups. The second point refers to the development of entrepreneurship. How do entrepreneurs develop in traditional societies? They are indeed arising in the Oceanic world, and are coming out of an improbable set of circumstances, but we do not yet know enough about the process to do much predicting. The third economic factor that I think is terribly important is that of marketing and exchange. Successful technical innovation depends on more than just production. In terms of fish production, we must be concerned with an exchange and marketing system that will get fish to a wide spectrum of people.

Finally, a word about ecology. The relation of man to these island ecosystems must also be part of any concept of technological transfer. Here cultural values become important because in any society culture imposes a screen between the people of that society and the ecosystems in which they exist. This screen is embedded in linguistic concepts and the language that a people use. The

cultural screen results in a model not of the ecosystem as it actually exists, but rather as a cognitive model by which the people perceive their environment. This cognitive model is always simpler than the reality. It is important, because technical innovation may affect the ecosystem adversely, but this adverse effect may not penetrate the cognitive model.

In developing practical approaches, I think we must also recognize the element of time. Technical innovation, if successful, triggers off a series of social and economic changes that have a feedback effect in terms of future innovations, so that as we look at the diffusion of ideas and of successful technologies, the time element is extremely important. As a rule of thumb, I would say you cannot get a kind of complete cycle of innovation in less than 7 to 10 years. I think that has been true with the introduction of high-yield rice strains in Southeast Asia.

If it is possible, and I firmly believe it is, to introduce new technology in fisheries and aquaculture into a pilot area such as Oceania, conflicts may arise between traditional and modernizing aspects of Oceanic cultures. I don't think we should be disturbed about it. I think this is something that can be anticipated. More important is that any project that is to be developed does not have to be elaborate. It only needs to be successful. I am leery of too great elaboration of projects. I think one of the advantages of this area is that any proposed project does not have to be elaborate to be effective.

In conclusion, I hope also that a social and behavioral science component can be built in to any project that is undertaken, for two reasons. First, I think the social and behavioral scientist can make some contribution by indicating problem areas in the sociocultural field that must be taken into account if the project is to be successful. Second, there is an opportunity here to develop an analytic and systematic set of observations that can contribute to the data base of the social sciences in understanding the factors involved in the diffusion of ideas and technologies across cultural boundaries. In this connection, without in any way criticizing the Rockefeller-Ford project on the introduction of high-yielding rice strains in Southeast Asia, I wish the social scientists had a more complete record of what actually happened in the diffusion of these strains. Any project of the kind we are here proposing can be very valuable in expanding a data base that we all need.

Small Boat Fishing

R. Barry Fisher

I am a small-boat fisherman. I am one of those who generally have been left completely out of worldwide fishery development efforts since World War II. I have spent the major part of my life in sixty-to-seventy foot-long boats. I can catch fish. I also know that I can show people how to catch fish.

Even with all the proof of what small boats can do, and I would submit to you that small boats still produce the overwhelming majority of ocean fish in the world, there is still comparatively little being done in the development of gear, or methods of technology or education, for the small-boat fisherman. Engineers and scientists love the big boats. Parenthetically, let me also say that the fishermen have invented every major piece of gear, every technological innovation, that we have had in the last fifty years in the fisheries. Not the engineers, not the scientists, but the fishermen.

In Oceania, fish was the traditional protein. Islanders had pigs and chickens, but they were reserved for feasts on high occasions. Their day-to-day protein was fish. Now, islanders are eating less and less fish because it is very expensive or largely unobtainable. There has been a need in the islands for cash --islanders are being inexorably drawn into a cash economy. The only thing they had for sale, once we decimated the sandalwood forests in places like Fiji, was copra. Copra production became the only source of cash production and hence labor specialization entered. Remember that these island areas usually had a very carefully balanced sustenance economy in which one spent the day acquiring food. Labor specialization for cash led to concentration upon copra and a decline of the traditional food production and modes of that food production.

Some people and organizations in the area, such as the South Pacific Commission, have been concerned with the increasing cost of fish. There is the South Pacific Islands Fisheries Development Agency, composed in the past mostly of colonial administrators and outside experts. They designed a fishing program to help overcome these problems of scarcity, of decline in the production and

consumption of fish. The original goals were to conserve marine resources, and to promote the rational exploitation of aqua-protein for the nutritional and economic benefit of the islanders. In fairness to SPIFDA, they were not funded to anywhere near the levels requested; they got roughly 25 percent of the funds they asked for. In the SPIFDA program, the money was spent almost wholly on aquaculture and primarily for oyster culture. But oysters are a shellfish that islanders in general don't eat. I am not aware of a pound of ocean or reef fish that has been put into an islander's stomach as a result of SPIFDA, although I don't think it was entirely their fault. The inevitable result was that this year the islanders and some sympathetic whites at the SPC fisheries conference meeting killed SPIFDA.

We have talked about behavior and value systems. In the Pacific, most of the fishing training projects that I have known have sought to develop fishermen to go into big-boat fisheries, where production is for the consumers of developed nations. These programs failed and are failing. The reasons are easy to understand. There was, for example, an attempt to recruit Micronesians, to send them to Hawaii for long periods of time and to train them there to become live-bait-and-pole fishermen. The people were removed from their villages and sent to a big city, which they could not cope with. Those few who did fish when they returned had to leave their ancestral homes and go to Palau to work, and the turnover rate in that effort has been very high.

The second training program was one which trained Samoans to fish in Oriental long-liners. A Samoan is no longer a sea person, but a reef person. They wanted to put Samoans on Japanese, Taiwanese, and Korean long-liners--vessels that were away at sea four weeks to three months. The work norm, sixteen to eighteen hours a day, is wholly for production. The living accommodations are primitive and filthy. The Samoan is very clean, bathing two and three times a day. He is also big--five-foot-ten-inches to six-foot-two-inches tall--and husky. But the bunks on a tuna long-liner are designed for Oriental fishermen, who are much smaller. The results were predictable. Some fifty or sixty Samoans were trained the first year. There was one man left in the program after one year and he is no longer in it.

There has been an intensive tuna fishery effort in the Pacific, particularly as stocks of the tuna have leveled off in spite of intensified effort. Today you have three canneries, one in Honolulu, two in Pago Pago, and several buying stations in other areas. There are some common characteristics to all of these efforts. There is very little employment of islanders. There is virtually no

fish for them to eat from these fishing efforts, and there is currently a rash of similar development, following this line of intense competition, going on all over the Pacific. Every island in the Pacific has been receiving multiple proposals from various companies, none of which really treat with the islander or his problems. The islanders are angry and they are confused. The Pacific, as far as fishing is concerned, is becoming a Japanese, Taiwanese, and Korean lake. The vessels are from all these countries, and the companies are Japanese and American.

The islanders are trying to get some kind of employment, as they need cash and fish for local consumption. Based on the history of the efforts to date, I don't think that prospects for the satisfaction of the islanders' needs are very good. They want fish to eat. Many of them want to catch fish, and they want to catch fish without becoming American, Chinese, or Korean. But they don't know how to accomplish this goal.

Islanders have seen a couple of small, imperfect examples of how to catch and eat their own fish. The dory projects that we ran in Ponape and Samoa made sense to them. The dory is nothing more than a very stout, fast, sea boat that isn't really too expensive to build, and can be built easily by any set of jackknife carpenters. It is a fast and good sea boat that can carry a lot of fish. It is also labor-intensive. When these boats are built in Oregon, we get a raw boat from the builder and then we rig it up ourselves. If you had to buy that boat finished, it would cost $13,000 to $14,000, but if you take the raw boat, or, better still, teach people how to build raw boats, it will cost about $6,500, including necessary gear, even after exorbitant freight rates. What are the net results of having built six dories and transmitting the skills to the Samoans? There are eighteen dories in the water, fishing. There are fifty dories on order.

American Samoa imported 200,000 to 250,000 pounds of low-grade frozen fish from New Zealand in 1972. According to the Department of Marine Resources in American Samoa, that import has ceased and the import of tinned fish is declining. I submit that something can be done about helping people to provide themselves with fish in underdeveloped areas.

What do the islanders have to work with to meet the goals of fish production and consumption? They have fish. Pelagic fish abound in waters near the shores. These near-shore fish are tuna, skipjack, and yellowfin primarily. There is also labor, the only <u>surplus</u> economy available.

What else do the islanders have? They have <u>developing leaders</u>. Some of them are already on the scene, and they are very clever. More important, most of them are coming from the age groups of roughly twenty to forty. Some of them are

educated, and some are uneducated in terms of college degrees, but they are leaders.

What don't the islands have? There really isn't any capital for fishery development work. They have capital to buy boats. But one of the most shocking things about the dory projects is that, although there is money to buy boats, there isn't money for training and development.

What else don't they have? They don't, at this moment, have systematic training opportunities that will produce fish, employ the fishermen, and allow them to come home at night to the family environment of the village. They don't have a very adequate extension or communication network for spreading small-boat expertise or for the transmission of aquaculture expertise.

What about new technology? I think that, at least in this area of the world, you don't need new technology in terms of small-boat fisheries. The technology already exists. What you do need is a transfer of that technology through application and through training and demonstration. Fishing boats and gear are perennially undergoing evaluation. The innovations are modest, but sometimes what looks like a modest innovation is really profound.

So we are evolutionists. I am not going to wait around for the perfect boat or engine for the islands. One is guided by marketplace realities. Does it work? Can it catch fish? Does it make money? And you continue to evolve. There can be a transfer of technology of such things as processing, drying, smoking the fish, simple refrigeration systems, and so forth. I would further submit that we don't need any more massive studies by two-day experts. What we do need, in at least the Pacific islands, is a systematic organization of fishing that will feed people within the cultural norms. Fishery research is badly needed, but not taxonomy, not life studies. That has been done. What we do need is stock assessment, population dynamics.

Small-boat fisheries in this area can supply two things: directions and data. In the area of directions, we have things like stock assessment, migration, the behavior of fish, and population dynamics. Data should be taken from reef ecology, and some insights may be gained into fish migration, both intra-island and inter-island. We also need data and research in anthropology.

We must get a practical small-boat fishery training effort for islanders. It is worth it in the Pacific.

Aquaculture in the Pacific Basin

Harold L. Goodwin

I would like to clarify some of the terms we have been using. By "subsistence," we mean fisheries and aquaculture that start at the family, kinship group, village, or in some cases, at the provincial center level. The difference between "subsistence" and "commercial" from this point of view is one of scale rather than one of kind. There is also a species difference. As we look at the case of the Pacific, one of the fishes most commonly eaten there is of the Siganid family, called a rabbitfish. It is a very good fish, but it is not a commercial fish in the usual sense. Rabbitfish is one of the priorities assigned in our Pacific mariculture conference simply because it is a food fish for the people of the islands. Commercial-scale rabbitfish mariculture might develop within the market where rabbitfish is eaten, but probably not outside of it. That would limit the scale.

There is also a question of defining, in our terms, who does aquaculture. Generally, commercial operations are started by entrepreneurs who have substantial financial backing. They have to operate on a large scale, which requires considerable capital investment. On the other hand, a local person who is operating at the village level can, with the labor of his own group, essentially create the facilities for aquaculture with minimal capital. I think we should be clear about these distinctions of scale, and in some cases, species. The difference essentially is that between subsistence farming and commercial agriculture.

The goal that we suggest is to enable the indigenous peoples to develop fisheries and aquaculture in order to benefit from their own enterprises, whether their purpose is simply to provide a kinship group or village center with fish or other aquatic products, or whether the enterprise is to become commercial as the scale develops. This approach is not at all incompatible with what is going on; there is a substantial amount of aquaculture taking place in the Pacific basin right now. Aquaculture is not new. For centuries, the Polynesians have been collecting mullet juveniles, putting them in impoundments, and growing them out.

But the technique has begun to disappear in many places. In some island groups, they have also been collecting milkfish juveniles as well as mullet from the environment and growing them out. We have seen the rise of tilapia culture, particularly in the far western Pacific. We did not include tilapia as a priority fish in our Pacific island mariculture conference because the techniques are so well-developed. So, a great deal is going on that provides a base on which to build.

Another base was put into place by SPIFDA, the South Pacific Islands Fisheries Development Agency. Its aquaculture enterprises really did not suit the original purpose for which it was set up, which was to provide food for the islands. The three major SPIFDA centers, two of which were funded under the UNDP and the third funded by Sea Grant, are growing oysters as the primary crop. The indigenous peoples of the Pacific generally do not eat oysters, so they are producing an export crop. However, oysters are not the entire story, because at Bay St. Vincent in New Caledonia they are growing several other species, including rabbitfish. In Fiji, they are doing remarkably well with the oysters, developing a salable crop that does help the cash economy. In Palau, our investigators are also working on rabbitfish and on turtles. These are three bases that offer an opportunity for expansion as training facilities. We have had a half-dozen Micronesians training at our Palau center.

Perhaps I should define aquaculture. The simplest definition is that it is simply the culture and husbandry of aquatic plants and animals under partially or fully controlled conditions. The state of aquaculture at the moment is really comparable to that of the early days of farming. In the very early days, the farmers had to grow their own seed, or collect wild seed and plant it. That is pretty much the state of aquaculture today, except for certain species for which there is a substantial history. The Chinese started with carp, and carp culture is by far the largest single aquaculture crop in the world and is still growing. There are not too many animals whose life cycles are under complete control. In the United States, we have catfish, trout, and salmon whose life cycles we can control. Recently, the Malaysian prawn has been brought under complete control and there is now a hatchery operation in Hawaii. Molluscs are less of a problem. There are good hatchery techniques that have been developed for oysters and clams, but clams are not produced in very many places because of economics, not because of our inability to grow them. The species most prized in the Pacific areas include mullet and milkfish, which are not under full control. We have heard that the Chinese have succeeded in spawning at least one milkfish, and the Oceanic

Institute in Hawaii is making good progress with mullet.

We will not have truly viable aquaculture until we can supply seed to the aquatic farmers. This is also a prime requirement in the United States for any species that we may wish to culture.

On the other hand, there is a good deal of knowledge on how to grow aquatic animals, particularly in a labor-intensive system. Successful aquaculture, as it now exists, is labor intensive. Ponding using fresh water, or ponding using tidal flow for flushing, or creating revetments as the Polynesians did, are well-established techniques. The efficiency with which the techniques are used varies from place to place. We find in the Pacific islands, for example, that they do not have any real concept of how deep their water should be in order to protect their stock from extreme solar heating during the hot season. They have no real feeling for what water flow is necessary. Such rather small improvements in aquaculture techniques can be applied quite easily and would help to produce a better product in a more efficient way without more capital.

New species are coming under control, and we see the beginnings of polyculture. We are beginning to realize that, in a given pond or system, there are a number of ecological niches that can be filled with different animals. One animal may fill a niche by day, and another the same niche by night. We have seen the beginnings in carp culture, where different species of carp are put in the pond to maximize use of the water column. When this is done, the productivity of aquaculture will greatly exceed the yield per acre of any land crop.

A very good possibility for the Pacific is similar to what the Filipinos and Indonesians have been doing in rice paddies, using the wet paddy as a place in which a fish crop can be cultured. In the case of the Pacific island, it would be wet taro. Suitable aquatic animals added to the taro patches can grow to marketable size in the same growth period that the taro requires. This is certainly true of the Malaysian prawn. There is a great deal that can be done with such simple technology.

Part of the question that I have been asked to answer is, "Why the Pacific?" Felix Keesing, back in 1942, said: "From the days of Captain Cook and the other voyagers, the South Sea Islands have fascinated the peoples of the busy Western World. Imagination conjures up sultry lagoons, coconut palms bending before the trade winds, unhurried and uninhibited people with flowers in their hair, laughter or plaintive songs drifting through mysterious tropic nights, and perhaps deep in the jungle a lurking cannibal or headhunter. The picture is half-true and half-fantasy. This has served as an Elysium of the spirit and a way of escape from the

disciplines and frustrations of our highly experimental civilization. Recently, however, these islands, so useful for our emotional prophylaxis, have moved into the focus of reality."

The reality in the present case is malnutrition. I have seen reports of nutritionists whose conclusion is that kwashiorkor, a protein-deficiency disease, exists and simply has not been previously diagnosed. No one really starves in the bountiful Pacific; they simply don't get enough protein to develop their full capabilities. This is especially true of the children. One of the curious things to me about these cultures is that they love children, and illegitimacy in our sense is not a factor of life at all, but nevertheless they put the children lowest on the totem pole when it comes to feeding. The adults eat first and the children get what is left. When there is a shortage of protein, it is the kids who get hurt. It is a very serious problem. The situation is exacerbated by the changing economic situation. By aiding the islands to produce fish in sufficient quantity, we would hope that present trends would be reversed.

Looking at the Pacific in terms of a total world goal in the war against hunger, we find that the Pacific is characteristic of the entire area around the globe between the Tropics of Cancer and Capricorn. This is where most of the underdeveloped and developing nations of the world are located. The Pacific basin has the whole spectrum of geographic areas for fisheries and aquaculture that one can find in the developing countries, although some elements are smaller in scale than others. These are pure oceanic, reef, lagoon, estuarine, mangrove. There are warm seas and cold seas. We think of the South Pacific as being entirely warm, but if you look over to the eastern Pacific, the waters are too cold for coral reefs. There are also flatlands where typical aquaculture can take place, although there are not many flat areas available. As we turn to fisheries, we find pelagic fisheries, bottom, mangrove, and deep and shallow reef fisheries. This pretty well covers the spectrum of world fishing.

I think the Pacific basin is particularly challenging because of the mix of cultures, from the very primitive all the way to the Hawaiians, who are totally Westernized. It is a real challenge to fit small-boat fisheries and small-scale aquaculture into this variety. There also exists a very strong interaction between the Pacific basin and the rim cultures. There are populations of ethnic groups from around the rim countries in many of the Pacific islands. There is also interaction at scientific conferences, particularly those of the Pacific Science Association and, to some extent, the South Pacific Commission. Nevertheless, the islands are isolated enough so that manageable projects can be

initiated and followed to completion. To tackle such a program in the Philippines, where I have had some experience, would be extraordinarily difficult because of the hierarchal structure there and because of all the institutions that would be involved. But one can start in almost any group of islands and receive a warm reception; indeed, results can be seen relatively soon.

There is a full mix of political structures in the Pacific. There is a general lack of rigid bureaucracies, and there is an eagerness to attack problems. They do not go through the routine of "Let's begin a study and develop a commission and create a hierarchal system," as Barry Fisher's experience with the dory projects has demonstrated.

The Pacific islands share all of the problems of the circumtropical areas of the world. The problem of being able to preserve food once you get it and distribute it to places where it is not produced is critical. There are cultural blocks of one kind or another, where some kinds of fish may not be eaten in one island group but are prized in another. There is the inability to afford expensive imports, particularly of animal feeds, and aquaculture must rely on indigenous feed sources. There is a precarious economic base. There is population pressure, as the population continues to grow rather rapidly. There is a lack of trained personnel at all levels.

The Pacific, which happens to be the largest physical entity on earth, is also a microcosm of the entire world. Moving technology westward would not be difficult, because there is competence on which we could draw in Thailand, Singapore, and Taiwan. Certainly the Japanese can help a great deal. The Filipinos have much to offer in hands-on levels of aquaculture. So interchange of techniques would begin immediately.

Another question is, why should Hawaii be a center of operations?

Hawaii represents the only real center of scientific and technological strength in the Pacific basin. It is as good in aquaculture as any state in the Union and a good deal better than most. I have in my notes a listing of the institutions that are available in Hawaii and they add up to a very large and very solid base. Also, there are private groups associated with these institutions. There is aquaculture ongoing in Hawaii, and because it grew out of the institutions that I have mentioned, the aquaculture people are very receptive to bringing in trainees from other areas. In fact, there are many Pacific islanders who have already been trained through the East-West Center and the university.

There are smaller institutions with some capability in other parts of the Pacific--mainly the University of Guam; and the University of the South Pacific,

Fiji; and the University of Papua and New Guinea, which probably needs help most of all. And there are technical institutions of one kind or another, in several island groups, all of which offer some facility for certain parts of a program, including the training of the mechanics necessary to keep even a minimal amount of machinery running.

With that general background, if we look at the conceptual framework, I suggest that an immediate start can be made. In fact, there has already been a start with the dory projects, and Barry Fisher is ready to make a definite proposal for the establishment of a fisheries training center. For aquaculture, the situation is a bit more complex, but only because specific individuals and ongoing island aquaculture enterprises must be identified. We know the people and activities are there. Barry Fisher has identified leading fishermen in most island groups, but no one has inventoried the aquaculturists at the local levels.

The whole thrust of the concept is to depend on indigenous peoples, and not on Western experts. The Western experts have to be in the background, to be sure, but the real essence of the whole concept is extension, providing technical expertise through indigenous people who are trained to work within their own areas in order to build up both aquaculture and fisheries. The techniques are somewhat different in that aquaculture is much more widely spread, while fisheries training can be focused with a bit more ease.

We also suggest that existing organizations and institutions should be used. The term "catalyst" was used earlier, and I think it is very appropriate; the proposed program would stimulate and catalyze, but not duplicate. The amount of investment in aquaculture research in the Pacific is really quite large. I would guess that it is about three-quarters of a million dollars at this time. That makes an inroad into research needs, but it is not enough. The initial budget that was cast up at our Pacific Islands Mariculture Conference in February was a million dollars a year from all sources. I think that is a little low, because it did not take into account overhead rates for the institutions in which the research is done. Since overhead rates are going up, one probably would have to add a factor of 50 percent. There are enough institutions forming a base in the Pacific so that new institutions need not be created. I think that is a very critical point.

A second major consideration in the concept is to work from the operating level up. My own experience in dealing with fisheries and resources officers and with other officials indicates this would not be a problem. A pragmatic, village level program would be welcome, and would indeed be supported in kind and with

funds that the particular territory or island had available. This is my reason for saying that funds should be provided on a cooperative basis wherever possible. One of the objectives, for the long range, is to produce indigenous scientists and engineers. They are already being produced to a limited degree. It is mostly a matter of identifying people and helping them.

The kind of center necessary for training and research in fisheries development does not presently exist in the Pacific. Hawaii is not the place for it. Hawaii is not a fishery state. It does not offer the variety of opportunities necessary for the development of a fisheries center, nor does it offer the proper ambiance. Garth Murphy's report on the training of fishermen in Hawaii pointed out that it was a bad place to train them, because the islanders move into a totally alien culture and become so confused that the results are simply undesirable. We suggest Fiji as the proper location, because the waters around Fiji offer the whole spectrum of fisheries, the Fijians are receptive, their university exists to do this kind of thing, particularly in extension work, and the government is prepared to support such a center. Culturally speaking, the Fijians are acceptable to most cultures in the Pacific even though some of those cultures may battle with each other. In looking over the whole Pacific, it seems that Fiji would be the most sensible location for this kind of center. Furthermore, it is at the heart of western Pacific transportation. One can get to Fiji from almost anywhere, but one cannot get to most of the other islands easily. There is very heavy ship travel and supplies can be moved with relative ease.

Aquaculture initiation means taking what exists and helping the entrepreneurs to improve what they have so that they can act as demonstrators and show how it can be done. We know the number of small aquaculturists is growing. The cultured species of immediate interest are milkfish and mullet, depending initially on recruiting juveniles. Carp can be introduced. Carp cultures already exist in Fiji. Tilapia and rabbitfish culture can be added wherever they apply, wherever the fish are culturally acceptable.

Down in the Cayman Islands in the Caribbean there is a commercial turtle farm. It is successful in making money for the investors. It has depended in the past on collecting eggs from the beaches around the Caribbean and then growing the turtles to adult size. Recently, turtles were bred successfully. This opens up considerable possibilities for green turtle culture in the Pacific. The good thing about the turtle is that all of it can be used except the head; every bit of it is part of commerce. I mentioned that oyster culture is going well, but oysters are an export item or perhaps suitable for local tourist consumption. We really

have not examined all the possibilities. One of the interesting combinations is rabbitfish and oysters in the same system. Cage and basket culture of fish, shellfish, and even seaweeds are distinct possibilities in some places where there is reasonable water flow.

Another step is to accelerate what the scientists are doing to solve some of the problems. Seed stock is a major problem. Disease has not been too serious a problem yet, but epizootics are always probable when you start to crowd animals, and particularly when you stress them in higher than normal temperatures. Preservation of environmental quality is a very important consideration. There has not been enough aquaculture in the Pacific to really affect the environment at all, and I can't really imagine a growth big enough to endanger it seriously. The number of species suitable for aquaculture must be increased by scientific research. I always have the feeling that there are possibilities that we have not yet touched.

We can't leave it entirely to the scientist to worry about aquaculture, because each scientist has a tendency to ask his own questions. Sometimes the questions are really not relevant to the immediate need. We need research that is directed sharply toward problem-solving, and the problems must grow out of the operations themselves.

Advisory and technical assistance is another element of the suggested plan. It ties in with all the rest and is really the lead item. We know from every report and conference that technology transfer is of highest priority.

The need for food technology and distribution speaks for itself. There are two problems: one is to feed the aquacultured animals themselves, and the other is to develop ways of getting the food to people.

Let me end on one vital note: if a program is started, it must continue. The Pacific peoples have been promised too much for too long from people who did not follow through. It would be an enormous disservice to start something that could not be finished.

A PROPOSAL

For the Creation of an International Center for Living Aquatic Resources Management (ICLARM)

John A. Pino

Aquatic animals--fish, crustaceans, and molluscs--supply about 18 percent of the animal protein consumed worldwide; however, that total obscures the importance of fish as a protein source throughout much of the underdeveloped part of the world. In the developed countries fish constitute 6.7 percent of animal protein supplies; in the less developed countries, 21 percent. Even these estimates are deceptive; an estimated 750,000 people of the Pacific basin, Southeast Asia, the Indian subcontinent and coastal Africa and South America derive between 50 percent and 85 percent of their animal protein supplies from fish harvested from coastal zones, estuaries, and fish ponds.

Although the people in these underdeveloped areas are dependent on fish for animal protein, widespread undernourishment and endemic malnutrition and hunger give all too clear evidence of their inability to supply themselves with sufficient quantities of fish to provide subsistence-level diets. Increasing populations, the economic and ecological exigencies of land use, generally weak technical bases and inadequate economic infra-structures suggest a worsening of protein deficiencies unless scientific and technical resources existing in the developed nations are applied to expand fisheries resources throughout the underdeveloped areas.

While the world growth rate of fish production has been about 6 percent per year over the past 20 years, and currently exceeds 70 million metric tons, these data refer to aquatic resources that for the most part are harvested by and for the benefit of the developed nations. The underdeveloped nations are heavily dependent on subsistence fishing in coastal zones and on aquacultural production; there is no evidence that production from these sources has increased to any marked degree during the past 20 years. Furthermore, increased demand for fish within the developed countries has resulted in processed fish supplies being withdrawn from markets in underdeveloped areas or priced beyond the reach of all but a small section of the population.

It would be naive to assume that developing nations can attain an increased yield, either in capture fisheries or from aquaculture without encountering serious constraints--inadequate international regulations; sea fishing advantages accruing to nations with high technology; site competition; political, cultural,

technological, organizational, and manpower and training problems and deficiencies being just some of them. By the same token it is incumbent on organizations with worldwide concerns and responsibilities to place the rapid fostering of aquatic protein supplies for the world's hungry very high on their list of priorities.

Fisheries are one of the few food-producing industries whose growth rate has kept ahead of the rate of population increase since World War II. In order to maintain present per capita consumption, however, fish production will have to reach 107 million tons by 1985. If this goal is to be attained without depleting valuable stocks and endangering prized species, greater national and international attention will have to be given to every aspect of living aquatic resources management.

Although there are a great many governmental agencies, university programs, and private enterprises concerned with fishery research and development and water quality control in this country and abroad, the field of living aquatic resources management remains fragmented and unfocused. A prominent Japanese expert remarked that fishery research and development is like a symphony orchestra without a conductor. It is probably worse than that.

The inventory of major problems and restraints must start with the the absence of clearly defined national and international priorities and goals, leading to a lack of consensus on legal, commercial, and scientific questions and a total lack of organization. Authorities disagree about the potential sustainable yield of the oceans; they differ over which species to include in estimating the potential harvest. The economics of exploiting ocean resources have never been analyzed at the international level, nor have precise studies been made of the economic base for private or public investment in particular areas. Governments continue to clash over fishing rights in international waters; in coastal fisheries where aquaculture is being practiced or will be practiced during the next few decades, private investment is discouraged by government restraints and by possible conflicts of economic interest and use patterns with regard to the intensive use of land-water interface; the advancing technology of ocean fishing is making small operations uncompetitive and raising costs to the consumer. Fishing fleets and factory vessels roam the open seas depleting stocks of commercially valuable species with impunity; offshore and estuarial pollution from cities and from industry is endangering fish populations as well as diadromous species like salmon and shad which move seasonally from salt to sweet waters.

Like other branches of agricultural science, the field of living aquatic resources management is plagued by disciplinary compartmentalization at both

academic and professional levels and by a lack of communication between relevant theoretical and practical branches; channels are lacking for getting information from research laboratories to commercial producers. Extension of practical information to subsistence fishermen is almost non-existent--even countries that have well-developed fishery industries have no organization or trained personnel for this type of work. The developing countries suffer from a shortage of scientific and technical personnel, ranging from marine scientists to ecologists and fish biologists to skilled fishing-fleet skippers to food technologists, economists, and market analysts.

But if the problems and the needs are great, so is the potential. Fishery development is important not only as a source of protein, but also as an element in economic development--a means of generating profits, creating jobs, encouraging investment, and providing exports, which brings in foreign currency.

The growth rate of fish production, about 6 percent per year over the past 20 years, is higher than the overall growth rate of food production, which has been maintained at about 3 percent per year, but indications are that this rapid increase may soon level off; authorities believe it cannot be sustained for more than 10 to 15 years unless new and less desirable types of fish are added to those traditionally harvested.

Unit of effort, both in technology and time spent on fishing, has risen sharply during the time of the great expansion of world fisheries. The current increase in total yield from most fishing areas is not at all commensurate with the investments that went into increasing the effort. In addition, the regulation of capture fisheries awaits the application of new social inventions, such as limited entry, special region leases, and the like, which have been discussed by economists and legal experts for a long time.

Fish farming as it is practiced today is still essentially the raising of wild animals in captivity, and where advanced technology has been applied, pond-raised fish and shellfish are mainly high-priced commodities raised for luxury markets. In the traditional ponds of Southeast Asia, where fish culture has been practiced for centuries, average yields are low, and costs of technological improvements are beyond the means of most producers. Nonetheless, the potential of fish farming for both commercial operations and small farmers is calculated to be enormous. A survey of Philippines fishery resources made for The Rockefeller Foundation in 1967 estimated that in brackish water ponds, proper management could increase production from 450 kilograms per hectare to 2,000 kilograms; in freshwater ponds, the use of modern methods could be expected to raise the yields from

350 kilograms per hectare to 3,500.

In addition to its economic potential, fishery development can contribute to pollution control. Sewage has been used successfully as a base for fish farming in Eastern Europe and Asia, and in this country fish have been raised in power plant effluent. Thus fish farming can effectively utilize the nutrients in waste and at the same time improve water quality.

The economics of fishery enterprises are complicated. An FAO commodity study for 1968-69 concludes, in essence, that the market for fish in developed countries is limited because people have too much money, and in developing countries it is limited because people have too little. The study reports that "with rising income, there is a tendency (in the affluent nations) to substitute meat for staple fishery products"; in developing countries there has been a good export market for fishmeal and high-priced crustaceans, but "expansion of the domestic market is checked by...lack of purchasing power." It is generally agreed that government programs and subsidies aimed at increasing fishery output must stimulate enterprises that will eventually be able to stand on their own feet. At the same time, governments have a stake in getting cheap protein to the lowest-income groups without depressing profit incentives to producers.

The complexity of the scientific, economic and social, legal, and environmental questions raised, and the interlocking and often conflicting nature of the national and commercial interests involved in fishery development and trade, point to the need for a more systematic and integrated approach at the international level, in terms of defining goals and priorities, developing the necessary information base to guide policy decisions, implementing programs, and facilitating communication and exchange. This kind of effort should embrace not only governmental agencies, research centers, commercial centers, and other organizational entities, but also a wide range of scientific disciplines both theoretical and applied.

It is therefore proposed that an International Center for Living Aquatic Resources Management (ICLARM) be established to work toward the increased production and distribution of aquatic resources.

While evidence of animal protein shortage is general throughout the underdeveloped regions, the nature and complexity of the problems differ markedly from country to country. It would be impractical to attempt to address all of the problems in all of the protein-deficit areas simultaneously. At this time, the Pacific basin would seem to be the most appropriate area for the center to focus on initially for several reasons: a combination of scientific and educational institutions in Hawaii constitutes a strong technical resource that could provide a

base for scientific investigations in aquaculture; the higher land areas and coral islands of the region lend themselves to a wide range of aquacultural methods; reef and coastal fishing gear and techniques are typical of those found in other areas throughout the underdeveloped regions of the world; and, importantly, local leaders have expressed a desire and willingness to work within the context of such a program. Much of the area suffers from protein deficiency, and there is concern on the part of national and international leaders to alleviate this situation.

The objective of the proposed center is to create a measurable and significant impact on the productivity levels of subsistence fisheries and aquacultural farming in the Pacific basin. It will accomplish this by:

(1) Identifying major impediments to increased fisheries yields, with major emphasis on acceptable food species;

(2) Establishing in conjunction with local institutions one or more fisheries training centers able to instruct selected village-level fisheries leaders in methods of boat-building, mechanical repair, and use of fishing equipment.

(3) Supervising local developmental programs designed to encourage use of appropriate aquacultural and fishing techniques throughout the area;

(4) Through emphasis on use of advanced research procedures, strengthening research programs, and encouraging the resolution of problems and the creation of new knowledge relevant to the management of living aquatic resources;

(5) Through cooperative efforts, assisting in devising comprehensive plans and policies for fisheries development at the national or regional level which include social, economic, and technological considerations;

(6) Assuring an adequate level of professional training of outstanding Pacific basin scientists concerned with fisheries;

(7) Arranging, through cooperative effort, for the collection of data relevant to aquatic resources management and developing means for providing broad access to that information;

(8) Conducting conferences and seminars and encouraging the publication of reports and other material, in order to foster exchanges and cooperation among scientists and technologists in related disciplines.

ICLARM would develop as a center for coordinating and focusing the efforts of independent but cooperating institutions, thus encouraging the several active Hawaiian aquacultural research institutes--the University of Hawaii, the Oceanic Foundation, the Hawaiian Institute of Marine Biology, and the Anuenue Fisheries Research Laboratory--develop a coherent complex of research programs directed

toward a more efficient aquacultural management. In conjunction with such indigenous institutions as the University of the South Pacific, in Fiji, ICLARM would work with various island groups in establishing a facility to train fisheries leaders from other areas. The assistance of the South Pacific Commission and other agencies, as well as local government, churches, and community organizations, could be enlisted in helping development programs in aquaculture as well as coastal fishing methods reach local fishing communities.

Since it should be unnecessary to conduct in-house scientific investigations, the staff of the proposed center could be small, comprised of a multidisciplinary team qualified to work with and through established agencies.

Initially, the personnel of the center would consist of a program director, charged with formulating and administering the program, and his staff. Ideally, he would be a man with administrative experience, familiar with problem areas facing the aquaculturist and subsistence fisherman, and motivated to involve existing scientific and technical institutes in achieving the center's goals.

Realistically, one must assume that substantial improvement in fisheries production will not be easy; policies will change, unforeseen problems will arise, and planning must be long-range. Socioeconomic conditions in more populous areas will present difficult problems. Nevertheless, the potential for increase in the supply of aquatic protein is so great--and the need so imperative--that maximum effort should now be exerted to build professional capabilities in aquaculture and to ensure that new information, along with improved methods and gear, are immediately available to the small fisherman as well as to the commercial producer.