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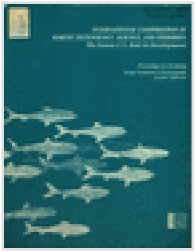

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INTERNATIONAL COOPERATION IN MARINE TECHNOLOGY, SCIENCE, AND FISHERIES: The Future U.S. Role in Development

Proceedings of a Workshop

January 18-22, 1981
Scripps Institution of Oceanography
La Jolla, California

Marine Technical Assistance Group
Ocean Policy Committee
Commission on International Relations
National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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MARINE TECHNICAL ASSISTANCE GROUP
OCEAN POLICY COMMITTEE

CONTENTS

PREFACE

Investigation of the ocean and management of its resources have become matters of increasing international concern. Developed and developing countries alike have extended the boundaries of their maritime jurisdiction and are exercising new responsibilities over the exploitation of renewable and nonrenewable marine resources. These changes have come about in part through advances in ocean science and technology, which have made possible expanded use of marine resources. In many instances, management of those resources and protection of the marine environment will depend on fuller understanding of small-scale as well as global ocean phenomena and on strengthening institutions of marine science in developing countries. Because the ocean, like the atmosphere, links the nations of the world, the pursuit of knowledge of the ocean necessitates interaction among nations. Thus, marine technical assistance and cooperation with developing countries can advance national, international, and scientific causes.

The Ocean Policy Committee has maintained a continuing interest in the nature and effectiveness of U.S. programs of marine technical assistance and cooperation. In April 1979 the committee established the Marine Technical Assistance Group to undertake four related tasks: (1) to assess the relationship between the objectives of marine technical assistance and cooperative programs and the means that have been developed to achieve them, (2) to project future U.S. policy objectives and future needs of developing countries for marine technical cooperation, (3) to assess U.S. capabilities to meet its objectives and fulfill the needs of developing countries, and (4) to recommend policies and mechanisms for future U.S. programs of marine technical assistance and cooperation.

These proceedings reflect views expressed by workshop participants--scientists and technologists from the United States and developing countries and from national and international agencies. Marine science is closely tied to fisheries in many developing countries. Accordingly, most workshop participants devoted comparatively little attention to other marine resources and technologies.

The participants organized themselves into four regional working groups, each of which prepared a report assessing marine-related needs in the region. Although those reports differ in important respects and merit separate attention, they also reveal an unexpected concurrence on a number of major issues among the regions. Key recommendations have been drawn from the reports of the working groups and are presented in Recommendations of the Workshop. The Summary and Introduction reports briefly on the major issues discussed in plenary sessions of the workshop. The main body of this volume consists of papers prepared by workshop participants for use as background information.

On behalf of the Marine Technical Assistance Group, I wish to thank the workshop participants for their individual and collective efforts both before and during the workshop. I wish to thank the Scripps Institution of Oceanography for providing meeting facilities and logistical support. I also wish to acknowledge the work of the Ocean Policy Committee staff, led by Mary Hope Katsouros, executive secretary, who was assisted by Debra Luks, Hollys Harloff Ender, Mary Tolios, and H. Dale Langford, who prepared these proceedings for publication.

Finally, the Marine Technical Assistance Group acknowledges the financial support of its sponsors, the Agency for International Development, the National Oceanic and Atmospheric Administration, the U.S. Department of the Navy, and the U.S. Department of State.

John Liston, chairman
Marine Technical Assistance Group
April 1981

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WORKSHOP AGENDA

Future of International Cooperation in
Marine Technology, Science, and Fisheries
La Jolla, California
January 18-22, 1981

Sunday, January 18

Reception and dinner

Welcoming address by John Liston, chairman
Workshop Steering Committee

Monday, January 19

Plenary session, chaired by John Liston

Overview, presented by Roger Revelle

Panel on the U.S. Program in Marine Technical Assistance, chaired by John V. Byrne
Panel members:
- Judith Kildow
- Vic Klemas
- Philip Roedel
- David Ross
- Christopher Vanderpool
- Francis Williams

Panel on International and non-U.S. National Programs, chaired by Bernhard Abrahamsson
Panel members:
- Geoffrey Holland
- Dale Krause
- Ulf Lie
- Julio Luna
- Harry Winsor

Panel on New Directions and Alternative Mechanisms for Marine Technical Assistance, chaired by Richard Meunier
Panel members:
- Agustin Ayala-Castanares
- Francis Henderson
- Vladimir Kaczynski
- Francisco Palacio
- Ziad H. Shehadeh

Organization of Working Groups

INTRODUCTION AND SUMMARY

Negotiations at the Third United Nations Conference on the Law of the Sea and extensions of maritime jurisdiction by many coastal countries reflect the growing economic importance of ocean resources and their management. Many developing countries have expressed new interest in the exploitation of marine resources, including fisheries, in their 200-mile economic zones. The Marine Technical Assistance Group, of the National Research Council's Ocean Policy Committee, has examined the implications of these changes for future policies of marine technical assistance to, and cooperation with, developing countries. The Workshop on the Future of International Cooperation in Marine Technology, Science, and Fisheries was one part of that study. A principal objective of the workshop was to solicit the views of representatives of countries concerned with marine-related assistance as recipients or, in some cases, as donors.

Of the 59 workshop participants, 20 represented developing countries, international institutions, or donor countries other than the United States. The participants organized themselves into four regional working groups, which were the core of the workshop. Before the working groups convened, participants met in plenary sessions, during which various panels explored topics important as background information for the working groups. Each of the four working groups--on Africa, Latin America and the Caribbean, Southeast Asia and Oceania, and the Near East and India--prepared a report for presentation in a final plenary session. (See Reports of the Working Groups.)

Several themes emerged from the plenary sessions of the workshop. Developing countries have a strong interest in marine technical assistance and cooperation, particularly if those activities are based on

- Participation as an equal partner with the United States or other donor country

- Institution-to-institution bilateral arrangements

- Long-term commitments from participating countries and institutions

- Maximum flexibility and a minimum of bureaucratic constraints in the management of programs

- Recognition of the need for economic and political benefits to the participating countries, including the United States

Participants stressed the importance of basing the management of marine resources on a firm foundation of technical and scientific expertise. Although traditional fishing methods have occupied an important place in the economies of many developing countries, few are able to make use of modern marine technologies without assistance. Moreover, some participants felt that the ocean environment is so uniquely different from the land environment that technicians, engineers, and researchers who have not been specifically trained in marine sciences will not be effective. Thus, an important aspect of marine assistance is the technical education and training of local people as marine scientists, engineers, technicians, and managers. Participants considered such education and training, coupled with the strengthening of marine technical institutions, essential to the establishment of self-sufficient fisheries and other marine enterprises in developing countries.

The workshop brought out a definite preference among developing countries for bilateral rather than multilateral arrangements for marine-related technical assistance and cooperation. Representatives of developing countries expressed a growing interest in direct relationships with developed countries that could lead to the transfer of technology to meet to their national needs. Multilateral arrangements were viewed as generally less effective in meeting the development needs of any particular country. However, workshop participants favored regional cooperation in technical training and in the use of expensive research facilities.

Participants expressed the need for a central point of contact within the U.S. government for information regarding marine technical assistance. Such an office was deemed necessary to coordinate information on the marine-related programs currently administered separately by several federal agencies. An important function of the office would be to direct inquiries and research proposals by foreign as well as U.S. scientists to the appropriate agencies.

Participants from the United States and from other countries recognized that, as an important justification for any U.S. program of marine technical assistance, the program should be seen as producing mutual benefits and furthering U.S. interests as well as the interests of the host countries. Thus they underscored a major theme of the workshop: Countries that have in the past been recipients of technical assistance desire to work toward participating in future programs on an equal, cooperative basis.

The following is a summary of discussions in the plenary sessions of the workshop.

The first plenary session opened with Roger Revelle's presentation of an overview of marine technical cooperation in the 1980s. (See "Marine Technical Cooperation in the 1980s: An Overview.") Needs for marine technical cooperation include improving the management and productivity of the world's fisheries, increasing understanding of offshore deposits of oil and gas, protecting and developing coastal zones, and understanding the interactions between the ocean and climate. Ways in which technical cooperation can be carried out include the education of scientists, engineers, and managers; training of marine technicians; provision of research equipment and technical information; cooperative research projects; and strengthening of the scientific and technical institutions in developing countries. Dr. Revelle stressed the need for cooperation not only to improve social and economic conditions in developing countries but also to increase understanding of the oceans and of ocean phenomena on a global basis.

John Byrne chaired a Panel on the U.S. Program in Marine Technical Assistance in the second plenary session. Other panel members were Judith Kildow, Vic Klemas, Philip Roedel, David Ross, Christopher Vanderpool, and Francis Williams.

The United States has provided marine technical assistance for many years to developing countries. The objectives of current marine technical assistance programs are to promote economic growth and political stability in developing countries, to provide access to foreign waters for U.S. marine research, and to help achieve international economic goals--through increased world use of marine resources--without harming U.S. markets. A number of U.S. federal agencies are involved in providing marine technical asssistance to developing countries, as is indicated in "Federal Support for Marine Technical Assistance" (see pages 63-75). There has been mixed success in achieving the current objectives because of several identifiable problem areas, including (1) absence of an official network among agencies, universities, and private foundations involved in technical assistance; (2) absence of social sciences contributions to management of science and technology and in resolving conflicts over use of the coastal zone; (3) lack of emphasis on marine engineering and technical innovation; (4) absence of overall planning of marine-related assistance programs; and (5) emphasis on directing U.S. assistance to the poorest elements in developing countries rather than to people and institutions who are better able to use U.S. technology.

The panel found that most marine technical assistance programs of federal agencies are administered independently of each other and lack the central direction of a national policy on marine technical assistance. Emphasis on marine fisheries and aquaculture as elements of technical assistance to developing countries has varied cyclically within U.S. agencies, specifically within certain key agencies, such as the Agency for International Development and the National Oceanic and Atmospheric Administration. Panelists felt that the current U.S. policy of directing assistance primarily to the poorest segments of the population within developing countries has not been effective with regard to marine sciences and technology. This point was underscored in a later panel by the representative from the International Center for Living Aquatic Resources Management in the Philippines, who said, "Helping the 'poorest of the poor' sometimes challenges common sense and flies in the face of the laws of economics."

A Panel on International and Non-U.S. National Programs, chaired by Bernhard Abrahamsson, examined the marine technical assistance programs of Canada, Norway, Sweden, the United Nations Development Program, the Inter-American Development Bank, and the United Nations Educational, Scientific, and Cultural Organization. Panel members were Geoffrey Holland, Dale Krause, Ulf Lie, Julio Luna, and Harry Winsor. The panel found an increasing interest worldwide in ocean fisheries. Much of that new interest derives from nations' adoption of 200-mile exclusive economic zones and their acceptance of new responsibilities over the marine resources, including fisheries, within those zones. There is a need for greater understanding of the composition and dynamics of the world's fisheries; in this respect, all nations are underdeveloped. Although much of the necessary new understanding of marine resources depends on scientific and technical achievement, panelists Krause and Luna stressed the importance of political action. In the United States as well as in developing countries, there is a critical need to establish political support for technical assistance directed to fisheries.

Richard Meunier chaired a plenary session Panel on New Directions and Alternative Mechanisms for Marine Technical Assistance. Other panel members were Agustin Ayala-Castanares, Francis Henderson, Vladimir Kaczynski, Francisco Palacio, and Ziad Shehadeh. International institutions such as the Intergovernmental Oceanographic Commission and the Food and Agriculture Organization of the United Nations have directed their marine assistance efforts primarily toward specific problems identified by the recipient nations and have emphasized regional cooperation in solving those problems. Although this approach has been effective, it has stressed short-term, technical projects, such as experimentation with aquaculture, rather than the long-term goal of providing self-sufficiency in marine sciences and technology. The panel found that the key problems to be addressed by assistance programs are institutional, not technical or financial. Rather than the narrow technical emphasis of past marine-related assistance programs, future programs should stress the building of marine institutions similar to international agricultural research centers. International joint ventures by commercial fishing concerns and developing countries generally have not realized their potential as means for expanding marine technical assistance and cooperation. Many developing countries view past joint ventures with companies in more developed countries as primarily exploitative.

A Panel on the Needs of Less Developed Countries in Marine Science, Technology, and Fisheries was chaired by Harris Stewart. Other panel members were E. O. Bayagbona, A. R. Bayoumi, Manuel Murillo, and Inocencio Ronquillo, who were chairmen of the four regional working groups. Although the panelists agreed that technical assistance is necessary for development of the marine sciences in their regions, views differed on the most effective means by which assistance could be provided. Bilateral assistance programs are favored in most regions, including Latin America and the Middle East, while multilateral programs such as those of United Nations agencies are considered more effective in some African countries. Specific needs among the regions included assessment of fish stocks, strengthening of marine institutions, reduction of postharvest fish losses, and improvement of local training and education facilities. Dr. Bayoumi stressed the importance of cooperation, as distinguished from assistance, in marine programs in the Middle East and the need to go beyond stock assessment to studies of how best to use available fish stocks. Dr. Ronquillo pointed out that recent expansion of commercial fisheries in the Philippines and throughout much of Southeast Asia has led to overfishing. He stressed the region's need for assistance in conservation through basic research related to fisheries and oceanography.

A panel chaired by John Craven discussed joint ventures in fisheries as a means of technical cooperation, the potential for ocean thermal energy conversion, and strategies for linking the marine and fisheries interests of developing countries to the oceanographic and related research interests of the United States. Panelists were John Costlow, Vladimir Kaczynski, and Michael Molitor.

Members of the Marine Technical Assistance Group met to consider possible policy initiatives arising from the discussions of the panels and the working groups. John Liston reported the consensus of the group in a plenary session near the close of the workshop. It was agreed that there is a need to establish in the U.S. government a central, coordinating office on marine scientific and technical assistance to act as a clearinghouse for U.S. interests as well as those of developing countries. The group also agreed that the socioeconomic aspects of marine technical assistance, including its planning, management, and evaluation, should be carefully considered as well as the scientific and technical aspects. There was agreement on the need for continued support for the marine technical assistance and cooperation programs of regional governmental and nongovernmental organizations, such as the International Center for Living Aquatic Resources Management and the East-West Center. There is a related need to encourage increased communication and cooperation among national aid agencies, including the Swedish International Development Authority, the Norwegian Agency for International Development, the Canadian International Development Agency, and the U.S. Agency for International Development.

RECOMMENDATIONS OF THE WORKSHOP

The following key recommendations are abstracted from the reports of the regional working groups at the Workshop on the Future of International Cooperation in Marine Technology, Science, and Fisheries.

NEEDS OF DEVELOPING COUNTRIES

Programs on international cooperation and technical assistance in marine-related fields should

1. Assist developing countries to learn the extent of their marine resources by synthesis and interpretation of currently available information on renewable and nonrenewable marine resources and by detailed surveys of marine resources within their 200-mile economic zones. Specific needs include advanced techniques and training for assessing multispecies fish stocks, conducting hydrographic surveys, and assessing mineral resources especially in the deeper waters within the 200-mile zone.

2. Provide for the training and education of local people as scientists, engineers, and technicians. Assistance should be directed to building the scientific, technological, and academic institutions necessary to train and employ scientific and technical personnel in resource exploration, utilization, and management.

3. Promote the establishment of regional training centers and research facilities in fields of regional concern, including stock assessment, aquaculture, reduction of postharvest losses, and management of marine fisheries. Centers for marine-related training and research should be patterned after successful regional centers for agricultural training and research.

4. Include economists and social scientists in the planning, management, and evaluation of marine-related projects to assure adequate consideration of the sociopolitical and economic framework of the host country.

5. Provide technical assistance according to priorities established by the host countries.

6. Promote regional coordination of marine-related research and the dissemination of research findings.

7. Encourage establishment of links between governmental agencies and the private sector with respect to training and research programs and marine technical development.

8. Include mechanisms for ongoing supervision and evaluation of project performance.

9. Promote the development of scientific leadership for the future by encouraging the participation of younger scientists. Programs also must be structured in such a way that they will be accepted by the present scientific leadership in the host country.

U.S. PROGRAMS OF TECHNICAL ASSISTANCE

Agencies of the United States government that support programs of marine technical assistance should

10. Establish a clearinghouse for information on marine technical assistance. An office within the federal government should be designated as the central point of contact for U.S. or foreign investigators seeking information on U.S. support for marine-related projects.

11. Encourage increased cooperation between U.S. scientists and scientists from developing countries in planning and carrying out projects of mutual benefit. One proven mechanism for accomplishing this is the institution-to-institution approach.

12. Promote greater flexibility and continuity of funding support for assistance projects. There should be a commitment to the long-term support necessary to build the institutions that will make marine technologies and fisheries self-sustaining in developing countries.

13. Place increased emphasis on fisheries and marine science in U.S. foreign-aid programs. Agencies supporting marine-related technical assistance should maintain strong professional staffs

competent in marine and fisheries affairs. Because 200-mile exclusive economic zones are major extensions of national jursidiction, marine sciences, technology, and fisheries should receive equal emphasis with agricultural and other land-based systems as means for economic and social development.

14. Recognize and address the language constraints in non-English-speaking countries. In particular, the United States should consider providing English-language training for non-English-speaking students.

MARINE TECHNICAL COOPERATION IN THE 1980s: AN OVERVIEW

Roger Revelle
University of California, San Diego
La Jolla, California
January 1981

Let us begin by discussing the different possibilities for international cooperation in the development and utilization of ocean resources. Consider first the problems of fisheries, which we may conveniently divide into questions of management, harvesting technology, aquaculture and saltwater agriculture, means for prevention of postharvest losses, distribution and marketing systems, and improving the welfare of fishing communities.

FISHERIES

Management. The emerging Law of the Sea places a responsibility on each coastal state to establish policies which will achieve and maintain an optimum sustainable yield from the living resources of a 200-mile-wide economic zone off its coast. Ideally, besides developing its own fishing industry, the coastal state should decide on the year-to-year allocation of fishing rights to fishing vessels of other countries. This will require estimates of stock sizes and availability of fish and shellfish, and of recruitment of new year-classes into the fisheries. For highly migratory species such as tuna, the nations need to cooperate in making estimates of total stock size and recruitment over a wide ocean area. From a strictly national point of view, knowledge of likely variations in stock size and availability over an extended period of years is essential to evaluate the potentials for investment in fishing vessels and human capital.

Even in a well-managed fishery, interannual variations in the catch may be very large. These appear to be related mainly to fluctuations in the ocean environment. Upwelling regions off the west coasts of continents provide a striking example.

The main upwelling regions of the world (Cushing 1969) lie in four regions of eastern boundary currents: the Canary Current off the Iberian Peninsula in northwestern Africa; the Benguela Current off southwestern Africa; the Peru Current off western South America; and the California Current off western North America. All four are characterized by broad, slow equator-ward flow of the upper ocean waters, high phytoplankton productivity, and massive pelagic fish stocks that have experienced extreme fluctuations. There are also extensive stocks of benthopelagic rock fishes, round fishes, and flat fishes. Very similar assemblages of pelagic fishes constitute the major portion of the exploitable biomass in all four regions. In each, there is an anchovy, a pilchard (sardine), horse mackerel (jack mackerel), hake, mackerel, and bonito. The similarity of the pelagic fish communities suggests that the environmental processes occurring in all four of these systems may be analogous and that variations in these processes regulate the recruitment and population fluctuations of the major fish species. Year-to-year variations in four categories of environmental processes are believed to have important effects: horizontal advection; vertical stability of the water column; horizontal and vertical distribution of temperature; and vertical advection resulting in convergence and divergence of flow near the sea surface. The latter is linked to variations in the wind stress on the surface which determine the Ekman drift in the upper 50 to 100 meters. Comparative research on the variations in these processes and their relationships to spawning success and recruitment of new year-classes into the fisheries could be of great value in improved predictions of year-class sizes and, consequently, in the determination of management policies and fishing-industry strategies.

Off the west coast of the United States, variations in the wind-induced transport of near-surface ocean waters differentially affect the reproductive strategies of different ecological groups of fishes. The benthopelagic group of rock fishes, round fishes, and flat fishes, which reproduce from central California north to British Columbia, have a peak spawning period in February--about two months before the beginning of strong upwelling. The emerging larvae are held in the favorable nearshore environment by the prevailing onshore transport. When seasonal offshore transport begins about two months later, the juveniles are large enough to hold themselves near shore by swimming or vertical migration.

The epipelagic groups of sardines, anchovies, hake, jack mackerel, and Pacific mackerel spawn off southern California and northern Baja California during the spring months of intense upwelling and consequent high phytoplankton production. As Lasker (1978) has shown, the concentrations of phytoplankton are usually characterized by a high degree of patchiness, and it is only in these patches that the quantities of phytoplankton are high enough to provide an adequate food supply for survival of the larvae. Strong winds during the winter can destroy phytoplankton patchiness by mixing--with a markedly adverse effect on the survival of the larvae and the recruitment of a new year-class.

Substantial catches of Pacific mackerel (Scomber japonicus) commenced off California in the late 1920s, and the fisheries expanded rapidly from 1932 to 1935. Landings reached a peak of 66,500 metric tons in the 1935-36 season. Thereafter, the fishery went through a long, fluctuating decline until it was nearly exhausted in the early 1950s. Good recruitment in 1953 and 1954, and in 1958-60, rejuvenated the fishery, but a series of poor recruitment years in the 1960s brought it to a temporary close. More recently, the population has rebounded strongly.

Parrish and MacCall (1978) have shown that during the first period of poor recruitment at the beginning of the 1950s there was an extended series of poor upwelling years in the upwelling maximum region off northern California. Anomalously low upwelling in the Baja California spawning area occurred during the decline in recruitment in the 1960s, while extremely vigorous upwelling in the 1970s resulted in excellent reproductive success in 1974 and 1976. This enabled the Pacific mackerel stock to rebound from its previous collapsed state. These environmentally dependent relationships are now being used by the state of California in its management strategy for Pacific mackerel.

The commercial salmon harvests in western Alaska during 1973 and 1974 were the lowest since the inception of the fishery at the end of the last century. This appears to have been the direct consequence of anomalously low air and sea temperatures during the winter and spring of 1971-72, which adversely affected the 1971 and 1972 year-classes. The severe winters and delayed thawing of lakes and streams destroyed the eggs or larvae and delayed migration of juveniles to the sea. Anomalously cold sea temperatures delayed the migration of adults into lakes and streams to spawn.

Because of the seasonal reverses of the monsoon, boundary currents in the Indian Ocean have a somewhat different character than in the Atlantic and the Pacific. Some sections of the broad continental shelf off the Malabar coast of India are flushed partially clean of life each year as the monsoon and the current turn, the thermocline rises toward the surface, and the oxygen-poor, cool water under it shallows and creeps in over the continental shelf (IOC 1976). Swimming animals are forced to the surface and toward the beach. Adult shrimps school in the upper water layers, and sole by the tens of tons surface and come into the beach seines. Farther north along the Saurashtra coast, the great Indian salmon, or dara (Polydactylus), swarms into the bottom-set nets.

About 80 percent of the marine fish catch of India is made on the west coast. The principal components of the catch, by volume, are the oil sardine (Sardinella longiceps) and the Indian mackerel (Rastrelliger canagurta). Both are subject to very wide fluctuations in yield. Over the past 100 years, the sardine catch has varied from 9 tons in 1946-47 to 191,000 tons in 1957. The catch peaks sharply during the transition period between monsoons, when cool, low-salinity coastal waters, characteristic of the southwest monsoon, are replaced by the warm saline waters of the northeast monsoon. The mackerel catch, while not so widely variable as that of sardines, also has a broad range. Generally speaking, when the sardine catch is up, the mackerel catch is down, and vice versa. Oceanographic and biological research to understand these variations in yields and their relationship to changing ocean conditions could be beneficial in several ways.

Agreements for cooperation in this research between American and Indian marine scientists were made at the Indo-U.S. Workshop on Oceanography in Goa, November 1978 (Department of Science and Technology, Government of India 1979).

Knowledge of oceanic events during the early life stages of many commercial fishes can be used to predict population sizes two or three years hence and thus to determine changes in management strategies. Where environmental conditions affect the behavior or availability of the adult fish or where the life cycle is short, this lead time is not available. For example, the large variation from year to year in the availability of skipjack tuna off Hawaii can be explained by year-to-year variation in the flow of the north equatorial current and the surface wind-driven currents (Seckel 1972). Similarly, year-to-year variations in the formation of ocean currents in the eastern North Pacific affect the availability of albacore tuna (Laurs and Lynn 1977). In these cases, climatic predictions several months in advance must be made in order to prepare for the changing availability of the resources.

Anomalously cold winter sea temperatures over the eastern seaboard of the United States have an adverse effect on the valuable shrimp resources of that coast. In years of below-normal temperatures, as in 1958 and 1977, shrimp catches may be only 30 percent of normal. Here is another example of the need for prediction of ocean climate.

In establishing policies for optimum sustainable yields, given the best possible estimates of stock sizes and recruitment, one role of international cooperation should be exchange of information and experiences among countries. How successful and politically feasible are policies for limiting entry into a fishery, compared with regulation of mesh sizes in fishing nets, length of fishing season, types of fishing gear, size and character of fishing vessels, or other means? International exchange of information on methods of collecting and using catch statistics for determining age distributions and other characteristics of harvested populations is equally desirable.

In recent years, it has been recognized that the problem of fishery management is really an ecological one. All species of important finfish and shellfish in a particular region should be considered together as an interacting ecosystem in which the different species compete for food and serve as food for each other at different stages of their life histories. A human fishery for one or several species disturbs the previously existing ecological equilibrium, and a sustainable harvest over a period of many years can be obtained only if a new equilibrium is established. In principle, therefore, effective fishery management must take into account these interspecific interactions. Unfortunately, neither adequate data nor useful theoretical models are available in most regions as a basis for such multispecies management, and much research is needed to establish essential parameters. International, multidisciplinary cooperative research among specialists from various countries is almost certain to be the most satisfactory means of solving these problems.

Harvesting Technology. The continuing dramatic rise in the cost of oil to power fishing vessels has made it essential to increase the energy efficiency of fishing technology, that is, to increase the quantity of the usable catch landed at the dock per unit of fuel consumed. All fishing nations need to improve their technology for locating and catching harvestable stocks of fish and shellfish, preferably as close to shore as possible, and to raise the fuel efficiency of their fishing vessels, including the fuel used for freezing and other on-board processing.

The potentials for energy conservation may be substantial. For example, it is said that in the North Sea fisheries, 20 kcal of fossil fuel energy are used for every kcal in gutted fish, or 8,000 kcal/kg of whole fish (Holt 1978). At $1.00 per gallon for fuel, the direct energy cost, not counting human labor, is about $0.25 per kilogram of whole fish and much higher for the edible portion.

Aquaculture and Saltwater Agriculture. One means of improving fuel efficiency is the cultivation of marine organisms in ponds or other confined areas. Aquaculture can also furnish alternative or additional employment for unemployed or underemployed fishermen and farmers. In developing countries it can provide a source of protein food, and if high-value species like shrimps and prawns are grown, a source of much-needed foreign exchange. In combination with agriculture, it represents a desirable means of utilizing human and animal wastes and also the waste heat of industry.

On a worldwide basis, aquaculture has made encouraging progress in the past 20 years, producing significant quantities of food, income, and employment. According to the 1978 Ocean Yearbook, it is now practiced in 66 countries, of which 35 are developing coastal states. In 1975, aquatic farmers in these 35 countries produced over 4 million tons of fish, shellfish, and seaweed, more than two-thirds of world aquacultural production of slightly over 6 million tons. These figures can be compared with total world marine catches in 1975 of about 60 million tons. It has been estimated that the area now under aquaculture is of the order of 3 to 4 million hectares. Average yields are between 1.5 and 2.0 tons per hectare, ranging from less than 1 ton to more than 20 tons per hectare. With improved techniques, these yields could be increased two- or three-fold in a relatively short time, and a ten-fold expansion of aquacultural areas is considered feasible. A doubling of world aquaculture production could be achieved in the next ten years, and a five- to ten-fold increase in three decades. But this will require accelerated transfer of technology, massive financial investments, suitable legislation, intensive research, manpower training, and development of institutions and other essential infrastructures (Pillay 1978).

Because future growth of aquaculture must involve development and transfer of technology on a large scale, regional and interregional cooperation assume special significance. The Consultative Group on International Agricultural Research (CGIAR) has recognized the need for coordinated regional networks of research centers in Asia, Africa, and Latin America to undertake systems-oriented, interdisciplinary research. Within the United States, the U.S. Sea Grant Program is sponsoring a National Aquaculture Information System. A principal problem, however, is the shortage of adequately trained and experienced field personnel with the ability and knowledge to assist aquafarmers through national or international extension services. Educational programs for aquacultural scientists and technicians are thus urgently needed.

Among the scientific and technical problems of aquaculture are breeding and larval production (or in the case of one commonly used fish, tilapia, prevention of frequent breeding to avoid overpopulation of ponds and consequent stunting of the adult fish), reducing feed costs, improving management of ponds, pens and cages, disease control, and harvesting technology. Chinese and Indian carp and gray mullets have been induced to breed by injections of pituitary hormones. Shrimps have been brought to reproductive maturity in the laboratory, and the spawn have been carried through the various larval stages of their life cycle. Controlled reproduction of oysters and hatchery production of oyster seed is a development of considerable importance, because among other reasons it has helped in genetic selection of strains for special qualities such as resistance to diseases.

Just as in agriculture, where corn--which originated in Central America--is now an important crop in China, and soybeans have migrated in the reverse direction, international exchanges of cultivated fish and shellfish species have become widespread. The possibly adverse effects of these introductions on local fauna and flora and in the transmission of communicable diseases are perhaps much greater than in agriculture.

Closely related to aquaculture are the research results obtained on genetic improvement and homing adaptation of salmon, which have made "sea ranching" economically profitable. Loren Donaldson of the University of Washington has bred salmon varieties that reach full maturity after 18 months at sea, and he has "imprinted" young salmon in a saltwater bay on the coast of Oregon. The adults return directly to a processing plant on the bay shore and its contained saltwater ponds, where selected animals can be milked for eggs and sperm and a new generation produced.

Carl Hodges of the University of Arizona and Emanuel Epstein of the University of California, Davis, have been experimenting with halophytic crop plants (Epstein, et al. 1980). Epstein's approach has been to increase the salt tolerance of conventional crops by genetic manipulation, while Hodges has been working to increase the quantity of useful products from plants that thrive under marine conditions. Both these promising technologies, even at the present stage of development, could find wide applications in coastal regions of arid lands.

Prevention of Postharvest Losses. In the developing countries, only 54 to 63 percent of the protein in fresh fish landed on the shore is retained for human consumption compared with 62 to 74 percent in the industrialized countries (FAO 1975). For salted and dried fish, less than 40 percent of the protein is retained in developing countries and about 55 percent in developed countries. Between 60 and 70 percent of the original protein is present in skinned and frozen fish consumed in the developed countries.

In addition to losses in processing, large quantities of the world's fish catch are discarded at sea as "trash fish," even though they could serve as a desirable human food. For example, Maschke (1976) has estimated that three metric tons of edible fish are thrown overboard for every ton of shrimp landed, basically because the volume of hold space in shrimp vessels is limited. This represents a total waste of 3 to 4 million tons annually. Overall, perhaps 4 to 6 million metric tons of fish (about 10 percent of the world fish catch) are discarded at sea after being landed in fishing vessels. International cooperation to reduce losses in processing and in capture could produce significant savings. In developing countries, special attention should be paid to improving and expanding the use of traditional methods of fish preservation such as the fermentation processes used in Vietnam and elsewhere in Southeast Asia.

The hake (*Merluccius productus*) is a major component of fish populations off the west coast of North America. But Americans do not use it for food because the flesh becomes soft and mushy before it can be marketed. Large catches have been taken in United States waters by Japanese and Soviet fishermen, however. The fish is frozen quickly in large factory ships so that the flesh retains a firm texture. It has been suggested that the textural deterioration in the absence of freezing is caused by a microorganism that infects the eastern North Pacific hake but is not present in the closely related species of other upwelling areas. This situation illustrates the complexity of the technical and economic problems involved in transferring technology between countries for fish preservation.

Distribution and Marketing Systems. Distribution and marketing systems for marine products are so intimately embedded in the economic and social conditions of individual countries that there may be little room for international cooperation to improve them. Buying and selling in the great Tokyo fish market are vastly different from the ways in which single, small fishing boats sell their catches on the beaches of Tamal Nadu in southeastern India. Yet both probably serve well to meet the needs of fishermen and consumers.

Of the total world harvest of living resources, 30 to 35 percent enters international trade in various stages of processing (Holt 1978). Quality regulation and control is a major problem for both producing and receiving countries, and international cooperation in setting quality standards is clearly necessary.

Improving the Welfare of Fishing Communities. In most developing countries, ocean fishing is carried out largely by artisanal fishermen, using small boats and traditional fishing gear. These fishermen usually live near the shore in small, relatively isolated fishing communities, and they are almost always desperately poor. On some coastlines, they augment their incomes by smuggling, but even so, they are often underemployed. Improving the welfare of these communities is a humanitarian responsibility for the larger society. This can be accomplished by providing capital and technical assistance for better fishing vessels and fishing gear, fish processing plants, and transport vehicles, as has been accomplished in the Norwegian Technical Assistance Program for the fishermen of the Malabar coast of India. Alternative means of employment such as aquaculture can also be developed, and the incomes of the fishermen can be enhanced by encouragement and advice for the formation of fishermen's cooperatives.

A small fishing community exists on the beach near the University of Lagos in Nigeria. Here fishermen have developed an alternative product, namely, sand for concrete construction which they obtain by diving and filling buckets in the shallow waters of a large lagoon. Their productivity and incomes could be greatly increased by provision of simple dredging equipment.

In a long bay on the island of Ambon in Indonesia, the principal catch of the village fishermen comes from communities of fish concentrated on small coral reefs and heads. With the growing farming population on the island, forests are being cleared for agriculture. Drastic erosion results. The sediments washed into the sea from the cleared areas are slowly strangling the corals, and the fish populations are declining. A sophisticated scientific study by marine biologists could well produce a remedy for this situation.

OIL AND GAS

Outside the OPEC countries, the world energy crisis is much more severe for the developing countries of Asia, Africa, and Latin America than for the industrialized countries. With the continuing rise in the prices of petroleum and natural gas, the import bills for these commodities are becoming a frighteningly large fraction of the gross national products of many poor countries (Revelle 1980). Exploration and exploitation of local sources of fossil fuel are consequently of the very greatest importance. In coastal states, significant deposits are likely to be found on the continental shelves and slopes. Many of these deposits may be too small (less than 10 to 20 million metric tons of recoverable reserves of oil) to be sufficiently profitable for the major oil companies. Yet they could be of great importance in reducing the foreign exchange needs of a developing country.

Assistance in using the techniques of geophysical and geological exploration for offshore oil and gas fields is needed by many developing countries. As soon as possible, their own nationals should be trained in these techniques and in evaluating the data obtained so that they can help their governments in negotiations for leases, royalties, and bonuses.

Each developing coastal state needs to be able to appraise the recoverable reserves and potential resources of fossil hydrocarbons in its 200-mile-wide economic zone and the continental shelf off its coast. Training programs, perhaps under international auspices, are needed to equip scientists and engineers of each country with a sophisticated ability to make these evaluations.

After oil or gas are found, they must be produced and transported to a point on shore. A knowledge of the range of probable sea bottom, water, and meteorological conditions is necessary for the design, installation, and operation of offshore drilling rigs, production equipment, and pipelines. At present, the ability to obtain this knowledge rests primarily in the developed countries, and transfer of the technology through cooperative educational programs is called for.

COASTAL ZONE PROTECTION AND DEVELOPMENT

Coastal Zone Planning. Because coastlines are essentially one-dimensional, they represent a very limited resource. As populations grow and economies develop, the demands on this resource are likely to exceed the supply, with the result that conflicts among different uses quickly arise. The nature of these conflicts can be easily seen by listing some of the potential uses of the shoreline: ship docking and warehouse facilities; recreational beaches, marinas, and parks; sewage and other waste outfalls; electricity-generating plants with ocean cooling-water intakes; fishing ports; pipelines and cables; military facilities; human habitation; commercial activities; wind-and-wave power installations; and ocean mining installations.

A primary task of the coastal zone planner is to identify and resolve actual and potential conflicts among these uses of the coastal zone (U.N. 1977). To do so, he must be able to analyze the economic and social costs and benefits of different uses, both now and in the future. In the present state of understanding, coastal zone planning is as much a legal and political art as a socioeconomic science. Planners in all countries could benefit from exchange of ideas and information and from sympathetic consideration of each other's problems. One of their objectives should be to ensure public access to the shoreline and adjacent waters--often against considerable political opposition.

Another should be to preserve certain parts of coastal areas, as nearly as possible, in their natural states. These are the coastal wetlands, salt marshes, and mangrove forests that are valuable nurseries for fish, breeding grounds for waterfowl, and shoreline stabilizers. Planners must keep in mind the "externalities" likely to be produced by some kinds of coastal zone use--particularly pollution of nearshore and estuarial waters by industries.

Coastal Protection. Protection should cover both the inhabitants and the physical structure of the coastal zone. The inhabitants must be protected against catastrophes such as tsunamis and storm surges, and the structures must be protected against erosion.

In the late 1960s, a giant storm surge caused by a hurricane in the Bay of Bengal killed some 500,000 people in low-lying land near the coast of Bangladesh. In subsequent years, similar monstrous waves have claimed many human victims on the northeastern coast of India. To prevent such catastrophes, a warning system and places of refuge for the population are needed. The problems of warning a dispersed rural population without modern communications facilities are awesome, but the first requirements are to gain an understanding of the detailed mechanisms of generation of storm surges in particular locations, in relation to the motion and intensity of hurricanes over the nearby ocean; and to develop forecasting methods based on satellite and other weather data. Some oceanographers and meteorologists in both developed and developing countries possess the needed background in hydrodynamics for these tasks. Progress in understanding and in forecasting skill will come more quickly if they work together.

The technology of protection against erosion on open coasts has been much developed in several industrialized countries. Some of the knowledge thus obtained could be usefully applied in developing countries, in spite of the considerable economic differences between the two groups of nations.

Harbor Engineering. No two actual or potential harbors are alike: each has unique characteristics. Yet the ocean processes that affect harbors and sometimes seriously damage or even destroy their usefulness are similar. Problems of flushing by tidal and other currents, siltation, and wave- and storm-surge protection are characteristic of many ports. Surges from the Adriatic through the Lido entrances into the Lagoon of Venice frequently flood the Piazza San Marco. After World War II, a violent storm surge came into the estuaries of the Scheldt, the Rhine, and the Meuse, killing many people and causing great property damage. Bristol in England and Ostia in Italy are examples of harbors that once were thriving centers of commerce which have silted up and become useless for shipping. A similar fate may be overcoming the port of Calcutta in eastern India. Flooding of the Port of London is prevented only by enormous man-made structures.

Hydrodynamic models, both analog and digital, are one of the principal design tools of modern harbor engineering. Formerly, large physical models were used, such as those at the Vicksburg Waterways Experiment Station. These are being superseded by digital models on big computers. For both types of models, data obtained in the field on tidal and other currents, turbulent diffusion, wave statistics, and bottom sedimentary processes are needed as a basis for the computations. The mathematical skills and hydrodynamic institution needed to design the models and to interpret the results exist in only a small number of laboratories in different parts of the world. These should be more widely disseminated through cooperative educational programs. The problems of design and modification of most harbors are continuing ones, as new structures are built and economic and demographic changes occur.

Pollution Abatement. At the Stockholm Conference on the Human Environment in 1972, pollution was defined as: "...the introduction by man, directly or indirectly, of substances or energy into the marine environment, resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of seawater, and reduction of amenities" (Thacher and Meith-Avcin 1978). Among the kinds of pollutants in the ocean are: petroleum hydrocarbons, halogenated hydrocarbons such as PCB and DDT, other synthetic chemicals, heavy metals, municipal sewage, runoff from agricultural lands, solid wastes, waste heat, and radioactive substances. In sufficiently high concentrations, all these pollutants can have adverse effects on the marine environment and its living resources, but the most dangerous for human health are disease-causing organisms in human wastes--salmonella, vibrio, clostridium, the virus of infectious hepatitis--and some helminthic parasites in fish. To these should be added the poison produced by the dinoflagellates in "red tides," which in turn apparently are often caused by pollutants from the land.

Ocean pollution is most serious in partially enclosed seas surrounded by heavily populated or industrialized land areas such as the Mediterranean, the Baltic, the Caribbean and Gulf of Mexico, the North Sea, the Persian Gulf, and the seas and archipelagos of East Asia. In all these areas, regional agreements have been entered into by the bordering countries, encouraged by the United Nations Environment Program (UNEP), to cooperate in monitoring and if possible in mitigating pollution.

Off the coasts of the United States, the "mussel watch," initiated by Professor Edward Goldberg of the Scripps Institution (Goldberg 1976), has proved to be an effective device for pollutant monitoring. These filter-feeding organisms extract and concentrate heavy metals, chemicals, and infectious organisms in the sea water. A similar "oyster watch" has been recommended in East Asian waters (IOC 1976).

Among the serious environmental effects of solid wastes and other pollutants in tropical areas are the destruction of coral reefs and possibly of mangrove forests. Special studies are needed to overcome these problems.

Applied oceanographic research is necessary to guide the design of sewage outfalls for municipal wastes and to investigate the effects of pollutants on marine organisms. The safe disposal of radioactive wastes presents a separate problem, namely, to find areas in the ocean such as the sediment-covered centers of oceanic crustal plates where these wastes could remain undisturbed for millenia (Frosch, Hollister, and Deese 1978).

THE OCEANS AND CLIMATE

The actual state of the atmosphere at any instant is called the weather. It is the domain of meteorologists who are gradually developing skills in forecasting the weather for a few days in advance. But meteorologists are generally agreed that atmospheric dynamics makes it impossible to forecast the details of changes in the weather for more than about ten days. They are hopeful, however, that it may eventually become possible to predict the climate, that is, the average weather conditions over periods of months to years, several months in advance, provided changes in the motions and properties of the ocean can be monitored and understood. Because of its high heat capacity and sluggish motion, the ocean has much greater inertia than the atmosphere; significant changes occur over periods of months rather than days.

In many ways, climate statistics and climate forecasts could be as valuable in human affairs as weather forecasts. If Indian farmers could know in advance the times of onset and continuation of the monsoon rains, they would be able to adjust the time of planting of their crops. If seasonal variations in rainfall and runoff could be forecast, hydrological engineers would know how much water they could safely release from irrigation and power dams. Energy industries in temperate regions could plan the quantity of heating oil or coal to be produced and stored if they knew what the average winter temperatures would be. Forecasts of droughts in the Sahel and in northeast Brazil several months in advance of the events could be used to plan food and unemployment relief for Sahelian nomads and Brazilian farmers.

There are already some indications of the interactions between ocean conditions and climatic variations. Jerome Namias of the Scripps Institution has been able with fair success to project average temperature and rainfall over the United States from measurements of sea surface temperatures over the North Pacific. Cooling in the Arabian Sea caused by intensification of the great Somali Current off Africa appears to be related to variations from year to year in the monsoon rains over the Indian subcontinent. Many years ago, Sir Gilbert Walker of the British Meteorological Office pointed out that atmospheric pressures over Australia are high when they are low off the coast of South America, and vice versa. This "Southern Oscillation" has been shown to be related to climatic variations from western South America to eastern Africa. Recently, Klaus Wyrtki of the University of Hawaii has found that the Southern Oscillation is related to fluctuations in the currents of the equatorial Pacific. When the trade winds are strong, equatorial waters flood into the western Pacific; as the wind velocities slacken, warm surface waters flood back into the eastern Pacific, causing the El Nino off the coast of Peru, which has such destructive effects on the anchovy population and on the guanay birds.

Climate can be roughly simulated by large computer models of the atmosphere, called General Circulation Models. But these are less than satisfactory at the present time because it has been impossible to couple ocean phenomena with those in the atmosphere. In particular, what is needed is more knowledge of the poleward transport of heat by the ocean waters and variations in the exchange of heat between the ocean and the atmosphere as the oceanic mixed layer shoals or deepens.

Periodicities or cyclical phenomenon in oceanic and atmospheric climate have long been sought. P. R. Bell of the Institute for Energy Analysis at Oak Ridge, Tennessee, believes he has found two such periodic phenomena, one corresponding to the 22.3-year sunspot cycle and another to the 18.6-year lunar tidal cycle in the ocean. He believes that these periodicities can be seen with a five-fold amplification in the long time-series temperature records of the Bay of Fundy.

In the past, it has been impossible to monitor climatic fluctuations in the ocean with sufficient accuracy and degree of detail to be helpful to climatologists. The development of ocean surveying satellites that can measure variations in sea level and wind stress over the sea surface may make such monitoring possible in the near future--particularly if the needed "sea truth" can be established from tide gauges on oceanic islands and coasts, supplemented by drifting ocean- and atmosphere-measuring buoys and expendable bathythermographs (XBTs) and other expendable instruments used on "fleets of opportunity." Details of seasonal and year-to-year fluctuations in the ocean observed in a few critical areas by ocean research vessels may also be an essential part of an adequate ocean-monitoring effort.

Data systems for transmittal, compilation, and use of these various kinds of ocean observations must be established. Both ocean monitoring and data handling are planned components of the World Climate Research Program being organized by the World Meteorological Organization and the International Council of Scientific Unions. Because the needed observations must be taken throughout the world oceans, cooperation among all coastal states is essential.

In the long run, climate statistics and climate forecasts should be of most value to drought-prone developing countries. Quick results cannot be expected, however, and the dilemma is that extensive cooperation by these countries in ocean monitoring must begin as soon as possible, perhaps long before practical applications can be achieved.

DEVELOPMENT OF OCEAN RECREATION AND TOURISM

The nearshore zones of warm seas offer a matchless opportunity for invigorating recreation for human beings. Sailing, swimming, surfing, sunbathing, and sportfishing can be happy activities for people of all ages. In many developing countries, these opportunities are used more by foreign tourists than by local citizens. But tourism can be a major source of foreign exchange and of employment. To increase the attractiveness of their coastal regions as tourist centers, countries of the tropics and subtropics should do several things, in addition to building onshore structures.

They should develop the coastal zone, including provision of public access to the shore and the nearby waters, abatement of pollution, construction of marinas and recreational harbors, and protection of coral reef against pests, suffocation by sediments from nearby land areas, and indiscriminate or unduly destructive coral harvesting. They should attempt to protect tourists against poisonous or hazardous marine organisms, e.g., lionfish, large sharks, sea urchins, and sea snakes. They should develop such Coast Guard services as navigational aids, weather warning signals, and search-and-rescue for small sailing and power vessels. They should study the location, abundance, and life histories of local game fish and take measures to ensure the food supply and to diminish predation on these fish at different stages of their life cycles. In many places, underwater parks and reserves can be established as special attractions.

In several of these activities, scientific and technical advice from marine specialists in developed countries may be useful and desirable.

Space does not permit much discussion of the prospects for other ocean resourses. These include ocean wave and tidal power and ocean thermal energy conversion (OTEC). A pilot model of an OTEC electric power plant, generating about one megawatt has been constructed and operated in Hawaii. This energy source could find future use in many coastal developing countries of the tropics and subtropics.

Other than petroleum and natural gas, the principal minerals mined from the seafloor in recent years have been sand and gravel, lime, sulphur, tin, titanium sand, iron ore, and precious coral. In the future, the highly metalliferous Red Sea brines, phosphorite deposits, and manganese nodules, with their relatively large concentrations of manganese, copper, nickel, and cobalt may become important commercial sources. Common salt, magnesium, and bromine are among the dissolved substances extracted in commercial quantities from seawater or fossil ocean brines. Major freshwater supplies in some arid countries such as Saudi Arabia and Kuwait, are obtained by treatment of seawater to remove the dissolved salts. International cooperation in these developments primarily involves technology transfers among countries.

MODES OF COOPERATION

For our present purposes it is useful to list some of the ways in which marine technical cooperation can be carried out.

(1) Professional Education of

- marine biologists
- biostatisticians
- physical oceanographers
- geophysicists and marine geologists
- marine chemists
- climatologists
- marine engineers
- naval architects
- fisheries managers
- coastal zone planners
- aquacultural scientists

(2) Training of Marine Technicians

- tide gauge operators
- XBT (expendable bathythermograph) observers
- communications technicians
- fishing specialists
- aquaculture extension workers
- plankton sorters
- equipment maintenance and repair technicians
- instrument makers

(3) Provision of Equipment, Spare Parts, and Information

- research vessels
- research vessel instruments, including computers
- drifting and anchored buoys
- tide gauges
- XBTs and other expendable equipment
- satellite receiving stations
- books and journals
- information services

Modes of Cooperation - continued

(4) Cooperative Research

- exchange of data and samples
- cooperative field research on ocean vessels

(5) Cooperation in Institution Building in Developing Countries

- marine science and engineering departments in universities
- oceanographic and marine biological institutions
- governmental services

  .coastal zone and fisheries legislation
  .archiving and compiling ocean data
  .fisheries statistical agencies
  .Coast Guard services
  .pollution monitoring and abatement
  .atmospheric and oceanic forecasting services
  .ocean survey agencies

RESOURCES FOR COOPERATION

Technical cooperation between developed and developing countries requires both money and people. Within the United States, funding for marine technical cooperation has come largely from the Agency for International Development (USAID) and, where cooperative research projects are involved, from the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the Office of Naval Research (ONR), the National Aeronautics and Space Administration (NASA), and the Department of Energy (DOE). Nongovernmental funds have been furnished by several private foundations, including among others the Ford, Rockefeller, and Tinker foundations. Universities, oceanographic institutions, private corporations, and U.S. government scientific agencies such as NOAA, the U.S. Geological Survey, and the Smithsonian Institution have been the principal sources of United States scientific and technical personnel for cooperative marine programs.

The governmental technical assistance agencies of West Germany, Japan, France, United Kingdom, the Netherlands, Sweden, Norway, and Canada have provided funds and scientific and technical personnel for cooperative marine projects. Within the United Nations family, the U.N. Development Program (UNDP) has been a major source of funds for resource surveys and planning, while the UNESCO Division of Marine Sciences and the Food and Agriculture Organization (FAO) have undertaken programs of education and training. The Intergovernmental Oceanographic Commission (IOC), the World Meteorological Organization (WMO), and FAO have helped with planning, coordination, dissemination of data and information, and development of data systems. The nongovernmental International Foundation for Science (IFS) has provided research support for young scientists in developing countries working on problems of aquaculture; and the Scientific Committee on Oceanic Research (SCOR) of the nongovernmental International Council of Scientific Unions (ICSU) has helped to identify and elucidate a wide range of scientific problems and to develop research methodologies on an international basis.

WHY COOPERATE ?

From the standpoint of the developing countries, it would appear that there are several persuasive reasons for international marine cooperation. To improve their people's welfare, these countries need to develop their ocean resources, particularly the living resources, potential deposits of fossil fuels, resources for tourism, and harbors and other facilities for ocean commerce. They need to protect the physical structures, the ecology, and the human inhabitants of their coastal zones from storm surges and other catastrophes and from slow, deleterious changes such as pollution and shore erosion. But their efforts to meet these needs are severely constrained by shortages of investment capital and scientific and technical personnel, and by the many conflicting demands for trained specialists and investment capital in other socioeconomic sectors.

The new ocean regime, emerging from the protracted negotiations of the United Nations Conference on the Law of the Sea, places new rights and responsibilities on all coastal countries. To meet these responsibilities and to exercise these rights, a new level of understanding of the marine realm must be attained, and a range of governmental policies must be initiated. This will require an extensive learning process on the part of both developed and developing countries. Both sides will benefit if the learning can be undertaken cooperatively.

Public understanding of science and of the scientific approach to problem solving is vitally important to all countries. Because the marine sciences deal with a familiar and visible, yet mysterious part of the real world, they are well suited to create public understanding of the purposes and methods of scientific research. They can help people realize that science is unmagical--something everybody can do and to some degree has to do in the modern world.

The developing countries need to enhance their own scientific capabilities if they are to lift themselves out of poverty and dependence. They cannot do this simply by studying other people's science; they must themselves participate in the world scientific enterprise. Because the oceans are so vast and so little known, almost any nation that borders on the sea can make important scientific contributions, even with a modest effort.

Other reasons for international cooperation in marine science and technology are equally applicable to developed as well as developing countries. We have already emphasized that the possibility of predicting variations in climate from year to year probably depends largely on measurement and greater understanding of changes in ocean conditions. Because of the interconnectedness of the oceans, these changes must be studied on an oceanwide basis.

In the face of the intensifying world energy crisis, all countries, both developed and developing, are concerned with the need to increase world reserves of oil and natural gas. In economic terms, these fossil fuels are "fungible" commodities. If a developing country discovers and exploits for its own internal use the oil or gas reserves on its continental shelf or slope, many other countries will benefit by the reduction in economic pressure on the fossil fuel resources moving in international trade.

From a longer range point of view, all countries need greater understanding of the probable consequences of increasing levels of atmospheric carbon dioxide and of the role of the oceans in absorbing a large fraction of CO^2 production. This will require ocean studies on a worldwide basis.

In the future, the progress of basic oceanographic research will depend more strongly than in the past on international cooperation. Many of the most significant ocean phenomena occur in the exclusive economic zones established by the Law of the Sea negotiations. These include both the strong, narrow western boundary currents and the broad, slow currents on the eastern sides of oceans, upwelling and the accompanying high biological productivity, and many of the processes occurring at the margins of the great tectonic plates.

In fisheries, rational management of tunas and other highly migratory species must be undertaken cooperatively. These wanderers of the sea have little respect for international boundaries.

In these last decades of the twentieth century, many people as well as tunas wander widely over the surface of the earth. Health conditions everywhere, particularly the causes and incidence of infectious disease, are thus matters of concern to all nations. They need to work together in eliminating pollution by infectious disease organisms and hazardous chemicals in coastal waters.

Finally, humanitarian, socioeconomic, and political reasons combine to give the people and governments of industrialized countries an abiding interest in improving the welfare of the rapidly growing populations of the developing countries. International cooperative efforts to help these countries use their resources more effectively are a necessary, though far from sufficient, condition to achieve this end.

A FINAL WORD

This paper will have attained its objective if it stimulates discussion, brings out ideas, and encourages expression of a wide range of views. Many questions have been left unanswered. What combinations of basic and applied science and engineering are most desirable in marine technical cooperation? What are the perceived needs for such cooperation, and what are the obstacles to a more effective effort? How can marine technical cooperation be made more useful and satisfactory to all concerned? One of the purposes of our Workshop on the Future of International Cooperation in Marine Technology, Science, and Fisheries during the next few days will be to find realistic answers to these and related questions.

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REPORTS OF THE WORKING GROUPS

The following four papers, written during the workshop, report the conclusions and recommendations of the regional working groups, in which the workshop participants considered regional needs for marine technical assistance and cooperation.

Report of the Working Group on Africa

The region under consideration includes the African states facing the Atlantic or the Indian oceans and the islands of the Seychelles, Mauritius, and Madagascar. For the purpose of the working group, both brackish-water and freshwater aquaculture was included within "fisheries."

The group addressed the three categories of questions provided as guidelines to all the working groups.

What needs to be done in marine technology, science, and fisheries in the region?

Recent policy developments of significance relating to U.S. and African interests in science include initiation of bilateral talks between the United States and Nigeria in 1978 and the 1980 visit by the then U.S. Presidential Science Advisor Frank Press to four African countries to discuss mutual science and technology interests (including marine science and marine resource development cooperation).

The discussion revealed that a wide and varied set of requirements could be expected because recipient states ranged from countries with established marine science institutes and marine industries to those with no technical infrastructure or capability at all.

For example, the group learned that a strong inshore demersal fishery has existed in Nigeria for 15 years exploiting resources in up to 60 meters of water; however, the resources beyond this depth are not adequately surveyed and private industry is not prepared to undertake this task. The shrimp fishery is also in need of more detailed studies. The economics of oil and gas, however, is such that commercial interests probably will provide the needed technology to assess oil and gas resources offshore.

In general, the group considered that there is an obvious need for marine technical assistance and cooperation in the region. Broad information concerning fish stocks and, to a certain extent, nonrenewable resources, is available; but this needs to be synthesized and is generally insufficient for investment purposes in commercial sectors. In this context, more detailed surveys need to be conducted on a country-by-country basis. In addition, planning and managerial expertise certainly needs to be provided to take advantage of the information base and increase the efficiency of existing resource harvesting and the management and conservation of the ecological system.

The representative of the Ivory Coast stated that the main problem of his country is the training of local manpower, although the Institute of Marine Sciences at Abidjan has been in existence for 20 years.

There is a chronic need for skilled manpower, especially indigenous workers. Concurrently, the infrastructure to enhance and maintain the scientific and technological base must be constructed. To do this, an assistance program must cover short-, medium-, and long-term objectives related to training in general.

Africa has very few trained marine scientists and marine-resource managers. The point was made that where possible, some advantage could be achieved by retraining professionals (social scientists, mathematicians, engineers, etc.) to focus their attention on marine problems.

The group agreed in principle that each country needs its own expertise in order to control and manage its marine resources, though the degree of need and the time frame would vary from country to country. There was agreement on the benefit of regional or subregional cooperation if the political realities of such ventures could be overcome. Examples are the sharing of a research or survey vessel and the funding of a regional or subregional institute, which, despite the administrative difficulty, could be effective as an interim measure in achieving the final goal of self-sufficiency in marine science for each country. The working group also supported the concept of the sister institute, or the twinning of a university or other institution in a developed country with a similar institution in a developing country. The group recognized the difficulty of assuring continued funding, however, for a U.S. sister institution dependent on grants or contracts. Obviously, for those developed countries with little capability in marine science, technology, and fisheries, the initial growth pattern must be achieved in other ways, and it was suggested that assistance to build up laboratories and facilities could include providing resources to field units of regional, subregional, or national institutions to undertake appropriate surveys and research in less fortunate neighboring states. Thus the program would begin to form a nucleus for training and technical capability in those states and promote regional cooperation.

The working group considered the question of graduate students from developing countries studying in the United States and conducting research unrelated to the needs of their own countries. Not all participants saw this as a problem, depending on whether a student stresses general scientific techniques or aspects of science that are applicable to the fisheries or geographic zone of the student's own country.

A requirement for training in specific modern technologies and instrumentation was mentioned. These programs could be supported by private U.S. interests in view of the possible market opportunities such training would produce.

Concluding the debate on manpower requirements, the group defined three categories of scientific and technical personnel:

1. Science and resource policy advisers to government.

2. Applied scientists and technicians to work closely with resource utilization.

3. Scientists for basic marine research in support of the first two personnel categories.

The first and second categories were needed for short-term objectives and the third for long-term objectives. Although the final objective of all assistance programs must be to establish self-sufficiency within the recipient country, some short-term needs will have to be filled by direct provision of expertise from the donor country.

Management of marine resources and environment covers the whole field of activity from research results to surveillance and enforcement, from multispecies and population dynamic models for the provision of year-class predictions to marine weather forecasts; from sea-surface temperature charts to search-and-rescue capabilities. All have to be addressed and priorities for each will depend on the needs of the recipient countries, which, in turn, have to possess or acquire the expertise to formulate assistance program proposals adequately.

The group felt that the status of African fisheries has been well documented by host countries, the Food and Agriculture Organization, and other groups. The report of a study by UNESCO and the U.N Economic Commission for Africa on marine-related activities in Africa will be available in March or April 1981. That study does not include offshore exploration and exploitation of oil and gas, which would be of interest to Nigeria, Cameroon, and Angola at present. Other projects and workshops of importance deal with harbor development, tourism, pollution, environmental management, mineral extraction, offshore oceanography, coastal erosion, coastal marine research, hydrography, general marine development, and law of the sea matters.

Finally under the category of regional needs, the group discussed the priority assigned to marine science assistance programs. The group concluded that there is a lack of priority assigned to these programs within the United States and that this does not reflect the high priority assigned to the marine sector by the developing countries. The point was made that if it were not for pressure from developing countries, the existing marine projects within U.S. assistance programs could be even smaller. It was agreed that developing countries need to stress the importance of assistance in the marine area in terms of national development goals. It is not merely a matter of the cost-effectiveness of a dollar spent on agriculture compared with a dollar spent on fisheries, because many African countries have fishing communities with pressing needs that must be addressed. Marine assistance programs must be put in the context of integrated rural-area development.

How well are present programs working?

The U.S. Agency for International Development (AID) is currently funding two small capture fisheries programs. One program is related to improved catch and operational fishing methods in Djibouti and involves two people for an initial period of two years. The other program is the posting of two scientists to Guinea-Bissau for an initial period of one year (one is an adviser to the Director of Fisheries and the other works in a coastal fishing community).

Peace Corps aquaculture programs, some with financial aid from AID, are taking place in several countries, including Morocco, Sierra Leone, Liberia, Kenya, Zaire, Central African Republic, Cameroon, and Niger.

Additionally, both AID and the National Oceanic and Atmospheric Administration (NOAA) have provided experts in various fields for short-term assistance, including most recently, assistance in enforcement and surveillance.

There are several U.S. programs that have potential for application to areas of interest identified in Africa. Major efforts include NOAA's International Sea Grant Program, the Science in Developing Countries Program (SDC) of the National Science Foundation (NSF), and a variety of programs administered by the Department of Defense. These include the following programs in hydrography training sponsored by the U.S. Navy:

1. International Training Program in Hydrographic Surveying/Coastal Oceanography: A 52-week course at the Naval Oceanographic Office, Bay St. Louis, Mississippi. Twenty African nationals have completed training.

2. Hydrographic Survey Assistance Program (HYSAP): In-country technical assistance tailored to needs of participating countries to develop a national hydrographic survey capability.

3. Graduate Education Oceanography (Hydrography) at the Naval Post Graduate School, Masters Degree to Allied Officers.

Other programs of potential value include the U.S. Army Corps of Engineers Civil Works Division assistance and advisory services in coastal engineering and riverine and estuarine navigation control.

There are also a variety of nongovernmental sources of potential value in promoting scientific cooperation and exchange of information with African counterparts. Included are U.S. professional associations (in the physical sciences and the social sciences), e.g., American Society for Public Administration (ASPA) and area studies associations, such as the Mid-Atlantic Regional Africanist Association at Howard University. A newly established African Development Foundation (patterned after the Inter-American Foundation) was discussed for its potential as a vehicle to assist rural African fishery communities.

In the opinion of the group, progress is being made although none of the aquaculture programs yet has achieved the level of production sufficient to offset the cost of governmental or international support.

The United Nations Development Program as well as programs of U.N. agencies use U.S. expertise and are supported in part through U.S. contributions. Other U.S. contributions supporting activities of the World Bank, foundations, and regional organizations are important, including the federal and institutional support toward meeting the education costs of accepting foreign students.

The group felt that many of the assistance programs would benefit from the direct involvement of scientists especially at the planning and development stages. The lack of scientific advice during these formative stages has often hindered successful implementation of projects.

Many past and present assistance programs have been underfunded and the duration of the support usually has been inadequate. Noting that the duration of a program can vary from months to decades, depending on its objectives, the group agreed that programs should be carried through to the completion of their objectives whether they be short- or long-term.

The managerial and social environment surrounding a program is very important; hence, in the planning of an assistance program, care must be taken to tailor the program to the recipient country.

Many problems exist within the United States that constrain assistance programs. These problems include lack of national policies for assistance, fragmentation of effort, lack of information on assistance mechanisms and procedures, cumbersome bureaucracy, inadequate formulation of assistance programs, inexperienced technical staff for assistance programs, lack of continuity of funding mechanisms, and delays in implementation or renewal of assistance programs.

The working group recognized that one-year fiscal funding is not conducive to good planning and that, although multiyear funding appears possible, the mechanisms are not clearly understood. There is a need for "seed" money to support exchanges between scientists before formal planning for an assistance program begins. This would ensure a more informed development of program proposals. The working group suggested that one way to increase communication among scientists and to benefit both the donor and the recipient countries in an assistance program would be to take advantage of the travel of U.S. scientists engaged in other matters. The working group believed that seed money is needed also during a program's formal planning stage to assist institutions in the formulation of the program and to support visits overseas if necessary.

The working group felt that the lack of information on mechanisms for assistance stems from the fragmentation of marine-related assistance programs in the United States and in recipient countries. This lack of information could be overcome through establishment of a "front desk" in a suitable U.S. government office to act as a clearinghouse and information center. The group learned of instances in which individual approaches to a U.S. agency were held confidential until the last moment, resulting in an inferior proposal because of the lack of all available information. It could be argued that a clearinghouse also was required for the host country. The group recognized the importance of basing assistance programs on the most complete information available and recommended that pre-project activities be intensified to that end.

It appears that some specialized agencies, such as the Food and Agriculture Organization, already recognize the need for pre-project work. Regional offices of these agencies could provide useful pre-project assistance to aid programs, although the group recognized that in some instances excessive delays can occur through an overemphasis on pre-proposal activities. For bilateral programs, the group stressed the importance of selecting project officers who have relevant experience in the region in addition to their technical expertise.

What is to be done in the future?

The group recognized that the 1979 U.N. Conference on Science and Technology for Development and the new ocean regime arising from the Law of the Sea Conference have important outcomes at the national level. Changes are now occurring in African priorities in science and technology--particularly marine sciences--as a result of those conferences. In order for developing countries to assume these new directions, all research potential must be used. Suitable programs include

- strengthening of existing research centers and development of infrastructure
- training programs
- consultants, contracts, visiting scientists, etc.

Therefore, a full range of fisheries and marine science must be available (local, regional, contract, exchange, etc.) with emphasis on the applied aspects but without neglecting the social sciences and the need for basic scientific excellence. These sciences include

- fisheries biology
- aquaculture
- biological oceanography
- physical oceanography and atmospheric sciences
- geological oceanography
- management and operational sciences

Expertise in these areas is needed to tackle a wide range of local problems and phenomena, and to provide the infrastructure upon which long-term activities are based. The group recognized that no list of topics for study could be complete but noted that, for Africa, these topics would include the following:

- fisheries management, surveillance, and enforcement
- river basin and coastal zone planning
- environmental management (mangrove, coral)
- harbor construction
- coastal erosion
- marine meteorology
- climate research (monsoon)
- aquaculture
- taxonomy

- public health
- offshore mineral resources (including oil and gas)
- tourism and conservation
- hydrographic surveying
- data and information handling

The expertise available in the United States applies across the entire field. The group foresaw a benefit in some cases from funding advanced research within the United States, the results of which would apply to problems of developing countries. In other cases, U.S. science may be too advanced for direct transfer to be effective.

The group identified a need to assist developing countries in setting up national management mechanisms for fisheries and aquatic systems. The group called particular attention to the need for taxonomic research in some countries, where understanding of ecology and living resources is far below that required for adequate management.

Experience with fisheries surveillance and enforcement systems will be required, as commercial interests have already developed this capacity in expectation of the extended fishing zones.

The group identified as a serious problem the lack of foreign-language ability, specifically in French and Portuguese, among U.S. scientists participating in African projects. An indication of language skills could be an important part of the U.S. Directory of Marine Scientists, published by the National Academy of Sciences. Scientists and administrators must be able to communicate. The United States should consider English language training assistance programs for non-English-speaking students.

The United States should consider additional support for regional and other cooperative programs such as CINCWIO (Cooperative Investigation in the North and Central Western Indian Ocean) and CECAF (Committee for Eastern Central Atlantic Fisheries). The group recommended that direct aid to the organization, earmarked funds, or contributions to voluntary assistance programs of the Intergovernmental Oceanographic Commission would be of most benefit.

Recommendations appearing in the U.S. UNCSTD document were endorsed by the group as still valid. For example, the group endorsed the recommendation that

> ...the United States declare its readiness to support, through the U.S. Sea Grant Program, long-term training for developing country scientists, extension services to

developing country institutions, and cooperative research on the marine environment, especially in estuarine and coastal areas. Such programs would be greatly strengthened by a U.S. offer to help finance, where requested, acquisition of modern facilities and provison of temporary personnel to help build up regional institutes of marine resources.*

In conclusion, the group reemphasized the long-term objective of all technical assistance programs, namely achieving self-sufficiency within the developing country. The group recognized that this goal may be achieved through the development of the country's own infrastructure or through the linkages or regional agreements with other countries. To this end, the group supported the recommendation in the UNCSTD document (p. 168) that "... the United States declare its readiness to support suitable elements within a three-pronged program providing for training, extension, and cooperative research...."

Recommendations (not necessarily in order of priority)

The Working Group on Africa recommends

1. Attention should be paid to the synthesis of existing resource information followed by the application of surveys on a country-by-country basis. The latter should be of sufficient detail for investment purposes in the commercial sectors and for effective management and conservation of resources.

2. Top priority for assistance programs in Africa should be the training of skilled manpower, especially indigenous workers, and in the longer term, establishment of the infrastructure within the host country necessary for such training.

3. The concept of "sister" or "twinning" institutes should be strongly supported.

4. Assistance to established laboratories and facilities should include support for surveys and research in neighboring, less fortunate countries, thus building on regional cooperation and available expertise.

5. The private sector should be encouraged to suppport specific training programs for foreign scientists because training in modern instruments and technology would create potential market opportunities.

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*U.S. Science and Technology for Development: A Contribution to the 1979 U.N. Conference. Executive Committee, Study on U.S. Initiatives for the U.N. Conference on Science and Technology for Development, National Research Council. Washington, D.C.: U.S. Government Printing Office, 1978, p. 27.

6. The priority given to fisheries and marine science within U.S. assistance programs should be raised to more adequately reflect their importance in many developing countries.

7. The funding mechanisms available for assistance programs should recognize the need for continuation of funds up to the achievement of objectives, whether they be short-, medium-, or long-term. Ongoing programs should, in general, have greater priority than proposals.

8. Funds should be made available for pre-project planning purposes, exchange visits by scientists, and synthesis of information.

9. A clearinghouse should be established within the U.S. government to act as an information center and overall management office for the many U.S. assistance programs.

10. A full range of fisheries and marine science capability, including natural, social, planning, and management sciences, should be available to developing countries.

11. Language constraints on assistance programs in French- and Portuguese-speaking African states should be recognized and addressed by the United States.

12. Marine-related recommendations appearing in the U.S. UNCSTD document, U.S. Science and Technology for Development: A Contribution to the 1979 U.N. Conference, should be reiterated.

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Report of the Working Group on Latin America and the Caribbean

I. PROGRAM RATIONALE

The following considerations were noted by the working group as a basis for the recommendations in Section II.

Ocean processes do not recognize geographic limits. Many marine-related problems cut across the exclusive economic zones of coastal countries. Cooperation or, at least, the agreement of the countries involved is necessary--

1. To help develop science per se in the world community and to assist developing countries in consolidating their scientific, technological, and educational infrastructure;

2. To contribute to the overall knowledge and understanding of the ocean, including its resources and uses.

Investigation of the ocean and its resources is a responsibility that must be shared both by industrialized and developing countries. Suitable topic areas for scientific and technical cooperation include

1. Marine transportation problems;

2. Coastal zone research and management for increased socioeconomic benefit and resource conservation, including aquaculture and improvement of water quality;

3. Scientific instrumentation maintenance, repair, and design to increase efficiency of ongoing programs;

4. Training in marine engineering to allow indigenous personnel to provide the technical base for application of marine science.

II. BASIC RECOMMENDATIONS

The working group recognized a need for improving the organization and coordination of international cooperative efforts in marine science and technology. The working group proposed the following ideas to improve the effectiveness and continuity of U.S. cooperation in marine science and technology in Latin America.

1. Communication and coordination within and among Latin American countries and institutions with respect to marine science and technology should be improved. The United States should establish a steering committee to coordinate the activities of agencies and groups concerned with marine scientific and technical assistance in Latin America.

2. There must be a commitment on the part of countries and institutions involved in the cooperative and assistance programs to ensure that the programs will continue after foreign participation and support end. Assistance should be gradually phased out so that national commitments can gradually be increased. As a result, the recipient country must build scientific infrastructures and strong institutional structures.

3. Any proposed program of technical cooperation or assistance must incorporate the best scientific leadership in each country and promote new leadership as well as assure peer linkage among nations.

4. There must be credible scientific and technical advice for all proposed programs and evaluations. A mechanism for supervision and evaluation must be an integral part of these projects.

5. Cooperative programs must emphasize the mutual benefit for U.S. and Latin American scientists, assuring common interests and complementary investments.

III. CRITERIA FOR PROJECT IDENTIFICATION

The working group proposes the following criteria for identification of cooperative and assistance projects to be executed within the region with U.S. cooperation:

1. Geographic Approach. Projects should address--

   1.1 Specific national needs
   1.2 Needs created by natural phenomena affecting more than one state, e.g., El Nino
   1.3 Common regional needs, e.g., aquaculture
   1.4 Limited regional needs, e.g., commuter transportation among Caribbean islands
   1.5 Needs specific to the east or west coast of Latin America or to the Gulf regions.

2. Institutional Approach. Projects should address--

2.1 University/Education needs
2.2 Government/Public institutions management
2.3 Private/Business technology application
2.4 Single projects as vehicles for technology transfer

3. Complementary Ideas for the Process of Project Identification, Execution, and Evaluation

3.1 Although it is desirable that existing and future marine and technological institutions develop expertise in all pertinent oceanographic areas, the committee recognizes that financial limitations dictate that available talent and resources be used as a basis for building centers of excellence for persons all over the region. Recognizing that regional centers have many advantages, the working group understands that regional centers present management problems that must be carefully considered when they are established (e.g., provision for an international board). The working group also appreciates the importance of a national commitment by the host country to the success of a marine technical assistance program.

3.2 To achieve lasting results from this workshop, follow-on activities should involve scientists from cooperative programs in periodic meetings. It is desirable that those activities culminate in the creation of a strong association of marine science and technology. Periodic meetings would serve as a means of challenging the best scholars to produce high-quality work. These meetings would also promote interest in younger scientists and students with potential for becoming qualified scientists. Existing regional organizations or associations, either governmental or nongovernmental, should be used to sponsor such meetings. Funds should be made available for bringing the most accomplished scientists as well as young scientists to these meetings.

3.3 Latin American scientists should take advantage of periodic scientific meetings--for example, symposia and workshops--to provide the scientific community with information about existing institutions, programs, or projects and related activities in the marine sciences.

3.4 Projects should result in significant contributions--not only publications but also practical applications--toward improving a nation's well-being.

3.5 Long-term, continuous programs are required, supplemented by short-term interactions on specific training and consultation. The International Sea Grant program is an appropriate example of such a commitment.

3.6 Students should not be away from their home institutions so long that they become divorced from their home institutional environments. To help alleviate this problem, dissertations should be relevant to problems in the trainees' home countries.

3.7 An integral part of assistance efforts should be the organization of workshops to develop regional research programs and to stimulate the dissemination of information in prevailing areas of interest in the marine sciences. An example of such a workshop is the Symposium on the Gulf of California conducted at the University of Mexico.

3.9 Degree-granting as well as non-degree-granting programs should be sponsored.

3.10 Programs should provide the means through which qualified technicians as well as support and maintenance personnel could be trained in support of ongoing activities.

3.11 Systems for exchange of information and documentation should be implemented through use of existing networks; additional efforts should be made toward computerizing information.

3.12 To take full advantage of cooperative and assistance programs, institutions must make long-term commitments to provide employment and adequate compensation to trained personnel.

3.13 A directory of Latin American and Caribbean marine research institutions, including their activities, facilities, and personnel, should be prepared and disseminated.

3.14 Nations receiving assistance should be committed to establishing adequate research facilitites equipped with appropriate instrumentation and the personnel necessary to design, repair, and calibrate it.

3.15 The working group further recommends attention to the following considerations and observations in any reshaping of U.S.-Latin American programs:

a. Development should be regarded as a continuous process in which U.S. as well as foreign interests are integrated and are not approached in a fragmentary way.

b. Marine science affairs should be integrated into national policies and institutions.

c. Marine science and technology should be linked to fundamental national interests so that as it grows it will come to be recognized as essential to national well-being.

d. Institutions should provide internal incentives to scientists, reflecting a strong national commitment to development of marine science and technology. Incentives should include both remuneration and an intellectual environment that allows scientists to do productive and challenging work.

e. The diversity of national approaches to ocean problems should be seen and dealt with as complementary aspects of a world view of the ocean.

f. Foundation-supported and other privately funded programs of regional significance should form an essential part of regional marine science and technology programs wherever possible.

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U.S. Department of State

Report of the Working Group on the Near East and India

The first day's discussions were largely of a preliminary nature in trying to understand the major problems of the region. The Red Sea and the Mediterranean Sea in particular are notable for the relatively low productivity of their fisheries. Despite this region's potential for supporting tourism, which may have greater economic significance for the countries concerned than development of fisheries, the group felt that there is need for better understanding of the currents and the nutrient cycles in the Mediterranean and the Red seas, noting that such information could serve for any future marine technology development programs. The members from Egypt and Israel held the view that there is urgent need to develop the marine resources of many of the countries of the region with relatively undeveloped fisheries and marine sciences, in particular, Somalia, Ethiopia, and the countries of the Arabian Peninsula. Dr. Revelle pointed out the problems of developing cooperative programs with countries that do not already have a technical base, either in expertise or in physical facilities. He emphasized that even countries such as India that have attained a certain level of advancement with regard to their scientific manpower in marine science would require further upgrading of their technical expertise to better appreciate their own problems and to evolve suitable programs of cooperation.

Subsequent discussions considered various questions relating to the needs of India and countries of the Near East in marine sciences and technology. Recognizing the wide disparities in capabilities among the countries in this region, the group limited itself to discussion of general problems and developed the following conclusions and recommendations.

There is need to undertake surveys of the nature and extent of marine resources. Although some countries, like India, have a fairly well developed system of coastal resources assessment, the group saw a need throughout the region for surveys of minerals and other nonliving resources, port facilities, and the shore-based facilities for landing, processing, and marketing of fish. There is a particular need for surveys of resources in the underexploited and unexploited deeper waters within the exclusive economic zones.

For this purpose, the scientific and technical personnel would require training. Training for middle-level technicians also would be essential. In view of possible language problems, particularly for the non-English-speaking peoples, regional training centers should be established, for example, in Elath, Israel, for mariculture and in Egypt for lagoon fisheries development.

For proper marine resource management, policies sould be developed which are consistent with the requirements and policies of the governments concerned and take into account the region as a whole. Economists and social scientists have an important role to play in this respect and should be associated with the formulation of management programs right from the beginning. Public education in rational exploitation and conservation of marine resources also is essential to create a greater awareness of the problems involved.

Marine-based industries are fairly well developed in the region, except perhaps along the northwest coast of the Indian Ocean. Nevertheless, there is still scope for cooperation in this field to help in better utilization of marine resources. Mariculture and lagoon fisheries are two areas in which the need for cooperation is strongly felt.

Both Egypt and Israel are planning major engineering projects that will involve marine aspects, i.e., flooding the Qatarra Depression, and making a canal from the Mediterranean to the Dead Sea. These projects will require the skills of many natural scientists and social scientists and should be of worldwide interest in environmental management. Another future concern of the region is desalinization of seawater or brackish water, a process that can have a large environmental impact.

While reviewing the existing systems of U.S. cooperation in the Near East and India, the group felt that suggestions for specific areas for cooperation and assistace usually are best made directly by he developing countries according to their individual needs. The United States in turn can screen the proposals according to its own policies and interests. However, the group recommended that the United States consider supporting a greater share of the current U.S.-Egyptian program of marine science studies.

Another important recommendation by this group was that all cooperative scientific programs be based on scientific needs, with full involvement by scientists in the decision process.

Data collected during any cooperative program should be made fully available for the benefit of both cooperating agencies.

Joint ventures in fisheries in this region have not been very significant. The few joint ventures were of short duration and were in specific areas. Future joint ventures and licensing arrangements may be considered in areas were the present fishing intensity is low because of lack of facilities. The mutual benefits to be derived from such arrangements are perceived as being large and ought to be considered a criterion for cooperative programs.

With regard to the question of meeting the long-term responsibilities of managing the marine resources of the region, it is necessary to set up new priorities and to build up the capacity to assess, allocate, exploit, and manage the resources now falling under the control of the respective countries. This applies not only to fisheries but also to minerals, oil and gas, energy, and tourism (pollution and shore protection). Coordination of research and dissemination of results and their interpretation must be improved.

In each of the above-mentioned fields, the expertise available in the United States will be helpful in upgrading the existing level of performance. Where infrastructure is lacking, middle-level technology training should be provided. If would be extremely useful if such expertise were made available through a central clearing agency in the United States. Such a clearing agency would provide information on the technical assistance that can be rendered and by whom. It would provide a central point of contact for those seeking assistance and for those who are able to give it.

One technique to develop cooperative assistance could be to establish, where feasible, a binational science and development foundation between the United States and the recipient country. Such a foundation would ensure continuity and a feeling of partnership, would permit flexibility in the funding mechanism, and could also develop into a multinational institution.

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Report of the Working Group on Southeast Asia and Oceania

International Cooperation and Technical Assistance: An Overview

The working group for Southeast Asia and Oceania believes that the recognition of exclusive economic zones (EEZ) offshore has placed a renewed emphasis on the oceans as a major component of the world's resources.

The establishment of the EEZ has brought large areas of the continental shelf of Southeast Asia and deep waters of the Pacific Ocean under the direct control of coastal developing countries that do not have at this time the management capabilities or the technological skills to exploit and manage them.

As such, the need for continued and increased cooperation in marine science, technology, and fisheries is paramount for both the developed and the developing countries in these regions. The management of renewable and nonrenewable resources in the EEZ calls for international cooperation that is deserving of equal consideration with similar land-based systems, including food production, mineral extraction, and energy generation.

The ability and effectiveness of the United States in international cooperation in marine science and technology, as well as in extending assistance to developing countries, are contingent upon the competence and strengths of its national institutions that are responsible for implementing cooperative and assistance programs, and the federal mechanisms that coordinate these activities. Similarly, the capacity of the developing countries in the regions to contribute to, and benefit from, these programs is also dependent on their institutional strengths.

It is the conviction of the group that effective cooperative and assistance programs call for a parallel strengthening of the institutional bases in the United States and in those countries seeking mutually beneficial relations in marine science and technology.

The complexity of the task, which involves technology development and transfer and institution building, requires long-term continuity and action at the bilateral, multilateral, and international levels within a logical framework under cohesive, well-focused direction.

The group recognizes that the institutional elements of the framework are already extant; for example, the U.S. Agency for International Development (AID), the National Marine Fisheries Service (NMFS), the Sea Grant programs, the National Science Foundation (NSF), the American university systems, the Peace Corps, the private sector, UN agencies, and the International Center for Living Aquatic Resource Management (ICLARM).

But the framework is weak, lacking strong direction at a policy level. To help rectify this weakness, the group recommends that there be a permanent core staff of professional fisheries personnel based within U.S. AID in Washington, D.C., aware of needs and conditions in developing countries and of all national and international programs and projects in fisheries and marine science.

The group recommends also that there be an interagency panel from the federal agencies involved in international marine science and technology. Panel members should be aware of each other's work, act as a focal point for national information, and provide an information center for international inquiries to prevent the autocracy and decentralization of U.S. technical centers overseas.

In summary, the group believes that international cooperation and technical assistance, if better managed and more flexibly operated, are highly desirable activities for the United States at this time. The mutual benefits of such international programs and cooperative projects in marine science and technology (for example, the broader geographic data base, shared costs, and direct technical aid) are most opportune in light of the increasing cost of energy, increased national jurisdiction, and the need for international use and management of nonrenewable and renewable resources. Consequently, U.S. participation in international cooperation and technical assistance is timely and is not out of keeping with U.S. national policies nor is it patronizing to developing countries.

Suggested Directions ad Mechanisms

The group recommends that U.S. agencies and program staff recognize a distinction between--

- marine scientific and technical cooperation, and
- direct technical assistance.

The group considers scientific and technical cooperation to be the joint planning, direction, and execution of such activities as research or training projects, each country paying its own costs of involvement. Technical assistance, on the other hand, may be considered the donation of materials, funds, equipment, or personnel necessary to develop or sustain an activity. Agencies that support marine science and technology should consider these two forms of support independently. The terms of reference of such agencies do not readily lend themselves to recognizing the difference between cooperation and assistance or the differing time factors involved, and should be reviewed and changed. Some agencies appear to have no clear definition of their program objectives or even their capacity or incapacity to commit support to specific areas of marine science and technology. Funding agencies are not, and cannot be, all things to all men.

In view of the new dimensions of international cooperation and assistance in the marine sciences and technologies and the need for new approaches, the group recommends two mechanisms as worthy of support and evaluation over a 5- to 10-year period:

1. Cooperative programs in applied science and technology through joint efforts of the United States and one or more overseas universities or agencies to establish projects for the benefit of the local community. These projects would be long-term mission-oriented activities involving strong elements of

    a. research and development
    b. advisory services and extension
    c. education at all levels

2. Institutional support and project support for unaffiliated international organizations that are not representative of any nation, but have the structure and competence to be flexible and yet responsive to important topics that catalyze further bilateral support for cooperation.

Some international centers have already demonstrated that a freedom of choice of topics coupled with the intimate contributions and involvement of overseas scientists and personnel can achieve much more than large programs of technical assistance in a shorter time, at less cost, and in a more appreciated way.

Such unaffiliated centers require general discretionary funding for projects of opportunity and require support for the central core of personnel and operations.

The group recognizes that the problems associated with international cooperation in marine science and technology are predominantly institutional problems and are not confined to the United States but are characteristic of multilateral and bilateral associations.

The following recommendations are especially important for future consideration in creating agency policies and directions. The group recommends the following:

1. Appointment of professional agency staff who are closely in touch with the social and technical needs of the host countries;

2. Recognition that international development is risky and long-term, and that short-term evaluations concentrate on management and approach, not results;

3. Avoiding indiscreet release of budget cost data and avoiding documentation of funding categories that would subsequently embarrass or perplex a host nation; e.g., a project should not be described as providing $1 million in technical assistance for country X if 75 percent of the project funds were spent on salary and equipment for U.S. personnel or for studies conducted in the United States;

4. Greater program and budget flexibility to accommodate the professional staff to prevent replacement of senior U.S. project personnel in the field by less experienced staff;

5. Better understanding of the professional and social commitments of the host country national staff involved in cooperative efforts, e.g., their hierarchical standing, pay differentials, and agreement of service terms;

6. Better understanding of the real social benefits or adverse effects of projects beyond the principal objectives of food production or education; e.g., who might be put out of work? and will there be jobs for the people who receive the education?

7. Better management and operation efficiency at the supporting agency to reduce protracted start-up of projects;

8. Establishment of a contingency budget, or budget of opportunity, for discreet use at the international, national, or private level for small, one-time support to respond to emergencies or initiatives without tne need to consult higher authority or to produce lengthy formal documentation;

9. Direction of financial resources primarily toward research in the field;

10. Recognition that federal agencies must be able to establish vital links with the private sector to achieve specific objectives and to perform specific tasks without coming into conflict with other parties in a project involving multiple donors.

Specific Areas for Cooperation and Assistance in the Region

The group recognizes the importance of renewable and nonrenewable resources to development throughout Southeast Asia and Oceania. (See background papers, in this volume, detailing needs of specific countries in marine science and technology.)

Nonrenewable resources. There is a need to identify the extent of nonrenewable resources--continental-shelf as well as deep-sea resources--in the region.

Identifiable nonrenewable resource in Southeast Asia and Oceania include mineral deposits, geothermal energy from vents, oil and gas, ocean energy, and nutrient enrichment. Although such assessment is necessary within the 200-mile exclusive economic zones, it would require high investment. Moreover, jurisdiction over some areas has not been established.

Each country in the region sets its own priorities, and there are usually differential values of resources, both in composition and cost.

Resources of building materials from the sea (sand, coral, silica) an land reclamation were not of high priority for cooperative assistance, but environmental peturbations might be worthy of subsequent cooperative study.

The group feels that developing countries in the region generally place a low priority on cooperative assistance programs related to nonrenewable resources other than fossil fuels. Although there may be increasing pressures to reap quick benefits from the region's nonrenewable resources, the group anticipates that this could be achieved only by governments or the private sectors through joint ventures. The group's discussions dealt with managanese nodules (and their varying abundance and quality), tin, and other minerals.

Considerable attention was given to ocean thermal energy conversion (OTEC) and its potential economic benefits for energy production and other benefits in such areas as water desalinization and aquaculture. The group called attention to the need for recognition that technology for OTEC is different in regions subject to typhoons and monsoons. Sites for OTEC installations exist in Nauru, Samoa, Guam, and Hawaii; Japan is already in the preliminary operational phase of development in a Pacific atoll. Technical criteria are well established. The magnitude of benefits is large and increases with the proximity of land and larger temperature differentials. Although OTEC is high technology, there is room for cooperation and cost-sharing.

Renewable resources. There is widespread opinion among countries of Southeast Asia and Oceania that assistance is required urgently for the management of living renewable resources (fisheries). The need is identified so clearly by all countries that regional action is indicated. Despite the multiplicity of agencies involved in extending assistance in this field, their efforts have been subverted by a lack of continuity, which precludes development of management capabilities in institutions of developing countries.

There are needs throughout the region for special attention to assistance in the following areas:

1. stock assessment
2. all aspects of aquaculture
3. postharvest technology
4. extension services
5. management of environmental effects
6. fishing technology

Discussions on stock assessment were predominant, as this was considered the top priority. (Although the other needs are also important, time limitations prevented their full discussion.) Yellowfin and skipjack tuna are vital fisheries to the region, particularly Oceania. The group recognized that new techniques being used in the Philippines have resulted in the efficient catching of small tunas and breeders, and this has exacerbated the overfishing problems.

Larval recruitment surveys were recognized as vauable, but the group did not designate the best methods for plankton sampling or remote sensing for this work.

One international problem recognized by the group was the increasing incidence of ciguatera poisoning, but because cooperative studies already are under way, the problem was excluded from further discussion.

Because of a lack of information on stock assessment in the region and its priority, especially for multispecies fish stocks, there is a need to identify the possible approaches and the support requirements for this work.

The group generally accepted the suggestion of a systems approach to the problem of stock assessment. However, this approach should not be based entirely on direct transfer of methodology and experience; for example, from temperate waters to tropical waters.

Noting that information on coastal gyres is proving to be valuable to information on fish stocks, the group recommended work on oceanographic chemistry and physics.

There is a need throughout the region for socioeconomic studies in concert with the more traditional biological studies, especially on small-scale fisheries. Lack of attention to this dimension has already caused some unexpected problems, such as uncontrolled numbers of fishing vessels entering a fishery.

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FEDERAL SUPPORT FOR MARINE TECHNICAL ASSISTANCE AND RELATED ACTIVITIES IN DEVELOPING COUNTRIES

Federal support for international technical assistance and cooperative programs related to the marine sciences is extensive and affects more or less directly many agencies of the federal government. The Marine Technical Assistance Group of the National Research Council's Ocean Policy Committee is assessing the relationship between the objectives of marine technical assistance and cooperative programs and the mechanisms developed to achieve them as one part of a study of U.S. marine technical assistance and cooperation in fisheries and oceanography. This summary of the marine-related activities of several federal agencies was prepared for that study and specifically as background information for participants in the Ocean Policy Committee's Workshop on the Future of International Cooperation in Marine Technology, Science, and Fisheries, January 18-22, 1981, at the Scripps Institution of Oceanography.

Although many agencies carry out responsibilities that somehow involve marine-related activities with other countries, only a few agencies are centrally concerned with marine technical assistance and cooperation with developing countries. The Department of State is the agency of government charged with formulating and carrying out U.S. foreign policy, including U.S. policy in international ocean affairs. The Agency for International Development is the agency principally responsible for U.S. nonmilitary assistance to developing countries. The National Oceanic and Atmospheric Administration, including the International Sea Grant Program, is centrally involved in cooperative programs related to marine science and technology. The following summaries are intended to provide brief overviews of the marine-related assistance and cooperative activities of the agencies for which such activities are a central concern.

The following summaries do not include the marine-related activities of a number of other agencies. For example, the Commodity Credit Corporation of the Department of Agriculture administers the ocean transportation of U.S. agricultural products donated to foreign governments and voluntary assistance organizations. The Department of Energy carries out cooperative international programs on energy-related matters, including nuclear nonproliferation and the international fuel cycle. The summaries also do not include such specialized activities as the ad hoc committee convened by the Federal Coordinating Council for Science, Engineering, and Technology, under the Office of Science and Technology Policy, to consider technical assistance in obtaining food from the oceans.

The summaries include information abstracted from the Marine Technical Assistance Group's forthcoming inventory of federally supported fishery, aquaculture, and oceanography projects. The summaries also have drawn upon papers, prepared for the Marine Technical Assistance Group, which discuss in depth the marine technical assistance activities of the Agency for International Development and the National Oceanic and Atmospheric Administration. Those papers are, respectively, U.S. Agency for International Development Programs in Fisheries and Aquaculture for Fiscal Years 1980-81 by Shirley A. Clarkson and NOAA's Activities in Marine Technical Assistance and Cooperation by Philip M. Roedel. A third paper, Marine Science and Technology for Development: In Search of a Policy, prepared by Christopher K. Vanderpool of the Michigan State University discusses the evolution of U.S. policy governing foreign assistance and cooperative programs related to marine science and technology.

Department of State

The Department of State advises the President in the formulation and execution of U.S. foreign policy. The department's primary objective in the conduct of foreign relations is to promote the long-range security and well-being of the United States. The Department of State formulates and implements U.S. policy in international ocean affairs with the assistance of other federal departments and agencies having responsibilities relating to the oceans.

The Bureau of Oceans and International Environmental and Scientific Affairs is one of the nine "functional areas" of the Department of State. The bureau was established in October 1974 pursuant to Public Law 93-126 (22 U.S.C. 2655a). It has the principal responsibility in the department for policies and proposals for the scientific and technological aspects of U.S. relations with other countries and with international organizations. The bureau also manages a broad range of foreign policy issues and global problems related to oceans, fisheries, environment, population, and so forth. It represents the department in international negotiations in its area of responsibility; provides policy guidance to the U.S. oceanic, environmental, scientific, and technological communities on activities and programs affecting foreign policy issues; ensures effective coordination of policy responsibilities between the Department of

State and the Agency for International Development in regard to science and technology; and directs the Scientific and Technological and Fisheries Attache Program. The State Department's Deputy Assistant for Oceans and Fisheries Affairs directs the interagency Panel on International Programs and International Cooperation in Ocean Affairs (PIPICO). The panel coordinates federal activity in international marine cooperative affairs, including marine technical and scientific development.

The State Department contributes the U.S. share of financial support for a number of international organizations concerned with marine science and technology and which have technical assistance components. Those organizations include the World Meteorological Organization (WMO), the Intergovernmental Maritime Consultative Organization (IMCO), the United Nations Environment Program, and other U.N. organizations. IMCO is concerned with the facilitation and safety of shipping and provides technical assistance to developing countries to meet IMCO standards. Two of the principal United Nations organizations supporting marine-related activities are the Food and Agriculture Organization (FAO) and the United Nations Educational, Scientific, and Cultural Organization (UNESCO).

The FAO supports seven regional marine fisheries commissions, which promote research on fishery products and technology. Among services the FAO provides are data compilation, assessment of world fish stocks, and sponsorship of technical conferences. The principal marine-related activities of UNESCO are supported through the Intergovernmental Oceanographic Commission (IOC), a semiautonomous body whose purpose is to promote scientific investigation with a view to learning more about the nature and resources of the oceans. The IOC coordinates programs in basic marine research and related services, promotes the exchange of oceanographic data and the publication and dissemination of the results of oceanographic investigation, and promotes development of education and training programs for specialists in the marine sciences. Training, Education, and Mutual Assistance (TEMA) activities of the IOC are monitored by the interagency panel, PIPICO.

The Department of State also contributes to the support of eight international fishery commissions established by treaty. They are the following:

International Pacific Halibut Commission
International Pacific Salmon Fisheries Commission
Inter-American Tropical Tuna Commission
International Whaling Commission
International North Pacific Fisheries Commission
North Pacific Fur Seal Commission
Great Lakes Fishery Commission
International Commission for the Conservation of Atlantic Tunas

The objectives of U.S. participation in these commissions are (1) to provide a means of preventing disputes between the United States and other nations fishing in common fishing grounds on the high seas and fishing for common stocks of fish, (2) to ensure the conservation of fishery resources important to the United States, and (3) to increase the opportunity for U.S. fishermen to share in the catch of fish. The commissions also carry out or coordinate scientific studies on the resources for which they are responsible and recommend conservation measures to member governments. The Department of State provides funds for the travel expenses of the U.S. commissioners and their advisers.

The State Department provides funds to the International Council for the Exploration of the Sea (ICES), which proposes and organizes fishery and oceanographic research in the Northeast Atlantic Ocean and disseminates the research results. Studies recommended by the council are carried out by national organizations. U.S. participation in ICES is coordinated through PIPICO.

Thus, although the Department of State does not engage in direct marine technical assistance to developing countries, it addresses a wide range of interests, including technical assistance, through its support of international organizations concerned with marine affairs. A weakness of this approach has been a lack of sustained, adequate attention to specific needs for marine technical assistance when other interests have taken precedence. Such assistance activities as the State Department does support have been constrained by the necessity to protect U.S. interests insofar as they might impinge on international programs.

Agency for International Development

The U.S. Agency for International Development (AID) was established in 1961 pursuant to provisions of the Foreign Assistance Act of 1961 (75 Stat. 424; 22 U.S.C. 2381), as amended. The agency administers assistance programs designed to promote economic and political stability in certain less developed countries and to help the people of those countries develop their human and economic resources and increase their productive capacities. AID is the principal U.S. agency responsible for carrying out nonmilitary foreign assistance to developing countries. Until 1979, when AID became a subagency of the International Development Cooperation Agency, the administrator of AID reported to the secretary of state. AID's proposed budget for Fiscal Year 1981 is $4 billion.

AID functions through (1) Missions in countries where U.S. economic assistance is large, continuing, and usually involves several kinds of assistance projects in more than one economic sector; (2) Offices in countries where U.S. economic asistance is moderate, declining, or has relatively limited objectives; and (3) Sections in

U.S. embassies in countries where U.S. economic assistance is small or is being phased out. The central headquarters staff of AID in Washington, D.C., is organized into four central and four regional bureaus.

Centrally funded assistance projects in fisheries and aquaculture are managed through the Fisheries Division of the Office of Agriculture in AID's Development Support Bureau. The division also provides technical advice on request to AID missions. However, there are no specialists in fisheries or aquaculture on AID's permanent staff. The National Oceanic and Atmospheric Administration (NOAA) provides such personnel to AID through an advisory service contract.

In accordance with overall AID policy, the Fisheries Division directs its assistance efforts toward development of "small-scale" fisheries and aquaculture, although there is no generally accepted definition of small-scale. AID policy requires that such assistance efforts be designed to benefit the rural poor directly through increased production and distribution of low-cost fish protein and to provide income for unemployed or underemployed rural people through jobs in fishing and related activities. In February 1980, AID listed 13 continuing or projected centrally funded projected projects related to fisheries.[1]

Some of those centrally funded projects began as "211(d)" grants. Section 211(d) of the Foreign Assistance Act of 1966 made AID funding available to U.S. educational institutions to "strengthen their capability to develop and carry out programs concerned with the economic and social development of less developed countries." Centrally funded 211(d) grants were made by AID to the University of Rhode Island (URI) and to Auburn University. The 211(d) grant to URI totaled $2,010,000 and the 211(d) grant to Auburn totaled $1,438,000. Auburn University has received other funding (more than $6 million) from AID for 34 projects (both short- and long-term) since 1967 through basic ordering agreements, task orders, and grants.

The four AID regional bureaus and the AID country missions initiate and support the majority of AID-supported fisheries and aquaculture projects. As of September 1980, there were 17 such projects in Africa, Southeast Asia, and Latin America.[2] The AID missions generally contract with U.S. universities and private

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[1]Personal communication to the Marine Technical Assistance Group, Ocean Policy Committee, from Kenneth Osborn, AID, February 1980.

[2]See U.S. Agency for International Development Programs in Fisheries and Aquaculture for Fiscal Years 1980-81, unpublished paper prepared for the Marine Technical Assistance Group, for a listing of regional and mission-supported projects in fisheries and aquaculture.

concerns for technical advisers. A substantial number of Auburn's fishery projects are supported in this manner.

Title XII of the Foreign Assistance Act of 1975 established a mechanism--the Board for International Food and Agricultural Development--for providing AID funds for collaborative research, including projects related to fisheries and aquaculture. On the basis of a 1977 BIFAD planning study, one collaborative research support program (CRSP) in aquaculture has been undertaken and others are projected. AID expects to provide $420,000 in Fiscal Year 1981 for the first phase of a project entitled CRSP-Planning Aquaculture (Pond Dynamics). The study is to develop detailed plans and identify sites and research institutions in developing countries for a future study of principles and mechanisms of pond aquaculture. Similar studies are projected to consider stock assessment and postharvest losses.

According to the Marine Technical Assistance Group's inventory of federally supported fishery and aquaculture projects, AID has funded 93 projects through the various funding mechanisms totaling nearly $112 million from the 1950s through 1979.

Most of the recent AID projects contain small fishery development components compared with their agricultural components. Although currently projected AID funding areas for the 1980s indicate an increasing interest in fisheries and aquaculture, especially in West Africa, overall funding for fishery projects remains small in comparison with funding for agricultural concerns.

There are a number of agency-wide problems at AID with regard to technical assistance for fisheries and aquaculture, including the lack of a central fisheries office and of specialized fishery and aquaculture personnel. This shortcoming underscores the absence of an AID policy for marine and fisheries technical assistance. For example, the role of science in fisheries assistance at AID is not clear, and the dominance of agricultural assistance at AID has led to an overemphasis on aquaculture as compared with marine capture fisheries. These problems of policy often are compounded by problems of communication between country and regional offices and between missions and AID headquarters.

BIFAD is a potentially effective means of support for fishery and aquaculture research but has not been extensively used for that purpose.

National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce was formed in October 1970, incorporating the department's Environmental Science Services Administration and a number of functions formerly administered by other federal agencies. Reflecting NOAA's predominantly U.S. domestic orientation, the agency carries out the majority of technical assistance activities concerning oceanography, fisheries, and training under the general terms of a variety of public laws. Sea Grant International, the international component of the Sea Grant College Program, is the only marine technical assistance program at NOAA for which there is specific legislative authority.

The major units of NOAA involved in international marine affairs are (1) the National Marine Fisheries Service, (2) the Office of Research and Development, and (3) the Office of Oceanic and Atmospheric Services. The Office of Research and Development administers the Sea Grant Program.

The National Marine Fisheries Service administers a number of international fisheries training programs in addition to providing technical personnel to AID under an advisory service contract. In this respect, NOAA functions as the operating arm of AID in marine matters. The training programs, which bring individuals from other countries to the United States for training primarily in academic institutions, are sponsored by the United Nations, the Agency for International Development, the Department of State, and private foundations. At the end of June 1980, there were 19 AID-sponsored trainees in the United States; six others were sponsored by the United Nations Development Program, and two were sponsored by their own countries.

NOAA's Office of Research and Development is the focal point for the agency's cooperation with international scientific organizations and programs, including the World Meteorological Organization, the United Nations Environment Program, the Intergovernmental Oceanographic Commission, and the Global Atmospheric Research Program.

The Sea Grant College Program, in the Office of Research and Development has had an international component since 1976, when Congress established the International Cooperation Assistance Program (ICAP) with passage of the Sea Grant Program Improvement Act of 1976 (Public Law 94-461). ICAP was intended to enhance the marine research and development capabilities of developing countries and to promote international exchange of information with regard to development and use of marine resources. The program's emphasis has been on cooperative education and training projects between universities in the United States and developing countries. With passage in June 1980 of Public Law 96-289, which amends the National Sea Grant College and Program Act of 1966 (Public Law 89-688, 33 U.S.C. 1124a), ICAP was renamed the Sea Grant International Program. Sea Grant International has awarded three annual sets of grants, totaling about $910,000 each year, and currently supports 11 projects in 19 developing countries, including 11 small Pacific island nations.

Technical assistance activities of NOAA's Office of Oceanic and Atmospheric Services are largely concerned with atmospheric science.

Through its Environmental Data Information Service, the office is involved in the compilation and transfer of information pertinent to needs of developing nations. The International Affairs Office of the Office of Oceanic and Atmospheric Services supports some oceanographic training of individuals from developing countries.

A change of direction for marine technical assistance at NOAA is emerging in the current program of cooperation with the People's Republic of China. A protocol for cooperation in marine and fishery science and technology between NOAA and China's National Bureau of Oceanography is one of two protocols administered by NOAA under terms of a U.S.-Chinese bilateral agreement signed in January 1979. The second protocol concerns cooperation in atmospheric science and technology. NOAA funding for activities under the two protocols in Fiscal Year 1980 totaled $611,000, of which $472,000 supported marine-related studies. Current cooperative marine activities with China are (1) development of a marine data center and data-exchange mechanism, (2) a cooperative study of marine sedimentation dynamics in the outflow of the Yangtze River, and (3) study of marine and freshwater aquaculture.

Under terms of bilateral agreements signed in late September 1980, Nigeria and Senegal are purchasing marine technical assistance--primarily fishery resource assessment--from NOAA. In Nigeria, NOAA also is assisting in the instrumentation of offshore platforms and is providing U.S. advisers to help establish oceanographic departments in Nigerian research institutions.

Although NOAA has acquired major responsibilities for marine technical assistance to developing countries, a number of factors impede the agency in carrying out those responsibilities. The agency's predominantly domestic orientation reduces its effectiveness in dealing with international questions. Except for NOAA's Sea Grant program, for example, the agency's marine-related cooperative and assistance programs lack specific legislative mandates. Sea Grant International is not as effective as it could be, because its budget has been held essentially constant since it was founded and its activities generally lack coordination with related activities of other units of NOAA. Throughout NOAA, atmospheric programs are better developed than their oceanographic counterparts.

National Science Foundation

The National Science Foundation (NSF) was established by the National Science Foundation Act of 1950 (64 Stat. 149; 42 U.S.C. 1861-1875), as amended, and was given additional authority under the National Defense Education Act of 1958 (72 Stat. 1601; 42 U.S.C. 1876-1879). The National Science Foundation is charged with developing and encouraging the pursuit of a national policy for the promotion of research and education in the sciences. Although its major emphasis is on basic research, the NSF also supports research applied to selected social needs. The NSF supports research principally through grants and contracts.

Leadership of the NSF consists of the National Science Board of 24 members, and a director, each appointed by the President to 6-year terms. The director is the chief executive officer of the agency.

International programs and cooperative scientific research activities of the National Science Foundation are supported principally through exchanges of scientists and engineers, joint research projects, participation in activities of international scientific organizations, and travel to international conferences.

Concern with marine science and technology and technical assistance to developing countries cuts across several units of the National Science Foundation. The Division of Ocean Sciences supports about half of all federally sponsored oceanographic research conducted by U.S. universities. In Fiscal Year 1980, the division awarded 520 grants averaging $79,500 per award for basic research in oceanography. Those grants included support for large-scale, multidisciplinary projects formerly supported through the International Decade of Ocean Exploration. The division also provided about $20 million, or 70 percent, of the total operating cost of the 26 research vessels in the University National Oceanographic Laboratory System (UNOLS) fleet.

The Division of International Programs supports the U.S. component of approximately 300 cooperative science programs annually in about 40 countries and currently participates in 21 formal agreements for science and cooperation. Eight of those agreements are with developing countries, and three--with India, Korea, and Taiwan--include marine-related elements.

The Division of International Programs administers the Science in Developing Countries program, which in 1980 grew out of the Scientists and Engineers in Economic Development (SEED) Program and discussions related to U.S. participation in the United Nations Conference on Science and Technology for Development. The program is intended to strengthen science and engineering collaboration with developing countries according to mutual benefit. It provides research participation grants allowing U.S. scientists to participate in research projects in about 50 developing countries and allowing scientists from developing countries to participate in research in the United States. The program also provides conference grants to support national, regional, and international meetings concerned with the application of science and technology to problems of development and supports dissertation improvement grants for supplemental support of dissertation research projects by students from developing countries working at U.S. institutions on problems of development.

The Special Foreign Currency Program of the Division of International Programs uses U.S.-owned foreign currency to support international science activities. Such funds have supported primarily geological activities in India, Pakistan, Egypt, Burma, and Guinea. The International Travel Grant Program supports travel by U.S. scientists to participate in international meetings and conferences.

The National Science Foundation was not intended to provide direct technical assistance to developing countries in the way that the Agency for International Development does. NSF programs in developing countries therefore have not supported certain activities deemed not directly related to strengthening a developing country's scientific and engineering capabilities. These disallowed activities include construction of physical facilities, procurement of commodities, clinical sciences, business administration, and certain other technical assistance.

One result of NSF's emphasis on supporting only activities that yield a direct benefit to science is that international programs of NSF have been directed most often to the more scientifically developed countries. There has also been a lack of continuity in some NSF projects designed to strengthen science in less developed countries. Since the end of the International Decade of Ocean Exploration, there has been less emphasis on encouraging participation by scientists from developing countries in research supported by the Division of Ocean Sciences. Nevertheless, the nature of marine sciences dictates that international, marine-related activities of the National Science Foundation increasingly will affect developing countries of the Third World.

Department of the Navy

The principal activities of the U.S. Department of the Navy in cooperative marine science and related programs with developing countries are directed through the U.S. Naval Oceanographic Office, which carries out a wide range of scientific and technical functions related to exploration of the oceans and their boundaries. The office established the Harbor Survey Assistance Program (HARSAP) in 1964 to stimulate hydrographic data collection by providing training and technical assistance during harbor survey operations. The program, which was renamed the Hydrographic Survey Assistance Program (HYSAP) in 1980, loans the necessary technical equipment for a country to conduct hydrographic surveys and produce nautical charts of harbors and coastal areas. Twelve Latin American countries were participating in the program as of November 1980.

The Naval Oceanographic Office also directs the International Training Program in Hydrographic Surveying/Coastal Oceanography. The purpose of the training program is to assist maritime nations in improving their hydrographic and oceanographic capabilities with regard to nautical charting. Since 1957 when the program began, nearly 400 students from more than 40 predominantly developing nations have received such instruction.

The Office of Naval Research directs a number of cooperative marine science activities through its Contract Research Program. The Geography Program has funded field investigations performed under contracts with U.S. investigators in the coastal regions of Surinam, Nicaragua, Brazil, Turkey, Israel, and Egypt. The Oceanic Biology Program has funded contracts and grants directly with institutions in Egypt, Israel, and India.

When U.S. Navy research vessels are conducting marine research in the territorial waters of another country, the Office of Naval Research provides for scientists from that country to participate in the research aboard U.S. Navy research ships and aircraft. Scientists from more than 20 countries have participated in marine research in this way since 1973. The Office of Naval Research also has worked with the University of Michigan in planning the International Symposia on Remote Sensing of the Environment, which have addressed the needs of developing nations.

The Navy has participated in the training of allied officers in the Naval Postgraduate School Environmental Science Program and, in cooperation with the National Science Foundation, has supported such large-scale marine science projects as the Mid-Ocean Dynamics Experiment (MODE) and the North Pacific Experiment (NORPAX) under the International Decade of Ocean Exploration.

Peace Corps

The Peace Corps was established under the Peace Corps Act of 1961 (75 Stat. 612, as amended; 22 U.S.C. 2501) and now is organized within ACTION, an independent agency established to mobilize U.S. citizens for voluntary service in the United States and in developing countries. ACTION administers domestic and international volunteer programs sponsored by the federal government and designed to help meet basic human needs and support self-help efforts of low-income people.

The Peace Corps currently supports more than 6,000 volunteers serving in 63 countries. Services vary according to the skills of the volunteers and the needs of the host country but are intended to match volunteer work at the community level with the resources of the host country and of international organizations to solve specific problems of development.

Most of the Peace Corps's involvement in fisheries assistance has been in freshwater fishculture. About 90 percent of the 300 volunteers now working on fisheries projects in some 30 countries are working on freshwater fisheries. This emphasis results in part from the greater number of requests from Peace Corps offices in developing countries for assistance with freshwater fisheries than marine fisheries.

Since the first fishery project in 1962, Peace Corps volunteers have worked in a total of about 45 marine fisheries projects in 29 countries. The design of these projects changed as the overall philosophy of the Peace Corps evolved. Some of the early marine fisheries projects emphasized teaching of new fishing techniques and demonstrating new types of fishing gear to artisanal fishermen. Later projects involved research and university instruction by more highly skilled volunteers. In accordance with the Peace Corps' current emphasis on meeting the basic needs of people living in the poorest areas of countries in which the Peace Corps works, a recent <u>Marine Fisheries Programming Guide</u> points to the promise of small-scale, village-level development programs for marine fisheries. Such programs would be directed toward helping artisanal fishermen and would involve volunteers in all aspects of marine fisheries development, including applied fisheries research.

United States Coast Guard

The United States Coast Guard was established under the Act of January 28, 1915 (14 U.S.C. 1) and became a component of the Department of Transportation in 1967, pursuant to the Department of Transportation Act of October 15, 1966 (80 Stat. 931). The Coast Guard is a branch of the Armed Forces of the United States and is a service within the Department of Transportation except when operating as part of the Navy in time of war or when the President directs.

The Coast Guard carries out broad responsibilities related to marine technical and sociotechnical assistance under some 50 international instrumentalities, not including an additional 22 international fishing agreements. The Coast Guard assists other U.S. governmental agencies in training within the United States individuals from at least 59 developed and developing countries and has provided mobile training teams to Jordan, Saudi Arabia, and Haiti. Training is in the areas of search and rescue, merchant marine safety, port security, law enforcement, and aids to navigation and is conducted in cooperation with the Department of State, the Agency for International Development, the Military Assistance Program of the Department of Defense, and in accordance with loran agreements between the United States and other nations.

Besides these forms of training assistance, the Coast Guard provides various forms of operational assistance, such as dispatching oil pollution strike forces to the Straits of Magellan and Malacca.

The Coast Guard carries out other marine, scientific, and operational functions through the International Ice Patrol, through operational and technical direction to loran stations overseas, and through participation in United Nations activities, including 11 U.N.-Intergovernmental Maritime Consultative Organization subcommittees and the U.N. Conference on the Law of the Sea.

The Smithsonian Institution

The Smithsonian Institution was created by an act of the United States Congress, approved August 10, 1846 (9 Stat. 102; 20 U.S.C. 41 et seq.), to carry out the terms of the will of James Smithson of England, who in 1829 had bequeathed his entire estate to the United States "to found at Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men."

The marine-related activities of the Smithsonian Institution, under the Assistant Secretary for Science, focus on the classification and ecology of marine organisms and investigation of biological and geological phenomena of marine environments.

The most significant international marine-related activity was the establishment of the Mediterranean Marine Sorting Center in Tunisia in 1966. It provides services similar to the Smithsonian Oceanographic Sorting Center, but its use is limited to scientists and institutions involved in Mediterranean marine science programs. The center provides the facility and logistical support to a number of projects in Tunisia funded from the Smithsonian Foreign Currency Program and also provides administrative support to a study of eutrophication elements in Lake Tunis which is being undertaken with the Environmental Protection Agency.

Another bureau of the Smithsonian Institution which plays an important role in marine research assistance to foreign states is the Smithsonian Tropical Research Institute. The institute conducts research on basic biological processes, supports advanced training, supports research in the tropics by others, and works on behalf of conservation in the tropics.

PROJECTIONS OF THE FUTURE FOR MARINE TECHNICAL COOPERATION AND OCEAN SCIENCE

The following eight papers discuss the future of marine technology and science in relation to present U.S. technical assistance and cooperation in developing countries and the changing political and economic conditions concerning the ocean. The papers were prepared by members of the Marine Technical Assistance Group and, before the workshop, were sent to participants as an unpublished background document.

THE SIGNIFICANCE OF MARINE TECHNICAL ASSISTANCE FOR DEVELOPMENT

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October 1980

ABSTRACT

Developments in science and technology and changes in jurisdiction over marine resources as a direct or indirect result of the ongoing Law of the Sea (LOS) negotiations and earlier international agreements on the continental shelf have increased the significance of aquatic resources for many developing countries. New technologies are rapidly developing for fishing and seafood processing as well as for aquaculture and mariculture. Advances in science and engineering technology have made possible recovery of deep-sea resources, derivation of energy from the oceans, and *in situ* living and processing capabilities. Global concerns such as weather prediction and remote (satellite) sensing are developing rapidly. Nations need assistance in the identification and management of aquatic resources as well as in applying modern techniques for harvest or exploitation of these resources. Cooperative scientific assistance would be advantageous to both developing and developed countries since the latter need access to resources or to research sites. In the long run, the development of scientific capability in the developing countries would bring them into the world scientific community and thereby facilitate both global science and total technology development.

The aquatic resources of many poor or unevenly developed countries are surprisingly important to their economic growth and social improvement. Fresh water is essential for agriculture and for drinking water, and adequate supplies are essential for survival, let alone development. Excess water, whether by rainwater accumulation or marine intrusion, can lead to floods causing death and destruction of crops and property. Water is a pivotal determinant of the health of communities, because it is associated with such parasitic diseases as malaria and bilharzia and with bacterial and virus diseases, including cholera and infectious hepatitis. Many food processing operations are dependent on ample supplies of clean, potable water.

Water is itself a resource that is widely used for the generation of energy and for industrial purposes. To ensure high effectiveness in these applications, it is necessary to have good control of the resource and the kind of predictive ability that derives from modern scientific techniques, including weather prediction and remote sensing. Seawater is not used to the same extent as fresh water, though research on ocean thermal energy conversion (OTEC) and on wave forces as well as older studies on tides and salinity-difference processes suggest that seawater may play a role in energy generation in the future. The availability of abundant energy is the basis for the efficiency of modern machine-related processes and is essential for technical development to take place.

Water traditionally has provided a means for transportation. New developments in the production of essentially self-contained floating factories suggest the possibility of its use both as a transport medium and as a locus for processing operations where water is near the raw material production point. Significant advances in the design of floating (or fixed) platforms that are both stable and seaworthy suggest possible extensions of seaborne manufacturing and processing operations. Argument for such operations clearly becomes more cogent if seabed resources remote from land are to be tapped. (See Ocean Technology and Development, by John P. Craven.)

The aquatic resource that traditionally has been exploited most widely consists of aquatic animals and plants, now referred to as renewable aquatic resources. These have been harvested and used principally for food but also for other purposes (e.g., reeds for mats and woven baskets, fish leather, lamp oil, etc.). In many parts of the developing world, fish has been and remains the principal source of animal protein in the human diet. Aquatic plants, however, are not eaten as widely as terrestrial plants nor do they constitute such a large food resource. This is because aquatic plants are rarely high in starch, do not have universally appreciated flavor, and cannot be cultivated easily as standard crops. Localized examples of water plants eaten as food include Spirulina in certain alkaline tropical lakes (where it may be the staple food for the local population), watercress, and the cultured algae of the Orient.

Clearly there is some potential for enhanced culture and harvest of aquatic plants, particularly seaweeds, both for human and animal food and for industrial uses (mostly carrageenin, agar, and alginates). Recent years have seen interesting technological advances in the culture and harvesting of aquatic plants, and there is good U.S. expertise in this area. With regard to freshwater plants, the main developments lie in the conversion of nuisance weeds such as the water hyacinth to beneficial agricultural purposes as feed or fertilizer.

Fisheries are, of course, ancient and almost universal and range from the small-scale fishing by individuals using spears or hook and line to the capture of many tons of pelagic fish in a single, large purse seine from sophisticated, modern ships. In a number of developing countries, the few grams of fish protein available daily or several times a week are the main factor standing between the people and protein malnutrition. Fisheries have been a primary target for development assistance among aquatic related activities and, apart from military concerns and transportation, the only significant area of marine technical assistance. An early view was that the sea is an almost limitless source of edible protein for human use. No doubt the fact that the oceans cover more than 70 percent of the earth's surface makes this view superficially plausible. When it is recognized that most harvestable fish and shellfish are found within a few miles of the shoreline, the projected magnitude of the resource dwindles sharply; it is now generally recognized that fish and shellfish resources are limited so that only approximately a doubling of the present harvest is projected for the future.

Enormous amounts of protein are theoretically available at lower trophic levels. Much interest has focused recently on the krill resource of the Antarctic, but the difficulties of economic use of this resource are severe. From a biological standpoint, there is concern over proposals to harvest at lower points in the food chain than is done now because of the danger of dislocating a finely balanced system and thereby affecting production of desirable fish species. The importance of krill fisheries to developing countries, which are mostly tropical, poor, and remote from the Antarctic, is as an addition to the world's edible animal protein supplies. These supplies come under increasing pressure as population increases and--more urgently--as average incomes increase, because this has been found to generate greater demand for animal protein. At this time, it seems unlikely that scientific and technical programs of cooperative assistance will lead to actual participation by developing countries (except Chile) in a krill fishery. If krill protein becomes available through exploitation by industrially developed nations, however, technical assistance might take the form of help in the utilization of this new source of protein in local diets.

Fisheries are important to developing countries because they affect food supply, income, and employment. The widespread adoption of a 200-mile coastal zone of national jurisdiction has made fisheries important as a possible basis for political and economic power hitherto denied to many countries. Many international fisheries lie wholly or partly within the exclusive economic zones (EEZ) of developing countries, and suspension of foreign fishing activities in such zones is possible. Indeed, rather than the laissez-faire policy traditionally applied to marine fishing, most nations (including the United States) now insist on written agreements before permitting foreign fishing. This has brought requests from the developing countries to the United States for assistance in the management and regulation of the harvest of fish within their exclusive economic zones with the objective of maintaining the stocks and obtaining maximum benefit from their use. Such systems must be based on an understanding of the fisheries as reflected in effective management plans and the necessary technology to monitor and implement both the management plan and the control system. This is something of a departure from past efforts in fisheries assistance, though stock assessment and some management theory and technology have been the subjects of earlier marine technical assistance efforts. Fisheries are discussed more fully in the paper by Francis Williams, World Fisheries and Aquaculture a Decade Hence.

The two primary areas of interest in fisheries development assistance at present are aqua/mariculture and small-scale (artisanal) fisheries. This represents a recent shift of emphasis from the previous concern with industrialization of fisheries as a way to increase total production and (it was hoped) decrease total costs and, therefore, prices. The shift results from a change in the philosophy of technical assistance programs away from capital-intensive systems and toward labor-intensive systems, recognizing the seriousness of unemployment and underemployment and that some kind of balance is normally maintained in developing countries by spreading production over many small units.

Artisanal fisheries are important in providing employment and a livelihood at and above the subsistence level for millions of people and as the principal source of cheap, fresh fish in a number of countries. From a technical standpoint, these fisheries are usually inefficient and probably "uneconomic," but they persist and provide a living for fishing communities. The technical needs of artisanal fishermen run the gamut of fish biology and technology, oceanography, and even ocean engineering. Artisanal fishing often depends on poorly understood fish stocks; probably only the inefficiencies of the catching procedures protect these stocks from depletion in many cases. Catch rates are inconsistent but usually are very low. Part of the catch is lost through decay and attack by insects and rodents, and part loses values because of a rapid decline in quality. Preservation methods are lacking or are primitive and inefficient.

Much can be done to improve the condition of artisanal fishermen by application of science and technology. But if this assistance is to result in improvement for the country as a whole, it must be coupled with good management, both biological and social, to prevent depletion of fish stocks while also preventing increased unemployment. Accordingly, technical assistance for a developing country should be based on a comprehensive view of that culture, recognizing the interconnection of its various parts. The marine technical assistance component of such an effort would be directed to those problems whose solution would lead to desirable social consequences, for example, improved production and income, sustained or increased employment, and reduction in individual drudgery.

Enhanced production and increased employment are widely seen as consequences of developing fisheries in the agricultural mode through aquaculture and mariculture. Aquaculture and mariculture are ancient processes that have been applied at one time or another in most parts of the world to produce food. In modern times, their application has been rather restricted and they have not developed in the way that beef, pork, and poultry production has on land. This is obvious from the fact that there is no truly domesticated fish species, though some long-cultured species such as carp may be tamed and made amenable to captivity. It is clear from the limited development of fish culture in most countries that this method of food production is intrinsically more difficult or less productive than land-based animal production or that its expansion has not fit the socioeconomic mold of modern development. One factor has been the abundance and increasing availability, until recent years, of cheap fish from the capture fisheries, which have grown with and benefited from the industrial developments of the last 100 years.

Williams discusses the many systems of fish and shellfish culture presently being used and some of the difficulties connected with this production process. These difficulties have increased in recent year because of the increase in population and industry throughout the world and involve water availability, water quality, pollution, and human disease transmission in addition to species selection, nutrition, fish disease, and other husbandry factors. A common modern problem is conflicting use of inshore and enclosed waters for such activities as navigation, waste disposal, recreation, and industrial cooling. There are conflicting uses of fresh water for drinking and irrigation as well as for related aquatic activities, such as mining of sand and gravel or mineral, oil and gas recovery, and coral mining. Nevertheless, aquaculture and mariculture hold considerable promise as lower energy using methods for food production; a number of developing country governments have elected to promote these activities and have requested scientific and technical assistance from industrialized nations. This is certainly an area where additional scientific research is necessary and where LDC scientists could work in cooperative programs since this is relatively low-cost research. Surprisingly little is known concerning the simple genetics, nutritional needs, and even the common diseases of most of the cultured species of fish and shellfish.

A number of specialized problems important to the capture fisheries of developing countries would be appropriate for technical and scientifc work. These relate to disposition of the shrimp by-catch, selective fishing of mixed tropical species, dealing with toxic fish and shellfish, and preservation of fish in warm, humid climates. All of these problems cause economic loss or human distress, and their solution would be of obvious benefit.

The relationship between fisheries and the environment is complex and touches both land and sea. Use of freshwater resources for power generation and irrigation may affect freshwater fish stocks positively or negatively and sometimes in both ways and at the same time, depending on the fish species involved. Dumping of waste into fresh or marine waters is usually deleterious to fish stocks, but small quantities of waste can enhance production in a few instances. Dredging of channels and construction of ports clearly changes the aquatic environment in ways that affect the living resources. Oil and gas recovery from the seabed has also been found to cause mixed effects. Oil spills and leakage are, on the whole, deleterious, but fixed oil-drilling platforms seem to attract fish populations and could lead to a new technology of fish attraction and harvesting which is already being applied in some parts of the Pacific (Craven). The effects of the shallow-water seabed mining of sand and gravel (and more specifically, tin) should already be known, but it is not clear that this is the case.

To understand and deal with these complex interactions in a way that will ensure a sustained harvest of aquatic resources requires a level of scientific and technical expertise possessed by few in the developing countries. Moreover, the collection of accurate data, which is a prerequisite for identifying, understanding, and managing aquatic resources, requires in some important cases sophisticated ships and instruments not easily available to many countries. Scientific and technical cooperative assistance clearly could provide the short-term expertise and equipment these countries need and, by means of appropriate training programs, such assistance could lead to the development of regional expertise to sustain the management effort. Lacking scientific and technical assistance, it is likely that some developing countries would, at best, derive less than maximum benefit from their resources or, at worst, might destroy the living resources through ill-advised managment.

It is important to recognize also the developed nations' direct self-interest in providing cooperative assistance: their need for imported materials and the necessity of avoiding local environmental degradation that might affect the larger ecosystem. Two obvious, specific problems are (1) the possibility of excessive fishing of tunas as they pass through waters of an exclusive economic zone and (2) the destruction of juvenile stages of marine animals that may spend the early years close to a coastline different from the coastal or offshore area from which the adults are fished.

Environmental effects of human activitiy in the marine environment are most immediate in the coastal zone. Coastal zone management is rapidly developing as a distinct field of knowledge and understanding in the United States and other industrially developed countries. However, it is not well understood in many developing countries where environmental pressures of industrial expansion are less apparent, though the pace of environmental degradation actually may be quite high. There is a need for scientific and technical assistance in this area, in which the developed nations have learned by hard experience the negative effects of certain industrial development patterns whose environmental influences may have been insidious or cryptic in the early stages.

It must be recognized that much of the content of technical and scientific assistance must be presented in terms of "do as I tell you, not as I've done myself," and this is difficult for developing countries to accept. There is a feeling, well expressed by Vanderpool, that the aid donors are primarily seeking to deprive the poorer countries of the chance for technological development by raising unnecessary fears of environmental disaster. That this is not true can be seen only in terms of scientific reality and the clear prospect of faster, more productive technological progress by some alterative pathway. Fortunately, necessity has forced this pattern in some countries, as witnessed by the gasohol development in Brazil.

It is clearly important that donors of scientific and technological assistance work closely with and, in a sense, at the behest of the developing country recipients. Donors should have a clear understanding of the long-term effects as well as the immediate effects of their activity and a sensitivity to the concerns and human aspirations of the people receiving the assistance. One aspect of this sensitivity is the willingness to recognize the utility of local technology and to apply modern knowledge to adapt and improve on this where possible rather than introducing an entirely new system. This is directly applicable to marine technical assistance; in the past, attempts have been made to introduce boats, gear, and port facilities designed for other climes and other times--often with disastrous results.

On the other hand, it is important to developing countries that scientific and technological assistance should not encourage dependence on obsolescent and inherently inefficient systems. It is sometimes advantageous to make a technological jump to pass directly from eighteenth-century to near twenty-first century technology. In science, computers and calculators are now commonplace, and to teach the use of the slide rule would be justifiable only on pedagogic grounds. This kind of comment is applicable to marine technology, of course, in a very direct way. Remote sensing, sonars, fish finders, loran, etc., are commonplace tools of marine science and industry, and their introduction with suitable training can only be beneficial in developing countries.*

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*This paper does not address the specific but very important area of technology transfer through industrial operations. Much of this is likely to be through joint enterprises of one kind or another, and these are dealt with in another publication: V. Kaczynski and D. LeVieil (1980) International Joint Ventures in World Fisheries. Washington Sea Grant Technical Report 80-2, 33 pages.

The litany of advantages flowing to developing countries from cooperative assistance in marine science and technology could go on and on. We are moving rapidly into an era in which marine and other aquatic resources are likely to become more and more important as land occupancy and use become more intensive. Moreover, the fundamental strangeness of the aquatic environment to land-based animals (i.e., humans) requires that a higher level of technology be utilized in harvesting its resources (in the broadest sense). This means that in the long run, it will be necessary, especially for developing countries bordering the sea, to acquire sufficient capability in ocean science to support future technology.

In the short run they will need access to ocean science expertise from external sources so that they may deal effectively with scientific and technological developments affecting marine operations in general and resource utilization in particular, which, largely as a result of consequences flowing from LOS, will now affect all coastal nations directly. These developments include new fishing technologies, new techniques of deep-water oil, gas, and mineral recovery, and related scientific developments affecting capability for underwater activities; the related LOS-derived effects are Exclusive Economic Zones and probable regimes for deep seabed resource recovery. (See Ocean Science, Law of the Sea, and Marine Technical Assistance, by John V. Byrne, and The Politics of International Development Assistance: The Evolving Context for Marine Technical Aid, by Richard E. Meunier.)

Programs of scientific and technological cooperation and assistance in the marine (aquatic) area can help developing countries deal with the present and prepare for the future. Moreover, it will be seen that, just as the waters of the various seas interconnect to form the world ocean, so ocean science is interlinked; discoveries in one locale can yield new technologies half a world away. Ideas flow through a network made up largely of scientists and technologists, and the ideas are reduced to practice only if they can be interpreted both in scientific and social terms. Connection to this network requires interpreters as well as participating scientists. One important goal of well-designed science and technology assistance programs is to provide a link to this network and to enable developing countries to participate in the experimental work leading to the generation of new ideas.

Thus, it is important that developing countries recognize that scientific and technological assistance can lead to participation in the world scientific community--a community that is largely independent of particular social or political philosophies. This is especially important in marine science, where the research necessary to develop new technologies often is extremely expensive and may require ships and equipment from several nations and study in several ocean areas, including exclusive economic zones.

THE POLITICS OF INTERNATIONAL DEVELOPMENT ASSISTANCE: THE EVOLVING CONTEXT FOR MARINE TECHNICAL AID

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August 1980

ABSTRACT

Technical assistance programs largely reflect the surrounding patterns of political interaction in the international community. Far-reaching changes have occurred in that political environment during the past decade. The proliferation of the new states, mostly quite small and resource-poor developing countries, has altered the membership and missions of most international organizations. Developing countries consistently have stressed a cluster of issues relating to economic equality and development. Conference diplomacy through the United Nations has led both to the articulation of new international norms relating to development aid and to the creation of new agencies and programs to implement those norms. Technical assistance is recognized as critical to developing countries acquiring the capabilities to reduce their dependence on imported technologies. The Law of the Sea negotiations have mirrored these trends, as both the exclusive economic zone and the emphasis on marine technology transfer are intended to permit eventual developing country participation in marine resource exploitation. The enhanced coastal state jurisdiction likely to result from these negotiations is also likely to make technical assistance an integral component of research in coastal waters of developing countries. New mechanisms will be necessary to expand and coordinate technical assistance by marine researchers and to create enduring links to marine institutions in developing countries.

PRELUDE

Formally, technical assistance programs are responses by donor organizations to official requests from recipient states. These requests reflect the prevailing patterns of political and institutional interactions among states. Future U.S. marine technical assistance programs will therefore be shaped by the evolving international political environment and legal regime of the oceans. Likewise, changing development needs and aid expectations of recipient countries will also affect future marine technical assistance requests. The purpose of this paper is to explore recent trends in the politics of development assistance and to project their potential impact on marine technical aid.

Significant changes have occurred within the international political system during the past decade. These resulted largely from the decolonization movement of the previous two decades and the subsequent entry of many newly independent states into international political and technical organizations. The less developed countries (LDCs) have altered the membership and missions of most international organizations and have initiated far-reaching changes in international relations. The Second United Nations Development Decade conducted during the 1970s reflected new international priorities and infused economic development considerations into every facet of relations between states.

THE CHANGING POLITICAL ORDER

During the 1970s, U.S.-Soviet relations were joined by other issues at the center stage of international politics. The proliferation of new states introduced another key dimension of interactions--between the industrialized "have" states and the "have not" developing countries. These LDCs increasingly have focused their diplomatic efforts on the theme of economic development. Consequently, interactions among states have become less constrained by East-West ideological disputes and more governed by issues relating to independence, economic development, and specific regional conflicts.

Growing global interdependence has been exacerbated by the insatiable appetites of the industrialized countries for raw materials. In many cases, these materials are controlled largely by developing nations, whose bargaining power has risen in proportion to demand for their resources. The most dramatic example is energy supply, where OPEC (Organization of Petroleum Exporting Countries) control of petroleum has underwritten a fundamental redistribution of financial and political power. As political leverage has become more widely distributed among nations, new international concerns have emerged, particularly the priority accorded to economic development. These concerns encompass many activities, such as marine science research, which were formerly considered beyond the realm of politics.

Differing endowments in natural resources and differing populations have increasingly stratified the developing countries during the 1970s.* Some have made impressive strides toward industrial economies serving world markets, while others have been crippled by soaring fuel costs. The stratification and resultant divergence of interests have often fragmented formerly cohesive LDC negotiating blocs. Yet, despite diverging national interests, the resource-rich developing nations have remained spokesmen for their less-advantaged

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*A common categorization lists three tiers of developing countries--upper, middle, and lower--based on attributes such as national income, resource base, population, and industrial capacity. These are explained more fully in the companion paper by Christopher Vanderpool (Issues of Development: A Decade of Uncertainty).

brethren, and have used their influence in international forums to promote enlarged commitments to development assistance. They also have become significant contributors of development assistance, particularly financial aid.

Stratification among developing nations also is manifested in the scientific and technical spheres. Rapidly industrializing nations with growing technical infrastructures may themselves become donors of technical assistance to other developing countries. These "upper tier" developing countries may seek technical cooperation rather than aid from the industrialized states. Such cooperative programs may involve organizations other than the official development assistance agencies of the developed nations. On the other hand, some very small or poor developing nations will continue to require outside assistance for very basic technical services for the indefinite future. Donor nations thus are called upon to provide a broad variety of technical services geared to the recipient's particular needs.

Another international trend with far-reaching consequences is the growing importance of regional organizations and regional development strategies. Regional organizations traditionally have been established to pool resources and provide services that no single state in the region could afford. Likewise, they have been used to present united fronts in bargaining with the outside world. These potential benefits led to marked increases in the number and capabilities of regional organizations during the 1970s. Despite some glaring failures, they have become major actors in establishing regional political strategies, in setting developmental priorities, and in providing technical and research services to member states. The more affluent developing countries have become major contributors of capital and political leadership to these organizations. Many regional organizations have become channels through which development assistance from the industrialized nations or multilateral agencies is passed. Even the very poorest states can draw upon substantial regional expertise in defining their development strategies and technical assistance needs.

THE NEGOTIATING CONTEXT

The foregoing changes in the global political order have occasioned new patterns of international diplomacy. The newer members of the international community have used their numbers to reorient many international organizations toward better serving the common interests of developing countries. Conference diplomacy through the United Nations has become increasingly prevalent during the 1970s--from the U.N. Conference on The Environment in 1972 to the Conference on Science and Technology for Development in 1979.

The conference diplomacy format has assisted the articulation of new international norms emphasizing economic development--e.g., the New International Economic Order and the Code of Conduct for Multilateral Corporations. These calls for economic equality have expressly recognized the importance of scientific and technological capabilities in building economic self-reliance.

Beginning in the late 1960s, new priorities were incorporated into most aid programs. The previous focus on capital transfers and creation of infrastructure for industrial development was replaced by programs designed to meet the "basic needs" of the predominately rural masses--agriculture, health, energy, and education. Improvement of global living standards requires attention to immediate needs, rural areas, and basic welfare services. Accordingly, the United Nations has adopted a "poorest of the poor" strategy both within and among nations. Aid is channeled primarily to the poorest nations, and to the poorest segments within recipient nations. Nearly all donors have adopted similar strategies. Most concessional aid (grants, technical assistance, low-interest loans) therefore flows to the 25 to 50 poorest countries, with aid to the wealthier developing countries concentrated on commercial services (export credits, investment guarantees, etc.).

Another outgrowth of evolving aid priorities has been the movement toward intermediate or appropriate technologies. Locally developed technologies using local materials and skills are considered not only more affordable, but also helpful in reducing LDC dependence on technologically advanced nations. A closely related trend in international development assistance is Technical Cooperation among Developing Countries (TCDC), which is designed to provide aid through advisers more likely to be conversant with the recipient country's particular needs and conditions.

Again, the Law of the Sea negotiations reflect these general international trends. While the United States and the Soviet Union have been primarily concerned with freedom of passage to preserve the deterrent balance, the Group of 77 also has focused on issues relating to economic benefits and building local capabilities to manage and exploit marine resources. Technical assistance is seen as a necessary foundation for developing countries to participate as equals in future negotiations over marine resource exploitation. The proposed limitations on scientific activity within the coastal zone would enable the coastal state to charge economic rent on use of its zone for research purposes. Such rent could be paid in the currency of technical assistance. Morever, a global treaty on the oceans would make these claims to technical assistance a matter of legal right rather than one of moral suasion.

DELIVERY OF DEVELOPMENT AID

During the 1970s, the volume of development assistance increased substantially. This growth was due to inflation, the necessity to offset rising costs of imported fuels, and the establishment of various new agencies for the delivery of development aid. These factors compensated for the leveling off of aid from the larger industrialized countries. Likewise, the "graduation" of some upper and middle tier LDCs enabled donors to concentrate concessional aid more on the poorest countries.

Foremost among the new aid channels was the creation of aid programs by the oil-exporting states. New aid agencies were created by OPEC, by the Arab oil-exporting states acting in concert, and by individual oil-exporting states.

The issues of transferring technology and the capabilities to develop or modify technology locally have been infused into nearly all international negotiations conducted through the United Nations.

The Law of the Sea negotiations mirror these general trends in international diplomacy. The "common heritage of mankind" concept first enunciated in 1967 recognized the potential economic benefits from exploiting ocean resources and sought to ensure that developing countries not be excluded from these opportunities by technical backwardness. Beginning in 1974 in Caracas, the Third United Nations Conference on Law of the Sea represented the most ambitious exercise in conference diplomacy ever undertaken. A complex agenda of issues spanning the entire spectrum of ocean uses was to be resolved through a conference at which nearly all sovereign states were represented. The Group of 77, a coalition composed exclusively of developing nations, emerged at this conference as an important negotiating bloc. Although it was in many cases a diverse and fragile coalition, the Group of 77 nonetheless consistently brought the interests of the developing nations to the forefront of the deliberations. Enhanced coastal state control over adjacent ocean spaces was coupled with LDC emphasis on technology transfer and building local capabilities to manage and exploit ocean resources.

INTERNATIONAL DEVELOPMENT ASSISTANCE

Evolving diplomatic patterns within the international community have profoundly affected the significance and content of development assistance programs, both bilateral and multilateral. The goal of international economic equality has basically altered the role of development aid. Rather than a manifestation of donor largess, aid is now perceived as a necessity--a mechanism to redistribute the world's wealth and compensate for past colonial exploitation. Development aid is one among many devices to fundamentally revamp patterns of economic relations among states. Other necessary steps include new patterns of trade relations, revised monetary and banking systems, and preferences for imports from developing countries. However, aid programs are also considered necessary interim measures to meet the most immediate developmental problems and assist the most needy countries. Development assistance is thus intended to ameliorate the most glaring disparities in standards of living until more equitable new international economic structures can be erected. Scientific and technical assistance should reflect these priorities by addressing the most immediate needs of the developing countries.

Developing countries also have criticized past aid programs and approaches to development. Greater recipient participation in planning and executing aid projects is considered necessary to minimize the hidden agendas (such as political motives or export promotion) of many bilateral aid programs. The implicit assumption underlying many aid projects, that Western-style industrialization is the preferred outcome, is rejected in favor of locally determined and culturally appropriate development. In short, the political conceptions governing acceptable objectives and proper administration of development assistance also have evolved.

Concessional aid from the oil-exporting states amounted to nearly $6 billion during 1977, with the majority earmarked for Muslim countries.* Although donors of financial aid, the OPEC nations remain net recipients of technical aid, which is obtained mostly through jointly-funded cooperative programs with the major bilateral donors. A second category of new donors consists of the small, principally northern European states whose aid programs were enlarged substantially during the early 1970s. This category includes the Scandinavian countries, the Netherlands, and Canada. Although relatively small in absolute terms, their aid programs represent major national commitments in terms of aid as a percentage of GNP. Most of these states have maritime traditions and skills that could make them especially valuable in marine-related technical assistance. A third category of increasingly active aid donors is composed of nongovernmental organizations (NGOs). This includes charitable foundations, religious groups, volunteer service agencies, university centers for development-related research, and "appropriate technology" institutions. Development assistance grants by voluntary agencies of the OECD countries totaled nearly $1.5 billion during 1977.** These new donors could provide additional channels for the joint funding and execution of marine aid projects.

Similarly, new aid procedures and missions have been adopted by many existing agencies, particularly the technical organizations within the United Nations system. Nearly all multilateral agencies now have some development assistance tasks in addition to their specialized technical missions. Administrative procedures have been adjusted to accommodate these new tasks, and to facilitate coordination among the many aid donors. Within the U.N. system, the principal coordinating agencies are the U.N. Development Programme (the primary funding agency for U.N. technical assistance projects) and the World Bank (the leader in development assistance planning and evaluation). Increased donor efforts during the 1970s were complemented by significant progress within the recipient states. Many recipient countries have become skilled in development planning, economic feasibility analysis, and administration and coordination of development assistance programs. National and regional institutions increasingly take a leading role in planning and administering development programs. The "country programming" procedures (multiyear aid commitments set jointly by donor and recipient) implemented by most donor agencies have given aid recipients the primary responsibility in planning assistance programs, as well as substantial latitude in allocating aid funds. Developing countries have devoted substantial attention to building technical institutions and policy planning capabilities in science and technology. Recipient countries generally have become more adept at seeking aid--locating donors with the requisite skills, assembling aid packages involving multiple donors and

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*Organization for Economic Cooperation and Development, Development Assistance Committee, Development Cooperation, 1978 Review (Paris 1978), p.266.

**Organization for Economic Cooperation and Development, Development Assistance Committee, Development Cooperation, 1978 Review (Paris 1978). p.202.

projects, fitting specific projects into overall development plans, and administering the field execution of aid projects. In addition, recipients have more access to regional organizations for obtaining assistance in development planning. They tend to be more able to seize the initiative in seeking outside assistance in meeting local needs.

The Law of the Sea negotiations have fostered a similar awareness of potential marine resources and of local needs for managing and exploiting these resources. The prolonged conference proceedings have fostered personal and diplomatic linkages in the maritime field and may in some cases have enhanced the visibility and prestige of local marine scientists and institutions. Future marine aid programs will probably be negotiated by more knowledgeable LDC diplomats. LDCs may take advantage of enhanced coastal state controls by formally requiring aid programs as entry conditions.

THE FUTURE

Projecting future political trends is uncertain at best. However, some projections for the 1980s represent continuation of clear present trends that, barring major political upheavals, should persist into the coming decade. In the diplomatic context, political conflict between the superpowers will not disappear, but will continue to share the spotlight with economic development issues. Developing countries will continue to stress self-reliance, reduced dependence on industrialized countries for technological imports, and equal participation in resource exploitation. At the same time, the industrialized nations will be called upon to assist in the creation of more egalitarian economic structures and to redress past imbalances through direct assistance to the developing nations. Escalating costs of fossil fuels will require technical assistance to implement new strategies for economic development based on nonconventional fuels. The ultimate goal of technical assistance programs will be to create local expertise and infrastructure for solving technical problems with local resources. Regardless of the outcome of the Law of the Sea negotiations, developing coastal states have become increasingly aware of their marine resources and will seek new arrangements to convert their enlarged marine jurisdiction to national benefit.

Within aid-recipient countries, administrative experience will enhance the capacity for absorbing outside aid. Developing country requests for technical assistance will be backed by greater planning and management capabilities. Different resource and population bases will sharpen the differentiation between developing countries, and will result in further divergence of interests among them. Regional agencies will perform more development-related services, particularly as the wealthier states begin to subsidize services to the less advantaged states of their respective regions. Domestic economic problems may be a disincentive to new or enlarged assistance programs by the industrialized states, but development aid will retain its symbolic importance in international political forums.

For developing coastal states, the ocean will be recognized as a critical source of food, revenue, and other resources for development. Altered rules of conduct governing ocean spaces are likely, either through a comprehensive Law of the Sea treaty, one or more treaties on specific topics, or a series of unilateral actions. A new ocean regime could add substantial costs to conducting scientific research and exploiting marine resources. However, the number and scope of LDC marine institutions will increase the possible channels and targets for the technical assistance mandated as a condition for entry into coastal waters. These institutions could also enhance coastal state ability to define and negotiate technical assistance needs. Finally, the perfection of new marine technologies or processes could generate specific assistance demands related to these emerging technologies and tied to entry into coastal waters. This linkage could present difficulties to U.S. marine researchers who lack funds or authority to meet such conditions.

These trends will combine to shape requests for U.S. marine technical assistance during the coming decade. First, technical assistance could become a *sine qua non* for research activities in most waters controlled by developing countries. Trade-offs may become necessary between the scientific content of research cruises and the conditions for entry into coastal waters. Mechanisms for financial subsidies to U.S. researchers in meeting these political costs should be devised, lest research activities be curtailed. Second, other actors, such as LDC political or development officials, could become involved in negotiations over marine technical aid. Projects administration could become more formalized, bureaucratic, political, and costly. Technical assistance would necessarily be designed into cruise plans from inception rather than added informally in foreign ports. Informal assistance programs could thereby be deterred.

Third, stratification among developing coastal states will produce widely differing needs and technical assistance requests. Mechanisms for marine cooperation formerly applied only to other industrialized states will become more broadly applicable to the technically advanced developing countries or to regional institutions. Correlatively, new mechanisms may become necessary for assisting very small coastal states or those without existing marine science institutions. As requests for technical assistance or cooperation become more numerous, the diversity of recipients and needs will require ingenuity in devising means to couple assistance with research.

Fourth, on a more positive note, there will be more aid donor agencies to assist in funding and execution of marine technical assistance programs. U.S. marine scientists may have to seek linkages to these aid agencies in addition to the traditional funding agencies for marine research. Likewise, recipient marine institutions will grow in number and provide more targets and counterpart institutions for aid projects. For example, the possibilities for institutional linkages will become greater as more LDC marine science institutions are established. Coordinating these diverse actors will require new mechanisms and considerable effort on the part of marine scientists, but the situation does contain some room for maneuvering.

In summary, the evolving international order of the 1970s has introduced new expectations relating to development assistance, particularly in the marine sector. Technical assistance in the 1980s will be delivered in a context of increasingly knowledgeable recipients, both from development planning and technical viewpoints. For many developing countries, technical assistance will converge with scientific cooperation among equal partners, but will nonetheless be advanced as a right backed by legitimate claims to control over ocean spaces. U.S. marine scientists will be faced with a wider range of technical assistance needs and conditions, but will have available more channels, donor agencies as well as recipient institutions, through which to funnel their aid. Ingenuity and effort will be necessary to create new cooperative aid projects while meeting fundamental research tasks.

ISSUES OF DEVELOPMENT: A DECADE OF UNCERTAINTY

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ABSTRACT

The recurrent and new issues of development facing developing countries in the next decade are demographic, ecological, economic, social, and political. These issues have to be viewed within the context of the growing diversity of needs and capabilities in the developing world. The general slowdown of economic growth in developed countries is leading to an emergent protectionism drastically affecting the relationships between developed and developing countries and is accompanied by shifts in bilateral and multilateral assistance patterns. There is, however, a growing emphasis on science and technology in the developmental process with a specific focus on technology transfer and types of capital- and labor-intensive technologies. Marine science and technology has become an important area for assistance and cooperation because of the new prominence marine resources have received as a result of developments in the Law of the Sea negotiations and as a result of the increasing knowledge of the global dynamics of the ocean frontier. The economic uncertainties of the next decade may generate an environment that is not conducive to increased support for marine assistance programs. However, economic uncertainty also permits reappraisal of existing efforts and makes possible the creation of new pathways for cooperation in marine science and technology for development.

THE ISSUES

The developmental problems facing developing countries in the next decade represent a range of issues, some of which are unresolved from prior decades and others of which are "new." The "new" issues are those that emerged in the seventies as a result of the increasing cost of energy, the growing gap between rich and poor within and between nations, and the movements of developing countries beyond a concern only with infrastructural development, e.g., transportation, communication, institution building, etc., to concern with the "quality of life" of their citizens. These recurrent and new issues can be grouped into the following categories: (1) demographic, (2) ecological, (3) economic, (4) social, and (5) political.

The demographic issues are those related to the continued explosive growth of population in the majority of developing countries--in particular, those nations that have the lowest per capita incomes (Hopkins and Puchala 1978). In the next two decades, the world population will increase by two billion, according to the 1980 Report of the Independent Commission on International Development Issues (Brandt 1980). Despite a decline in fertility rates in many developing countries, 90 percent of the increase in world population will occur in developing countries. This increase will continue the current disparity in age distributions between the populations of developed and developing countries. Populations of developed countries are becoming older while the developing countries have burgeoning, youthful populations. The population increase and the age distribution in developing countries contribute to a continuing and rapid expansion of the labor pool and an increasing demand on health, education, and welfare systems. Despite the increasingly widespread application of population control methods in the developing world, evidence suggests that such methods are most effective when a nation has begun to sustain its own development and its citizenry enjoys better economic opportunities. Thus, development provides the best environment for reducing birth rates (Brandt 1980).

Population increases in developing countries generate and exacerbate serious ecological problems in the areas of food and nutrition, environmental quality and pollution, and energy development and conservation. Chronic food shortages, instability in food supply, food import security, and chronic malnutrition are present in much of the developing world. Low agricultural productivity reduces the ability of developing countries to feed themselves (Chou and Harmon 1979, Adler-Karlsson 1978). The need for more agricultural land at a time of rapid industrialization and urbanization is placing enormous pressure on the environment. Large areas have become deforested; coasts, rivers, and lakes have suffered the effects of pollution; and many developing countries are plagued with airborne pollution. Needs for food, employment, and maintenance of large urban centers have combined to increase dependence on petroleum and petrochemical products. Because of the rapid rise in energy costs, the development of renewable and unconventional sources of energy--e.g., solar- and wind-energy systems--is a new, pressing priority for developing countries.

Economically, the expansion of industrial bases to lessen dependence on manufactured goods from the developed world and to increase employment opportunities for the unemployed and underemployed are continuing interests. But rising prices for energy and commodities have seriously hampered the ability of developing countries to generate savings for capital accumulation (World Bank 1979). Governments and citizens face recurrent cycles of economic stagnation and inflation; sometimes the cycles are concurrent, producing "stagflation." Those developing countries that already have a significant industrial base are anxious about the growing support for economic protectionism in some quarters of the developed world. At the same time, many developing countries suffer trade imbalances, which detract from their ability to stabilize their economies and foster economic growth (Ward 1973). Even though many parts of the developing world have achieved very high levels of annual economic growth, the gap between rich and poor nations has not been narrowed. Whether those developing countries can sustain such growth levels is in question because of global economic conditions marked by escalating prices of energy and commodities (Leontief 1977, Uri 1976).

Increasing attention in the next decade will focus on the social issues of development, e.g., quality of life, poverty and income inequality, women and development, and infrastructure efficiency. Improvements in quality of life are dependent upon major efforts to establish and maintain adequate health, education, housing, and welfare systems (Brandt 1980). Rising costs of health care, for example, are becoming a major problem, and efforts to reduce those costs are focusing on the factors contributing to illness (poverty, malnutrition, poor hygiene, and poor sanitation).

The target audience of developing country governments and international aid donors is the "poorest of the poor" (Leontief 1977, Low and Howe 1975). The numbers of poor people have increased, and in some societies the proportion of the population living in absolute poverty--people whose incomes are $250 or less--has also increased. The frequency and patterns of poverty vary among developing countries (Gwin 1978, Uri 1976). In some countries experiencing rapid economic growth, such as Taiwan, poverty and income inequality appear to have been reduced. In others, such as Brazil, the number of poor has decreased, although the gap between rich and poor has increased. Among slower growth countries, such as Sri Lanka, poverty and inequality have been reduced, but the country overall remains poor. In some countries, such as India, inequality has remained constant while the number of poor has increased. Because of the increases in the number of poor and the conditions of their existence, there is a growing international recognition that the eradication of poverty may be a binding obligation of the international community (Gwin 1978).

The role of women in the process of development--that is, their contribution to development and the effect of development on their lives--has now been recognized and will assume new prominence in the next decade (Tinker and Bramsen 1976, Brandt 1980). The contribution of women to development can be enhanced through equal access to education, training, jobs, ownership, credit, and business opportunities. Diminishing the ardous tasks in domestic and agricultural occupations can enhance the participation of women in development efforts. Accordingly, the subject of women in development is a new focal point in national and international development programs.

Another critical social problem is the often inefficient and ineffective bureaucratic infrastructures responsible for initiating and maintaining a nation's development programs. Rife with red tape, infighting, and often with ineffectual personnel appointed for reasons other than their expertise, these infrastructures many times do not act as vehicles of developmental change. Development programs and assistance from abroad have difficulty in reaching their target audiences and getting aid to where it is needed most. In the 1950s and 1960s, the creation of such infrastructures through programs of "institution-building" was a central issue, but in the 1980s their reform and revitalization will become a core problem area.

Success in managing and solving these demographic, ecological, economic, and social problems of development will largely hinge upon the domestic and international political milieu of developing countries. On the one hand, developing countries are likely to improve their ability to exert control over the development process; increasing their own expert staffs, they will acquire a greater capacity for policy analysis and implementation (Wriggins 1978). Development programs and projects will be jointly planned by representatives of both the developed and the developing world. Developing countries will be more active in the international community, seeking to achieve equality for themselves in the global political and economic system and lessening their dependence on the developed world (Caporaso 1978, Smith 1977). Management of political and economic affairs without outside interference is a priority (Ul Haq 1979).

On the other hand, the developing countries face a politically unstable period marked by growing populations with rising expectations at home and a more competitive international political environment, not only between developed and developing countries but also between developing countries themselves (World Bank 1979). The need to maintain military and political security is likely to increase the arms expenditures of many developing countries (Wriggins 1978). Some of this emergent competition among developing countries may yield to expanded cooperation in efforts toward collective self-reliance. Such cooperation may be evident in the trade of labor-intensively produced mass-consumption goods, in the design and implementation of rural development programs and small-scale technologies, and in joint ventures in the generation of capital for processing and manufacturing (Gwin 1978). Cooperation may lead also to the establishment of regional organizations performing political and economic services for groups of developing countries.

GROWING DIVERSITY

The above thumbnail sketch of development problem areas should be carefully viewed in the context of the growing diversification of the needs and capabilities of developing nations. The developing world increasingly is characterized as having three tiers--upper, middle, and lower. The upper-tier countries comprise two types of nations: the OPEC nations, which have substantial financial surpluses and can pay in full for the technical assistance they need, e.g., Venezuela, Saudi Arabia, Libya; and the rapidly industrializing countries that have access to private capital but continue to have large pockets of poverty, e.g., Brazil and Mexico. The middle-tier countries, such as Tunisia, Peru, and Kenya, have some industry but still require assistance to help their poor and to sustain their current levels of economic growth. The lower-tier countries, such as Bangladesh, Chad, Ethiopia, and Jamaica, rely heavily on concessional aid to finance their development programs and need assistance in meeting the basic human needs of their populations.

The development needs of these nations vary (World Bank 1979). In the middle-tier nations, the main need is to redistribute income and assets and rapidly to expand employment opportunities. To achieve sustained economic growth, such nations will have to reduce their imports and accelerate their exports through increased manufacturing. For the domestic market, increasing the efficiency of industrial production is a priority. The improvement of investment choices and of industrial productivity can assist in the absorption of labor.

The lower-tier countries present a more complex set of needs. Because poverty is widespread in these countries, the most important needs are agrarian reform, promotion of small-scale enterprise, and significant change in the organization and delivery of basic public services. The alleviation of poverty also requires rapid expansion of employment opportunities, slowing the growth rate of the labor force and the population, and expansion of low-cost public services. In all developing countries, the agricultural sector is a prime target of development programs, because 70 percent of the poor live in rural areas.

The upper-tier and middle-tier countries have capital surpluses or are quickly becoming exporters of capital goods (Brandt 1980). These attributes permit new patterns of interaction between developed and developing countries with regard to assistance for development. Multilateral relationships can be established among developing countries alone or in some form of partnership with developed countries. Such arrangements can help in allaying fears of developing countries with regard to dependence on the industrialized nations. A good example is the recent efforts of Thailand in providing marine technical assistance in fisheries to other developing countries.

ECONOMIC UNCERTAINTIES

The general slowdown of economic growth in developed countries is leading to an emergent protectionism, which is drastically affecting the relationships between developed and developing countries (Brandt 1980). These effects may be seen in the following ways. First, there is a trend among developed countries to protect their internal markets by controlling developing country imports. Non-tariff barriers, such as formal and informal quotas and the restriction of government subsidies or purchases to domestic companies, are implemented more frequently now than in the past two decades. Secondly, this protectionism is accompanied by decreases in the inflow of capital and debt-servicing capacity to developing countries, putting added constraints on their efforts to meet rising costs and the costs of industrialization (World Bank 1979). Thirdly, there is a general weakening of opportunities for migrant workers in developed countries, which further increases unemployment rates in developing countries. Finally, during the 1970s, there were shifts in bilateral assistance. Assistance by the major bilateral donors began to level off, but new donors, such as the OPEC nations and the Scandinavian countries, emerged. Moreover, it became politically expedient to channel bilateral aid through multilateral agencies; approximately 30 percent of bilateral aid now flows through such agencies.

These changes constrain the efforts of developing countries to progress but could also lead to greater self-reliance and to new opportunities for trade with other developing countries. The slowdown in the economies of developed countries reduces the demand for the primary commodity exports upon which some developing countries depend for earnings. For developing countries, earnings from the export of primary commodities were 57 percent of total export earnings in 1978--81 percent if oil is included (World Bank 1979). In some developing countries, commodity export earnings contribute as much as 60 percent of the GNP. The implication of these percentages is clear: There can be no reasonable development planning unless basic price instabilities are resolved. However, some developing countries may be able to increase their trade with eastern European countries and with other developing countries. Such markets are particularly important for those developing countries that are expanding their manufactured exports. In general, the next decade will be marked by considerable economic uncertainties, which are likely to produce new patterns of trade, assistance, and financial relationships between developed and developing countries.

These economic uncertainties require new directions in the economies of developing countries. Diversification and greater flexibility are necessary, but problems of access to markets in developed countries are a major limiting condition. Balanced trade expansion, reduction in protectionism, and commodity price stabilization are key factors in the resolution of those problems (World Bank 1979, Leontief 1977, Sewell 1979). Also critical is the ability of developing countries to manage successfully a transition from exhaustible to renewable resources to reduce their balance-of-payment problems. Moreover, because of the large pool of underemployed and unemployed, an emphasis on assistance to benefit those workers who derive a meager income from small-scale activities, e.g., repair, handicrafts, construction, etc., is important. The primary needs in this sector of the labor force are easier access to credit, training to upgrade skills, technical advice to improve products, and better tools and infrastructural facilities (Adler-Karlsson 1978).

SCIENCE AND TECHNOLOGY

Efforts to foster industrial development highlight the issue of capital-intensive versus labor-intensive industries and technologies. The issue is thorny because, on the one hand, labor intensiveness can help resolve part of the employment problem. On the other hand, many developing countries are skeptical about calls for labor-intensive technologies and economies that would continue their technological dependence on the developed world. Possession of high technology and the establishment of capital-intensive industries, in this view, would better enable the developing country to reach a self-sustaining level of technological production. Those who argue in favor of labor-intensive technologies and industries, however, point out that development strategies biased in favor of capital-intensive technology and industry absorb only a small proportion of new job applicants, reinforce technological dependence, siphon-off profits, and stifle local initiative. As a consequence, they aggravate the lack of employment opportunities in developing countries. Opportunities can be enhanced by focusing on small-scale industrial development in the rural sector and the service sector in the urban economy.

This debate will continue in the next decade and the outcome will most likely be determined by the programmatic implications of technologies and industrial patterns that were put into effect in the late 1960s and during the 1970s. But as the debate continues, there will be increasing calls for the development and transfer of technologies that are "appropriate." The definition of appropriate has been hotly contested, yet agreement appears to be emerging.

Appropriate technolgies are those that are patterned to meet or are adaptable to the socioeconomic needs and conditions in a developing country. The call for appropriate technology results in the transfer of a mixture of technologies--both capital- and labor-intensive. Because socioeconomic needs are the targets of these technologies, assistance is needed not only in developing and transferring appropriate technology but also in gathering information to determine local socioeconomic needs. Managerial and marketing assistance to maximize the economic efficiency of such technologies is critical to adapting them to local conditions in developing countries.

Priorities for technology transfer include projects and programs to alleviate poverty and employment problems, to increase food production, to explore and develop energy and mineral resources, and to expand domestic processing of commodities (Brandt 1980). A variety of technology transfer channels both public and private can be used, e.g., training and exchange programs, joint ventures and management contracts, the direct purchase of technology, and the acquisition of consulting and engineering services. The question facing developing countries is how to increase effectiveness of technology transfer channels.

Enhancing the flow of technology to developing countries will require tackling a complex set of issues. Greater support is needed for technical assistance through bilateral international agencies and for research into more efficient production, development, and marketing (World Bank 1979). Studies are needed to understand how developing countries can cope with major technological breakthroughs and their implications and how to adapt technology to the problems of the developing world. These efforts generate a need for more effective coordination of technological efforts among nations.

Developing countries are also seeking control over the choice of imported technology. Such choice implies increasing the flow of technological information to developing countries, having experts with competence in technical fields, and creating organizations to facilitate and monitor the transfer of technology. It also means that developing countries need a basis for accurately estimating technology transfer costs. Costs include: preacquisition costs (e.g., scanning international markets for appropriate technologies), direct costs (e.g., the purchase of technology and equipment), and indirect costs (e.g., payment of inputs and resources linked to technology transactions, the training of personnel, etc.)

Beyond these issues lie others that are more long-term. The concern of many developing countries regarding their dependence upon developed countries is leading to a careful scrutiny of the technology transfer process and who gains what from it (Ul Haq 1979). Of particular concern are the multinational corporations whose actions are often viewed as beneficial only to themselves. In the next decade, developing countries will attempt to regulate and control the operations of multinationals (Brandt 1980). They will try also to institute mechanisms spelling out the financial and legal terms of commercial transfers. The developed countries and their economic enterprises may advocate similar mechanisms to ensure a more secure environment for their investments abroad. Similarly, reform of patent systems in developed countries will be viewed as increasingly necessary.

Interest in technology transfer during the next decade will be accompanied by an increasing emphasis on science development. Developing countries are recognizing that sustained development cannot occur solely through technology transfer. Indigenous technological growth is also necessary. The intimate connection between technological and scientific knowledge is being rediscovered. The fostering of science development occurs through the promotion of scientific and technical information exchanges, establishment of scientific infrastructures, and proposals for regional scientific institutions.

Programs of joint research are critical to science development efforts. Developing countries are reacting strongly against research that is solely planned and executed by scientists from the developed world. They see such research as an example of continued dependence; it does not provide an opportunity for their own scientific communities to gain the experience necessary to produce centers of excellence and often it does not address critical problems of development. Research that is designed and executed jointly by scientists and technologists from both worlds is the preferred alternative. Such research will require additional equipment, funding, and personnel if it is to achieve the goals developing countries see as necessary to their interests. In addition to meeting needs of developing countries, marine research is important for increasing knowledge of global dynamics of the oceans. Much of this research must be done off the coasts of developing countries. If developed countries are to continue their research in coastal areas of less developed countries, joint research may be required.

A related issue is the establishment of scientific and technological institutions specifically oriented to research on development problems. In the developed world, new cooperative institutes of science and technology for development are emerging, such as the Institute for Scientific and Technological Cooperation, which was proposed in the United States. They are designed to strengthen the capacity of developing countries to solve development problems through scientific and technological innovation, to foster research on development problems, and to facilitate scientific and technological cooperation with developing countries. There are also recurrent calls to establish regional scientific and technological institutions in the developing world. The regional approach is advocated because many of the problems developing countries face are both widespread and unresolvable by a single nation. Regional institutions are seen as enabling developing countries to pool their scientific and technical expertise and thus improve their chances of success; alone, these countries would not necessarily have the manpower, financial resources, or equipment to make significant progress. However, past regional approaches have not achieved their goals, although in many cases, the development of regional scientific and technological institutions clearly appears to be the only viable alternative.

In the next decade, therefore, international agencies and rich as well as poor nations will place a continuing emphasis on science and technology for development. However, in spite of such efforts as the 1979 U.N. Conference on Science and Technology for Development, and other international forums for policy discussion, the future of scientific and technical aid for development is uncertain. Given the general economic conditions in both the developed and the developing world, it is difficult to project how much support will be given to programs of science and technology when there are numerous other needs for added financial commitment by governments. In addition, emergent protectionism is challenging the wisdom of sharing scientific and technological information and hardware with other nations and of engaging in the large-scale transfer of technology. In a perverse way, this view also recognizes the importance of science and technology to the social and economic development of a nation. Calls by developing and developed countries for increased cooperation in science and technology will continue, because it is now acknowledged that a nation cannot achieve self-sustained development without an adequate scientific and technological base.

MARINE RESOURCES

In the past, marine resources received only passing attention in development programs by assistance donors. The focus was primarily on the contribution of land-based resources in achieving sustained economic growth. This land emphasis continues, particularly in discussions of possible solutions to problems of food and nutrition in the developing world. In the last decade, however, marine resources achieved a new prominence in assistance and cooperative efforts between developed and developing countries. This prominence is likely to continue in the next decade.

The Law of the Sea negotiations have served as the major vehicle for a growing awareness of the importance of marine resources to development. With the establishment of exclusive economic zones (EEZ), many developing countries will have authority and responsibility over significant fishery resources. Most stocks present in traditional fishing grounds in the North Atlantic and North Pacific are fully exploited and to some degree depleted. The Food and Agriculture Organization estimates 30 to 40 million tons of the remaining unused conventional species are available to developing countries (Saetersdal 1979).

In addition, developing countries are looking to the sea for hydrocarbon and mineral resources to assist in the development of energy reserves and industrialization. Law of the Sea (LOS) negotiations have also stimulated developing country interest in working together with the developed world in tackling the problems of pollution of the marine environment. Finally, LOS has numerous provisions for increasing the assistance to developing countries in exploring and exploiting the oçeans.

These developments indicate that marine resources in general and fisheries in particular can generate a variety of benefits to developing countries. These benefits include increasing the supply of food and improving nutrition, generating an important source of foreign exchange earnings, increasing employment opportunities, and raising the standard of living of communities dependent upon income from the sea (Gulland 1979). However, the majority of developing countries have not been able to realize these benefits. For example, only a quarter of the total per capita supply of protein from the sea has been available for consumption in developing countries (Saetersdal 1979). The world catch distribution does not reflect the abundance of fish resources in the oceans, but the historical evolution and structure of world fisheries and consumption patterns. Until recently, the fisheries off the coasts of developing countries have been unexploited or fished primarily by the distant-water fleets of developed countries. Consumption of fish products in the developing world is limited by problems of preservation, marketing, distribution, and cost of fish products. Yet, with the growing awareness of the importance of marine resources, LOS developments, and the provision of marine scientific and technical assistance, developing countries can begin to derive major economic benefits from the sea.

To realize this potential requires assistance and cooperation in a variety of areas. First, developing countries will have to specify their general objectives in the marine area and the consequences of marine resource exploitation to their society. Secondly, the developing countries need to determine the kinds, distribution, and abundance of marine resources that exist off their coasts. And thirdly, they must appraise their ability to exploit these resources and to manage the exploitation.

Developing countries need scientific and technical assistance to address these issues. Information and advice from experts in such disparate fields as oceanography, fish biology, resource economics, ocean engineering, and sociology are required (Gulland 1979). Of particular concern to developing countries is assistance in developing and managing their marine resources so that they can formulate appropriate policies governing resource exploration and exploitation. Many developing countries lack experience in marine policy development and in establishment of conservation and management regulations. Both legal and organizational assistance are needed.

Capital and investment are also priorities, in light of the needs for shore installations, vessels, equipment, and development of industrial infrastructure. In the case of fisheries, advice and cooperation on processing, marketing, and distribution are of importance. Emphasis is likely to be placed on investment in both artisanal and capital-intensive fishery development. In many developing countries, the artisanal fishermen represent a segment of the "poorest of the poor," and improving their quality of life is emerging as an important issue. The development of artisanal fisheries is critical also for alleviating under-employment and unemployment.

Besides aid to artisanal fisheries, capital-intensive aid is also necessary, particularly for the development fish meal plants and deep freezer storage and for the purchase and modernization of distant-water vessels. But care is needed to ensure that new patterns of technological dependence do not emerge and that overexploitation of resources does not occur as a result of the development of capital-intensive industries. Many developing countries--Cuba, for example--will opt for capital-intensive assistance or a mixture of both capital- and labor-intensive aid to provide a basis for developing their export earnings (Ceres: July-August, 1979).

The development of the marine science and technological base is important if developing countries are to maximize their marine resource benefits and to achieve some degree of self-sufficiency. In the next decade, multilateral and bilateral exchange programs providing for training of developing country scientists and technicians in marine science and technology will increase in importance and number. In addition, more joint research projects will be planned and executed, partly because of agreements that provide research vessels from developed countries access to coastal and EEZ areas. Moreover, developed countries and international agencies can be expected to provide support for participation of developing countries in international collaboration on general problems in the marine environment, e.g., marine pollution, and for regional and subregional research in developing countries. Such research is important to fisheries, because of species migration and other phenomena that can be studied only on a regional basis, e.g., El Nino.

These general issues and assistance approaches, however, regard the developing countries as a generic group despite their diversity. Marine resources are not evenly distributed across the coasts of developing countries--some have abundant resources, others do not. Some coastal areas have been extensively studied, others are relatively unexplored. Moreover, some developing countries, e.g., Mexico and Brazil, have growing marine scientific and technological establishments, whereas others do not. There are also differences among countries in their economic potential, their current level of development, and their political commitment to the oceans.

The question for developed nations and for international agencies providing marine scientific and technical assistance is whether scarce financial support should be given to those nations that currently have the greatest potential to achieve self-sustained growth in the marine area. The argument has been made that many of the lower-tier nations would not be able by themselves to support an adequate marine scientific and technological infrastructure and that they require assistance on a continuing basis. On the other hand, upper- and middle-tier nations, in particular the former, would with some initial assistance and cooperation be able to establish a more viable scientific and technological infrastructure. Clearly, this will be one of the central issues in marine scientific and technical assistance in the next decade.

Marine technical assistance and cooperation face additional hurdles related to the growing global economic uncertainty. Given the land fixation of past development assistance, a major shift in donor and recipient interest toward the development of marine resources is highly unlikely. If levels of support for development assistance and cooperative activities in general are stabilizing and in some cases falling, most developing and developed countries as well as international agencies will seek to continue existing programs, which are mostly nonmarine in emphasis. The development of the marine resource potential of developing countries requires long-term programs and commitments. But the current environment for international assistance does not appear conducive to such commitments or the launching of new programs.

Despite the uncertainty of the next decade, the Law of the Sea and the continued progress in marine science and technology will bring international attention to the wealth of the sea. Increasing knowledge of the global dynamics and the resource potential of the ocean frontier may reduce the fears of donors and recipients of marine technical assistance. If so, and if the international economic environment improves, there will be increased opportunities for marine technical assistance and cooperation. The uncertainty of the next decade also provides both donors and recipients a context for reappraising current and past policies and actions, discarding and improving upon those that have not achieved their objectives. Through such reappraisal, it may be possible to discover new pathways of cooperation in marine science and technology for development.

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OCEAN SCIENCE, LAW OF THE SEA, AND MARINE TECHNICAL ASSISTANCE

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ABSTRACT

To ocean users the 1970s can be thought of as the Decade of the Law of the Sea. Intensive negotiations during the U.N. Conference on the Law of the Sea have led to the development of at least a common law of ocean use. Scientific ocean research is to some extent governed by this common law, particularly in the exclusive economic zone, which extends seaward from the territorial sea. In this area between the territorial sea and 200 miles from shore, the conduct of science is subject to consent of the coastal nation and to obligations on the researching nation.

Ratification of the draft convention on the Law of the Sea will dominate the next phase of ocean legal activities. Debate will focus on the relative values of "a treaty" versus "no treaty". A treaty could bring legal consistency but at a cost. Absence of a treaty could result in legal uncertainties, some beneficial to science, others detrimental. Ratification could bring into effect a formal development of marine technology transfer.

As a partial result of the prolonged, intense focus on ocean rights, all countries are more aware of the importance of the ocean, and it is now very likely that most, if not all, U.S. research in waters of other coastal nations will include some form of marine technical assistance with an accompanying increase in the cost of doing research.

Marine technical assistance can be worthwhile and mutually beneficial; if it is done for the wrong reasons, it can also cause frustration and inconvenience. Regarded as an opportunity and carried out with good intentions, such cooperative endeavors can make a major contribution to world harmony.

INTRODUCTION

"There is no such thing as a free lunch!"

Oceanography has been conducted in a politically free environment during most of its history. Whatever constraints existed were primarily constraints of imagination and resources. With the 1958 Convention on the Continental

Shelf, oceanographers began to experience a restriction of the freedom to do oceanography even where and when resources would permit. The past decade has seen an ever-increasing imposition of political barriers to the conduct of science in the oceans. Although political and financial restrictions are often more limiting today than constraints of the mind, scientists still often think and plan in terms of freedom of science. Projected investigations are based on ideas regardless of political or other limitations. The intellectual challenge continues to lead oceanographers to attack scientific problems where something worth knowing can be learned and where probabilities of success are reasonable.

During recent years, numerous predictions have been made as to the nature of future ocean science. Many of these projections recognize the constraint of international legal regimes; but the view of future science has been based primarily on the optimism of freedom of ocean research. Much of the research projected for the future can be done almost anywhere, but some research must be conducted in specific geographic locations. Scientific problems may be localized to the continental shelf or margin or to the deep sea. Much continental shelf research can be done on virtually any continental shelf; deep-sea research can be done in many areas of the deep sea. However, the many geographically specific research projects fall directly into the web of international legal regulations. It is for these geographically specific investigations that the new international legal regime for the oceans becomes so important. The day of the free lunch is over if, in fact, it ever existed. Ocean scientists of the future must consider the additional costs, obvious and hidden, created by the new "Law of the Sea."

LAWS FOR OCEAN USE

"It ain't no sin if you crack a few laws now and then,
just so long as you don't break any." -- Mae West.

For oceanographers and other ocean users, the 1970s could be called the Decade of the Law of the Sea. During this decade, more than 150 nations negotiated intensively to establish a legal regime for virtually all uses of the oceans. By the end of the decade delegates to the Third United Nations Conference on the Law of the Sea consigned to paper ocean "laws" that had been adopted informally. The second revision of the Informal Composite Negotiating Text (ICNT-Rev.2) presents in both detail and vagueness a code of law that is rapidly becoming a "common law for the oceans," although it has not been formally adopted. For the marine scientist, the new regulations are seen as constraints, limitations, frustrations, and added expense to the old, free way of doing ocean science.

Most of the rules for doing science in the ocean are described in Part XIII of the ICNT-Rev.2. A few other rules are included in the articles concerning the high seas (The Area), the protection and preservation of the marine environment, and the development and transfer of marine technology. After stating some widely accepted, general principles, Part XIII addresses specifically the conduct and promotion of marine scientific research (Section 3, Article 245). The general principles: All states shall have the right to conduct marine scientific research subject to the rights and duties of other states and, together with competent international organizations, should help promote and facilitate the development and conduct of marine scientific research; the research shall be done exclusively for peaceful purposes; it will make use of appropriate scientific methods and shall not unjustifiably interfere with other legitimate uses of the sea. Certain aspects of global and regional research efforts will be stressed through the promotion of cooperation, the establishment of bilateral and multilateral agreements, and the dissemination of useful scientific data and information to those states competent to use them.

It is Section 3 of this part of the ICNT that lays down the rules, regulations, and laws that may restrict scientific research in the ocean. Inside its territorial seas, which extend 12 nautical miles from shore, a coastal nation has the exclusive right to regulate, authorize, and conduct marine scientific research. Of course, research in territorial seas can be conducted only with the express consent of the coastal nation. It is outside the territorial sea where the new restrictions apply. From the edge of the territorial sea to 200 nautical miles from shore is the "exclusive economic zone." Here too, the coastal nation exerts its authority over the exercise of marine scientific research. Research in this area requires the consent of the coastal nation, but in normal circumstances, that consent shall be granted without unreasonable delay.

The text indicates that normal circumstances may exist despite the absence of diplomatic relations between the coastal nation and the nation wishing to do research. However, consent may be withheld if the research relates directly to the exploration and exploitation of natural resources; or if it involves drilling into the continental shelf; or if it makes use of explosives or the introduction of other harmful substances; or if it involves the construction, operation, or use of artificial islands, installations, or structures; or if the information communicated to the coastal state is inaccurate; or if previous obligations to the coastal nation have not been satisfied. Outside the exclusive economic zone, research may be conducted freely except in those areas publicly designated by the coastal nation as areas in which exploitation or detailed exploratory operations are occurring or will occur within a reasonable period of time. The researching country must provide the coastal country with certain information 6 months before the expected starting date of the research. The nature of this information is spelled out in Article 248. The coastal nation has 4 months from the receipt of the request to inform the researching state that consent has been withheld, that additional information is needed, or that outstanding obligations exist from prior research. Consent to do the research is implied if the coastal country does not specifically withhold its consent within 6 months of the original request.

There may be a number of conditions imposed on the researcher (Article 249). These include: assuring coastal state scientists that they can participate in the research project; providing preliminary reports to the coastal nation as soon as practicable; forwarding to the coastal nation final results and conclusions after completion of the research; allowing access, on request, for the coastal state representatives to all data and samples derived from the research project; and furnishing to such representatives data that may be copied and samples that may be divided without damaging their scientific value. Also, if requested, the researcher must provide the people of the coastal country an assessment of data, samples, and research results or must provide assistance in their assessment or interpretation. Research results must be made available internationally through appropriate national or international channels as soon as feasible. Any major changes in the research program must be communicated to the coastal nation; unless otherwise agreed upon, any scientific research installations or equipment must be removed after the research is completed. These conditions, laid out in Article 249, can add to the cost of doing research. Other sections of Part XIII pertain to the suspension or cessation of research activities, the rights of neighboring landlocked and geographically disadvantaged states, the legal status of scientific research installations or equipment in the marine environment, responsibility and liability, and the settlement of disputes and interim measures.

Clearly, to scientists who have been unrestricted in the conduct of research outside the territorial seas of coastal nations, these regulations can present a considerable restriction, which may jeopardize the very initiation of research, add to the cost of research, and otherwise delay the progress of research. To representatives of many of the coastal nations of the world, these regulations seem entirely justified in view of the potential value of the research, both to them and to others concerned with the use of the ocean's resources off their coasts.

Will a formal, legally binding treaty actually result from this decade of intense deliberations? As the U.N. Conference on the Law of the Sea draws to a close, it is appropriate to consider the future and the effects of these deliberations.

THE FATE OF LAW OF THE SEA

"We should be concerned about the future because we will have to spend the rest of our lives there." -- Charles F. Kettering.

After a treaty document has been drafted and signed, the process of ratification will begin. Nations all over the world will debate the value of having a treaty or of having no treaty pertaining to the uses of the sea. The decision of the United States Senate to ratify or not ratify the treaty will have a profound impact on the reactions of other nations. If the United States Senate does not ratify the treaty, it is quite likely that other major nations also will fail to ratify it; the treaty may not enter into force, and a major opportunity for the further development of world legal order will have passed. However, if the United States ratifies the treaty, there is a good chance the treaty will enter into force. Considerable additional effort will then be devoted to refining and developing the procedures needed for the operation of such a treaty.

A third possibility exists. It is one in which the necessary number of nations fail to ratify the treaty even though the major ocean-using nations do adopt the treaty. Under such circumstances, the possibility exists for further international negotiations. Regardless of which alternative materializes--treaty, no treaty, continuing negotiations--it seems likely that the provisions of the ICNT-Rev.2 concerning marine scientific research will represent customary international law. There is a clear trend toward increasing international legal restrictions on research. These restrictions will be more confining to the conduct of science than was true in the past. No doubt the results of the ratification process will affect the intensity with which these restrictions are imposed.

Treaty--With the adoption of the treaty, the provisions outlined in the ICNT-Rev.2 will go into effect. These provisions will pertain to researching and coastal nations. Coastal nations that have previously denied access to coastal waters will feel pressure to provide such access, even though the draft document contains loopholes that could enable them to deny consent. The treaty would deter coastal nations from extension of their authority beyond the exclusive economic zone or the continental shelf. On the other hand, some nations that have not already adopted regulations and obligations for doing research can be expected to do so. A treaty would increase the uniformity of conditions governing ocean research. Although these new constraints might be considered more restrictive than those that now exist, they would establish general limits to the development of even more detrimental restrictions in the future. It would still be possible for nations to negotiate individual cooperative agreements (bilateral and multilateral) and, thereby, soften the restrictions imposed on each other. Then as now, the flag state would be responsible for the actions of all of its members. For a nation such as the United States with a number of operating oceanographic units, the action of any single unit could conceivably affect future activities of all.

No treaty--In the absence of a treaty, the worst case would involve extreme extension and tightening of control over marine research. Coastal nations could attempt to extend jurisdiction unilaterally and to prohibit research in their newly claimed territorial waters. Negotiations with such coastal nations would be done on an individual nation basis. In some cases, bilateral arrangements would be developed; in others, negotiations might take place on a project-by-project basis. Restrictions and burdens on the researching nation could be much greater under these circumstances, altbough in some cases, individual nations might be able to reach less restrictive agreements than would be the rule under an all-encompassing treaty. There would be no common law; each state would determine its own rules and regulations pertaining to the waters it claims. The effectiveness of such regulations would depend on the ability of the coastal nation to enforce them. It is probable that the number of international incidents involving research would be greater under a no-treaty situation than if a treaty were in effect.

Continuing negotiation--Should a situation arise in which a treaty is not signed but negotiations continue, circumstances might be much as they are today. Some coastal states would make claims that are not recognized by other, researching states. This could result in ambiguity, leaving the oceanographic researcher frustrated and in an uncertain position.

FUTURE IMPACTS

"Long range planning does not deal with future decision, but with the future of present decisions." -- Peter Drucker.

The fate of the negotiations on the Law of the Sea will strongly affect marine science throughout the world for decades. Already the new international legal regime has had a constraining effect on the conduct of marine science by the U.S. oceanographers. U.S. oceanographic teams have already experienced refusal of entry, delay in granting permission, and cessation of research. These are annoyances and nuisances at least; in some cases, they have resulted in considerable waste of the scientist's time, effort, and money. A treaty would clarify the basic ground rules for doing research in distant waters. A treaty could be construed to improve the present situation but require a greater expenditure of funds. To conduct research, the researcher could be required to provide marine technical assistance--which costs money.

A general failure to develop a treaty could result in a worse situation for research. If the failure could be attributed directly to a U.S. refusal to ratify, a disastrous situation for U.S. oceanographers might result. Today, U.S. foreign policy is not well regarded in many parts of the world, and refusal to ratify a treaty that is acceptable to many of the world's nations would clearly cast the United States in an unfavorable light. In such a situation, the ability of U.S. oceanographers to obtain consent to conduct research in foreign waters could be very difficult.

With or without a treaty, the tendency will be to conduct more research on the continental margin in waters of the United States or of friendly nations. This will be a deterrent to research in the tropics and at high latitudes.

Lesser developed countries will feel the outcome of the treaty negotiations differently than developed nations will. With a treaty, developing nations can expect cooperative research programs with leading research nations. With or without a treaty, bilateral and multilateral research agreements might be developed depending on the existing international political atmosphere. A complete failure of international cooperation resulting in no treaty could eliminate research in the waters of many less developed coastal nations. Deep-ocean research and research off the coasts of the leading researching nations would result. Marine science in the leading researching nations would advance relative to that of the lesser developed states. The knowledge gap between developed nations would increase.

A treaty would bring into effect formal "development and transfer of marine technology" (ICNT-Rev.2, Part XIV). One element of the text calls for the establishment of "national and regional marine scientific and technological centers," especially in developing coastal states. In this regard, a treaty would be in the direct interest of the lesser developed nations. Of course, there is no assurance that such centers would be established under the treaty, and certainly there is no prohibition to their creation in the absence of a treaty. Nevertheless, with a treaty in force, it is likely that efforts would be made to establish such regional and national centers.

MARINE TECHNICAL ASSISTANCE

"The secret of education is respecting the pupil." -- Ralph Waldo Emerson.

If the Law of the Sea negotiations have done nothing else, they have at least created an awareness on the part of a number of lesser developed countries of the value of the ocean. The negotiations also have made many lesser developed countries aware of their inadequacy to understand and use the ocean. Draft treaty provisions for marine technical assistance are an attempt to allow the Third World to catch up. Assistance can be imposed by rules, regulations, and laws, or it can be voluntary. In today's world, technical assistance programs are created by contributing nations for political and for altruistic reasons. Whatever the motivation, and whether imposed of voluntary, technical assistance programs must be done well to be effective. They must reach a variety of users who have different levels of sophistication and need.

Programs of marine technical assistance almost certainly will become an integral part of research activities carried out in distant coastal waters. The conduct of such technical assistance programs will cost money. These costs will be borne largely by the researching nation. Marine technical assistance programs may have a number of beneficial results. These include increased levels of scientific competence in lesser developed countries, the possible availability of personnel and facilities in foreign countries, and providing coastal nation scientists access to the scientific resources of the researching nation. Most coastal nations of the Third World will be more concerned with the applicability of the results of the research than with the intellectual sophistication of the results. Both parties benefit. Further, if such cooperative programs are done well, they could result in enhanced international cooperation in other areas.

PITFALLS, REALITIES, AND OPPORTUNITIES

"It is a condition which confronts us--not a theory." -- Grover Cleveland.

Marine technical assistance on a voluntary basis can be a noble challenge. The goals and objectives, once achieved, can be well worth the cost, the inconvenience, and the multitude of social, economic, logistic, and political obstacles and hurdles. However, technical assistance only as a requirement to conduct research can be a nuisance, an inconvenience, a frustration, and otherwise bothersome.

Many researching nations will consider the cost of marine technical assistance detrimental to the research effort, but it may be essential. Changing cruise plans to accommodate coastal state researchers and taking extra time to instruct them will be inconvenient. Ignorance of the political, social, and economic infrastructures of lesser developed countries may frustrate oceanographic researchers from developed nations. New layers of U.S. bureaucracy may be needed to ensure that past obligations to developing countries are met.

Those who would conduct marine science must adjust to these conditions. It will be necessary to learn the infrastructure and the politics of lesser developed coastal nations; it will be necessary to disseminate that knowledge for the benefit of those wishing to or forced to carry out technical assistance programs. Clearly, the future conduct of ocean science will be more complex and more expensive. It will involve international colleagues; it will require a sharing of resources and knowledge. It is also likely to result in an overall improvement of science and a broadening of the scope of activities of researching nations. Ultimately ocean science should result in an improvement in the management and use of the world's resources.

During the aeons of his development, man has lived on islands separated by the oceans. In many ways, the peoples of these islands have developed independently, often with little regard to their counterparts on other islands. The next stage in our evolution could see the oceans serving not as a barrier or as a separator, but as an agent to bring the people of the islands closer together. Perhaps, but only perhaps, we can make that happen. It seems worth the effort.

> "It is not necessary to hope in order to undertake, nor to succeed in order to persevere." -- Charles the Bold (1433-77).

FUTURE OF U.S. OCEANOGRAPHY[1]

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May 1980[2]

ABSTRACT

In spite of the risk of trying to predict the future, several areas of marine research appear particularly promising for research opportunities. These include: increasing the yield of animal protein from the ocean; deriving energy and mineral resources from the ocean; controlling pollution; predicting climate; and understanding the role of the oceans both as a sink and as a source of elements. Perhaps even more important than these general research topics is that several key factors may override and perhaps control the directions of marine scientific research in the coming decade. These factors include:

- Law of the Sea restrictions, implications, and opportunities;
- Role of marine science in U.S. foreign policy;
- U.S. budgetary changes and inflation;
- Development of large-scale oceanographic programs;
- Increased emphasis on applied programs, especially in the coastal zone.

Not only the currently promising areas of marine research but also these potentially overriding research-related factors may offer increased opportunities and encouragement for cooperative work with developing countries in marine science.

INTRODUCTION

There is considerable risk in trying to predict the future[2] for any field of endeavor, and this is especially true in such a

[1]Woods Hole Oceanographic Institution Contribution No. 4693
[2]As I reread (April 1981) this article, about a year after it was written, I am startled by the changes in marine science that may result from a new administration in Washington, D.C. There has been a change in our focus at the United Nations Law of the Sea Conference and a possible end to the National Coastal Zone Management Program, the National Sea Grant Program, and the National Oceanic Satellite System (NOSS). Nevertheless, I have decided to leave the paper as it was, perhaps making it a vivid example of the difficulty of trying to predict the future.

multidisiplinary science as oceanography. However, recent studies and an appreciation of U.S. needs for the future suggest specific questions for marine scientific research. These include how to increase our animal protein harvest from the ocean, how to extract energy and minerals from the ocean, how to control ocean pollution, how to forecast climate, and how to use the oceans as a sink for disposal and perhaps as a source for some elements. Several of these areas of research will be especially appealing for collaborative work with developing countries.

In my opinion their are several key factors emerging in the United States and elsewhere that will strongly influence and even control some aspects of marine science in the 1980s. The more important of these factors include:

- Law of the Sea (LOS) restrictions, implications, and opportunities;
- Role of marine science in U.S. foreign policy;
- U.S. budgetary changes and inflation;
- Development of large-scale programs like the Ocean Margin Drilling Program (OMD) and the National Oceanic Satellite System (NOSS); and
- Increased emphasis on applied programs, particularly in the coastal zone (and especially programs directed toward deriving energy from the sea) and the possible designation of the 1980s as the Decade of Ocean Resource Use and Management.

I suggest that these factors will play an important role in driving marine science in the 1980s, and should be considered in speculations about the future. These factors and the types of scientific problems that will develop in the 1980s could lead to increased cooperative work with foreign countries. LOS restrictions and budgetary problems, however, could work against such cooperative efforts, unless special programs or emphasis are developed within areas of the U.S. marine science community or funding agencies. Implicit in these remarks is that U.S. oceanographers may have a decreasing role in the development of their science.

GENERAL COMMENTS

A few generalizations are necessary before discussing specific points. Oceanography (or marine science) is a mixture of various natural sciences directed toward the study of the ocean. Traditionally, a marine scientist is expert in one, or part of one, of four or five divisions that make up the total field, i.e., biological oceanography, physical oceanography, chemical oceanography, geology or geophysical oceanography, and ocean engineering. A marine scientist's education, usually to the Ph.D. level, generally has followed one of two pathways:

1. Training in a specific scientific discipline (e.g., biology) and special emphasis on a marine aspect of that discipline, or

2. Some training in all fields of oceanography, but with a specialization in one division.

The latter probably produces the more general oceanographer, while the former more likely produces a specialist. However, these differences can be muted by many individual factors, including experience.

Future training of U.S. marine scientists probably will continue to follow the format outlined above, although increasing emphasis on applied research and specific, long-term programs indicates that different types of training might be appropriate. For example, if the 1980s are going to focus on ocean resources and their management, professionals will be needed in government and elsewhere with scientific training and with business, legal, or managerial experience. In addition, countries just beginning marine scientific efforts probably cannot afford the luxury of large numbers of highly trained experts, but rather will need more generally trained oceanographers as well as the scientific and managerial types mentioned above. These needs could lead to new marine-education efforts.

In recent years, individuals from social sciences (anthropology, and economics, for examples) have become increasingly interested in ocean-related problems. This interest has led to the emergence of a new, rather poorly defined field, commonly called marine policy, that has attracted some practicing oceanographers. Considering the trend toward applied studies of the oceans, this new field might be a factor in the future development of marine science.

"Interdisciplinary studies" is a common phrase used in proposing oceanographic research. An interdisciplinary approach becomes a necessity when the uses of the ocean are considered, especially in coastal regions. This approach is necessary because the problems associated with ocean use and the solutions and ramifications of those problems are too broad to be handled by individuals or groups from one discipline alone.

An important aspect of the future of marine studies is development of new technolgies that will allow long-term (months to years) *in situ* monitoring of oceanographic phenomena such as bottom currents and sediment movement. These technologies, coupled with more sophisticated satellite observations (combined with ground truth), and experiments using the ocean will give oceanographers the ability to consider problems that only a few years ago were beyond their scientific capabilities. The new technologies will have a high cost and probably will not be available to all institutions, groups, or countries, although the opportunity for sharing or cooperative work exists.

It should be emphasized that "breakthroughs" in marine science can come from many directions. These include new instrumentation and technology, interdisciplinary studies sometimes involving fields not previously associated with the ocean, new studies in unique areas, new approaches to old problems often motivated by economic or social factors, and luck. Recent findings, such the discovery of hydrothermal vents in the Galapagos Rift, suggest that the ocean still holds surprises that might change or influence certain fields of oceanography.

Ocean science on almost any level is expensive, and only a few academic institutions are able to consider most or all of the five major disciplines of oceanography. On the other hand, at least eight federal agencies have objectives in the ocean: Coast Guard, Environmental Protection Agency, Department of Energy, National Aeronautics and Space Administration, Department of the Navy, National Oceanic and Atmospheric Administration, National Science Foundation, and the Department of the Interior, through the U.S. Geological Survey and the Bureau of Land Management. Within the U.S. marine research effort, there are three principal groups of players.

1. Federal Agencies. These principally include the National Oceanic and Atmospheric Administration (Commerce) and the U.S. Geological Survey (Interior). Their efforts are mainly regulatory, and surveys are common operations, although each has in-house programs that consider both basic and applied research. Both organizations also subcontract (mainly USGS) or award grants for research (Sea Grant, part of NOAA). The National Science Foundation and the Office of Naval Resarch are the other major funders of marine research; the former supports mainly basic research.

2. Research Institutions and Universities. These organizations perform much of the basic marine research in the United States and are funded to a large degree by federal agencies. However, they also do a significant amount of applied research as indicated by the large number of Sea Grant-supported activities at U.S. universities.

3. Industry. Industry often focuses on practical application of marine science (for example, extraction of ocean resources) but sometimes funds basic or applied research, especially for environmental studies, at universities.

In evaluating the future, it is, of course, important to consider the past. During the past decade and a half, a considerable amount of U.S. legislation has been passed that has influenced the directions of marine scientific research and its funding. Examples are:

- Establishment of the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA).
- Passage of the Federal Water Pollution Control Act Amendments of 1972, the Marine Mammal Protection Act of 1972, the Marine

Protection Research and Sanctuaries Act of 1972, the National Sea Grant College and Program Act of 1966, the Coastal Zone Management Act of 1972, National Ocean Pollution Research and Development and Monitoring Planning Act of 1978, and the Fishery Conservation and Management Act of 1976, among other federal laws.

In spite of these acts, there is a common, and probably correct, view that the federal government lacks a clear policy toward ocean-related activities. The National Advisory Committee on Oceans and Atmosphere (NACOA) has stressed this point and has said that in spite of the extensive federal activity, the result is disjointed and lacks a cohesive purpose.[3]

Before discussing some important, specific scientific areas, a discussion is presented of the five key factors, mentioned earlier, that will have a large influence on marine science in the 1980s.

KEY FACTORS THAT WILL INFLUENCE MARINE SCIENCE IN THE EIGHTIES

Law of the Sea Restrictions, Implications, and Opportunities[4]

The past freedom to conduct marine scientific research in most of the ocean has allowed U.S. scientists to make major marine scientific discoveries. On the other hand, it may be unrealistic to assume that the more restrained consent conditions to be imposed as a result of the present Law of the Sea (LOS) negotiations will reduce the rate of scientific breakthroughs; more likely they will determine the geographic regions of discovery. The Law of the Sea will immediately affect how individual scientists maintain the style of their research. Most U.S. marine scientists have little interest in the process of negotiating permission for entering foreign waters and, in any case, might be hesitant to meet the LOS conditions necessary to get such permission. Pressures for promotions, funding limitations, etc., may preclude scientists from developing training or assistance programs with foreign countries. Thus a probable initial effect of LOS is that many marine scientists will avoid working in those regions where difficulty is anticipated and will focus instead on the deep sea or on U.S. waters. There is some evidence to suggest that this has already happened; Dr. Dirk Frankenburg, then division director of ocean sciences of the NSF Oceanographic Section, indicated in February 1980 that none of the five then pending proposals for research projects similar to those carried out under the International Decade of Ocean Exploration involved work in foreign waters. In addition, he

[3]Letter dated 31 March 1980 from Evelyn F. Murphy, chairman of NACOA, to various individuals concerned with marine science.

[4]See "Ocean Science, Law of the Sea, and Marine Technical Assistance," by John Byrne.

noted that many regular NSF proposals for work in foreign waters had "fall-back positions" in case difficulties arose in obtaining permission. Funding agencies, in general, seem to be taking no action or consideration toward research changes because of LOS problems. By avoiding difficult regions, we make our worst fears about the LOS come true, unfortunately, without really testing or stressing the LOS articles on marine scientific research. Alternatively, it may be that those first few countries that open their waters to U.S. scientists will find many takers waiting. The recent NOAA-sponsored oceanographc cruise to the People's Republic of China (even though it had several restrictions) may be an early example of this.

The LOS negotiations and their wide publicity may have other, more subtle effects than the potential restraint of scientific research in the ocean. The LOS negotiations already may be adversely affecting numbers of new students in and the interest toward the field of marine science. Several institutions have noted a drop in the number of applicants, although it is hard to establish the causes at this time. If this trend continues, U.S. institutions may make more opportunities available for foreign students.

It is fair to say that there is potential for good to come out of the marine scientific research articles in the LOS. Specifically, they should inspire less-developed coastal countries to become more concerned about their adjacent waters and perhaps encourage cooperative research with other countries. Our understanding of the ocean would benefit by having other countries develop a scientific interest in the ocean.

Potential Role of Marine Science in U.S. Foreign Policy

For various reasons, including an attempt to improve on the Informal Composite Negotiating Text (ICNT) resulting from the Law of the Sea conference, several types of cooperative arrangements are being or have been negotiated recently with foreign coutries. NOAA has been especially active in this capacity, having recently negotiated a bilateral agreement with China and presently discussing possiblities with Venezuela and Ecuador. The U.S. State Department has had discussions with several other countries. The arrangements, often driven by nonscientific considerations, should offer some opportunties for cooperative scientific research with developing countries, but they do have the potential for difficulties and high costs. This topic is beyond the scope of this paper but is treated in a separate study by a subgroup of FOSTG (Freedom of Ocean Science Task Group) of the Ocean Policy Committee of the National Research Council's Commission on International Relations.

In the future, some aspects of international marine science may be driven more by national and political implications, economics, and diplomacy than by the science. Bilateral and similar arrangements, involving technical assistance and training, could become a common *modus operandi* of marine science in the future.

U.S. Budgetary Changes and Inflation: The Costs of Doing Science

Marine research is obviously influenced by finances. Recent increases in the cost of fuel are posing problems for the academic fleet, the National Ocean Survey (the ship operations group of NOAA), and naval research vessels. At the time of this writing, all these organizations are making cutbacks in their operations. The potential of the fuel-cost problem is considerable and may severely limit or restrict distant water operations. It seems likely that even closer cooperation will be needed within UNOLS (University National Oceanographic Laboratory System) and with NOAA and the Navy to ensure the full and efficient use of ships that are operating.

The problems of inflation reach elsewhere. In the past, many institutions grew roughly in proportion to the funding they received. However, with the increase in inflation beginning in about 1978, growth, if any, often correlates better with a constant dollar factor. As costs and salaries rise to keep pace with inflation, research and support funding fall behind in real dollars, and some adjustments must be made. These adjustments can include:

- closing or reducing the size and scope of oceanography departments and institutions;
- reducing ship operations and delaying replacements of older ships; and
- supporting very broad consensus-like studies and specific applied studies with short-term results.

Financial exigencies could encourage closer and longer-range cooperative agreements with foreign countries, especially if the agreements involved financial support arrangements. In addition, the opportunity to use foreign research vessels could become extremely appealing as ship time becomes more expensive and harder to obtain in the United States.

Large-Scale Programs

Certainly one major component of U.S. marine science in the 1980s will be large-scale (many disiplines, many institutions, many agencies) scientific programs. Three of these programs are fairly well started (although still vunerable to budget changes): Ocean Margin Drilling (OMD), National Oceanic Satellite System (NOSS), and the National Climate Program; a fourth program, directed toward deriving energy from the ocean, seems forthcoming.

The OMD is a very sophisticated and expensive project. Present plans are to drill 15 holes between 1984 and 1989 mainly on passive continental margins (about 12 holes) with the remainder for active margins, paleoenvironment studies, and ocean crust studies. The Glomar Explorer will be refitted and equipped with a riser and complete well-control facilities for blowout prevention. This vessel will replace the highly successful Glomar Challenger. When modified, the Explorer will be able to drill with risers in waters up to 4,000 meters deep and penetrate 6,000 meters into the seafloor. The total cost of the ten-year project is estimated at $700 million. Several U.S. oil companies and foreign countries are expected to participate. Plans for this and other projects have been discussed by a wide group of international geologists and geophysicists from many nations over several years.[5]

NOSS is a cooperative effort of the U.S. Department of Energy, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration. Past studies have shown the value of satellite observations in oceanographic research[6] and in operations activities. NOSS is planning a demonstration of the feasibility of measuring surface wind velocity, significant wave height, sea-surface temperature, sea ice conditions, current measurements, and chlorophyll and other optical characteristics of the water column. NOSS information will be of considerable use to the oceanographic community as well as to the federal agencies. NOAA, for example, will use the information to improve its weather forecasting ability, and the Navy will use it for such applications as ship routing and global ocean data forecasting. NOSS will provide information for marine transporation, offshore mining, fishing and exploration activities, as well as providing scientific information about sea-surface dynamics. Conferences were held around the country to inform potential users of NOSS data and to develop participation in the NOSS program.

The third large program now under way is the National Climate Program, a five-year interagency effort coordinated by NOAA. One focus of this program will be to evaluate the effect of increasing levels of atmospheric CO_2 on global climate. In addition to NOSS and the National Climate Program, other large programs concerning marine pollution (a five-year plan is being developed) and seabed mining will be coordinated by NOAA. Although NOAA's budget has tripled in the last decade (to $800 million) and its responsibilities

[5]The Ocean Crustal Dynamics Program Plan for the 1980's. Joint Oceanographic Institutions (JOI), Inc., is another large-scale earth science project probably with less chance of success than OMD.

[6]See "Technology Transfer to Developing Countries: Future Use of Remote Sensing in Biological Marine Resource Development," by V. Klemas.

have expanded, the size of the agency's staff has increased by only 2 percent. Thus, it is possible that in future years, even more extramural work will be sponsored by NOAA.

The broad scope of these current large-scale programs and their international aspects suggest that they could also be useful in developing cooperation in other marine activities between U.S. and foreign scientists on state-to-state or on individual levels.

Increased Emphasis on Applied Programs and Possible Designation of the 1980's as the Decade of Ocean Resource Use and Management

In 1979, a group of 12 U.S. Senators and 40 Representatives sent a letter to President Carter urging increased emphasis on ocean resources and their potential. They requested that the 1980s be designated the Decade of Ocean Resource Use and Management. The objective in part would be an extension of work done by the International Decade of Ocean Exploration (IDOE) in the 1970s, but with more emphasis on resources, especially energy. At this writing, the letter has not received a significant response, although NACOA has been asked by the Executive Office to consider what such a designation would mean.

I have assumed in writing this document that a trend toward more applied research is developing in the United States. Evidence for this view is the types of large-scale programs being developed (OMD, NOSS, National Climate Program); increased activities of NOAA; growth and success of the Sea Grant Program; general statements of members of Congress toward applied, especially energy-related, marine research (see, for example, Sea Technology, 21:35-43, April 1980); and my own experience and conversations with colleagues. Other topics of applied research that should or will be stressed in the 1980s are deep-sea mining of manganese nodules; ocean thermal energy conversion (OTEC); disposal of waste products in shallow water; the possibility of nuclear waste disposal in the deep sea; and satellite studies of coastal zone processes. The trend toward increased extramural funding of projects by NOAA, the relative decline of ONR as a funding source (recent events suggest the possibility of increased military growth that could affect ONR), and the addition of several coastal-zone-type vessels to the UNOLS fleet also suggest increased coastal and applied research in coming years. It should also be mentioned that the United States will gain a considerable amount of marine territory through the LOS negotiations.

If this projection of increased study of the U.S. coastal zone (i.e., our EEZ) is correct, it follows that there may be a similar increasing interest among U.S. scientists and institutions in working in the EEZs of foreign countries. Techniques, skills, and educational opportunties refined in U.S. work would make an appealing package for cooperative efforts, especially with LDCs.

SPECIFIC SCIENTIFIC AREAS OF CONCERN FOR THE 1980s

This paper is not the first attempt at prediction of marine science in the 1980s. Several reports and documents have focused on all or part of the question. Probably the most comprehensive of these reports is The Continuing Quest: Large-Scale Ocean Science for the Future,[7] which looked at future IDOE-type programs and drew upon the results of several workshops organized by the National Science Foundation. John V. Byrne also prepared a paper[8] for the Ocean Policy Committee's 1979 Workshop on Coordination of International Oceanographic Research, in which he attempted predictions.

It seems most constructive for this short note to list briefly what might be the major areas of emphasis in marine science in coming years. The Continuing Quest has been a major source for my information. Several key areas for marine research are obvious. These research areas, although often involving fundamental scientific questions, are relevant to society and to use of the ocean. Among the more important are:

1. Increasing the Harvest of Animal Protein from the Ocean. Important questions include defining the processes that affect the dynamics of fish growth, including climate, pollution, fishing activities, and interactions between various species. Use of new fishing technologies, species (krill, for example), and management techniques (such as, exploiting natural fluctuations in recruitment) are also important aspects.[9]

2. Energy from the Ocean. Increased hydrocarbon production from the continental shelf and slope, exploration of the continental rise, and the study of clathrates as a potential source of natural gas are important to obtaining energy from the oceans. Other marine sources of energy, such as biomass conversion, OTEC,[10] waves, tides, currents, and salinity differences, also will be explored more throughly than in the past.

[7]Prepared for the National Science Foundation by the Post-IDOE Planning Study Steering Committee of the Ocean Sciences Board, Assembly of Mathematical and Physical Sciences, National Research Council. Available from the National Academy of Sciences, Washington, D.C., 1979.

[8]Within a Crystal Ball: Possible Future Directions of Marine Science and International Implications.

[9]See "World Fisheries and Aquaculture a Decade Hence: One View," by Francis Williams.

[10]See "Ocean Technology and Development," by John Craven.

3. Mineral Resources. Marine sand and gravel is already a multimillion-dollar industry in England, but before it can become a major U.S. industry, environmental and scientific questions must be answered. Many of the same questions must be answered with regard to the mining of manganese nodules. Heavy metal deposits in the Red Sea (which are close to being mined) and the Galapagos region may also be important.

4. Pollution. Marine pollution problems are immense. Especially important are defining the effects of a potential pollutant and knowing its source and rate of introduction, its history and pathways in the environment, its tranport processes and rates, and its ultimate fate.

5. Climate. Air-sea interactions are major factors in determining climate and the development of storms. It is especially important to develop better mechanisms of long- and short-term weather prediction, ways of modifying weather, and an assessment of potential effects of man's activities; for example, the increase in atmospheric carbon dioxide resulting from the burning of fossil fuels.

6. The Oceans as a Sink. The increasing volume of waste products on land coupled with the decrease in available disposal space make the prospect of waste disposal at sea, including disposal of nuclear waste, especially appealing. Important scientific questions such as waste-product interactions with the biological community should be answered before economic considerations become overwhelming.

7. The Oceans as a Source. Recent discoveries from the Galapagos Rift suggest that some chemical elements may be entering the ocean through the volcanic and hydrothermal activity along rift systems, although the implications of this process are relatively unknown.

Areas 1, 2, 4, and to some degree 6 are those that should have the most appeal to developing countries. Energy from the sea--OTEC, for example--would be an especially attractive technology transfer item, especially to energy-poor countries situated in tropical or near-tropical regions adjacent to a water mass having a large vertical range in temperature. The combination of OTEC with an aquaculture-like system could be even more appealing if it becomes economically feasible.

Specific subjects mentioned in The Continuing Quest are the following:

- Physical Oceanography. Estuarine-shelf dynamics, continental shelf dynamics and shelf-ocean coupling, western boundary region dynamics, midocean (interior) dynamics, large-scale atmosphere-ocean coupling

• Biological Oceanography. Climate variability and productivity, physical forcing of species succession, biological interactions among species, trophic-level coupling, community structure, patchiness, recruitment

• Chemical Oceanography. Water-column fluxes and reactions, seafloor fluxes and reactions, fluxes from the continent to the ocean, transient-tracer studies, gas-exchange studies, tracer-injection studies

• Marine Geology and Geophysics. Characteristics and driving mechanisms of the deep lithosphere and asthenosphere, evolution and variability of the ocean crust and upper mantle, structure and evolution of passive continental margins, structure and evolution of convergent-plate margins, diagenesis at depth, the ocean's role in climatic change over the past 150,000 years, and climate over the past 5 million years

Other evaluations of future projects include those of the Ocean Sciences Board, which has recently started a series of discussions on future trends in various fields of marine science. One such meeting[11] in Feburary 1980 on marine chemistry mentioned the role of the oceans in the CO_2 cycle, mathematical models of chemical cycles, thermal midocean vents as sinks rather than sources of chemicals, continued searches for hot spots to better assess their role, research on the biological factors in geochemistry, deep drilling in basalts, and use of natural radionuclides to study ocean processes. Participants in the meeting also considered the need to develop remote and long-term chemical sensors.

In a letter dated 2 April 1980 to various members of the oceanographic community, Mr. Richard Frank, adminstrator of NOAA, indicated several areas of importance for his administration in fulfilling NOAA's long-term oceanic and atmospheric responsibilities. These areas include:

• Oceanic/atmospheric interactions. The data set from the Global Weater Experiment, planned to be made available in 1980, will provide an unprecedented collection of observations that can be used for studies of air/sea interaction. Future experiments should be designed to develop and test predictive models of important phenomena.

• Oceanic heat transport and storage. The climate program is expected to include more studies on interannual changes in heat transport by oceanic currents to polar latitudes and on the storage of heat in oceanic surface layers, which can provide a basis for climate monitoring.

[11]As reported in Ocean Sciences Log, April 1980, No. 13 - an information publication compiled by R.C. Vetter of the Ocean Sciences Board, National Research Council.

• <u>Marine assimilative capacity</u>. NOAA's 5-year plan for study of marine pollution proposes long-term studies of natural ecosystems, the processes of transport, the fates and effects of contaminants, and the development of predictive models to aid in the evaluation and control of marine pollution.

• <u>Coastal water and sediment dynamics</u>. NOAA is proposing new research on coastal circulation and its effect on biological productivity, coastal sediment transport as it affects shore structures and beach stability, and wave and severe-weather sea level variations as a basis for understanding the coastal environment as a site for human activity and technological development.

• <u>Application of remote sensing techniques</u>. With NOAA's increased satellite responsibility, the agency will need refinement of acoustic and satellite remote sensing techniques to assist in the study of oceanic and atmospheric research problems.

Much of NOAA's planned work will be of interest to LDCs, and this agency could become a leader in foreign collaborative research.

In the field of marine policy, considerable progress was made in the 1970s with strong legislation for environmental protection and the development and relative acceptance of the Coastal Zone Management Program. The theme for the 1980s will likely be multiple-use, sustained-yield, ocean resource management,[12] with energy a dominating factor.

CONCLUSIONS

U.S. oceanographers will have some very important marine science questions to consider in the 1980s. The success with which oceanographers deal with these questions will be strongly influenced and perhaps controlled by factors beyond their control: Law of the Sea restrictions, implications, and opportunities; political factors; budgetary changes and inflation; large-scale programs; and trends toward more applied programs, especially in the coastal zone. The developing trend in the United States toward applied oceanographic research, in particular, could increase enthusiasm for working cooperatively with less-developed countries, depending on financial and Law of the Sea constraints.

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[12]J.W. Curlin (1980) Ocean policy comes of age: The end of the beginning or the beginning of the end. <u>Sea Technology</u>, 21:11-28 January 1980.

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TECHNOLOGY TRANSFER TO DEVELOPING COUNTRIES: FUTURE USE OF REMOTE SENSING IN BIOLOGICAL MARINE RESOURCE DEVELOPMENT

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ABSTRACT

Developing countries are showing an increasing interest in remote sensing technology for the development of their renewable and nonrenewable resources. Although most of the early applications of remote sensing have been in the agricultural and geological areas, the synoptic and repetitive coverage of satellites seems particularly well suited for monitoring the properties and managing the resources of large coastal and marine regions. The transfer of remote sensing techniques to developing countries is aided considerably by regional and national centers that are staffed and equipped to handle Landsat technology. New developments in marine-related remote sensing, such as synthetic aperture radar for wave studies, microwave radiometers for salinity measurements, and multispectral scanners and laser fluorosensors for chlorophyll mapping will require a concerted effort by national and international agencies to set up regional centers, sponsor joint research programs, and conduct workshops for transferring this technology to interested developing countries. Otherwise, the transfer of marine-related remote sensing technology will lag well behind the current transfer of Landsat technology for agricultural and geological applications.

INTRODUCTION

Economic pressures to extract oil and other deposits, to increase the harvest of food, and at the same time to protect the coastal environment are creating a need to monitor the properties of large ocean and coastal water bodies. As a result, efforts to accumulate data concerning biological coastal and marine resources have recently come to rely significantly on remote sensing techniques, which are being applied with varying degrees of success to accomplish the following objectives:

- mapping wetland habitat size, plant species diversity, and productivity;

- monitoring man-made and natural changes in the coastal zone, including the impact of land use change on estuarine habitat;

- mapping chlorophyll and nutrient-rich upwelling regions important to fisheries resources management;

- charting current circulation, fronts, and other dynamic properties important to studies of phytoplankton, zooplankton, and fish egg/larvae circulation;

- determining the identity, concentration, and dispersion of certain natural substances and pollutants, such as suspended sediment and oil slicks.

These applications of remote sensing require a wide assortment of data analysis techniques ranging from visual photointerpretation of color infrared film for wetland boundary mapping; to standard digital techniques for thermal infrared charting of coastal upwelling; to sophisticated multispectral analysis methods for studies and quantitative determination of marsh biomass and chlorophyll concentration in water. The objective of this paper is to illustrate by means of specific examples how the various data acquisition and analysis techniques are being employed to solve coastal resource management problems in developing countries.

STATUS OF REMOTE SENSING OF BIOLOGICAL COASTAL RESOURCES

To manage living marine resources, one must monitor and evaluate the fish-habitat relationships and be aware of the trends in available wetland habitat, including the primary productivity. Obtaining field measurements on such factors has proved costly in terms of time, manpower, and funds. Also, the results are specific to the sample site and may not be representative of surrounding areas.

Remote sensing can provide considerable information for a minimal cost and time when large coastal areas are to be surveyed. Potential applications of remote sensing to determine available habitat, surface water productivity, and fish availability are shown in Table 1. Color and color infrared photography have been used to map tidal wetland boundaries, vegetation species, and net primary production (Reimold et al. 1973, Anderson and Wobber 1973, Bartlett and Klemas 1979b, Klemas 1976). Multispectral digital satellite techniques have been employed to map plant types, density, and height of the standing crop, and other properties related to the quantity and quality of marsh biomass

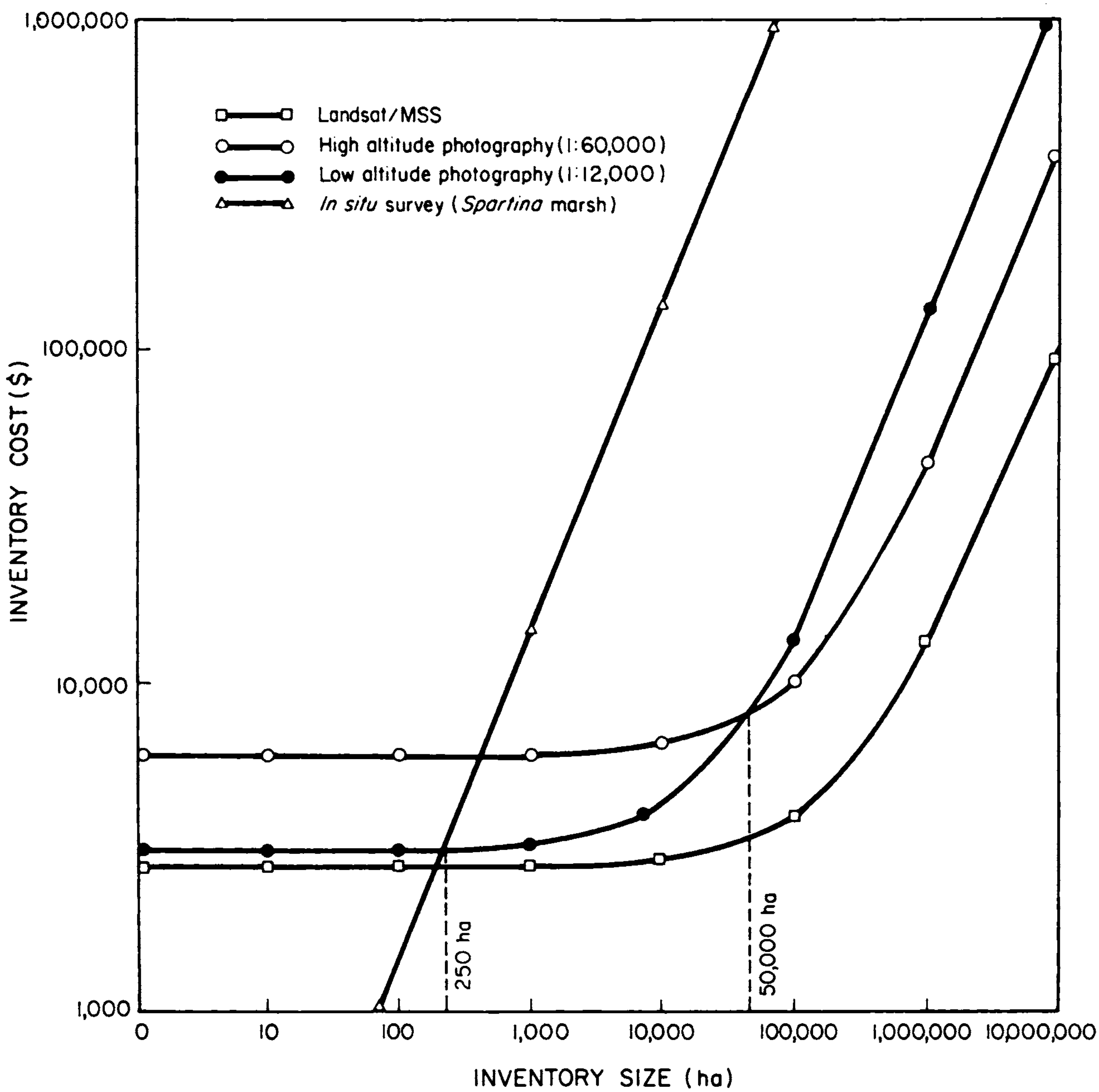

Figure 1. Inventory cost versus total area of wetlands inventories for three remote sensing platforms and *in situ* survey.

(Klemas et al. 1975, Anderson et al. 1975, Bartlett and Klemas 1979a, Carter and Schubert 1974).

Photographic and satellite data sources have advantages and limitations with respect to providing all data elements in an accurate cost-effective manner. Landsat data processing is a least-cost method of producing coastal land cover maps and tabular data for large areas (Figure 1). Planning studies, however, often require more detailed information on coastal vegetation and habitat at an accuracy level that is difficult to provide consistently over a range of categories through the Landsat data extractive process. Manual interpretation of aerial photography is a more expensive and time-consuming process than digital multispectral processing, but it yields a more detailed categorization of wetlands and habitats that many planning activities require.

As shown in Table 1, multispectral scanners (MSS) and laser fluorosensors are being tested for monitoring of primary productivity of coastal surface waters and the outflow of plankton and detritus from marshes and estuaries. Four selected laser excitation wavelengths have been used to induce chlorophyll fluorescence, which is indicative of both the concentration and the diversity of phytoplankton (Brown et al. 1977, Mumola et al. 1973). To map concentrations of organic and inorganic substances in coastal waters, multispectral scanner data are being analyzed by using the angular separation of eigenvectors representing each mapped substance in spectral signature space (Philpot and Klemas 1979). Both techniques are still experimental and will require considerable field testing before their reliability is established. Satellite, aircraft, and drogue techniques developed for monitoring the drift and dispersion of pollutants can be adapted to chart the flow and dispersion of detritus and other suspended matter (Klemas and Polis 1977).

Estimates of the availability of pelagic fish (in special cases also biomass) are normally obtained from biological studies, fishing fleet results, or reports of fish product companies. Smaller spotter planes are used to guide certain fishing boats to schools of fish, such as menhaden. From satellite altitudes, fish schools cannot be seen directly. However, satellites have been employed to locate areas of high probability for fish availability, such as the highly productive, nutrient rich, upwelling areas off the coasts of Peru, the western United States, and Africa. Upwelling areas can be mapped by multispectral scanners primarily because of their strong thermal and spectral gradients caused by the colder upwelling water and its spectrally different nutrient and chlorophyll content (Clarke et al. 1970, LaViolette 1974).

There also appears to be a correlation between certain coastal water properties, such as water color, turbidity, chlorophyll concentration, and the presence of fish. Computer classification of Landsat MSS data into high probability fishing areas off the coasts of

TABLE 1 Summary of Remote Sensing Techniques Used to Determine Wetland Habitat, Water Productivity, and Fish Availability

AVAILABLE WETLAND HABITAT	SURFACE-WATER PRODUCTIVITY	FISH AVAILABILITY
Habitat size, location vegetation species, tidal conditions	**Gross flow of organic detrital turbid water into estuaries and bays**	**Upwelling and other water masses having unique spectral/thermal signatures**
Aircraft color & color infrared photography	Aircraft multiband photography	SMS, NOAA thermal infrared scanners (HRIR)
Landsat MSS	Satellite MSS	Satellite MSS chlorophyll, turbidity and color (CZCS)
GT: Field checks (S)	GT: Current measurements & water sampling (M)	GT: Boat fish catch (M)
Marsh productivity, plant vigor, and water quality	**Concentration of chlorophyll and phytoplankton in estuaries, and coastal waters**	**Detection of fish schools and related properties**
Aircraft color infrared photography	Digital MSS from aircraft or satellite	Fish oil detection by aircraft spectrometers
Digital MSS from aircraft and satellites	Laser fluorosensing low altitude aircraft	Fish-induced luminescence detected by sensitive TV cameras
GT: Harvest & water sampling (L)	GT: Water sampling (L)	Fish egg and larvae drift into estuaries as a function of winds and currents measured by microwave sensors
		GT: Fishing boat reports, spotter planes (L)

GT = Ground truth required
S = Small amount
M = Moderate amount
L = Large amount
MSS = Multispectral Scanner

SMS = Synchronous Meteorological Satellite
CZCS = Coastal Zone Color Scanner
HRIR = High Resolution Infrared Radiometer
NOAA = NOAA Series Satellites

Louisiana and Mississippi produced promising results (LaViolette 1974, Kemmerer 1976). The applicability of similar techniques for locating other fish types, such as thread herring and croakers, are being investigated. Measurement of surface winds and currents by microwave sensors, such as the scatterometer, altimeter, and radar mapper on Seasat, can be used effectively to verify fish egg and larvae drift models of interaction on shelves and in estuaries (Brucks and Leming 1977, Born et al. 1979).

Many finfish and shellfish that spawn offshore depend on surface currents to transport their eggs and larvae into estuarine nursing grounds. This period of egg and larval drift represents the most critical survival period for certain marine fishes. When surface currents do not provide favorable transport or when coastal density fronts prevent their drift, the respective fishery may be severely affected.

At the present time, surface transport for fishery applications is calculated by estimating geostrophic wind field from surface atmospheric pressure fields prepared by groups such as the U.S. Fleet Numerical Weather Service. Sea-surface stress is normally inserted into the appropriate Ekman formulation, including the Coriolis parameter, to obtain an estimate of the surface transport. However, this approach is limited to about 300 km in range and by about one month in time (Brucks and Leming 1977).

Satellite remote sensors can be used to monitor certain oceanographic features synoptically over wide areas and with frequent temporal coverage. Specifically, it appears that a Seasat-type scatterometer could be used to map sea-surface stress with the following advantages: (a) Synoptic coverage over a large area (2 x 500 km swathwidth), (b) Reasonably high resolution (50 km), (c) 36-hour repetition frequency, (d) A direct measurement of sea-surface stress, which can be converted into surface transport for correlation with actual fish larvae movement (drift). Seasat-A scatterometer algorithms for estimating wind-induced surface layer transport are being modified for coastal conditions and their accuracy is being evaluated (Brucks and Leming 1977).

Another important aspect to be considered is the influence of coastal and estuarine fronts on the movement of fish eggs and larvae. Scientists have found that coastal and estuarine fronts seriously influence the drift and dispersion of oil slicks, phytoplankton, and other suspended matter. In recent experiments in Delaware Bay, oil slick and phytoplankton were found to line up along convergent fronts rather than follow the drift pattern predicted by a model using wind and current information (Klemas and Polis 1977). Convergent fronts have been observed regularly along the East Coast on the shelf and in the Delaware and Chesapeake bays. Fronts and their movements can be monitored by NOAA-5, Landsat, and aircraft sensors. Descriptions of the Landsat, NOAA, and SMS/GOES satellites are presented in Tables 2, 3, and 4.

A summary of remote sensor applicability to fisheries resources studies is presented in Table 5. From these results, it is reasonable to conclude that remote sensing techniques can be used effectively and reliably to map the location, size, and quality of wetland habitat; to chart fronts, slicks, and upwelling regions; to observe the dispersion of certain pollutants; and to monitor sea-state conditions. However, remote sensing techniques being developed for determining surface water productivity, detritus and nutrient flow, and fish availability require additional field testing to establish their reliability.

FUTURE DEVELOPMENTS AND THEIR SIGNIFICANCE

Table 5 shows that from the viewpoint of fisheries resources management, remote sensors currently have several shortcomings:

1. Depth profiles of water properties cannot be obtained remotely.

2. Temporal coverage is insufficient, particularly in view of frequent cloud obscuration of critical fishing areas, such as Georges Bank.

3. Chlorophyll measurements are not reliable, particularly in coastal waters.

4. More sensitive techniques for measuring ocean salinity need to be developed.

5. Better synoptic measurements of surface winds and currents are required.

6. Closer cooperation is required between remote sensing specialists and the actual data users.

It is in these six areas that we expect the most significant advances to take place in the future, because considerable pressure is being applied to the remote sensing community by various users, such as the National Marine Fisheries Service.

In the visible bands, two new sensors will dominate satellite remote sensing in the next decade. The Coastal Zone Color Scanner (CZCS) was launched in 1978 on Nimbus 7. As shown in Table 6, the CZCS measures upwelling spectral radiances from the ocean waters in thermal and near infrared and four visible bands, which are selected according to optical properties of chlorophyll, yellow substances, and suspended matter (Austin 1979). The infrared bands serve to map land/water interfaces and temperature of coastal and ocean currents.

TABLE 2 Landsat

Launch:	1972, 1975, 1978		
Orbit:	900 km circular near-polar, sun-synchronous		
Cycle:	18 days		
Return Bean Vidicon Cameras (3)			
Multispectral Scanner			
Band	4	0.50 - 0.60 μm	
	5	0.60 - 0.70	
	6	0.70 - 0.80	
	7	0.80 - 1.10	
	8	10.5 - 12.5	(Landsat-3)
Resolution:	80 meters	(57 m x 79 m)	
	240 meters	(Band 8)	
Coverage:	184 km Strip 10% Sidelap at Equator		
Two Tape Recorders and Direct Readout			
Data Collection from Platforms			

TABLE 3 NOAA (ITOS, TIROS)

Launch:	ITOS(TIROS-M)	1970
	NOAA 1 - 5	1970 - 1976
Orbit:	sun-synchronous, near-polar	
	1,470 km 12 orbits/day (9AM, 9PM)	

Coverage: 3,400 km swath

VHRR (Very High Resolution Radiometer)

0.60 - 0.70 μm	1 km resolution
10.5 - 12.5	

SR (Scanning Radiometer)

0.40 - 1.1 μm	4.2 and 8 km resolution
10.5 - 12.5	

VTPR (Vertical Temperature Profile Radiometer)

8 channels

VHRR direct readout

SR tape and direct readout

TABLE 4 SMS/GOES*

Launch:	1974 (105°W)	1975 (75°W)
	1975 (135°W)	1977
Orbit:	earth-synchronous	(geostationary)
	35,800 km	

Coverage: 60° N-S

VISSR (Visible IR Spin-Scan Radiometer)

8	visible channels	0.55 - 0.70 μm	0.8 km
2	IR channels	10.5 - 12.6	8
	(radiance temp. meas. 180°K to 315°K)		

Space Environment Monitor

Data collection from meteorological platforms every 6 hours

*Synchronous Meteorological Satellite/Geostationary Operational Environmental Satellite

TABLE 5 Remote Sensing Systems for Fisheries Applications

	Temperature	Salinity	Chlorophyll	Color	Suspended Sediment	Sea State	Fronts	Patchiness	Oil
LANDSAT MSS	0	0	1	2	3	1	2	2	2
NIMBUS - G (CZCS)	0	0	2	3	3	1	2	1	1
NOAA - 5 HRIR	3	0	0	0	0	1	3	1	1
DMSP	3	0	0	0	0	1	3	1	1
HCMM	3	0	0	0	0	0	2	1	1
SEASAT	3	1	0	0	0	3	2	2	2
HAA MSS (OCS)	0	0	2	3	3	1	2	3	3
HAA PHOTOGRAPHIC	0	0	1	1	2	1	2	3	2
MAA PHOTOGRAPHIC	0	0	1	2	2	2	2	3	2
MAA MSS (M2S)	3	0	2+	3	3	2	3	3	3
MAA INFRARED (THERMAL)	3	0	0	0	0	1	3	2	2
MAA MICROWAVE	2	2	0	0	0	3	2	1	2
MAA RADAR	0	1	0	0	0	3	1	2	2
HELICOPTER FLUOROSENSOR	0	0	2+	1	1	1	2	2	3
SMALL AIRCRAFT PHOTOGRAPHIC	0	0	1	1	2	2	2	3	3

HAA = High Altitude Aircraft (U-2)

MAA = Medium Altitude Aircraft (C-130)

HCMM = Heat Capacity Mapping Mission Satellite

DMSP = Defense Meteorological Satellite

MSS = Multispectral Scanner

OCS = Ocean Color Scanner (10 bands)

M2S = Modular Multispectral Scanner (11 bands, including thermal infrared)

Photographic = Zeiss and Mitchell - Vinten Cameras

0 = Not applicable

1 = Limited Value (Future Potential)

2 = Needs Additional Field Testing

3 = Reliable (Operational)

TABLE 6 Nimbus

Launch:	Nimbus 1 - 6	1964 - 1975
	Nimbus 7	1978
Orbits:	sun-synchronous	near-polar
	Nimbus 1 - 6	1,100 km
	Nimbus 7	955 km
Coverage:	twice daily	

SMMR (Scanning Multifrequency Microwave Radiometer)

CZCS (Coastal Zone Color Scanner)

Channel	1	0.433 - 0.453 μm	chlorophyll absorption
	2	0.51 - 0.53	chlorophyll correlation
	3	0.54 - 0.56	gelbstoffe
	4	0.66 - 0.68	chlorophyll absorption
	5	0.70 - 0.80	surface vegetation
	6	10.5 - 12.5	surface temperature

Although its spatial resolution of 800 meters from Nimbus 7 altitude of 955 km limits its use in estuaries and near-shore regions, it already is providing interesting results on deep ocean color and chlorophyll.

Another advanced optical scanner is the Thematic Mapper, to be launched on Landsat-D in 1981. Although its spectral bands, shown in Table 7, are not optimized for chlorophyll mapping, its high spatial and spectral resolution will help significantly to improve mapping of wetlands and studies of organic and inorganic suspended matter in coastal waters (Bracken et al. 1979).

In 1984, NASA expects to launch the National Oceanic Satellite System (NOSS). The primary sensors on the NOSS satellite, like Seasat, will consist of a scatterometer operating at 14.6 GHz; a radar altimeter at 13.5 GHz; a scanning multichannel microwave radiometer (SMMR) from 6.6 to 37 GHz; a coastal zone color scanner (CZCS) with eight channels in the visible reflection region; and an advanced, very high resolution radiometer (AVHRR) in the thermal infrared (Bracken et al. 1979). Table 8 shows that the sensors on this satellite will significantly improve our ability to monitor ocean-surface chlorophyll, turbidity, winds, and currents, thus responding to items 3, 4, and 5 on our original list of six areas requiring improvements. The frequency of the measurements, ranging from every 3 hours for wind to every 48 hours for chlorophyll, will also improve the temporal coverage of most sites. Furthermore, cloud cover will cause fewer difficulties, because most of the sensors will operate in the microwave region (Callio 1979).

Another promising application of microwave radiometry is the measurement of surface salinity from low aircraft altitudes. Sea-surface salinity with an accuracy of 1 per thousand and sea-surface temperature with an accuracy of 1°C have been measured with a 1.43 and 2.65 GHz radiometer system after correcting for the influence of cosmic radiation, intervening atmosphere, sea-surface roughness, and antenna beamwidth. Flight measurements from aircraft over bay regions and coastal areas of the Atlantic resulted in contour maps with spatial resolution of 0.5 km (Swift 1980). Although the ability to detect salinity changes of 1 per thousand is insufficient for deep ocean work, microwave radiometry offers a definite potential for measuring ocean-surface salinity.

Significant new results have been obtained with synthetic aperture radar (SAR) on Seasat (Born et al. 1979). The SAR, imaging in the L-band (1.275 GHz), looked to the starboard side of the subsatellite track with a swath 100 km wide centered 20° off nadir. The length of the SAR image track was determined by the view duration of the receiving station, with about 4,000 km being the maximum. The spatial resolution of 25 km, needed for wave analysis, required a very high rate of data acquisition so that onboard recording was not possible. As a result, only those developing countries that were within view of

TABLE 7 Landsat-D Orbital and Sensor Characteristics

- Landsat-D Orbital Characteristics

Altitude	705 km
Inclination	98.2°
Sun Angle	9:30 am at descending node
Coverage	16 days

- Sensor Characteristics

	TM	MSS
Channels	0.45-0.63 μm	0.5-0.6 μm
	0.52-0.60	0.6-0.7
	0.63-0.69	0.7-0.8
	0.76-0.90	0.8-1.1
	1.55-1.75	
	10.40-12.50	
	2.08-2.35	
IFOV	30m (Channels 1-5 & 7) 120m (Channel 6)	80m
Ground Swath	185km	185km
Data Rate	85 Megabits/second	15 Mbs
Quantization Levels	256	64

TABLE 8 NOSS Primary Outputs

Parameter	Precision	Absolute Accuracy	Range	Frequency	Delay	Model Grid Size	Horizontal Resolution
Wind							
Speed	0.5 m/s	2 m/s	0 to 50 m/s	12 hrs	3 hrs	200 km	25 km
Direction	5^{o}	10^{o}	0^{o} to 360^{o}	12 hrs	3 hrs	200 km	25 km
Sea-Surf. Temp.							
Global	$0.25^{o}C$	$1.0^{o}C$	$-2^{o}C$ to $35^{o}C$	3 days	12 hrs	200 km	25 km
Local	$0.10^{o}C$	$0.5^{o}C$	$-2^{o}C$ to $35^{o}C$	1 day	12 hrs	10 km	10 km
Waves (Sea State)							
Sign. Wave Ht.	0.3 m	0.3 m	0 to 25 m	12 hrs	3 hrs	100 km	25 km
Amplitude Components	0.7 m	0.7 m	1 to 8 m	12 hrs	3 hrs	100 km	25 km
Wave Length Components	10%	10%	6 to 1,000 m	12 hrs	3 hrs	100 km	25 km
Direction	10%	10%	0^{o} to 360^{o}	12 hrs	3 hrs	100 km	25 km
Ice							
Cover	15%	15%	0 to 100%	3 days	12 hrs	20 km	20 km
Thickness	2 m	2 m	0.25 to 50 m	3 days	12 hrs	50 km	50 km
Age	New, 1st yr multi-yr	New, 1st yr multi-yr	0 to 3 yrs	3 days	12 hrs	20 km	20 km
Sheet Height	0.1 m change	0.5 m change	-5 to +5 m/yr	1 yr	30 days	TBD	10 km
Bergs	N/A	$\pm$2 km of true location	N/A	2 days	12 hrs	N/A	0.1 km
Water Mass Definition							
Chlorophyll	10% (mg/m^3)	Within factor of 2	0.1 to 100 mg/m^3	2 days	8 hrs	TBD	0.4 km
Turbidity	0.1 PPM	Lo, Med, Hi	0 to TBD	1 day	10 hrs	TBD	0.4 km
Horizontal Surface Currents							
Speed	5 cm/s	5 cm/s	0 to 250 cm/s	1 day	1 day	100 km	20 km
Direction	10^{o}	10^{o}	0^{o} to 360^{o}	1 day	1 day	100 km	20 km

SOURCE: Callio (1979).

U.S. receiving stations could be covered by the SAR. During Seasat's 3-month lifetime, the SAR measured waves and wave spectra to oceanic wavelengths of 50 m and greater in addition to recognizing ocean fronts, sea ice features, and interfaces between water and land. Comparison with surface and aircraft measurements indicates agreement to within ± 15 percent in wavelength and ± 25° in wave direction for waves 100 to 250 m in length. The SAR penetrated to the surface during unfavorable viewing conditions, including major storms such as hurricanes. There is little doubt that aircraft and satellite SAR systems will play a major role in all-weather observation of ocean waves, current, and ice conditions in the future.

Laser systems have been used for nearly a decade to obtain wave and bottom profiles. Now, dramatic advances are expected in fluorosensing of suspended matter within the water column. Laser fluorosensing systems are being investigated for remote detection and characterization of oil slicks and phytoplankton (Mumola et al. 1973). Any fluorescent material, when excited by light at one wavelength, will almost immediately reemit the energy as light at longer wavelengths than the exciting wavelength. Generally, the emission is strongest over a rather narrow range of wavelengths and for a particular excitation wavelength. The success of a laser fluorosensing system depends on the fact that the excitation spectra and emission spectra are distinct for different materials. Thus, in phytoplankton, each pigment will have different fluorescence characteristics. Since each species of phytoplankton has its own characteristic balance of various pigments, it may be possible not only to detect the presence of phytoplankton, but also to identify the color group if not the specific species. Mumola et al. (1973) have developed a multiwavelength laser system to make use of this species-dependent variability of wavelength in fluorescence. By using four excitation wavelengths and observing the fluorescence at the four corresponding emission peaks, they have been able to detect the presence of chlorophyll and have also been able to estimate the chlorophyll concentration in the water. With range gating, these systems have the potential for measuring depth profiles of organic and inorganic substances in the water column.

Laser studies are also being performed for the remote measurement of subsurface seawater temperature and salinity by means of Raman scattering (Chang and Young 1972). Measurements of Raman spectra of water in the O-H stretching region show a shift to longer wavelength with increasing temperature, with increasing salinity, and with crossed polarizers in front of the light source and detector. The feasibility of measuring subsurface ocean temperatures remotely by observing the Raman spectrum of light backscattered from a laser beam has been evaluated by laboratory experiments and by estimates of field performance. A precision of about 0.2°C has been achieved down to a depth of 30 m in clear ocean water.

In summary, it is reasonable to conclude that new remote sensing systems will be deployed during the next decade and will satisfy most of the shortcomings of remote sensing of marine biological resources outlined at the beginning of this section. Simultaneously, remote sensing centers being established at various academic and government institutions will insure closer cooperation between remote sensing specialists and data users.

IMPACT ON DEVELOPING COUNTRIES

In developing countries the term "remote sensing" has become almost synonymous with "Landsat." This is understandable in view of the long-term success Landsat has enjoyed in agricultural and geological applications in the United States and overseas. The governments of developing countries in particular, with strong support of such agencies as the U.S. Agency for International Development, the World Bank, and the Inter-American Development Bank, have successfully fostered Landsat related investigations of land use, food resources, and mineral deposits, including desertification, irrigation, crop management, deforestation, and exploration for minerals and metals. As a result, about 55 countries and more than five international organizations are involved in Landsat investigations. Landsat data receiving stations or data analysis centers have been set up in a number of developing countries, including Brazil, Egypt, Kenya, India, Thailand, the Philippines, and Zaire. Additional receiving stations are scheduled for Argentina and Chile.

The backbone of AID's technical assistance program is the development of regional centers that will be focal points for remote sensing activities (Conitz 1978). The first of these centers has been established in Kenya in cooperation with the new Regional Centre for Services in Surveying and Mapping, sponsored by the Economic Commission for Africa. It is particularly important to establish a close working relationship between the multidisciplinary remote sensing community and the traditional mapping community. Many of the newly ordained remote sensing specialists have tended to focus on the extraction of data from satellite imagery and aerial photography, often through the use of relatively sophisticated techniques. It is felt that it is of equal, or perhaps greater, importance first to develop the capability for presenting those data in cartographic formats useable by planners. To do this requires a knowledge of cartographic processes, such as establishment and use of ground control, image recitification, the use of various map projections, and others. It is also important to develop means, such as a coastal mapping system, for systematically storing, retrieving, and analyzing data.

The Nairobi center began operation in 1977. Other centers are being developed in West Africa, Asia, and Latin America. AID in cooperation with the National Science Foundation has already supported a center in Egypt that could be expanded to supply assistance to countries in North Africa and the Middle East.

Each center will be staffed by four or five specialists representing different diciplines, and by local technicians. Each center will also contain analytical equipment, imagery files, a technical library, and ground-truth equipment. In addition to being able to provide workshops and other training, each center will have a strong outreach or extension capability. The staff will be encouraged to acquire familiarity with the needs of the countries of the region to provide the kind of assistance that will satisfy those needs directly.

The regional centers will be focal points for the development of networks and linkages. They will be important contact points between local resource managers and experts in the United States and elsewhere. The personnel of the centers will work closely with national universities in the introduction of remote sensing into their curricula. Remote sensing is seen as a tool in resource management just as mathematics is a tool in science or engineering, and the objective is to have remote sensing taught as an integral part of any resource oriented curriculum. Accordingly, in establishing these centers AID is not attempting to create permanent new institutions but, rather, temporary organizations that can satisfy an immediate need.

To differentiate South American countries according to their technological development in remote sensing, Adrien (1978) has divided them into three groups, the most advanced of which receive and analyze digital satellite data. Table 9 shows that 5 out of 24 Latin American countries are participating in technology transfer at the highest level, including multispectral digital analysis. Seven more countries can absorb techniques of moderate complexity, such as visual analysis with optical enhancement of aircraft or satellite imagery. The ratios of technologically advanced centers to total numbers of centers is somewhat lower in Asia and Africa, even though there are some fairly advanced laboratories in the developing countries of those continents, particularly in Egypt, India, Iran, Kenya, the Philippines, Thailand, and Zaire.

When we turn to coastal and marine applications of remote sensing in developing countries, the results appear far less encouraging. Landsat's optical sensors have limited appplication to coastal and marine studies, which require thermal infrared and microwave sensors as well. Whereas most developing countries are covered by the satellites shown in Table 10, most of these countries neither receive nor analyze thermal infrared or microwave satellite imagery. Thus, the impressive system set up by AID and other international agencies for transfer of remote sensing technology pertains primarily to Landsat technology for agricultural and geological studies and almost

TABLE 9 Classification of Latin American Countries According to Remote Sensing Activities

Beginning	Moderate-Intermediate	Advanced
Bahamas	Colombia	Argentina
Barbados	Costa Rica	Bolivia
Cuba	Ecuador	Brazil
Dominican Republic	El Salvador	Chile
Guyana	Guatemala	Mexico
Haiti	Peru	
Honduras	Venezuela	
Jamaica		
Nicaragua		
Panama		
Paraguay		
Uruguay		

TABLE 10 Satellites Gathering Data for Development Projects in Latin America

	Satellite	Wavelength Region (micrometer)	Spatial Resolution (meter)	Repetitive Coverage
1.	Landsat-1	Visible (0.5-0.7) Near Infrared (0.7-1.1)	MSS=80 = 0.465 Ha.	No longer in operation
2.	Landsat-2	Visible and near IR	MSS=80 = 0.465 Ha.	Every 18 days
3.	Landsat-3	Visible, near IR and thermal (10.4-12.6)	MSS=80 = 0.465 Ha. RBV=40x80 Thermal - 240	Every 18 days
4.	Seasat	Synthetic aperture Radar (23.8 cm L band)	25	Only where real= time reception available U.S., Canada, & United Kingdom
5.	Nimbus-G	Coastal color scanner Five visible narrow bands (± 10 nanometers)	800	Every 6 days
6.	NOAA-5	Visible daytime, thermal at night	Low = 4,000 High = 1,000	Every 12 hours
7.	NOAA (VHRR)	Visible and thermal IR	900	Every 12 hours
8.	TIROS-N (AVHRR)	Visible, near IR	900/4,000	
9.	GOES	Visible and thermal	2,000/5,000	Every half hour

SOURCES: NASA and NOAA, Washington, D.C.

totally neglects transfer of thermal infrared and microwave technology for oceanographic applications. For instance, several countries, including Chile, Peru, and India, have a long-standing involvement in satellite tracking networks or meteorological data analysis, receiving and analyzing low-resolution (8 km) thermal infrared imagery from satellites such as the Geostationary Operational Environmental Satellite (GOES). However, these stations and new remote sensing centers being set up in Argentina, Brazil, Chile, Ecuador, Egypt, Syria, Kenya, Thailand, and the Philippines do not have the capability to recieve or analyze high-resolution thermal infrared data from NOAA-type satellites or microwave data from Seasat-type satellites. Yet this is the kind of data required for coastal and oceanographic studies; including coastal upwelling and current circulation.

In view of the present slow transfer of available technology in spacecraft oceanography, the outlook for adapting more advanced techniques appears even more difficult, unless a number of national and international organizations seek more effective ways for transferring this technology. Such organizations include the U.S. National Oceanic and Atmospheric Administration, the Intergovernmental Oceanographic Commission Working Committee for Training, Education and Mutual Assistance, the International Council of Scientific Unions' Committee on Science and Technology in Developing Countries and Committee on Space Research, and the Marine Technical Assistance Group of the U.S. National Research Council's Ocean Policy Committee. These organizations already sponsor conferences, training workshops, and joint research projects, which allow foreign scientists to glimpse the advanced techniques used in the United States and Europe. Conferences and training workshops are relatively inexpensive and can be arranged on short notice. However, they lack continuity and continuing support and frequently train the wrong people. However, they lack continuity and continuing support and frequently train the wrong people. Joint research projects developing and demonstrating major applications of the technology are usually conducted under expert control and produce tangible results for a commitment that is limited in time. However, the success is not always transferable and the research in he developing country is frequently used by the expert to test his approach in a new environment, write a paper, and move on to other investigations without having truly interacted with the local scientific establishment.

To transfer this technology effectively may require that, just as in the case of Landsat, regional centers be established for applying remote sensing to coastal and oceanographic problems on a permanent basis. The advantage of regional centers is that they establish continuing local access to the technology, involve local support, and insure long-term program continuity. The disadvantage of centers is that they require expensive long-term commitments and are affected by regional politics. The typical cost of establishing a Landsat receiving station with associated data analysis equipment is about $7 million; maintenance and operation costs average about $3 million per year. This obviously consitutes a major burden on the sponsoring agency and local governments. However, the additional cost of converting existing satellite data receiving stations to receive kilometer-resolution NOAA satellite thermal infrared imagery is in the range of $50,000 to $200,000. This step is recommended for countries such as Peru or India, which already have Landsat or GOES receiving stations and have a strong interest in adding high-resolution ocean observation capabilities to their land and cloud observations.

Agencies such as AID, the Food and Agriculture Organization, and the U.S. Geological Survey, which already are involved in transfer of remote sensing technology, should be encouraged to expand into the marine applications area with guidance provided by specialists from NOAA/NESS and the academic community. NOAA in particular should be encouraged to provide technical support to developing countries in the application of remote sensing of marine resources, because it has impressive expertise at the National Environmental Satellite Service (NESS). NOAA's Sea Grant International Program could serve as a successful model for such technology transfer. Sea Grant now sponsors about half a dozen research and training projects in the marine sciences, managed jointly by U.S. universities and universities in developing countries. Although the overall program does not exceed $1 million, it seems to be quite effective. On the other hand, the Intergovernmental Oceanographic Commission Working Committee for Training, Education and Mutual Assistance (IOC/TEMA) should pursue more agressively its role as marriage broker, helping graduate students and specialists from developing countries find proper training at U.S. or European institutions. The United Nations, the Food and Agriculture Organization, the Committee on Space Research (COSPAR) of the International Council of Scientific Unions, the Marine Technology Assistance Group of the National Research Council's Ocean Policy Committee, and others should expand their roles in organizing appropriate training workshops.

CONCLUSIONS

Developing countries are showing an increasing interest in remote sensing technology for the development of their renewable and nonrenewable resources. Although most of the early applications have been in agricultural and geological areas, the synoptic and repetitive coverage of satellites seems particularly well suited for monitoring the properties and managing the resources of large coastal and marine regions. The transfer of remote sensing techniques to developing countries is aided considerably by regional and national centers staffed and equipped to handle Landsat technology. The application of remote sensing to countries that lack a sufficient technological base to form such centers is producing significant short-term benefits to agriculture and geological exploration, despite the lower degree of technology transfer attained.

Landsat sensors are limited to the visible and near infrared reflective region and were designed primarily for land-related studies. Marine and coastal application requires sensors in the thermal infrared and microwave regions as well. New developments in marine-related remote sensing, such as synthetic aperture radar for wave studies, microwave radiometers for salinity measurements, and multispectral scanners and laser fluorosensors for chlorophyll mapping, will require a concerted effort by national and international agencies to set up regional centers, sponsor joint research programs, and conduct workshops for transferring this technology to interested developing countries. Otherwise, the transfer of marine-related remote sensing technology will lag well behind the current transfer of Landsat technology for agricultural and geological applications.

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OCEAN TECHNOLOGY AND DEVELOPMENT

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ABSTRACT

Important changes have taken place in marine technology that could revolutionize the development process in island and coastal states and in communities having significant access to the sea. New technologies that can be used at the indigenous level include (a) fiberglass, polymeric, and buoyancy materials for boat hulls, tanks, hatcheries, and coastal-zone structures, (b) low-cost satellite receivers for communication and navigation, (c) low-cost computers for management systems, (d) sensors and life support for shallow underwater operations, (e) advanced energy sources, power plants, and fuel cells, (f) modernized sail. These technologies go hand in hand with new understanding of (a) ocean processes affecting, for example, hatchery technology, (b) behavior of pelagic and migratory fish, and (c) assimilation, aggregation, and dilution of wastes and nutrients. Developing nations should prepare for joint ventures in oceanic energy-production systems, oceanic energy-processing and transportation systems, open-sea mariculture and fishing systems; ocean mining, urban marine mass transit systems, and marine transport for bulk, containerized, liquid, dry, and gaseous cargoes; riverine and sea-based public works and public utility systems; sea-based waste disposal systems; floating hotels, condominiums, office complexes, and shopping centers; and sea-based park and recreation systems.

INTRODUCTION

Substantial and significant changes in marine technology have taken place in the past two decades. Application of new marine technologies could revolutionize the development process in island states, coastal states, and communities having significant access to the sea. These new technologies could advance, at the indigenous level, the economic viability of traditional fisheries and permit early evolution into the open-sea harvesting, farming, mariculture, and pond aquaculture of nontraditional species. They would also permit the development of a modest and appropriate oceanographic capability within the resources available to the developing state. On a greatly magnified scale requiring major infusions of investment and development, the new technologies could result in the development of major systems and subsystems of the society with lower capital cost, higher efficiency, minimal environmental impact, greater compatibility with traditional ways of life, and greater flexibility in the face of demographic or political change, than the more traditional land-based counterparts.

INDIGENOUS TECHNOLOGY AND DEVELOPMENT

We shall therefore examine these technologies at both levels. At the indigenous level, we shall assume that assistance programs can provide the necessary training in the skills required for acquisition, operation, and maintenance of the system, as well as the training for skills required to construct unsophisticated hardware for the system. Sophisticated equipment, on the other hand, will be limited to off-the-shelf hardware of major industrial developers (IBM, Raytheon, Sperry, etc.) or equipment available to the general public through retailers (Texas Instruments, Radio Shack, Sears Roebuck, Pete's Modelcraft, etc.)

At this level the most significant technological advances are the following:

- Development of low-cost, long-lived materials and fabrication techniques for construction of ships and structures. Most prominent of these is fiberglass for use as a primary structural material for boat hulls, tanks, hatcheries, containers, and perhaps more significantly as a coating for repair, preservation, and protection from corrosion, biological fouling, toxic materials, etc.

- Development of plastic materials, in particular, the polymers (polyurethane, polyethelene, and polypropylene). Plastic pipes, valves, pumps, etc., are an absolute requirement for biological systems if toxicity or the introduction of metal contaminants into the food chain is to be avoided. Polymers, acrylics, and other plastics, such as Teflon and nylon, have major application for noncorrosive coatings, transparent hulls and ports, ropes and connectors, bushings, etc. A major and most significant development is in the foams that provide buoyancy and nonsinkable properties for hulls and equipment. The light-weight, buoyant surfboard is, for example, a highly developed structural sandwich of fiberglass laminates and buoyancy foams in an optimized hydrodynamic configuration. With proper training, inwater personnel can use it as a sophisticated sea sled.

- Development and availability of satellite navigation and communication systems. Now, and in the near future, increasingly sophisticated weather and climate maps and advisories should be available on a world, regional , and local basis by means of satellite communications. Technical advisory services and seminars are in embryonic form (as in the PeaceSat) but are rapidly developing on a global basis. Satellite navigation is also widely available, but the currently available commercial receivers are needlessly accurate and sophisticated and, as a consequence, needlessly expensive. An ancillary aspect of the communication revolution is the development and availability of short-range line of sight, accurate, and high-bit-rate navigation and communication systems. Precision location of nets, traps, buoys, etc., is now economically feasible. When coupled with transponder systems, these navigation and communication systems can provide security as well as efficiency in the harvesting of common property resources.

- Development and availability of low-cost, high-bit-rate computer systems. This revolution applies to almost every aspect of personal, local, national, regional, and international life and cannot be ignored in the future projection of any human system. When combined with a telecommunications network (even as unsophisticated as the local telephone system) the computer terminal, coupled with central and peripheral computers and sensors, provides real management and monitoring of the total fisheries process. Catastrophe, predation, and disease are a costly overhead expense on fishery and oceanographic operations, in many cases increasing the cost of the final product by an order of magnitude. The monitoring, analysis, and response capabilities in a communication-computer network are enormous, as are the savings that result from immediate response to catastrophe, immediate awareness of predation, and the early detection of incipient disease. Video terminals, typed printout, and computer capabilities with adequate memories are now available for a few thousand dollars. This is true also for television monitoring systems. Costs are decreasing and their use will soon be ubiquitous.

- Sensors and life-support equipment. A host of sensors and life-support equipment for humans as well as marine animals and biological organisms have been developed and are commercially available. The underwater swimmer has an ever-growing array of commercially available scuba equipment and life-support systems--diver vehicles, communications, wet suits, hot suits, decompression facilities, swimmer support vehicles, etc. Sophisticated diving capabilites on air to a depth of 50 to 60 meters are thus available. The black coral and abalone fisheries have employed divers, but their use in other fisheries has been needlessly limited. To dive deeper than 60 meters requires mixed gas and probably is too sophisticated to be introduced at the indigenous level. The techniques for monitoring dissolved oxygen, pH, water chemistry, free oxygen, other gases, pollutants, etc., are well developed and commercially available. There are few inhibitors to water quality measurements in the modern world--if we only had a good current meter.

- Developments in energy sources and power plants. Relatively few of the developments in power and energy will be available at the indigenous level. For tropical countries (i.e., most developing nations) it should be possible to manufacture alcohol without a net deficit in oil imports. The commercial availability of engines designed and modified to use gasohol or alcohol as a result of the U.S. energy program or the Brazil alcohol program could then provide a net energy benefit. (This is particularly true if power systems were available for low-proof alcohols.)

The marine gas turbine may also be a factor in improving the efficiency, versatility, speed, and power of fishery and oceanographic ships and machinery.

Depending on the price and availability of oil, we can expect the reintroduction of the motor-sailboat. Very substantial improvements in sail are both possible and already developed. These improvements include new, high-strength-to-weight materials, long-lasting fabrics, titanium masts, and automated rigging. If these are combined with computer optimized sailing tracks and computer optimized sail configurations and rudder settings, then economic trade-offs favoring the motorized sailboat will occur with increasing frequency.

These technological developments go hand in hand with a new understanding of ocean processes. Some of the understandings having a major interaction with the new technologies are as follows:

1. There is new understanding of the environmental conditions required for spawning, survival of the spawn, hatching, survival of larvae, survival of juveniles, growth of young adults, maturation, etc. A number of species have been carried through the life cycle in the laboratory (Machrobrachium Rosenbergii, mullet, milkfish, salmon, mahi mahi, oysters, clams), and a number have been carried through substages that permit farming (Penneus Japonicus, Penneus Marginatus, sturgeon, yellowtail, unagi). The possibilities are increasing rapidly on a species-by-species basis. Technologies that must follow include hatcheries and holding pens and (where the cost of feeding is prohibitive) open-sea cages or pond and bay environments in which predators and disease can be controlled.

2. There is new understanding of the behavior of pelagic and migratory fish. An understanding of migratory patterns, of the role of temperature and temperature gradients as a confining mechanism, of the role of flotsam in congregating and aggregating behavior, and of the role of symbiotic animals--bait fish, dolphins, sea birds--in the schooling and migratory process is now developing. Technologies associated with this understanding include fish aggregating buoys. Highly successful initial experiments suggest that the proper location of appropriately designed buoys in the migratory path of tuna, billfish, and dolphin fish (mahi mahi) will result in aggregating behavior of commercial significance. A number of innovative designs and deployments are certain to follow. (The tuna yield in the Philippines has already substantially increased as a result of evolutionary development of raft and line aggregation devices.) Future associated developments include the use of fish attractants, bait fish, and modified configurations to enhance both attraction potential and multispecies potential of the buoys. Extensive further evolution of purse seining techniques can also be expected. Current technology of winches, blocks, tackle, nets, launches, seines, etc., already employs modern materials and structures. Techniques have been developed for permitting and encouraging captured porpoises to escape before the seine is closed.

Such improvement in seining, long lining, pole, and bait fishing are, however, evolutionary changes in old techniques. The fullest understanding of the herding and aggregating process will allow the substitution of mechanical gate and enclosure devices more closely matched to the on-board storage and processing techniques.

3. There is new understanding of the process of assimilation of waste and nutrient aggregation and dilution in ocean environments. As a result of the pressure of environmental concerns, a new understanding of the effect of waste discharge in ocean waters is emerging. From studies by SCWRRP (Southern California Water Resources Research Project) and at Woods Hold Oceanographic Institution and the University of Hawaii it is now recognized that with appropriate attention to waste system inputs and with appropriate outfall configurations, waste effluents can greatly enhance food-fish populations.

The problem of viral contamination, which currently limits the use of sewage for feeding shellfish and other filter feeders, may soon be solved by sterilization techniques. In that event, sewage and waste systems can be developed in conjunction with aquaculture, fish-attractant, and fish-farming techniques.

A further supplement to nutrition can be obtained in many tropical and subtropical areas through pumping of deep ocean water to the surface. Novel, low-cost devices such as the Isaacs wave pump are available for pumping this water to the surface. A number of novel schemes have been developed for the use of this water in shellfish culture, salmon culture, cultivation of opihi and Irish moss, of algae, and the cultivation of salt-tolerant plants through use of the "trickle" condensate on pipes carrying the deep ocean water.

Other processes whose enhanced understanding will aid fisheries and oceanography include air/sea interaction as it relates to the forecasting of weather and climate, geophysical and oceanographic conditions that signify the location of an animal or mineral resource, and new methods of food processing and preservation. Modern technology for use in coastal waters and the coastal zone is advancing at the indigenous level and will greatly benefit resources development in remote or hazardous sea environments. As the present handicaps of remoteness and peril are reduced, fishery and oceanic alternatives to land-based food production and resource development become more attractive to a developing society.

EXOGENOUS, CAPITAL-INTENSIVE TECHNOLOGIES AND DEVELOPMENTS

With large-scale capital investment, marine technology now permits the development of major societal systems that appear to be economically competitive and environmentally sound. By virtue of their sea basing, they can be introduced into a developing society without the necessity of developing an expensive land-based infrastructure or capital base, and they will probably cost less and consume less energy than their land-based conuterparts.

These oceanic systems include: oceanic energy-production systems; oceanic energy-processing and transportation systems; sea-based industrial systems; open-sea mariculture and fishing systems; ocean mining systems; marine transportation systems for bulk, containerized, liquid, dry, and gaseous cargoes; urban mass transit systems; riverine and sea-based public works and public utility systems; sea-based waste disposal systems; floating hotels, condominiums, office complexes, and shopping centers; sea-based park and recreation systems.

Indeed, nearly all land-based systems have their oceanic counterparts, and it is gradually becoming evident that in almost every instance, the use of modern technology will give the oceanic alternative economic and environmental superiority.

The most significant technical development is that which has decoupled sea systems from the surface of the sea and as a consequence has eliminated or alleviated the motions associated with sea-based operation. This development is significant in that it permits the use of equipment, techniques, and life-styles designed for a low-motion environment such as exists on land. Not only the discomforts, but also the perils of the sea are nearly eliminated by this development. Five mechanisms have been employed to achieve this result:

1. The use of very large conventional carriers and conventional displacement forms. For displacement of not less than 40,000 tons--ideally 100,000 tons of more--conventional hull forms will provide a platform sufficiently stable for nearly every social or industrial process (except billiards) in all but extreme sea states.

2. The use of semisubmerged (small waterplane area) platforms and semisubmerged ships for displacements of 1,000 to 10,000 tons will provide a sufficiently stable platform for nearly every social or industrial process in all but extreme sea states.

3. The use of semisubmerged platforms with displacements of 10,000 tons or more can result in platforms which are of satisfactory stability for nearly every social or industrial process (including billiards) in all weather conditions.

4. The use of incidence-control hydrofoils or fin-stabilized semisubmersibles controlled by a control system with sea-surface sensors can provide a platform of satisfactory stability for high-speed (50 knots) transfer of goods and people with adequate comfort.

5. The use of submarines at depths of 500 feet or greater will provide a platform with adequate stability for nearly every social or industrial process and in all sea states.

Accompanying the development of the stable platform has been the development of prestressed concrete for very large structures. This development has appeared in large semisubmersible structures designed for oil storage and processing in the North Sea. The successful construction and deployment of these structures in the most hazardous of ocean environments conclusively demonstrates that ocean structures of major magnitude (1,000,000 tons) can be manufactured in one site for use in remote location.

The possible uses of such stable platforms and barges are both obvious and legion. Japanese industry has already built a power plant and a paper mill on barges in Japan for use on a river in Brazil. Significantly the deployment was antipodal. The project demonstrated further that no major modification was required to the land-based community employed in cutting wood for the paper mill. The wood is floated to the barge, and the processed paper is carried away by a transport barge to the distribution port. This paper mill could have as easily been a cannery and fish processing facility.

Less successfully, the Westinghouse Electric Corporation has been attempting to develop barge-mounted, sea-based nuclear power plants. Offshore Power Systems, a joint venture of Westinghouse Electric Corporation and Westinghouse International Power Systems Company, Inc., was established in Jacksonville, Florida, to manufacture and secure licensing of eight floating nuclear power plants. Contracts were let with New Jersey's Public Service Electric and Gas Company in September 1972 for construction of the first two plants and in November 1973 for two more plants. A combination of environmental, political, and financial pressures, including estimates of reduced growth in demand for electricity, led to the cancellation of those initial orders in December 1978. Although Offshore Power Systems currently has no further orders, it continues to work toward licensing of a standardized manufacturing process for the production of floating nuclear power plants.

Other systems developed for mounting on barges and semisubmersibles include liquefied natural gas plants and scientific and commercial drilling rigs.

The obvious companion to the semisubmerged platform is the semisubmerged platform (SSP) ship. This high-speed, low-drag, stable surface ship sacrifices above-water payload for its superior performance in sea-keeping and energy conservation. For most missions except bulk cargo transport, however, the above-water payload capacity of the surface ship is superfluous and underutilized. This is particularly true for car and passenger ferries. The SSP is thus ideal for deep-river, bay, port, coastal, and interisland transportation of light freight, cars, and passengers. When supported by high-speed hydrofoils for passenger transport and barges for bulk liquid and dry freight, a total transportation net in many coastal environments is superior to its land-based counterpart in delivery capability, cost, and energy consumption. The combination of stable marine transport and stable platform makes ocean space a usable environment for nearly every social and industrial function whenever the cost, energy, and environmental configurations are more effective than the land-based alternative.

An acceleration to the ocean development process may result from the development of ocean thermal energy. The initial development of this system, which extracts energy from the temperature difference between tropical surface waters and Arctic or Antarctic subsurface water, has been successful. Ocean thermal energy systems are also generators of artificial upwelling and, in one of its configurations (open cycle), are generators of fresh water. Calculations by the Johns Hopkins Applied Physics Laboratory and others suggest that the system is economically competitive with fossil fuel and nuclear power. Two pieces of recent legislation, the Ocean Thermal Energy Conversion Research, Development and Demonstration Act (Public Law 96-310) and the Ocean Thermal

Energy Conversion Commercialization Act (Public Law 96-320), authorized the construction of two 40-megawatt demonstration plants. Thus, there is the possibility of commercially available ocean thermal energy by the year 1990. The magnitude of the resource is enormous in the zone between twenty degrees north latitude and twenty degrees south latitude (probably 300 quads per year). The system will be most immediately effective as a source of power for tropical island communities, such as Hawaii, Guam, the Samoa Islands, Micronesia, the Society Islands, Kiribati (formerly the Gilbert Islands), and Fiji.

Should the development of ocean thermal energy conversion (OTEC), the stable platform, and the stable ship evolve within the next decade, then the entire development process will be altered for island and coastal tropical states.

WORLD FISHERIES AND AQUACULTURE A DECADE HENCE: ONE VIEW

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ABSTRACT

Future development of fisheries and aquaculture as means to increase world food supplies is likely to be shaped in large part by a few key factors: the establishment of zones of extended national jurisdiction by most coastal states, the high cost of fuel and its effects throughout the fishing industry, the physical limits of the oceans to produce fish, and the need to provide employment for rural people in many poor nations. Among important needs for technical assistance to fisheries and aquaculture in less developed countries are improved methods for assessing stocks in major fisheries; improved fishing techniques and gear, particularly to increase the harvest of previously underexploited species; and means to reduce postharvest losses. Future assistance must also recognize the importance of traditional technologies, traditional social and cultural practices, and the need for training to increase local technical and managerial skills. Although developed nations continue to lead in climatological and ecological research directed toward better understanding of fisheries, benefits to less developed countries in the coming decade may be limited to increased application of remote sensing and increased awareness of the effects of natural and man-made changes in aquatic habitats. Perhaps the most important key to future development of the world's fisheries is the establishment of sound fisheries management, which, in turn, depends on continuing scientific and technical advice and especially on the political will of all nations to work together toward that common good.

INTRODUCTION

Any attempt to predict the possible state of fisheries and aquaculture in the year 1990, or even 2000, must take into account the anticipated global food requirements at that time and the 1980 baseline conditions.

Maulden (1980) has indicated that world population growth is likely to slow in the next 20 years except in Africa. However, the population of the less developed countries (LDCs) will increase by 50 percent in the same period, and this means an increasing demand for food, particularly animal protein--including fish. Alleviation of the problems of global hunger and poverty will require accelerated development and application of broad-based, multidisciplinary integrated programs in the LDCs (Wortman 1980).

The major factors affecting the fisheries baseline in 1980 are (1) the establishment by most coastal states of zones of extended jurisdiction,* usually of 200 miles, and the consequent disruptions and changes of previous marine fisheries practices, e.g., harvesting and management; (2) the crises for the mechanized fishing vessels and shore-based infrastructure throughout the world because of the increased cost and decreased availability of fuel for production, processing, and distribution; and (3) the finite limits of the ocean to produce fish products, particularly of those types traditionally used. There remains even a lack basic knowledge of fisheries productivity in the world's major tropical river systems. With regard to aquaculture, there is an underlying concern that despite more effective operational methods, technological advances, and economic incentives for production of high-value species, often for export, the means and incentives for increased production of high-volume, relatively low-value species for local consumption have been slower in coming.

RESOURCES

Assessment

Rational management of fisheries relies on resource assessment as a principal tool to permit sustained exploitation at some optimal level. Most current resource assessment techniques have been developed, or refined from basic concepts, since World War II in the developed countries of the Northern Hemisphere. The population dynamics models in use are mainly for cold-water, single-species stocks. The techniques employed rely on relatively advanced field surveys, well-developed shore-based scientific support, and access to good statistical data on landings. Exploitation of fisheries resources from the artisanal to the large commercial level has increased, especially in tropical and Southern Hemisphere regions, following declines in traditional Northern Hemisphere stocks, or increases in protein demands based on declared national policies, or, in the case of the developing world, a continuing need for increased

*Throughout this paper, such zones are referred to as exclusive economic zones (EEZs), which is the case in most nations, though actual sovereignty is claimed by some nations while other nations, including the United States, claim control only over fisheries.

protein supplies. Many fishing techniques of the Northern Hemisphere can be used in the Southern Hemisphere because the species are similar, but this is not true in the tropical regions.

The major problem for developing nations, which are located mainly in the tropics and where artisanal fishing is still extremely important, is that resource assessment is difficult because of the usually large number of species involved in a fishery and the acute lack of statistical data. The large number of species involved requires a considerable knowledge of their ecological interactions with each other and with their tropical environment, which is relatively sensitive to natural and man-made perturbations. On the statistical side, fish landing sites are remote, and only the fishermen themselves know the gear they use and the species composition of the catch. These problems and others mentioned previously are emphasized in the report of the Workshop on Stock Assessment in Tropical Waters, sponsored by the Agency for International Development (AID) and held at the University of Rhode Island in October 1979 (Saila and Roedel 1980).

How will these difficulties be overcome? They will be overcome, of course, by the application of existing models as well as new models for multispecies fisheries. One approach is the combining of single-species assessments, though the problem then becomes one of partitioning the "catchability coefficient" (q) within trawl hauls. At the theoretical level, the complex, data-rich, multispecies stock-assessment models developed for temperate areas, such as the model developed for the North Sea by Anderson and Ursin (1977), will be refined as additional scientific information is obtained. The overall problem remains, however, one of determining the set of biological interactions arising from recruitment relationships; more fundamental work on the stock-recruitment relationship is needed.* But of what value will the above models be in the near future to the very different situations in tropical LDCs? It must be realized that the degree of overall development or potential development of the LDCs varies greatly and that this will have a considerable effect on application of most aspects of stock assessment. There should be improvements in the collection of statistics, which at least will give reliable confidence limits for estimates of total landings (catch) from small-scale and artisanal fisheries. Such improvements include the modification of the sampling procedures used by Bazigos (1974) for African inland fisheries and their possible application to marine systems. Nevertheless, as Munro (1980) has stated, the improved data collection procedures must take into account sociobiological problems at the fishing village level. Gulland (1980) has shown how valuable information on fishing effort or similar indices could be obtained through small improvements in national annual statistical data on number of fishermen, boats, gear, and the like, given the conservative nature of fishermen and their practices over time. However,

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government commitment is needed for improvements in statistical data bases that can be of long-term value; such improvements probably would be achieved first for lakes and major riverine and coastal centers.

Gathering of biological life history data must continue in LDCs for the long-term, especially in the larger countries with considerable scientific manpower. However, there is present and future need for radical changes in the types of biological information used for rapid assessments of stocks. Such changes may include use of approximations and generalized data to delineate those biological mechanisms and environmental effects that set the upper and lower limits to those parameters (e.g., growth, mortality, fecundity, and trophic position) needed by fishery scientists for stock assessment (Pauley 1978a,b; 1979 a,b; 1980 a,b). Similarly, Marten (1978) suggested a radical departure from conventional methods, which appears worthy of further testing. More basic research is certainly needed to develop tropical multispecies population models whose biological and other components must not be extrapolations of the single-species models of temperate zone fisheries. Instead, they should be explicitly developed for tropical fisheries where many kinds of gear are used and species currently caught, where many species have short life spans, e.g., fishes, shrimp, and squid, and where there are complex ecological interactions involving large species assemblages. The interrelationships between predator and prey and their effects on yield must be investigated; at present most work is limited to temperate freshwater situations. In this respect, the effect of the removal of certain groups of commercially valuable species from tropical food webs has often led to their replacement by a few species currently of little value locally, e.g., the Balistes explosion in West African waters in recent years.

The data appropriate for tropical fisheries models will be relatively easy to obtain from large-scale commercial operations. However, it will be much more difficult to determine the relationship of models derived from such data to the small-scale and artisanal fisheries in similar geographic areas utilizing similar stocks. In this respect, there should be effort to carry out some controlled experimental fishing studies with artisanal gear in different fishery ecosystems for comparison with results from large-scale commercial operations.

A determined effort should be made to produce a clear regional inventory of existing information on tropical fisheries. Valuable information is often available, but for a variety of reasons, appears little used by LDCs. For example, the West African hard- and soft-bottom habitats with their respective snapper- and croaker-dominated fish communities (see Fager and Longhurst 1968, Williams 1968) are not dissimilar to those of northeastern South America, the Bay of Bengal, and the South China Sea. Yet apparently there have been no attempts, except briefly for the first two regions (Lowe and Longhurst 1962, Lowe-McConnell 1977), to compare these situations for generalizations that may hold good the regions. Thus, the oft-repeated plea of LDCs for "no more surveys" may well be valid in light of the lack of synthesis and use of existing information. Tropical fisheries in the field of stock assessment are ripe for advances equivalent to the Beverton and Holt, Schaefer, and Ricker population dynamics models of fisheries in the north temperate zones after World War II. This is especially true for assessments in those special tropical ecosystems such as coral reefs and mangrove areas fished with indigenous gear, e.g., traps, hook, and line.

In terms of overall biological productivity of an area, there is the possibility of extending the methods of estimating general levels of potential yield from various environmental and biological variables. Such models have been used successfully in North American and African lakes (see Toews and Griffith 1979, and references therein) and in some rivers. Whether there can be successful extension of this methodology to small marine areas for the assessment of potential yield in small-scale and artisanal fisheries is unknown.

The present state of acoustic survey in fisheries was discussed by Cushing (1978b). In the next decade, advances in acoustic survey techniques will be made by the developed countries especially in relation to evaluating underutilized and unutilized resources, such as krill, squid, and mesopelagic fishes. The major problem will remain the need for identification of acoustic targets, particularly difficult in multispecies tropical fisheries. The sophistication needed to operate and maintain such acoustic assessment systems will continue to pose problems in LDCs. Nevertheless, the potential value of the equipment in locating and quantifying resources may be realized in scientific joint ventures between developed and developing countries. Remote sensing from satellites and aircraft has distinct advantages in certain ocean areas in determining the occurrence and geographic extent of physical phenomena (e.g., upwelling, frontogenesis, transition zones, and related biological events, both seasonal and aperiodic), which in turn may have important tactical value even in small-scale fisheries, particularly for pelagic species. A possible example would be in the fisheries for the oil sardine and the mackerel off the west coast of India, where availability to the fishermen depends on the location and extent of seasonal upwelling and other phenomena related to distance from shore. However, in most cases, the fundamental linkages between a fishery and environmental events are still unknown. In the realm of river floodplain fisheries, remote sensing in conjunction with ground surveys can be of great value in determining on an annual basis the maximum and minimum flooded areas. This use of remote sensing needs further investigation in regard to assessment of stocks and general productivity (Welcome 1979). Welcome (1975) and Payne (1976) pointed out that methods for sampling fish population in large rivers and lakes, other than by use of commercial catch, are unreliable.

To better understand stock structure in major fisheries, especially for pelagic species, studies will continue on the identification of stocks by biochemical and genetic methods, as well as by the usual tagging studies. Vital parameter comparisons, and analysis of catch and effort data. Gulland (1977) commented on the need for only one country in a given area to perform biochemical and genetic work, while the other countries provide the fish and the participants.

Harvesting

Harvesting techniques and gear now in use will continue to be used, although modifications may be expected to reflect increased operating costs, especially for fuel and new materials. In addition, gear will be adapted to, and fishing will be concentrated on, those components of the resource previously underutilized for various economic reasons but which are now more valuable in the light of declining traditional catches. There may be some efforts also to use for direct human consumption species now harvested for fish meal, and this may necessitate modifications in gear and handling of the catch.

The decade may see increasing trends toward less random hunting of pelagic species and more use of artificial free-floating attractant devices (Klima and Wickham 1970), some of which have been used in traditional artisanal fisheries (see references in Matsumoto et al. 1979). Recent examples of such devices are the bamboo payao rafts used in the Philippines (Murdy 1980) and the attractant devices used experimentally in the western equatorial Pacific (Yamanaka et al. 1977, Pacific Tuna Development Foundation 1980), off Hawaii (Matsumoto et al. 1979), Samoa (Pacific Tuna Development Foundation 1980), and the Marquesas Islands (IATTC 1980), principally for tunas. Considerable information has been gathered in the past decade with regard to fixed platforms, e.g., oil drilling rigs and their subsequent fish attractant powers. Coupled with studies of chemical and mechanical fish attractants, more detailed research should be undertaken on fixed and free-floating attractant devices at surface or subsurface levels in areas where there are known fish concentrations or migrations that may be suitable for exploitation by small-scale and artisanal fishermen. The provision of artificial reefs as additional habitats to enhance both commercial and recreational fisheries in developed countries has been successful, and the underlying scientific aspects should continue to be investigated to see if they would be advantageous for certain LDCs.

Schärfe (1979) has pointed out that methods currently are available in the developed world for virtually automated trawling operations--locating fish, steering the vessel, lowering and aiming the net, capturing the fish, and returning the net to the deck. Shipboard computers would receive parameter inputs from navigational, acoustical, and environmental equipment and sensors and from ship machinery so as to control fishing operations. Present improvements and innovations in gear design and materials have led to the use of automated demersal longline gear in North European vessels, pole-and-line machines for tuna fishing on Japanese vessels, and midwater trawls for krill and mesopelagic fishes. During the decade, better detection and assessment techniques for squid will lead to development of improved methods for their capture, probably special, large midwater trawls. Recent suggestions include the use of a large catamaran as a high-seas floating harbor that could accommodate six vessels at once and provide fuel, food, and repairs and could hold and transfer catches (Anonymous 1980a). How far introduction of new fishing options will progress in the 1980s will depend on the perceived savings in operational costs versus the initial capital outlay for the equipment, to say nothing of catch efficiency.

In the past, LDCs mistakenly purchased fishing vessels and equipment inappropriate for tropical fisheries. They wish now to see modifications of existing boats and gear and the development of new ones that are more appropriate and effective for their individual situations and are acceptable to the target community (Schärfe 1979). The developing countries desire modifications ranging from low-cost and labor-intensive for artisanal fisheries to medium-cost and equipment-intensive for their own or joint venture commercial-scale operations. Schärfe also has emphasized how important it is that innovations be acceptable within the traditional conservative lifestyles of artisanal and small-scale fishermen, their families, and their communities. For a given country, the appropriate mix and rates for development of combination large-scale, small-scale, and artisanal fisheries for harvesting the available resources must be determined in consultations with fishermen, boat operators, fish vendors (wholesalers and retailers), administrators, and scientists.

Already the increased cost of fuel, necessary concentration on stocks within national EEZs, and reductions in stock sizes have elicited production of highly efficient combination vessels of all sizes. The production of such vessels for the developed world probably will lead in time to the local design and production of similar combination boats for tropical LDC fisheries but without the degree of automation demanded in the developed world. However, in some LDCs the canoe fisherman is already a combination fisherman (at the lowest level) using various gear or stocks as the seasons change; in many other situations he must use specific gear and must fish for specific species. In some cases, fishermen in LDCs fish with traps for high-value export species, such as spiny lobsters, but prefer to return to port during the trap soak time, which might be spent more productively in adjacent areas hook-and-line fishing for other species such as snappers and groupers for local markets (Robins 1980).

Sail is appearing again as an auxillary source of power in some northern developed countries and will be used again on many fishing boats in LDCs now using outboard and small inboard engines.

Nevertheless, designs are still needed for small, fuel-efficient fishing boats for rivers, tropical lakes, and coastal seas. Thus, it is encouraging to see that considerable attention has been paid recently in the South Pacific region to providing more efficient fishing platforms that will permit artisanal fishermen to reach new grounds and use new gear (Anonymous 1980b). Problems have revolved mainly around design of the boats and propulsion systems. A principal finding was that no single design is suitable for use throughout the region and that they must be tailored to the particular needs of a given area. In this manner, Wright and Herklots (1980) and Anonymous (1980c) have shown that traditional boat building expertise in Sri Lanka was just right to permit production of "stitch and glue" technique, low-cost plywood dories suited to local fishing conditions. The advent of newly designed lightweight, air-cooled diesel engines will probably radically alter the propulsion systems of many small fishing craft during this decade. Wray (1980) has discussed the virtues of these units, especially the portable ones, which can be used on shore for other purposes and which were design tested on a Philippine outrigger canoe (Anonymous 1980d).

The problem of fish by-catch in the tropical shrimp fisheries has to be solved, because millions of tons of mainly small fish, both marketable and unmarketable, now are dumped over the side. The technology exists to separate these so-called trash fish in the trawl net during the tow, but incentives--largely economic, though some are technological--are lacking to encourage landing of by-catches. Provided suitable storage space is available aboard the vessels, these fish can be sold directly to middlemen. This was the case in Nigeria in the late 1960s for some local vessel operators. The by-catch probably can be more effectively processed to minced fish or fish meal in the same plant where the shrimp are processed, as at the plant of Vikingos S.A., Cartagena, Colombia. The world cannot afford the waste of food that currently occurs in the shrimp industry.

Adequate use should be made of the catch from tourist-oriented sport fishing in LDCs. For some species, such an integrated fisheries-tourism approach might be highly effective, and such possiblities should be fully investigated.

Postharvest Losses

It has been estimated that as much as 35 percent (about 8.75 million metric tons) of the annual world catch of fish destined for direct human use is lost between capture and consumption (Parisier 1979). This is two to three times the postharvest loss in the agricultural sector. Such losses are particularly large in the artisanal and small-scale fisheries sector of LDCs in the tropics and subtropics, and in many areas may approach 50 percent of the catch (Day 1980).

In the LDCs, fish are an important, and sometimes the only, protein source and also can be a principal income source for the poorest sector of the population. Allowing such postharvest losses to continue is clearly indefensible. An entire meeting was devoted to this topic in 1976 (Tropical Products Institute 1977) and was also indicated to be a high priority need of LDCs in the U.S. AID/BIFAD Title XII planning document for fisheries and aquaculture (Craib and Ketler 1978). The present decade will see concentrated effort to end such losses, though it should not be expected that improvements in traditional processing methods in LDCs will be rapid.

Any future assistance plans to reduce postharvest losses must be comprehensive and include technological, sociological, and cultural aspects. The last of these should include attempts to understand why the major categories of traditionally processed fish products, and also imports, are preferred by the consumer in the LDC. How would the consumer react to improvements and changes that might involve taste, quality, costs, species, and shelf life? How would the processor react to improved yield, better transportation, and the like?

In certain areas, the establishment of fisheries has been sufficiently recent to permit introduction of modern preservation methods such as ice and refrigeration. This is true for medium to large-scale commercial operations for high-volume species, e.g., sardines, and for high-value food species at large coastal centers in LDCs, major riverine systems in central and southeast Asia, and lakes in Africa. In other cases, the export value of the product has led to the provision of facilities, often on a cooperative basis, for preserving the catch, for example, spiny lobster in Belize or the development of live-fish transportation on the rivers of Asia, Africa, and South America. Such preservation facilties can be expected to increase during the decade. However, a very large segment of the artisanal and small-scale fisheries, which produce perhaps more than half the total catch in the LDCs, will still be in need of assistance.

Basic improvements will include the use of more "off-ground," protected, initial fish-processing facilities. It is envisaged that introduction of low-cost though relatively inefficient energy generators, e.g., windmills, and solar power, may help the traditional processing methods (drying, smoking), particularly in areas, such as the Sahel, that are low on wood fuel. More attention will be given to traditional fermented fish products now used in Asia and Africa and to use of nontoxic chemicals of local origin to prevent fish spoilage. Recent work (Anonymous 1980e) has suggested that lactic acid bacteria may be useful in the preservation of fish.

Losses due to insects and rodents before delivery of the fresh or locally processed products to the consumer are significant problems. Examples of progress, however, are the simple packing methods that have been used successfully for fresh fish in India (Perigreen and Nair 1977) and for processed fish in the Lake Chad area of Africa (Day

1980). Considerable advances will be seen in this field, especially in methods using locally produced materials.

There is probably general agreement that in recent times there has been little progress in the processing sector except in refrigeration, which is still not universally available for fishery products in tropical areas. Whether advanced freezing and processing techniques will be wanted by LDCs is another matter, in view of the rather flavorless products created by modern technology. A revolution in preservation and processing is needed to reduce LDC postharvest losses. Perhaps wave-pump energy (Isaacs and Schmitt 1980) would be used to chill salt water or fresh water in artisanal and small-scale fisheries boats; this would require that wave-pump generators be perfected and become in the next two decades as relatively inexpensive and widely available as today's outboard motor is to LDC fishermen.

Finally, in considering reduction of postharvest losses, it should not be ignored that it is the women in LDCs, especially in Africa, who are principally involved in fish processing at the village level and in subsequent marketing at the consumer wholesale and retail levels. Any advisory services will have to convince those women, and the fishermen, of the economic advantages of change. Joint ventures may reduce postharvest losses in large commercial fishing operations, and advanced techniques may filter down to some small-scale operations. However, such a process is unlikely to have much effect on artisanal fisheries.

AQUACULTURE

The 1976 Food and Agriculture Organization Technical Conference in Japan (FAO 1976), thoroughly discussed the global state of aquaculture through presentation of more than 125 technical papers (Pillay and Dill 1979). Subsequently, Craib and Ketler (1978) provided an assessment of the needs of LDCs in terms of problems and research priorities in aquaculture.

The global production from aquaculture was estimated at 6 million metric tons in 1976 (Pillay 1979), although accurate statistics are difficult to obtain, as evidenced by the recent corrections in the fisheries statistics of the Peoples' Republic of China (FAO 1979). However, there seems no problem in agreeing that there have been significant increases in the last decade, especially during the last 5 years. This is the case in the developed world, where aquaculture has been pursued on a commercial scale by private capital enterprises and in those developing countries where, through national policy decisions, aquaculture has been integrated into general development plans for the food producing sectors of the economy. In a number of countries, both developed and developing, there has been a mix of the two approaches.

The increased role of aquaculture globally is due not just to the continuing demand for animal protein but to other developments as well, such as reduced stocks in the wild, the establishment by most nations of zones of extended national jurisdiction, the high cost of fuel and its effect on all sectors of the fishing industry, and sometimes the need to provide more employment opportunities in the rural sector. These developments, and continuing food crises, will exist throughout this decade and on to the year 2000, Thus, most advances in both intensive and extensive aquaculture will be in response to these pressures.

The intensive aquaculture systems found in most developed countries and some upper-tier LDCs have developed largely because of the high cost of land, labor, and--sometimes--available water. These systems have concentrated, therefore, on high-value species (salmon, trout, shrimp, oysters) or speciality items (catfish), many of which demand high levels of feeding but can compete with other high-quality protein sources in the marketplace (Bardach et al. 1972). The increasing cost of labor and feed alone has forced, and during this decade will continue to force, experimentation and adoption of improved culture methods leading to increased yield. These new techniques will be based on results of continuing, high-quality scientific studies related to nutrition, physiology and behavior, production of "seed" stock, optimal stocking densities, genetic selection and hybridization, and aquatic pathology. For some considerable time to come, these studies will be limited to those fish and invertebrate species for which the basic technology of culture is already known and the market is assured (e.g., trout, salmon, shrimp). As the profitability increases, so will the probability of diversity of cultured species.

Many private corporations have spread their intensive aquaculture operations for high-value products, e.g., shrimp, into the developing countries in an effort to reduce costs of labor and land and increase profitability, i.e., economic viability. Whether this is worthwhile to the developing country depends on the country, its state of development, and its national plans, especially for extensive aquaculture. However, application of techniques used in intensive aquaculture have been invaluable in increasing yield in traditional aquaculture in many upper-tier developing countries, e.g., India and Israel--polyculture; Thailand--catfish; Mekong River Basin--cage culture.

In the developed countries, so-called vertically integrated aquaculture industries, which control production, processing, and sales, will become common for some species because of the economic advantage of large units. This may not be the case in countries that have more species diversity or that are in an intermediate position between intensive and extensive systems.

In the field of extensive aquaculture, represented classically by pond culture of finfish and crustaceans in the tropical developing countries (especially Southeast Asia; see Long 1977), substantial progress may be expected in the 1980s. This will result from the current ability to close the life cycle in captivity of freshwater prawns (Macrobrachium) and some marine shrimps (penaeids), milkfish, mullet, and others. In addition, there will be major efforts to utilize local nontraditional species of fish and shellfish rather than introduced exotics, though Mann (1980) has stressed that not all exotics are harmful. Special emphasis will be placed on the freshwater fishes of Africa and South America as well as the ubiquitous Tilapia for stocking of local lakes, ponds, reservoirs, and seasonal aquatic areas.

Research results will be forthcoming during the decade on the basic functioning and efficiency of the pond culture system, especially the low stock density systems found at the subsistence level in many tropical LDCs. An understanding of the pond ecosystem, especially such aspects as nutrient flow, food chains, and predation, will be reached. This in turn will lead to changes in existing operational techniques to increase yield and/or development of aquaculture in additional areas and for other species not traditionally "farmed." Such understanding is certainly necessary for greater extension of the polyculture systems such as those practiced in China (Ryther 1980) and Southeast Asia (Ling 1977) and in the managed use of tropical mangrove areas as sites for aquafarms.

In the marine sector, the culture of genetically selected species and hybrids for subsequent "planting" in the rich estuarine and coastal environment will become even more widespread than it is at present. ("Planting" here refers to emplacement of juveniles on cultch, racks, lines, and in baskets and cages). Certainly programs will encompass more species of algae, invertebrates, and fishes, especially those with short life histories. One possible future extension of these semicultured stocks could be into the even richer upwelling and mixing areas where they approach the shore or in island wakes.

The transplantation of exotic species, e.g., Pacific salmon to Chile and the North Atlantic, and "sea ranching" will become more common but are highly dependent on results of present experiments. Mann (1980) has discussed the policy questions to be asked and the criteria to be applied regarding transplantations and introduction of exotic species. The recent natural spawning in an enclosed population of the Pacific bluefin tuna (Thunnus thynnus) in Japan (Anonymous 1979) has shown that controlled culture may be possible for even a large, long-lived, oceanic migratory species. Thus, forms of sea-ranching in the widest sense become feasible in the future. Beyond the year 2000, we can probably envisage the release of cultured fish into natural areas to feed but to return to a central point on a command--either an acoustic signal or a chemical attractant. To take this a step further, could dolphins be trained to round up fish by means of natural behavior links such as those thought to exist between some dolphins and yellowfin tuna in the eastern tropical Pacific?

Realistically, the decade will see more conventional advances. Although tried experimentally in several areas, the raising of cold, nutrient-rich subthermocline water (so-called artificial upwelling) for either shore-based aquaculture or even offshore enclosures has not yet been demonstrated as economically feasible, mainly because of the engineering costs involved. However, by the end of the decade this technique could be feasible if coupled perhaps with ocean thermal energy conversion (OTEC) power systems or even some form of wave-pump energy system. Very important developments can be expected in the use of waste water, waste heat, industrial effluents, municipal sewage, and agricultural wastes (plant and animal materials) in aquaculture systems as sources of water, nutrients, and food. Currently in much of the developed world, public health regulations prohibit the use of the waste and effluents for culture purposes and prohibit the use of the resultant product for human consumption, despite the use of many such wastes for centuries in traditional aquaculture in LDCs.

The culture of organisms other than for food products, such as shellfish for pearls, seaweeds for alginates, live bait fish for tuna fishing operations in areas without natural bait fish stocks, and the rearing of ornamental fish for the aquarium trade (Conroy 1975), now exist. The systems in use, especially for culture of bait fish and ornamentals, will become more efficient in terms of yield and energy costs. Indeed aquaculture probably can learn much from the aquarium trade about phenotypic manipulation and hybridization in freshwater fishes and about the use of vaccines and drugs for bacterial and viral infections.

Some of the well-known hazards to sound aquaculture development have been discussed by Matsuda (1978). These revolve around the lack of concern for economics on the part of many scientists and lack of concern for the social cost on the part of the private company. To this may be added the lack of integrated development goals and policy for aquaculture on the part of some LDC governments. Palacio (1979) has indicated that in Latin America, aquaculture's potential for meeting food needs generally is limited but that the social value of providing additional protein and work opportunties in rural areas is immense. The problem is one of the lack of diffusion of policy decisions and of responsibility for implementation through the governmental bureaucracies. More recently Luna (1980), also speaking of Latin America, stated that the two impediments to aquaculture development are managerial and operational. One impediment results from a lack of experts, especially of the extension agent type (as found in agriculture). The other impediment is the land-tenure system, which discourages aquaculture because most of the land is worked by tenant foremen.

The economic, social, political, engineering, operational, and biological problems in aquaculture are immense. Clearly there is a need to tackle these problems through integrated approaches that can be applied to different geographic regions, national developmental states and policies, species selection, and the like. Thus, it seems likely that we will see the emergence during the 1980s of International Aquaculture Research Centers* partly analogous to the highly successful International Agriculture Research Centers.

RESOURCES AND THE ENVIRONMENT

Effects of Climate

The effect of climate on fisheries was reviewed by Cushing and Dickson (1976), and a workshop was recently devoted to the topic in the United States (University of Rhode Island 1979). Indeed such meetings relating fisheries and oceanography are commonplace in Japan, as illustrated by the reports of five such symposia in 1979 published in the Bulletin of the Japanese Society of Fisheries Oceanography. Generally it has been agreed for some time that oceanic and atmospheric climate affects fish stocks in an overall sense, though the nature and mechanism of the relationships are poorly understood (Cushing 1978).

Fish stocks are highly variable in terms of catches or yields, e.g., Peru, India, North Atlantic, either on an annual or longer term basis, principally because of fluctuation in year-class strengths. These variations are associated with the availabilty of a suitable food supply for the early life history stages, and food supply in turn varies with ocean productivity in the area and overall ocean-atmosphere conditions, e.g., upwelling, solar radiation, winds, and waves. The local oceanic climate may also be related to air-sea interactions and events at great distances, e.g., El Nino off Peru and events in the southwestern Pacific and off Australia.

In addition to the long-term effect on year-class strength, climate may also affect the interannual and interseasonal distribution and aggregation of fish, e.g., albacore on the U.S. West Coast (see Laurs 1977). A report of the Advisory Committee on Marine Resources Research (ACMRR 1978) suggested that these types of strategic effects may be more important for the LDCs than variations in abundance, insofar as allocation of catch and management problems are concerned. Additionally, strategic annual or seasonal forecasts about geographic distribution of fish can be of considerable economic value in view of today's fuel costs. Cushing (1978) stated that attempts at direct empirical correlations between environmental factors and year-class strengths have seldom been successful because of the limited sets of

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*C.R. Robins: personal communication; P.M. Roedel: personal communication.

observational data available per year and the wide choice of factors that can be selected. Fundamental studies designed to achieve a full understanding of the various interrelationships between biological and physical events that control year-class strength, e.g., food, are currently under way (Lasker 1975, 1978) and will be intensified in the 1980s. In particular, larval fish behavior and food requirements in relation to micro-scale environmental conditions will be carried out in the laboratory and in situ in the ocean. Increased research will be undertaken on the physiology, biochemistry, and behavior of adult fish in response to changes in the aquatic environment. Despite Cushing's previously mentioned warning, attempts to determine empirical relationships between fish and the environment will continue, and derived hypotheses will be tested in the field.

As well as the medium- and long-term studies of strategic effects of climate on fisheries, the decade will see a continuation of work on the effect of climate on fisheries at the tactical time scales of days and weeks. Information on thermocline depth, location of horizontal and vertical fronts, localized upwelling, large-scale meanders and eddies of major current systems, e.g., the Kuroshio, and similar events has been correlated with localized aggregations and availability of fish. Information in processed form is then transmitted to the fishing fleets by radio (voice and facsimile). Tomczak (1977) has discussed in detail such fishery environmental services, many of which relate to pelagic fisheries, such as those for tunas. A comprehensive review of tunas and their environment in the Pacific Ocean is provided by Sund et al. (in press). The decade of the 1980s will see the refinement of many of these forecasting systems because of more and better observational data, the input of more scientific information on the physiology and behavior of the fish themselves, and better knowledge of the physical processes concerned with the vulnerability of fish to fishing gear under various conditions. In addition, the delivery softwear for dissemination of the forecasting information will be clearer, faster, and available to more vessels through the reduced cost and the simplicity of operation.

In the field of environmental control of recruitment in fish stocks, one of the key studies was that of Botsford and Wickham (1975) which correlated upwelling index with Dungeness crab catch off Oregon. Recent advances have allowed the inclusion of environmental parameters in stock-recruitment models. The two most important examples to date are the models for the Atlantic menhaden (Nelson et al. 1977) and the Pacific mackerel off California (Parrish and MacCall 1978). Further advances along similar lines will be made during the decade, and indeed an international workshop was held recently in Peru to consider the effects of environmental variation on the survival of larval marine fishes (Sharp, in press).

The need for an ecological basis for management of multispecies fisheries, as in the Southern Ocean, was discussed by May et al. (1979) using relatively simple models based on adult stocks. More recently the subject was considered in a general sense by the National Academy of Sciences (NRC 1980), which stressed the complexity and diversity of the problems and time and space scales in ocean ecosystems, and suggested priorities for research to solve them. There is considerable uncertainty as to the amount of progress that will be made on ecosystem fisheries models during the next ten years in the developed nations of the world. There is little doubt, however, that remote sensing, especially from spacecraft, will continue to increase in importance during the 1980s as a means of observing oceanic phenomena (fronts, color, chlorophyll, turbidity, temperature, waves, etc.) synoptically and regularly over large geographic areas for strategic and tactical fisheries forecasting. Szekielda (1976) reviewed the use of remote sensing of the ocean by spacecraft in support of marine science in the widest sense. Over the last decade many authors such as Wooster (1973), Qasim (1973), Ross and Smith (1974), Kemmerer (1977), and Stewart (1978) have indicated the importance of a full understanding of atmospheric and physico-chemical ocean parameters in suport of environmental needs relative to fisheries.

Questions undoubtedly will be raised as to the likelihood that any of these research results and applications will be of direct value to the LDCs in the 1980s. Perhaps as ACMRR (1978) pointed out, delineation of geographic distribution of fish in time and space could be used for allocation of catches. Such information also could be used to assist LDC fishermen directly by indicating availability of fish aggregations outside the fishermen's normal sighting range, e.g., the oil sardine and mackerel fishery off the west coast of India. In an analogous situtation, sophisticated Landsat data are actively being used by LDCs in the agricultural sector.

Habitat Modifications

The word "habitat" is used here in the sense of the natural environment of the living resources, and the concern is with man-made perturbations of habitat, primarily those originating on land. In this respect the establishment of EEZs has brought moral as well as legal responsibility for environmental protection and for resource development, utilization, and management. Certainly environmental events in nearshore waters, rivers, and lakes determine the intricate relationship of factors critical to product utilization and fishery production, especially by small-scale and artisanal fishermen in LDCs.

Robinson (1980) has pointed out the serious conflicts in use of the coastal zone and its resources in the developed world, e.g., fisheries, oil and gas extraction, mining, dumping, and land reclamation. The LDCs, where considerable industrial development will take place in the next two decades, will be prone to the same and additional problems of habitat modification and perhaps can learn from the mistakes of the developed world in this respect. For obvious reasons most development will take place along the coasts and estuaries, and also along the shores of rivers and lakes. Problems will continue to arise with regard to point-source discharge of effluents, such as raw and partly processed material, thermal and chemical pollution in addition to urban sewage and solid waste as communities grow. There will be additional problems with regard to non-point sources of agricultural effluents from increased use of fertilizer, insecticides, herbicides, etc., which enter the rivers through runoff and are transported to the lakes and the sea. Coupled with these potential changes are those that can result from extraction of oil, gas, and minerals and from the construction of ports and harbors. Obviously it would be rare to find all these sources of habitat modification in one location but, singly or in various combinations, they can have a serious effect on the aquatic habitat and accompanying biological productivity.

There are few, if any, cases of measurable effects due to pollution or other habitat modification of any large marine fisheries for free-swimming species (Wise 1978). Obvious exceptions are the anadromous and catadromous fishes, e.g., salmon, shad, sturgeon, which are prevented from migrating because of dams and other obstructions, though this problem has been partially alleviated by use of fish ladders and similar devices in most developed countries. However, pollution and other habitat modifications can have disastrous effects on shellfish populations and benthic organisms in coastal estuarine and lacustrine areas. Indeed the humble mussel is used as an excellent pollution monitor for inshore water quality. Even if the resources are not affected directly, they may be affected indirectly through destruction of nursery areas, alterations in hydrodynamic flushing rates, and changes in food webs with subsequent changes in species composition. Although catastrophic events such as large spills of oil and chemicals can cause death to shellfish and some less motile fishes and invertebrates, the problem of chronic pollution and subsequent bioaccumulation of toxic materials has caused public health problems through human consumption of affected animals. Ongoing research in the developed world by early in the decade will be able to provide generalized and acceptable criteria for prevention of damage to living resources due to deterioration in water quality and other habitat modifications. However, the problem will remain one of the applicability of even generalized scientific results from the temperate climes of the developed world to the usually tropical and subtropical fauna and environments of the LDCs themselves; thus the developing world, at least the upper-tier nations, will need to study closely the potential differences in the scientific sense between the temperate and tropical situations. This is essential if the LDC governments are to balance habitat modification wisely with natural industrial and agricultural development plans.

Of prime importance to many LDCs is the role of mangroves in maintaining coastal biological productivity and as nursery areas for living resources. The value of the mangroves to LDCs is not simply in terms of fisheries but also as a source of timber, firewood, charcoal, and tanning products. Research data available now and over the next five years will assist in planning simple strategies for their survival from uncontrolled agricultural, industrial, and urban development. Another example of unfortunate habitat modification is the removal of coral "rock" in insular situations to provide building materials for tourism development (hotels, roads, airports, employment) at the expense of the very resource,the coral reef, that provides part of the basis for the tourism (underwater scenery, sport fishing, and commerical fishing for food).

Welcome (1979) has drawn attention to the considerable impact of drainage shemes, dam construction, and other land and water-management practices on the freshwater environment. In particular, he drew attention to the complex nature of river floodplain ecosystems in the tropical LDCs and how man's modifications for increaing the stability of the ecosystem usually act to the detriment of the fisheries. This can occur not only in the riverine sector but also in the adjacent sea area, e.g., failure of sardines off the Nile Delta after completion of the Aswan High Dam. However, Welcome is realistic in stating that such current practices to solve socioeconomic problems are inevitable in some countries. Thus, it is likely that in the 1980s we shall see efforts, through research, to collect some of the basic resource and environmental data needed for determining which modifications cause the least damage to ecosystems. Similarly, in addition to pollution, many of the lake systems in LDCs are subject to habitat modifications caused by considerble fluctuations and changes in inflow and outflow, which affect the aquactic resources. The damming of rivers to form reservoirs can have both positive and negative effects on the biota.

Knowledge of what is happening in natural aquatic systems clearly depends on the accuracy and scope of the monitoring operations in what is not a static system (White 1980). To what degree even simple monitoring systems will be set up, or need to be set up, in LDCs in this decade is debatable. However, use of a species such as the mussel for pollution detection and monitoring as mentioned above could lead simultaneously toward increased production of that species in the LDCs.

The Ciguatera Problem

The problem of ciguatera poisoning from human consumption of tropical food fishes is a major, and greatly underestimated, deterrent to increased fishery development in the Pacific and Atlantic oceans, and to lesser extent in the Indian Ocean (de Sylva and Higman 1980 and references therein; Parrish 1980). The causes of ciguatera have been summarized recently (de Sylva 1979, de Sylva and Higman 1980). It seems clear that the toxins are derived mainly from reef-dwelling microorganisms (Yasumoto et al. 1979, de Sylva and Deichmann 1979) and are magnified through the trophic chain with highest concentrations in upper-level predators such as fishes. The cyclic nature of ciguatera outbreaks, from seasonal to decadal, and the highly localized but varying geographic distribution of ciguatoxic fishes have led to a virtual lack of fisheries or potential development for certain groups of fishes in many tropical regions. Recent advances have provided a laboratory-based radioimmunoassay for toxicity in fish flesh (Hokama et al. 1977) but in the next decade a simple, cheap, portable field method to give similar results is needed. Such screening techniques will be important, at least initially, from the standpoint of the commercial fish trade, especially for export. However, for subsistence-level fishermen, personal experience probably will remain the sole guide to ciguatera for the foreseeable future. Better delineation of ciguatoxic areas and species coupled with continued and accelerated research on the trophic ecology of ciguatera will be beneficial to full development and managment of the multispecies fisheries of shallow, tropical areas. In this respect it should be remembered that ciguatoxic island areas of the tropical Atlantic, Indian, and Pacific oceans are among the poorest in the world in terms of local sources of animal protein if fish are excluded from the diet. A long-term understanding is needed of the environmental features that might be involved in the temporal, spatial, and species distribution of ciguatera, in particular the effects of artificial, man-made perturbations of the marine ecosystem, e.g., chemical pollution and dredging (Bagnis 1969).

MANAGEMENT

The establishment of exclusive economic zones, usually to 200 miles, by most coastal states appears to be an irreversible decision that will be recognized by any treaty to arise from the current deliberations of the United Nations Conference on the Law of the Sea. Extended jurisdiction is already having a major impact on fisheries economics, particularly of the developed nations, in that about 99 percent of the world commercial catch is from areas now under or liable to national control (EEZs). The main disruptions of fisheries include those related to fishing fleet operations, trade in fisheries products, and the social structure of fisheries communities. A review of fisheries management in the light of present-day events is given in ACMRR (1980).

With the right to exclusive use of resources in the EEZ, the coastal state assumes the corresponding responsibility to manage the resources properly. Indeed this is an excellent new, though time-limited, opportunity for rational management to be established. However, this opportunity will be of short duration, and problems of the past, e.g., overfishing, will continue or recur if political inertia or lack of scientific advice hampers decision making. This in turn could lead to a downturn in the growth of the world fish catch during the first half of the decade. Management must be considered in the broadest sense, including such aspects as shore-based infrastructure, the investment sector, and the fishermen themselves. Indeed, the question of strategy in fishery management and development was raised by Rothschild (1973). In the developing world, the degree of response will vary according to the level of development of the LDC, its perceived national goals relative to fisheries, and its political will to achieve those goals. There has been much advice offered on how the LDCs should manage their "new-found" resources. Not all of this advice has been altruistic. Indeed the question must be asked as to whether the developed world really can provide the programs needed to assist LDCs, given the developed nations' own very uneven record in previous management groups (see Cardoso 1978 for discussion of enforcement of fishery regulations).

During this decade, the developed coastal states will redefine their management and enforcement systems with the clearly increasing national demand (socioeconomic, political) for utilization of resources by ther own fishermen. Quotas for foreign fishermen will diminish unless it is clearly to the advantage of the coastal state to permit foreign fishing; even then license fees will be very high. Enforcement will become stricter and probably will include the introduction, at least on large vessels, of transponders for instant indentification from vessels, aircraft, and satellites. Concurrently, parties found breaking fishery regulations will face stiffer penalties with mandatory loss of quotas and licenses to fish.

With extended jurisdiction, most LDCs will gain control of increased resources because of increased "territory." What are the problems which then face the LDCs? The problems are a need to utilize the total resources, which involves capture, processing, distribution, marketing, etc., to understand the fisheries in scientific, technological, and economic terms and to manage the system. The ability of a nation to utilize the existing resources will depend, of course, on its current state of development and on the size and components of the resources. In an earlier section, comments were made regarding the vital need for stock assessment ability in the LDCs, which presupposes adequate scientific manpower. The local management system itself has to evolve based on the development of national policies on fisheries and the associated legislation. Given the likley slowness of this political process, the assistance required by LDCs will be long-term, broad-based education and training that includes fisheries technology, science, economics, enforcement, surveillance, information transfer, etc., at the levels required to produce the multidisciplinary approach needed in fisheries. However, detailed analysis should be made to determine whether simpler and cheaper management systems, though perhaps less efficient by current world standards, could be used initially; these systems might be based on a mix of traditional, indigenous practices and scientific advice and should be considered by the LDC communities themselves.

LDCs well-versed in fisheries development can probably offer assistance more effectively to other LDCs than the developed world can. This aid could be through joint ventures to use the resources on a diminishing scale over a fixed period in return for training, e.g., Thailand to Bangladesh, which also meets the needs of those LDCs losing access to resources in the exclusive economic zones of other LDCs.

Obviously for the larger, more advanced LDCs with large fisheries potential and scientific manpower, an effective management strategy is simply to consider that all resources are reserved for one's own fishermen, even if the catch is not maximal at once or for some time to come. Indeed artisanal and small-scale fishermen could be given exclusive rights over certain inshore areas, and certain species or seasons. For the smaller nations with more limited resources, the management problem is more difficult and acute, and external assistance will continue to be needed on a regional or subregional basis. Bilateral agreements with developed countries will continue to be made but with marked scrutiny and increased emphasis on their value in terms of training, fish production, and cash flow (rent, profit, etc.) to the LDC partner.

Scientific research on common fisheries problems will increase at the regional and subregional level and will be applied to analysis of fisheries situations such as multispecies management and the finfish by-catch in shrimping operations which are of special importance to many LDCs. Locally migratory species shared by two or more nations will be dealt with either as resident stocks or with the assistance of neighboring states on a bilateral or subregional basis. But one must recognize that LDC governmental actions (like those in the developed world in the past) will continue to be made primarly for the sole benefit of individual nations unless there is an apparent need for a united front to prevent "predation" by the developed world.

Clearly no fishery management system can be effective unless there is the will and the ability to enforce it. Necessary actions range from the surveillance and prevention of unauthorized foreign fishing to enforcement of regulations affecting local fleets at all levels with respect to net mesh size, closed areas, banned gear types, etc. Again the degree of the enforcement problem varies with the nation's level of development, its size, resources, financial state, and most importantly its political will. In this respect it is interesting to note the present requests of resource-rich LDCs in West Africa, e.g., Mauritania and Guinea-Bissau, for training the fisheries surveillance and enforcement methods,* despite the cost and operational problems of such measures. Certainly high-level political officials and civil servants need to be included in the long-term educational assistance programs. With regard to supranational enforcement, the suggestion has been made† that an inter-nation court within a region would

*P.M. Roedel: personal communication.
†D.H. Cushing: personal communication.

serve a useful purpose; in this respect, the European Court is a very potent force.

The decade will see in the more advanced LDCs some successes in the development and operation of fishery management systems designed specifically for developing nations. Relatively slow progress will be made at the other end of the spectrum in the "Fourth World" nations, where fisheries development will be uneven because of ill-advised bilateral agreements, continued lack of control over foreign fishing, and a lack of scientific and technical manpower. Often the manpower problem will be one of higher priorities assigned to even more pressing developmental needs. Unfortunately it is often in this poorest tier of countries, where governmental bureaucracies are least effective, that major infrastructural administrative changes, including interdepartmental collaboration and linkages with academic and technical sectors of the education system are difficult to investigate but are urgently needed. In a general development sense, Moravcsik and Ziman (1975) reinforce this argument and state that for LDCs to be better managers they will need (1) to establish bureaucracies more responsive to current events and (2) to have the scientists themselves become more adaptable to their country's needs. Kasahara (1973), on the other hand, considered that introduction of management systems in LDCs might be easier than expected because there were no long-term historical contraints on industry or fishermen.

It is with the smallest and the least developed nations that regional and subregional groupings for fisheries management could be most valuable. However, these groupings should be totally under local control even though technical and financial assistance to them may be from international agencies. The degree of management sophistication to be applied has to be related to the costs and benefits to the LDC and to the effects that management may have on the local fishermen themselves. How can or should LDC fishermen be involved in the decisions? The desired mix of high-technology, commercial-scale fisheries, and labor-intensive, artisanal fisheries should guide the establishment of a management system and any provision of technical assistance.

Prediction of the detailed effect of extended jurisdiction on the large number of exisiting fisheries commissions is extremely difficult because of their various roles in fisheries problems. However, events to date indicate that some fisheries commissions will change drastically and that others will be dissolved and replaced by new ones. Commissions have given good scientific and technical advice in the past, but whether this can be translated into political action in the future remains to be seen.

The nature of highly migratory species, such as tunas, and of the fisheries in which they are caught certainly requires international management at least initially on a regional, ocean-wide basis. However, for the management of such species to be effective in the near future, there will need to be compromises between the unrestricted use of a common resource, which favors the developed nations, and the need to encourage local industry through national quotas or even through coastal state control within its EEZ, as is favored by many developing nations.

Gopalakrishnan (1977) offered an interesting approach to ocean management, which with modifications might be adapted to some currently or potentially resource-rich LDCs. He suggested that the multinational corporations (MNCs) operating in the developing world could be encouraged to offer assistance in the development of living and nonliving marine resources as an alternative to the LDC's exercising operational or fiscal control over the MNC. Given the potential international political scenarios for the LDCs and the MNCs in the 1980s, is there any hope that such an idealistic, rational approach for joint development and economics could be achieved? Perhaps such radical approaches, in which both parties would profit, could be the key to future development and management of fisheries in all but the most resource-poor nations.

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ADDENDUM

Since the revised version of this paper was completed, a short series of articles on living marine resources has appeared in BioScience (March 1981) with an introduction by H.H. Steele (p. 205). Time has not permitted detailed review of these articles for citation in the foregoing text:

Bardach, J.E. and R. Miranda Santerre (1981) Climate and the fish in the sea. BioScience 31(3) 206-15.

Clark, C.W. (1981) Bioeconomics of the ocean. BioScience 31(3):231-37.

Rothschild, B.J. (1981) More food from the sea? BioScience 31(3):216-22.

Ryther, J.H. (1981) Mariculture, ocean ranching and other culture-based fisheries. BioScience 31(3):223-30.

NEEDS AND PROGRAMS OF DEVELOPING COUNTRIES IN MARINE SCIENCE AND TECHNOLOGY

The Marine Technical Assistance Group requested that workshop participants from developing countries prepare papers discussing the marine technical abilities and needs of their countries and adjacent regions. The following twelve papers were distributed at the opening of the workshop. Included here is the paper by Enrique Torrejon, of Uruguay, although he was unable to attend the workshop.

OUTLINE OF THE PRINCIPAL NEEDS OF PERU IN FISHERIES AND RELATED INVESTIGATIONS

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Callao, Peru
January 1981

I have been asked to outline for this workshop the needs for research and technical development in marine and relevant freshwater areas in Peru and in adjacent fisheries. The purpose of the workshop is to develop recommendations on future directions for U.S. cooperative assistance in marine sciences and technology of benefit to the scientific communities of the United States and the developing world. The invitation to attend the workshop is encouraging in the sense that it may be understood as an indication of a serious intention to overcome certain past tendencies to consider the actual benefits to developing countries only as a by-product of cooperation, as is pointed out in more than one of the background papers.

It is well known that fisheries in Peru have developed much more rapidly than the growth of scientific investigation, with the result that the routine knowledge necessary for efficient management of the fisheries is lacking, despite considerable help from abroad. Consequently, our needs for investigation and technical development of our fisheries are still at the level of conventional physical, chemical, and biological investigations. Such investigations clearly include studies related to climatic variability. It is of prime necessity for us to get to a clear understanding of the mechanisms operating the variations in our upwelling system, including the periodic occurrences of El Nino and Antinino, and the consequent variability in fish production. Study of ocean upwelling near Peru is important for several reasons. The first is that our upwelling system and the occurrence of El Nino and Antinino are not only local phenomena. On the contrary, their correct understanding requires oceanographic knowledge in a wide area of the South Pacific, including changes in sea level and movement of currents, masses of water, and winds. Large areas of this part of the Pacific, however, are not subject to regular and permanent study. At present we have research programs like Estudio Regional del Fenomeno El Nino [Regional Study of the Phenomenon Known as El Nino] (ERFEN) and VACOM, a study of coastal upwelling ecosystems near Peru, to cover in some measure the areas immediately adjacent to our coast. We feel an immediate need, however, for international cooperation in research projects extending from longitude 120 to 140 degrees west toward the South American coasts.

The second reason for study of ocean upwelling is that the effect of climatic variability on fisheries production seems to operate principally through the trophic processes characteristic of pre-adult stages. These stages critically determine the coincidence, both in a quantitative and qualitative sense, of adequate conditions for spawning, survival of eggs and of larvae, etc. What is required is an adequate understanding of critical processes at a physiological scale without losing sight of the overall energy balance of the system. In short, what is required is research in fields of investigation open to sophisticated methodologies, which are, of course, the proper field for cooperation with developed countries.

Our needs in marine fisheries investigations run mainly along four lines:

1. We need studies of the oceanography of the South Pacific from longitude 120 to 140 degrees west toward our coasts, with emphasis on the phenomena that may be relevant to the occurrence of El Nino and the Antinino and on other phenomena presumably responsible for certain qualitative and quantitative aspects of the coastal upwelling.
2. Coastal oceanography should be studied at the scale relevant to spawning processes, the survival of eggs and larvae, etc.
3. As a consequence of the collapse of the large populations of anchoveta, we need to reorient our outlook on population dynamics from a single-species to a multispecific point of view.
4. There is a need for dependable methods to determine the age of most of our fish, which, although not strictly tropical, offer the same difficulties.

With regard to our Amazonic waters, it is important to point out that the quick development of this region as a consequence of fast oil exploitation and subsequent industrial and urban activities, is disclosing a considerable potential for fishery products in the region. Thus arises another line of needed investigation:

We need an adequate understanding, at the appropriate scale, of the possible effects of such developments on aquatic ecology.

Finally, we need to narrow the gap already noticeable between the increasing contamination of marine and fluvial waters and our capacity to monitor it. These needs for investigation all are relatively large in scope and require a considerable command of new or advanced technologies, such as remote sensing and other highly sophisticated methods of investigation. In short, they imply the additional need for intensive training in new and highly advanced technologies on the part of less developed countries. This is vitally important considering that a command of advanced and new techniques is not only necessary for the field operation of projects but also for their follow-up, evaluation, and interpretation. Among cooperative activities between Peru and developed countries, three in particular illustrate Peru's experience with projects involving advanced technology. Those projects are VACOM (mentioned above); JOINT II, a series of observations of coastal upwelling ecosystems off the northwest coast of South America undertaken in the International Decade of Ocean Exploration; and ICANE, a joint Canadian and Peruvian study of coastal upwelling.

JOINT II represents the typical large-scale cooperative project, in which study objectives directly related to problems of less developed countries do not weigh very heavily. In this type of project, only a very small fraction of the total effort is devoted to problems deriving from the disadvantage of less developed countries in matters of advanced technology. One obvious step to overcome this difficulty is to arrange for the less developed countries to participate fully in the project, beginning with its first stages: definition of objectives, choice of study methods, and establishment of goals. We believe that in these early stages needs related to the difference in technical level can be identified most effectively. Ideally, special effort would be given to defining the extent of the need for general technological advancement, and that would become the objective of a project. Of course, our idea of full participation does not end at the first stages but extends to the evaluation and interpretation stages.

These needs for participation have been considered in the other two projects mentioned--VACOM and ICANE. For the most part, Peru has gained by its experience in these latter two projects. We believe that such experiences, both positive and negative, must be taken into account in any serious attempt to raise cooperative research ventures to a level consistent with the principles of equity now reinforced by the draft convention on a new law of the sea.

NEEDS AND PROGRAMS IN MARINE TECHNOLOGICAL AND SCIENTIFIC COOPERATION

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November 1980

SUMMARY

Marine technical assistance to countries in the first phase of development of the marine sciences should be limited to very few subjects which are of importance to the economy of these countries. In most developing countries these subjects should be: coastal fisheries, mariculture, and shore processes. Research programs should be carefully planned so as to be able to show results of some economic or social importance at an early stage.

Countries such as Israel in a more advanced phase of development of the marine sciences but lacking the infrastructure existing in the developed countries can also benefit from marine technical assistance and from cooperation with the developed countries. The best method of cooperation is joint research and development projects carried out, at least in part, in the developing country.

A. Although Israel cannot be considered a developing country because of her developed agricultural, industrial, and social structure, Israel recently has faced problems which are similar in many aspects to those now facing developing countries.

In the marine sciences this is even more obvious, because modern oceanographic research began only in the late 1940s, and the exploitation of marine resources in Israel is still in the beginning stages. Only now are we achieving a more comprehensive approach to the marine sciences.

In retrospect, we now realize that many of our mistakes in Israel were (and probably still are) also made by other developing countries. Overexploitation of the meager resources of sand and other building materials led to the deterioration of many potential tourist attractions; fishing the coastal waters without sufficient knowledge of scientific management of the fish population led to fluctuations in the size of the trawling fleet and to social instability among fishermen. These and other mistakes are probably typical of a country in which population pressure in the coastal area urges fast development and which is unaware of the research that, ideally, should precede any development.

In some other developing countries, it seems, the problem may be even more difficult. Instead of overexploitation and irrational use of resources, there is a lack of awareness of the potential resources.

Both these examples lead us to suggest that the first need of developing countries in the field of marine research is to make an "inventory" of the resources which each country could develop and exploit in the oceans and seas bordering it. What resources should be considered worth exploiting depends, of course, upon the natural and political situation in each particular case. The inventory approach should not be interpreted as a recommendation to study the geology, biology, chemistry, and physics of the marine environment in the greatest detail. Stress should be put on potential resources that can be exploited within the economic, social, and scientific framework of the developing countries. If we exclude countries with unusual natural conditions, such as countries bordering on upwelling areas or countries with known offshore mineral resources (oil, tin, etc.), we find that there are more or less similar social, economic, and scientific situations in most of the developing countries as far as marine resources are concerned.

1. These countries are too poor to develop a marine resources exploitation scheme which calls for large investments.

2. Most countries lack sufficient scientific and technological infrastructure to be able to cope alone with studies and research involving "high" technologies. If there is a group of technologists or scientists that can master "high" technology, this group is usually concentrated in one place which is not necessarily the best place from which to conduct marine research.

3. In almost all the developing countries, there is a wide gap between the scientific/technological community and the people who are supposed to benefit from the new know-how and technology developed by the scientists. The problem of transferring technology and know-how is in many cases much more difficult than the problem of developing the technology.

4. Most developing countries consider the 200-mile economic zone as a national resource and are very suspicious of foreigners trying to exploit this area. In practice, however very few developing countries can use the deeper waters of the economic zone. The immediate

development of the economic zone will probably include the shelf area and maybe only the nearshore waters.

As a result of all these considerations, we feel that there are very few areas of marine research to which priority should be given in developing countries. These areas of research are (1) management of nearshore fisheries, especially in lagoons and estuaries, (2) marine aquaculture, (3) shore processes.

It is extremely important to determine the economic and social goals of the research and to plan the research strategy carefully. Most countries beginning to develop marine research usually want to know what the expected economic and social benefits are and when the results of the research will be felt.

As to determining the economic and social goals of the proposed research, a few examples will make this clear: (1) The aim of mariculture development is not to supply cheap protein to the "hungry masses" of the world, but rather to produce fish and other marine food for consumption in the near area, or to produce luxury marine food to sell in a richer area. (2) Similarly, the aim of developing fisheries in lagoonal and estuarine environments is not to develop an industry of economic significance, but rather to supply protein to the populations of the coastal areas. (3) The study of coastal processes should not aim at planning an international port or an intercontinental canal, but rather at helping to keep lagoons open, at preventing the deterioration of tourist beaches, or at the planning of fishing harbors and small-craft anchorages.

Limiting our research goals sometimes necessarily leads us to limit the scope of our program, especially when we plan the first stages of the research. A few examples of what we consider to be the right attitude toward research planning will clarify this problem.

1. From 1967 until 1979 Israel was responsible for the management of the Bardawil Lagoon in Northern Sinai, which was then under Israeli military control. When left to itself, the entrance of this lagoon is silted up, the water in the lagoon becomes hypersaline, and all fish species die. The first stage in the research on the lagoon involved the study of the silting mechanism at the lagoon entrance. After this problem was solved and a way was found to keep the lagoon open, the main effort went into biological research. It was decided to study first the biology of the two main fish species, even before basic biological information, such as primary productivity and biomass of plankton and benthos, was known. This decision was made because it was felt that the most urgent need was to formulate a fisheries management plan. In the research that followed this decision, the gonadal cycle of two species was studied, the spawning period was determined, and the migration pattern of spawners and of post-larvae was observed.

The immediate result of this research was a decision on a fishing regime. During the months of spawning and migration, fishing was prohibited, and during other months the maximal mesh size of fishing nets was determined.

As a result of these somewhat simple research efforts and apparently primitive management regulations, the yield of the lagoon more than quadrupled within a few years.

There is no doubt in our minds that a more systematic research involving the study of the primary and secondary productivity, of the various food webs and of the competition between species of commercial importance and other species, would have led to further increase in fish yield. This increase may have been even greater than that achieved by the more "primitive" approach. However, results from such more "basic" research would have been felt in the field only after a long period of research. Very often we cannot afford such a delay.

2. Another example is research in mariculture. Whenever a research institute begins to do research in the field of mariculture, it usually faces the problem of deciding which marine organisms to choose for domestication. The usual mistakes are either to spend too much time on testing many potential candidates or to work on only one aspect (e.g., nutrition, diseases) of a few species. We believe that research in mariculture should concentrate on one species or at most on a few species living in polyculture. Accordingly, we began to work on one fish, Sparus aurata, but on many aspects of the culture of this fish--nutrition, cage technology, reproduction, diseases, etc. At first, most of the research was done with fish grown in the laboratory from fry caught in the wild, and the main emphasis was on formulating an optimal diet, growing the fish in floating cages, and combating diseases. Only after these problems were solved more or less satisfactorily was the second stage of the research begun. In this present stage, research on nutrition, diseases, and cage technology continues, but much effort is being devoted to production of fish fry in captivity and to hydrobiology of fish ponds. While the first stage consists of problems for which a preliminary solution can usually be found within a few years, the second stage includes more complicated problems requiring long periods of time to solve and involving "high" technology.

When doing applied research in developing countries, one should always keep in mind the "technology transfer" problems. Solutions which are scientifically sound but cannot be applied in a certain country are worth very little from that country's point of view. We would like to stress this point by comparing research in nearshore fisheries with research in mariculture. New methods of fishing can be practiced by a single fisherman or a group of fishermen with relatively small changes from existing practices and with relatively small capital costs. Mariculture, on the other hand, involves in most countries (except very few in Southeast Asia) new ways of thinking and large investments. Research in coastal fisheries should not involve too much "high" technology, because in the process of applying the knowhow developed by the research effort, too sophisticated a technology would prevent its easy transfer. Mariculture calls for large investments, which can be supplied in developing countries either by big companies or by central authorities. Such an organization can support central research and development and a technology transfer system which can cope with "high" technology. Research in mariculture, therefore, can make use of more complicated research methods, especially in those areas that call for a central research laboratory (e.g., fry production).

B. At present, oceanography in Israel can no longer be described as that typical of a developing country. We are now in the second phase of development of marine sciences, a stage which many other developing countries will reach sooner or later. At this stage, decisions on fields of priority in the marine sciences have already been made, the first economic and social impact of marine research is beginning to be felt, and oceanography is recognized by politicians as a legitimate field of activity.

The main problem for countries such as Israel is the danger of remaining at the same stage for too long. As mentioned before, effective research in a developing country necessarily involves limiting the scope of the research. The tendency to limit scientists to research fields yielding immediate results must not be allowed to continue indefinitely. As most research administrators have come to realize, scientists who are not permitted to pursue their own scientific curiosity (at least for part of their time) will sooner or later lose interest in their work.

This problem is acute in small or developing countries, since it is easier to keep the marine scientist interested in oceanography in the industrialized countries with major oceanographic institutions. The versatility of stimuli in large institutions, the variety of subjects for reserach, and the number of available research cruises lead to great freedom of choice for any scientist interested in a particular problem or even a particular part of the globe.

A marine scientist in a country were oceanography is less developed is in a difficult situation if he becomes interested in problems of a more general oceanographic nature. The big research vessels, the heavy equipment, and sometimes even laboratories where certain new research equipment is being developed are as a rule not available to him.

International cooperation seems to be one of the best solutions in this situation, but in fact much depends on the form of this cooperation. There are many ways of cooperation. Some are more efficient from the point of view of the small country, while others may be satisfying only from the point of view of the individual scientists. For instance, scientists from developing countries can join their colleagues abroad for one or two legs of a research cruise. This form of scientific cooperation, however, is the least beneficial for the small or developing country. The instrumentation and research possibilities of a big, well-equipped vessel may not be available to the research scientist from a small country when he returns home.

The best form of cooperation is, we believe, a joint research program carried out in the small country (at least partly) in cooperation with a major oceanographic instituion, using not only the big research vessels of the developed country but also local craft and equipment when available.

It is our experience that problems of the general oceanographic interest which could be stimulating for marine scientists from developed countries can be found not only in the large oceans but also in smaller seas and lakes. Let me cite a few examples from our region. Problems of oligotrophic seas exist not only in the central gyres of some oceans but in the eastern Mediterranean and northern Red Sea as well. The Red Sea, like any other rifting area in the oceans, may be interesting to the geochemist and the geophysicist. Problems of the mechanisms governing red tide blooms can sometimes be studied more easily in lakes having dinoflagellate blooms, such as Lake Kinneret, Israel, than in the open ocean. There are many other examples in other countries and other seas as well.

CONTRIBUTION BY THE NIGERIAN INSTITUTE FOR OCEANOGRAPHY AND MARINE RESEARCH

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December 1980

1. NIGERIA'S NEEDS FOR RESEARCH AND TECHNICAL DEVELOPMENT IN AREAS OF NIOMR'S COMPETENCE

1.1 The mission of the Nigerian Institute for Oceanography and Marine Research (NIOMR), established in November 1975, is to conduct research into the resources and physical characteristics of the Nigerian territorial sea, the exclusive economic zone, and the high seas beyond, and to train manpower required for the fishing industry, i.e., for both the public and private sectors.

1.2 The research objectives of the institute have been formulated to meet the following national needs for research and technical development in matters within the purview of the institute.

(a) Knowledge of how much fish is available for commercial exploitation in the Nigerian brackish waters (creeks and lagoons which mix with seawater) and coastal waters at least out to 200 nautical miles and beyond. To have information of fisheries resources off other coastal African countries in the eastern Atlantic so that our fisheries resources in comparison with them, and possible interactions between them, can be known.

(b) Adequate scientific data about the fish stocks in Nigerian coastal and brackish water to enable the resources to be managed rationally so that Nigeria can derive maximum long-term benefits from them.

(c) Development of technologies necessary for improvements in fish catching, handling, storage, processing, and distribution methods as applicable to available fish resources.

(d) Socioeconomic evaluation of the commercialization of the results of (a), (b), and (c) above.

(e) An understanding of the geology and geophysics of the seafloor off Nigeria and its sediments with a view to controlling beach erosion, determining seafloor topography, thickness and economic possibilities and type of sediments, the presence of petroleum gas pockets in the sediments, the presence and concentrations of heavy minerals, and sand and gravel deposits.

(f) Knowledge of the chemical and physical characteristics of the coastal waters and their influence on living resources, the weather and movements of water masses at sea. In particular, to study the effects of pollutants, monitor their concentrations and determine best ways of removing them in order to protect the environment and its living resources.

(g) The patterns of water movements (currents, waves) at sea off Nigeria with a view to knowing how pollutants will be carried along, to or from our coasts and to plotting least-time tracks for coastal shipping.

2. AREAS FOR U.S. COOPERATION AND ASSISTANCE

2.1 Feasibility study of a tuna fishery based in Nigeria and a fish stock assessment of the Nigerian exclusive economic zone and territorial sea.

Description: An exclusive economic zone of 200 nautical miles has been declared in Nigeria by Decree No. 28 of 2nd October, 1978. Some tuna, in waters now under Nigerian jurisdiction, have been reported in previous surveys and fishing operations conducted from outside Nigeria. This potentially valuable fishery should be studied to see if an investment by Nigerians is warranted; and if justified, to suggest patterns for development of a Nigeria-based tuna fishery.

The search for tuna and the necessary tuna bait survey give an opportunity for a comprehensive fish stock assessment of the Nigerian exclusive economic zone and territorial sea (i.e., the first 200 nautical miles). Available stock assessment information is only in respect of exploited demersal fish and shrimps out to the 40-meter isobath. Information is needed regarding pelagic, midwater, and demersal stocks beyond the 40-meter isobath.

Long-range objectives:

(a) To find means of contributing to the solution of the nation's food and agricultural problem by supplying animal protein for the satisfaction of nutritional needs and improvement of the standard of living.

(b) To identify means for increasing the range and efficiency of marine operations of the community of fishermen dependent on fisheries for a livelihood and thus to assist the people of Nigeria through their own efforts to produce more food.

(c) To contribute to the nation's economic development by creating foreign exchange through the exportation of fish and shrimps into the international market; this to be achieved in part through the accelerated and intensified production of fish from more distant grounds, out of range of smaller crafts, with modern techniques and equipment.

Immediate objectives:

(a) Determination of the abundance and availability of tuna within a 500-nautical-mile range of Lagos.

(b) Determination of available bait fish concentrations along the coast.

(c) Assessment of the abundance and availability of pelagic, midwater, and deep-water demersal (below the 40-meter isobath) fish in the Nigerian exclusive economic zone.

(d) Determination of the most efficient methods of capturing available fish, and determination of the types of vessels and gear best suited for the operations. To train Nigerians in these methods.

(e) The conduct of marketing, processing, and economic studies necessary to maximize the benefits from discovered resources.

(f) The initiation of routine oceanographic investigations necessary to support the fishery that would arise from the findings of the survey.

NIOMR's input

Manpower: Two marine scientists and two assistants per cruise to assist and get on-the-job training.

Five to ten fishing and engineering crew members each cruise to assist and get on-the-job training.

Vessel: A 36-meter stern-trawler research vessel will be available after January 1981. Its sea time will, however, have to be shared with other projects, e.g., geological and oceanographic. It will have the following electronic hydro-acoustic equipment:

(a) Research echosounder system Simrad EKS 38

(b) Digital echointegrator system with Simrad QD high-speed computer

(c) Two-channel tape recorder for storing echos and synchronizing signals

(d) Synchronizer for tape recorder

(e) Echoscope Simrad C1

(f) Scale expander MC - 01

(g) Hydrographic echosounder Simrad EA

(h) Simrad AB 100 - range printout generator for printout on EA recording paper of range being used

(i) Standard oceanographic equipment

The research vessel itself will have the following characteristics:

LOA	118' 10"	=	36.22m
LPP	98' 5"	=	30.00m
Depth mid to forecastle deck	21'	=	6.40m
Depth mid to main deck	13' 5"	=	4.10m
Design draft moulded	10' 10"	=	3.30m
Freeboard over DWL	2' 7"	=	0.80m
Engine power	1280 BHP (Trop Cond.)		
Propeller speed	340 RPM		
Trial speed	12.3 knots		
Service speed	12.0 knots		
Fish hold capacity	2500 cbf	=	$70m^3$
Fuel oil	170 tons		
Lub oil	25 tons		
Freshwater	15 tons		

Crew: Captain + 8 men + 7 scientists + 4 assistants

The vessel should be able to trawl down to 300 meters bottom, trawl midwater, and carry a live bait well with cooling grids capable of reducing the temperature 5° below ambient.

Shore facilities:

A jetty designed to take the research vessel - draft 12 feet
20 tons capacity cold stores

Fish meal reduction plant
Laboratories
2 living apartments, each 3 bedrooms, will be available after mid-1981

Type and Preferred Mechanism for Cooperation and Assistance

An appropriate specialized tuna vessel (pole and line fishing using live bait) with crew and gear will be chartered for at least 18 months in the first instance for the tuna survey, which should start in September 1981.

A bait survey should start in July 1981 using a chartered vessel and crew from a firm with bait fishing experience in West Africa.

NIOMR's new research vessel (to be available in March 1981) will be used for general oceanographic data support for these surveys and for the pelagic, midwater, and deep demersal fish surveys. Assistance is needed for visiting scientists in hydro-acoustic surveys to use the equipment in the vessel and also to train NIOMR staff to use them. If experts in midwater and deep demersal trawling can be found in scientific institutions, their assistance as visiting scientists will be needed. Otherwise they will have to be hired as consultants from the private sector with the U.S. institutions helping by facilitating our contacts with them.

Visiting scientists will also be needed in the following disciplines:

Planktology: Phytoplanktologists and zooplanktologists to function as team leaders to NIOMR counterpart staff in the establishment of routine studies in larval, food chain, and primary productivity studies.

Physical and chemical oceanography: To establish routine work pattern, and instrumentation for routine data collection, processing and interpretation. To advise on further action necessary to improve instrument repairs and maintenance support.

Population dynamics: To assist and upgrade the efforts of NIOMR staff in studies needed for stock assessment and the drawing up of appropriate management measures.

2.2 Research and Monitoring of Petroleum Oil Pollution

Objective: Protection of coastal and marine environment through the evaluation of petroleum oil and industrial effluents on coastal and marine environment.

Cooperation or assistance needed include:

(a) Standards for evaluating industrial effluents for toxicity on marine organisms and human beings.

(b) Formulation of industrial control regulations including the use of pesticides.

(c) Methods of water and tissue analyses and correlation of values with field data.

(a), (b), and (c) above should last two years. As soon as possible, a consultant (visiting scientist) is required to evaluate the entire environmental research program, and to recommend necessary training. The training of NIOMR research officers and technical staff for laboratory work in bioassays and field sampling methods is considered necessary, right from the start.

2.3 Beach Erosion Studies

Objective: Determine causes of beach erosion along the coast of Nigeria with initial emphasis on Bar Beach, Lagos, with a view to controlling it.

NIOMR's research plan: (1) Determine wave refraction patterns (orthogonals) in problem areas. (2) Map beach profiles in problem areas and determine historical changes from previous area photographs, in view of urbanization - breakwaters, harbors, dredging of sands from rivers.

Type of assistance or collaboration needed: Collaborative research with United States universities such as Scripps Institution of Oceanography, Coastal Erosion Research Center (Drs. Inman, Shepard, and Currey), Woods Hole Oceanographic Institute (Dr. K. O. Emery's group or with competent research consulting firms). Special assistance is needed in the construction of wave refraction diagrams and data interpretation.

Available personnel: Young and inexperienced in data acquisition, interpretation, and solutions applicable to erosion-control methods.

Available equipment: Research vessel, distance finder, land leveller, and compass.

Training required: 3 to 6 months training in beach erosion methods in a United States institution or with a collaborative consulting firm.

This study is targeted for three years and will be accomplished in two phases:

PHASE I: (a) Preliminary study -
Preparation and setting up bench marks at selected sites throughout the coastal strip of Nigeria (about 4 months)

(b) Field work (about 14 months)

(c) Write up of results (about 6 months)

PHASE II: (a) Detailed study of particular problem areas (12 months)

(b) Implementation of results of Phase I - application of erosion control methods (12 months)

2.4 Geological Oceanography

Objectives:

(a) To determine the outer limit of the Nigerian continental shelf.

(b) To assess the economic potential of heavy minerals and sand and gravel deposits.

(c) To determine favorable sites for oil well platforms.

Description: Work involves study of thickness of Holocene sediments on the Nigerian Shelf, sediment types and distribution patterns, and economic potentials of sand and gravel deposits in the inner shelf, bottom topography and slope stability, mineralogy--heavy mineral concentrations and their economic possibilities.

Assistance required: Seismic team (visiting scientists) to join NIOMR staff to run high-resolution seismic profiles along selected sites from the inner shelf to the edge of the continental margin and to process and interpret the data. We lack the manpower in this geological area.

Equipment: The NIOMR research vessel will be available for this work.

Duration of study: (18 months)

PHASE I: Field work (3 months)
PHASE II: Laboratory analysis and write up of report (about 15 months)

2.5 Library

Cooperation and assistance required: Access to publications and reprints on the basis of exchange, subscriptions, and donations.

SUMMARY

(1) The research and technical development needs of Nigeria in the areas of NIOMR's mandate are listed.

(2) Priority areas for cooperation and assistance by the United States are identified as

(a) Resources survey including tuna, and tuna bait, other pelagic fish species, demersal fish and shrimps beyond the 40-meter isobath, and fishes in midwater.

(b) Pollution research and monitoring

(c) Beach erosion

(d) Geological oceanography

(e) Development of our library

(3) The type of cooperation and assistance needed in each area is indicated, e.g., visiting scientists, for whom detailed arrangements can be worked out later, e.g., housing and transportation, are needed in the following areas to establish a work routine and give on-the-job training.

Hydro-acoustic surveys
Midwater trawling technology
Deep demersal trawling technology
Planktology
Physical oceanography
Chemical oceanography
Marine pollution expert, especially in bioassay work
Seismic team
Collaborative research is proposed for beach erosion studies

Access to formal training opportunities is requested for all the main areas, especially in bioassay work. Access to research publications in the marine sciences is considered necessary. We will pay for what we cannot get free.

NEEDS FOR RESEARCH AND TECHNICAL DEVELOPMENT OF THE AQUATIC RESOURCES IN EGYPT AND ADJACENT FISHERIES

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November 1980

1. INTRODUCTION

The immense variety of circumstances that exists in the developing countries (the Third World) must necessarily have considerable impact on perceptions of just what comprises development need. Not only are the economic circumstances widely varied, but there are also the readily observed differences in climate, topography, culture and social custom, traditions, etc.

All of these enter into the determination of development need and character. Consequently, a rather pronounced danger exists in the tendency to generalize on the subject of development. Moreover, there is confusion between identification of need as differentiated from demand. Research institutions in developing countries sometimes confuse the two, with the result that many research reports consider problems and set forth solutions for which there are no users. At the same time, in the developing countries, given the very limited resources and assistance for research and development, it is especially important that what is worked on is relevant, that the efforts are likely to be successful, and that the results will find application.

2. THE DEVELOPING COUNTRIES INSTITUTIONS INVENTORY IN THE MIDDLE EAST

There are some institutions in the developing countries (DC) in the Middle East region with acceptable facilities and well-qualified and experienced scientific staff in the field of Marine Sciences and Fisheries and related activities. Few of these institutions have specific strengths in special fields which reflect principal or primary local needs and demands. Some of these institutions have received support from foreign countries and international as well as regional and subregional organizations. As a rule, they have had experience at the international level and the facilities and equipment are generally up to date. On the other hand, as marine sciences are finding greater interest, many new institutions have been established recently, especially in some Arab countries in the Gulf area. These newly formed institutions are in the stage of strengthening their capabilities both in manpower and equipment. In general, they are depending on expatriate scientific staff from other countries, especially from Egypt.

2.1 Historical Review of Egypt's Role in Marine Sciences

2.1.1 The Egyptian participation in marine sciences and oceanographic activities goes back to the 1930s when the Marine Biological Station at Al-Ghardaqa, Red Sea, and the Alexandria Institute of Hydrobiology were established. In early 1930s, Egypt participated in the famous John Murray Expeditation to the Indian Ocean (1933-34), by contributing its research vessel Mabahiss to take an active part in the expedition with Egyptian oceanographers on board.

At present, the Institute of Oceanography and Fisheries (IOF), belonging to the Academy of Scientific Research and Technology (ASRT), with its headquarters in Cairo, is the main scientific body concerned with the various aspects of research in the field of oceanography and fisheries as well as coastal protection (Annex I).

2.1.2 The Department of Oceanography, Alexandria University, is the leading department in the Egyptian Universities responsible for education in the field of oceanography and marine science. Research activities are also carried out by its staff members.

Activities in the field of marine biology, aquaculture, and fish processing are carried out in some departments of:

Cairo University
Ain-Shams University
Suez Canal University
Mansura University

3. NEEDS FOR RESEARCH AND TECHNICAL DEVELOPMENT OF MARINE (RELEVANT FRESHWATER AREAS) OF EGYPT AND ADJACENT FISHERIES

To identify collaborative research programs, it is necessary to determine the DC needs for research. It is rather difficult and time-consuming to give, in this short paper, a broad spectrum of all the needs and demands for research and technical development of marine sciences and fisheries in Egypt and adjacent developing countries.

However, some selected needs in Egypt can be grouped under the following major categories.

3.1 Studies of Important Environmental Processes, such as:

3.1.1 Surveying the natural marine resources for both the Mediterranean Sea and the Red Sea coastal strips.

3.1.2 Research study to establish a protection plan for some vital coastal zones and its environment along the Mediterranean Sea, such as:

3.1.2.1 Abu-Qir bay
3.1.2.2 Rosetta Promontory
3.1.2.3 Baltim headland
3.1.2.4 Ras-El-Barr zone
3.1.2.5 The sandy barrier between northern lakes and the Mediterranean Sea

3.1.3 Research program to develop plans for protecting the Delta lakes exits to the Mediterranean Sea.

The above-mentioned programs, which are needed not only for immediate objectives, but also for long-range future goals, can be implemented if assistance from the United States is directed toward marine operations through securing:

- Seagoing research vessel capable of working during storms.
- Modern equipment for the research vessel, such as positioning systems using satellites.
- Computer equipment needed for the vessel.
- Sub-bottom profiling equipment.
- Deep-sea boring equipment.
- Side-scan sonar device for scanning sea-bottom features.
- Other supplementary navigational and marine research devices.

In any case, estuaries and nearshore studies should be given great concern and be incorporated where appropriate into all major programs.

3.2 Search for ways to detect, measure, and remove pollutants, to reverse human-caused environmental damage and to convert wastes into harmless or profitable products. Research in this field is of great importance.

3.3 Fisheries and aquaculture are considered highly important items for the development of Egypt. There is evidently a strong desire for Egypt to increase fish production. Any assistance or cooperation should aim for utilization rather than merely exploration of the aquatic environment.

3.3.1 Capture Fish

A plan is needed to start deep-sea fishing operations, especially in the Mediterranean Sea in areas more than 150 meters deep; some concern also needs to be given to deep-sea shrimps and bottom fish in the Red Sea. The Red Sea proper territorial waters are underexploited and any effort directed toward utilization of these areas is promising.

3.3.2 Aquaculture

Egypt is characterized by the presence of large areas of natural water ponds, and of freshwater, brackish, and marine-water bodies which are most suitable for fish culture. Moreover, the climate is more or less uniform all year round, except during the few winter months, which is most favorable for aquaculture practice and fish growth rates for the reared fishes.

3.3.2.1 Cultured Fish and Shrimp

The species being cultured in Egypt vary according to the locality, the ecological and chemical characteristics.

i) In fresh waters:

Mugil cephalus, *Mugil capito* and *Mugil saliens*, *Tilapia nilotica*, *Tilapia gallilea* and *Tilapia zillii*, *Clarias lazera*, *Lates niloticus*

ii) In brackish and marine waters:

Mugil cephalus, *Mugil capito*, *Mugil saliens*, *Chrysophrys aurata*, *Dicentrarchus labrax* and *Dicentrarchus punctatus*, *Tilpia zillii* and *penaeid* shrimp (mainly *Penaeus krathurus* and *Metapenaeus monoceros*)

The culture of molluscs, oysters, and seaweeds is not practiced in Egypt at present despite the availability of large areas suitable for such purpose.

3.3.2.2 Problems for future aquaculture development:

i) Mass production of quality seed of the culturable species. At present, the fry are collected from their natural habitat. The occurrence of fry is unpredictable and fluctuates widely from year to year and is considered a limiting factor for aquaculture expansion.

Experiments to produce fry under controlled conditions by induced spawning are urgently needed.

ii) Development of cheap methods for production of natural food organisms.

iii) Formulation and manufacture of efficient and economical supplementary feeds from available local ingredients.

iv) Lack of well-equipped research centers to conduct:

a - Technical training

b - Research on the basic biology of cultured species

c - Experiments, aimed at the improvement of existing culture practices and the development of new ones

4. COASTAL ZONE PLANNING

It is the responsibility of the planner to insure that the future environment of man develops by design rather than by accident. He must be aware of human needs and values, on the one hand, and resource potentials and environmental limitations, on the other. He must plan, not only for immediate objectives but also for long-range future goals. Therefore, there is a great need for the following:

4.1 An understanding of climatic variability and its effect on biological systems. This might require long series of climatological observations at the coast or in offshore waters.

4.2 Broad classification of coastal areas as a basis for crude assessment of ecological values and the potential damage from coastal development. Such classifications can include:

- Production of renewable resources
- Exposure of coastline to open sea
- Configuration of coastline
- Freshwater runoff characteristics
- Topography (steepness and breadth of intertidal area)
- Substrate (rock, cobble, gravel, sand, mud)
- Character and dynamics of sedimentary materials
- Vegetation
- Fauna

4.3 Research to study the impact on receiving waters from the discharge of treated or untreated sewage effluent. Needed research includes oceanographic and biological studies of receiving waters.

4.4 Preparation of specific development models to protect the natural and human environments. This will stimulate the creation of areas to protect resources and designate protected areas and national parks. Egypt's coral reefs in the Red Sea are unsurpassed and constitute one of the wonders of the natural world.

4.5 Development of a systematic approach for the different legislative measures for the coastal area to insure consistent implementation of decisions by all agencies concerned. In this regard coastal legislation can be grouped into five categories:

1. Adaptation to the coastal areas of town planning techniques
2. Measures for the protection of shorelines
3. Integrated natural resources management
4. Special plans for critical sections of coastal areas

5. Establishment of national guidelines

All of the above-mentioned research items are necessary and, from my point of view, are of great concern, being an integral part of any Development Master Plans for regional development in Egypt.

5. HARBOR AND PORT DEVELOPMENT

Groins and jetties to protect a harbor entrance may result in the destruction of adjacent beaches. In general, port and harbor construction or enlargement invariably involve disturbance and often restructuring of segments of the coastal environment. When such a disturbance occurs in particularly sensitive coastal areas, e.g., estuaries, there can be acute and long-term ecological impact on populations of species, communities, and ecosystems. Dredging and filling operations associated with construction of ship-loading facilities can disrupt certain critical food chains leading to important commercial species in an estuary.

The Development Plan of Egypt includes many harbor and port works which justify supplementary research aimed at selecting the most suitable sites for ideal ports and harbors.

6. OTHER USES OF THE OCEAN (SEA)

Among other uses of the oceans which might be of some interest in Egypt are the following:

1. "Man-in-the-sea" observational program for an underwater saturated-diving/living facility, especially in the Red Sea areas with clear water and faunal richness

2. Coral reef geology and reefs as harbor shelters

3. Harvesting corals, shells, and aquarium or exotic fish

4. Marine pharmacology (extraction of drugs) from some marine organisms. In this aspect the Red Sea Marine Station would probably be best used as a collecting site

5. Marine antifouling

6. An approach of modifying the environment to increase organic production

   The Gulf of Suez is an ideal area with enormous potential.

The Marine Biological Station at Al-Ghardaqa, Red Sea, is ideally located for investigation of several important problems in marine biology, physical and chemical oceanography, and fisheries. A quantitative survey of benthic organisms and demersal plankton is important as basic information for necessary subsequent studies.

7. APPLICABILITY OF REMOTE SENSING TECHNIQUES IN OCEANOGRAPHY AND MARINE RESOURCES IN EGYPT

The presence of the Remote Sensing Center in Egypt, with well-qualified and experienced scientific staff and acceptable facilities gives a great potential to be operational in marine sciences, oceanography, and fisheries research. Some examples of its use are shown in Annex 2.

8. COOPERATION AND ASSISTANCE THE UNITED STATES COULD BEST PROVIDE TO FUTHER DEVELOPMENT

The following should be considered of key importance for concrete and sound cooperation and assistance the United States could best provide to further development in developing countries:

- To identify clearly areas in which cooperation or assistance or both could be given.
- The project should fit into one of the defined program areas, with sound scientific quality and nonduplication of effort, and should aim for utilization rather than merely exploration of the aquatic environment.
- To ensure that programs are developed for the benefit of developing countries with a view of strengthening their research capabilities.

Therefore, the following recommendations could be given for the Future of International Cooperation in Marine Technology, Science, and Fisheries:

1. There is a need for a Joint Body for Scientific and Technology Cooperation, with a permanent operational office or committee or both for marine sciences.
2. Recommend a plan of cooperation and focus it on concrete action. This can be achieved by an exchange of formal views; however, because of the problem of time schedules, it is worth stressing the need for informal contact at the technical level so that the staffs of the American and

Egyptian scientific communities can each be fully informed of its partner's activities.

3. To concentrate on problems of continental shelf and estuarine areas, and an effective management plan must be developed by the scientists involved.

4. Coordinate and disseminate the results of research, and in the meantime design and establish systems for translating the results of the research and development projects into practical achievements, e.g., shore-protection constructions, aquaculture ponds, pollution control devices, and a cheap feed for fish culture.

5. To undertake a continuing review and evaluation of the programs and related activities in order to avoid duplication of effort and gaps in projects. Evaluation principles and processes to be employed must be an integral part of the overall project design.

6. Training opportunities for planners, scientists, and technicians should be available according to a well-established, flexible plan.

Annex 1

BRIEF ACCOUNT ON HISTORY AND ACTIVITIES

OF

THE INSTITUTE OF OCEANOGRAPHY & FISHERIES, EGYPT

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1. Historical Review

Egyptian participation in oceanographic activities goes back to the 1930s, when the Alexandria Institute of Hydrobiology and the Marine Biological Station of Al-Ghardaqa, Red Sea, were established. In the early 1930s, Egypt participated in the famous John Murray Expedition to the Indian Ocean (1933-34), by contributing its Research Vessel Mabahiss to take an active part in the expedition with Egyptian oceanographers on board.

At present, the Institute of Oceanography and Fisheries belonging to the Academy of Scientific Research and Technology, with its headquarters in Cairo, is the main scientific body concerned with the various aspects of research in the field of Oceanography and Fisheries.

2. Objectives

The main objectives of the Institute could be summarized as follows:

1. Carrying out and supervising basic scientific research dealing with the different aspects of oceanography, fisheries, and fishery biology.

2. Undertaking applied and economic research for conservation of fishery resources and their development.

3. Survey of the Egyptian fishery grounds and discovery of new fishing regions and the best fishing gear.

4. Carrying out environmental research with particular attention to the pollution, its level, effects, and transport in the marine waters, coastal and inland lakes.

5. Carrying out research for best ways of fish utilization.

6. Establishing fish farms under governmental or private auspices, and supervising their management.

7. Giving technical advice to the concerned authorities and governmental bodies for laws and regulations related to fishing managements.

8. Sharing in the preparation of the governmental plans for fishery development.

9. Supervising and cooperating in fish statistics works.

10. Undertaking hydrographic, geological, geomorphological, and beach surveys for investigating the ways and means of shore protection.

11. Organizing training programs for research and technical assistance.

3. Infrastructure

3.1 Branches

The Institute comprises the following four branches:

1. Mediterranean Sea Branch: headquarters at Alexandria, with three Research Stations on the coastal lakes Maryut, Burollos, and Manzalah. Establishment of new stations is under consideration.

2. Red Sea Branch: headquarters at Al Ghardaqa, with three Research Stations at Al-Ghardaqa, Suez, and Port-Tawfik.

3. Inland-Water Fisheries and Fish Culture Branch: headquarters in Cairo, with Research Stations at Nile Barrages near Cairo, Serow, Lake Quarun and Lake Nasser (Aswan). It is planned to establish a station at Souhag in upper Egypt for the Nile fisheries.

4. Shore-Protection Research Branch: headquarters at Alexandria, with two Research Stations at Abu Kir and Ras El-Bar.

3.2 Departments

For the fields of marine and freshwater environments, the following 13 departments (with different Units) serve the first three branches irrespective of the geographical location of the branch:

- Department of Physical and Geological Oceanography
- Department of Chemical Oceanography
- Department of Ichthyology

- Department of Fisheries Biology
- Department of Hydrobiology
- Department of Marine Invertebrates
- Department of Fish Culture
- Department of Statistics and Population Dynamics
- Department of Limnology
- Department of Artificial Breeding and Acclimatization
- Department of Biochemistry
- National Oceanographic Data Center*
- National Marine Biological Reference Collection Center**

For the shore protection research, the following six departments serve the work in the Shore-Protection Branch in coordination with the similar departments of the Mediterranean Sea Branch:

- Department of Geology
- Department of Physical Oceanography
- Department of Hydrodynamics
- Department of Shore Constructions
- Department of Data Processing
- Department of Model Testing

4. Research Trends

(a) The Mediterranean Sea Branch is carrying out research programs, directed toward the detailed survey of the Egyptian waters in the Mediterranean Sea and the neighboring coastal lakes: Maryut, Edku, Burollos, and Manzalah. The research activities include physical and chemical oceanography, marine geology, hydrobiology (primary productivity, plankton, and benthic studies), fishing gear and technology, as well as the fisheries biology of the species of economic importance. Special attention has been given to the various pollution problems in coastal waters and coastal lakes.

The Mediterranean Branch of the Institute cooperates closely with the other branches of the Institute, particularly with the Inland Waters and Fisheries Branch, with the University of Alexandria (Department of Oceanography, Department of Sanitary Engineering, High Institute of Public Health).

The research vessel Faras El Bahr, operated by this branch is being used for the survey cruises. It is a converted trawler, 21 meters long, with a 160-horsepower diesel engine and equipped with a small laboratory, trawlwinch, an echosounder, and radiotelephone communications.

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*Planned to play a regional role in the future.

**Planned to be ranked at the level of the branches in the future.

(b) The Inland Fisheries and Fish Culture Branch is carrying out research activities aiming to raise the commercial fish population in artificial ponds, natural, and man-made lakes and in inland running water. In this respect, a successful program has been carried out in Lake Quarun and in an artificial pond of large area in the Delta for improving the methods of handling, transport, and acclimatization of fish fry such as Mugil sp. and Sparus auratus. The introduction of new species such as the grass carp, Ctenopharyngodon idellus, is also considered.

Studies on the artificial and natural breeding of some inland fishes are undertaken.

Experiments have been designed to obtain a high yield of fishes per hectare through artificial feeding, mixed species, and different stocking rates.

(c) The Red Sea Branch is concerned with research in the Egyptian waters of the Red Sea and the Gulf of Suez. In addition to main fields of general interest, attention is paid to the ecology of the rich coral reef communities of the Red Sea and to the exchange of fauna between the Red Sea and Mediterranean through the Suez Canal. Taxonomy, ecology, and development of invertebrates, particularly crustaceans, molluscs, echinoderms, and polychaetes are also some of the concerns for future benefit of the country as well as for all the countries of the region. The Marine Biological Station of Al Ghardaqa has received and still welcomes many foreign visiting scientists and specialists, who are interested in tropical and subtropical regions. The station has also hosted Regional Training Courses on the Red Sea and the Gulf of Aden, and receives annually a good number of university students for training.

(d) The Shore-Protection Research Branch is mainly concerned with the ways and means of protecting the Mediterranean shores, as the flood silt which was usually carried annually by the Nile River to the Mediterranean is no longer discharged after the erection of the High Dam at Aswan. Hence, attention is given to investigate the problem of shore erosion, and to provide the scientific basis for solving this problem.

The branch operates two research vessels, each about 20 meters in length and provided with the necessary onboard equipment for field surveys. In addition, a smaller boat about 12 meters long is also available for the nearshore surveys.

5. Research staff

The Institute's research staff includes 6 professors, 12 assistant professors, 24 researchers, 42 assistant researchers, 30 research assistants, and 120 specialists. The first three categories are of

Ph.D. grade, the assistant researchers are of M.Sc. grade, while the other two categories are those who are applying for M.Sc.

6. Publications

The Institute issues an annual journal entitled "Bulletin of the Institute of Oceanography and Fisheries." This bulletin is a substitute for the formerly issued "Publication of the Marine Biological Station, Al-Ghardaqa, Red Sea," the last independent issue of which was No. 14 of 1967, and for the "Notes and Memoirs" formerly issued by the Alexandria Institute of Hydrobiology, the last independent issue of which was No. 74 of 1967. The bulletin is exchanged with more than 500 foreign institutes, and has, therefore, a wide international distribution.

Annex 2

APPLICABILITY OF REMOTE SENSING TECHNIQUES IN OCEANOGRAPHY AND MARINE RESOURCES IN EGYPT

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1. Beach Erosion & Coastal Dynamics along the Mediterranean Shores

After the construction of the Aswan High Dam, the River Nile flow pattern, as well as the silt sediment load going downstream of the river to the Mediterranean Sea in the North has been changed significantly. During the past few years, and as a result of these river flow conditions, significant changes has been taking place along the coast of Egypt at the base of the Delta and farther east and west along the Mediterranean coast. Beach erosion, especially in some critical locations, has been of great concern to Egypt because of its effect on the urban and ecological environments at these locations.

The study of this problem is receiving priority assignment from the government of Egypt. Sequential satellite images of Landsat-1, 2, and 3 at various seasons and over a reasonably long period of time (data are available continuously since 1972) can reveal some significant data, which would be supplemented by some groundwork.

2. Investigation and Development of Red Sea Fisheries

Presently, fishing activity from the Red Sea is poorly exploited in most part, where fisheries are concentrated in the Gulf of Suez with some limited activity at Al-Ghardaqa. In order to investigate the remote parts of the Red Sea for fisheries potential, remote sensing techniques could be applied at two levels:

1) Preparation of basic regional maps for the Red Sea, scale 1:250,000 from enhanced Landsat images. General bathymetric maps especially for pelagic and deep-water areas can be provided by digital processing of Landsat-MSS data and categorization of band 4 to obtain color coded images in different seasons.

2) Airborne sensing from low-altitude flights to cover some selected areas with high fisheries potential. This survey would include combined techniques of normal aerial photography and multispectral photography using a four-lens aerial camera, in addition to coastal right-time flight during each dark phase of the moon. There will be a need to

supply the Remote Sensing Center with a Low-Light Level Image Intensifier (LLLII).

3. Assessment of Surface Area, Siltation, and Plant and Fish Production of Aswan High Dam Reservoir (Lake Nasser)

Satellite remote sensing techniques offer unique opportunities for the study of Aswan High Dam Reservior. Digital processing of Landsat-MSS data in different dates could be used for:

1) Following up the changes in the configuration of the reservoir and its tributaries since the construction of High Dam.

2) Calculation of the reservoir surface area at different dates for the development of geomophological and water balance models.

3) Mapping the geographic distribution and intensity of siltation as responsible for turbidity at different degrees in various parts of the reservoir.

4) Mapping the geographic distribution and intensity of chlorophyll content representing the pattern of aquatic weeds and algae.

5) Regional bathymetric mapping of the whole reservoir.

4. Assessment of Water Quality in the River Nile and Aswan High Dam Reservoir

These water bodies have a particular hydrodynamic regime dependent on contributions of wind, water elevation gradient, tides, and solar radiation. This activity is important to the distribution of dissolved gases, liquids, and solids in the water body. Water circulation and heat capacity are normally manifested at the water surface by variations in radiant heat. Accordingly, thermal scanning is useful to record relative temperature differences.

5. Monitoring of Water Pollution in the Mediterranean Sea and Red Sea

Multispectral data both from Landsat and aircraft sensors can be used to map large oil slicks that occur offshore because of leaks from oil-drilling platforms, pipelines, or accidental ship discharges. Also they can be used in mapping industrial discharges such as waste-treatment plume outfall. This is mainly based on studying the temperature patterns in the mixing zones to differentiate between water masses that are moved about by nearshore currents.

General Applicability of the Various Remote Sensing Techniques

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A. <u>Multispectral Sensing</u>

1. Mapping of aquatic vegetation.
2. Determination of bathymetry.
3. Study of the thermal effluents and associated water mass movements.
4. Detection of industrial discharges.
5. Mapping of large oil slicks near shore.
6. Detection of siltation and chlorophyll concentrations.

B. <u>Photography (B & W and Color)</u>

1. Detection of polluted water.
2. Detection of oil slicks.
3. Mapping the configuration of water body.

C. <u>Thermal Scanning</u>

1. Detection of circulation patterns.
2. Studying the water quality.
3. Identification of oil slicks.

D. <u>Radar Techniques</u>

1. Measurement of sea-surface phenomena.
2. Study of the sea-surface water conditions.
3. Detection of oil films, turbidity, and near-surface effluents.
4. Determination of water quality aspects.

E. <u>Thermal Microwave Sensing</u>

1. Surveying marine environment.
2. Studying the distribution of surface water temperature and salinity.

F. <u>Low-Light Level Image Intensification</u>

1. Study of the concentration of luminescing organisms in the upper 100 meters of water bodies.
2. Detection of population densities of pelagic fishes.

NEEDS FOR RESEARCH AND TECHNICAL DEVELOPMENT IN MARINE FISHERIES AND OCEANOGRAPHY IN THAILAND

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January 1981

A. Background Information

Thailand has a land area of 514,000 sq. km while its sea covers an area of 320,000 sq. km. With such a relatively large ocean area, there is a promise of economic benefits that can be reaped from the sea, which contains a considerable amount of minerals, fossil fuels, and marine food supply.

The first oceanographic survey in the Gulf of Thailand was carried out by the British Royal Navy in 1856. Fifteen years later the Royal Navy and the Siamese Navy worked together using Thai vessels for topographic study in the gulf. In 1912, Commander F. Thomsen of the Royal Danish Navy led the Thai team to conduct a systematic survey of the Gulf of Thailand, and the hydrographic work has been undertaken by Thai officers since then. The Hydrographic Department was formed in the Thai Navy in 1914 and the Oceanographic Division was set up in 1933. Most of the work carried out by this department was concentrated on currents and tide tables along the coast of Thailand.

The development of marine research was accelerated during the first National Economic and Social Development Plan of Thailand (1961-66). Using its new vessels made in Germany, the Hydrographic Department started large-scale surveys in the gulf in 1956. The Faculty of Sciences, Chulalongkorn University, also opened new courses in marine biology, with assistance from the Fulbright Foundation. More important was the first extensive survey on the ecology of the Gulf of Thailand by the vessel Stranger of the Scripps Institution of Oceanography during 1959-61, under the joint sponsorship of the Thai, Vietnamese, and U.S. governments. Such developments have created interest and support for marine science programs in Thailand for the first time. The success in introducing the otter-board trawling to the fishing industry in 1961 also produced a significant expansion of Thai marine fisheries. The procurement of large research vessels by the Department of Fisheries led to expanded activities of the fishery exploration surveys in the Southeast Asian waters as well as related research in oceanography and marine biology in Thailand.

The 1960s were indeed a good decade for marine science development in Thailand. The oceanographic and fishery resource surveys in the Gulf of Thailand, Andaman Sea, and adjacent waters were carried out by the Department of Fisheries since 1961. The Hydrographic Department conducted surveys on various physical aspects, including surveys in the eastern Indian Ocean under the International Indian Ocean Expedition during 1963-64 and the VAMP survey (on variability, acoustics, magnetics propagation) with the U.S. Navy during 1967-70. The Department of Mineral Resources, Ministry of Industry, also started surveys for offshore petroleum in the Gulf of Thailand in 1968, in the Andaman Sea in 1974, and for offshore mineral resources in cooperation with ESCAP/CCPM (Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas).

Although a considerable amount of information has been collected from various surveys and expeditions during the past two decades, little has be applied to development. The main constraint is the lack of expertise in various fields of marine science and technology, resulting in delay in analyzing, interpreting, and integrating the outcomes for developmental purposes. It is therefore obvious that, above all, a vigorous program of education and training in marine science and technology deserves to be launched on a scale significantly larger than the present effort in order to augment the economic and social development of the country.

B. Needs

The needs for research and technical development in marine fisheries and oceanography in Thailand could be summarized as follows:

1. Marine fisheries

Marine fisheries in Thailand accounted for 93 percent of the total production by volume and 83 percent of the total value in 1978. The fisheries, buoyed by the success in otter-board trawling and the venture into new fishing grounds, rapidly developed and expanded in the late 1960s and early 1970s. After a temporary setback due to the oil crisis in 1974-75, the marine catch went up to 1.55 million tons in 1976 and hit a peak in 1977 with a total of 2 million tons. In 1978-79, however, the marine production declined to 1.7 million and 1.5 million tons respectively.

It is evident that the golden days of the Thai marine fisheries have passed. The development period is now ended and replaced by the management phase. Serious problems due to depleted resources in the Gulf of Thailand and the impact of the new law of the sea, particularly the extended jurisdication of the exclusive economic zones (EEZ) by the neighboring countries, are recognized in the fifth National Economic and Social Development Plan (1982-86). Emphases are placed upon the management of the fishery resources in Thai waters, the management of the fishing fleets in various areas including extraterritorial waters, the development of coastal aquaculture as well as small-scale fisheries, and the improvement of postharvest technology for better utilization and export.

In order to improve the management of marine resources, as well as the marine fishing industry, the following needs were identified:

a. Effective fisheries administration and management systems to improve management techniques and organizations, including fishery enforcement and joint-venture arrangements in other countries.

b. Data management systems to collect, compile, and analyze the extensive fishery statistics and resource survey data for effective use in forming management policies. Advanced technology such as automatic data processing is required. Strenghening of information services, e.g., libraries, exchanges of publications, and procurement of foreign technical journals, is also essential to support research and development in various aspects.

c. The following resource assessment technologies to assess fisheries resources and effects of fishing on stocks:

   i) simple methods to monitor the status of stocks under the impact of fishing in various areas,

   ii) methods to assess multispecies fisheries,

   iii) methods to assess the status of stocks shared by neighboring countries, including ways and means for effective management of these shared stocks,

   iv) methods to assess availability and potential of coastal resources for small-scale fisheries.

d. Ecosystem analysis involving research on environmental parameters with respect to the well-being of fishery resources and their interrelationships affecting production in particular areas. Such analysis is needed in order to formulate criteria for protection and maintenance of particular stocks.

e. Detailed research on intricate life history studies, including early life history, food and feeding, growth study for tropical fish, natural mortality, reproduction, and interspecific relationships among species in the specific communities in the sea. Basic studies on such subjects have been carried out on some economically important species in the Gulf of Thailand, but the results thus obtained are still inadequate for multispecies management.

f. Improvement of fishing technology at the village level, including vessel and fishing gear development to reduce costs and thus increase earning, improved methods of handling and processing, development of alternative sources of energy for communities of small-scale fisherman and others.

2. Oceanography

a. Development of a national oceanographic data center to compile data obtained from various surveys and expeditions.

b. Strengthening of the present oceanographic surveys conducted by various institutes. This could be accomplished by means of synoptic surveys to increase efficiency in data collection and also reduce costs of operations.

c. Improvement of methods and equipment for oceanographic surveys to obtain essential information (e.g., on current and water masses) that is inadequate at the present.

d. Development of modern technology in assessing the marine environment, e.g., by greater use of remote sensing or satellite imagery. Training of personnel in such techniques is most essential and is urgently needed.

e. Development of international cooperation in oceanographic study in certain regions, e.g., the South China Sea, which became the exclusive economic zones of bordering countries under the new regime of the sea.

3. Coastal zone management

a. Development of coastal zoning to avoid conflicts in land use along the coast. Extensive surveys are required, both on land and in the sea, to classify coastal areas into preservation, conservation, or industrial zones.

b. Development of coastal engineering expertise through education and training.

c. Port development to facilitate the increased needs for commerce, fishing, recreation, and offshore mining.

d. Development of effective coastal aquaculture methods, e.g., molluskan (shellfish) culture, pen culture for marine fish, fish apartments, and shrimp farming.

e. Prevention, control, and mitigation of coastal pollution created by man's activities, e.g., industrialization, port development, mining, and shipping in the coastal areas.

4. Seabed exploitation

a. Development of technology and equipment for surveys of offshore petroleum and mineral deposits.

b. Development of methods and technology to prevent environmental deterioration from offshore mining, e.g., for tin and natural gas.

C. Recommendations for Cooperation and Assistance from the United States

The exploitation of renewable and nonrenewable marine resources to augment economic and social development requires a thorough understanding of the ocean regime. Although Thailand has made considerable progress in this field during the past two decades, lack of manpower, equipment, and modern technology has limited development in many ways. The multispecies nature of the fishery resources has created difficulties in managing fish stocks and has led to serious problems in marine fisheries. The industrial development along the coast also has created pollution problems greatly affecting coastal aquaculture in some areas.

The cooperation and assistance from the United States in the field of marine fisheries and oceanography in Thailand was minimal during the past two decades. It is acknowledged however that the work of the Scripps Institution of Oceanography on the NAGA Expedition (1959-61) was of great value to the marine scientists in Thailand. Nevertheless, the interest of the U.S. government in fisheries development of Thailand has been placed mainly on inland (freshwater) fisheries. Resource assessment and marine technology, in which the United States has greater knowledge and experience, have been totally neglected in past assistance programs.

In 1978, Resources Development Associates advised USAID and BIFAD (Board for International Food and Agricultural Development), in their study of Title XII research opportunities in fisheries and aquaculture, that

> Thai fisheries scientists are among the most competent and experienced in Southeast Asia and could contribute considerably to any Title XII collaborative research program in this area,

especially those involving problems of tropical fish culture and marine fisheries.

Within this context, it is therefore possible for cooperation to occur in the fields of marine fisheries and oceanography between the United States and Thailand under the CRDC (Collaborative Research in the Developing Countries) programs, provided by Title XII of the Foreign Assistance Act of 1975. Possible areas of cooperation and assistance include

a. Education and training in U.S. universities and institutions in fields related to marine fisheries research and oceanographic study, particularly automatic data processing, remote sensing,and stock assessment.

b. Grants for needed equipment, such as oceanographic equipment and data compilation systems.

c. Collaborative research on particular subjects, such as multispecies stock assessment, trophic dynamics, environmental study, mangrove ecology, and coral reef ecology. Attempts should also be made to increase the exchange of scientists between the institutions concerned.

d. Contributions (technical as well as financial) for selected projects of mutual interest in the field of marine fisheries and oceanography.

MARINE TECHNOLOGY, SCIENCE, AND FISHERIES DEVELOPMENT IN THE PHILIPPINES

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January 1981

Introduction

The Philippines is a tropical country made up of 7,100 islands and islets, an archipelago with more than 18,000 kilometers of coastline. Its continental shelves underlie only 18 percent of its territorial waters. About 55 percent of its population of 49 million inhabit the coastal zone and a great many of them are dependent on marine and coastal resources of the country. The archipelago is frequently visited by tropical cyclones (typhoons) during the southwest monsoon months, contributing to destruction of coastal areas and also to nutrient mixing of coastal waters.

Marine resources of the country come from demersal and pelagic fishes, shrimps and prawns, seaweeds, sea shells, oysters and mussels, corals, squids, fuel oil, minerals, turtles, echinoderms, and many other minor products. Mangroves come from brackish-water or estuarine areas, fishes and prawn are cultured in coastal ponds, mollusks come from mariculture, and fishes from estuarine rivers. Freshwater resources include fishes and invertebrates from lakes and reservoirs, fishes cultured in pens and cages in lakes, and tilapia from rice-paddy culture.

It is estimated that the subsistence fishery resources near shore and the coastal demersal fisheries of the country are in, or near, a state of overexploitation. Significantly increasing fish production from subsistence fisheries is not expected. There is still room for increased production of mackerels, tuna, skipjacks, and bonitos from the pelagic fisheries.

Environmental concerns in the development of marine and other aquatic resources of the country are centered on the following problems:

1. Industrial pollution, which causes degradation of the freshwater and marine environments in urban and some rural areas targeted for industrial development.

2. Overexploitation of coastal fishery resources, their stock assessment, management, and conservation. Government is also concerned with the possible unemployment of fishermen dependent on coastal resources and how those workers can be shifted to other jobs in areas such as mariculture.

3. Deforestation of watersheds, which causes rapid siltation of lakes, reservoirs, and even coastal areas. Flooding of lowland areas is also taking place more frequently.

4. Socioeconomic problems of people in marginal coastal areas, now considered the poorest of the poor.

5. Increasing clamor for more intensive and extensive exportation of marine products to pay for imported fuel oil. (Philippine oil production is only 10 percent of the present demand.)

6. Overexploitation of mangrove and coral resources: export of corals and conversion of mangrove areas into brackish-water fishponds.

7. Little understanding of interrelationships between land and water resource systems--between marine and estuarine resources, between estuarine and freshwater resources, and among marine resources. This inhibits effective management and conservation of coastal and other aquatic resources.

8. Oil pollution and its prevention, control, and monitoring from tanker spills and from industrial activities, ports and harbors, and oil refineries.

9. Nuclear pollution from nuclear power plant wastes, now that the country is developing its first nuclear power plant.

Projects and Programs of the Philippines

In the present decade, the Philippines envisions implementation of projects and programs dealing with the exploitation, management, and conservation of marine and aquatic resources and the prevention of environmental degradation in the coastal zone. These new or ongoing activities include the following:

1. Stock assessment, management, and conservation of demersal and pelagic fishery resources in order to prevent their further overexploitation and depletion and to optimize their sustained yields.

2. Development of coastal aquaculture (brackish-water pond culture and mariculture) and freshwater aquaculture (rice-paddy fish culture, pond culture, pens and cages in lakes). For freshwater and brackish-water culture in ponds, the aim is to increase production per

unit area through more intensive systems of culture; for mariculture and rice-paddy fish culture, the aim is to expand operations.

3. Improvement of fish handling aboard fishing vessels, improvement of fish processing and preservation, and attention to the marketing system and channels to reduce marketing costs and the high fish spoilage rate in the country.

4. Coral conservation and management to prevent further depletion of coral resources caused by high export demands. Coral resources have also been destroyed by the use of destructive fishing methods, such as blast fishing, and by siltation of marine waters.

5. Conservation and preservation of forests and mangrove swamps, which have already been exploited for firewood, construction materials, tanning materials, and rayon making, and have been converted into brackish-water fishponds and human settlements. Only 140,000 hectares of mangrove areas remain in the country, according to interpretation of land satellite imagery.

6. Conservation of sea shells, now also being heavily exploited for export.

7. Socioeconomic assistance to coastal inhabitants dependent on marine resources.

8. Watershed protection and rehabilitation to protect aquatic environments (lakes, reservoirs, and coastal seas) and to prevent flooding of lowland areas.

9. Assessment of the environmental impact of industrial projects to reduce degradation of the environment, including the coastal zone.

10. The Philippine coastal zone management program being implemented by several agencies of the government and being coordinated by the National Environmental Protection Council.

11. Limnological studies of Philippine lakes and reservoirs totaling 230,000 hectares. Only Laguna de Bay is studied well because of its economic importance and nearness to Metro Manila and the need to draw water from it for domestic consumption by Manilans.

12. Development of tourism and recreation in coastal and lake areas, now major dollar earners for the country.

13. Studies of heavy metals, organics, and nutrient and sediment loads in the aquatic environments.

14. Control and monitoring of oil pollution from tankers, ports and harbors, oil drilling, oil refineries, and other industries.

15. Studies for proper control of the dumping of mine tailings in aquatic environments and the exploitation of beach minerals.

Problems of Implementing Projects and Programs

The country will encounter certain problems and difficulties in the implementation of projects and programs involving fisheries, technology, and science of the marine and freshwater environments. These problems are as follows:

1. The difficulty of coordinating and supervising multi-agency implementation of projects and programs. Many government agencies and universities are involved in aspects of science and technology, fisheries and coastal resources, environmental protection, socioeconomics of coastal inhabitants, processing and marketing of marine products, and other areas related to the marine and inland waters of the Philippines. There will be wasteful duplications and overlaps of activities among agencies that have limited manpower, facilities, and funding.

2. Deficiencies of manpower or expertise in the fields of oceanography and limnology, marine engineering, fishing science, fishing boat construction, fish processing and preservation, fish stock assessment, fishery and resource economics, marine geology, oil pollution, sociology and anthropology in marine studies, and many others.

3. Insufficient funding for marine projects and programs, limiting the scale of implementation and operation of many projects. The holistic ecosystem approach in studies is not feasible because of insufficient funds and manpower. Even for bilateral projects with more developed countries, there is difficulty in securing counterpart funds from the Philippine government.

4. Projects and studies that are carried out in many pilot areas rather than following an ecosystem approach lack an appreciation for resource systems and the ecosystems in which they are located.

5. Because of the vast expanse of Philippine marine waters to be covered, marine research requires extensive funding to bear the expense of research vessels, equipment, and their maintenance. Priorities among research topics, resources, programs, and projects will have to be established.

6. There is a need to generate appropriate technology for socioeconomic assistance to coastal inhabitants rather than technology that requires heavy inputs of capital and which only the rich can afford. Technology transfer programs will have to be improved so that adoption of new technologies will spread to the grass-roots level. Too often, new technology requires big investments, and even with

government credit programs, only the rich and educated are willing to take that risk.

7. Technical personnel trained in developed countries often leave the Philippines because of low salary scales in universities and government research agencies. Therefore, trained manpower in the Philippines is eventually lost to more advanced and developed countries and to international agencies.

Implementing Mechanisms for Bilateral Projects and Programs

The rules and policies governing bilateral projects and programs between two governments (the Philippine government and the U.S. government through the U.S. Agency for International Development), based on personal experience, are as follows:

1. Assistance by the U.S. government is given either as a soft loan or as a direct grant to the recipient government.

2. The assistance program usually entails the following components, particularly in direct grants:

   a. technical assistance (American experts) to the program,

   b. funds to procure necessary equipment, either brand-new or excess military equipment (used and need repairs), and

   c. scholarships and fellowships for nationals of the recipient government for training or formal education in the United States.

3. Equipment purchases and training and education will have to be done in the United States.

4. Approval of bilateral programs in the Philippines is vested in one government agency (National Economic and Development Authority). Consideration is given to projects and programs of priority in the country.

5. Counterpart funding is required of the recipient country, which must also identify the agency and personnel who will work with the program.

The problems of bilateral agreements covering programs are the following:

1. The cost of American experts consumes a big chunk of the assistance appropriation of the U.S. government, not considering the cost of their housing accommodations, which is shouldered by the recipient government.

2. In equipment procurement, only American-made goods and excess military equipment can be purchased. Specifications of new vehicles and equipment sometimes are not satisfied because of bidding procedures in the U.S. government. Excess military equipment requires expensive repairs and maintenance.

3. Bilateral projects and programs suffer from red tape and the bureaucracies of both the recipient and donor governments.

4. At the end of the bilateral program, it suffers discontinuity due to funding difficulties, the exodus of trained personnel to other agencies or countries, and poor equipment maintenance and repair.

It is recommended that future mechanisms for bilateral programs in marine science, technology, and fisheries consider solutions to the above-cited problems. Priority projects in developing countries should also consider the following points:

1. Benefits from the program should spread to the poor.

2. Technology generation should be appropriate and applicable to the recipient country and not borrowed technology from more advanced and temperate countries unless it is modified to suit the recipient country.

3. Assistance to universities and training institutions in developing countries is the best way of establishing a nucleus of manpower.

4. American experts to be assigned to developing countries should be properly screened, taking into account experience in the field and adaptability to conditions in developing countries.

5. Equipment for programs should meet required specifications and should not be a burden to the program in the long run because of the expense of repairs and maintenance.

6. Because of the difficulties of obtaining counterpart funding from developing countries, especially during these times of economic crises, the U.S. government should examine possibility of helping with the maintenance and operating expenses of bilateral programs and projects and ensuring that the recipient country can continue the program even after U.S. assistance ends.

7. Programs and projects will have to be proposed by the recipient country without influence from the U.S. government. It is to be hoped that this will assure continuity of programs and projects by the recipient country.

NEEDS FOR RESEARCH AND TECHNICAL DEVELOPMENT IN THE MARINE AND RELEVANT FRESHWATER AREAS OF THE PHILIPPINES

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January 1981

INTRODUCTION

In 1947, soon after World War II, the Philippine Fishery Program of the U.S. Fish and Wildlife Service was set in operation and it continued until 1951 as part of the rehabilitation of the Philippines by the U.S. government. It was responsible for rehabilitating the fishing industry and providing the needed manpower to assist in marine scientific and fisheries research and the rapid development of marine fisheries for decades. Through this program, some 120 trainees were sent to the United States and given on-the-job training in the fishing industry; five trainees received formal graduate courses leading to a master's degree.

The Philippine Fishery Program introduced the otter trawl (30 to 80 gross tons) in 1947, and by the following year, most of the Japanese beam trawlers had been converted into otter trawlers. Trawling experiments undertaken in shallow waters in 1949 proved that the most productive areas in the limited trawling grounds of the country have depths between 6 and 20 fathoms. The Philippines leads Southeast Asian countries in this fishery by a full decade.

Twenty years later, larger trawlers were used in deeper waters and larger fish became available. However, most of these deeper areas are now fully exploited.

In the 1950s, small baby trawls (dugouts) powered by 2- to 6-horsepower gasoline engines were used with fine-meshed nets to catch tiny shrimps (Acetes), and larger shrimps were fished in shallow waters. These boats (baby trawlers), operating in waters one to five fathoms deep, soon became numerous and very popular in enclosed bays, such as Manila Bay and San Miguel Bay on Luzon Island, and this eventually led to overfishing of these bays.

Ten years ago, with the depletion of the shallower waters, medium trawlers using dugouts propelled by jeep engines were developed and used in waters up to 25 fathoms deep in productive bays. The use of these vessels became so successful that the Manila Bay trawl fishery is now based on these larger trawlers. Because the catches are mostly shrimps, the gear can pay for itself. The fish catches are composed primarily of some 90 pelagic and demersal fish species, mostly immature, but with a sufficient percentage of shrimps to pay for the operation. The trend thus illustrates that the traditional fishing grounds are fast being depleted as artisanal or sustenance fishermen increase in number.

The largest sector of the Philippine fishing industry is the marine fisheries. Marine fisheries studies undertaken concurrently include biological studies of important species with emphasis on resource assessment; exploration of new fishing grounds, and limited fishery oceanographic investigations.

A sector that includes the fisheries in estuarine and freshwater areas is the inland fisheries. Research related to inland fisheries includes studies of pond and lake fisheries management techniques, fish culture and propagation, limnological investigations, and water pollution studies. Generally, both sectors of the fishing industry are already developed, especially with the recent foreign aid in terms of expertise and laboratory facilties and other forms of technical assistance in aquaculture. Most marine fisheries still need to be regulated, particularly with regard to management, to obtain optimum sustainable yield in coastal zones. Fishery oceanographic research, resource assessment, and marine biological research, especially in the Philippine territorial seas and the exclusive economic zone, are badly needed.

THE NEEDS

Because of the lack of expertise in many aspects of marine research, there is a gap between the fishing industry and fisheries researchers in terms of biological, ecological, technological, and economic information. Some sectors of the industry need assistance for development and expansion. With the fast development of a fishery, the needed basic research sometimes lags. This occurs because of two major constraints: lack of expertise and lack of better facilities for the conduct of fisheries research.

Education, Manpower, and Training Needs

Although there is a sufficient number of fisheries high schools and junior colleges situated all over the country, there are not enough qualified faculty members who can train students to become independent and capable fishermen or research assistants when they graduate. Thus, there is a need for high-caliber leadership in academic research as well as in administration of fisheries insitutitions.

At the moment, the need for trained manpower is less acute in the field of aquaculture than in fisheries. Through the assistance of the U.S. Agency for International Development, the United Nations Development Program, the Food and Agriculture Organization, and the International Bank for Reconstruction and Development, the Philippines has acquired expertise in the various aspects of aquaculture. Several researchers have been sent to the United States to pursue advanced degrees in aquaculture. They are now actively engaged in research in several aquaculture centers.

In marine fisheries, however, there is a definite need for upgrading the technical personnel of the government fisheries agency in most disciplines. Although local fellowships recently have been available for advanced degrees in some aspects of biological sciences, including marine biology, there is still a need for expertise that only the United States can provide through universities that have traditions of basic research in fisheries and marine biology. Although the Philippines leads Southeast Asian countries in development in some aspects of fisheries, such as pond culture, lake cage culture, eucheuma farming, modern purse seine and trawl fishing, still it is beset by a lack of technically trained manpower to undertake sophisticated, integrated basic research in the marine sciences, fisheries biology, and marine fisheries.

As of 1978, the Philippines exports some 239,000 tons of tunas and tuna-like fishes, which are caught mostly close to the shore. There is little information on the tuna resources in the Philippine exclusive economic zone, which may be good fishing grounds and should be investigated so that it may be managed at a sustainable level.

There are needs for assessment or evaluation of the most important fisheries, such as tunas, the small pelagic species, and the demersal species both in traditional and nontraditional fishing grounds, including those in the Philippine exclusive economic zone. The country needs expertise in stock assessment and fisheries management.

Mariculture is developing in the country and is thus another area that requires basic research. It has been proved in the Philippines that research can lead to the development of a fishery in a few years; one such example is the culture of eucheuma, a red alga. The algae became a multimillion-peso fishery after seven years. There is a need for invertebrate and fish biologists with training or specialization in hatchery techniques to undertake artificial breeding of important mollusk species.

Shellfish culture is becoming as popular as fish culture, yet no effort has been exerted to purify fresh shellfish before they are sold in markets as is done in other developed countries. Shellfish purification is necessary for public safety. Expertise and research along this line are needed badly.

Equally important is information on fish diseases and parasites, which are another problem associated with aquaculture, particularly in intensive farming. A fish-disease and parasitology laboratory is needed in the country.

Numerous marine animals are known to provide pharmacological products of great value especially for treatment of cancer. Research on pharmaceutical and toxic products from marine organisms therefore is necessary.

Biological and management studies of mangrove and coral reef communities are to be given priority to save those communities from total destruction.

There is also a need to study the effects of coastal urbanization (e.g., infrastructure development and water pollution) on the marine environment and living aquatic resources.

During the last seven years, there has been a rapid development of beaches for recreational use, especially near urban areas. Coral reefs abound in these areas. Recently, a number of marine areas have also been designated as marine parks, which, under the management of the Ministry of Tourism, attract tourists and are open to scuba divers. There are now prohibitions on the gathering of corals and marine turtles.

The country is now trying to program the protection and enhancement of the coastal zone. A limited research and data collection is now being undertaken to set up needed regulations to allocate appropriate areas for public beaches, tourism, marine parks, human settlement, etc.

Several government agencies are concerned with coastal zone planning, management, and protection of beaches and estuaries. Again, there is a need for more expertise in urban planning.

Although there are sufficient engineering colleges in the country, advanced-degree programs related to the preservation of the marine environment and coastal zone management are not readily available.

The Philippines has now embarked on an ambitious port and harbor development program, with foreign financial loans. Some nine fishing and commercial ports are to be constructed in strategic areas to serve the country's need for more fishing ports, especially for larger vessels.

With this development, studies of the marine environment in the port areas are needed to determine the environmental effects of such infrastructure development. Hydrographic data have been collected in a few port sites. We need expertise to determine what has to be done in these area with harvestable fish resources landed there.

Facilities

Several aquaculture centers and laboratories have already been established, mostly for training purposes, but we still need to establish a central, government research laboratory for marine sciences. The Bureau of Fisheries and Aquatic Resources (BFAR) has no laboratory at present, because the Dagat-dagatan Central Laboratory at Malabon was reclaimed after the area became polluted. BFAR plans to set up a marine fisheries research center where research on fisheries biology and mariculture will be conducted. Assistance in the form of oceanographic and biological laboratory facilities will be necessary to carry out fisheries and oceanographic research.

In some regions of the country, there are a few regional fishery laboratories. However, in addition to the lack of technically trained manpower, these laboratories are not equipped with the facilities necessary to carry out basic marine biology research. Thus, there is an urgent need for research facilties, the present lack of which, in a way, accounts for the slow growth of marine biology and marine fisheries research in the country as a whole.

Because the Philippine government cannot provide for foreign fellowships in marine sciences and fisheries, it has to rely on foreign assistance, espcially from the United States and from the United Nations and other international granting institutions for the badly needed advanced studies and training.

During the Philippine Fishery Program, (1946-51), formal training in marine sciences, fisheries biology, and fisheries technology led to the improvement of fisheries research and development in the decades following World War II. Those who were trained in that program are responsible for the training that fisheries leaders are now obtaining in the country.

It is believed that a program on marine fisheries with emphasis on estuarine and shallow-water areas would lead to the development of mariculture and would assist greatly in supplying the protein needs of Filipinos.

A program of manpower development is badly needed in the Philippines, especially by the BFAR, to assist its personnel in the field of fisheries research, management, administration, and extension service. This program may be undertaken for several years and implemented according to priority.

The number of fellowships to be made available may be staggered, and a few slots may be filled annually, depending on the priority given by the recipient office.

Selection must be made so that qualified junior and promising researchers get a chance to receive advanced degrees abroad.

Since the Philippines needs more leaders in fisheries research to make the growth and management of the fishing industry comparable to the growth in agriculture, we need to train more capable, young, and promising scientists of the BFAR and other government institutions engaged in marine sciences, fisheries, and aquatic research. Such training should be provided through a fellowship program to enable them to study in U.S. universities where advanced degrees in the marine sciences and in fisheries are offered. Although the majority of fellowships may be pursued up to the master's degree, a few fellowships leading to the doctorate degree are necessary.

Fields of study may include the following:

1. Marine Biology
2. Marine Fishery Biology
3. Fish Population Dynamics
4. Biological Oceanography
5. Marine Ecology
6. Coastal Zone Management
7. Marine Microbiology
8. Fish Diseases and Parasites
9. Marine Affairs
10. Ichthyology
11. Naval Engineering
12. Sanitary Engineering
13. Marine Meteorology
14. Marine Engineering
15. Marine Pharmacology
16. Chemical Oceanography
17. Physical Oceanography
18. Limnology

A number of training programs are necessary for the technicians of BFAR. These programs may be pursued for at least six months in the following fields of specialization:

1. Fish and Shellfish Hatchery Techniques
2. Shellfish Purification
3. Coastal Zone Planning and Management
4. Microbiology
5. Larval Fish Identification
6. Zooplankton Identification
7. Fish Feed Formulation and Preparation
8. Phytoplankton Identification
9. Water Pollution Control
10. Marine Refrigeration Engineering
11. Fish Biology and Taxonomy
12. Fisheries Extension
13. Design and Construction of Fishing Gear
14. Fish Detection Using Echo Sounding

The above lists are by no means complete and should be considered as indicative of present needs.

There are numerous universities in the United States that can assist developing countries in training in marine sciences and fisheries research. Among such universities are the University of Hawaii and institutions on the East Coast and in Florida.

There are now several mariculture projects of the BFAR that show prospects of further development, especially in the culture of mussels, oysters, windowpane shell, sea basses, eucheuma, pearl oyster, and other invertebrates.

The BFAR could use the services of experts for a limited period in invertebrate culture, freshwater and marine water primary productivity, invertebrate breeding and taxonomy, fish diseases and parasites, and mariculture, among other fields.

It is recommended that some arrangement of mutual assistance be made between laboratories in developing and researching countries. Such arrangements may include the donation of laboratory equipment and the services of scientists in return for certain privileges granted to researching institutions.

In exchange for granting a U.S. institution the privilege of undertaking research in archipelagic and territorial waters and collecting specimens for research, the Philippine government may consider, for example, accepting the services of fisheries experts to assist the government in specific research and development programs or the donation of some badly needed equipment.

ASSISTANCE TO RESEARCH AND DEVELOPMENT OF BRAZILIAN FISHERY RESOURCES

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Rio de Janeiro, Brazil
October 1980

I. THE STRUCTURE AND CHARACTERISTICS OF THE FISHING INDUSTRY*

a) Marine Fisheries

Brazil has an area of 8,511,965 sq km and a population (1978)** of 115,400,000. The length of the coastline is 7,408 km and the shelf area (to 200 miles) is about 820,000 sq km.

The Brazilian fishing industry comprises both artisanal and industrial fisheries which each account for about a half of the catch. The artisanal fleet consists of nearly 50,000 vessels of less than 20 gross tons, of which about one in eight is motorized. While by definition completely motorized, the industrial fleet, which is composed of nearly a thousand units over 20 GT is generally poorly equipped and widely diversified.

The trawl fleet operation in the southeast and southern regions catches mainly croakers and weakfish (Scianids) and shrimp (Penaeids). The trawl fleet in the northern region catches almost exclusively shrimp and catfish for export. Some of the shrimp trawlers are foreign leased boats.

The fleet of purse seiners is concentrated along the southeast and south coasts catching sardines, mackerel, bluefish, and mullet.

The lobster fleet operates in the northeastern region (Abrolhos) harvesting high-quality fishes (Serranids) and in the north and northeast regions, where it exploits mainly snappers (Lutjanids) for export.

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*Source: FAO Fishery Country Profile 1979, prepared by G.S. Neiva, SUDEPE.

**A new census is now being taken.

One whale catcher operates from July to December to supply the only whale shore plant in the country located in tne state of Paraiba. It catches mainly minke whales according to the quotas established by the International Whaling Commission (IWC).

Trawlers have been leased from Asia and fish in the southern region.

Tuna longliners and large purse seiners have also been leased, and four longliners are operating from the southern region.

Since 1979 a tuna live-bait fishery has been rapidly developing in the southeastern region. The vessels are locally converted line boats and others.

Joint ventures are being considered but none has so far been initiated.

The industrial fisheries are associated with some 400 companies spread along the whole coast. About half of these are situated in the southeast and southern regions. Fish is marketed iced (37 percent), frozen (16 percent), salted (24 percent), canned (13 percent), and in other ways (10 percent).

Under the impact of the fiscal incentive granted in 1967, the industrial fishery has shown a steady development. Such stimulus made possible the establishment of a modern fisheries industry particularly in the southern and southeastern regions, and, during the decade of 1967 to 1977, fish production practically doubled, (Table 1) with particular interest being shown in the production of easily exportable products--shrimp and lobster (Tables 2 and 3 and Chart 1).

b) Inland Fisheries and Aquaculture

The production from inland fisheries is of the order of 150,000 tons, of which approximately two-thirds is caught in the Amazon basin (mainly catfish). Most of the remainder of the inland-fisheries catch comes from elsewhere in the northeast, of which about 20,000 tons are caught in 104 reservoirs administered by the National Department of Drought Control (DNOCS), 10,000 tons from the man-made lake of Sobradinho (Sao Francisco basin), and the Mearim basin (Maranhao). Production in the southeast region is very modest mainly because of the environmental changes caused by the construction of dams and by industrial pollution.

Aquaculture has some significance in the northeast region, where many farmers practice the semi-intensive monosex culture of tilapia (*Sarotherodon niloticus*) and of male hybrids of *S. hornorum* x *S. niloticus* producing up to 6,000 kg/ha/year.

II. DEVELOPMENT PROSPECTS*

There are indications--based on exploratory investigations--of the existence of various underexploited or unexploited resources. It has been estimated that the marine and estuarine fishery production could be increased to within a range of 1.4 to 1.7 million tons annually considering only the resources available within 200 miles of shore.

Off northern Brazil the fishery is little developed, except for shrimp, and little is known about the potential of the stocks. The major resources appear to be weakfish, croaker, and other bottom species; and flying fish, catfish, tuna, kingfish, and sharks. In the mouth of the Amazon--which is rich in nutrients--the potential of pelagic fish is likely to be considerable and increased catches can be looked for. Off the northeast coast, the shelf gets narrower and productivity is low. The inshore stocks are considered to be already overfished and the offshore resources, except the tunas, are being increasingly exploited. However, in the state of Maranhao, there are resources such as fish, crabs, and mussels that are not being exploited. Off the southeast and south there are good stocks of pelagic species, notably sardine and tuna, and demersal species. Off the south there are abundant anchovy, squid, and demersal resources notably during the periods when the subtropical convergence moves toward the Brazilian coast (end of autumn, winter, and beginning of spring).

The production of inland fisheries can be increased in the Amazon and Prata basins.

The best prospects for fish production lie in the development of freshwater intensive aquaculture and mariculture in view of the large areas of low-cost land, abundance of water, and diversity of climate.

There are 2 million ha. of dammed water used for the generation of hydroelectric power and irrigation where extensive aquaculture is being developed.

III. RESEARCH

The Superintendency for the Development of Fisheries, SUDEPE, is the federal fishery institution of the Ministry of Agriculture responsible for the national fisheries research and development policies. In the field of research it coordinates programs and provides financial resources to federal and state institutions and universities for the execution of such programs. Through its own Fisheries Research and Development Program it maintains a national

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*Source: FAO Fishery Country Profile 1979, prepared by G.S. Neiva, SUDEPE.

system for the collection of statistics and biological data, undertakes an evaluation of the stocks of the main exploited species, operates research vessels for exploratory fishing and prospecting and undertakes economic, marketing, and aquaculture studies. SUDEPE is also responsible for fishery regulations and enforcement, a program of incentives to the fishing industry, and a Plan of Assistance to artisanal fishermen.

IV. BILATERAL AND MULTILATERAL AID

Brazil receives technical assistance from various countries, from the Food and Agriculture Organization of the United Nations and to a lesser extent from the Organization of American States (see Chart 2). A Fisheries Development Program--SUDEPE-IDB--has been approved by the government of Brazil and the Inter-American Development Bank (IDB).

Regarding the bilateral technical assistance two projects are of greater importance for the development of fisheries and aquaculture. Canada has recently approved a project for the study of herbivorous species of the Amazon Basin with a view to the culture, and Japan has agreed on a project for the survey of the fishery resources of the northern region of the country.

Among the various projects developed or being implemented by the United Nations Development Program (UNDP) and FAO, the establishment of a Regional Latin American Aquaculture Center in Sao Paulo is worth special consideration in view of its future impact on the development of aquaculture not only in Brazil but throughout Latin America.

A global program for the Development and Coordination of Aquaculture is being financed by UNDP and executed by FAO with the help of other multilateral agencies and bilateral aid.

Among other activities the program is establishing a system of six regional centers of aquaculture in Nigeria, Thailand, India, Philippines, China, and Brazil.

To accommodate the regional center in Brazil, the installations of an Experimental Station of Biology and Fishculture of SUDEPE located in Pirassununga, state of Sao Paulo, are being enlarged by that institution.

The installation of a trout station in Campos de Jordao and a mariculture station in Cananeia, both of the Fisheries Institute of Sao Paulo, also will be available to the center.

The center will collaborate with other national institutions and the five other centers mentioned above.

The objectives of the center are (1) practical training, (2) research, and (3) extension.

The contribution of UNDP during the three first years of operation of the center will be US$592,000, which will cover the costs of a senior research adviser, a senior training adviser, consultants, and equipment.

The IDB will allocate US$250,000 to cover the costs of fellowships to Latin American trainees. The yearly training capacity of the center will be about 25 trainees. The courses will have a duration of one year.

Multilateral and bilateral donors may contribute to the costs of completing the team of eight international experts specialized in the following fields: (1) reproduction, (2) nutrition and feeding, (3) genetics, (4) diseases, (5) management, (6) economics, (7) engineering, and (8) instruction, practical and theoretical.

The SUDEPE/IDB Fisheries Development Program consists of the following subprograms:

Subprogram A (Global Line of Credit)

(a) Financing the construction of at least 100 new shrimp boats to replace foreign leased boats.

(b) Financing the construction of 60 boats (purse seiners, trawlers, and hand line fishing) to renew the fishing fleet of the southeast-south region.

(c) Financing the construction of 10 medium-size tuna boats.

(d) Financing of equipment and machinery to modernize fishing and to preserve fish.

(e) Financing of 10 private fishculture stations to produce 1 million fingerlings of freshwater species each in 16,000 ha of ponds.

(f) Credits to artisanal fishermen cooperatives to finance the purchasing of boats, motors, nets, fish reception installations, transport boats, and cold-storage equipment.

Subprogram B (Fish Terminal)

Construction of a fish terminal in Porto Grande, in the state of Maranhao to support the artisanal fisheries.

Subprogram C

This subprogram aims at further supporting fisheries development in Brazil as follows:

(a) Increase research, identification of new fishing areas within and beyond the territorial sea, construction of two modern research vessels for SUDEPE, technical assistance for research, cooperatives of artisanal fishermen, and extension to fisheries and fishculture.

(b) Establishment of eight government stations of aquaculture for the production of fingerlings, to support the development of aquaculture. The stations should have a yearly production of 20 million fingerlings and will be located in the states of Parana, Pernambuco, Bahia, Minas Gerais, Sao Paulo, and Santa Catarina.

(c) Construction of an inland waters fishery research center in the Amazon region and support for the completion of the installations of the Regional Latin American Aquaculture Center.

(d) Contract for consultancy services to plan the research vessels, the aquaculture stations, and to advise on the operation of fishermen cooperatives and extension services.

(e) Gradual organization of the artisanal fisheries into fishing enterprises. Organization of artisanal fishermen cooperatives and regional marketing units with preference to the north and northeast regions.

The total value of the program will be 131.2 million dollars. The IDB contribution will be 66.4 million dollars (50.6%) and the Brazilian, 64.8 million dollars (49.4%).

COOPERATION AND AID FROM U.S.A.

Past cooperation

While the shrimp agreement between the United States and Brazil was in force, a cooperative research program was successfully developed between SUDEPE and the Southeast Fisheries Center of the U.S. National Marine Fisheries Service. The Oregon II conducted research in the shrimp areas, and a working group of scientists of both countries met regularly to compare and analyze shrimp data. This program was discontinued with the lapse of the agreement, and the fruitful relationship between the two institutions came to an end.

The Directorate of Fisheries and Fishculture of the National Department of Drought Control in the northeast benefited for various years from the assistance given by experts from Auburn University particularly on the culture of tilapia hybrids.

Present cooperation

At present, Brazil is participating in the planning of peneid shrimp mark-recapture experiments in northern South America to be started in 1981 by the UNDP/FAO Inter-Regional Project for the Development of Fisheries in the Western Central Atlantic.

In this connection two Brazilian scientists recently participated in the Galveston Laboratory of the National Marine Fisheries Service, in shrimp marking and recapture studies.

Future cooperation

Management of Fishery Resources.

The fishery resources of Brazil have been exploited with increasing intensity, with the result that, in some cases, their optimum levels of exploitation appear to have been reached or even surpassed. There is a need therefore to establish scientific criteria for their rational exploitation (Table 4).

The evaluation of the stocks of the majority of the species has been based on models of catch and effort which have been descriptive but not analytical. They do not take into consideration the variations in levels of abundance of the resources and do not allow the evaluation of the dynamic relationships, growth, mortality, recruitment, etc. According to the acquired experience, the techniques used so far do not always reflect the problems related to the state of the stocks and the sustained catches.

Greater emphasis should be given therefore to the evaluation of stocks based on analytical models which would take into account the dynamic relationships responsible for the equilibrium and abundance of the populations particularly of shrimps, snappers, lobsters, sardines, and catfishes (piramutaba).

Brazilian fishery scientists should be trained therefore in the application, adaptation, and development of analytical models of the dynamics of the exploited fish populations.

The assistance of experts to analyze programs for the collection, processing, and interpretation of data is also essential.

The activities of the experts would be the following:

- Diagnosis of the programs of collection of biostatistical data of the stocks selected for analysis.
- Critical review of the evaluation of stocks and fishing effort/stock being carried out by national groups of selected species.
- Evaluation and critical analysis of the effects of regulatory measures of the fisheries of selected stocks.
- Advice on the interpretation of data.
- Training of national scientists on each species being studied.

Assistance required:

- One consultant on fishery statistics for 6 months: Should have ample experience on fishery statistics, particularly on statistical methods for the evaluation of stocks. Will advise on planning and implementation of statistical surveys and evaluation and interpretation of their results.
- Two consultants on fishery biology for 6 months: Should have broad experience on the application of analytical models for the evaluation of stocks.
- Fellowships--duration of 6 months each.
- Training in adaptation, application, and development of models of the dynamic of exploited populations : 5 scientists
- Management of marine fisheries : 1 scientist
- Management of inland fisheries : 1 scientist
- Management of lake fisheries : 1 scientist
- Fish statistics : 1 scientist
- Collection and processing of data : 1 scientist

SURVEY OF PELAGIC RESOURCES

Along the coast of Brazil there are various pelagic fishery resources but their magnitude, geographical distribution, and behavior are not well known. Some stocks are sub-exploited, others are not effectively exploited, and some may be overexploited.

There is a need for

(1) Evaluation of the biomass of the pelagic resources of the northern region.

(2) Critical analsis of the project for evaluation of the pelagic stocks completed or under way in the southeast-south region.

(3) Training of personnel in hydroacoustic research.

Assistance required:

Technical assistance could be in the form of consultants and training. Training could be provided by the consultants in Brazil and be completed in the United States.

Two consultants to advise on operation, utilization, calibration, and maintenance of hydroacoustic equipment - 6 months.

Two consultants to advise on the elaboration of quantitative acoustics surveys, interpretation, and analysis of data - 6 months.

Fellowships - duration 6 months each.

Operation, utilization, calibration, and maintenance of hydroacoustic equipment - 3 technicians.

Elaboration of quantitative acoustic surveys, interpretation, and analysis of data - 3 scientists.

Aquaculture.

The Regional Latin American Aquaculture Center described above will be the only Latin American center to conduct research on native species as well as introduced species in the region, such as trout, tilapia, carp, and others. It will coordinate its work with national centers in Brazil and other Latin American countries. Its activities should be of interest not only to the countries of the region but also to those outside it.

The United States may find it of interest to give technical assistance to the center in the fields mentioned above open to bilateral donors but also to have its scientists participating in the research and training programs.

TABLE 1 EVOLUTION OF CATCHES

YEARS	TONS	ANNUAL VARIATION (%)
1939	103.278	-
1940	110.559	7,1
1941	116.284	5,1
1942	119.844	3,0
1943	123.079	2,8
1944	114.823	-6,7
1945	122.204	6,3
1946	122.410	0,1
1947	139.732	14,2
1948	144.767	3,6
1949	152.606	5,5
1950	153.107	0,3
1951	158.297	3,4
1952	174.630	10,3
1953	160.677	-8,0
1954	172.033	7,1
1955	189.292	10,4
1956	208.092	9,6
1957	216.289	3,9
1958	214.899	-0,6
1959	253.100	17,8
1960	281.512	11,2
1961	330.140	17,7
1962	413.000	25,1
1963	421.000	1,9
1964	333.000	-20,9
1965	377.000	13,2
1966	436.000	15,6
1967	429.422	-1,5
1968	500.387	16,5
1969	501.197	0,2
1970	526.292	5,0
1971	591.543	12,4
1972	604.673	1,3
1973	698.802	15,6
1974	765.499	4,6
1975	759.792	3,8
1976	658.847	-13,3
1977	752.687	14,2
1978	806,328	7,1
1979 *	864.000	7,2

SOURCE: Superintendency for the Development of Fisheries (SUDEPE)/Instituto Brasileiro de Geografia e Estatistica (IBGE)

* ESTIMATE

TABLE 2 - BRAZILIAN EXPORTS OF FISH (TONS)

CATEGORIES \ YEARS	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
FROZEN FISH*	2.741	3.631	4.213	4.143	7.792	6.959	7.315	9.734	9.158	17.994	17.921	15.420
SHRIMP	1.656	3.206	3.061	4.435	6.783	2.687	2.437	1.787	1.785	3.110	4.925	7.169
LOBSTER	1.683	2.474	2.794	2.514	2.630	2.555	3.069	2.499	2.353	2.796	3.181	3.745
SARDINE	-	8	22	509	1.018	1.217	545	927	722	843	3.072	1.756
SEAWEED	-	-	-	110	215	1.810	2.239	466	474	223	214	287
OTHERS	167	253	313	434	407	3.519	1.512	1.191	805	1.657	3.818	1.916
T O T A L	6.247	9.572	10.403	12.145	18.845	18.747	17.117	16.604	15.297	26.623	33.131	30.293

SOURCE: Superintendency for the Development of Fisheries (SUDEPE)/PDP/
Carteiro do Comercio Exterior (CACEX)

* In this category is included the fresh iced fish.

TABLE 3 - BRAZILIAN IMPORTS OF FISH (TONS)

SPECIES	YEARS												
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
COD FISH	36.404	40.240	45.071	47.222	32.243	31.444	38.091	24.252	24.818	18.962	14.173	16.300	18.079
FISH ICED OR FROZEN	1.077	3.012	4.498	5.826	6.635	2.494	15.724	21.312	74.113	57.200	47.071	45.113	68.780
BONITO (CANNED)	219	357	228	190	610	344	1.067	936	820	612	2.149	3.056	3.303
FISH MEAL	6.827	7.784	8.983	7.060	10.157	2.496	-	842	8.219	250	0,1	91	216
OTHERS	1.165	2.798	3.001	2.267	2.963	3.272	2.781	2.582	2.012	2.384	1.961,9	2.103	5.467
TOTAL	45.612	54.191	61.781	62.565	52.338	40.050	57.663	49.924	109.982	79.408	64.855	66.663	95.845

SOURCE: Superintendency for the Development of Fisheries (SUDEPE)/PDP/
Carteiro do Comercio Exterior (CACEX)

TABLE 4

PRESENT STATUS OF THE EXPLOITATION OF THE MAIN SPECIES AND AVAILABLE DATA ON THEIR POTENTIAL YIELD

1 - NORTH REGION
Amazonian catfish

1.1 - (*Brachyplatystoma vailantii*)

CATCHES: average 1975/79:22.691 t
1979: 20.379 t

POTENTIAL YIELD: 24.500 t for an effort of 7X10^3 days at sea

1.2 Brown Shrimp, Brazilian Shrimp (*Penaeus subtilis*, *P. brasiliensis*)

CATCHES: average 1975/79: 2.138 t
1979: 3.306 t

POTENTIAL YIELD: 18.580 t for an effort of 78,1X10^3 days at sea (whole area Brazil-Guyanas)

2 - NORTHEAST REGION

2.1 - Red Snapper (*Lutjanus purpureus*)

CATCHES: average 1975/79 5.404 t
1979: 4.227 t

POTENTIAL YIELD: 5.860 t for an effort of 12,8X10^6 hook-hour

2.2 - Spanish mackerel (*Scomberomorus caballa*)

CATCHES: average 1976/79: 763 t
1979: 1.047 t

POTENTIAL YIELD: 3.500 t for an effort of 5,5X10^6 hooks - day (only for the State of Ceará)

2.3 - Spanish mackerel (*Scomberomorus brasiliensis*)

CATCHES: average 1976/79: 971 t
1979: 1.411 t

POTENTIAL YIELD: 4.100 t for an effort of $8,1X10^6$ hooks day (only for the State of Ceará)

2.4 Four-wing Flying fish (*Hirundichthys affinis*)

CATCHES: average 1976/79: 632 t
1979: 1.019 t

POTENTIAL YIELD: unknown

2.5 Tuna and related species

CATCHES: average 1976/79 2.791 t
1979: 3.054 t

POTENTIAL YIELD: unknown

2.6 Spiny Lobsters (*Panulirus argus* and *P. laevicauda*)

CATCHES: average 1975/79: 8.661 t
1979: 11.033 t

POTENTIAL YIELD: 8.800 t for an effort of $18,8X10^6$ traps/day

2.7 Amberjack (*Seriolla* spp.)

CATCHES: average 1976/79: 489 t
1979: 744 t

POTENTIAL YIELD: unknown

3 - SOUTHEAST/SOUTH REGION

3.1 Croaker (*Micropogon* spp.)

CATCHES: average 1974/79: 25.855 t
1979: 22.963 t

POTENTIAL YIELD: unknown

3.2 - King weakfish (Microdon ancylodon)

CATCHES: average 1974/79: 9.947 t
1979:7.937 t

POTENTIAL YIELD: unknown

3.3 - Striped weakfish (Cynoscion striatus)

CATCHES: average 1974/79: 9.018 t
1979: 12.405 t

POTENTIAL YIELD: unknown

3.4 - Croaker (Umbrina canosai)

CATCHES: average 1974/79: 18.070 t
1979: 13.886 t

POTENTIAL YIELD: unknown

3.5 - Sardine (Sardinella brasiliensis)

CATCHES: average 1975/79: 152.452 t
1979: 149.452

POTENTIAL YIELD: 200.000 t

3.6 - Bluefish (Pomatomus saltator)

CATCHES: average 1974/79: 6.287 t
1979: 4.053 t

POTENTIAL YIELD: Unknown

3.7 - Tunas and related species

CATCHES: average 1975/79: 2.328 t
1979: 4.712 t

POTENTIAL YIELD: unknown

3.8 - Brazilian Shrimp, Pink shrimp (Penaeus brasiliensis, P. paulensis)

CATCHES: average 1975/79: 8.635 t
1979: 11.637 t

POTENTIAL YIELD: 6.000 t for the industrial fleet

3.9 - Marine catfishes

CATCHES: average: 1974/79: 5.172 t
1979: 3.799 t
POTENTIAL YIELD: unknown

3.10- Sharks

CATCHES: average: 1974/79: 8.344 t
1979: 7.875 t
POTENTIAL YIELD: unknown

3.11- Sea bob shrimp (Xiphopenaeus kroyeri)

CATCHES: average 1975/79: 11.453 t
1979: 12.522 t
POTENTIAL YIELD: unknown

3.12- White shrimp (Penaeus schimitti)

CATCHES: average 1974/79: 585 t
1979: 1.114 t
POTENTIAL YIELD: unknown

3.13-Mullet (Mugil sp.)

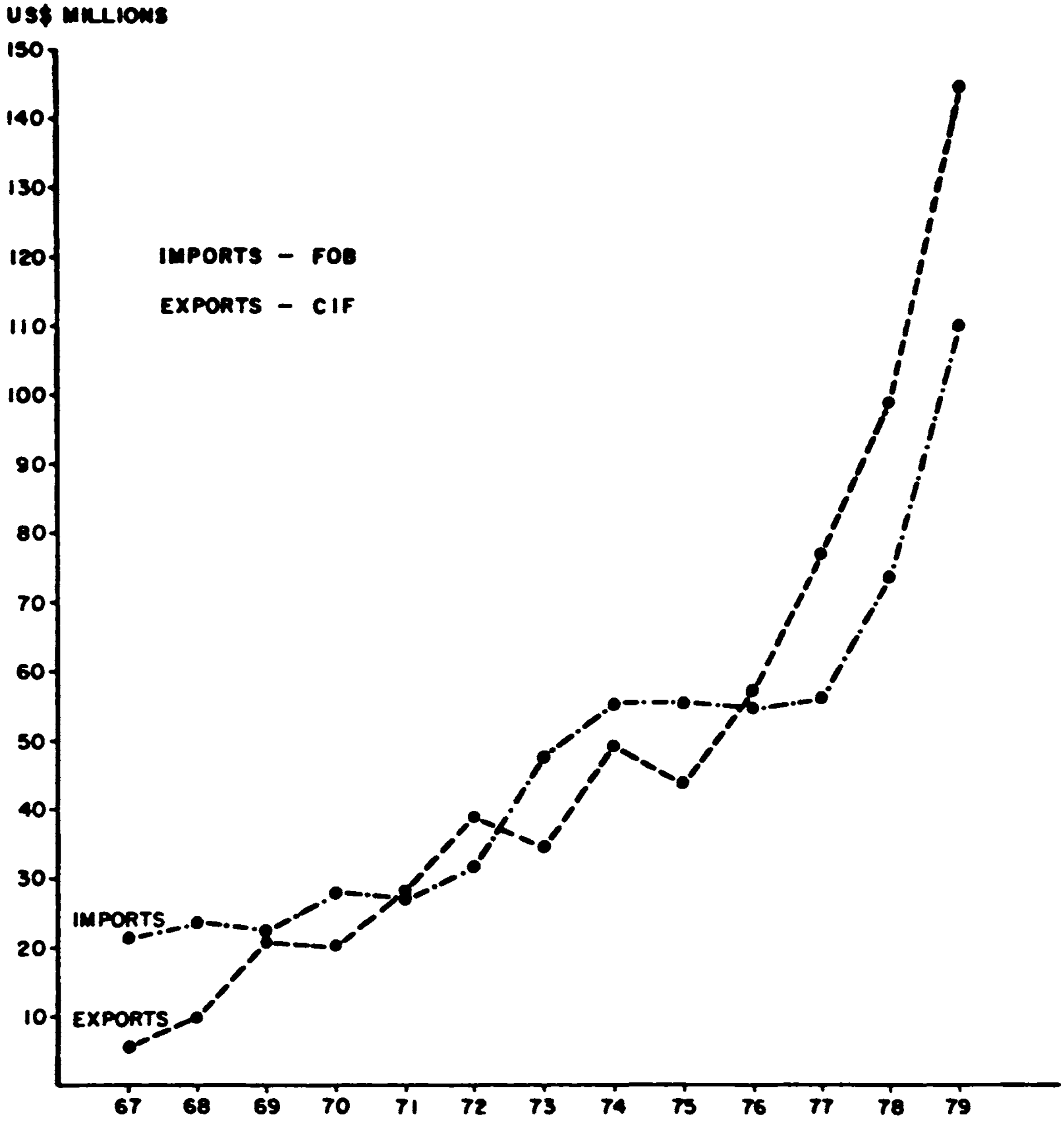
CATCHES: average 1974/79: 5.818 t
1979: 5.558 t
POTENTIAL YIELD: unknown

3.14- Hake (Merluccius merluccius hubbsi)
CATCHES: average: 1975/79: 33.664 t
1979: 38.786 t
POTENTIAL YIELD: unknown

SOURCE: Department of Management of Fishery Resources; Fisheries Research and Development Program, SUDEPE.

EXPORTS AND IMPORTS

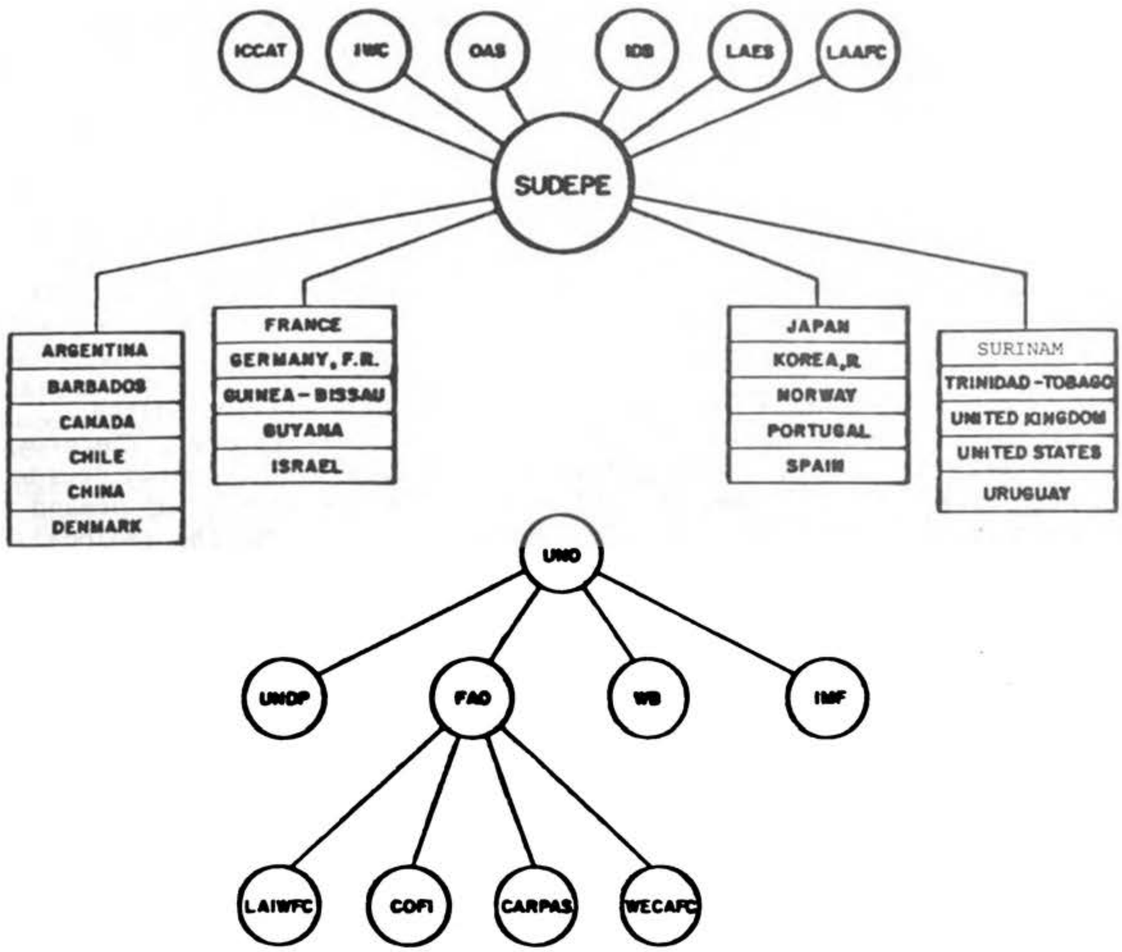
CHART 1



SOURCE: Carteiro do Comercio Exterior (CACEX)

CHART 2

INTERNATIONAL RELATIONS OF SUDEPE



LAES – Latin America Economic System
IWC – International Whaling Commisson
WB – World Bank
IMF – International Monetary Fund
FAO – Food and Agriculture Organization of the United Nations
UNO – United Nations Organization
IDB – Inter-American Development Bank
UNDP – United Nations Development Program

ICCAT – International Commisson for the Conservation of Atlantic Tunas
OAS – Organization of American States
LAAFC – Latin American Association of free Commerce
CARPAS – Advisory Regional Fishery Commission for the South West Atlantic
COFI – FAO Commttee of Fisheries
WECAFC – Western Central Atlantic Fishery Commission
I AIWFC – Latin American Inland Waters Fisheries Commission

THE NEED OF DEVELOPING RESEARCH AND TECHNICAL CAPABILITIES IN THE MANAGEMENT OF MARINE RESOURCES IN THE INDONESIAN AND ADJACENT WATERS

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January 1981

1. INTRODUCTION

The Indonesian waters, an area of over five million square kilometers, cover two-thirds of the Indonesian territory. Therefore, how fully and wisely these waters are utilized in the coming decade will affect our economy, our ability to meet the increasing demand for food and raw materials, our position and influence in the regional community of nations, our national resilience, and the environmental quality of the country as a whole, in which the marine environment is the dominating physical factor.

The rich and diversified life of our seas has been an important source of food for the Indonesian people for centuries. Fishes, crustaceans, mollusks, and seaweed are a few examples of these resources. In addition, the minerals and hydrocarbon resources currently have been tapped from the shallower parts of our waters.

Aside from the renewable and nonrenewable resources, our seas have many other roles, such as for interisland, regional, and international shipping for trade, communications, recreation, and tourism. Unfortunately, however, lately as a result of our efforts in economic development in almost all sectors, the marine environment experiences severe pressures, either directly or indirectly, such as the increasing incidence of pollution and the general degradation of certain coastal areas.

Present knowledge and experience to allow us to make decisions on alternative courses of action for developing the resources of our seas are still very limited. Therefore, in our long-range plan we have to include a program to increase our capabilities in marine science. This includes, among other things, improved communications and coordination throughout the marine science community, establishment of a National Marine Data Center, upgrading the quantity and quality of the manpower, and expanding and improving the research facilities.

2. THE PHYSICAL ENVIRONMENT OF INDONESIA

The Indonesian physical environent is unique. Geographically, the Indonesian archipelago is situated between the Asian and the Australian continents and between the Pacific and the Indian oceans. It is located between 94 and 141 degrees east longitude and between 6 and 11 degrees south latitude. The archipelago consists of more than 13,000 islands with more than 81,000 km of coastline, probably one of the longest in the world.

Generally speaking, the Indonesian territorial sea is divided into several parts. The shallow Sunda shelf in the west, the Sahul shelf in the east, the deep ocean in the south, and the deep seas, straits, and channels in the middle. Various expenditions, whether they be international: Challenger, Dana, Albatros, and Galathea, or regional and national: Siboga, Snellius, Baruna, and Rumphius (see Soegiarto 1978) contribute to our knowledge and understanding of the oceanographic features of our waters. Because of its geographic location, the Indonesian archipelago is strongly governed by monsoon-type climate. Generally, the northwest monsoon lasts from about December to February and the southeast monsoon from June to August. The rest of the year represents the transition periods from the northwest to the southeast monsoon (March - May) and from the southeast to the northwest monsoon (September - November). During the northwest monsoon, the wind blows eastward and causes heavy rainfall throughout most of the Indonesian archipelago. Rainfalls combined with the heavy runoff of many rivers from the greater Sunda Islands (Sumatra, Java, and Kalimantan) result in a general lowering of salinity near shore. Sometimes the 30 per mil isohaline is pushed far toward the open sea. At the same time the surface current from the South China Sea brings the low-salinity water into the western part of the Java Sea, which is surrounded by those three islands and pushes the higher salinity eastward. With the onset of the southeast monsoon, these low-salinity waters are transported back westward and into the Java Sea and South China Sea, i.e., they are replaced by waters of the higher salinity from the Macassar Strait and the Flores Sea. The maximal westward penetration of the high-salinity water masses generally occurs in or around September. For further review of the oceanographic features of the Indonesian waters, see Soegiarto (1978) and Soegiarto and Birowo (1975).

The almost 81,000 km coastline basically consists of three different bottom types: rocky, sandy, and muddy. Their distribution is partly governed by strength of water energy (current patterns and wave actions). Along the coastline, one can find various types of ecosystems, such as coaral reefs, mangrove, sago, nipa, and other swampy forests.

3. THE RESOURCE POTENTIALS

Slowly the utilization of the marine resources in Indonesia is growing and expanding in order to meet the increasing demands for food, energy, raw materials for industries, job opportunties, and foreign exchange. Currently, the annual production of living aquatic resources in Indonesia is about 1.7 million metric tons, whic consists of about 1.3 million tons production from the marine sector and 400,000 tons from the freshwater and aquaculture sectors. The annual rate of increase during the 2nd PELITA (Five-Year Development Plan, 1974-1979) was between 3 and 5 percent. However, this increase generally was confined to the marine sector only. The production from inland waters slightly declined from year to year due, in part, to urbanization, absorption of the labor force by other sectors of economy (e.g., logging industries), siltation and eutrophication in many lakes, swamps, and rivers, and reduction in mix-culture practices due to the increasing use of pesticides and herbicides in agriculture.

Potentially, the Indonesian seas can produce an estimated maximum sustainable yield of 4 million tons annually. Therefore, the current production of 1.3 million tons represents only 30 percent of the potential yield. On the other hand, the estimated potential yield of freshwater capture and culture (including brackish water) is 2.3 million tons. Thus, our current production is only about 17.4 percent of the potental yields. A strong upward trend has also become apparent in the volume and value of exports of living aquatic resources in Indonesia. The export activities are mainly dominated by the export of shrimps and prawns. Export of fresh prawns was negligible before 1966. In 1967 the export value was a low US$25,000 and rose quickly to US$877,000 in 1969, US$3,630,000 in 1970, and US$13,742,000 in 1972. The value of exports in living aquactic resources in 1979 was over US$220 millions.

Slowly the marine fisheries in Indonesia are growing and expanding not only to meet the increasing demand for inexpensive animal protein for the people, but also to contribute urgently needed foreign exchange. It is realized, however, that in order for the fishery industries to grow more rapidly, many constraints have to be overcome, such as the widespread need for developing technical skills, modernizing equipment and fishing methods, expanding the existing fishing grounds while looking for new ones, studying the life cycle, migration, and population dynamics of the more economically important species, and seeking new exploitable species.

In 1979 the total petroleum production in Indonesia was about 1.5 million barrels per day (bpd). Although most of the production is still derived from the land-based oil fields, an increasing proportion is coming from the offshore fields. At present about 3.5 percent of the production is derived from offshore wells. Concurrent with the increase of oil production, exploitation of offshore natural gas has begun in, among other fields, the Arun (Northern Sumatra), Bontang

(East Kalimantan), and Jatibarang (north coast of West Java). The natural gas from Arun and Bontang is mainly to be exported to the United States and Japan, whereas from the Jatibarang field is piped to the Krakatau Steel Plant at Cilegon, West Java. At present there is no known figure for true potentials of the petroleum and natural gas from our marine environments. However, research and exploration are still being carried out for new reserves.

In addition, many minerals are also mined from the Indonesian coastal areas. They include: tin, bauxite, nickel, iron sands, coal, sand and gravel.

4. ORGANIZATION OF MARINE RESEARCH

For many years marine research was considered to be part of agricultural activities. In government agencies it used to belong to the Ministry of Agriculture. Only in the last 15 years have the activities in marine science been transferred to other agencies, namely to the Indonesian Institute of Sciences (LIPI) for the basic and cross-sectoral research, the Indonesian Navy for the hydrographic surveys, and the Ministry of Agriculture retained only the fisheries-oriented research portions.

In 1904 the director of Bogor Gardens established a "Visscherij Station" at Pasar Ikan, Jakarta. The station was renamed the Institute of Marine Research (Indonesian: Lembaga Penelitian Laut; Dutch: Laboratorium voor het Onderzoek der Zee) in 1919. Since that time, research in marine biology has continued, although in most cases it is still classified as fisheries research.

In 1962 almost all the institutions belonging to the Botanical Gardens, including the Institute of Marine Research, were transferred from the Ministry of Agriculture to the Council for Sciences of Indonesia, which later became LIPI. Part of the reason was that these institutions were, and still are, doing basic and cross-sectoral research.

The Council for Sciences realized the importance of marine research and the urgent need for combining and coordinating the efforts of the scientists and the institutions to "exploit the wealth of the sea" for the Indonesian people. In addition to the buildings, laboratories, and scientific staff, two research vessels were available, the R.V. Jalanidhi (750 tons DWT) and the R.V. Samudera (200 tons DWT). These were war reparation from Japan and a gift from the United States. In the same year (1962), a National Committee on Oceanic Research (NCOR) was established to coordinate all research activities and to advise the Council for Sciences of Indonesia on the scientific side of the activities. The committee consists of several member institutions. They are the following:

Institute of Marine Research (in 1970 renamed the National Institute of Oceanology),
Naval Hydrographic Office,
Institute of Marine Fisheries Research,
Center for Meteorologic and Geophysical Studies,
Directorate of Geology and Mining, and
A few universities that have marine science programs.

Unfortunately, however, NCOR did not live long. The unstable political and economic conditions prior to, during, and after the communist upheaval in 1965 were partly responsible for the dying out of NCOR.

Due to the ever-increasing need and urgency of establishing a national coordination of marine research, the Indonesian Institute of Sciences in 1978 established a National Committee on Marine Research (NCMR). So far, 23 agencies, research institutions, and universities are members of the committee. Various commissions have been established in the committee, such as commissions on research programs, training, and education, international relations, and data management.

5. CURRENT PROGRAMS

During the era of the National Committee on Oceanic Research, we successfully developed three kinds of research programs:

1. Participation in international and regional cooperative programs, such as the International Indian Ocean Expedition and the Cooperative Study on Kuroshio.

2. National cooperative programs, such as the 1st to 4th Baruna Expeditions (a number of Japanese scientists took part in the 1st Baruna Expedition).

3. Institutional programs, in which each institution carried out its own programs according to its mission and scope of tasks.

Unfortunately, however, since the end of NCOR in 1970, the national ooperative programs have also fizzled out. Each agency now carries its own institutional programs and tries its best also to take part actively in international or regional programs according to its field or mission. For example, the Naval Hydrographic Office cooperated with Japan, Malaysia, and Singapore in surveying the bathymetry of the Malacca Strait, the Marine Fisheries Research Institute participates in the FAO-supported South China Sea Fishery Project, and the National Institute of Oceanology has become the national member of the UNESCO Intergovernmental Oceanographic Commission (IOC). Through the institutional programs, NIO has developed a few international expeditions carried out in Indonesian waters. For example, the Rumphius Expedition, a biosystematic study of the Moluccan waters, is carried out every two years. The first expedition was carried out in 1973 with six foreign participants, the second expedition was in 1975 with five foreign scientists, and the third expedition with four foreign scientists. The fourth Rumphius Expedition was just carried out in October and November 1980 with five foreign scientists from the Netherlands, United Kingdom, France, and Australia.

Currently NIO, with the assistance of UNDP and UNESCO, is preparing an international oceanographic expedition in the eastern part of our archipelagic waters. This expedition will be called the 2nd Snellius Expedition. The first Snellius Expedition was carried out by Dutch oceanographers between 1929 and 1931 in the eastern archipelago waters. Thus, the 2nd Snellius Expedition will commemorate the 50th anniversary of the 1st Snellius Expedition and will check the long-term changes of the oceanographic features in these waters. It is expected that some foreign scientists and research vessels will take part in the expedition.

The following are the current NIO programs in the field of marine science. Cooperation and assistance can be channeled through these programs.

a. Inventory of Marine Resources

This is a long-term biosystematic study of marine biota of the Indonesian waters. The following groups of biota have been studied: fishes, molluscs, crustaceans, corals, echinoderms, algae, phyto- and zooplankton. At present the priority areas are: Jakarta Bay, the north and the south coasts of Java, Bali, South Celebes, and the Molluccas.

The Rumphius Expedition is part of this program. The expedition is organized every two years.

b. Oceanographic Research of the Indonesian Waters

The objective of this research program is to study the physical, chemical, and biological properties of the Indonesian seas, especially their interdependency with the larger bodies of waters, such as the Pacific and the Indian oceans. Current priority areas are:

- the Java Sea and its surrounding waters
- the eastern archipelago waters
- the Strait of Malacca and the Strait of Macassar

c. Research on the Biology and Ecology on the Marine Biota of Economic Importance

The aim of this study is to acquire a better understanding of the biology and ecology of the economically important species. Based on this knowledge, it is hoped that we can exploit the species more rationally, without endangering the natural stock. The knowledge gained from this study can be used also in the effort of culturing the species. The following species have been studied: Decapterus spp., Siganid spp., penaeid shrimps, Eucheuma spp. (seaweed), etc.

d. Research Programs on Mariculture

These programs are seeking more effective and efficient methods in culturing marine organisms. They are carried out both in the laboratory and in the field. The Pari Field Station is especially designed for such activities. The following species have been used in the studies: Eucheuma spp., blue crabs, oysters, penaeid shrimps, Siganid spp.

e. Special Research Programs for the Ambon Station

The object of the programs is to develop the research capabilties of the Ambon Field Station so that in the near future the station will be able to carry out its own activites in the eastern archipelago waters. The current programs include:

- The biology and ecology of bait fish, Stolephorus spp.
- The biology and ecology of mangrove
- The physical and chemical oceanography of the Ambon Bay
- The biosystematics of coral ecosystems
- The plankton of the Ambon Bay
- Study on the pollution problem of Ambon Bay

6. EDUCATION IN MARINE SCIENCE

One of the main constraints in the development of marine science capabilities in Indonesia is the shortage of properly trained personnel and the shortage of proper rewards for them. This problem is, in part, due to the education system in Indonesia. Although the sea is the dominating physical feature of our environment, our education system is still terrestrially oriented. A limited number of young people who enter into the field of marine science are generally university graduates who have not had proper training in marine sciences. To alleviate this problem, in the last few years a fishery-oriented program has been established in many Indonesian education institutions. Although this program still has many shortcomings, we interpret it as one step forward.

In late 1974 we organized a National Seminar on the Sea to formulate policy on alternate courses of action and requirements in developing our marine-science programs in order to meet the need of the marine sector in the economic development of the country. Coincident with this seminar, the Department of Education and Culture laid out a basic policy on higher education in the country. In short, each university is encouraged to develop its own major science pattern (in Indonesian: Pola Ilmiah Pokok, or PIP). As a result, three universities have contemplated developing marine science at their PIP. They are:

- Diponegoro University at Semarang, Central Java
- Hasanuddin University at Ujungpandang, South Celebes
- Pattimura University at Ambon, the Moluccas.

Preparation and development plans have been under way for these three universities to become leading educational institutions in marine science in Indonesia. However, probably it will take another five years before they can produce their first group of graduates in marine sciences. In the meantime, recruitment for university graduates has to be done from non-marine-science faculties. An approximate analysis shows that over a four-year period to and including 1973, the average annual sarjana (between B.Sc. and M.Sc. degree level) graduate production in sciences applicable to aquatic resources studies was as follows:

Mathematics	9	Chemistry	19
Physics	22	Geology	19
Biology	37	Geophysics	1
Electrical Engineering	53	Fisheries	39

We could compare the sarjana production in other fields:

Law	710	Economics	531
Architecture	110	Agriculture	257
Pharmacy	90	Social & Political Sciences	300

Naturally, as can be expected, only a small fraction of the graduates in sciences enter into aquatic resources studies.

7. THE ROLE OF TECHNICAL ASSISTANCE

There are three kinds of technical assistance in Indonesia:

- technical assistance through bilateral arrangements,
- through United Nations agencies,
- through international foundations or organizations, such as the Ford Foundation, Rockefeller Foundation, International Development Research Centre (Canada), Max Planck Institute, and the Humbold Institute.

The major sources of technical assistance in marine science come from the UN agencies, such as UNESCO, FAO, and UNDP. So far, very limited assistance comes from international organizations and a fair amount derives from bilateral arrangements. Probably for many years to come, technical assistance through UN agencies will play an important role in helping us to develop our marine-science capabilities. However, at present we are also trying to increase the amount of technial assistance through bilateral arrangements, for example, with Japan, Australia, the United States, and West European countries. In general, favorable responses have been given to us from those countries.

However, in order for any technical assistance to be successful it has to be geared toward helping the developing nations to help themselves in identifying their needs and defining their programs and priorities. To avoid gross errors, it is imperative for the foreign experts or consultants to work together with the local scientists, teaching, where needed, the basic sciences and then helping the local scientists in formulating their own programs adapted to their special conditions.

Marine science is often perceived as one of the means whereby industrialized countries improve their advantage in benefiting from increased use of the ocean and its resources. As a result, therefore, it is conceivable that at the Law of the Sea Conference, for example, the developing nations will favor strict controls over marine research conducted by developed maritime countries. At the same time, the developing nations will make efforts to develop our marine science so that we too can obtain the benefits that knowledge may provide. Possibly a meeting of minds could be reached where the more developed maritime countries will assist the developing nations to achieve that goal through bilateral technial assistance. This assistance could be used to improve the research facilities, for manpower development through training and fellowships, purchase of scientific books and subscriptions to scientific journals in this field, and sharing the expertise between the foreign experts and their native counterparts in solving current problems of common interest.

8. THE NEED FOR REGIONAL COOPERATION

The majority of the shores and coastlines of Southeast Asian countries are influenced by water masses of the same origin. Water circulation in one body of water has a direct or indirect effect on the current patterns of other bodies of water in the region. For example, during the northeast monsoon, oceanographic patterns of the South China Sea have a direct impact on the conditons in the Java Sea, the Sulu Sea, and the Strait of Malacca. Simiar kinds of fish and other economically important marine biota are harvested or cultured in the Association of Southeast Asian Nations (ASEAN) region. Therefore, many similar factors--whether they be biological, socioeconomic, or concerned with the use of appropriate technology--govern their productivity and their mode of exploitation.

In addition, the Southeast Asian countries have somewhat similar environmental problems. Marine pollution, for example, recognizes neither physical nor territorial boundaries. Therefore, regional cooperation is urgently needed. The need is further accentuated by the fact that, in general, there are inadequate facilities (research and pollution-cleanup) and too few marine scientists and marine environmentalists in each of the Southeast Asian countries. However, by regional cooperation we could pool our knowledge and enable our manpower to carry out research and development on problems of common interest. Since marine environmental research, in most cases, is very costly, a system of regional cooperation would somewhat ease the financial burden on each member country. Regional cooperation in marine-environment studies would also offer other advantages:

- wider geographical coverage
- in the case of seasonal variation studies, there would be more representative samplings from different areas of the region
- comparison of results

The need for regional cooperation in marine science has been identified and agreed upon by the Committee on Science and Technology of the Association of the Southeast Asian Nations (COST-ASEAN). Two programs have been identified and formulated. They are:

- Tide and tidal studies in the ASEAN region
- Oceanographic studies in the ASEAN waters

In the American-ASEAN Dialog held in Washington, D.C., in 1979, the United States agreed in principle to support those programs. At present, Indonesia is preparing a more detailed and integrated proposal that will be submitted to the United States for consideration.

The need for regional cooperation in marine-pollution studies has been identified and agreed upon in the FAO/IOC/UNEP International Workshop on Marine Pollution in East Asian Waters (Penang, Malaysia, 1976). In June 1980 in Baguio City, the Philippines, UNEP organized an expert meeting to review the "Draft Action Plan for the protection and development of the marine environment and coastal areas of the East Asian Region." The meeting approved the proposed Draft Action Plan and recommended that it be implemented first in the ASEAN region. Last month (December 1980) the proposed Regional Seas Action Plan was discussed and was expected to be approved formally for implementation by government representatives from the five ASEAN member countries (Indonesia, Malaysia, Philippines, Singapore, and Thailand).

Another regional cooperation, albeit larger in scope and geographical coverage, is the UNESCO/IOC Program Group on the Western Pacific (IOC-WG WESTPAC), which was established in 1978 in a meeting in Tokyo, Japan. Currently 18 countries are members of the WESTPAC, spreading in the western portions of the Pacific Ocean from the Bering Sea to New Zealand and from Indonesia to French Polynesia. Several programs have been formulated, such as:

- physical ocean monitoring of the Pacific,
- geology and geophysics of the Northwesten Pacific,
- coastal transport of pollutants,
- monitoring of pollution by using shellfish as determinants.

Various workshops and training groups were organized in 1980 and several are still being planned in the first quarter of 1981. The second session of the IOC-WG WESTPAC is scheduled to be held in Jakarta, Indonesia, in September 1981.

9. CONCLUSIONS

In conclusion, although Indonesia has a rather long history in marine science, unfortunately, however her capabilities never reach beyond the descriptive level. The reasons for this are many. Until only recently there was no definite commitment and awareness among the decision makers that Indonesia's marine resources potentially could be developed and managed to improve the quality of life of the people and to strengthen the economy. As a result marine science for many years has been neglected. However, when we did realize that our future as a nation probably depends partly on how rationally we will utilize and manage the seas, marine science was not quite ready and, thus, was not adequate to supply the urgently needed basic data and information on which to base the formulation of policies on alternative courses of action. Technical assistance, from United Nations agencies and bilateral arrangements, and regional cooperation are needed urgently, in the short term, to assist in providing those data and information. But more important, such assistance is needed in the long term to assist us to develop our own capabilities in order to meet the challenge of developing and managing our marine resources rationally for the betterment of our country and people.

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MARINE SCIENCES AND TECHNOLOGY: NEEDS FOR INDIA

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LIVING RESOURCES

India is the one country bordering the Indian Ocean which exploits the maximum of marine resources from this region. India is ranked among the first ten fishing nations of the world, with a national income from fisheries alone on the order of nearly Rs 4,000 million (about $500 million). India has a coastline of 6,100 km and a continental shelf area of 414,868 sq. km. During the last two and one-half decades, marine fish production increased from an estimated 0.5 million tons to nearly 1.2 million tons. Recently India also enacted legislation to claim jurisdication over its exclusive economic zone (EEZ) of 200 miles and promulgated the Maritime Zone Act, which came into force in 1977. This has enlarged the country's exploitable marine zone to nearly 2 million sq. km and has added considerable responsibility for study and management of the resources to ensure their optimal exploitation. In the matter of marine products exports, the country's earnings stand at the level of nearly Rs 2,200 million (about $280 million). Nevertheless, it may be pointed out that at present the country exploits only the resources within a narrow coastal belt extending seaward to depths of 50 meters. The fishery resources beyond this region remain virtually unutilized. The study of the oceans assumes a new dimension for India and for other countries in this region in view of their increasing populations and growing needs. Even though the increase in marine fish production may appear impressive, this evidently does not seem to be commensurate with the actual potential. Estimates in recent years have indicated that a harvest of at least 10 million tons of fish should be possible from the whole of the Indian Ocean, which would bring the level of exploitation up to that of the better exploited oceans, like the Atlantic and the Pacific.

Pelagic and bathypelagic fishes constitute the more important components of Indian marine fisheries. Among the pelagic fishes, the oil sardine (*Sardinella longiceps*) and the mackerel (*Rastrelliger kanagurta*) occupy the first place, followed by a variety of other species. However, the wide annual fluctuations in these two important fisheries are often reflected in the total marine fish landing. The factors actually responsible for such fluctuations are even today not adequately understood, and without such understanding, proper management policies cannot be formulated. Vital information relating to the population dynamics, stock size, migration and behavior patterns, spawning grounds, rate of recruitment, etc., for these fisheries are yet to be understood. Although a considerable amount of catch statistics and general biology of these two important fishes has been accumulated during the past years, there are still several significant gaps in the information.

The demersal fishery resources are much more varied than the pelagic ones and comprise at least eight important groups in addition to several minor varieties. Special mention may be made of the shrimps, which are fairly well exploited all along the inshore regions. The intensive fishing for shrimps is now believed to be almost at a level of overfishing and has been prompted mainly by the demand in export markets. However, as regards finfish, there seems to be scope for doubling the present demersal catches for the shelf waters even though closer study is needed to reveal the actual potential. Generally there is urgent need to obtain more reliable data on the productivity of different fishing grounds, the size of demersal fish stocks, bottom communities that sustain the benthic fish populations, impact of the present fishing intensity on the exploited stocks, their migrations, etc. Besides these stocks, preliminary exploratory surveys have revealed that a number of miscellaneous and latent fishery resources also exist in this region and are yet to be tapped.

Apart from exploitation of the available marine resources, India has also launched a vigorous research program in coastal aquaculture. Within a short time, our experiments have revealed the possibilities of obtaining a high level of production both through finfish and shellfish culture in the coastal saline water. Milkfish and mullet culture in coastal lagoons as well as mussel culture in open bays have yielded very encouraging results. Technologies are being developed rapidly so that coastal aquaculture as an industry can be taken up by coastal fishermen. A technology for appropriate planning of capture and culture fisheries has great significance for a developing country like India, and the current research and development programs lay considerable emphasis in this direction.

Although fundamental and long-term research projects have an important place in the overall concept of fishery research, rapid surveys and problem-oriented, time-bound projects should receive priority consideration for India and other developing countries. At this stage, one can ill afford the luxury of an approach heavily weighted in favor of fundamental research. Critical evaluation of the more practical problems and identification of contraints and the gaps in knowledge are essential in order to make rapid progress in the coming years and to help in formulating methods for rational exploitation of the resources. For such programs, a coordinated, multidisciplinary approach that brings modern technologies to bear would be essential. Planning should take into consideration the study of primary and secondary production, exploratory surveys, study of ecosystems and environmental damage, stock assessment and recruitment, upwelling, ocean currents, nutrient cycles, and a host of such environmental parameters.

NONLIVING RESOURCES

In regard to seawater and its prudent use, not much advancement has been made, except in the extraction of salt and certain chemicals. With increased urbanization and rapid industrialization, there is constant demand on water supplies. To overcome water shortages for such purposes, better seawater management technologies similar to the freshwater management policies in agriculture may be advantageous. Economic desalination of seawater will soon become essential to combat industrial water problems. Similarly, following the encouraging results demonstrated by certain countries in the use of saline water for limited irrigation, India also has been carrying out studies in the use of seawater to grow selected crops. Exploitation of the seabed for the various well-known, nonliving resources, like oil, minerals, and metals, has recently been receiving increased attention in India as well as in other countries. With a growing awareness of the existence of such vast potential, further exploration and the evolution of appropriate technologies have become essential. Some efforts are already under way in his direction, and certain organizations are actively pursuing the various problems, subject to the available physical facilities.

AGENCIES FOR OCEAN SCIENCE STUDIES

India has established a number of agencies for oceanographic and related investigations, both for the living and nonliving resources. (See the Appendix for a list of such institutions with their respective fields of interest.) With such a large number of agencies involved in different aspects of marine science and technology, it has become necessary to bring about some coordination and to establish liaison with similar, international bodies. The Indian National Committee on Oceanographic Research (INCOR) was constituted during the International Indian Ocean Expedition (IIOE) of 1959-65. Later, realizing the need for a more integrated approach to oceanographic research and development, the Indian government set up a committee to review the entire situation. This committee rightly pointed out the need to bring together scientific and research organizations with similar objectives as the physical and infrastructural facilities essential for study of the living and nonliving resources of the region. This coordinated effort would cover the entire spectrum of oceanographic R&D for the fullest utilization of manpower and research facilities and for advancement of marine sciences and technology without duplication of effort. Thus an Ocean Science and Technology Agency (OSTA) was established under the government's Department of Science and Technology. Its important task is to oversee and rationalize the major research requirements in this field and to cooperate with other scientific agencies to promote continuous scientific observations in the study of the ocean. Both INCOR and OSTA have made in-depth studies of the whole gamut of problems and drawn up certain broad programs for an integrated approach to oceanic research in this country.

TECHNICAL ASSISTANCE AND COOPERATION

Much of the recent scientific information relating to the Indian Ocean was obtained during the IIOE program. Unfortunately, at that time the Indian participation in the IIOE was somewhat limited because of a lack of indigenous seagoing facilities. Earlier, a few pioneering oceanographic cruises in this region were undertaken by foreign expeditions, the data of which have served as the basis for other oceanographic studies. Even though the raw data from a few other cruises by foreign vessels in the Arabian Sea and the Bay of Bengal have not been available, the processed information is of great value. India also has benefitted from a few bilateral cooperative programs in the study of this region. These programs include the Monsoon 77 and the Indo-Soviet Monsoon Experiment (ISMEX-73). India remains associated with the international agencies and exchanges scientific information from time to time. Most of these exchanges are devoted to general oceanographic studies related to meteorology.

In regard to fisheries,the major cooperative endeavor has been the Indo-Norwegian Project, which functioned for a while along the southwest coast and was devoted largely to an integrated approach to developing the local fishing industry with special emphasis on the improvement of the conditions of the fishermen. This was concurrently supported by an FAO/UNDP-assisted Pelagic Fisheries Project. This project continued until a couple of years ago and concentrated its attention on the main pelagic fisheries of the southwest coast, viz., the sardine and the mackerel fisheries besides the important clupeid group of white bait and anchovies. As a result, it may be said that today we have better knowledge of the extent of these fisheries and their behavior and related data on meteorology and physical and biological oceanography. Off the Bombay-Saurashtra coasts there has been an Indo-Polish survey and a few exploratory surveys by a Japanese enterprise. Currently the country has initiated some studies taking advantage of the more modern and sophisticated technologies provided under the remote sensing satellite programs (LANDSAT) for marine data collection and for better understanding of resource characteristics. The Central Marine Fisheries Institute in Cochin is at present collaborating with the Ahmedabad Space Research Center and the

National Remote Sensing Agency in Hyderabad for resource surveys off the west coast. Already 500 sq. km off the west coast have been covered in studying the areas of upwelling, ocean surface features, and other aspects of general oceanography.

NEED FOR RESEARCH AIDS AND TECHNICAL DEVELOPMENT

In multidisciplinary areas like oceanology and fisheries there is need for a variety of field facilities that are somewhat capital intensive. Well-equipped research vessels are a prime need. India and many other developing countries of this region have somewhat limited capabilities for construction of oceangoing research vessels. It may be said in this context that two 36-meter research vessels have just been constructed and launched and are expected to be available for research within the course of a year. Thus, there will be three full-fledged research-cum-training vessels. The OSTA is also acquiring one research vessel exclusively for work on nonliving resources and, later, another for living resorces. Besides research vessels, other important infrastructural facilities include the more modern and sophisticated oceanographic equipment for which the developing countries necessarily depend upon the help of the more advanced nations. These include submersibles, platforms, aircraft equipped with remote sensors, etc. While India may claim expertise in certain areas of fisheries and oceanographic research in conventional spheres, its scientists have to be exposed to the more advanced technologies taking place in developed regions, especially precise estimation of biological productivity, recruitment in major fisheries, aerial acoustics, remote sensing, satellite data collection and interpretation, etc. As already indicated, technological development for economic desalination of water along with use of saline waters for raising selected agricultural crops would be another important area where it will be advantageous for many of the developing countries to evolve suitable programs with the help of those who have succeeded in this line of work.

APPENDIX

Name of Institution	Field of interest
1. National Institute of Oceanography, Panaji (CSIR)	Physical, chemical, geological, and biological oceanography
2. Central Salt and Marine Chemicals Research Institute, Bhavnagar (CSIR)	Chemical and biological oceanography
3. National Geophysical Research Institute, Hyderabad (CSIR)	Geophysics
4. Central Marine Fisheries Research Institute, Cochin (ICAR)	Chemical, physical, and biological oceanography with particular reference to fisheries
5. Central Institute of Fisheries Technology, Cochin (ICAR)	Marine fouling, corrosion
6. Oil and Natural Gas Commission, Dehra Dun (Ministry of Petroleum and Chemicals)	Magnetic and gravity measurements and bottom topographic surveys, sea bottom sediments
7. Physical Research Laboratory, Ahmedabad	Remote sensing in oceanography
8. Botanical Survey of India, Calcutta (Ministry of Education)	Marine flora
9. Geological Survey of India, Calcutta (Ministry of Mines & Metals)	Bottom sediment samples, bottom topography, and mineral deposits
10. Zoological Survey of India, Calcutta (Ministry of Education)	Marine fauna and ecology
11. Survey of India, Dehra Dun (Geodetic & Research Branch, Ministry of Science & Technology)	Tidal observations and geomagnetics
12. Naval Hydrographic Department, Dehra Dun (Ministry of Defence)	Hydrographic surveys, preparation of navigational charts and bathymetry, special surveys for offshore oil exploration on the continental shelf of the west coast, marine biology, bottom sedimentation studies, and magnetic surveys

3. Naval Physical and Oceanographic Laboratory, Cochin (Ministry of Defence)	Underwater acoustics, physical oceanography, instrumentation, and seismic research
14. Engineers India Ltd., New Delhi (Ministry of Petroleum and Chemicals)	Ocean engineering including marine surveys, design, engineering, fabrication, installation of offshore structures, submarine pipelines, terminals, etc. Ports and harbor development consultancy
15. Naval Chemical and Metallurgical Laboratory, Bombay (Ministry of Defence)	Chemical oceanography and marine biology
16. Naval Science and Technological Laboratory, Visakhapatnam (Ministry of Defence)	Marine biology
17. Bhaba Atomic Research Centre, Bombay (Department of Atomic Energy)	Tracer studies for siltation in harbors, marine pollution, and offshore exploration and atomic minerals
18. Tata Institute of Fundamental Research, Bombay	Geophysical and geochemical studies of sea and seafloor
19. Deep Sea Fishing Station, Bombay (Ministry of Agriculture)	Exploratory fishing
20. Intetrated Fisheries Project, Cochin (Ministry of Agriculture)	Exploratory fishing
21. Central Institute of Fisheries Education, Bombay (ICAR)	Training in marine fisheries and principles in oceanography
22. Central Institute of Fisheries Operatives, Cochin (Ministry of Agriculture)	Training in marine fishing operations
23. India Meteorological Department, New Delhi (Ministry of Tourism and Civil Aviation)	Temperature, ocean current and salinity, wave-swell data, and air-sea interactions
24. Andhra University, Waltair	Physical oceanography and marine biology
25. Annamalai University (Marine Biological Station, Porto Novo)	Marine biology

26.	Cochin University, Cochin	Marine biulogy and oceanography
27.	Kerala University, Trivandrum	Marine biology
28.	Mahatma Phule Krishi Vidyapeeth (Marine Biological Station, Ratnagiri)	Marine biology
29.	Karnataka Regional Engineering College, Srinivasnagar, Surathkal	Basic and applied research in various aspects of coastal engineering

PROSPECTS OF INTERNATIONAL COOPERATION FOR MARINE SCIENCE AND TECHNOLOGY DEVELOPMENT

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OUTLINE OF SCIENCE AND TECHNOLOGY REQUIREMENTS IN THE MARINE AND FISHERIES SECTOR: CHILE AND URUGUAY

This paper is intended to provide an outline of marine science and technology development in Chile and Uruguay and a synopsis of their assistance needs. Progress reached by both countries in this field in the past five years is noteworthy in South America. Their main needs for assistance are those related to stock assessment, fisheries management, fish utilization, and marketing. However, specific topics are also identified and described.

The cooperation of Prof. W. Tarky, Catholic University of Valparaiso, Chile, and C/F Carlos Menafra, Professor of the Faculty of Humanities and Sciences of Uruguay, is acknowledged.

1. CHILE

General Information

Chile appears to be one of the most experienced countries in Latin America. Extensive analytical studies on marine phenomena have been carried out. The development of fisheries activities and fishing specifically, has succeeded after great effort. Marine bottoms are rough with depths of well over 200 to 400 meters. The distance from consumption centers, fuel, machinery, and equipment supplies completes the general panorama.

The coastal region is remarkably high. The lack of natural geographical accidents makes the construction of protected ports difficult and the fluvial system is unsuitable for installing inland ports.

The continental and oceanic territory's potential lies in the favorable country conditions of the South, which is propitious for aquaculture and high-seas fishing development. Nutrients are provided by the hydrographic system and the Humboldt stream. Landings in 1970 totaled 1 million tons, 2.4 million tons in 1979, and the estimated tonnage for 1980 will be slightly over 3 million.

The substitution of the traditional species used in fish meal production--anchoveta (Engraulis ringens)--by jurel (Sardinops sagax, and Trachurus murhy) and caballa (Scomber japonicus peruanus) has been noticed. Main production figures for 1979 are: caballa 89,000 tons, jurel 600,000 tons, sardina espanola 1,600,000 tons, anchoveta landings decreased to approximately 50,000 tons in 1979. Total production has been 2,560,000 tons.

A deterioration of fish stocks has been observed. Particular examples are: merluza (Merluccius gayi) and sierra (Thyrsities atun), camaron (Heterocarpus reedi) and langostino (Cervimunida johni), loco (Concholepas concholepas) has diminished in size due to its increased production (3,750 tons in 1970 to 16,570 in 1979).

The utilization of resources for human consumption is good but still represents only 4 percent of the total catches.

1.1 MAIN ACTIVITIES IN PROGRESS

1.1.1 Aquaculture

Efforts in aquaculture have been made since 1886. The Rio Blanco pisciculture station in the Los Andes region, was built in 1905. Species such as Cyprinius carpio, Salmo salar, Salmo trutta, Salmo gairdneri, Oncorhynchus keta, have been introduced and Salvenilus fontinalis, silversides, and atherinidae, as well as the Chilean and Argentine atherinidae families, have been propagated in the Chilean streams.

Several programs with Oncorhynchus tshawytscha, Oncorhynchus kisutch, and Oncorhynchus keta culture development are operating. Fourteen trout and salmon pisciculture stations exist with a production capacity ranging from 100,000 to 5 million eggs annually. Although some of these stations are government property, most of them are local private enterprises, universities, or Japanese and American firms.

Installations for mussels (Mytilus chilensis) and (Chromytilus chonus) and oysters (Ostrea chilensis) are situated in the Channels region. Yields shown are above 52 million oysters per season. The potential stock estimated for 1979 was 15,000 tons.

The growth period has been reduced to 3 from 5 years. Repopulation of indigenous species programs would be of great interest since they are in extinction.

The gathering of bivalve larvae is the prime and permanent concern of government organizations.

The introduction of Crassostrea gigas from Australia and abalone (Concholepas concholepas) very similar to the Chilean species although of harder texture, has been tried in the last few year. Ample information on the possiblities of different cultures has been supplied by seminars and meetings, (e.g., Seminar on the Development of the Chilean Fishery Sector, 1975; First Meeting on Chilean Fisheries, Fisheries on the Southern Zones, September 1979; Second Meeting on Chilean Fisheries of the Central Zone, September 1980, among others.

1.1.2 Harbors

The harbor designs along the coast did not consider fishing activities. However, they are performing efficiently in the unloading of raw material for the fish meal industry in the north of Chile. In other regions, the fishing industry has built its own docks, as in Coquimbo, with an unloading capacity of 100 to 120 tons per hour. In other ports, efficiency is still low because their structure and managerial system were not planned with the fishing industry in mind.

The efficient integration of a fishing fleet, port facilities and processing plants is dealt with, by using a simulation model, in "Outlook of Port Infrastructure Development," 1979 IFOP, Escuela de Ciencias del Mar y de los Alimentos. An analysis of economic assessment, effects on private enterprise, and the social repercussions of a probable location of fishing ports in the Southern Zone, are jointly dealt with.

1.1.3 Water contamination

Intensification of large oil tanker traffic through the Magallanes strait and the prospect of new oil wells have created great concern for the ecology of vast areas with enormous fishing potential because of eventual overflows of hydrocarbons into the sea.

At the International Working Meeting on Pollution in the South East Pacific, held in Santiago de Chile in 1978, cases which had arisen in the mouths of the Maipo, Aconcagua, and Bio-Bio rivers and in the Antofagasta Bay were presented.

Research programs on contaminants are being conducted in most of the universities with financial support from the government and private enterprises in order to gather actual biological and chemical contamination data and to make projections for the future.

1.1.4 Fish utilization

The exploitation of traditional species, those at present used in the manufacture of fish meal, such as jurel, sardina espanola, caballa and the increasing need for a better utilization of fish as a raw material motivated the interest of various institutions to investigate development areas for new products. As examples, massive canning of jurel, caballa, and sardina espanola prepared as frozen fillets for export, has been implemented. The installations' capacity is over 1 million tons per day (198 g/24 per box).

Feasibility studies for the production of salted dried fish are under consideration due to strong demands for the product from tropical countries.

Meetings sponsored by the Inter-American Development Bank (IDB), June-September 1980, with FAO cooperation, demonstrated the increasing interest in the exploitation of the accompanying fauna, deep-water and pelagic species. The basic idea is to obtain low-cost massive consumption food from exporting countries, which have a protein deficiency condition.

1.2 INSTITUTIONS DEALING WITH MARINE SCIENCE AND TECHNOLOGY

The Fisheries Secretariat, a dependency of the Ministry of Finance, is the leading agency in the country with total authority in fisheries. Academic institutions, foundations, and private organizations are also devoted to research and extension work. Progress in marine science and technology is implemented with government contributions, institutions' own resources, special agreements, private contracts, and, in a few cases, with grants from foreign institutions.

UNESCO (1979) published a Directory of Marine Sciences in South America. A synoptic listing is attached to this document (Annex 1).

The contribution of institutions embraces subjects such as research, data processing, oceanographc cruises, resource assessment, fishing vessel and gear design, quality control, pre- and post-graduate courses, special training courses, research and development.

Hydrography, Marine Meteorology, Physical, Chemical and Biological Oceaography, Aquaculture, Fisheries Biology, Fisheries Economics, Marine Geography, Ecology, Animal and Algae Taxonomy, Parasitology, Fisheries Extraction, and Fisheries Management and Technology are identified as the main subjects cultivated.

1.3. ASSISTANCE REQUIREMENTS

Technological assistance requirements should meet the national outreach and be in line with the government's economic policies and those of the production sector. Pragmatic examples have proved that cooperation obtained from different international organizations, bilateral cooperation, and private grants has had extremely efficient results.

Particular fields of interest are the following:

1.3.1 Fisheries development

a) Fish, crustacea, and mollusk stock assessment and resource monitoring, subject to industrial or artisanal exploitation. It should also include continental and high seas species.

b) Antarctic resource population dynamics and management studies in the XI Region (Chilean Antarctic Territory).

c) Operational analysis to reduce fish production costs in different regions.

d) Fishing gear design and operation.

1.3.2 Pollution

a) To study and monitor the presence of contaminants in continental and oceanic waters with a view to determining the effect of heavy metals, detergents, and pesticides on aquatic life. Thermal contamination effects on benthonic organisms are also important.

b) Research on domestic and industrial sewage and consequences in health, organic production, and ecological effects.

1.3.3. Developments in aquaculture

a) Massive production of eggs and fish larvae, crustacea, and mollusks. Application of modern techniques.

b) Control and identificaton of infectious diseases in fish.

c) Fish farms--engineering and economic aspects.

1.3.4 Fish utilization

a) Production of fresh, frozen, and processed fish products--studies of microbiological quality.

b) Biochemical functional features of accompanying fauna and underused species.

c) Research toward the identification of new marketable products and their development. Engineering and ecological aspects of plants location.

d) Utilization of small pelagic species for human consumption.

e) Artisanal fishing, development, and support.

2. URUGUAY

2.1 GENERAL INFORMATION

Uruguay is situated between 30 and 35 degrees south latitude and between 53 and 58 degrees west longitude, bordered by Brazil, by the Atlantic Ocean (210 km of coastline), and by the Uruguay and Plate rivers, which separate it from Argentina.

Territorial area	176,215 km^2
Insular area	105 km^2
Jurisdictional waters:	
Rio Uruguay	528 km^2
Rio de la Plata	15,240 km^2
Territorial waters	125,057 km^2
Laguna Merim	1,631 km^2

The population is 2,763,964, 80 percent of this being urban, with 1,339,748 persons residing in its capital, Montevideo.

Uruguay has access to rich fishing grounds. In 1975, the National Fisheries Institute (INAPE) initiated an ambitious and coherent program in this sector in order to make use of the available potential. In four years, fish landings increased from approximately 15,000 tons in 1974 to 110,000 tons in 1979. About 85 percent of its fish products are exported to over twenty countries. The balance is consumed locally.

A target of 200,000 tons of fish landings has been set by the authorities in a first stage, to avoid overfishing hazards. A large fishing harbor is under construction in the East, on the Atlantic coast, with the idea of decentralizing Montevideo.

High standards of hygiene are requested by INAPE. Constant monitoring and assistance are provided by their technicians both at field level and through the laboratories.

Total catches in the last five years increased from between 12,000 and 14,000 tons in 1975 up to approximately 130,000 tons in 1980.

2.2 MAIN ACTIVITIES IN PROGRESS

2.2.1 Oil prospecting

Research on hydrocarbons is being carried out by the National Fuel Administration (ANCAP) through contracts and agreements. The continental platform area has been investigated by the Compagnie Gènéral de Geophysique (France) by seismic, gravimetric, and geomagnetic methods.

Chevron (USA) carried out the drilling phase with negative results. A ministerial level commission was appointed to gather further information and study new possibilities for future drilling. A bilateral agreement with Yacimientos Petroliferos Fiscales (Y.P.F.) of Argentina, provided studies and work in the Rio Santa Lucia territorial area and surroundings to detect the existence of natural gas. These results were not satisfactory either.

2.2.2 Exploration of heavy sands

A deposit has been located in the area of Aguas Dulces, Department of Rocha, 280 kilometers east of Montevideo, which extends along the coast for 12 kiolmeters with an average depth of 6 meters and with characteristics and form similar to those exploited in other parts of the world. ANCAP has carried out trials at the pilot plant level using industrializaton schemes provided by CARPCO (USA) and Pechinery-Saint Gobain (France).

Initial basic schemes were perfected, obtaining fluxograms and work conditions which assure the possibility of obtaining minerals of a quality required by the consumer market. A first stage with an annual production of 100,000 tons of heavy minerals was suggested. Heavy minerals evaluated to date are approximately 7 million tons, composition being: ilmenite 60%, zircon 5%, rutile 1%, monazite 0.6%. It is possible to obtain a range of final products of high commercial value from basic minerals.

2.2.3 Aquaculture

Uruguay has more than 400,000 hectares of inland water which can be used for aquaculture, especially for fish culture. This extension covers environments allowing for different types of production, such as:

a. Agricultural and hydroelectric dams
b. Rice production areas
c. Salty coastal lagoons

This activity can be carried out on the ocean coast between Punta del Este and Chuy.

The National Fisheries Institute, carries on a research program to develop the culture of freshwater autochthonous species. This centers around silversides (Odontesthes bonariensis) and black catfish (Rhamdia sapo). The Laguna del Sauce Pisciculture station has been reconditioned. The first stage of the Villa Constitucion Fisheries Reseach Center has been constituted in Salto. This center was planned in accordance with the guidelines and designs provided by the FAO Technical Cooperation Program.

Once the installations are finished, the culture of Pacu (Colossoma spp.) and other catfish species will be investigated. These stations will be used also as seed production centers for future industries, to take advantage of the technology developed.

In the salty coastal lagoons it is planned to start research on shrimp culture (Penaeus paulensis), "Lisa" (Mugil spp.), and "Lacha" (Brevoortia spp.). This program will require large infrastructure and investment, for developing techniques for the artificial control of sand banks obstructing the mouths of lagoons, as well as all related biological aspects.

From the aquaculture point of view, the oceanic coast has the disadvantage of not having natural havens where fixed structures can be installed for cultures. The Faculty of Humanities and Sciences of the University of Uruguay plants to carry out investigations in the next four years on the feasibility of cultivating mussels in the Maldonado Bay area.

A common aspect in all the work areas is pollution. Although there are at present no commercial aquaculture installations, pollution problems and fish mortality due to the use of agricultural pesticides have been detected in rural dams. To date, the quality of inland waters has been studied and monitoring permanently done by State Waterworks (OSE).

2.2.4 Harbors

The Hydrographic Department of the Ministry of Transport and Public Works (MTOP) plans and executes the coastal and port engineering works. The National Port Administration is responsible for work on the Port of Montevideo and its operation.

A mission to advise on fishing port requirements was provided by the United Nations Development Program and FAO. Later investments under National Fisheries Development Plan terms resulted in:

a) The port of Piriapolis being reconditioned.

b) The La Paloma fishing harbor being designed, and essential services, such as landing piers, being constructed adjacent to the area where industries are being located. A dry dock and other facilities, such as control services, customs, and National Fisheries Institute, are also integrated.

c) Enlarging an existing zone in the Montevideo port dedicated exclusively to a fishing wharf.

Natural agents (wind, waves, tides, currents, etc.) are the cause of continual changes in the coastline due to its predominantly sandy nature. Sediment, erosion, and roads built along the coast, alter the topography of ports and beaches, sand banks in the stream mouths are modified, the outlets of the lagoons on the east coast and also port conditions change. Continuous dredging, especially in the ports of Montevideo and La Paloma, is needed.

2.2.5 Environmental pollution

Rio de la Plata
Rio Uruguay and affluents
Coastal strip (maritime front)

No precise information is available on coastal waters contamination. This could be significant in various sectors. Principal sources would be of continental origin, sewage and industrial effluents emptied, with little or no treatment, directly into streams or coastal waters.

Legal responsiblity over the quality of the littoral waters is shared by various organizations dealing with research or through implementation measures for their conservation. Recent decrees to prevent pollution of watercourses, classification of receptive bodies according to their use, limits of contamination parameters, and regulations for emptying effluents have been dictated, such as, Law 14.859 Code of Waters - 15/XII/78 and Decree of 8 May 1979.

The Treaty of the Rio de la Plata and its Maritime Front (19/XI/973) created a Joint Technical Commission (Argentina-Uruguay). Pollution research activities in coastal waters were assigned to the Oceanographic, Hydrographic and Meteorological Service of the Navy (SOHMA).

In accordance with the treaty, a research project between Argentina and Uruguay was agreed to. Specific methodology on marine contamination problems, research, monitoring, correction, and prevention is required. The problem has been joined and faced by specialized personnel with important financial investment.

Among them: National Fisheries Institute (INAPE), State Water Works (OSE), Oceanographic, Hydrographic and Meteorological Service of the Navy (SOHMA), Ministry of Transport and Public Works (MTOP), and municipalities.

2.2.6 Tourism

Beaches Program. The natural sandy beaches extending from Montevideo to the Brazilian border have fostered the development of important international tourist centers, Punta del Este and Piriapolis, among others. The total source of foreign currency derived from tourism is equivalent to 20 percent of the country's exports.

Priority has been assigned to the conservation and improvement of beaches through a UNDP/UNESCO program. Its objectives are to provide basic information on the natural factors which intervene in the constant modification of the coast and to establish the type of work that should be carried out for protection of beaches and harbors.

2.3 INSTITUTIONS DEALING WITH MARINE AND FISHERIES SCIENCES

A list of the principal institutions is given in Annex 2.

2.4 ASSISTANCE REQUIREMENT

Development Plan priority areas should be considered in relation to the national economy. Favorable results would be obtained through scientific and technological aptitudes development. These should be proportioned to the country's requirements, with possibilities to absorb and take advantage of the institutional structure, idiosyncracy, accessible resources, and development. Oil and heavy sands prospecting, fisheries development, tourism, and others are specific examples.

The oceanographic regime or continental shelf characteristics in the Southwest Atlantic system where sub-Antarctic waters (Falkland current) converge with subtropical waters (Brazil current), produce complex conditions, about which little is known. The contribution of the coastal waters of the Rio de la Plata with undefined limits, should also be added.

Specific requirements are summarized as follows:

<u>Marine Fisheries Resources</u>

a) Identification of new areas and fisheries resources through an evaluation program oriented toward squid, tunids, and other pelagic and demersal species.

b) New fishing methods and gear development to increase catches.

c) Personnel training on board and on shore.

Continental Resources

Pisciculture stations establishment in large dams areas.

To program pisciculture in 35,000 hectares of rice area and river banks. Research development in these areas should observe the contaminating effects (use of pesticides in rice paddies) and most important, personnel training programs.

Fish Technology, Research, and Development

a) Research program on fish products and by-products. Identification, inspection, and quality control methods for integral raw materials utilization.

b) Training programs through INAPE.

National Data Center

A national data center should be implemented to meet the needs of the country's technical staff to have readily available existing and future data on scientific research.

ANNEX 1

1. Centro Nacional de Datos Oceanograficos de Chile (CENDOC, 1968) Depende del Instituto Hidrografico de la Armada.

2. Comité Oceanografico Nacional, (CONA, 1971). Institucion oficial.

3. Instituto de Fomento Pesquero (IFOP, 1964). Depende de la Corporacion de Fomento de la Produccion.

4. Instituto Hidrografico de la Armada (I.H.A., 1874) Institucion oficial.

5. Pontificia Universidad Catolica de Chile. Laboratorio de Zoologia (1970). Institucion Privada, depende del Instituto de Ciencias Biologicas.

6. Universidad Austral de Chile. Instituto de Zoologia (1955) Institucion oficial, depende de la Universidad Austral.

7. Universidad Catolica de Valparaiso (U.C.V.). Escuela de Ciencias del Mar y de los Alimentos (1956). Institutcion Privada. Depende de la U.C.V.

8. Universidad de Concepcion. Instituto de Biologia (1924). Institucion Privada, depende de la Universidad de Concepcion.

9. Universidad de Chile (Sede Antofagasta). Institudo de Investigaciones Oceanologicas (1975). Institucion oficial, depende de la Universidad de Chile.

10. Universidad de Chile (Sede Arica) Instituto de Biologia (1975) Institucion oficial, depende de la Universidad de Chile.

11. Universidad de Chile (Sede Osorno) Depto. de Matematicas y Ciencias Naturales (1966) Institucion oficial, depende de la Universidad de Chile.

12. Universidad de Chile Depto. de Biologia - Facultad de Ciencias (1957). Institucion oficial, depende de la Universidad de Chile.

13. Universidad de Chile (Sede Valparaiso) Depto. de Oceanologia (1941) - Institucion oficial, depende de la Universidad de Chile.

14. Universidad del Norte (Sede Antofagasta) Departamento de Pesquerias (1960) Institucion privada, depende de la Universidad del Norte.

15. Universidad del Norte (Sede Iquique). Centro de Investigaciones Marinas (1975). Institucion privada, depende de la Universidad del Norte.

ANNEX 2

Instituciones relacionadas con las Ciencias Marinas y Pesquerias (URUGUAY)

1) Investigacion y ejecucion de proyectos.

- Instituto National de Pesca (INAPE)
- Servicio de Oceanografia, Hidrografia y Meteorologia de la Armada (SOHMA)
- Ministerio de Transporte y Obras Publicas (MTOP)
- Direccion de Hidrografia del MTOP (DHMTOP)
- Obras Sanitarias del Estado (OSE)
- Administracion Nacional de Puerto (ANP)
- Administracion Nacional de Combustibles, Alcohol y Portland (ANCAP)

Educacion

2) Organismos de Estudio y Ensenanza

- Universidad de la Republica (UR)
- Facultad de Ingenieria (FI)
- Facultad de Humanidades y Ciencias (FHC)
- Facultad de Veterinaria (FV)
- Museo Nacional de Historia Natural (MNDN)
- Instituto de Investigacion de Ciencias Biologicas (IICB)
- Escuela de Nautica y Pesca de la Universidad del Trabajo (ENP)

3) Coordinacion a nivel nacional e internacional

- Consejo Nacional de Investigaciones Cientificas y Técnicas (CONICYT)
- Comision Nacional de Oceanologia (CNO)
- Instituto Nacional para la Preservacion del Medio Ambiente (INPMA)
- Comision Adminstradora del Rio de la Plata (CARP)
- Comision Técnica Mixta del Frente Maritimo (CTMFM)
- Comision Nacional de Energia Atomica (CNEA)

MARINE SCIENCE AND TECHNOLOGY DEVELOPMENT IN THE IVORY COAST

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December 1980

1 - INTRODUCTION

Marine science and technology development in Africa has been recently discussed in Addis Ababa (Ethiopia) from May 5 to 9, 1980, through an ECA/UNESCO project.

Field consultants' missions have been organized in east and west African coastal countries, including the Ivory Coast.

The expected official reports will present the consultants' observations and recommendations. But this paper has been prepared to glance over the particular case of our country, the main constraints of marine science and technology development, and the eventual recommendations for foreign technical assistance.

2 - OCEANOGRAPHIC RESEARCH STRUCTURES AND TRAINING

Before discussing the difficulties of marine activities development in the Ivory Coast, it is useful to present the different existing marine studies structures of the country.

2.1 OCEANOGRAPHIC RESEARCH CENTER OF ABIDJAN

The center includes five laboratories and a computing service. The laboratories are in these areas:

- Chemistry
- Plankton
- Benthos
- Fishery Biology and Aquaculture
- Hydrology and Oceanic Dynamics

The research activities are linked to the previous structures and are conducted in the sea as well as in lagoons.

The corresponding programs may be listed as follows:

2.1.1 Sea Programs

- Coastal studies

- Temperature and currents measurement in the coastal waters of the Ivory Coast

- Rational stocks exploitation of the Ivorian continental shelf

  This program includes the following elements:

  - Biology and dynamics of *Balistes capriscus*
  - Trawlers, sardine boats and shrimp boats fishery statistics
  - Marine artisanal fishery statistics
  - Stock dynamics of the Ivorian continental shelf
  - Deep-sea shark *Centrophorus granulosus* study
  - Deep-sea red crab *Geryon quinquedens* study

- Circulation and production in the Atlantic equatorial zone

  This program includes:

  - Equatorial dynamics
  - Primary and secondary production in the Guinea Gulf equatorial region

- Rational exploitation of the Atlantic tunas

  The main studies of this program are:

  - Tunas larval and fecundity study
  - Tunas environment
  - Tunas statistics
  - Tropical Atlantic tunas population dynamics

2.1.2 Lagoon Programs

There are many concerted studies undertaken in the coastal lagoons.

A - Lagoon hydrobioclimate

This program is divided into five research activities:

- Lagoon hydroclimate
- Lagoon primary production

- Lagoon secondary production
- Lagoon benthic production
- Lagoon heterotrophy

B - Rational exploitation of the main lagoon species

The following studies have been realized or soon will be:

Biology and ecology of

- *Ethmalosa fimbriata*
- *Elops lacerta*
- *Tylochromis j. jentinki*
- *Tilapia guineensis* and *T. heudelotii*
- *Callinectes* spp.
- Lagoon populations synecology
- General dynamics of the lagoon exploitable stocks

C - Pollution consequences in the Ebrie lagoon

Four research activities may be listed:

- Modifications of the physical and chemical medium and their consequences
- Water's autopurifying power against organic matter
- Reducing bacterial flora and fecal pollution
- Pollution's influence on primary production

D - Aquaculture

The following activities have been scheduled:

- Breeding and hatching of *Chrysichthys walkeri*
- Feeding of *C. walkeri*

But for the short term, the research activities will be concentrated on the species *C. walkeri* and *C. nigrodigitatus* according to two points of view:

- Induced reproduction
- Growth improvement in breeding

2.2 LAGOON AND MARITIME FISHERIES DIRECTION

This service is tightly linked to the Oceanographic Research Center (ORC) by their complementary activities. Its main work is based on fishery legislation in the Ivory Coast, rational stock management from the statistics provided by the ORC, and on the control of the sea products landed in our country.

This service also takes interest in aquaculture development and has created fishing centers along the littoral.

2.3 MARITIME STUDIES, RESEARCH, AND DOCUMENTATION INSTITUTE (IDREM)

One of the many activities of this institute is to undertake a hydrocarbons pollution survey in the Guinea Gulf and mainly off the Ivory Coast.

2.4 MERCHANT MARINE SCHOOLS ASSOCIATION

This association has a regional aim and accepts students from the other West African countries in many sections: The hands training section, the deck officers training section (merchant fleets), the deck officers training section (fishing fleets), the engineer officers section (merchant and fishing vessels). For social promotion there is a certificate of competency in inshore nagivation and fishing, and a driving licence for 350-horsepower marine engines. There are several sections of the first school, Centre Régional de l'Enseignement et de l'Apprentissage Maritimes (CREAM).

The second school, Ecole Supérieure de Navigation also has several sections:

- Deck branch: The section of officers, foreign trade
- Marine branch: The section of first class engineers officers
The 2nd class engineer officers section
- Harbor officers section.

It may be interesting to know that the Regional Marine Science and Techniques Academy project of Abidjan is essentially based on the Merchant Marine Schools Association.

The previous description of the structure linked to the marine activities is just given for information, but nevertheless the following observations may be made:

1) The Ivory Coast is one of the West African countries where oceanographic research, fishing, and maritime activities are relatively well developed.

2) The main problems to be resolved are:

- The place of the sea in Ivory Coast development
- National manpower training
- Technology transfer

3 - THE IMPORTANCE OF MARINE SCIENCE AND TECHNOLOGY IN THE IVORY COAST DEVELOPMENT

This problem already has been discussed in our general UNESCO mission report concerning many other West African countries.

Nevertheless it is important to mention that most of the Third World contries and the ACP group, including the Ivory Coast, are convinced that their way of development passes also through the sea.

In other words, the developing countries are interested in the use of the sea in the proper way and according to the following aspects:

3.1 THE MARITIME TRANSPORTS

We cannot pretend here to formulate all the problems dealing with these activities because they require technical approaches which are outside our competence.

However, we should only mention that the Code of Conduct Convention adopted in Geneva in 1974 represents an important step for the maritime transports.

The distribution into 40-40-20 percent of the cargoes allowing every national companies group of two countries the external trade of which is concerned to offer 40 percent of the cargoes, the remaining 20 percent are to be negotiated with other interested countries. The best distribution would 50-50.

There are two problems linked to the Code of Conduct Convention: the real application of this convention, and access to credit facilities to buy ships.

3.2 MARINE RESOURCES EXPLOITATION

The preliminary condition of rational exploitation of marine resources is oceanographic research. For fishing products, the ORC and the Lagoon and Maritime Fisheries Direction are doing their best respectively to elaborate dynamics models for a rational stocks management and to provide fish.

Oil prospecting and exploitation also interest the authorities; but the main constraint is the cost of operation.

3.3 COASTAL TOURISM DEVELOPMENT

The touristic industry is becoming more and more important in the country, but on the other hand the marine environment also needs to be protected.

The West African Action Plan has been drawn for rational management of the marine environment and the adjacent coastal zones in each country.

4 - RECOMMENDATIONS FOR THE FUTURE OF MARINE SCIENCE AND TECHNOLOGY DEVELOPMENT IN THE IVORY COAST

1. Whatever marine activity is considered, the lack of national qualified manpower is evident.

One of the ways to resolve this problem is to provide scholarships and fellowships to guarantee a good training of the local scientists.

2. The strengthening in equipment of the research structures like the laboratories would be really useful in our country.

In this purpose we need a laboratory for the marine and brackish waters pollution study.

3. The strengthening of the existing computing service will also be helpful for data processing in the institute.

4. The oceanographic research activities are decreasing because there is no adequate research vessel especially for offshore surveys.

5. The Ivorian lagoon programs being relatively more developed in West Africa, there is a need of engines for small boats and field scientific equipment.

6. The other important problem is to find financing means for the research programs already described.

The Ivory Coast will be thankful to any country which can encourage its oceanographic research activities in providing financing.

5 - CONCLUSION

The development of marine science and technology of the Ivory Coast needs concrete technical assistance.

And we do hope that the U.S. cooperative assistance will be of benefit to the scientific communities of the developing world.

<u>MARINE TECHNICAL ASSISTANCE PROGRAMS OF NON-U.S. DONORS</u>

The four papers that follow were prepared by workshop participants who described the activities of Canada, Norway, Sweden, UNESCO, and the Inter-American Development Bank in marine technical assistance and cooperation. The papers were distributed at the opening of the workshop for use as background material.

INTERNATIONAL AID IN FISHERIES AND OCEAN SCIENCE AND TECHNOLOGY: A CANADIAN VIEW

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1. INTRODUCTION

This paper outlines the institutional and financial framework within which Canadian ocean fisheries and technology aid and assistance programs operate and the facilities and expertise that are drawn upon. It also describes the Canadian aid assistance strategy in fisheries and oceanography and those areas that receive priority treatment. Ongoing aid and assistance programs in fisheries and oceanography are described, and some of the problems that have been encountered are highlighted.

The paper concludes with a discussion of the developments in the international arena with respect to transfer of technology in fisheries and oceanography, Canada's past and present involvements in multilateral efforts and some thoughts on future trends and activities.

2. GENERAL FRAMEWORK FOR BILATERAL PROJECTS

2.1 Institutional Arrangements

In Canada, the principal mechanism through which aid and assistance programs are carried out is the Canadian International Development Agency (CIDA), which, as the name suggests, is an agency of the federal government. A substantial amount of Canadian technology is used and transferred in many of CIDA's bilateral projects.

Another institution through which aid and assistance programs are implemented is the International Development Research Centre (IDRC), which was established in 1970 by the Canadian Parliament.

It is noteworthy that federal government departments in Canada were, until recently, neither mandated nor encouraged to become directly involved with or to initiate international aid and assistance programs other than by virtue of participation in various international bodies, such as the Food and Agriculture Organization and the Intergovernmental Oceanographic Commission. However, scientist-to-scientist dialogue and occasional bilateral or multilateral workshops, seminars, or research programs are carried out.

In all there are four types of aid and assistance funded by Canada:

1. The bilateral projects administered by CIDA and IDRC.

2. Multilateral programs carried out under the auspices and management of United Nations specialized agencies, such as the Food and Agriculture Organization.

3. Special programs carried out through nongovernmental organizations.

4. Emergency relief programs.

Funding assistance is provided by means of grants, capital assistance, or a combination of both. Grants are used in sending Canadian experts to the field, training technicians and scientists, setting up fisheries and ocean science schools and institutes, providing scholarships and fellowships tenable in Canadian universities or research institutes, etc. Capital assistance, on the other hand, is given in the form of "soft loans" with liberal conditions governing repayment, such as low interest rates and long-term repayment facilites extending as long as fifty years plus a ten-year grace period.

2.2 Canadian International Development Agency

There are basically three requirements that have to be satisfied before a federal aid program is approved by CIDA:

1. It must be initiated by a formal request from the developing country.

2. The requesting state must qualify as a "developing country" or "less developed country" (LDC) as defined by the United Nations.

3. The areas of assistance must fall within one of the ten "sectors" that have been identified by a Canadian survey as those which can be matched with existing Canadian research and development expertise; "fisheries" and "environment" are two of these sectors.

In sum, through the technological elements of its bilateral projects and in particular through its technical assistance program, CIDA makes a substantial contribution in assisting the developing countries to build up their science and technology capabilities. In so doing, however, the agency has not chosen to apply to any significant degree Canada's domestic research and development resources. For example, of the 3,200 projects active in fiscal year 1977-78, only 28, mostly related to agriculture, had some research element. In those programs that had technolgical elements, the effort was directed at a buildup of science and technology (S&T) capabilities in developing countries and not the use of very significant elements of domestic research and development (R&D) resources.

The overall aid strategy as formulated by CIDA puts greatest emphasis on helping the rural poor. The fisheries sector is seen as a dual concept. Large-scale offshore and distant-water types of fisheries, while having repercussions on local food consumption, are mainly geared to broad markets and function out of urban centers. Small-scale inshore or inland fisheries, on the other hand, are viewed as a component of an integrated rural development scheme aimed at upgrading the standard of living of rural populations and not only to increase economic returns.

An indefinable but substantial amount of Canadian technology is used and transferred as part of many of CIDA's bilateral projects. The development of national infrastructures in the power, transportation, and communications sectors, the provisions of water and health services, and the improvement of national capabilities in the agricultural, rural development, and resource management fields, all involve to some extent the application of science and technology in the broadest sense.

In terms of bilateral technical assistance, CIDA disbursed $56.6 million in fiscal year 1977-78, which amounted to 5.4 percent of the approximately 1 billion dollars for official developmental assistance. Even more was contributed over the same period to the technical activities of the United Nations and other international multilateral organizations--$84.9 million or 8 percent of the total. This latter included $6.36 million to the chain of international agricultural research centers. Although no data are available, some Canadian S&T expertise will undoubtedly be used by these international multilateral organizations; none of the Canadian contribution, however, is tied to the use of Canadian resources.

CIDA has not considered it necessary to establish a focal point through which its many technical cooperative activities could be coordinated. All bilateral projects are managed by the appropriate program officer, who is assisted in the case of projects having an S&T element by a small, dedicated, and efficient group of resource advisers representing most major disciplines.

2.3 International Development Research Centre

The International Development Research Centre (IDRC) was established in 1970 by act of the Canadian Parliament "to initiate, encourage, support and conduct research into the problems of the developing regions of the World and into the means for applying and adapting scientific, technical and other knowledge to the economic and social advancement of those regions." It is unique, being a wholly funded national body yet a public rather than a crown corporation, which ensures a large measure of autonomy. Able to respond quickly and flexibly to project opportunities and with the bulk of its projects in and managed by the Third World, IDRC undoubtedly represents one of the most direct and innovative responses by an industrialized nation to the scientific needs of the developing countries.

Though funded exclusively by Canada, the center is governed by an international Board of Governors drawn from ten countries, of which six are developing countries. From its inception in 1970 until October 1978, the IDRC initiated over 800 projects calling for appropriations close to $143 million. Its budget, in grant form, has increased steadily; its 1978-79 budget was $36.9 million.

Simply stated, the role adopted to date by IDRC is to support research <u>for</u> the developing countries, <u>by</u> the developing countries, and <u>in</u> the developing countries. This is in line with the emphasis that the governing board places on the objective of "assisting the developing regions to build up the research capabilities, the innovative skills and the institutions required to solve their problems." Research grants have been made to 100 countries and have covered a wide spectrum of scientific fields with the emphasis being placed in the agricultural sector. This strategy, coupled with the Governors from developing countries, has given IDRC staff an extremely valuable knowledge of the scientific needs and environment of the Third World.

Although IDRC's concentration on supporting research within developing regions meets a major need, it has tended to restrict the center's use of the substantial expertise represented by Canada's scientific community. Research activities using Canadian performers represented only 5 percent of the center's expenditures in the natural sciences for fiscal year 1975-76, 6.4 percent in fiscal year 1976-77, and 3.7 percent in fiscal year 1977-78. This translates into participation by Canadian performers in about 54 projects.

Therefore, until recently the IDRC, although very effectively supporting the development of indigenous scientific capabilities and infrastructures within the Third World itself, was not committed to meeting demands to devote more of Canada's domestic research to problems of developing countries or to responding to their appeal for more collaborative research with Canadian scientists.

2.4 Federal Government Organizations

As stated above, the science and technology oriented departments and agencies of the federal government were, until 1979, neither mandated nor directly encouraged to become involved in international development other than as part of their membership in the various international bodies that address this area. In only one case--that of the Department of Agriculture--is international development listed among departmental objectives.

Some departmental resources are nevertheless used--almost exclusively by CIDA--to promote international development; typical activities are the acceptance of developing country nationals for training (including the provision of some actual training courses), the execution of resource surveys, expert advice to CIDA and above all, the provision of scientists, technologists, statisticians, and other experts for work in the Third World. With certain exceptions, however, this involvement is fully funded by CIDA and is still peripheral to the mainstream of departmental activities.

2.5 Other Sectors

As of December 1978, no fewer than 26 Canadian universities were involved in 91 CIDA projects, reflecting the agency's use of this resource for a wide range of international development activities. However, in terms of research projects (as opposed to the many individual studies undoubtedly carried out by Canadian university staff during involvement in other projects), universities were involved in only 8 of the 28 identified with the agency in 1977-78. The IDRC on the other hand, has used Canadian universities in 31 of the 54 natural sciences projects using Canadian performers.

There are only scattered examples of use of the research capabilities of the provinces and industry. The British Columbia Research Council was used in 1975 by IDRC for research on fish pituitary extract, Canadian industry designed and developed the cane-separating machinery that forms the keystone of the large CIDA Uplands Sugar Mill Project ($2.14 million in 1977-78), and the Department of Agriculture reported using private sector resources in two of its eight externally funded research projects undertaken in 1977-78 for developing countries. Though a more detailed analysis would probably identify more involvement, the examples above are indicative of the low level of participation of Canadian provincial and industrial resources in R&D for the Third World.

3. RESOURCES, PRIORITIES, AND PROGRAMS IN FISHERIES AND OCEAN TECHNOLOGY

3.1 Resources

The Department of Fisheries and Oceans is the leading government department capable of providing technical aid and assistance in the marine sciences. This expertise is available in

- fisheries conservation and management
- development of fisheries technology
- fish processing and marketing
- fisheries research
- marine pollution
- hydrographic charting
- ocean information services
- ocean engineering
- physical, chemical, and ecological oceanographic research

The department operates a wide variety of laboratories and a fleet of research vessels.

Other government agencies have expertise in management or research in more specific marine areas. These agencies include

- Department of Energy, Mines and Resources
- National Research Council
- Department of Transport
- Department of the Environment
- Department of Public Works
- Department of Indian and Northern Affairs

Responsibilities of these agencies range from offshore resource management to coastal protection.

In most cases, assistance from government agencies has been at the expense of their own programs, even though additional expenses and overheads incurred may have been covered by the central aid funds.

In addition to the federal resource, there are many other excellent sources of expertise and technology in Canada, including provincial governments, universities, institutions, and the private sector. These sources are available through the mechanism of contracts or grants. The fisheries industry in particular is very strong.

3.2 Priority Areas and Overall Aid Strategy

As a coastal state with an enormous continental shelf and borders on three oceans, Canada has a very strong interest in fisheries and oceans. For this and other reasons, we have been actively involved in the evolution of international and national marine law culminating in the United Nations Conference on the Law of the Sea negotiations. As a coastal state, we are anxious to enhance the control and production of our offshore resources, sharing many of the concerns of LDCs. The imminent 200-mile exclusive economic zone (EEZ), while affording control over national offshore resources, will also force many LDCs to reorient their priorities in order to manage these resources soundly and effectively.

In Canada, CIDA has formulated guidelines for fisheries assistance and has categorized assistance activities as "high" or "low" priority according to current Canadian capabilities for providing assistance. The high-priority activities are

- resource management
- fish marketing and distribution
- education and training
- institution building
- preparation of integrated fishery expansion programs
- use of unexploited and underexploited species
- improvement of quality of fish and fish products
- promotion of breakthrough
- research programs undertaken by IDRC and other research organizations

The low-priority activities are

- education and training at postgraduate levels
- distant-water fisheries
- tropical aquaculture
- fundamental research
- some international fisheries such as tuna, shark, reef, and coral fish

An FAO-sponsored Technical Conference on Fishery Management and Development, which Canada hosted in Vancouver in 1973, arrived at a set of recommendations based on areas of most urgent needs in the fisheries sector of LDCs. These were

- stock management
- research
- training
- elimination of waste
- aquaculture

Although these areas of need are similar to the present CIDA priorities, there are distinct differences between the two lists.

3.3 Canada/Peru Cooperative Study - A Good Example

Notwithstanding the above, there are as yet relatively few Canadian aid programs devoted to fisheries and virtually none to oceanography. One notable exception was the cooperative Peruvian and Canadian research study of anchovy, which involved both oceanographic and fisheries research. The Peruvian anchovy represents a major economic resource to the country. The fishery, however, is dependent upon nutrients brought to the surface by an upwelling system near the coast. The fishery started to decline in 1972 because of the weakening of this system (the El Nino phenomenon) and because of overfishing.

In order to investigate the relationship between the biology of the anchovy species and the upwelling, a cooperative research project was funded by CIDA involving the Institute del Mar del Peru (IMARPE), the Bedford Institute of Oceanography, and Dalhousie University.

In 1977, the Canadian research vessel <u>Baffin</u> cruised Peruvian waters researching, together with Peruvian scientists, the food-chain dynamics and behavior of anchovy and competitive species. The resulting raw data were analyzed during 1978 at the Bedford Institute.

Apart from valuable data regarding the Peruvian anchovy, evidence of other fish resources of practical value has been developed, a seawater aquarium for study of marine organisms has been established at IMARPE, and a great deal of valuable training and experience has accrued to mutual benefit.

Many valuable lessons were learned from this program. The participation from both sides was fairly well balanced (49 scientists and technicians from Canada, 36 from Peru). The overall objective was to enable Peruvian scientists to improve their predictive model of the anchovy fishery; at the same time, the Canadian scientists gained a firsthand look at one of the world's most productive areas in collaboration with local experience. Much of the behavioral work was done ashore and the enhancement of the local research facility was an integral part of the program.

4. PROBLEMS ASSOCIATED WITH ASSISTANCE PROGRAMS

Canadian experience with aid and assistance programs has identified a number of problems and constraints. Some of the problems are associated with the recipient countries, and some are internal.

4.1 Lack of Recognition of Marine Sciences

Although agriculture and food production are high among Canada's aid priorities, the natural sciences are not. It is difficult therefore to make Canada's expertise in physical, chemical, biological, and environmental oceanography available to developing countries through bilateral channels. It is of interest to note that the developing countries themselves are becoming aware of the need for an adequate national scientific infrastructure as a necessary component of a healthy social and economic environment. It is to be hoped that this message will be received and acted upon by the funding agencies in the near future. However, pressure will be required from the developing countries themselves to force donor countries to amend present priorities. It is of interest to note in this regard that recent resolutions have been submitted at the United Nations and its agencies by LDCs urging recognition of these points.

4.2 External Problems

Of the problems external to Canada, many are those that would be expected to arise between countries of differing cultural, political, and developmental situations. They can be overcome only through experience, diplomacy, and patience by both recipient and donor. Problem areas include the following:

- cultural differences
- educational standards
- managerial standards
- availability of data
- commercial trade restrictions
- political constraints
- technological capabilities

4.3 Internal Problems

There are also internal constraints on transfer of technology because of the format or the lack of flexibility of present priorities and mechanisms.

The Canadian government has recognized the need for a permanently established, ongoing effort and, consequently, has begun to budget for this effort from fiscal year 1981-82 onward. The government has also encouraged departments to devote some of their own budgets and resources to aid programs. It has to be recognized, however, that changes in government programs take place over extended periods. An ability of departments to respond to LDC requirements on a continuing basis will prove highly beneficial. Up to the present, requests for aid tended to come on short notice and to conflict with planned national projects. Scientists involved often had to shelve their own projects in favor of one of lesser scientific interest. The lack of an ongoing aid program therefore had a disruptive effect on the national marine science program.

Although priorities are necessary in general, flexibility is required so that valuable aid opportunities are not lost. For example, although a bilateral aid program could be justified by present priorities to assist in crop enhancement in the Ganges Delta, no program can be approved for the storm surge problem that has frequently decimated the population and the economy of the area.

In cases where an ad hoc assistance project has been completed, very little can be done to ensure that the lessons learned are applied. Experience has shown that after the initial push, the project quickly grinds to a halt unless some form of continuing direction can be arranged. Again, this illustrates the need for long-term planning and budgeting.

5. RECENT DEVELOPMENTS

5.1 Law of the Sea

The new law of the sea is already having a profound effect on fisheries development and the transfer of marine technology, even though the conclusion of a treaty is not yet accomplished. The new law provides opportunities for developing coastal states to gain access to advanced technology for development of their ocean resources, but not without some difficulties.

The implications of Part XIV of the informal text of the draft convention on the law of the sea are well known. However, the importance of the time factor could be reemphasized here. Management, technology, and science must be transferred within a time frame that allows developing countries to use this assistance to their advantage. There is a danger in a country's feeling compelled to draw upon its ocean resources in the short term and being forced to enter into nonbeneficial contractual arrangements in return for the necessary expertise. Again, in areas of shared continental margins, unfair advantages may be taken of countries possessing little expertise in marine matters.

As part of the follow-up to the Third U.N. Conference on the Law of the Sea, a major international initiative is under way within the United Nations to identify needs for training, education, mutual assistance, and transfer of related technologies to developing countries.

Bernardo Zuleta, special representative of the Secretary General to the Third United Nations Conference on the Law of the Sea, is spearheading this program through various U.N. organizations, including the Intergovernmental Oceanographic Commission (IOC) and the Food and Agriculture Organization (FAO), both of which have had a continuing program in training and education for many years. The need to reemphasize and redeploy resources into this increasingly important problem area has resulted in a substantially closer working relationship between donor and recipient countries.

5.2 United Nations Agencies

Increased membership by developing countries within the United Nations system has led to a transfer of power within the various governing bodies and thereby to a change in emphasis of programs and activities. Developing countries, recognizing their lack of technology and expertise, are influencing most decisions to accommodate their requirements. Developed countries, although for the most part contributors to the agency budgets, have nevertheless been forced to accept a certain loss of influence.

5.3 Canadian Developments

A significant Canadian involvement took place through a multilateral project on fisheries--the CIDA/FAO/CECAF Seminar on the Changing Law of the Sea and the Fisheries of West Africa. The seminar was organized by the FAO Committee for the Eastern Central Atlantic Fisheries (CECAF) Project, and financed entirely by Canada through CIDA. It was held in Banjou, Gambia, in September 1977. Fifteen CECAF member countries participated. The delegates included senior officials with fisheries and legal backgrounds from the fifteen CECAF member countries as well as Canada and other observer countries. The seminar dealt with the legal and institutional aspects of fisheries development and management in the West African fisheries against the backdrop of the emerging international law of the sea.

The approach used by FAO, which was agreed to by Canadian officials, was to organize a forum for discussion of common problems and for jointly seeking common solutions rather than simply holding a training seminar.

The FAO is in the process of organizing a global, all-encompassing multilateral project aimed at assisting developing countries in the management of their exclusive economic zones. Canada is expected to assume a lead role in providing technical expertise and possibly financial assistance.

Canada's Ministry of State for Science and Technology and the Department of External Affairs have considered ways and means whereby a more meaningful assistance effort can be realized. Multilateral discussions such as the above meeting and the present La Jolla workshop held by the U.S. National Research Council's Ocean Policy Committee prove a valuable source of information and guidance.

6. NEW DIRECTIONS

6.1 Possible Actions

A rather obvious and direct way of satisfying the aid and assistance requirement is through participation in U.N. programs. Taking the IOC as an example, the marine science requirements of the developing countries are coming clearly to the surface within the commission simply because these countries now are in a majority. Their wishes must be heard. Yet their demands can be tempered by the views of the developed countries as expressed in the debates that accompany the formulation of new resolutions and programs. By participating in agreed upon programs and by earmarking funds for their support, countries such as Canada could be seen as being forthcoming in the provision of assistance. To show our dedication to the cause, we would have to make our marine science facilities much more readily available for training and educational purposes.

However, only by recognizing this assistance as an ongoing effort that requires continuing funding could a credible contribution be made to the problem.

Another possible direction could be the establishment of an international center designed specifically for the transfer of fisheries and ocean technology. If the center were adminstered by a nongovernmental management (thus retaining its autonomy, although obviously budgeted from national sources), it could undertake the administration and organization of aid programs in this area on its own behalf or on request from international or United Nations agencies.

Before arriving at a post-Law of the Sea period and formulating policies, a serious look must be taken by donor countries at their aid priorities. These priorities will differ from country to country depending on the respective political, economic, and geographical factors involved.

6.2 Canadian Initiatives

A recent study by the Ministry of State for Science and Technology (MOSST)* recognized the need for an increased role for R&D in aid programs and recommended, inter alia

- Current Canadian policy related to scientific and technological activities in support of the Third World should be expanded to mandate and encourage, within the framework of the nation's international development program, the application of Canada's domestic R&D resources to the solution of problems of the developing countries.

- Such Canadian resources should, where at all possible, be applied through cooperative or joint R&D ventures together with appropriate organizations within selected developing countries or regions with the aim of enhancing the indigenous capabilities of those nations.

- A deliberate strategy should be followed that will ensure the best possible match between the selection of developing country problems to be addressed and areas of Canadian R&D competence of domestic value and importance.

These recommendations were accepted by the Canadian government and announced at the U.N. Conference on Science and Technology for Development. As applied to fisheries and oceans technology, this strategy would enable developing countries to have access to the expertise in Canada, enable Canada to respond more effectively to the

*Cooperative International Development Research: Towards an Enhanced Application of Canada's R&D Expertise to Problems of the Developing Countries - MOSST Report, June 1, 1979.

post-Law of the Sea regime, and ensure maximum benefit for both recipient development countries and Canada's domestic R&D effort.

The study also recommended the use of IDRC as a focal point for the application of Canada's domestic R&D to the solution of the problems of developing countries and recommended an increase of funds to IDRC for this purpose. Again, IDRC has accepted the invitation of the Canadian government and the plan is now being implemented. Now that a more encompassing mandate has been established by government, the Department of Fisheries and Oceans will be able to bring its capability in the marine sciences more directly into the international aid arena. This initiative will also influence the directions and priorities of the larger bilateral programs toward ocean applications. The Canadian National Research Council has already announced the establishment of an office to facilitate the R&D programs within that agency on behalf of the Third World.

Canada is a coastal state with great ocean resource potential. It has taken a similar position to that of developing countries on many questions at the Law of the Sea Conference and has no large maritime or far-sea interests. It is also a major ocean science and fisheries power with a high level of marine research and technological expertise. It therefore enjoys the confidence of a wide range of countries in terms of technological transfer and, as demonstrated by the strategy adopted at the United Nations Conference on Science and Technology for Development, is attempting to respond realistically to the new regime and to work toward a union of the diverse needs and requirements around the globe.

In the preparation of this paper, officials of Canadian government departments and agencies, as well as several published and unpublished government documents were consulted. The opinions expressed, however, are entirely those of the authors and are not intended to reflect any official positions of the government of Canada.

ANNEX

Summary of Programs and Projects as of October 1980

1.	Number of Projects	30
2.	High Fisheries Content	14

3. Current Status

(a)	Planning Stage	14
(b)	Implementation Commenced or Fully Under Way	10
(c)	Temporarily Held in Abeyance	5
(d)	Extended Beyond Original Plan	1
(e)	Program under Review	1
(f)	Terminated	None

4. Form of Financial Assistance

(a)	Grants	28
(b)	Part Grant/Part Loan	2*
(c)	Loans	None

*(i) The Modernization of Artisanal Fisheries Project - Cameroon
(ii) The Motorization of Native Fishing Crafts Project - Senegal

5. Breakdown of Recipient Countries in Terms of Geographic and Regional Location

(a)	Francophone Africa:	Cameroon - 1; Senegal - 4; Total - 5.
(b)	Commonwealth Africa:	Ghana - 2; Regional CECAF - 1; Total - 3.
(c)	Asia:	Sri Lanka, Indonesia, Malaysia, Philippines and Thailand - 1 each; Regional (ASEAN) Project in Post-harvest Technology - 1; Total - 6.
(d)	The Americas:	Colombia - 3; Barbados - 1; Brazil - 2; El Salvador - 2; Guyana - 3; St. Lucia - 2; Peru - 2; Regional (WECAF) - 1; Total - 16.

INTERNATIONAL COOPERATION IN MARINE SCIENCE DEVELOPMENT

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INTRODUCTION

The purpose of this paper is to demonstrate the present dynamic development of marine science in the world today and the desirability of marine-related cooperation between developing and developed countries. The purpose of this international workshop is to promote such cooperation with special reference to the United States. The final section of this paper contains recommendations to this end, but they are also intended to refer in general to other developed countries in similar circumstances.

National marine science development is now a matter being considered by all governments at the highest levels. This results directly from negotiations under way at the Third United Nations Conference on the Law of the Sea (UNCLOS). As presented in the Draft Convention on the Law of the Sea (Informal Text), nations would assume major national responsibilities regarding management of the marine resources and environment which cannot be discharged without adequate marine science manpower and infrastructure. These national responsibilities carry with them simultaneously regional and international responsibilities.

Superimposed on these UNCLOS considerations are other national requirements for management of the marine resources and environment.

Most developing coastal states of the world are considering the priority of marine science development. Many of these have been able to transform a high priority into actual allocation of resources. The result has been a dramatic acceleration of marine science growth in developing countries, for both basic and applied marine science.

In the developed countries, the situation seems to be different but also characterized by change. Here the basic marine science seems to have reached maturity and is in general no longer growing. However, there is distinct growth in applied marine science, either by allocation of new resources or reallocation of existing resources. Examples of such growth areas are offshore oil exploitation and marine environmental protection.

Although national development of marine science is necessarily a national exercise, marine science itself is international in nature. This stems from the need to pool data and knowledge from all relevant sources.

The terms "science" and "technology" represent concepts that can be applied successfully to development only if used in suitable ways. The merging of these terms is causing serious confusion. The dictionary defines science as a branch of study concerned either with a connected body of demonstrated truths or with observed facts systematically classified and more or less colligated under general laws. Thus science is a body of knowledge, and the scientific method of research is a highly systematic pursuit of new knowledge.

Scientific research has a spectrum of objectives between its pure and applied ends. Basic science is undertaken to satisfy the need to find the answer to a problem about an unknown aspect of nature. Such investigations result in the accumulation of scientific data and information that are not required to have an immediate application; but much information derived from pure science forms the foundation on which applied science is built. Applied science is the application of scientific methods and data to the solving of specific practical problems. Technology is, according to the dictionary, the means of realization of the objectives of applied science. It is further used to encompass the totality of the means used to provide the objects and services needed by society. UNCLOS itself was unable to arrive at a definition separating basic and applied science.

MARINE SCIENCE DEVELOPMENT AS A DYNAMIC PROCESS

The process of marine science growth is not a recent phenomenon. What is new is the dramatic growth in developing countries and the high political visibility of marine science. A significant aspect of this political visibility is that marine science is not generally a political problem in the iternational affairs of nations, notwithstanding the UNCLOS debates on marine science research. Within other U.N. bodies such as UNESCO and its IOC and UNEP (United Nations Environment Programme), nations find cooperation in this field easier than in most others because of very strong common interests.

1. Oceanography is an interdisciplinary science covering all aspects of the marine sciences: physical, chemical, geological, and biological.

2. The oceanographic community has grown rapidly over the years as measured by directories prepared in part with SCOR (Scientific Committee on Oceanic Reseearch):

Year	Number of marine scientists	Number of countries represented
1950	750	48
1955	1,355	60
1960	2,265	79
1964	2,563	93
1970	5,740	91
1975	11,000	130

In the 1977 FAO/IOC International Directory of marine scientists (actually status of 1975), the 11,030 scientists had the following characteristics:

(i) Leading countries:

USA	2,916
Japan	1,091
UK	861
Canada	669
USSR	661
FR. Germany	513
France	425
Norway	304
	7,395 = 67.0% of total

(ii) Developing countries = 2,119 = 19.2% of total (note: about equal to all of world's oceanographers in 1960)

(iii) Leading developing countries:

India	422
Mexico	299
Brazil	273
Chile	190
Thailand	123
Indonesia	102
	1,409 = 66.5% of developing countries = 12.8% of total marine scientists

The rate of growth of the marine scientific community has been roughly a doubling every five years, except for 1960-64. There is no reason to suspect that this rate has changed although the composition of that community will change. Certainly growth in the developed world is continuing and will certainly continue over the next decade, though differently from region to region. As mentioned, present growth in the developed world is probably in the applied fields.

Another measure of growth and one of official national priority is that represented by national development projects funded by UNDP, self-benefiting funds-in-trust, international bank loans, etc.

UNESCO has been entrusted with the execution of numerous extrabudgetary marine science projects for the development of national laboratories, graduate schools, scientific manpower, research programs, etc. The role of the Division of Marine Sciences is to provide technical and intellectual back-up to other divisions associated with the daily execution of the projects (such as the Science Operations Division); such technical back-up includes project formulation, evaluating experts, specifying equipment, evaluating progress. It is emphasized that the funds involved (UNDP, self-help funds-in-trust, bank loans, etc.) are totally devoted to the objectives of the specific project for the benefit of the country concerned. The funds-in-trust (FIT) projects are particularly indicative of the high priority placed on marine science development of nations, because they have chosen to allocate their own national funds to this purpose. Most of the projects have grown out of regular program activities of the division and the IOC. Other extrabudgetary projects have been developed on a regional or global basis with UNDP and UNEP.

The growth of the Division of Marine Sciences since 1971 is shown in the following table. Note that in late 1972, the IOC Secretariat was established as a separate unit; before that time, the two units were amalgamated in the Office of Oceanography.

Several points should be noted:

- The regular program budget of the Division of Marine Sciences for activities has increased somewhat in 1973 constant dollars per biennium.

- The extrabudgetary marine science development program approximately doubled per biennium since 1973, despite the 1976 UNDP fiscal crisis.

- The increase in the 1979-80 extrabudgetary program is fivefold over 1977-78.

The program of the marine sciences in UNESCO (excluding the IOC[1]) has changed during 1971-80:

Biennium	Approved budget for activities (Div. Marine Sc.)	Budget increase over previous biennium[2]	Extrabudgetary development projects funds	Extrabudgetary development projects number
1971-72	$491,000	7.5%	$480,000	-
1973-74	$567,000	13.4%	$600,000	10
1975-76	$733,000	22.6%	$1,200,000	8
1977-78	$885,000	17.2%	$2,000,000	13
1979-80	$1,249,000	29.1%	$11,000,000	23
1981-82	$1,588,000	27.1%	$15,000,000[3]	-

[1]The IOC regular program budget for activities is approximately equal to that of the Division of Marine Sciences.

[2]The budget increase includes adjustments for inflation, depreciation of the US$ and some real increase for the marine science program.

[3]Extrabudgetary projects already anticipated for 1981-82.

EXISTING PROJECTS

	<u>AFRICA</u>	
1981 - 1981	UNDP UNESCO/ECA: (RAF/78/024) Development of marine science and technology in Africa (preparatory phase)	US$ (100,000)
	<u>ARAB STATES</u>	
1981 - 1982	<u>Libya</u>: (FIT) Strengthening of marine fisheries research center, Tripoli	825,000
1981 - 1984	<u>P.D.R. Yemen</u>: (Islamic Development Bank) Establishment of an Institute of Marine Sciences and Marine Resources in the P.D.R. Yemen	1,368,000
1981 - 1982	<u>Egypt</u>: EGY/73/058 Aquatic Pollution Centre, University of Alexandria	194,000
1981 - 1981	<u>Algeria</u>: (ALG/75/039) UNDP) Assistance au dévelopment des recherches océanographiques et des pêches	20,000
1981 - 1984	<u>Iraq</u>: (FIT) Establishment of the Marine Science Centre at Basrah	2,597,000
1981 - 1982	<u>Qatar</u>: (FIT) Oceanographic research vessel (preliminary design)	20,000
	<u>EUROPE</u>	
1981 - 1981	UNDP <u>Greece</u>: (GRE/77/005) Institute of Oceanography and Fisheries Resources	214,000
1981 - 1982	<u>Turkey</u>: (TUR/76/014) Marine Sciences	145,000
1981 - 1981	<u>Portugal</u>: (POR/77/016) (in cooperation with SC/HYD Environmental study of the Tejo Estuary	69,000
	<u>ASIA</u>	
1981 - 1984	UNDP <u>Thailand</u>: (THA/78/021) Improvement of marine science education	362,000

1981 - 1981	Indonesia: (INS/72/038) Marine Science Research	5,000
1981 - 1982	Burma: (BUR/74/017) Marine Science Teaching	1,105,000
1981 - 1981	Asia Regional (UNDP) (RAS/79/002) Training and research program on the mangrove ecosystem (pilot phase)	5,000
	LATIN AMERICA	
1981 - 1983	Cuba: (CUB/80/001) Investigation and control of marine pollution	US$ 836,000 (UNDP) 200,000 (UNEP)
	Mexico (FIT)	
1981 - 1981	Development of physical oceanography	70,000
	GLOBAL	
1981 - 1982	UNESCO/UNEP Working Group on a Review of the Health of the Oceans	60,000
	ANTICIPATED PROJECTS	
1981 - 1985	Oman (FIT) Marine Science	7,900,000
1981 - 1982	Kuwait (FIT) Design of Oceanographic Ship	250,000
1981 - 1982	United Arab Emirates (FIT) Marine Resources Centre (follow-up)	21,000,000
1981-1982	Qatar (FIT) Oceanographic research vessel (follow-up)	1,500,000
1981 - 1983	Libya (FIT) El Fatah University Marine Science Centre	3,200,000
1981 - 1982	Kuwait Action Plan (UNEP/regional organization)	1,000,000
1981 - 1984	Somalia (Bank Faculty of Marine Sciences	2,900,000
1981 - 1983	UNESCO/ECA (UNDP) Africa marine Science (follow-up)	2,000,000
1981 - 1985	Asia Regional (UNDP) (RAS/79/002) Training and research program on the mangrove ecosystem (implementation phase)	4,000,000

THE INDIVIDUAL MARINE SCIENTISTIS

Development of marine science on a long-term basis must promote the scientific productivity of the individual scientist. The three greatest problems facing a scientist in a developing country are isolation, lack of resources, and personal problems related to scarce resources. A system for overcoming these problems for the individual scientist can be envisaged as follows. Some components exist to some extent, others are conspicuously absent. Probably the greatest lack is the first item: a well-endowed international science foundation.

1. Provision of research funds through an international science foundation.

There is no international equivalent of, for example, the U.S. National Science Foundation, from which scientists in developing countries can obtain adequate research support. In most developing countries, national authorities place research support on an understandably low priority relative to critical immediate needs.

2. Provision of communication facilities and funds for linking networks of scholars on a problem-oriented basis.

These scholars can be linked via, for example, telex machines and telephones where most communications costs and all foreign exchange costs (often 50 percent of the total) could be funded by international grants. The scholars in each network would be encouraged to make liberal use of the communications channels. Extensive use of computer-conferencing would be encouraged also.

3. Provision of access to computerized bibliographic information and data services.

The scholars in the developing world are isolated from existing pertinent scientific references and data needed to carry out their research. Through direct telex and other links to designated centers, the scholars could make requests for specific information and searches. The centers could then interrogate by computer (or other link) appropriate bibliographic services (such as through DIALOG), information services (such as ASFIS and MEDI), and data services (such as the IODE centers).

4. Provision of (or provision of access to) major computer services, directly linked to scholars by remote computer terminals.

This will provide the scholars with the computing power needed to tackle modern research problems.

5. Provision of salary supplements to scholars so that they need not take inappropriate positions or have to take second, moonlighting jobs that prevent them from carrying out scholarly work.

6. Assurance of publication of scholarly works and their global distributions.

7. Provision of fellowships and problem-oriented training courses.

MARINE SCIENCE DEVELOPMENT THROUGH THE U.N. SYSTEM

The United Nations organizations constitute a system set up by the nations of the world so that they can mutually cooperate. Thus, this system is at the disposal of all the member states of all of the separate U.N. organizations to assist one another cooperatively in developing and managing the marine resources on both a national and global scale. After the Third United Nations Conference on the Law of the Sea finishes its work, the nations of the world will implement that outcome, whatever its form might be, through the existing U.N. organizations and any new bodies that might be formed. Another relevant conference is the recent United Nations Conference on Science and Technology for Development, Vienna, 20-31 August 1979. What is new is the recognition of the importance of marine science matters at high political levels and, furthermore, recognition at these levels of the need for the necessary manpower and infrastructure to develop and manage marine resources, both in developing and developed countries.

At the present time, there are many U.N. organizations that deal with these matters in a coordinated and cooperative way parallel to roughly analogous ministeries within each member state. The activities of the organizations reflect the governmental inputs into these organizations. Concerning the marine resources, many agencies have been charged with applied aspects. Through UNESCO, member states cooperate to ensure that the scientific basis for applications is strong with the concomitant development of the necessary manpower and infrastructure. The member states, through the United Nations Development Programme, provide funds for development on the basis of priorities determined by the individual member states themselves.

Marine science is both a discipline and a tool. It is an essential component of any system involving development and management of marine resources and the marine environment. This is firmly recognized within the U.N. organizations.

What does this mean in terms of the scientist or administrator who is charged by his government with the development and management of coastal and offshore resources? At the simplest level, he can take advantage of the diverse programs already existing within the many U.N. organizations that may be relevant to his particular task. The exact means of taking advantage varies from country to country. It must be realized that the U.N. organizations are governmental organizations and hence all the activities are governmental and so tend to be executed through governmental channels. On the other hand, the scientist or administrator can help shape the programs of the organizations themselves. This requires that he assist and convince his own government to set a high priority in this field. It is then necessary for the appropriate delegation of that government to take this to the governing body of a given U.N. organization and convince it, in turn, to give high priority in this field. Probably every government handles its formulation of planning activities in different ways. Nonetheless, the fact remains that a given U.N. organization can execute only that program which the member states have decided upon. The official channels for communication regarding different U.N. agencies often reside in ministries of a given government, and national delegations to a given U.N. organization often reflect the relevant national ministry.

Building Strength through Promotion of Marine Sciences

UNESCO, through the Division of Marine Sciences and the Intergovernmental Oceanographic Commission, helps nations to develop their marine science capabilities through a variety of mechanisms under its Regular Program. Five examples should suffice to show how this is done.

Building strength through catalytic activities--the Arab/African example

The development of marine science in Arab countries and in Africa is limited by a severe lack of trained manpower, both to perform scientific research and to inject the necessary policy elements at high official levels. However, the Third U.N. Conference on the Law of the Sea has injected a political awareness at that policy level. As a result of national reevaluations and UNESCO's catalytic actions, many countries in these regions have embarked on major projects to build marine science capacity.

The Mexican example

Ever since the Division of Marine Sciences (then the Office of Oceanography) and the Intergovernmental Oceanographic Commission came into being, Mexico has been an active participant in their program. Small catalytic activities, such as study and travel grants, fellowships, expert advice, and provision of critical equipment helped Mexico both to participate and to build up her marine science expertise and infrastructure. The technical assistance program with UNESCO began on a small scale in 1963 and has built to its present culmination. New Mexico has a vigorous research program of international recognition, both applied and basic, in several institutions, and is producing marine scientists at the M.S. and Ph.D. levels.

Building strength through research on ecosystems important in developing countries--the mangrove example

The mangrove environment is a ubiquitous and important coastal environment for tropical developing countries. The scientific skills and techniques developed to study the marine aspects of mangroves are in large part also applicable to offshore waters, as well as are a suite of research results. In 1978, a meeting in Asia examined the human uses of the mangroves. The meeting results plus results from research projects supported in Southeast Asia in earlier years plus national projects and meetings, such as those of Thailand, plus scientific analyses made with the international scientific community, plus a comprehensive bibliography led to an Asian symposium and workshop in 1980 which examined thoroughly the scientific aspects of the mangrove within the context of man's activities and produced recommendations for national priorities for research, regional cooperation, conservation, and infrastructure development. This is being done within the context of the Man and the Biosphere Program. In the meantime, UNDP has indicated a commitment to supporting a large-scale regional research and training program on mangroves beginning in 1980. The Asian experience is being applied to Latin America, and in general ways to Africa and the Arabian area.

Building strength through individual national characteristics--the Indonesian example

Individual countries are assisted, at their request, especially when the slender means available are likely to catalyze larger efforts, an example of which is Indonesia. Indonesia has the largest coastline of all developing countries and is one of the last equatorial or tropical areas of the world where significant oceanographic research is yet to be accomplished. The Indonesian marine science capacity is growing. A truly great oceanographic expedition and survey was carried out in these waters nearly 50 years ago (1929-31) by the Survey Ship Snellius. UNESCO and Indonesia are working together to use the 50th anniversary of the Snellius Expedition as a means of attracting international assistance to build Indonesia's marine science capacity and at the same time allow her to make a major contribution to science with her scientists working together with foreign colleagues.

Building strength through fellowships

National scientific competence is improved through fellowships to scientists on a competitive basis using applications submitted through governments and through direct requests.

UNITED STATES AND MARINE SCIENCE DEVELOPMENT

The influence of the United States on marine science development cannot be underestimated. As the nation with the world's largest marine science establishment, it provides an example for development on one hand, and provides a significant amount of the present marine science knowledge and technology on the other. As the United States is an important contributor to the budgets (25 percent) of the U.N. agencies and programs such as UNDP (U.N. Development Programme) and UNEP, it indirectly assists developing countries to develop their marine service capabilities and their cooperation with developed countries. U.S. marine science expertise is welcomed in most countries, and U.S. technology is highly appreciated. Complementarily, there is a strong willingness in general for the U.S. marine science establishment to cooperate with counterparts in developing countries. The protracted UNCLOS negotiations have somewhat eroded that willingness but its presence is still clearly seen.

Unhappily, that influence is weak in the U.S. marine science bilateral aid or cooperation programs. The National Academy of Sciences as well as several federal agencies have only embryo programs: National Science Foundation, State Department, National Oceanic and Atmospheric Administration (including the International Sea Grant Program), and the Defense Department. The major agency with a mandate in this field, the Agency for International Development (AID), has done comparatively little.

To this observer, the situation appears as follows. The executive branch, except for AID, is basically convinced of the worth of such programs. The participants of this workshop certainly perceive that worth. However, Congress has been reluctant to allocate funds (hence part of the reluctance of AID) for the lack of a vocal and effective constituency. According to this view, the problem of developing a well-funded cooperative program in the United States lies in convincing the U.S. voters that the effort is necessary. This is a task that should be undertaken as a first priority.

There are several reasons to believe the effort is necessary:

- Developing countries are major trading partners of the United States and are major sources of raw materials. This interdependence is likely to increase with time.

- The United States sees itself as a global power.

- There has been a keen interest in the sea by the U.S. public.

- Most of the necessary structural executive mechanisms already exist.

- Marine science is a relatively uncontroversial field for international cooperation (especially after UNCLOS closes).

- Such cooperation is necessary for the long-term marine science strength of both partners.

- This cooperation will contribute to improving cooperation in more difficult areas.

As in all public support for science, an appeal must be made to the aesthetic and idealistic instincts of the public as well as to the practical implications of the science.

Part of the question of votes has to do with the U.S. public's perception of the U.N. system and of developing countries. There are highly successful, low-profile cooperative programs in U.N. agencies and there are equally highly controversial, very visible programs in which extreme statements are common. Unfortunately, the public is most aware of the latter. An effective program of public information on the other cooperative programs, such as in marine science, would help to balance the picture.

The 21st General Conference of UNESCO met in Belgrade, Yugoslavia, from 23 September to 28 October 1980. As a follow-up to the United Nations Conference on Science and Technology for Development, this General Conference highlighted the science program of UNESCO. Of the proposed science programs, that of marine science was one of the most highly recommended. The delegates paid special attention to three aspects: (1) the major regional project on research and training leading to the integrated management of coastal systems, of the Division of Marine Sciences; (2) the climate and ocean project of the IOC; and (3) the need to strengthen the relevant program of UNESCO and the IOC in order to meet the needs of the member states relative to the Third U.N. Conference on the Law of the Sea. Other topics receiving considerable discussion included marine science development, regional projects, and other specific scientific topics.

This is the fourth General Conference in which this observer has participated. Each one has been characterized by a progressively more mature, better articulated, more responsible, and more science-oriented position of the delegations from the developing countries; this is a demonstration that development is truly working. The developing countries and the socialist countries urged UNESCO to have stronger and better science programs. In contrast, the voices of the Western developed countries seemed more dissonant and less interested in science than in the past. The U.S. delegation was a conspicuous exception to this--it had the strongest U.S. scientific representation this observer has seen, and its major science spokesman, Roger Revelle, galvanized the interest of the other delegations especially in the esoteric field of climate. The resultant support to this program demonstrated the impact that the careful selection of delegates can have.

Bilateral marine science programs, both large and small, are numerous, and they constitute a useful contribution on a global scale. However, there is no available summary of these programs and of which countries are participating. To increase the effectiveness of the whole system of marine science development, it would be useful for some international office to undertake such a summary in collaboration with the countries involved.

A note of caution must be expressed against relying too heavily on bilateral programs. One relatively wealthy developing country eventually turned to UNESCO to help develop her marine-science capability through a self-benefiting funds-in-trust project after trying other methods. The country had found that (1) for national projects, it didn't have the capability to manage the program successfully; (2) for contracted projects with companies or other entities, the delivered service was often not up to the standard expected; and (3) for bilaterial projects, there were often onerous political conditions.

Long-term productive marine science cooperation will entail cooperation between scientific peers on problems of common interest. Further, it will require that adequate resources are available to carry out that cooperation. Because the counterparts in the developing countries will in general not have the required resources, subsidization of the cooperation will be necessary. In the opinion of this observer, this subsidy should come from foreign aid funds rather than research grant funds, in order to encourage U.S. scientists to undertake such cooperation.

The United States should examine areas of successful cooperation as models for future cooperation. Three well-known models are (1) the cooperative research on the upwelling/El Nino system off western South America (CUEA-Coastal Upwelling Ecosystems Analysis); (2) the SEATAR program (Studies on East Asia Tectonics and Resources) in cooperation with IOC and CCOP (Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas, of the U.N. Economic and Social Commission for Asia and the Pacific); and (3) the older U.S.-Argentina cooperation in marine geophysics through the Lamont-Doherty Geological Observatory of Columbia University.

Finally, the United States has already prepared an excellent document on scientific cooperation in this and other fields, which recommends action fully compatible with the program of UNESCO and the IOC: U.S. Science and Technology for Development: A Contribution to the 1979 U.N. Conference; National Research Council, 1978, 212 pp. Should the United States implement those recommendations, the entire world would benefit.

SWEDISH AND NORWEGIAN PROGRAMS IN TECHNICAL ASSISTANCE TO DEVELOPING COUNTRIES IN THE FIELDS OF FISHERIES AND MARINE SCIENCES

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INTRODUCTION

The Scandinavian countries have long traditions in the area of technical assistance to developing countries, and DANIDA, SIDA, and NORAD are internationally known agencies of foreign aid in Denmark, Sweden, and Norway, respectively. The favorable reputation of the Scandinavian countries is based on the fact that their contributions to foreign aid relative to their GNPs are among the highest in the world. Furthermore, the Scandinavian countries emphasize social aspects in their technical assistance programs, and they are not affected by the stigma of colonialism in their dealings with the Third World.

Unfortunately, I did not receive the information on Danish technical assistance programs in time for the Workshop, and this paper is therefore limited to Swedish and Norwegian programs. Naturally, my knowledge of the Norwegian programs far exceeds that of the Swedish, and time did not permit me to check whether the materials available to me on the Swedish programs are complete. It is therefore conceivable that my analysis of the Swedish programs is less comprehensive than that of the Norwegian programs.

SWEDISH ASSISTANCE PROGRAMS TO DEVELOPING COUNTRIES IN FISHERIES ACTIVITIES AND MARINE SCIENCES

General

Sweden has a particularly favorable rating among countries engaged in technical assistance programs to developing countries. During 1974-79 Sweden contributed from 0.56 percent to 0.94 percent of its GNP to foreign aid, which is the highest relative contribution of any country in the world. The Swedish policy for development cooperation is based on economic and technical development especially in the poorest countries.

The Swedish multilateral cooperation with the United Nations organizations is under the responsibility of the Minister for Foreign Aid and the Ministry of Foreign Affairs, and the Swedish International Development Authority (SIDA) is responsible for the bilateral programs of cooperation with developing countries. During the last decade, the policy of SIDA has changed from support of more or less uncoordinated projects in individual developing countries, to cooperation in long-term programs in priority sectors of a country's development plans.

At present Sweden has bilateral agreements of cooperation with about 20 countries, but SIDA supports only three fisheries-oriented programs. The Institute of Marine Research under the Fishery Board of Sweden functions as the advisory body to SIDA in matters related to fisheries, and it is also responsible for the recruitment of personnel and for training programs in fisheries activities in developing countries.

The Swedish Agency for Research Cooperation with Developing Countries (SAREC) was established in 1975 as an advisory body to SIDA on questions related to the role of research in development cooperation. SAREC also gives support to Swedish researchers working on development research through grants. In 1979 SAREC was reorganized and made an independent government agency with its own budget for financing research. However, the terms of reference were not changed very much, and SAREC has retained its advisory function relative to SIDA. Until now, SAREC has not given direct support to projects in oceanography or fisheries science, but it has supported Swedish scientists in preliminary activities related to future research cooperation in marine sciences with East African countries.

The Present Bilateral Fisheries Programs of SIDA

The Bay of Bengal Program

The objectives of the program are to develop small-scale fisheries and to improve the conditions of life in the fishing communities in Bangladesh, India, Malaysia, Sri Lanka, and Thailand. The components of the program include development of techniques to improve fishing boats, fishing gear and methods, and aquaculture, as well as the processing and utilization of fish. The Bay of Bengal Program began in 1979, and it is expected to last for five years. FAO is the executing agency, and the total estimated cost to SIDA is about $4.75 millions.

Development of Coast and River Fisheries in Guinea-Bissau

The governments of Guinea-Bissau and Sweden signed an agreement in 1976 for a three-year assistance program in fisheries. The main objectives of the program were to increase the fish production, primarily for consumption in Guinea-Bissau and secondarily for export, and to increase the employment in fisheries. The major components of the program were:

a) to develop the traditional fishing and to build a fisheries industry based on national fish resources,

b) to improve the distribution of fish within Guinea-Bissau and to facilitate export of fish,

c) to develop boat types and fishing methods suitable for the fisheries in the coastal waters and the rivers of Guinea-Bissau.

The goal for the three-year project was to increase the fish production by 2,000 tons annually.

The total SIDA contribution to the fisheries program in Guinea-Bissau was $2.262 millions. A continuation of the program until 1984-85 is under consideration.

Development of Fisheries in Angola

The governments of Angola and Sweden signed an agreement in 1979 for a program of cooperation in the development of fisheries in Angola. The major objectives are to reach the same level of fish production as before the liberation of Angola in 1975 and to improve the distribution system for fish products within the country. The main components of the program are:

a) to provide equipment and literature to the Fisheries Research Center in Lobito and to finance repairs of the fisheries research vessel Goa,

b) to give fellowships for training of Angolan fisheries scientists in fisheries acoustics methods in Sweden and Norway and to recruit and expert in fisheries acoustics to serve as an advisor in Angola,

c) to train personnel for fishing vessels and for the fishing industry and to recruit experts to conduct such training in Angola,

d) to provide funds for improvements in the means of production in the small-scale fishing communities in Angola, and to give assistance for the organization of the distribution of fish products in the country.

The program was started in 1979, and the cost to SIDA for the three-year program is expected to be about $9.5 millions.

NORWEGIAN ASSISTANCE PROGRAMS TO DEVELOPING COUNTRIES IN FISHERIES ACTIVITIES AND MARINE SCIENCES

General

The Norwegian Parliament decided in 1972 that the total assistance program to developing countries by 1978 should reach 1 percent of the Norwegian GNP. It was realized that economic growth per se was not a sufficient requirement for improvement of the standard of living and the quality of life for the majority of the populations in developing countries, and social aspects of development have therefore been stressed in all bilateral and multilateral programs.

In principle, the contributions to bilateral and multilateral assistance programs should be equal, but during the 1974-79 period there has been a slight dominance of funds for bilateral projects (average 54.5 percent).

The majority of the bilateral projects are resulting from direct negotiations between the governments of Norway and individual developing countries, with the Norwegian Agency for International Development (NORAD) as the responsible executing agency in Norway. The bilateral program is based on the principle of geographic concentration, i.e., a small number of countries within restricted geographic regions are selected as "major countries of cooperation." These countries are selected on the basis of an evaluation of the respective governments' policies on development and social justice. "The major countries of cooperation" during 1974-79 (Tanzania, Kenya, Zambia, Botswana, Mozambique, India, Pakistan, Bangladesh, Sri Lanka) received about 60 percent of the bilateral funds, and the remaining 40 percent was distributed among 7 to 13 additional countries.

Part of the Norwegian bilateral assistance program, about 7-11 percent, is channeled through international organizations, with the Ministry of Foreign Affairs as the responsible agency in Norway. This program, below referred to as the "multi-bi" program, has global, regional, and national components.

In the Norwegian bilateral assistance programs, there are no projects in general marine science. Most of the projects are related to fisheries (5-9 percent of total bilateral assistance), and in the more recent projects, there is a tendency toward geology/geophysics in relation to oil exploration. The major programs of bilateral cooperation with developing countries have been through:

a) bilateral projects under NORAD,

b) multi-bi programs under the Ministry of Foreign Affairs,

c) fisheries research cruises with the research vessel Dr. Fridtjof Nansen.

In all the technical assistance programs with strong fisheries components, there have been fellowships for training and education (e.g., with India, Pakistan, Vietnam, Portugal, Mozambique), but in the NORAD reports the fellowships in fisheries are lumped with fellowships in agriculture, and therefore it is not possible to give a review of the situation with regard to the fellowship program in fisheries and marine science. In the review of Norwegian programs of assistance, projects such as harbor construction and improvements are deleted, and under the multi-bi program, only the projects related to science are listed.

The Bilateral Programs of NORAD

Tanzania

NORAD's assistance program with Tanzania in fisheries and related activities has particularly been directed toward the establishment of a training center at Mbegani, about 50 km north of Dar es Salaam. The activities at the center were originally limited to training of fishermen and boat builders, but after 1976 the center was expanded to include training of a variety of personnel for work on fishing vessels, in fish cooperatives, in fish processing factories, in fish-gear production, etc. The Norwegian contribution included a training vessel, ship-repair and docking facilities, and fishing gear facilities, as well as the operation cost of the center. The total cost of the project during 1974-79 was (in millions US $):

Year:	1974	1975	1976	1977	1978	1979
Cost:	0.03	0.03	0.45	1.30	0.18	0.94

In 1979 an expert committee recommended a major change in the training activities at the center, and it was further recommended that new buildings be constructed. In view of the limited fish resources in Tanzanian waters, it was not recommended to increase the number of trainees. The new project requires Norwegian contribution on the order of $10 millions, in addition to the costs of operation until the center will be taken over by Tanzanian authorities.

Kenya

The only fisheries-oriented NORAD project in Kenya has been the development of fisheries in Lake Turkana (Lake Rudolph). The major objectives of the project are to increase the fish production, and to enhance employment and economic activities. The project is an integral part of Kenya's plan for development of the entire Turkana area, which is very poorly developed. The NORAD project started in 1971, and it has particularly been directed toward the development of cooperatives, boat building, exploratory fishing, and training. A study of the resources indicates that the expected yield from the Lake Turkana fisheries will not exceed 5,000 to 7,000 tons per year, and measures for the regulation of the fisheries have therefore been taken. The Lake Turkana project includes utilization of as yet unexploited species, and improvements in the quality of the fish products through the provision of refrigeration facilities. The cost to NORAD of the Lake Turkana project during the period 1974-79 has been (in millions US $):

Year:	1974	1975	1976	1977	1978	1979
Cost:	0.28	0.36	0.30	0.11	0.12	0.96

India

Norwegian technical assistance for the development of fisheries in India has been one of the major components in the cooperation program between the two countries, and the first project was started already in 1952. The major projects since 1974 are listed below.

Fishing Vessels. An agreement was signed with the government of India in 1974 for Norwegian assistance to build six modern 100-foot fishing vessels for exploratory fishing and training. The Norwegian contribution was earmarked for strengthening the government shipyards in Goa and Calcutta, and for equipment for the vessels. The fishing vessels are of two different designs: one is for trawling and purse seining, and the other is for long-lines and seines. The ships will be operated by government fisheries institutions, and they will serve as models for further development of Indian offshore fisheries.

Fishing Equipment. Various equipment for fishing has been provided for fisheries stations run by local or federal governments. The equipment includes fishing gear, equipment and spare parts for fishing vessels, and equipment for fishing processing. Since 1977 the project has also included equipment for a fisheries research vessel.

Fisheries Research. During the period 1971-76, NORAD cooperated with the government of India, UNDP, and FAO in a project to assess the stocks of sardines and mackerel along the west coast of India. The study was carried out by scientific staff from the Institute of Marine Research, Bergen. Some of the NORAD funds were contributed toward building a fisheries research vessel.

National Institute of Oceanography (NIO), Goa. In 1976 NORAD decided to give $200,000 in support to the NIO in Goa for scientific equipment and training for the period 1976-79. In 1977 the project was increased to $260,000, and continued support for 1980-81 in the amount of $320,000 has been pledged by NORAD.

Continental Shelf Mineral Resources. An agreement for a five-year project in mapping the mineral resources on the continental shelf along the west coast of India was signed with the government of India in 1978. The NORAD contributions are for equipment, training, consultants, and experts. The NIO in Goa is the executing institution in India, and the Norwegian part is handled by a consulting firm and the Institute of Geology, University of Oslo.

The total NORAD budget for assistance to India in fisheries activities and marine science during 1974-79 was (in millions US $):

Project:	1974	1975	1976	1977	1978	1979
Fishing Vessels		0.16		1.53	3.32	2.78
Fishing Equipment	0.48	0.68	0.60	0.80	0.24	0.48
Fisheries Research	0.60	0.20	0.05			
NIO, Goa			0.20	0.11	0.13	0.02
Mineral Resources						0.40

Bangladesh

In 1974 NORAD provided nylon rope and twine worth $2 million for production of fishing gear for Bangladesh.

Vietnam

R/V Bien Dong. In 1975 NORAD signed an agreement with the government of Vietnam to provide a fisheries research vessel for mapping of fish resources and for exploratory fishing in Vietnamese waters. The ship is a 150-foot stern trawler/purse seiner, a replica of the Dr. Fridtjof Nansen and built by the same shipyard. The Bein Dong was delivered from the shipyard in November 1976, and after trials in the North Sea, it left for Vietnam in early 1977. NORAD gave financial support for operating the ship until 1979, and Norwegian crew members and scientists from the Institute of Marine Research were engaged in the operations and in the scientific programs.

Fish Processing Factory in Haiphong. In 1974 NORAD agreed to provide to complete factory for processing of shrimps, cephalopods, and fish to Vietnam. The construction started in 1975, and the factory was taken over by Vietnamese authorities in March 1977. The NORAD project was terminated in 1978 with the delivery of equipment for increasing the capacity of the factory.

The Ha Long Fisheries Center. The 1976 an agreement was signed with the government of Vietnam to develop a fisheries center in Haiphong. The project included support to shipyards for construction of large fishing vessels and for repair facilities for fishing gear. Two 100-foot stern trawlers and one combined stern trawler/purse seiner, which will serve as prototypes in the Vietnamese shipbuilding program, were built in Norway and delivered to Veitnam in April 1979. In addition, equipment has been provided for the first five ships to be built in Vietnam.

Fish-Meal Factory in Rach Gia. NORAD has funded the construction of a fish-meal factory in Rach Gia, which will produce Fish Protein Concentrate for human consumption with a capacity of 20 tons of raw materials per day. The construction started in 1975 and the factory was expected to be ready for production in 1980.

Refrigeration and Deep-Freeze Facilities. In order to improve the distribution of fish products within Vietnam, NORAD has funded refrigeration and deep-freeze facilities. The project includes equipment for ice production, and for refrigerated and frozen fish products, as well as for containers for refrigerated and frozen fish products for road and railway transportation. The total cost of the project is estimated at $10 millions, and the project was expected to be terminated in 1980.

The total NORAD budget for assistance to Vietnam in fisheries activities and marine science during 1975-79 was (in millions US $):

Project:	1975	1976	1977	1978	1979
R/V Bien Dong	3.54	1.62	0.94	0.76	0.72
Fish Processing Factory	1.15	0.24	0.17	0.01	0.04
Ha Long Fisheries Center	0.09	0.04	2.03	1.71	4.06
Rach Gia Fish-Meal Factory	0.68	0.36	0.12	0.002	0.20
Refrigeration and Deep-Freeze				2.54	5.60

Portugal

Fisheries Development. In 1976 an agreement was signed with the government of Portugal for an extensive assistance program directed toward the development of Portuguese fisheries. The project includes a fisheries research vessel, part financing of a chain of refrigeration and deep-freeze facilities, studies of fish resources in Portugese waters, and training programs in fish processing, aquaculture, and marine pollution.

R/V Noruega. A fisheries vessel for Portugal, the R/V *Noruega*, was funded by NORAD and built in Bergen. The ship which is of the same design as *Dr. Fridtjof Nansen* and *Bien Dong*, was delivered to Portugal in October 1978.

Regrigeration and Deep-Freeze Facilities in the Azores. In order to support the traditional coastal fisheries in the Azores, NORAD has agreed to build five small facilties for ice production, refrigeration, and deep freezing in small fishing harbors. The ice production and the refrigeration are expected to enhance the quality of the fish products, and the deep-freeze facilities are particularly intended for frozen fish bait. The construction was started in 1979.

The total NORAD budget in support of fisheries and marine science in Portugal during the period 1976-79 was (in millions US $):

Project:	1976	1977	1978	1979
Fisheries Development	0.08	0.16	0.48	0.05
R/V Noruega		4.04	1.78	0.13
Refrigeration and Deep-Freeze				0.36

The "Multi-bi" Program of the Ministry of Foreign Affiars

Part of the Norwegian bilateral assistance program to developing countries is carried out with the international organizations as planning and executing agencies. This program which is administered by the Ministry of Foreign Affairs and referred to as the multi-bi program, comprised from 7 to 11 percent of the total Norwegian bilateral assistance program during the period 1974-79. All the multi-bi programs in support of fisheries or marine science were executed by FAO.

Norway financed 49 fisheries-related projects during 1978-79, but only three of those involved fisheries science or marine science. Since 1974 the following research-oriented projects have received support under the Norwegian multi-bi program:

a) Training courses in the use of acoustic equipment in fisheries were organized in Morocco in 1974 and in the Philippines in 1975.

Budget: $137,000

b) A research center for fisheries acoustics in Peru has received Norwegian suport for salaries and other expenses for experts, for some equipment, and for renting a laboratory. This project is a follow-up of a series of training courses in fisheries acoustics arranged by FAO with NORAD support in Latin America.

Budget: $1,116,935

c) The establishment of a biological data collection system for tunas and related species in Mindanao and Celebes.

Budget: $65,100

d) An investigation to increase the utilization of small pelagic fish for consumption.

Budget: $427,750

R/V Dr. Fridtjof Nansen

In 1971 Norway agreed to build and operate a fisheries research vessel, which would be placed at the disposal of FAO. The ship, R/V Dr. Fridtjof Nansen, was built at the Mjellem & Karlsen shipyard in Bergen, Norway, and delivered in 1974. The ship is a 150-foot combined stern trawler/purse seiner, equipped with winches and laboratories for standard data collection and analysis in fisheries biology and oceanography. A 1,500-horsepower main engine gives the ship a 13 knots cruising speed. Dr. Fridtjof Nansen is Norwegian property, and it sails under the Norwegian flag.

In accordance with an agreement with FAO, Norway provides 60 percent of the cost of running the ship. The main objectives for Dr. Fridtjof Nansen are to carry out studies in fisheries biology and exploratory fishing to identify fish resources in FAO fisheries programs. However, because of financial difficulties in FAO, the ship was used only in bilateral projects during 1977, 1978, and the first half of 1979. During the first five years of operations the R/V Dr. Fridtjof Nansen has been engaged in the following projects:

- 1975-76. Pelagic Fish Assessment Survey of the North Arabian Sea. Joint FAO/NORAD project.
- 1977. Fish Assessment Survey in Pakistan Waters. Joint FAO/NORAD project.
- 1977-78. The Marine Fish Resources of Mozambique. Joint Mozambique/NORAD project.
- 1978. The Fish Resources in Seychelles Waters. Joint Seychelles/NORAD project.
- 1978-80. The Coastal Fish Resources of Sri Lanka. Joint Sri Lanka/NORAD project.
- 1979. The Marine Fish Resources of Bangladesh. Joint Bangladesh/NORAD project.

The Institute of Marine Research, Directorate of Fisheries, Bergen, Norway, was responsible for the operation of Dr. Fridtjof Nansen under a subcontract with NORAD. The planning, execution, and reporting in the various projects were carried out jointly with the relevant fisheries organizations in the countries concerned. The Institute of Marine Research had five or six members of its scientific staff on board all the time, and in addition there were scientists from the various countries on board on all the cruises.

The research program varied slightly in the different projects, but the major objectives on all the cruises were:

1. to map the distribution of the commercially important fish stocks,
2. to carry out biological studies of the commercially important species,
3. to study chemical and physical properties of the water masses and the bottom conditions in the area,
4. to estimate the abundance of the important stocks,

5. to evaluate the efficiency of different fishing gear,
6. to train scientific personnel from the developing countries in the methods of acoustic fish stock assessment.

In most of the projects the area of investigation was surveyed several times. The local scientific staff received training in standard oceanography and fisheries methodology on board or in shore-based laboratories in Norway or in the countries concerned. The table below shows the number of surveys, days at sea, scientists involved, and cost to NORAD of the various projects the R/V Dr. Fridtjof Nansen has been involved in during 1975-80.

				Scientists		NORAD
Area of Investigation	Year	Surv.	Days	Norw.	local	funds ($)
North Arabian Sea	1975-76	5	495	21	11	420,000
Pakistan	1977	5				300,000
Mozambique	1977-78	4	244	16	12	760,000
Seychelles	1978	1	14	4	6	
Sri Lanka	1978-80	3	140	11	10	120,000
Bangladesh	1979	1	18	5	2	

In addition, NORAD provided 60 percent of the cost of operating the ship, which during 1975-79 amounted to (in millions US $):

Year:	1975	1976	1977	1978	1979
Cost:	0.50	0.60	0.76	1.06	1.40

COMMENTS

The present review of Swedish and Norwegian programs shows a strong dominance of fisheries-oriented projects, and aspects of general marine sciences are included only as far as they relate to fisheries. In the bilateral technical assistance programs, the two countries are guided by the needs and priorities of the recipient developing countries, which often consider the exploitation of marine biological resources important contributions to their food production. Because of this emphasis on fisheries, it is natural that the FAO has been the most important international agency in executing Swedish and Norwegian bilateral and multilateral assistance programs related to the oceans.

Although there is still a substantial need for improving the fisheries methodology of developing countries, it has become increasingly clear that the biological resources of the world oceans are not inexhaustible and that we are approaching the limit of economical utilization of living resources in the oceans. However, the United Nations Conference on the Law of the Sea (UNCLOS) has given developing countries jurisdiction over vast areas in their exclusive economc zones, whose nonrenewable resources may be of considerably higher economic importance to many coastal states than their living resources. A shift in the emphasis toward the exploitation of mineral resources must therefore be expected in future bilateral programs of assistance to developing countries, and this new direction is already reflected in NORAD's program. The exploitation of North Sea oil resources has developed a level of know-how in Norwegian marine technology, which already is sought by developing countries in their cooperative programs with NORAD.

The technical assistance programs related to the oceans are heavily oriented toward resource utilization, and the associated scientific activities are therefore typical applied research. However, the resources of today will not necessarily be the most important resouces of tomorrow. Continued progress requires oceanic research in order to identify new resources, and such research is in the realm of basic science. It will probably not be in the interest of developing countries to defer basic marine science to the industrial countries, and the increasing interest among member states of UNESCO in the programs of the Division of Marine Sciences of UNESCO and the Intergovernmental Oceanographic Commission (IOC) is a proof of the increasing awareness of the importance of basic science for development. The Swedish SAREC organization is particularly well suited for cooperation on science and higher education, and SAREC's objectives are in agreement with the proposals in the Vienna Program of Action, resulting from the United Nations Conference on Science and Technology for Development (UNCSTD). There is no Norwegian organization comparable to SAREC, but the multi-bi program of the Ministry of Foreign Affairs is clearly in a position to support marine science programs through pertinent international organizations, such as the IOC. It is a necessary requirement, however, before any such actions can be taken by SAREC or the Norwegian multi-bi program, that developing countries themselves emphasize the need for basic marine science as a vehicle for development in their national programs.

FISHERY DEVELOPMENT: THE LATIN AMERICAN MODEL REVISITED

Julio Luna
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Washington, D.C.
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Twelve years ago, the Inter-American Development Bank started a process of promoting the possibilities and significance of fishery development in Latin America.

The fishery production of the Latin American countries amounted to 9 million tons in 1980, with an overall landed value of some 3 billion dollars. An estimated 2 million persons are engaged in fishing activities, the majority of whom are coastal fishermen with an average annual productivity of 3 tons per fisherman. Theoretically, the supply of fish in Latin American countries is 28 kilograms per person per year, but the actual human consumption is only near 8 kilograms per year. The remaining 20 kilograms per person are either exported or processed for animal or industrial use. These figures do not include the losses due to the lack of infrastructure (30 percent of the total catch in some countries) or as a result of inappropriate technologies (some 300,000 to 500,000 tons per year in the case of species caught together with shrimp).

DEVELOPMENT GOALS

It is estimated that Latin America has a deficit of 2 million tons of animal protein per year, which represents approximately 20 million tons of edible meat. Of the possible alternatives for dealing with this problem, fish would probably be the cheapest source of protein. If it is assumed that 25 percent of the protein deficit of Latin America could be satisfied with fishery products, it would mean that an additional 5 million tons of fish should be produced. This would imply a 75 percent increase over the present regional fishery production and would require an investment of about 3 billion dollars. Such an investment would also mean new employment opportunities for approximately 500,000 people.

The complexity and diversity of factors involved in the food supply problem of developing nations make it difficult to formulate long-term projections. Both socioeconomic structure and technological advancement are essentially dynamic; no one can forecast with certainty the population growth or the domestic migration trend between rural and urban areas over the next 15 or 20 years.

It is even more difficult to project the level of income, purchasing power, and individual preferences that the populations of developing countries will be showing in ten or more years.

On the other hand, the development of food technology during the last few decades has been focused mainly on the production of foods to supply the high-income markets whose consumers are normally eating more than they actually need. There are not enough institutions well equipped and strongly dedicated to development of novel technologies for the production of nonsophisticated foodstuffs for the vast masses of poor people in developing countries.

These limitations suggest that fishery development should be planned throughout successive stages, utilizing low capital-intensive technologies that maximize the use of the local resources normally underutilized. This is in contrast to the situation in industrialized nations where technology has to compensate for the scarcity of both human and natural resources.

AVAILABLE RESOURCES

The Latin American region has an additional potential of 7 million to 8 million tons of unexploited marine resources per year. This estimate refers only to those areas and species for which there is reliable information that could be used in preparing tentative projections of annual catch rates. The estimate does not include, therefore, species for which economic uses are still being developed, such as the Antarctic krill, nor does it include resources such as squid and octopus, the extent of which is still not well determined.

In addition to the natural resources available in the oceans and inland waters, aquaculture offers a good opportunity to increase production, involving substantial advantages such as diversification of agricultural activities, low capital-intensive projects, high productivity, easy and expeditious access to markets, and self-supply of protein for isolated human settlements. The problem arising in the implementation of a policy for aquaculture development is mainly of a managerial and operational nature. The Latin American region is short of aquaculture experts and suffers a serious scarcity of extension services. (Note: A regional training center is starting operation in Brazil through a project of the Food and Agriculture Organization and the United Nations Development Programme and a fellowship program of the Inter-American Development Bank.) The land property structure may also be an obstacle to granting loans to small fish farmers, because they commonly do not own the land where they live.

STRATEGY FOR ACTION

In accordance with the interest expressed by Latin American countries, the Inter-American Development Bank is providing assistance for the identification of priority areas for fishery development and for the preparation of specific investment projects suitable for financing by international lending institutions.

The first element in the strategy for action has been to promote integrated sectoral projects involving port infrastructure, fishing fleets, processing plants, marketing systems, training centers, and research programs. The purpose of this approach is to avoid the development of bottlenecks, as would occur if, for instance, boats were to be provided without port facilities or processing plants or marketing networks.

A second element is to create, on the basis of these projects, new development-minded fisheries institutions, since the fishery administration in most countries has been limited to small scientific and statistical units.

The third element of the strategy is to give special attention to projects with high socioeconomic impact, which normally involve various difficulties for rapid execution and which are less attractive to the private sector. That is the case of coastal artisanal fisheries that supply food for local consumption.

Another guideline is to design structures for project implementation that could be used for expanding the goals merely by adding new investment stages to the original framework. For example, integrated programs based on fisheries cooperatives or on fishing industries could be progressively expanded by incorporating new groups into the basic operation scheme.

Depending on the fisheries situation of each country, new production projects could be implemented through cooperatives of coastal fishermen or through fishing companies. However, in some cases they have to be set up through state corporations, until the sector becomes stable enough for the participation of private investment.

Intermediate labor-intensive technologies are carefully selected to make the best use of the available resources and to yield low-cost final products that would make foodstuffs accessible to the majority of consumers.

THE ACTUAL PERFORMANCE

To date, 32 investment fishery development projects and 34 technical assistance programs have been promoted and financed by the Inter-American Development Bank. Twenty-one countries have been beneficiaries of these projects.

The fishery projects actually under execution represent a total investment of US$734 million and involve financing in the amount of US$300 million. Projected production is 2,500,000 tons per year, which would represent an increase of 100 percent in the regional supply of fish for human consumption.

The capital-to-employment ratio averages US$16,700 of investment for each job created. This ratio is affected by the cost of the physical infrastructure and the technologies involved. Marine fishery projects show a ratio of between US$10,000 and US$25,000 for each new job. The aquaculture projects have an average ratio of only US$2,000 for each job created.

One of the most important contributions of this policy to the fishery sector in Latin America has been the promotion of new development institutions. All the new projects have required the organization of independent executive bodies, which are gradually acquiring the managerial capacity for decision making, although some considerable time will be necessary before they achieve a normal, efficient operation.

Because the fishing industry in many countries of Latin America was at an incipient stage of development, there has been little problem of dealing with established structures, vested interests, or complex political implications. However, this constitutes a big constraint in the sense that public and private funding for fishing projects has been weak because of the lack of political support within government for fishery projects. As soon as the first problems in the execution of a project arise, even if they are less serious than those found in other sectors, the authorities tend to become discouraged and reluctant to pursue the task. A program of hemispheric scope such as this one, involving a sector with very little experience or tradition, is bound to have areas of weakness where mistakes can be made. This risk will be increasingly reduced as the countries develop their programs and acquire skilled personnel.

Although the implementation of new development projects usually involves many problems and delays because of the lack of experience of the new institutions, it is possible to foresee that future stages will be more ambitious and more effectively implemented.

The experience of the Inter-American Development Bank in supporting the development of the fishery sector in such a vast area as Latin America indicates that financial development agencies can make substantial contributions to the general progress of some new areas at regional levels. It can be sustained that to implement an efficient policy for fishery development, it is necessary (1) to have global and accurate information about the sector, including natural and human resources, institutions, government policies, infrastructure, and production capacity; (2) to adopt reasonable projections for development, divided into stages with specific targets; (3) to design a flexible but aggressive policy for acheivement of the projected targets; (4) to offer convenient technical cooperation for strengthening the executing agencies, and (5) to establish a suitable monitoring system for both the follow-up of the project implementation and the evaluation of the project results.

The past 30 years of fishery development in Latin America show that when there is a choice between getting the process started even at the risk of encountering unforeseen problems or waiting until nearly perfect theoretical projects can be designed, the first alternative is the right one. Unless that first step is taken, nothing will be done,in the expectation of having someday that illusory, perfect plan.

OTHER AVENUES OF MARINE TECHNICAL ASSISTANCE TO DEVELOPING COUNTRIES

These two papers discuss fishery joint ventures and the prospect of ocean thermal energy conversion in relation to the needs of developing countries. The papers were distributed at the time of the workshop and were discussed in panel sessions by the authors.

AN OVERVIEW OF THE POTENTIAL FOR OTEC IN THE DEVELOPING WORLD: THE NEED FOR INTERNATIONAL COOPERATION

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La Jolla, California
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PREFACE

Science Applications, Inc., is conducting a study under a contract jointly funded by the U.S. Department of State and the Department of Energy to analyze the potential for ocean thermal energy conversion (OTEC) in the developing world. A comprehensive survey of the world OTEC oceanographic resource was made. This information was combined with market and sociopolitical-economic factors in order to identify candidate developing nations and territories for the utilization of OTEC in the 1986-2010 time period.

THE FUTURE OF OTEC IN THE DEVELOPING WORLD

A comprehensive survey has identified 98 nations and territories with direct access to adequate OTEC thermal resources within their 200-nautical-mile exclusive economic zone (EEZ). (See Table 1.) Based on extensive past OTEC studies, this resource is defined as an average temperature difference ($\bar{\Delta}T$) over 1000 meters of ocean depth exceeding 20°C. These nations can be categorized as follows:

1. Developed nations - 3 (United States, Japan, and Australia)

2. Territories of developed nations - 29

3. Nations with centrally planned economies - 3 (Cuba, China, and Vietnam)

4. "Free market" developing nations - 63

The focus of this study was on the "free market" developing nations plus the U.S. territories of Guam, Virgin Islands, American Samoa, and the Trust Territory of the Pacific. The objective was to establish the OTEC market potential and identify which of these 67 nations and territories had the greatest potential for utilizing OTEC in the

Table 1. Nations and Territories With Thermal Resource (Mean Annual $\Delta T \geq 20°C$ @1000 m Depth Within 200 nm EEZ)

GEOGRAPHICAL AREA	MAINLAND		ISLAND	
AMERICAS	MEXICO	GUYANA	CUBA	GUADA LOUPE (FR)
	BRAZIL	SURINAM	HAITI	MARTINIQUE (FR)
	COLOMBIA	FRENCH GUIANA(Fr)	DOMINICAN REP.	BARBADOS
	COSTA RICA	NICARAGUA	JAMAICA	DOMINICA
	GUATEMALA	EL SALVADOR	VIRGIN IS. (US)	ST. LUCIA
	HONDURAS	BELIZE (UK)	GRENADA	ST. KITTS (UK)
	PANAMA	UNITED STATES	ST. VINCENT	BARBUDA (UK)
	VENEZUELA		GRAND CAYMAN (UK)	MONTSERRAT (UK)
			ANTIGUA (UK)	THE GRENADINES (UK)
			PUERTO RICO (US)	CURACAO (NETH)
			TRINIDAD AND TOBAGO	ARUBA (NETH)
			BAHAMAS	
AFRICA	NIGERIA	GABON	SAO TOME AND PRINCIPE	
	GHANA	BENIN	ASCENSION (UK)	
	IVORY COAST	ZAIRE	COMOROS	
	KENYA	ANGOLA	ALDABRA (UK)	
	TANZANIA	CAMEROON	MADAGASCAR	
	CONGO	MOZAMBIQUE		
	GUINEA	EQ. GUINEA		
	SIERRA LEONE	TOGO		
	LIBERIA	SOMALIA		
INDIAN/PACIFIC OCEAN	INDIA	AUSTRALIA	INDONESIA	AMERICAN SAMOA (US)
	BURMA	JAPAN	PHILIPPINES	TRUST TERRITORIES (US)
	CHINA	THAILAND	SRI LANKA	GUAM (US)
	VIETNAM	HONG KONG (UK)	PAPUA NEW GUINEA	KIRIBATI
	BANGLADESH	BRUNEI (UK)	TAIWAN	FRENCH POLYNESIA (FRANCE)
	MALAYSIA		FIJI	NEW CALEDONIA (FRANCE)
			NAURU	DIEGO GARCIA (UK)
			SEYCHELLES	TUVALU
			MALDIVES	WAKE IS. (US)
			NEW HEBRIDES (UK/FR)	SOLOMON ISLANDS
			SAMOA	MAURITIUS
			TONGA	OKINAWA (JAPAN)
			COOK IS. (NZ)	WALLIS & FUTUNA IS. (FR)
TOTALS:	44		54	

1986-2010 time period. This OTEC potential was defined by oceanographic resource parameters and market factors that determine the ultimate cost of OTEC versus alternative energy sources.

Oceanographic Resource Parameters

OTEC plant costs and thus energy costs are dependent on the oceanographic conditions at specific sites. The parameters described below were used to evaluate the potential of OTEC in developing nations based on the oceanographic resource parameters.

Thermal Resource. OTEC plant net power, and thus cost, is a strong function of the thermal resource. The figure of merit is the average of monthly $\bar{\Delta}T$. Criteria of 16°C minimum ΔT and 20°C for the average of monthly $\bar{\Delta}T$ over 1000 meters of ocean depth have been used to define the preliminary list of candidate nations in Table 1. However, significant increases in net power output are realized as the average of monthly $\bar{\Delta}T$ increases above 20°C. Each 1°C increase in $\bar{\Delta}T$ can increase net power output (and thus decrease unit costs) by approximately 12 percent. An examination of the world thermal resource chart shows values in excess of 24°C, which equate to more than a 50 percent increase in net power output.

User Proximity. The proximity of the OTEC site to the potential user is a key parameter in selection of an OTEC site because of its impact on plant costs. The distance offshore to the thermal resource ($\bar{\Delta}T \geq 20$°C at 1000 meters depth) is the important figure of merit. Distance can determine the type of system (land-based, bottom-mounted, floating-moored, or floating-grazing) or costs for such subsystems as the cold-water pipe and electrical transmission cable. The minimum criterion of $\bar{\Delta}T \geq 20$°C within the 200-nautical-mile EEZ has already been applied to compile the list of nations in Table 1. It is obvious that increased flexibility and decreased costs will occur for nations with thermal resources closer to shore.

Thermal Resource Size. The siting of a single OTEC plant does not require a large thermal resource in terms of ocean space. However, the size of the ocean space is important in determining the future potential for OTEC to supply a large part of a nation's energy needs. It has been assumed that a nation will control the OTEC resource within the 200-nautical-mile EEZ. In general, the ocean space between the 100-meter depth contour (or depth for $\bar{\Delta} \geq 20$°C) and the 200-nautical-mile EEZ boundary represents the size of the thermal resource for OTEC applications. However, in practice, only grazing plantships can operate in much of this space since OTEC plant mooring requirements limit sites to those regions with depths less than approximately 2000 meters. Therefore, the length of the shoreline adjacent to the ΔT resource at 1000 meters of depth is more representative of the total ocean space.

Frequency of Severe Storms. OTEC plants are designed for the 100-year storm. However, the frequency of severe storms has an impact not only on survival design requirements but also on the plant availability factor due to either plant shutdown or environmental resource modifications for periods of time. It is possible to build OTEC plants in regions of high storm frequency. However, OTEC will have higher potential and lower costs in areas of lower storm frequency.

Currents. The presence of strong oceanographic surface or subsurface currents has an adverse effect on OTEC plant design requirements because of increased loads on the cold-water pipe and the mooring and dynamic positioning subsystem. Several factors are of concern, including the magnitude of surface currents, horizontal current shears, storm-induced currents, and upwelling-induced vertical current shears. Present OTEC plant design requirements include 0.6 m/sec for maximum design operational conditions and 1.0 m/sec for survival conditions for the maximum average surface currents. A minimum current of 0.13 m/sec is required in order to ensure a renewable thermal resource.

In addition to magnitudes of surface currents, it is important to consider anomalies due to upwelling, i.e., the phenomenon of cold subsurface waters ascending to the surface layer and being removed by horizontal flow. Upwelling is the result of horizontal divergence in the surface layer with the water typically coming from depths not exceeding a few hundred meters. This phenomenon is particularly prevalent along the western coasts of continents, where prevailing winds carry the surface water away from the coast, as well as in the equatorial regions. Upwelling can result in the unpredictable disappearance of the OTEC thermal resource for periods of time in those regions (such as on the western coasts of continents) where upwelling is prevalent. The impact of upwelling could be elimination of a potential OTEC site near shore requiring a more costly plant located farther offshore outside the upwelling region.

Although there are other important oceanographic parameters for OTEC plant design and costs, the above parameters are the most significant. Table 2 provides a list of values for the oceanographic parameters for the 67 developing nations and U.S. territories grouped according to these geographical areas.

OTEC MARKET POTENTIAL IN DEVELOPING NATIONS

A key factor in establishing the potential for OTEC is the projected demand for electricity. Installed electrical generation capacity and production data were compiled for the period of interest, 1986-2010. Of the 67 nations and territories, only 51 had readily available information on electric power. The other 16 were small nations with estimated power-system sizes less than 100 Mw. The

Table 2. Oceanographic Resource Parameters (values)

Geographical Area	Nation	Thermal Resource (°C)	User Proximity (km)	Thermal Resource Size (km)	Frequency of Severe Storms	Currents (m/sec)
Indian/Pacific Ocean	Indonesia	22-23	10-50	>1000	0-0.1	0.2-0.4
	Papua New Guinea	23-24	<10	>1000	0.1-0.5	0.4-0.6
	Kiribati	>24	<10	250-500	0-0.1	0.4-0.6
	Tuvalu	>24	<10	250-500	0-0.1	0.2-0.4
	Solomon Islands	23-24	<10	500-1000	0.1-0.5	0.4-0.6
	Nauru	>24	<10	100-250	0-0.1	0.4-0.6
	Trust. Terr. Pacific	>24	<10	500-1000	1.0-3.0	0.2-0.4
	American Samoa	23-24	<10	100-250	0.1-0.5	0.1-0.2
	Samoa	23-24	<10	100-250	0.1-0.5	0.1-0.2
	Philippines	>24	<10	>1000	>3.0	0.2-0.4
	Tonga	20-21	<10	100-250	0.1-0.5	0.1-0.2
	India	21-22	50-100	>1000	1.0-3.0	0.2-0.4
	Guam	>24	<10	100-250	1.0-3.0	0.2-0.4
	Fiji	21-22	10-50	250-500	0.1-0.5	0.1-0.2
	Sri Lanka	21-22	10-50	500-1000	0.5-1.0	0.6-0.9
	Maldives	21-22	<10	500-1000	0-0.1	0.4-0.6
	Mauritius	20-21	<10	250-500	1.0-3.0	0.1-0.2
	Seychelles	21-22	10-50	250-500	0-0.1	0.4-0.6
	Taiwan	21-22	10-50	250-500	>3.0	0.4-0.6
	Burma	21-22	10-50	100-250	0.5-1.0	0.2-0.4
	Malaysia	23-24	100-370	100-250	0.5-1.0	0.2-0.4
	Bangladesh	21-22	200-370	<100	1.0-3.0	0.2-0.4
Africa	Liberia	22-23	10-50	250-500	0-0.1	0.6-0.9
	Ivory Coast	22-23	10-50	250-500	0-0.1	0.6-0.9
	Ghana	22-23	10-50	250-500	0-0.1	0.6-0.9
	Nigeria	22-23	50-100	250-500	0-0.1	0.6-0.9
	Togo	22-23	10-50	<100	0-0.1	0.6-0.9
	Benin	22-23	10-50	<100	0-0.1	0.6-0.9
	Cameroon	22-23	50-100	100-250	0-0.1	0.6-0.9
	Gabon	21-22	50-100	250-500	0-0.1	0.6-0.9
	Mozambique	20-21	10-50	500-1000	0.5-1.0	0.6-0.9
	Sao Tome & Principe	22-23	10-50	<100	0-0.1	0.6-0.9
	Eq. Guinea	22-23	10-50	<100	0-0.1	0.6-0.9

Table 2. Oceanographic Resource Parameters (values) (Continued)

Geographical Area	Nation	Thermal Resource (°C)	User Proximity (km)	Thermal Resource Size (km)	Frequency of Severe Storms	Currents (m/sec)
Africa (Cont.)	Tanzania	20-21	10-50	500-1000	0-0.1	0.6-0.9
	Somalia	20-21	50-100	250-500	0-0.1	> 0.9
	Comoros	20-21	10-50	100-250	0.5-1.0	0.6-0.9
	Guinea	20-21	200-370	100-250	0-0.1	0.6-0.9
	Madagascar	20-21	10-50	250-500	1.0-3.0	0.4-0.6
	Congo	20-21	50-100	<100	0-0.1	0.6-0.9
	Kenya	20-21	10-50	250-500	0-0.1	0.6-0.9
	Angola	20-21	50-100	<100	0-0.1	0.6-0.9
	Zaire	20-21	50-100	<100	0-0.1	0.6-0.9
	Sierra Leone	20-21	100-200	100-250	0-0.1	0.6-0.9
	Thailand	22-23	200-370	<100	0.1-0.5	0.4-0.6
Latin America	Brazil	21-22	10-50	>1000	0-0.1	0.4-0.6
	Mexico	22-23	<10	>1000	1.0-3.0	0.2-0.4
	Costa Rica	22-23	10-50	250-500	0.1-0.5	0.4-0.6
	Panama	22-23	10-50	250-500	0.1-0.5	0.4-0.6
	Colombia	22-23	10-50	>1000	0.1-0.5	0.4-0.6
	Honduras	22-23	10-50	250-500	1.0-3.0	0.4-0.6
	Venezuela	22-23	50-100	>1000	0.1-0.5	0.4-0.6
	Haiti	22-23	<10	250-500	1.0-3.0	0.4-0.6
	Dominican Republic	22-23	<10	250-500	1.0-3.0	0.4-0.6
	Jamaica	22-23	<10	250-500	1.0-3.0	0.4-0.6
	Bahamas	20-21	<10	500-1000	1.0-3.0	0.4-0.6
	St. Vincent	22-23	<10	100-250	1.0-3.0	0.4-0.6
	Dominica	22-23	<10	100-250	1.0-3.0	0.4-0.6
	Nicaragua	22-23	100-200	250-500	1.0-3.0	0.4-0.6
	Guatemala	22-23	50-100	100-250	0.1-0.5	0.4-0.6
	El Salvador	22-23	50-100	100-250	0.1-0.5	0.4-0.6
	St. Lucia	22-23	<10	100-250	1.0-3.0	0.4-0.6
	Virgin Islands	22-23	<10	<100	1.0-3.0	0.4-0.6
	Guyana	22-23	200-370	250-500	0-0.1	0.6-0.9
	Surinam	22-23	200-370	250-500	0-0.1	0.6-0.9
	Trinidad & Tobago	22-23	<10	<100	1.0-3.0	0.6-0.9
	Grenada	22-23	<10	<100	1.0-3.0	0.6-0.9
	Barbados	22-23	10-50	<100	1.0-3.0	0.6-0.9

estimated installed electrical generation capacity for the 51 developing nations and U.S. territories in 1990 is 284,000 Mw. To maintain the growth rate projected for 1985-1990 through the year 2010, an additional electrical generation capacity of 1,176,000 Mw must be added between 1990 and 2010, resulting in approximately 1,460,000 Mw total capacity in 2010. Figure 1 illustrates the distribution of these nations' forecast installed capacity in 1990 and 2010.

In 1990, 45 percent (23) of the nations are projected to have an individual power-system installed capacity in excess of 1000 Mw. These nations account for 96 percent of the total installed capacity. An additional 37 percent (19) have an installed capacity between 100 and 1000 Mw, accounting for an additional 3.9 percent of the total installed capacity. The remaining 18 percent (9) of the nations and territories have power-system sizes less than 100 Mw, accounting for only 0.1 percent of the total forecast added capacity.

In the year 2010, 69 percent (35) of the 51 nations and territories have a forecast installed capacity in excess of 1000 Mw. These nations account for 99.6 percent ofthe total installed capacity of 1,460,000 Mw. An additional 22 percent (11) of the nations have forecast installed capacity between 100 and 1000 Mw, accounting for an additional 0.3 percent of total capacity. Only four nations are projected with capacity less than 100 Mw.

Thus, the potential for OTEC in developing nations in the time period 1990-2010 is represented by the projected installed capacity addition of 1,176,000 Mw in 51 nations and territories. Table 3 shows a breakdown of the added capacity for the ranges in size of forecast installed capacity in 1990 and estimates the number of plants required to fill the added capacity demand between 1990 and 2010.

The results in Table 3 should be regarded only as "OTEC potential" since it is unlikely, for a variety of reasons, that all of the added capacity would be allocated to OTEC. However, there are several key points that can be made:

1. A very large potential will exist in 1990-2010 for the large commercial-sized 400-Mw OTEC plants. Approximately 97 percent of the forecast added capacity between 1990 and 2010 could be accommodated using the commercial-sized 400-Mw OTEC plants.

2. Although representing only 3 percent of the forecast added capacity, a significant potential exists for intermediate "pilot plant" size OTEC plants in the 40-Mw range. This is important since this size plant may be in operation by 1990, whereas the 400-Mw commercial unit may not be available until the mid-1990s.

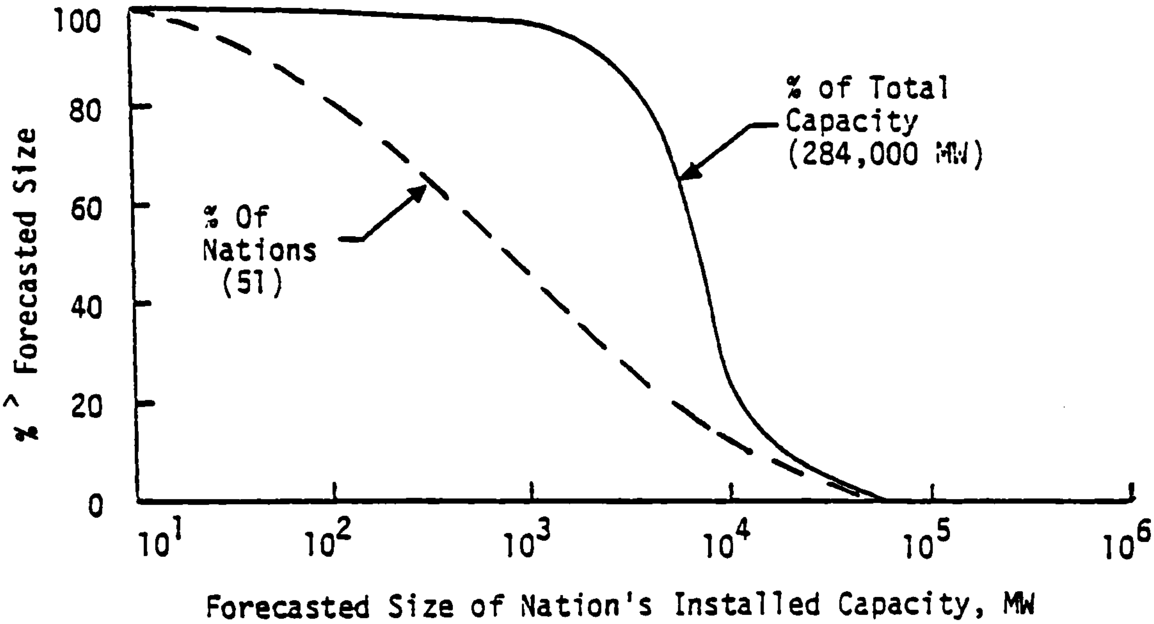


Figure 1a. Distribution of Installed Capacity Power System Sizes - 1990.

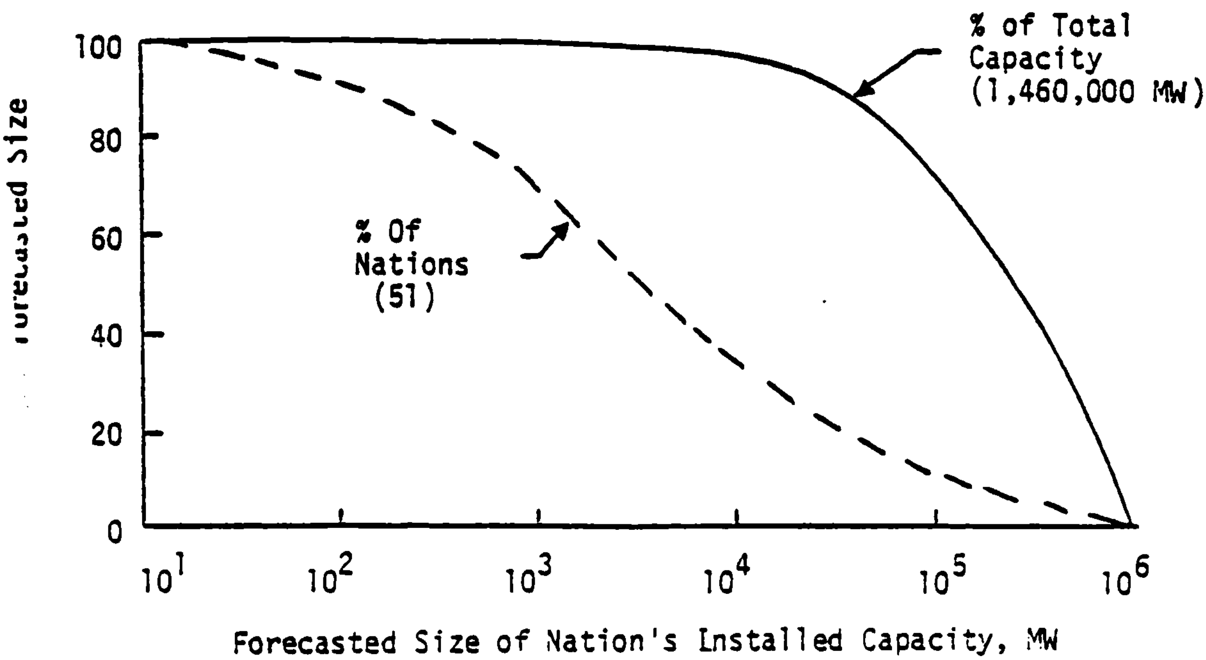


Figure 1b. Distribution of Installed Capacity Power System Sizes - 2010.

Table 3. Potential Number of OTEC Plants in Developing Nations and Territories

No. of Nations	Individual Forecast Installed Capacity in 1990	Total Added Capacity 1990-2010	Assumed (1) OTEC Plant Size	No. of OTEC Plants
9	< 100 MW	1,000 MW	10 MW	100
19	100-1000 MW	35,000 MW	40 MW	875
23	> 1000 MW	1,140,000 MW	400 MW	2850
51 (2)		1,176,000 MW		3825

(1) Assumes any power plant is less than ∿15% of the total installed capacity.

(2) Excludes 16 OTEC candidate nations and territories where data was unavailable.

3. The market for small-sized plants in the range of 10 Mw appears small based on Table 3. Less than 0.1 percent of the forecast total added capacity between 1990 and 2010 is for nations with less than 100 Mw installed capacity, which would require the use of 10-Mw plants. The message is that small-sized plants will have an insignificant impact on the total OTEC market potential added capacity. However, small-sized plants could have a significant impact in terms of the number of nations served by OTEC. Table 4 lists those nations that could utilize the small-sized 10-Mw OTEC plants based on available and estimated power needs. In addition to the 9 nations accounted for in Table 4, 15 of the developing nations and U.S. territories with insufficient data are expected to fall into this category. Also, most of the 25 territories of developed nations which were excluded from that study will fall into this category. Finally, several of the larger island archipelagoes, will most likely have a need for the small-sized units on more remote islands that are not connected to the electrical grid of the larger islands, which can accommodate the larger commercial-sized OTEC units. Thus, Table 4 shows that there are 51 nations and territories that could utilize the small-sized units. Although the total capacity filled by these small-sized units may provide a small impact on the total added capacity among all developing nations, it could alleviate the energy problems of a large number of nations and territories that are mainly dependent on imported oil at present. A final key point is that the technology for small-sized 10-Mw plants may be proven and available by 1990, whereas the commercial-sized 400-Mw units may not be available until the mid-1990s or later.

An overall assessment of the OTEC market potential requires comparison of OTEC power costs with alternative energy source power costs in the developing nations. Electrical energy in a modern power system is produced by a variety of energy sources such as hydropower, thermal, geothermal, or nuclear. This power is transferred to industrial, commercial, and domestic consumers over a large region to operate machines, equipment, and appliances. The system must be designed to meet varying levels of demand and to provide demand growth. Alternative sources of power have advantages for meeting differing requirements such as steam or nuclear for baseload; hydropower for mixed baseload and peaking; steam or combined-cycle units for the middle range; and combustion turbines or pumped storage plus nuclear or baseload thermal for peaking. OTEC represents an alternative baseload power source.

Comparison costs of power generation in oil-importing developing nations are provided in Table 5. These costs have been used as a basis for projecting alternative power source costs for the period 1986-2010 in Figure 2 for "large" and "small" (less than 5-Mw) power systems. It has been assumed that oil prices will increase at

Table 4. Candidate Nations and Territories for Small-Sized OTEC Plants

Developing Nations & U.S. Territories (Data Available)

American Samoa
Togo
Benin
Somalia
St. Vincent
Dominica
Congo
Grenada
St. Lucia

Developing Nations & U.S. Territories (Data Unavailable)

Kiribati
Solomon Is.
Nauru
Tuvalu
Trust Territory of the Pacific
Samoa
Tonga
Guam
Maldives
Bahamas
Mauritius
Sao Tome and Principe
Seychelles
Equatorial Guinea
Comoros

Territories of Developed Nations (Data Unavailable)

Belize (UK)
Grand Cayman (UK)
Antigua (UK)
St. Kitts (UK)
Barbuda (UK)
Montserrat (UK)
The Grenadines (UK)
Ascension (UK)
Aldabia (UK)
Brunei (UK)
Wallis and Futuna (Fr.)
New Hebrides (UK/Fr.)
Diego Garcia (UK)
Guadaloupe (Fr.)
Martinique (Fr.)
French Polynesia (Fr.)
New Caledonia (Fr.)
Okinawa (Japan)
Wake Island (US)
Curacao (Neth.)
Aruba (Neth.)
French Guiana (Fr.)
Cook Island (N.Z.)

Larger* Developing Nations Island Archipelagoes

Indonesia
Papua New Guinea
Philippines
Malaysia

*In addition to large commercial-sized OTEC unit utilization

Table 5. Comparative Costs of Power Generation Based on Various Types of Fuel

Reference: 12

Generator Type		Investment Cost [1] 1980 US Dollars per kW Installed	Fuel Cost 1980 US¢/kWh	Power Cost 1980 US¢/kWh
Hydropower	- Large, High Head	1100	N/A	2.4
	- Low Head Mini-Hydro	3500	N/A	12.7
Diesel	- Large, Heavy Oil Fuel Coastal Location	1000	4.2	6.7
	- Small, Light Oil Fuel Inland Location	800	10.9	13.2
Steam	- Large, Gas-Fired	800	0.4	2.4
	- Large, Coal-Fired	1000	2.7	5.2
	- Large Oil (Imported) Fired	800	5.5	7.5
	- Small, Heavy Oil-Fired Inland Location	1400	7.3	11.4
	- Small, Wood-Fired	1500	3.0	10.0
Geothermal	- Dry Steam Field	1400	N/A	3.0
	- Wet Steam/Hot Water Field	2800	N/A	6.0
Nuclear	- Large Multiple Units	1600	1.0	5.1
	- Single Small Unit	2200	1.0	7.4

N/A Not applicable.

[1] Investment cost includes costs of transmission and distribution. Delivered cost to major concern.

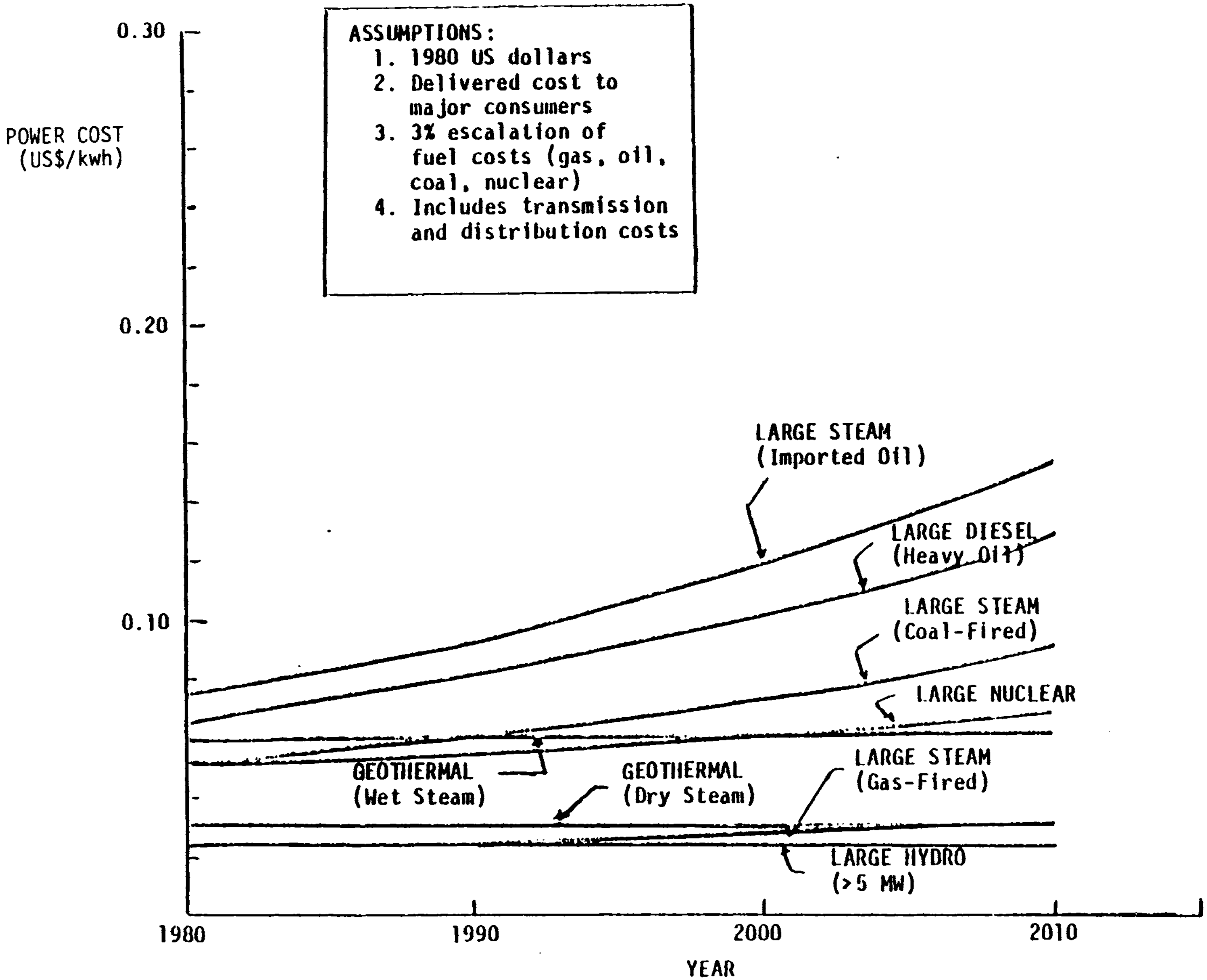


Figure 2a. Comparative Costs of Power Generation - Large Systems

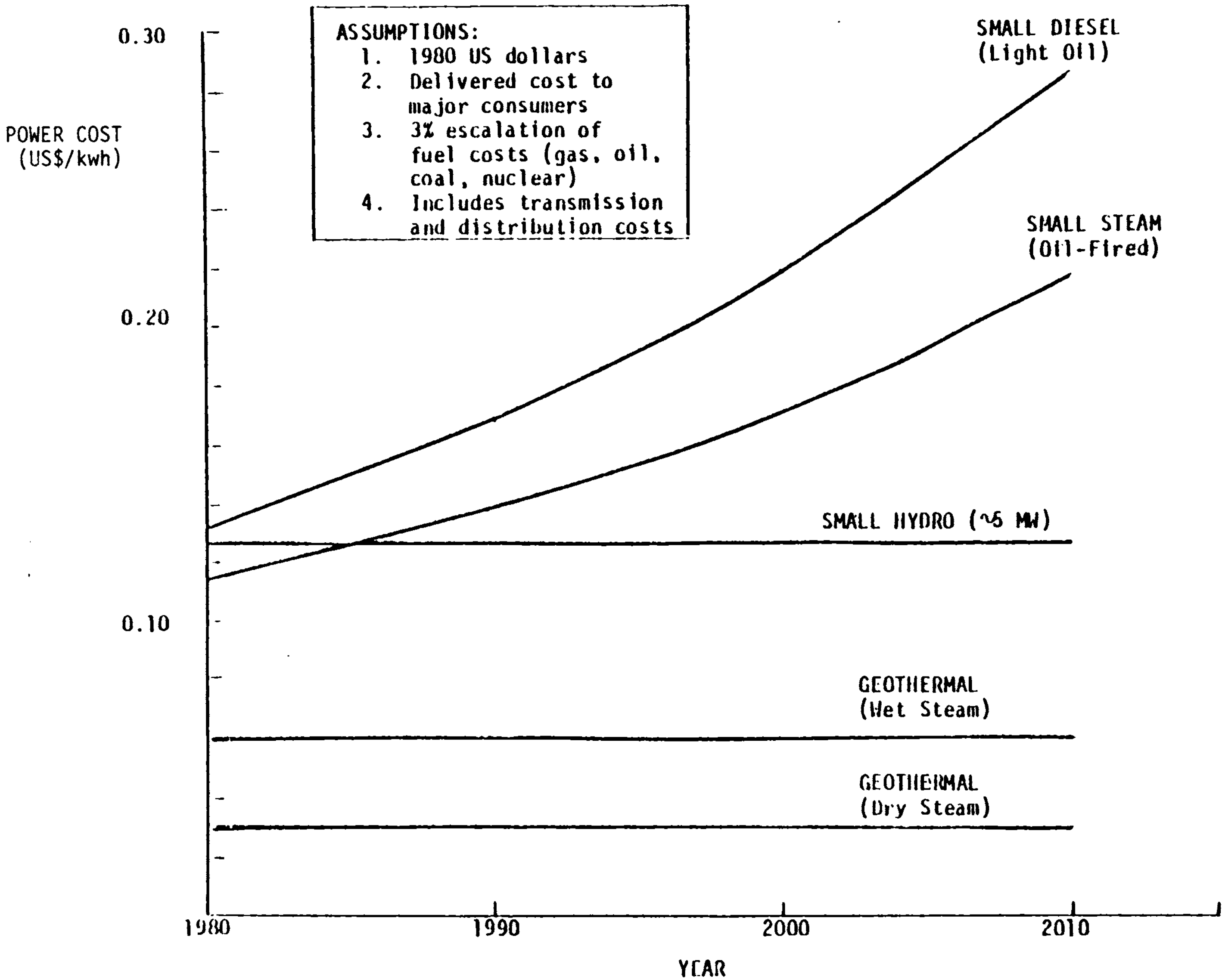


Figure 2b. Comparative Costs of Power Generation-Small Systems

3 percent in real terms and that other fuel costs will follow these real increases.

OTEC system cost estimates have been made for 5-400 Mw sizes as shown in Figure 3. These costs are eighth production unit costs based on domestic U.S. cost estimates. The uncertainty bounds include variations in system concept, e.g., land-based versus floater, as well as normal costing uncertainties. These installed costs were used along with the following assumptions to define the OTEC power costs in Figure 4:

- straight-line financial depreciation over 20 years for production facilities and 30 years for power plants

- sum-of-years-digits tax depreciation over 23 years for power plants

- for power plants:

  - 40% equity financing at a 15% rate of return
  - 50% debt financing at 10% interest rate
  - 48% federal tax rate
  - 4% state tax rate
  - 10% investment tax credit
  - 2% gross receipts tax rate
  - 1.4% insurance and property tax rate (on book value)
  - operation and maintenance costs of 10 mills/kwh (1980 dollars)
  - operation and maintenance costs of $25/kwe-yr (1980 dollars, first year)
  - 7% general inflation rate (deflator)
  - capacity factor: 0.75

For large commercial-sized OTEC units (approximately 400 Mw), a comparison of projected costs of $0.067/kwh for OTEC with the alternative large baseload system costs of Figure 2 shows the nominal OTEC cost to be much less costly than large, oil-fired steam and large, heavy-oil diesels in 1986-2010. For large, coal-fired steam, the nominal OTEC costs are less; but the uncertainty bands for OTEC, -20 percent to +40 percent or $0.054-$0.094/kwh, indicate the possibility of cost competitiveness in the 2000-2010 period. OTEC is only slightly more expensive than nuclear power or wet geothermal steam. OTEC cannot compete with large hydropower or dry geothermal steam plants.

For small-sized OTEC units (approximately 10 Mw), a comparison of projected costs of $0.147/kwh for OTEC with the alternative small system costs of Figure 3 shows the nominal OTEC cost to be competitive with small light-oil diesels in 1982, small oil-fired steam in 1991, and small hydropower in 1980. Consideration of the cost uncertainty bands with an upper bound of +40 percent or $0.206/kwh suggest the small plants will at least be competitive in 1998-2006. Only

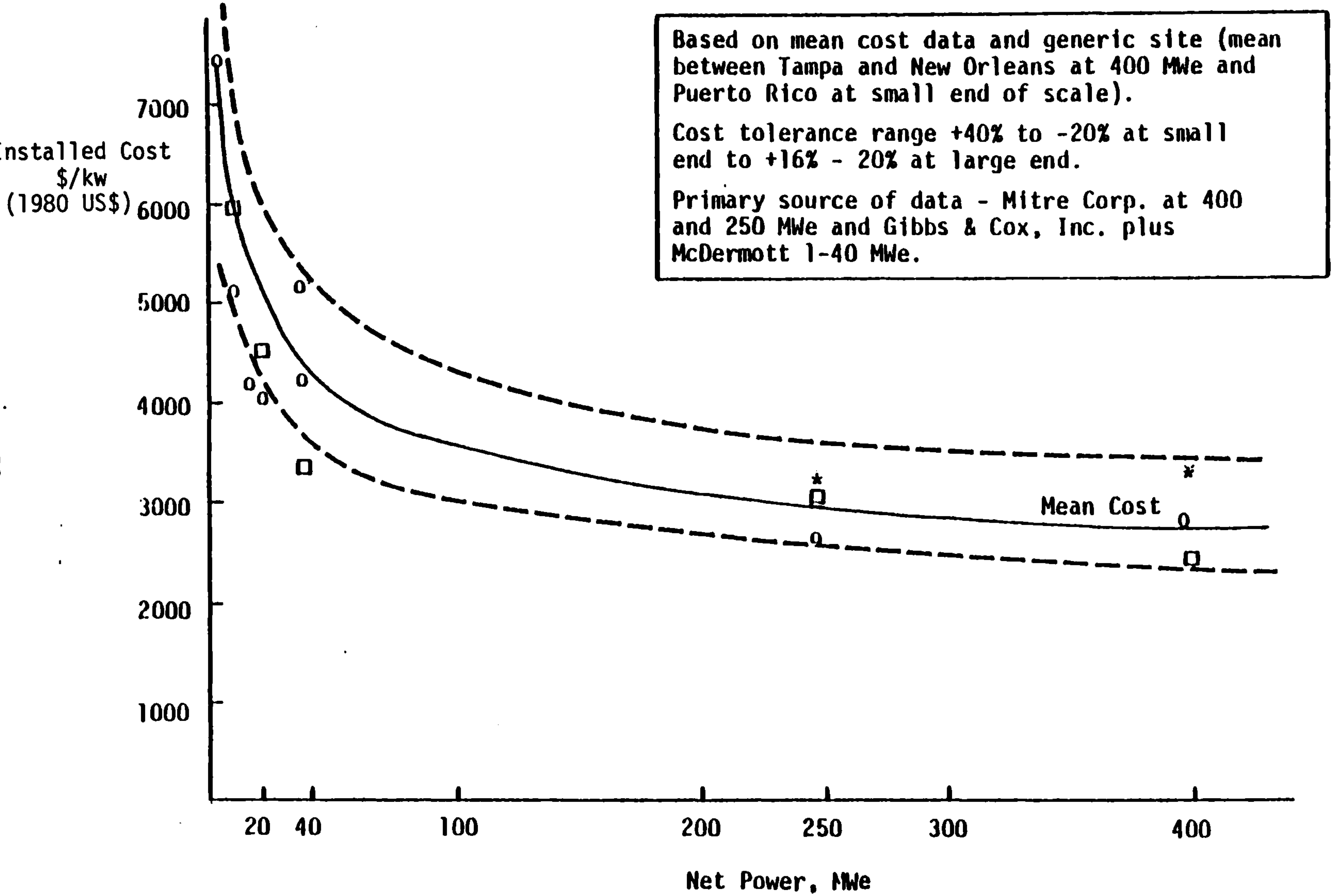


Figure 3a. Large OTEC Plant Costs.

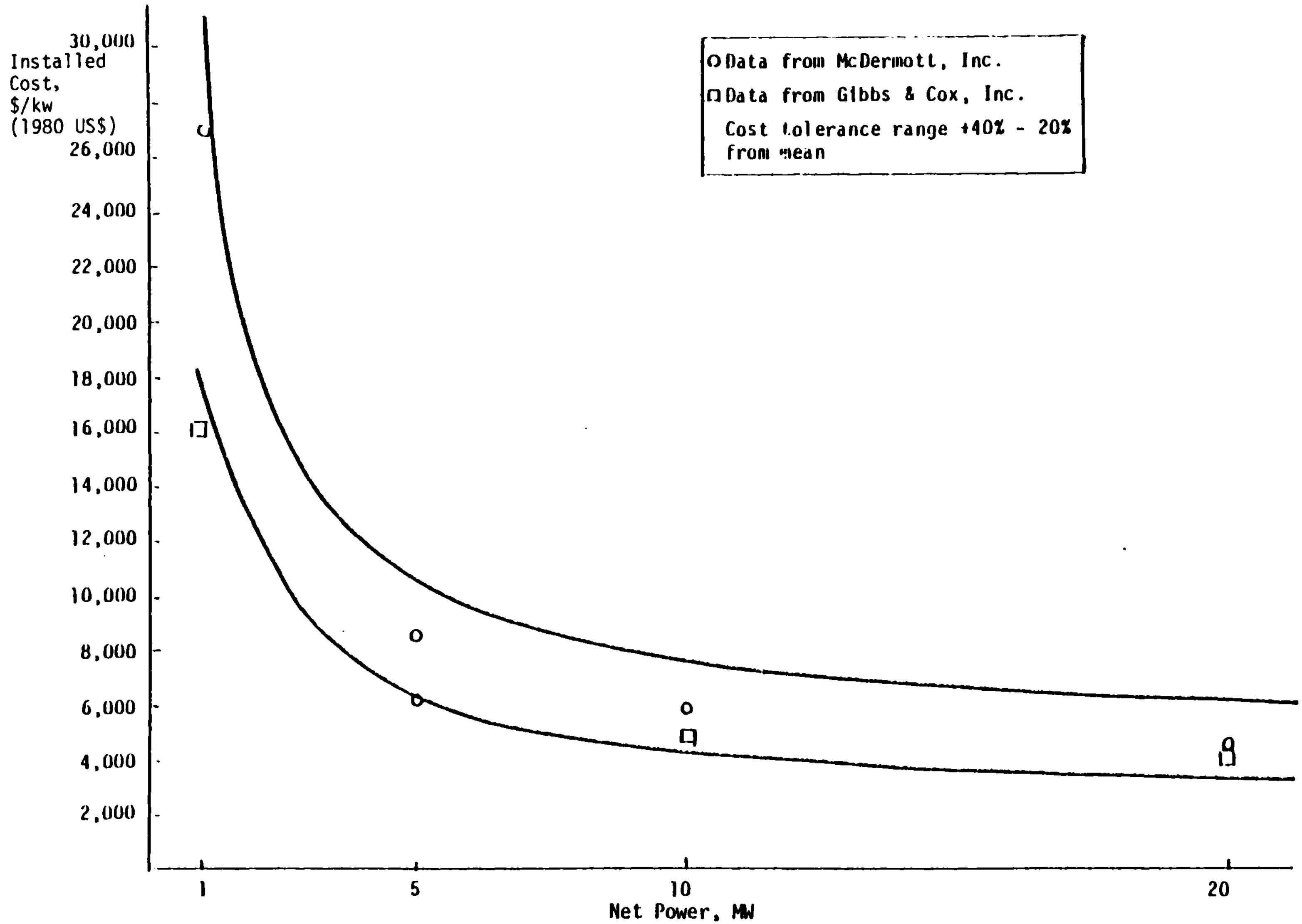


Figure 3b. Small Plant OTEC Costs

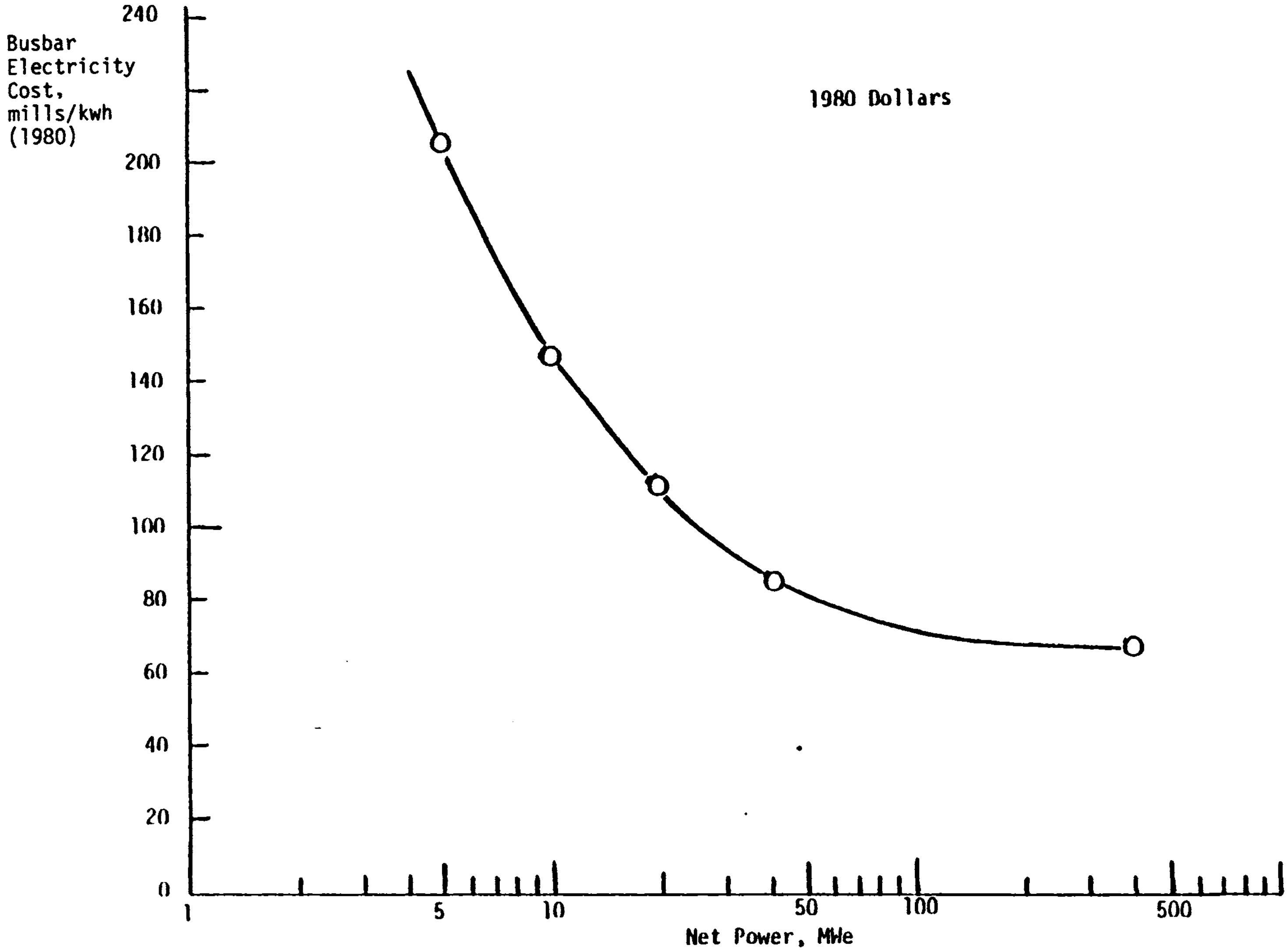


Figure 4. OTEC Busbar Electricity Cost Projections

geothermal power provides a more cost-competitive option than small OTEC plants.

The overall conclusion is that OTEC power costs are competitive with oil-fired plants and possibly coal-fired plants in developing nations. The primary competition for large OTEC plans is large hydropower and dry steam geothermal plus nuclear power. There is a potential cost-competitive market even for the small OTEC units (10 Mw) except incompetition with geothermal sources.

Thus, the major potential for OTEC to provide an alternative energy source and reduce the dependence of imported oil in developing nations in the period 1990-2010 is represented by a projected installed electrical generation capacity addition between 1,176,000 Mw in 51 nations with power systems of sufficient size to accommodate OTEC plants in sizes greater than 10 Mw. A total of 23 nations account for 97 percent (1,140,000 Mw) of this added capacity in power system sizes in excess of 1000 Mw, which accommodates the large commercial-sized OTEC units up to 400 Mw. This represents a potential for 2850 OTEC units at a total installed cost of approximately $2,850 billion (1980 U.S. dollars assuming $2500/kw installed cost) if OTEC were implemented to satisfy the entire added capacity demand. If this OTEC added capacity displaced oil-fired power plants, it would represent a savings of approximately 14 billion barrels of oil per year at a cost of approximately $420 billion per year (1980 U.S. dollars) in these 23 nations where the large commercial units can be used.

Providing the entire capacity addition by OTEC would require an average of nearly 150 plants per year over the 20-year period 1990-2010. This may be in excess of projected industrial capacity since the industry would only be initiating production of commercial-sized units in the mid-1990s. Assuming a more modest goal in 2010 of 20 percent of added capacity (228,000 Mw) in OTEC results in a potential for 570 commercial-sized 400-Mw plants in 23 developing nations at an approximate cost of $570 billion (1980 dollars). The goal would displace an estimated 2.8 billion barrels of oil equivalent per year and represent a savings of approximately $85 billion (1980 U.S. dollars) per year in imported oil costs.

The major objectives in considering OTEC for developing nations include:

1. Provide an alternative energy source for nations heavily dependent on oil imports. This improves the welfare of the people, reduces the economic burden of high costs of imported oil, and reduces world demand for oil.

2. Reduce the world demand for oil and thus reduce the upward pressure on prices. This can be accomplished

by alternative sources of power for oil-importing nations, as described above, or for oil-exporting nations, which could then export more oil to the non-OTEC world.

3. Provide environmentally acceptable, baseload electrical generation alternatives to nuclear power as a means to reduce the proliferation of nuclear materials.

4. Advance world trade between nations. This could include developing nations trading OTEC technology for oil or other products such as OTEC electricity-intensive products, ammonia fertilizer, or aluminum.

These objectives must be considered when deciding which nations might initially have the potential to utilize OTEC. However, the final selection must include key assumptions regarding the economics of OTEC in each nation compared with their alternative energy source development opportunities. These key assumptions are as follows:

1. Definition of OTEC plant sizes and costs is based on no single power plant exceeding 15 percent of the total power-system capacity.

2. OTEC is not cost competitive with large hydropower installations. Nations with significant hydropower potential will develop this resource as first priority. Their interest in OTEC would be to diversify their power sources.

3. OTEC is less costly than imported oil or coal-fired plants.

4. OTEC is marginally cost competitive with domestic coal-fired plants. Domestic coal will get first priority except for interests in OTEC to diversify or environmental concerns with coal.

5. OTEC is marginally cost competitive with nuclear plants. However, concerns for nonproliferation of nuclear materials will increase interest in alternatives to nuclear power such as OTEC.

6. Oil exporting developing nations will value their oil for domestic use at world prices. Thus, OTEC is cost competitive with domestic oil-fired plants.

There latter two assumptions are critical and would require the United States and other developed nations to implement policies to encourage support of these positions. Nations with larger power systems and limited domestic energy supplies will include nuclear power in their development plans since it is developed technology. Nuclear power expansion plans could be replaced in OTEC developing nations if encouraged and supported by governments of developed nations. Some oil-exporting developing nations undervalue their oil for domestic use. If the overall world demand for oil is to be reduced, these nations must be encouraged to utilize alternative energy sources such as OTEC and increase the supply of oil for the non-OTEC world. This could be an attractive trade option since an improved balance of trade could be obtained by exporting more oil at world prices and importing OTEC plants to satisfy domestic demand. In addition, they would be acquiring a new and renewable energy source for their future. Unfortunately, this would result in their people paying higher, world prices for electricity. Thus, incentives may be required by means of U.S. and developed nations' policies to attain this goal, which may be politically difficult for the developing world to implement. However, unless this goal can be obtained, the large OTEC market in key oil-exporting nations, such as Indonesia, Mexico, Venezuela, Nigeria, and Malaysia, will not be exploited.

CONCLUSION

It is clear that a significant OTEC potential exists in the near future for developing nations and territories. The successful development and commercialization of OTEC will be highly dependent upon cooperation among developed and developing nations. The developed nations, by providing for the transfer of OTEC technology and assisting with financing, may help begin to reduce the world demand for nonrenewable energy sources, which would consequently ease energy prices and help control escalating inflation rates. By providing competition for nuclear power, OTEC may also help to limit the proliferation of nuclear materials.

For the developing world the potential benefits are much greater. Any incremental advances in economic growth experienced by the developing world in recent years have been negated by the poorer nations' dependence upon imported energy. It is the rapidly increasing cost of this foreign energy that has provided for the majority of negative economic trends. The developing world's only hope in promoting the economic growth necessary to initiate a new international economic order lies in their ability to produce large amounts of electricity cheaply and independently. OTEC, if proved commercially feasible and competitive, may represent a major step toward reversing recent poor economic trends.

The developing world is very well endowed with natural resources. OTEC's applications to energy-intensive industries might have as significant an impact upon developing economies as electrical power generation for general consumption. For example, many nations mine valuable strategic minerals yet lack the means to process the ore and consequently must export the unprocessed material. Utilizing OTEC to process ores will provide for a very significant amount of additional revenue that is currently generated in foreign markets. In addition, the potential for fresh water as an OTEC by-product of the production of nitrogen fertilizers is very significant as the developing world continues to combat the problems of malnutrition and drought.

In conclusion, OTEC has the potential to solve energy problems for developed as well as developing nations. The need for mutual assistance must be initially recognized on a global basis as work continues on the research and development stages of OTEC. The key, therefore, to successfully commercializing OTEC and providing greater economic prosperity worldwide is international cooperation that recognizes the mutually dependent, international character of OTEC. Without this type of cooperation, both developed and developing nations will fall short of maximizing the benefits OTEC has to offer as neither party may capitalize without the assistance of the other. OTEC represents the basis for a truly significant milestone in international cooperation.

JOINT VENTURES IN FISHERIES: THEIR ROLE IN MARINE TECHNICAL AND ECONOMIC COOPERATION BETWEEN THE UNITED STATES AND DEVELOPING COUNTRIES

Vladimir Kaczynski
University of Washington
January 1981

Implementation of 200-mile exclusive economic zones by coastal nations has extended national jurisdiction over most of the important fishing resources of the world, and this has greatly accelerated international cooperative activity in commercial fisheries. The most common form of cooperation is the joint venture in which companies and governments from different countries cooperate in harvesting and processing operations and in the marketing of seafood commodities.

Approximately 500 fishery joint ventures were active in the late 1970s operating in nearly all ocean areas but with the majority operating in developing countries (Kaczynski and LeVieil 1980). This compares with only a few dozen fishery joint ventures in the 1960s--mostly involving Japan.

The main reason for foreign participants to enter into joint-venture arrangements is to gain access to fishery resources within a host country's coastal zone which otherwise would be almost or completely inaccessible to foreign fleets or commercial fishing companies. Developing countries offer other attractive features as foreign partners in joint ventures. These features include low-cost labor, proximity of fishing grounds to land-based operations, tax incentives, and sometimes reduced fuel costs. The host country usually has quite different expectations of joint ventures than the foreign partner(s) do. In most cases the host country is incapable of using the fishery resources to which it has recently acquired title, although it recognizes their potential significance in providing food, employment, new industry, and foreign (hard) currency. Thus, the country looks to the joint venture as a mechanism to capitalize quickly on its fish resources and usually enters into joint-venture agreements with the expectation that those types of benefits will result.

In practice, most joint ventures are concerned with harvesting, processing, and marketing, but a few concentrate on only one of these areas, such as the provision of boats and gear for harvesting. The degree of involvement by the parnters in fishery joint ventures varies from loose contractual or temporary arrangements to equity ventures, in which participants engage their capital, bring in-kind contributions such as vessels, equipment, and land installations, and share risks and benefits in all stages of joint activities (FAO 1977). Thus there is a variety of arrangements and operational practices in joint ventures.

There is also great variation in the technological, economic, social, and political effects of international joint ventures, and each situation must be analyzed individually. No standard pattern or set of criteria seems applicable. Nevertheless it is clear that for joint ventures to be effective as media for technology transfer and economic development for a host country, it is important that they operate within an agreed organizational framework and fulfill certain basic preconditions. These include

1. a high degree of interaction between the partners in regard to the capital involved, ownership of facilities, management responsibilities, risk sharing, and related factors;

2. a commitment to a long-term contractual arrangement and to equity ventures and joint research or exploration, etc., where appropriate;

3. agreement regarding the scope of the joint activities (e.g., harvesting, sea or land processing, cold storage, marketing);

4. agreement on the resource to be harvested and the volume of production;

5. provision and application of appropriate technology, management, and operating techniques by the foreign partner(s);

6. integration and development of production links between the new enterprise and local industry in consonance with the existing or developing infrastructure; and

7. agreement on appropriate marketing goals (export, host-county markets, mixed, etc.).

The practical significance of these criteria is illustrated by the international fisheries joint ventures involving U.S. companies as foreign partners. These joint ventures are listed in Table 1 according to host country, species harvested, base or area of operation, capital involvement, foreign and local shares, types of vessels and their flags, land installations, and marketing goals. Unfortunately, the data available are not complete, but some

Table I. FISHERIES JOINT VENTURES WITH U.S. COMPANIES AS FOREIGN PARTNERS
(during 1979)

Host country	Target Species	Base or Area of Operation	Capital Involved (shares)	Vessels Type Origin and Number	Land Facilities and Ownership	Product Marketing	U.S. Partner
French Polynesia(FP)	Tuna	Papeete	-	Chartered? 63 longliners (Taiwan?)	Cold Storage (FP)	Exports to U.S.	Starkist Foods, Inc. Bumble Bee Seafoods, Inc.
French Polynesia	Tuna	-	-	3 longliners 1 Ref. Carrier (U.S.?)	-	-	Van de Camp, Inc.
New Zealand (NZ)	Skipjack & other tuna, Albacore	Nelson	$0.8 mln NZ - 75% US - 25%	1 pole&line catcher, 1 purse seiner (U.S.) NZ flag	-	NZ and Exports	Starkist Foods, Inc.
Australia (Projected)	Tunalike species	-	-	1 purse seiner (charter)	-	-	Starkist Foods, Inc.
Papua New Guinea (PNG)	Tunalike Billfishes	Marcus Is.	PNG-40% WB -20% US -40%	3 Japanese catchers 1 Japanese mothership 1 Seiner (US)	Tuna cannery Value $15 mln	- -	Starkist Foods, Inc. World Bank (WB) (PNG will buy WB shares)
Philippines	Tuna	-	DM-100%	-	Canning plant	-	DelMonte Co. (DM) (ceased activities in 1978 . Required min. participation of local partner 70%

Host Country	Species	Operation	Capital	Vessels Type	Facilities	Marketing	U.S. Partner
Philippines	Tuna	Puerto Princesa (Polawan Is)	-	-	Freezing Plant, Cold Storage	Exports of 411 frozen ton a year	Atlas Food Specialties
Philippines (P)	Tuna	-	Min $4.7 mln P - 70% US -30%	2-Tuna purse seiners	3 floating cold storage vessels	-	-
Indonesia (I)	Shrimp	Amubon Is.	I - 20% US- 80%	4-Shrimp Trawlers	Processing/ storage installations	- -	Union Carbide Co.
South Korea (SK)	Skipjack	Masau	-	8 Tuna Catchers (Plans: 20 Vessels)	Cannery (?)	-	DelMonte Co.
India	Tuna, Spiny Lobster	Raunaq	-	6 tuna bait boats 1 Lobster fishing boat (Plans: 12 tuna vessels + 10 sardine purse seiners	Cannery and cold storage, Fishmeal Plant	Exports to USA	Spicewind Seafood Economy Assn.
India	Shrimp	-	4 mln Rupees Projection: 200 mln. Rupees US-100%	3 freezers (Projections: 50 trawlers)	-	-	Union Carbide Co., Inc. (wholly owned subsidiary in India)
South Africa/ Namibia	Tunalike Species	Valvis Bay	-	3 pole line Japanese charter 1 life bait catcher	Processing plant in Puerto Rico	Exports to USA	Starkist Foods Inc.

Host Country	Species	Operation	Capital	Vessels Type	Facilities	Marketing	U.S. Partner
Angola (Portuguese interests)	Pelagic species	-	$15 mln (?)	7 purse seiners	Fishmeal factory barge „Protangue", capacity 500 t/d	-	International Protein Co. (ended in 1977 and sold to South Yemin)
Cameroon (C) (Bernin)	Shrimp	Gulf of Guinea	$700,000 US - 50% C - 50%	8 shrimpers (Crew-C)	Shrimp processing plant	Exports to US	-
Nigeria	Shrimp Prawn	Sapele	$8 mln (projected)	16 Freezer shrimp trawlers (US) (crew training)	Ice plant, Repair shop, Dry dock Stores Shrimp process plant	-	U.S. Continental Seafoods Inc (subsidiary of Ward Foods, Inc)
Nigeria	Shrimp Finfish	-	6.3 mln Nairas US - 100%	10 Shrimp trawlers Catch: 800 t/yr, 5,200 t/yr of fish	-	-	Mundomar Enterprises, Inc. Investment Trust Co. (state agency)
Ghana	Tunalike Trawlfish	Tema	-	4 Japanese tuna catchers, Trawlers	1 Fish processing plant 1 Cold storage (Tema) 1 Cold storage (Accra)	Exports	Starkist Foods Inc (ended in 1974)
Morocco	Sardine (?)	-	-	2 Freezer trawlers	Fish process factory - cans and cardboard boxes factory	-	Lang, Inc.

Host Country	Species	Operation	Capital	Vessels Type	Facilities	Marketing	U.S. Partner
Portugal/Azores	6 months exploratory fishing	-	-	-	-	30% of catch for Azores local market	-
Guyana	Shrimp	Georgetown	US-100%	83 shrimp trawlers	Cold storage (225 t) Processing Plant (27 t/d)	-	-
Surinam (S)	Shrimp	Paramaribo	US - 49% S - 51%	34 US Japanese Korean shrimpers 15 Guyanese shrimpers	Processing plant, Cold storage	Exports to the US	Castle & Cook Ltd (parent Co. of Bumble Bee Seafoods)
French Guyana	Shrimp	Cocama	US - 100%	30-75 shrimp trawlers	Processing plant and slipway	-	Lexington Co. (+ subsidiary Compagne de Carenage du Maroni)
French Guyana	Shrimp in waters off (Guyana & Brazil)	-	-	50 shrimp trawlers (Brazilian crews)	Processing plant, shipyard, motel, cold store. 500 workers 230 onshore	U.S. partner responsible for marketing	Hands Trawler (Miami)
Peru (P)	Yellowfin tuna, Skipjack tuna, Swordfish, Bonito	Paita	$3.2 mln US - 49% P - 51%	-	Freezing, Canning, 8 Fishmeal plants in Paita/ Oquendo	-	Starkist Foods Inc. T.V. nationalized in 1975 (scandal)

Host Country	Species	Operation	Capital	Vessels Type	Facilities	Marketing	U.S. Partner
Mexico	-	San Quintin (projection)	-	-	Fishmeal plant	-	-
Mexico (M)	Tuna	Mexican 200 mile econ. zone	U.S. - 49% M - 51% $80 mln	10 tuna purse seiners from U.S. and Netherland Antilles	Processing to be carried out in Mexico	Exports to the U.S. (plans) and supplies for Mexican cons. market	U.S. investors
Mexico (M)	Anchovy	Baja California Santa Riosalia and San Carlos	U.S. - 51% M - 49%	20 anchovy seiners	2 fishmeal plants 27,000 up to 60,000 t/year	-	Zapata Corp.
Ecuador	Tuna	Galapagos area (1)	-	-	Cold storage	-	B&B Fisheries(?) or DelMonte (?)
Ecuador	Tuna	-	-	-	Cold storage canning plant	-	-
Costa Rica	Shrimp farming (aquaculture)	-	$10 mln	-	-	-	Overseas Private Investment Co. (newly established joint venture-1980)
Costa Rica	Tuna Sardine	Puntarenas	-	3 tuna seiners Costarican flag & U.S.A. flag	Canning factory	-	Zapata Seafood Inc. (subsidiary of Zapata Corp which owns 60 vessels & 7 plants in 4 different countries

Source: V. Kaczynski, D. LeVieil (1980)

conclusions can be drawn concerning the main trends as seen from the U.S. perspective. These conclusions may be listed as follows:

- More than 90 percent of the joint ventures (31) are in developing nations in the Southwest Pacific, Southeast Asia, India, Africa, and Latin America.

- There are 14 ventures involving tuna and 3 ventures in which tuna is included with other species as secondary targets (spiny lobster, trawl fish, sardine).

- There are 8 joint ventures involving shrimp with only one mixed shrimp-finfish operation.

- There are only 4 joint ventures concerned with harvesting of pelagic species. Three of those joint ventures are concerned with production of fish meal and one is concerned with canned products.

- The capital involvement and scale of investment by the U.S. partners appears to be considerable (though available data are incomplete).

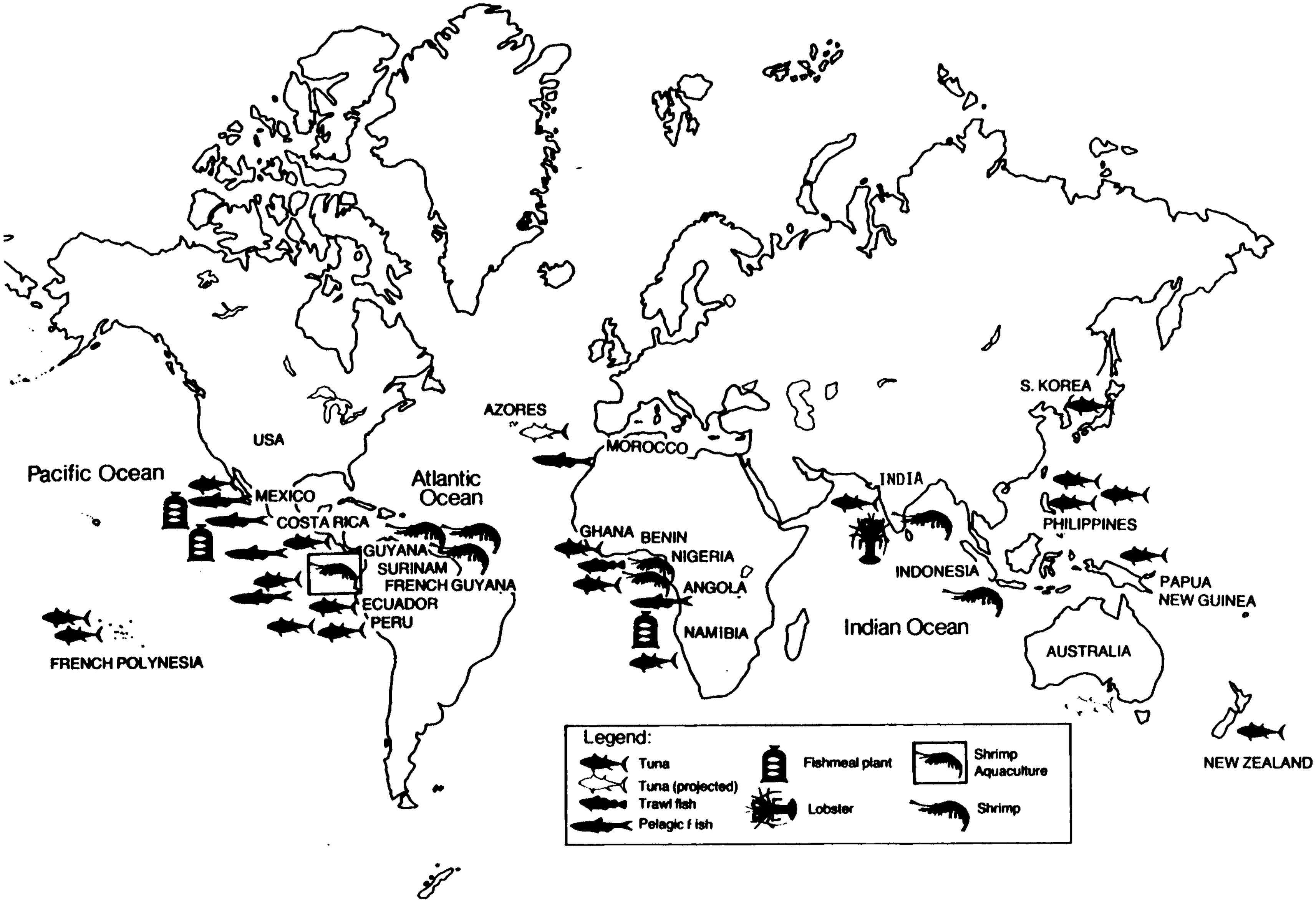
- Vessels used in joint ventures are of mixed origin and frequently are chartered Japanese, South Korean, and Taiwanese vessels and crews. Although a few local vessels and crews are employed, crews may not be host-county nationals. In addition, vessels are sent from the United States.

- Most joint ventures are based on land facilities (particularly processing plants) built by the joint company or rented from local companies (mostly cold stores, parts and repair services, etc.)

- Marketing data indicate most joint-venture products were sold abroad (exported) predominantly in the United States and usually involving the U.S. partner in the joint venture.

Most of the joint ventures involving U.S. companies are concerned with valuable species such as tuna, shrimp, and lobster and operate in waters that are fished intensively and sometimes are overfished (See Figure 1). There will be little room for new joint ventures related to these species. It is not surprising therefore that more than 40 percent of joint ventures in fisheries worldwide are in lower-value trawl fisheries (mainly bottom fish) where resources are more abundant.

The U.S. partners in fisheries joint ventures are seeking high-value species that sell easily in export markets and generate high income. Thus in the host country, such ventures generate foreign (hard) currency and create employment opportunities in land-based processing activities. Typically joint ventures with U.S. companies do not support development of the fishing potential for underutilized low-value species that could supply cheap seafood for local



Fiqure 1. International Joint Ventures in Fisheries with the U.S. Partnership as in 1979
(Prepared according to Table 1.)

host-country markets. This contrasts with the joint-venture activities of other countries. Technology transfer does take place as a consequence of the U.S. involvement since application of foreign technology is necessary for the successful export operation. The various patterns of technology and know-how transfer from developed to developing countries through joint ventures in fisheries are illustrated in Figure 2.

It can be seen that technology transfer occurs at practically all stages of the joint operations, but the intensity of transfer varies from one type of enterprise to another. Thus experience shows that technology transfer through fisheries joint ventures can and does occur, but for the transfer to be effective and beneficial for the technology-supplying partner (e.g., U.S. company), the recipient partner (host country), and for the joint venture itself, the host country situation must be considered and the following conditons must be met:

1. The types of fishing vessels used in the joint venture must be consistent with the resources potential of the coastal zone and must be appropriate to the species harvested. The technical sophistication of the vessels must correspond at least initially with the level of training of available crews and the available servicing facilities. If crew members are to be hired in the host country (and this is one of the most important trends in recent joint-venture operations), foreign fishing vessels should be adapted for use by local manpower, and the training of local crews should be an important component of the joint-venture operation.

2. Seafoods produced by joint ventures and destined for local markets must be designed for the specific customer demands and the cultural mores of the country. In many developing countries, whole fresh fish is in higher demand than processed seafoods; portions of fish not normally used for human food in developed countries are used as food in some developing countries. Thus it might be desirable in such countries for fish to be frozen and later thawed and distributed as fresh fish.

3. A local market study should precede joint-venture production for host-country use, and promotion of new products must be adjusted to existing and sometimes archaic marketing systems (Russek 1979). Characteristics of these marketing systems may include

- poor sanitation and lack of quality control
- many intermediaries and high commission rates
- retail trade frequently controlled by monopolistic intermediaries
- drastic seasonal ex-vessel price fluctuations

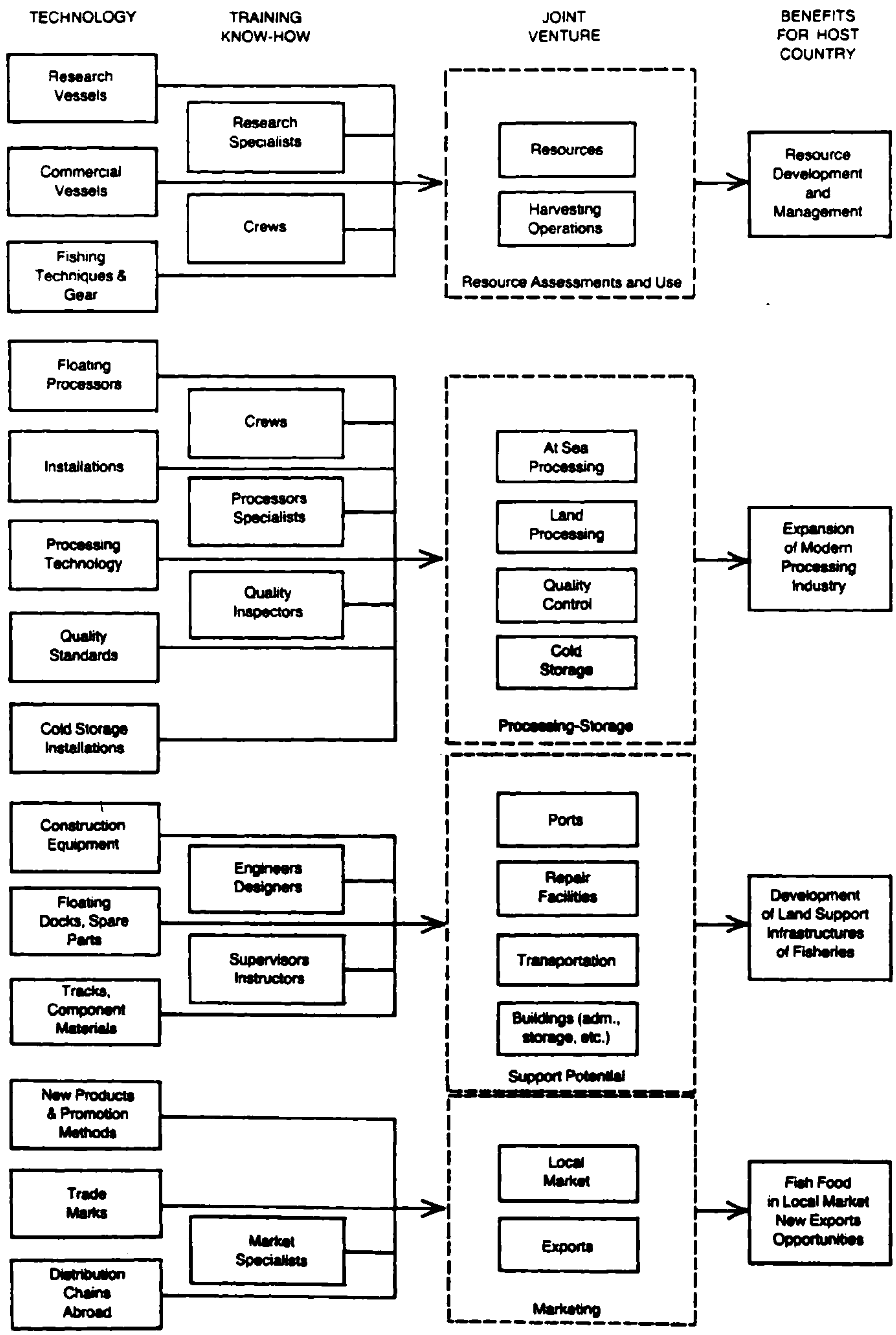


Figure 2. Technology and know-how transfer in joint ventures between developed and developing countries.

- lack of data on ex-vessel prices and wholesale price fluctations: concealment by "whispering auctions" and other local forms of sales

4. The modern technology brought by the foreign partners imposes a requirement for training of crews and shoreside personnel. To cope with this problem, foreign partners in some joint ventures have funded training centers for fishermen and have provided vessels for training. Stipends and scholarships are provided to local trainees as ship officers and business executives for employment in the joint ventures.

5. The organizational framework of joint ventures should include modern production methods but must adapt these methods to the status of technology and knowledge within the host country. Usually the developing country systems are unable to absorb modern technology, know-how, and management techniques quickly.

6. The generally undeveloped infrastructures of developing countries are particularly lacking in organizations, installations, and facilities related to fisheries, and this hampers technology transfer. Thus heavy investment in direct joint-venture installations such as processing plants and storage facilities and also in supporting systems such as ports, roads, warehouses, and even housing may be necessary.

It is important also to note the need to promote development of efficient institutional (bureaucratic) and legal systems as well as economic incentives for private-industry involvement as a precondition for effective technology transfer through joint ventures. More than simple investment fund assurance is needed to promote U.S. private industry involvement. The U.S. government should support and encourage such enterprises. Indeed it would be desirable that a long-term policy be formulated, defining national goals, priorities, and means of technology transfer within international joint ventures. There is also need for specific studies to determine the scope, methodology, and geographic locales for marine technical and economic assistance. Particular programs should be developed for individual developing countries, and these programs should be updated frequently as political, legal, socioeconomic, and cultural conditions change. There is need for direction in private-sector joint-venture activities to make them more effective as tools of development.

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