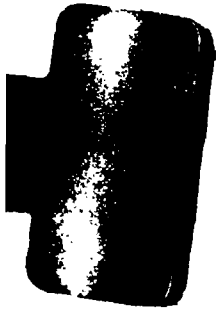
U.S.-Indonesia Marine Science Exchange Program, 1982-83

Summary Report



U.S.-Indonesia Marine Science Exchange Program, 1982-83
Summary Report

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PREFACE

From June 1982 to June 1983, the U.S. National Research Council, through its Board on Science and Technology for International Development (BOSTID), sponsored a U.S.-Indonesia Marine Science Exchange Program which provided support for visits by seven U.S. marine scientists to Indonesia. These scientists presented lectures on topics of interest to Indonesians, gained a better insight into the scientific phenomena of Indonesian waters, and discussed projects that could aid development of marine science in Indonesia.

This project resulted from the interest of Indonesia's Minister of State for Research and Technology, B. J. Habibie, in developing a marine science capability in Indonesia. Minister Habibie has identified marine science as a high priority in Indonesian science because of the large role that marine resources (petroleum, metals, fisheries, tourism, etc.) play in the Indonesian economy and life-style. This role will expand even further as Indonesia exploits its new 200-mile exclusive economic zone. This zone places the resources of over 6 million square kilometers of additional ocean under Indonesian control.

As a result of conversations between Minister Habibie and senior officials of the U.S. Embassy, U.S. Agency for International Development (USAID), and the National Science Foundation (NSF), a workshop was sponsored by NSF in January 1982 on potential U.S.-Indonesian cooperative marine science research. One of the joint recommendations of that workshop was the desirability of a marine science exchange program. At the request of the Ministry of State for Research and Technology and with the concurrence of USAID, the National Research Council agreed to undertake this activity. As a first step, they asked Dr. Dirk Frankenberg, director of the Marine Sciences Program at the University of North Carolina and chairman of the NSF-sponsored activity, to visit Indonesia in May 1982 to consult with the appropriate Indonesian officials on academic areas best suited for exchange and to seek advice on which Indonesian institutions should be visited by U.S. participants. These consultations and subsequent negotiations with potential U.S. participants, led to the following program.

Lecturer 1

Topic:	Primary Production Resource Limitation: Research Needs vs. Current Technology
Date of Visit:	September 1982
Lecturer:	Dr. Hans W. Paerl, Institute of Marine Sciences, University of North Carolina
Plan:	Lectures on coastal productivity at the National Institute of Oceanology, University of Brawijaya, Gadjah Mada University, and Hasanuddin University
Contact:	Professor Sumardi Sastrakusumah, Bogor Agricultural University

Lecturer 2

Topic:	Coral Reef Ecology, with an Emphasis on Indonesian Coral Reefs
Date of Visit:	November 1982
Lecturer:	Dr. James A. Marsh, Jr., University of Guam
Plan:	Lectures on coral reef ecology at the National Institute of Oceanology, Hasanuddin University, Pattimura University, and Diponegoro University
Contact:	Dr. Aprilani Soegiarto, National Institute of Oceanology

Lecturer 3

Topic:	Marine Geology of Indonesia
Date of Visit:	December 1982
Lecturer:	Dr. Joseph R. Curray, Scripps Institution of Oceanography, University of California, San Diego
Plan:	Lectures on marine geology of Indonesia at National Institute of Oceanology, National Institute of Geology and Mining, Gadjah Mada University, and Hasanuddin University
Contact:	Dr. H. M. S. Hartono, Institute of Geology and Mining

Lecturer 4

Topic:	Mollusc Aquaculture and Environmental Monitoring
Date of Visit:	January and February 1983
Lecturer:	Dr. Kenneth R. Tenore, Skidaway Institute of Oceanography
Plan:	Lectures on mussel aquaculture at the National Institute of Oceanology, Bogor Agricultural University, Indonesian Institute of Sciences laboratory at Serang, Pattimura University, and University of North Sumatra
Contact:	Dr. Aprilani Soegiarto, National Institute of Oceanology

Lecturer 5

Topic:	Ocean Engineering and Technology
Date of Visit:	May 1983
Lecturer:	Dr. Robert Corell, University of New Hampshire
Plan:	Lectures on ocean engineering at the National Institute of Oceanology, Institute of Technology at Surabaya, Institute of Technology at Bandung, Hasanuddin University, and Agency for Assessment and Application of Technology (BPPT)
Contact:	Dr. Achmad Amiruddin, Agency for Assessment and Application of Technology

Lecturer 6

Topic:	Coastal Zone Management in the United States, Major Oceanographic Research Projects
Date of Visit:	May-June 1983
Lecturer:	Dr. Dirk Frankenberg, Marine Sciences Program, University of North Carolina
Plan:	Lectures on coastal zone management at the National Institute of Oceanology as well as the following universities: Diponegoro, Gadjah Mada, Pattimura, Hasanuddin, and North Sumatra
Contact:	Dr. Aprilani Soegiarto, National Institute of Oceanology

Lecturer 7

Topic:	Tropical and Coral Reef Fisheries
Date of Visit:	May 1983
Lecturer:	Dr. Nelson Marshall, University of Rhode Island
Plan:	Lectures on tropical fisheries at the Department of Fisheries, Jakarta; Bogor Agricultural University; University of Indonesia; University of Sam Ratulangi, Menado; and University of Brawijaya
Contact:	Dr. Sumardi Sastrakusumah, Bogor Agricultural University

The objective of this exchange program was to increase the knowledge of and the contacts between the participating Indonesian and U.S. marine scientists, all of whom donated their time to this program. During the course of the seven visits, U.S. marine scientists visited most of the institutions in which marine science is currently conducted in Indonesia. These visits and the discussions associated with them provided insight into the importance of marine science to Indonesia and the activities that might enable the Indonesian government to meet its goal of establishing a marine science capability.

This marine science exchange is one activity in a larger program of cooperation between BOSTID and the Indonesian government. Begun in 1968, the program has featured a series of workshops on food policy, industrial and technological research, natural resources, rural productivity, and manpower planning. BOSTID's participation has been

supported in the context of a science and technology loan from the U.S. Agency for International Development to the government of Indonesia. The program with BOSTID calls for two to three activities (panel discussions, workshops, seminars, or small advisory groups) to be organized each year.

This report was prepared by Dr. Frankenberg, who served as a consultant in arranging this project, and BOSTID staff officer Rose Bannigan, using material provided by the visiting scientists. Sabra Bissette Ledent, BOSTID consultant, edited the report. Chapter 1 of the report describes the importance of marine science to Indonesia, and Chapter 2 provides recommendations for a program to assist development of marine science in that country. The two appendixes to this report include a brief description of scientific knowledge of Indonesian seas (Appendix A) and the formal trip reports of exchange participants (Appendix B).

CONTENTS

Chapter 1	The Importance of Marine Science to Indonesia	1
Chapter 2	A Program for Development of Marine Science in Indonesia	9
Appendixes		
A	An Introduction to Marine Environments in Indonesia	25
B	Trip Reports of Participants in the 1982-83 Marine Science Exchange Program	39

CHAPTER 1

The Importance of Marine Science to Indonesia

Marine science is important to Indonesia because it can provide the knowledge upon which to base rational plans for use and development of ocean resources. Although Indonesia is the world's fifth most populous nation, the area over which it exercises economic control is 15 percent land and 85 percent ocean. Ocean resources have always played a major role in the life of the Indonesian people, but this role is expanding as the growing population harvests more protein from the sea, and as economic development uses more petroleum, other minerals, and foreign exchange in efforts to generate seafood harvests from offshore areas. Development of Indonesian marine science capability is necessary if Indonesia is to use the economic and protein resources of its oceans wisely.

Indonesia is an archipelago nation. It consists of 12 major land masses--10 large islands as well as Kalimantan (Indonesian Borneo) and Irian Jaya (Indonesian New Guinea)--and over 13,000 small islands (see Figure 1). The 12 major islands account for 97 percent of the total estimated land area of 1,904,569 km^2. The small islands of Indonesia average about 4 km^2, and, taken together, make up 54,614 km^2. Overall, the islands range from tiny islets to land masses of less than 4,500 km^2.

The territorial seas surrounding the island masses include parts of the Indian and Pacific oceans and parts of the South China, Java, Sulawesi, Flores, Banda, and Arafura seas. Indonesia's land and territorial sea stretches from about 95°E (west of Malaysia) to 140°E (at the border of Papua New Guinea) and from about 7°N (just south of the Philippines) to 12°S (just north of Australia). Indonesian territorial seas make up 85 percent of Indonesia if areas are calculated from boundaries 200 miles seaward of the coastline.

As Wyrtki (1961) points out,

> The distribution of water and land alone characterizes the Southeast Asian Waters as one of the regions with the most complex structure on the earth. Numerous large and small islands subdivide the region into different seas, which are connected with each other by many passages and channels . . . practically all types of topographical features are to be found: shelves, deep sea basins, troughs, trenches, continental slopes of various shapes, and

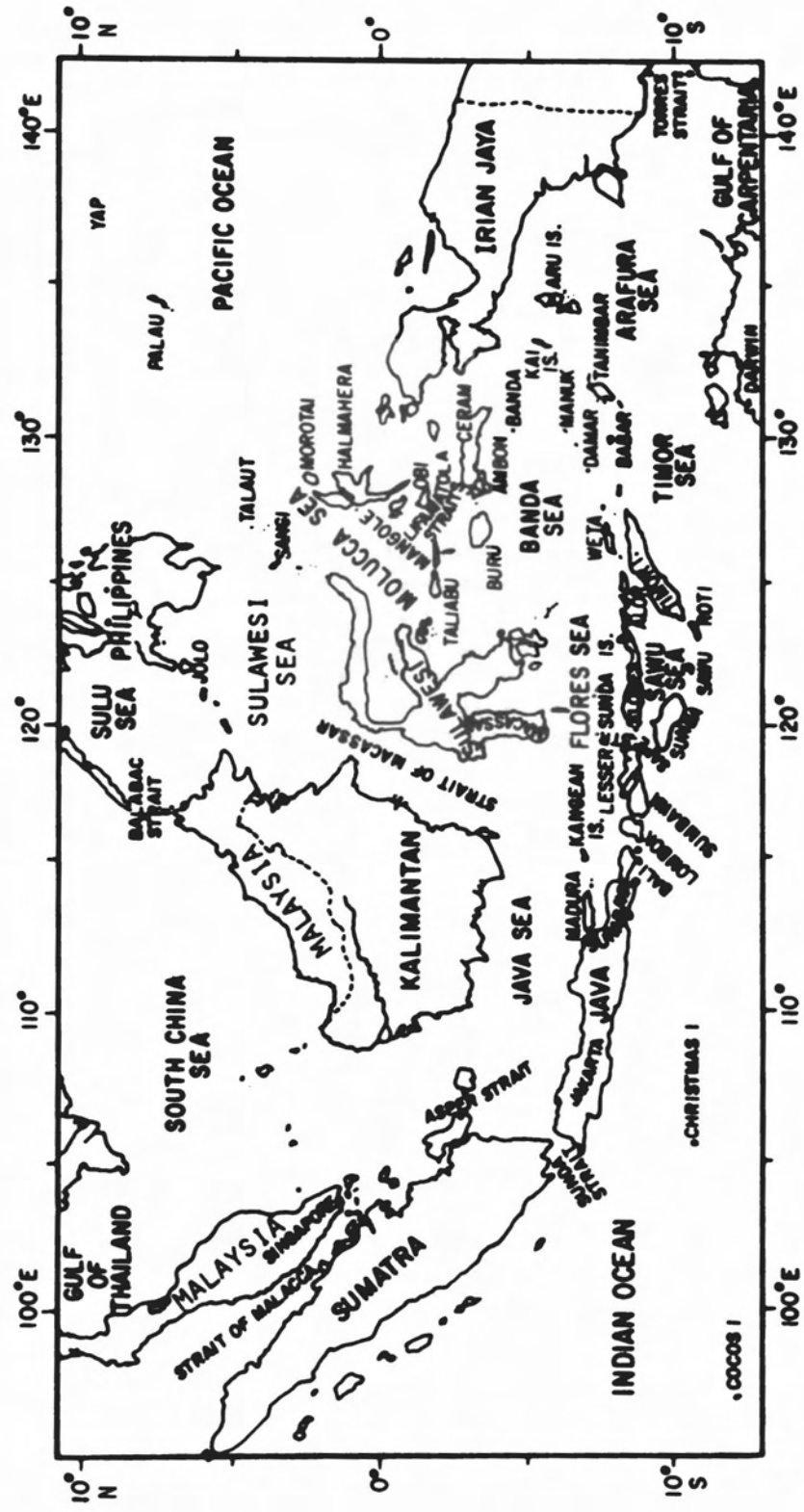

FIGURE 1 Indonesia and its surrounding seas.

volcanic and coral islands. Sills are formed between the islands by submarine ridges which divide the deep sea basins and govern the exchange of their bottom water, making them of special interest for the oceanographer.

The simplest major topographical region of the Indonesian territorial seas is the Sunda shelf which connects the three large islands of Sumatra, Kalimantan, and Java in western Indonesia. This shelf is not completely simple, however, as it is incised by two major systems of submerged river valleys: the Java Valley connecting eastward to the Bali trough and the Sunda Valley extending northward to the South China Sea. The two valley systems almost meet along a line between the southwest corner of Kalimantan and the Sunda Strait between Java and Sumatra (Kuenen 1935, 1950). West of the Sunda shelf, the sea floor topography is characterized by deep-sea trenches and basins reflecting the complex tectonics of the area. These deeps include the Bali trench, the Java trench, the Banda Basin, the Wetar trough, the Timor trough, the Weber Deep, and the Aru Basin (Wyrtki 1961). The deeps are associated with the deep-sea areas north, south, and separating two island arc systems. The Sunda-Banda arc includes the islands of the lesser Sundas, Wetar, Damar, Manuk, Banda, and the western part of Ceram, while another arc, external and concentric to the first, carries the islands of Sumba, Sawu, Roti, Timor, Babar, Tanimbar, Kai, and the eastern part of Ceram.

Coastal habitats on the islands themselves are similar to those of other Indo-West Pacific islands, i.e., coral reefs, lagoons, calcareous beaches, areas of subtidal and intertidal volcanic and carbonate rocks, sea grass and algal beds, estuaries, mangroves, brackish-water fish ponds, and sea edge systems. The Indo-West Pacific is the most diverse zoogeographic region on earth (Ekman 1953, Briggs 1974); thus each of these habitats is predictably rich in species. This richness influences the biological structure of the ecological communities, but does not significantly alter the general functioning of these communities from that observed in temperate and less diverse tropical communities (Soegiarto and Polunin 1981).

The high priority recently accorded marine science by Indonesia's Agency for Assessment and Application of Technology reflects an appreciation of the role marine science can play in developing the country's natural resources. Indonesians have used marine resources throughout human habitation of the archipelago. Indonesian shell middens, ornaments made of marine products, and primitive tools for gathering marine resources date back to 4,000 years before the present. Industrial use of marine mineral resources began with offshore tin mining in 1938, but the development of offshore oil production in the 1970s and 1980s has eclipsed tin in economic importance. Living marine resources have been harvested throughout Indonesian history, and they currently provide a livelihood for about 4.5 percent of all Indonesians and 30-50 percent of dietary protein intake (Sujustani 1980).

Marine resources will continue to play an important role in both the human and economic development of Indonesia. The recently declared

200-mile exclusive economic zone increases the ocean area controlled by Indonesia by over 6 million km^2. The marine resources of these waters are poorly known, but they are likely to be substantial and to contribute heavily to the development of Indonesia.

LIVING MARINE RESOURCES

Living marine resources already support a significant fraction of the Indonesian population. More than 3 million Indonesians are involved in marine capture fisheries or fish farming, and more than 9 million obtain a livelihood from these activities (Collier et al. 1979). The harvest from these fisheries has increased steadily since 1960 (Figure 2), but the catch per unit effort in some coastal capture fisheries declined rapidly between 1969 and 1974 and this decline appears to be part of a long-term trend (Table 1).

This decline is generally interpreted as evidence of overfishing (Soegiarto and Polunin 1981), which could have important consequences by leading to economic displacement of coastal fisherman and further decreases in the already minimal protein supplies of coastal residents. It is simply not known if the status of the northern Java fishery is characteristic of Indonesian coastal fisheries generally, but marine science can provide this kind of information.

The decline in coastal capture fisheries of the northern coast of Java is offset to some extent by harvests from man-made, brackish-water ponds (tambaks), which have increased slowly since 1960 (Figure 2). However, intensively managed individual ponds produce more than three times as much fish per year as casually managed ponds (Birowo 1977), and experimental ponds in southern Sulawesi are about twice as productive as intensively managed ponds.

TABLE 1 Evidence of Long-term Decline in Catch per Effort in the Fisheries of the Northern Coast of Java, 1940-1965.

Year	Catch per Boat (tons per year)	Catch per Man (tons per year)
1940	4.0	1.0
1951	4.0	1.0
1955	3.3	0.9
1961	2.7	0.6
1965	2.8	0.7

SOURCE: Krisnandhi (1969).

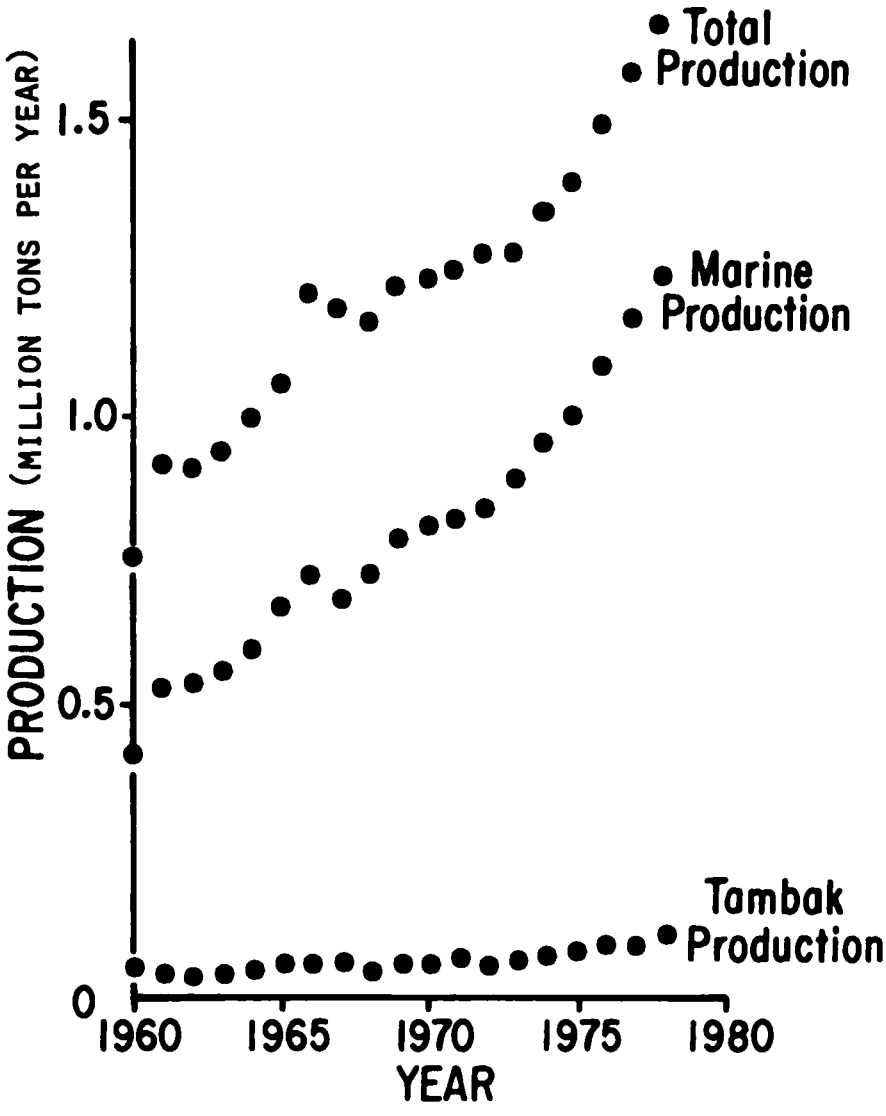

FIGURE 2 Marine fishery harvests in Indonesia (Source: Anonymous 1979a).

Thus increased harvest may be possible as tambak aquaculture techniques improve. Such improvement requires both scientific knowledge and the capacity to extend that knowledge to those who can apply it. Small beginnings have been made to produce the needed knowledge, but much more must be done if the average production of Indonesian brackish-water aquaculture is to achieve the levels reached in the Philippines and elsewhere. Marine science and marine extension activities can help achieve this increase.

Another area in which marine science can serve Indonesia is in developing artificial breeding techniques for the organisms grown to adulthood in tambaks. Indonesian tambaks are currently stocked with juveniles caught in the wild or imported. Breeding and larval rearing techniques have been developed at a project funded by the U.S. Agency for International Development at Pattimura University in the Moluccas and a project to develop such techniques in southern Sulawesi has just begun. The linkage between these projects could be improved, however, and there does not appear to be any plan for using the knowledge gained to develop hatcheries. A coordinated marine science program for Indonesia would link research, development, and production programs to better utilize results of research and available marine resources.

Although coastal capture fisheries and fish farming are the two marine activities that employ the largest number of Indonesians, other fisheries could also benefit from increased scientific knowledge. Thirteen different types of capture fisheries yielded 20,000 tons or more in 1977 (Anonymous 1979a). The status of three general types of fisheries are summarized in Table 2.

Table 2 oversimplifies the status of Indonesian marine capture fisheries by subsuming important species under the headings of pelagics, demersals, and shrimps, but it does indicate that Indonesian fisheries range from overexploited (the coastal fishery off the northern coast of Java) to greatly underdeveloped (the pelagic skipjack tuna fishery west of Sumatra). Table 2 also shows that a major fishery potential still exists in Indonesian waters, particularly in those offshore. The economic value of underexploited Indonesian fisheries has been demonstrated by development of the prawn fishery from a 1960s artisanal activity producing food for local consumption to a mechanized fishery generating more than US$150 million annually in the mid-1970s (Soegiarto and Polunin 1981). It would be unreasonable to expect large numbers of new fisheries to be discovered in the 1980s, but both marine algae (particularly Euchaema for industrial-grade carrageenan) and skipjack tuna off the western coast of Sumatra offer real potential for development. Marine science can provide a realistic assessment of the development potential of these and other living marine resources of Indonesia.

NONLIVING MARINE RESOURCES

Indonesian marine resources also include nonliving materials, the most obvious and valuable of which is petroleum. Indonesia is a member of the Organization of Petroleum Exporting Countries (OPEC), supplies

TABLE 2 Summary of Presently Reported Marine Capture Fishery Production Relative to the Estimated Potential by Area in Indonesia

Area	Status of the Fishery for[a]		
	Pelagics	Demersals	Shrimps
Western Sumatra	1	2	2
Southern Java	2	1	5
Malacca Straits	4	4	5
Eastern Sumatra	1	2/1	5?
Northern Java	4	4	5?
Bali/Nusa Tenggara	1?	1	1
(Bali Strait)	3	-	-
Western/Southern Kalimantan	1	2	5
Eastern Kalimantan	2	1	5?
Southern Sulawesi	2/1	2	2
Northern Sulawesi	2/1	1	-
Maluku/Irian Jaya	2/1	1	5

a/ 1 = underdeveloped; 2 = developing; 3 = close to maximal sustainable exploitation; 4 = traditional grounds fully exploited, offshore potential remains; 5 = fully exploited; - = not applicable.

SOURCE: Sujustani 1980.

about 16 percent of Japan's oil requirements, and is the world's largest exporter of liquefied natural gas (LNG). The percentage of Indonesia's oil output that comes from offshore wells increased from 0 percent in 1970 to 30 percent in 1977 and has continued to grow to 34 percent of the 545 million barrel Indonesian production in 1981 (Anonymous 1978, 1979b; Fletcher 1982). The offshore production comes from depths of only 30-150 m at present (Soegiarto and Polunin 1981), but geophysical data suggest that deeper reserves may also exist.

Oil accounted for more than 67 percent of total Indonesian export revenue in 1977 (Anonymous 1978). Because oil is Indonesia's main energy source and petroleum is used as a raw material by fertilizer and other industries, domestic consumption is high. Thus marine geological information is and will continue to be important to Indonesia's development. Specific knowledge of potential oil-bearing strata may be

developed by oil companies owning Indonesian petroleum concessions, but basic knowledge of the geophysical context within which these concessions occur is the appropriate concern of marine geology. It is clearly in Indonesia's interest to foster development of this science.

Other nonliving marine resources in Indonesia include iron-sands, tin, sand, gravel, and coral rubble (Soegiarto and Polunin 1981). Both tin and iron-sands are mined in large quantities along the southwestern coast of Sumatra (Anonymous 1979b), while sand and gravel are mined locally in shallow waters throughout Indonesia. Coral heads are used as building material, and coral rubble and shells are burned to produce lime (Soegiarto and Polunin 1981). Tin and iron-sand mining depend on knowledge about the distribution of marine sediment. Rational exploration for new sources depends on knowledge of the geological and oceanographic processes that control deposition of the sedimentary ore particles. Coral removal can have detrimental environmental consequences if not carried out with consideration for its impact on waves and their erosive power on beaches. Harvest of live coral and shells obviously destroys environments important to continued harvest as well as to tourism. The knowledge needed to find marine resources and to assess the environmental implications of their use can be provided by marine science.

CONCLUSION

Although the most obvious use of marine science in Indonesia is to find, and wisely exploit, marine resources, it can also be used to improve human living conditions and to serve as a vehicle for building academic institutions, both of which would benefit Indonesia. Indonesians who currently derive their livelihood from marine fisheries and fish farming could improve their living condition by using modern technology to increase or diversify their catch.

A marine extension service could help provide that knowledge. Formation of such a service would also provide employment for sons and daughters of fishermen and contribute to raising public awareness and concern for marine resources issues. The personnel required could be trained in broadened university marine science programs.

Expansion of these programs will be necessary to develop the scientific manpower needed to carry out basic marine research, conduct environmental assessments of resource distribution, or staff a marine extension program (National Research Council 1983). The needed growth will also provide opportunities for academic institution building. In this area, marine science can be particularly effective because it requires expertise in physics, chemistry, biology, fisheries, geology, and sometimes meteorology. Several academic institutions in the United States have used marine science as a vehicle to augment their basic science departments, and this model may be useful to universities in Indonesia, some of whom (Diponegoro, Hasanuddin, and Pattimura) have already determined that marine activities will be a major theme for their development.

CHAPTER 2

A Program for Development of Marine Science in Indonesia

Marine science is the application of scientific knowledge from the fields of geology, physics, chemistry, and biology to study of the oceans. In practice, however, the special requirements of ocean measurements and the disciplinary interrelatedness of marine phenomena bring these basic disciplines together into organized departments, colleges, and institutions of marine science. Only one such institution, the National Institute of Oceanology, exists in Indonesia, although Hasanuddin University has an informal "marine science team" on which all disciplines are represented. Thus a program for development of marine science in Indonesia will largely consist of building institutions.

The goal for development of Indonesian marine science should be to attain self-sufficiency in providing the knowledge needed to find and wisely develop its marine resources. Reaching this goal will require trained manpower, facilities, and institutions that can house, maintain, and nurture marine science programs.

In 1982, a National Research Council (NRC) and Indonesian panel discussed the manpower needs of an Indonesian marine science program (National Research Council 1983) and concluded that there are three general approaches to providing the needed manpower:

1. Direct technical assistance by foreign scientists and technicians
2. External training of Indonesian scientists and technicians
3. Internal training of Indonesian scientists and technicians

The approach selected for solving specific problems depends on the time scale within which a solution is needed. Direct technical assistance (hiring a foreign scientist or technician) provides an instantaneous, but ultimately temporary, solution. External training of Indonesian scientists requires 2-5 years, but provides native expertise once the training period is complete. Internal training of Indonesian scientists and technicians can only be carried out by a developed academic infrastructure.

The NRC panel recommended different approaches to different aspects of marine science development in Indonesia. For example, the immediate Indonesian need for knowledge of marine geology and geophysics, ocean

engineering, and coastal area management procedures was felt to be sufficient to justify programs of direct technical assistance. An immediate program of increased external training for Indonesian marine scientists in all fields was recommended because this seems to be the quickest approach to the overall goal of marine science self-sufficiency. Internal training of Indonesian marine scientists in fisheries was recommended, but internal training in other areas must await further development of marine science institutions.

The activities of participants in the 1982-83 U.S.-Indonesia marine science exchange provide a basis for recommending a specific program to develop marine science in Indonesia. These recommendations are based on approaches described by the 1982 NRC panel, direct observation of the current state of marine science activities in Indonesia, and knowledge of marine science plans and operations in Indonesian institutions. In general, the program includes:

- Direct technical assistance to aid curriculum development and research initiation and to establish marine geology and coastal zone management training programs in selected Indonesian universities
- External training of Indonesian academic staff through a coordinated program of enrollment in U.S. marine science institutions
- Internal training of Indonesian marine scientists in certain fields in selected Indonesian universities
- A funded program of cooperative research to augment and broaden the three other areas.

Specific projects recommended for inclusion in this program are described below.

DIRECT TECHNICAL ASSISTANCE PROJECTS

Development of Indonesian marine science would benefit greatly from establishment of a general technical assistance program in curriculum development and research initiation and from specific projects in marine geology, coastal zone management, and ocean technology and engineering.

Curriculum Development

No Indonesian university currently offers a formal degree in marine science although several offer degrees in the marine aspects of fisheries and biology. Many universities (Diponegoro, Hasanuddin, Pattimura) have, however, expressed great interest in developing curricula in marine science, but each needs assistance in planning its development. Many U.S. universities that have marine science curricula* also have faculty members who could advise Indonesian

*See Curricula in Marine Sciences and Related Fields, published by the U.S. Sea Grant Program, Rockville, Maryland, USA, 1981-82.

institutions on curriculum development. Such advice may range from course development (material to be covered, provision of visual and other teaching aids, review of available textbooks, etc.) to advice on marine program development (staff and facilities required, international funding sources, integration with existing programs etc.). Two specific examples mentioned to participants in the 1982-83 marine science exchange were curriculum development in marine fisheries at Bogor Agricultural University and in marine science at Hasanuddin University (see trip reports, Appendix B). Such a program could be based on short (1-month to 6-week) visits by one or two U.S. academic marine scientists to Indonesian universities desiring curriculum development advice. Although such a project would be relatively inexpensive, it would have a significant and much appreciated impact on development of Indonesian marine science.

Research Initiation

Marine science research in Indonesia would be greatly improved by direct assistance in research initiation. Current academic practice at many Indonesian universities does not emphasize research, and as a result, trained manpower produces less knowledge of marine resources than might otherwise be the case. All academic administrators of universities visited in the 1982-83 exchange program expressed a strong desire to change this current practice by encouraging faculty to increase their involvement in scholarly activity of all sorts, including scientific research. Limited facilities, equipment, and instrument maintenance capabilities constrain the types of marine research that could be effectively conducted in Indonesia currently, but much useful research could be initiated if encouragement and advice were provided.

Participants in the exchange program observed numerous research opportunities that could be initiated by the present staff using existing equipment. Some participants spent time in the field demonstrating research techniques that could be mounted with the facilities on hand and describing research opportunities (see Appendix B)--an activity much appreciated by the Indonesian participants. It was concluded that a formal program of short (about 1-month) visits by U.S. marine scientists (particularly marine biologists and fishery scientists) would greatly increase research initiation efforts in Indonesia. Such a program could be mounted at relatively low cost.

Marine Geology

Carbonate Geomorphologist, Faculty of Geography,
Gadjah Mada University

In Indonesia, geology is generally practiced at institutes of technology and government laboratories rather than in the

universities. This situation hampers the development of full-scale marine science programs in the universities because marine geology is an integral component of such programs.

The only university with a functioning geology program visited by NRC marine science exchange participants was Gadjah Mada University, where the geography faculty includes three carbonate geomorphologists--the dean of the faculty and two professors. All three have active research programs under way on the karst topography along the Indian Ocean coast of central Java, and all expressed great interest in augmenting their programs with the help of a submarine carbonate geomorphologist who could extend their coastal observations into the adjacent ocean. The submarine geology of the Indian Ocean coastline of Indonesia is poorly known. Thus great research opportunities await any marine geologist joining the Gadjah Mada group.

Discussions with this group led to development of a twin exchange concept in which a recent M.S. or Ph.D. graduate of a U.S. institution would go to Gadjah Mada on a 2- or 3-year appointment, while a young staff member from Gadjah Mada took graduate study at the same U.S. institution. At the end of the U.S. twin's term, he or she would return to the United States and would be replaced by the newly trained Gadjah Mada staff member. In this way direct technical assistance and external training would lead quickly to internal training. The U.S. institution identified in discussions with Gadjah Mada faculty was the University of North Carolina at Chapel Hill, but such an arrangement might be worked out at any number of U.S. institutions.

Equipment and a Submarine Geologist,
Geological Research and Development Center (GRDC)

The GRDC in Bandung is developing a submarine geology program based at a marine geology facility on the northern coast of Java. This facility already has a ship and the equipment to sample nearshore geological features, and they will soon have the capability to conduct high resolution seismic profiling in the coastal zone. In addition, the Indonesian Hydrographic Office has vessels capable of mounting the large winches needed for dredging and coring in any water depth.

These marine geological facilities would be greatly aided by provision of a 4-6 channel multifold seismic system and a side scan sonar system for use in shallow water and the large winch needed for deep-sea sampling. Other useful technologies would include multibeam bathymetry, multichannel seismic reflection, deep-sea drilling, offshore-onshore aeromagnetic surveying, and side scan seismic reflection. These latter technologies are newer and expensive, and might best be used in collaborative projects with investigators from developed countries.

The scientific problems that could be studied with the use of such tools include study of the collision zone between Irian Jaya and the Banda arc; deep-sea drilling in the Banda Sea and other basins to determine their age and origin; and aeromagnetic, side looking seismic reflection and bottom sampling surveys off the eastern rim of Sulawesi, in the Banda Sea, and off the coasts of islands.

While the provision and collaborative use of this equipment would greatly enhance the new marine geology program at GRDC, the short-term addition of an expatriate marine geologist would also be extremely useful. Such an individual could interact with geologists at the Department of Mines and Energy, the National Institute of Geology and Mining, and the Institute of Technology at Bandung. A scientist with research interests in shallow subbottom profiling would find many problems of great interest and would also interact effectively with the marine carbonate geomorphologist recommended for technical assistance to the Department of Geography at Gadjah Mada University. A staff addition in this interactive situation would stimulate interest in marine geology and greatly increase the development rate in this badly needed area.

Coastal Zone Management

A coastal zone management program will be developed during Indonesia's fourth 5-year plan (REPELITA IV) between 1984 and 1989. Preliminary efforts are already under way. An interministry team under direction of Dr. Aprilani Soegiarto of the National Institute of Oceanology is working to summarize known scientific information about Indonesian coastal zone habitats. No effort, however, appears to be devoted to cataloging existing laws and regulations affecting the coastal zone, nor is there any evidence to suggest that cultural systems of coastal resource allocation known to anthropologists will be studied for possible dovetailing with new coastal zone management regulations.

Coastal zone managers, lawyers, and anthropologists from the United States are familiar with these matters and can provide valuable technical assistance to the ongoing Indonesian effort. Other aspects of coastal zone management will also benefit from U.S. technical assistance, although specific areas of need will become obvious only as the Indonesian program moves forward. This situation creates the need for a flexible assistance program of the sort that could be supported by a USAID international program initiative to be funded in 1984. Studies to determine which countries will receive assistance from this project are currently under way, but decisions concerning the administrative mechanism for operating the program have apparently not yet been made. A program that focuses on Indonesia and is flexible enough to support an individual working with the interministerial team to provide specific technical assistance and provide specific consultants as necessary would be very useful.

Development of the Indonesian coastal zone management program will create an immediate need for trained manpower to administer it. Such manpower does not now exist in Indonesia, but it could be developed at universities that have an interest in such training. Such an interest was expressed to members of the 1982-83 marine science exchange program by the faculty at Diponegoro, Gadjah Mada, North Sumatra, and Hasanuddin universities, all of which have programs that could be augmented to train coastal zone management specialists if provided with technical assistance. Many U.S. universities (North Carolina, Rhode Island, Washington, Oregon State, Southern California, California,

Texas A&M, Delaware, etc.) are training young scientists who could provide this assistance, ideally through the same "twin exchange" mechanism described earlier.

OCEAN TECHNOLOGY AND ENGINEERING

There are substantial opportunities for ocean engineering and technology development projects with Indonesia, particularly projects focused on marine resources development and the economic development of the coastal margin. During the 1982-83 U.S. marine science exchange program, the opportunities for such activities were identified and discussed with several universities and technological institutions and the Agency for Assessment and Application of Technology (BPPT), an independent government agency chaired by the Minister of State for Science and Technology. These potential projects fall into two broad and major categories:

1. Projects of national scope and interest focused on technology development and its application in the broad area of coastal marine resources development.
2. Projects of an academic nature focused on science and technology interests that are of prime importance to Indonesia.

The projects of national scope and interest are conceived as potential joint ventures between BPPT, Indonesian universities and industry, and appropriate U.S. institutions and agencies. These projects were organized and summarized in a meeting between one of the 1982-83 U.S. marine science exchange program participants and the National Ocean Technology Committee chaired by one of the deputy directors of BPPT. Four major areas of research and technology development were identified:

1. Foods from the sea, primarily fisheries and aquaculture and their related technologies
2. Energy resources development within the coastal margin, including oil and gas, geothermal energy, and others
3. Extraction of raw materials from the sea and from the coastal margin, including minerals from the seawater, extraction of potable waters from the sea, and more classical mineral resources development
4. Marine pollution issues in Indonesian waters, both actual and potential. Serious potential problems exist with the large transport tankers that pass through Indonesian waters as well as with the infusion of pollutants from the large population centers on islands such as Java. Marine pollution seems to be one of the most serious marine-related problems and was consistently addressed by Indonesians. Therefore, the opportunity for joint efforts is significant, particularly in the development of appropriate technology for Indonesia and for the creation of needed hardware systems.

The projects related to individual academic institutions follow the four themes outlined above. However, specific mention is noted for the ocean engineering and technology activities. Several institutions are eager to expand both basic and applied research on technologies related to:

- Shipbuilding and marine engineering
- Broader interests in marine transportation
- Fisheries and aquaculture
- Marine pollution and pollution control
- Offshore systems and structures
- Ocean resources exploration, development, and production

The central theme in all proposed projects is the development of technologies that are appropriate to Indonesia, to the Indonesian economy, and to the technological and industrial infrastructure, and that will enhance the development of Indonesia's vast coastal resources.

EXTERNAL TRAINING PROJECTS

The development of Indonesian marine science will require an initial period for training manpower outside of Indonesia. Indonesian universities can train fisheries scientists and biologists, but there are no training programs for marine geologists, chemists, or physical oceanographers. The manpower needed to develop and operate such programs must be trained externally for several years. There are also areas in which short-term external training would benefit development of Indonesian marine science. Recommended approaches to both types of external training are described below.

Short-Term External Training

Marine Science Program Development

The absence of established marine science programs in Indonesian universities means that there is no internal model for development and operation of such programs. Hasanuddin University has been working on this problem since the mid-1970s, while other universities are either just beginning to establish marine science programs (Pattimura) or are considering such a move (Diponegoro, Gadjah Mada, North Sumatra, etc.). Senior faculty and administrators of these institutions have expressed the desire for short-term visits to U.S. universities with marine science programs. Such visits will provide an opportunity to observe a spectrum of academic marine science programs and to discuss the development strategy of such programs and how they are integrated into the traditional academic program of the university.

Although each U.S. marine science program is slightly different, a short (about 1-month) visit of Indonesian scientists to four or five carefully selected U.S. institutions should provide a representative

sample of the entire range. Such a program need not be large to be effective. A substantial impact could result if fewer than 10 marine scientists were to visit U.S. institutions over a 2-year period.

Research Techniques

Numerous ways in which marine science research in Indonesia could be enhanced by short-term training in research techniques were observed by participants in the exchange program (see Appendix B). A project to take advantage of such opportunities could be mounted by establishing a participant selection procedure and providing modest financial support to bring participants to U.S. institutions.

One example of such an exchange was discussed by Drs. Dirk Frankenberg and Aprilani Soegiarto during the former's exchange visit. This opportunity would provide training for one or two Indonesian marine scientists in the "mussel watch" techniques used in the U.S. marine pollution monitoring program. This program measures pollutant compounds in shellfish collected from U.S. shorelines and provides data on both "normal" levels of potential pollutants and detects unusual increases in their concentration.

Operating since 1976, this program is now being expanded internationally through support of the United Nations Development Programme, and is being introduced with a workshop in Australia in August 1983 with U.N. support. Two Indonesian marine scientists will attend this workshop, but it is not expected that they will be able to operate an Indonesian program--a high priority of Indonesian national laboratories--without further training. An opportunity for such training exists in the Moss Landing Marine Laboratory of the California State University System. Modest financial support would allow selected Indonesians to take advantage of this opportunity to learn first-hand the day-to-day operation and maintenance of the mussel watch program.

Graduate Degree Training of Indonesian Marine Scientists

Indonesian marine scientists are now being trained in the United States, but the number of students and institutions involved is small. This is due in part to financial constraints and in part to the small amount of previous contact between U.S. and Indonesian marine scientists and institutions. Increasing these contacts will be mutually beneficial as the Indonesian marine science initiative gains momentum. The NRC marine science exchange helped somewhat in this respect (see Appendix B), but a formal mechanism may be necessary to broaden contact between Indonesians seeking advanced training and U.S. institutions willing to provide it.

Ideas for such a mechanism were discussed by participants in the marine science exchange. The concept of a U.S.-Indonesian marine science network for coordinating U.S. training of Indonesian marine scientists was reviewed by Dr. Frankenberg and Dr. Sukadji Ranuwihardjo of the Indonesian Ministry of State for Research and Technology. The

concept has been enthusiastically received by the ministry, and Dr. Frankenberg has begun to determine U.S. institutional interest in participating.

There are, however, two major problems in establishing a U.S.-Indonesia marine science training network: (1) funding to support costs of the U.S. education, and (2) the language competence of potential Indonesian trainees. The first problem may be solved by funds from Indonesian, U.S., or private sources, but potential solutions to the second problem are not so obvious. Graduate programs at most U.S. institutions require a level of performance on the Test of English as a Foreign Language (TOEFL) that exceeds the capacity of many Indonesians. This creates a situation in which a technically qualified student cannot be officially admitted to graduate school, and, without such admission, cannot obtain support for study to improve his English language proficiency. Some institutions in Indonesia (Gadjah Mada University) have internal English language training courses, but most do not. Excellent English language training courses are taught in the United States.* But these courses are not accessible to Indonesian students who have not already been admitted to U.S. graduate schools.

This problem was recognized as a major obstacle to increased U.S. external training of Indonesian scientists by the 1982 NRC panel on science and technology planning and forecasting for Indonesia (National Research Council 1983), but no short-term solutions were recommended. Universities in other developed countries, most notably France, West Germany, and the Netherlands, solve this problem by admitting technically qualified Indonesian students on the condition that they complete a language training course before enrollment. U.S. universities may be willing to do the same if incentives and experience justify it.

INTERNAL TRAINING PROJECTS

Internal training of Indonesian marine science manpower will be difficult in fields other than biology and fisheries because no Indonesian academic institutions offer marine science degrees. Hasanuddin University comes the closest to having an appropriate staff, but their teaching program is not now organized to produce trained marine scientists. Advanced internal training in fisheries and biology can be obtained at several Indonesian institutions (Bogor, Diponegoro, Gadjah Mada, and Hasanuddin), but few of these programs have a marine orientation.

Improved Indonesian training programs in marine science will result from direct technical assistance in curriculum and faculty development and external training of faculty and administrators. Such efforts would probably be most quickly successful at the Bogor Agricultural and Hasanuddin universities where staff and administrative commitment to

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*For an up-to-date list, see "English Language and Orientation Programs in the U.S.," Institute of International Education. Available from UNIPUB, 345 Park Avenue South, New York, N.Y., 10010, USA.

such a program are strong. Similar efforts may also be worthwhile at Gadjah Mada and Diponegoro universities. The staff at Gadjah Mada is excellent and might be willing to work together in marine science if provided with administrative encouragement and incentives. The administrative commitment to marine science programs is strong at Diponegoro University, but marine-oriented faculty in many nonbiological fields will have to be developed.

Programs in ocean engineering and technologies are developing at two major technological institutes--the Institute of Technology at Bandung (ITB), the oldest technological institution in Indonesia, and the Institute of Technology at Surabaya (ITS)--and at Hasanuddin University. The program at ITS emphasizes shipbuilding, marine engineering, and naval architecture, but there is a strong interest in broadening the scope of the program to include such ocean engineering efforts as offshore structures.

The overall conclusion of U.S. participants in the 1982-83 marine science exchange is that most Indonesian Universities cannot be expected to develop effective training programs in marine science without 5-10 years of focused, well-supported effort. The initiation of such an effort is a high priority to the Indonesian Ministry of State for Research and Technology.

COOPERATIVE RESEARCH PROJECTS

Cooperative research projects involving U.S. and Indonesian marine scientists offer real advantages for rapid development of specific areas of marine science. For example, the geological research of Professor E. A. Silver, the University of California at Santa Cruz, in Indonesia has produced data of worldwide scientific interest as well as of practical importance to Indonesia. This work was carried out with the cooperation of Dr. H. M. S. Hartono of Indonesia's Geological Research and Development Center. In addition, a young Indonesian geologist, Dr. Hardi Prasetyo, recently joined Professor Silver's laboratory where he will work on project data while earning a graduate degree. Thus upon his return to Indonesia Dr. Prasetyo will be able to help strengthen his country's marine science community.
Professor Silver's program therefore effectively demonstrates all three approaches to improving marine science in Indonesia:

1. Direct technical assistance through study of new research topics
2. External training of a young Indonesian scientist
3. Improving internal training capacity by broadening Dr. Hartono's scientific experience and the training of a young scientist.

These possibilities exist in all cooperative research projects and provide the rationale for including such projects in any program for developing marine science in Indonesia.

The development of a U.S.-Indonesia cooperative marine science research program will not be difficult. The core of such a program

already exists in formal proposals resulting from the 1982 U.S.-Indonesia cooperative marine science research workshop sponsored by the U.S. National Science Foundation. Two projects developed at this workshop has been initiated and two others have been partially funded, but support for U.S. participation in four other projects has not been secured. Commitment of Indonesian resources to these projects was secured in 1982. The cooperative projects developed at the 1982 workshop had the official approval of the Indonesian government, and U.S. and Indonesian scientific counterparts to conduct the work were identified.

The core program represented by proposed projects from the 1982 workshop could be easily broadened to increase coverage of a cooperative marine science research program. Furthermore, the NRC-sponsored exchange paved the way for development of several cooperative research projects. For example, the first U.S. participant, Dr. Hans Paerl of the University of North Carolina, has prepared a full-scale proposal for study of primary productivity in Indonesian coastal waters. This project, which would be carried out in cooperation with Dr. A. Nontji of Indonesia's National Institute of Oceanology, would advance the institute's existing program development plan and provide data essential for evaluating the production potential of nearshore fisheries of the northern coast of Java. These fisheries appear to be overfished (see Chapter 1), but their theoretical production rate cannot be estimated without better knowledge of the primary production base of the food chain. Once again, the Indonesian component of the project is firmly committed, but funding for the U.S. component has not been secured.

Other potential cooperative research projects were discussed by all participants in the marine science exchange. Any signal that U.S. funding for such projects is a possibility would encourage development of full-scale proposals. Without such signals, the declination rate of proposals developed in the wake of the 1982 NSF-sponsored workshop discourages busy scientists from devoting time to preparation of proposals for cooperative research in Indonesia.

Participants in recently sponsored U.S.-Indonesia exchanges are not the only potential source of cooperative research proposals. Many other U.S. marine scientists are interested in developing research projects in Indonesia, in large part due to the intrinsic scientific importance of phenomena of Indonesian waters. Some of these phenomena are described in Appendix A of this report, but the great diversity of Indonesian marine biota, habitats, topography, geology, and circulation produces a plethora of potential topics for fruitful study. In preparation for the 1982 NSF-sponsored cooperative research workshop, the U.S. marine science community was queried about interest in potential Indonesian research. These queries resulted in more than 20 positive responses, with potential projects ranging across the entire spectrum of modern marine science. Most of these responses were from well-established U.S. investigators whose interest would need only modest encouragement for them to generate full-scale proposals. Members of the Indonesian National Ocean Technology Committee have already submitted several tentative proposals for technology-based

research and development activities: one in marine pollution control, one in marine biotechnology development, and one in the extraction of minerals, energy, and water from the sea. These examples give additional impetus to the interest for joint research and development activities with U.S. institutions and agencies.

In summary, there is a large group of U.S. and Indonesian scientists who are enthusiastic about working together on cooperative marine research projects. Such projects produce mutual scientific advantages and could help develop Indonesian marine science. A modest program of U.S. support for such research would be advantageous to both U.S. and Indonesian interests.

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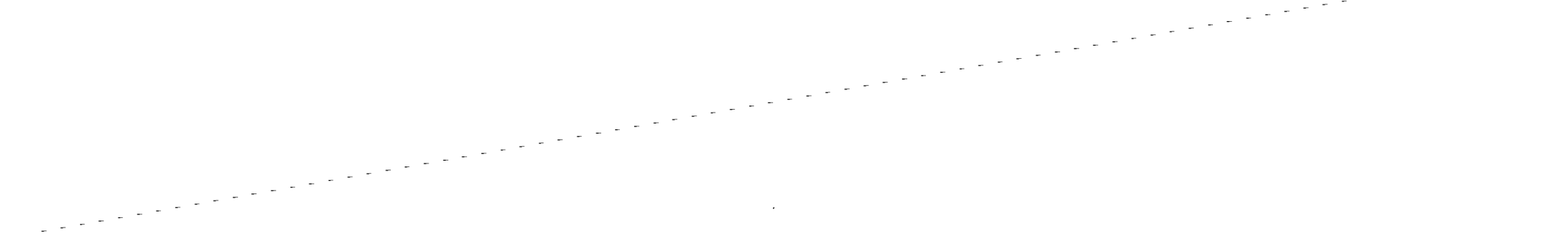
APPENDIXES



APPENDIX A

An Introduction to Marine Environments in Indonesia

BACKGROUND

Paradoxically, Indonesian marine environments have been studied little scientifically, although marine resources dominate the Indonesian economy and marine science expertise has increased greatly worldwide over the last 30 years. The scientific knowledge that has been published on Indonesian waters is widely scattered in expedition reports, special reports, and Indonesian and international journals.* Taken together these expedition reports, special reports, and scientific publications sketch a picture of Indonesian marine environments that is summarized briefly below and more extensively by Soegiarto and Polunin (1981), but the picture is lacking in detail. So few Indonesian marine environments have been studied that variations or general applicability of observations cannot be accurately assessed. This caveat must be kept in mind in reviewing any summary of Indonesian marine environments and is doubly applicable in the brief summary attempted here.

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*The expedition reports begin with those of Raumphius in the 1700s and include the 1929-1930 Snellius Expedition (Kuenen 1935) and the 1959-1961 NAGA Expedition (Wyrtki 1961). These early studies have been supplemented with a variety of special reports from UNESCO (1958, 1966, 1974); the Food and Agriculture Organization (FAO) of the United Nations (Cushing 1971, Gulland 1973, MacNae 1974); the South China Seas Fisheries Development and Coordinating Program; the U.S. Geological Survey (Hamilton 1979); and a variety of sources within Indonesia (e.g., special publications of the BIOTROP program, Bogor; Carbonate Symposium, Jakarta, 1977, National Institute of Oceanology; Bulletin of the Geologic Research and Development Center). These reports are valuable but less accessible to foreign marine scientists than the shorter summaries available in international journals (Keller and Richards 1967, Sobur et al. 1978, Silver and Moore 1978) or Indonesian journals (Marine Research in Indonesia, Oseanologi di Indonesia).

GEOLOGY

In recent years, the marine geology of Indonesia has been studied extensively as a result of momentum generated by the SEATAR (Southeast Asia Tectonics and Resources) program during the International Decade of Ocean Exploration (IDOE) and intrinsic interest in the complex tectonics of the eastern part of the Indonesian archipelago. The SEATAR program began with a conference in Bangkok in 1973 (Hayes 1975). Since 1976, a series of marine geologic and geophysical cruises have been carried out in Indonesian waters, staffed by investigators from the Scripps Institution of Oceanography; Woods Hole Oceanographic Institution; Cornell University; University of California, Santa Cruz; ORSTOM (Office de la recherche scientifique et technique outre-mer); Flinders University; and the University of Hawaii. These cruises have focused on geophysical data and plate tectonic interpretation, but they have been supplemented by additional geophysical studies as well as studies of marine sediments and island geology.

The plate tectonic history of eastern Indonesia has been shaped by the ongoing collision of the Indo-Australian plate with the Pacific plate and the plate fragments between them. It is generally agreed that this collision has produced two concentric island arc systems--one bearing the islands of the lesser Sunda group as well as Wetar, Damur, Manuk, Banda, and the western part of Ceram; the other bearing the islands of Sawu, Roti, Timor, Babar, Tanimbar, Kai, and the eastern part of Ceram. These island arcs are separated and flanked by deep-sea troughs and basins (Silver and Moore 1978). Interpretation of the tectonic processes that produced these island arcs and ocean deeps is a matter of current, active debate. One interpretation (Hamilton 1979) suggests that the Banda Sea Basin is young (about 20 million years) and was formed by spreading behind the Sunda and Banda island arcs. Another interpretation (Bowin et al. 1980) suggests that the basin is a trapped piece of Mesozoic crust. This debate has stimulated new study of the geology of eastern Indonesia, and new data can be expected soon on submarine topography, marine sediments (both surficial and cores), island and volcano rock types, and deep refraction subbottom profiles.

Interest in the tectonic history of eastern Indonesia has also resulted in the updating of other geological data. For example, the surficial sediment map produced by Neeb (1942) has been modified by E. A. Silver to include data from post-Snellius cruise cores taken by the research vessels Vema and Conrad. Paleontological descriptions of these cores have been prepared from data available from the U.S. National Geophysical and Solar-Terrestrial Data Center in Boulder, Colorado.

Unfortunately, the surge of scientific interest in the marine geology of eastern Indonesia has not been matched by comparable interest in the shallower waters between Java, Sumatra, and Kalimantan, which are known to be deeply incised by flooded river valley systems (Kuenen 1935, 1950; Wyrtki 1961). The sediments of this region have been studied and summarized by Neeb (1942) and Keller and Richards (1967), but relatively little recent information has been published in the open literature. The intense interest in petroleum exploration and

production from western Indonesia suggests that substantial geological knowledge of this area does exist.

PHYSICAL OCEANOGRAPHY

The physical oceanography of Indonesia waters has received little attention recently. The classic work of Klaus Wyrtki (1961), reporting on his 3 years of study in Indonesia and summarizing prior measurements in Indonesian waters, remains the major source of information. Wyrtki provides and summarizes data on winds and surface circulation, water mass properties, precipitation/evaporation energy exchange, circulation dynamics, and tides and tidal currents. Some aspects of this work are briefly described here, although the caveat concerning generalization mentioned earlier certainly applies as Wyrtki's report is itself generalized so that any summarization is even more so. Clearly, however, much work must be done to extend the general knowledge provided by Wyrtki in 1961 to a specific, up-to-date understanding of physical oceanographic phenomena in the topographically complex Indonesian seas.

Information about the physical oceanography of Indonesian seas can be conveniently divided into that on surface and deep-layer phenomena since both of these layers are well developed and are easily distinguished from one another by a sharp, thermally stratified discontinuity layer (Wyrtki 1961).

The surface homogeneous layer is mixed by the wind and averages 50 m in depth. The depth ranges from 100 m in the absence of upwelling events to 20–50 m after such events. The homogeneous layer has internal variations of less than 1°C, but salinity varies greatly from land runoff. The homogeneous layer is separated from more variable, deeper water masses of the Indonesian seas by a sharp thermal stratification, with temperatures typically decreasing about 20°C (from about 28°C to about 8°C) from the surface to approximately 600 m (Wyrtki 1961).

Surface circulation in Indonesian seas is dominated by monsoon winds, and it reverses seasonally (Wyrtki 1961). This monsoonal reversal is strikingly developed in the enclosed waters of the Java, Flores, Banda, and Arafura Seas because their east-west axis lies parallel to the major winds flowing to the equatorial low-pressure trough. In the northern winter, high pressure over Asia created by seasonal cooling combines with relatively low pressure over Australia to displace the equatorial trough to about 10°S. The resulting pressure differentials lead to a strong wind flow (force 5) from the northeast over the South China Sea. This flow turns to the east along the equatorial trough as it meets the southeast trade winds. The resulting strong west-to-east winds over Indonesian enclosed waters produce west-to-east surface currents that reach 75 cm/sec (Wyrtki 1961; see Figure 1, February). In the northern summer this situation reverses. Seasonal warming causes air to rise over Asia, creating low pressure, while the opposite occurs in Australia. The reversed pressure differential moves the equatorial trough back to the equator

and allows the southeast trade winds to blow unimpeded across Indonesia's enclosed water, creating east-to-west surface currents with speeds of 40-50 cm/sec (Wyrtki 1961; see Figure 1, August). The flow of water into the Java Sea from December through February brings high-salinity water that alters surface salinity values over much of the Java Sea.

The water masses that occur beneath the discontinuity layer originate at different locations in the Pacific Ocean and move in complex flow patterns across various topographic sills before reaching the deep basins (Wyrtki 1961). Six water masses have been identified as participating in this process. The characteristics of each are summarized in Table 1, and the flow patterns are diagrammed in Figure 2.

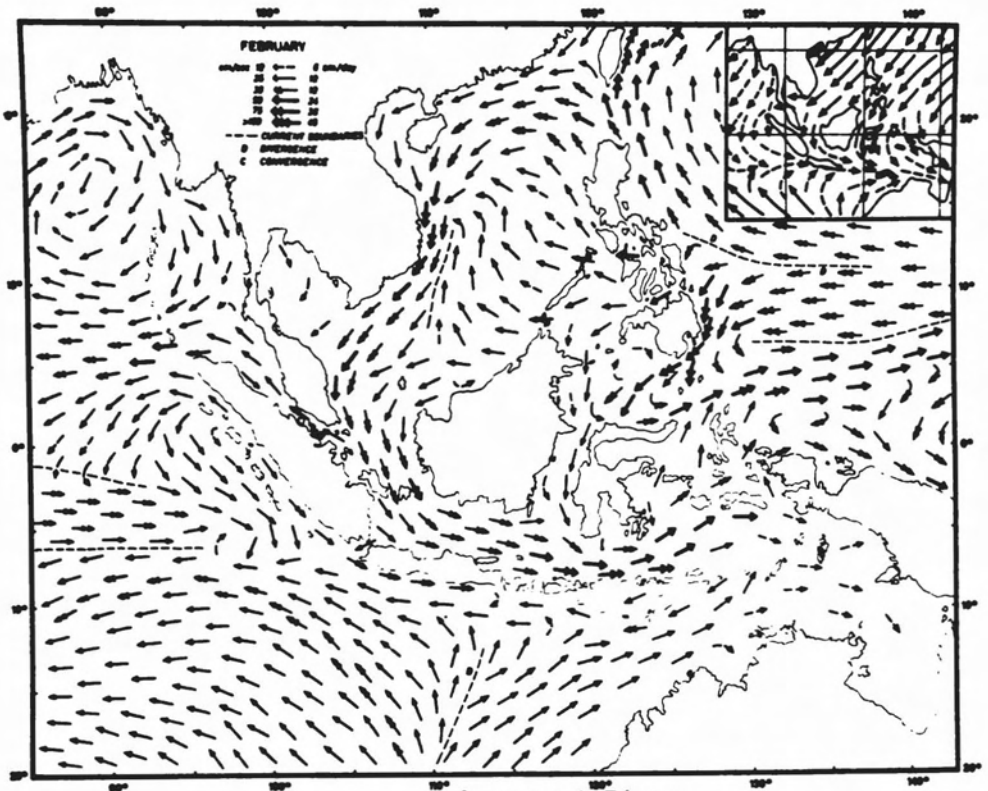
The general picture of physical oceanographic phenomena provided by Wyrtki remains the basis of our knowledge despite the fact that it was obtained 20 years ago. No other general synthesis of data from Indonesian waters has been published, although physical oceanographers at Indonesia's National Institute of Oceanology are collecting hydrographic data and the planned joint Indonesian/Netherlands Snellius II expedition, 50 years after the original, will produce new data that should add detail to Wyrtki's generalized synthesis.

TABLE 1 Properties of Some Subsurface Water Masses in Indonesian Enclosed Waters

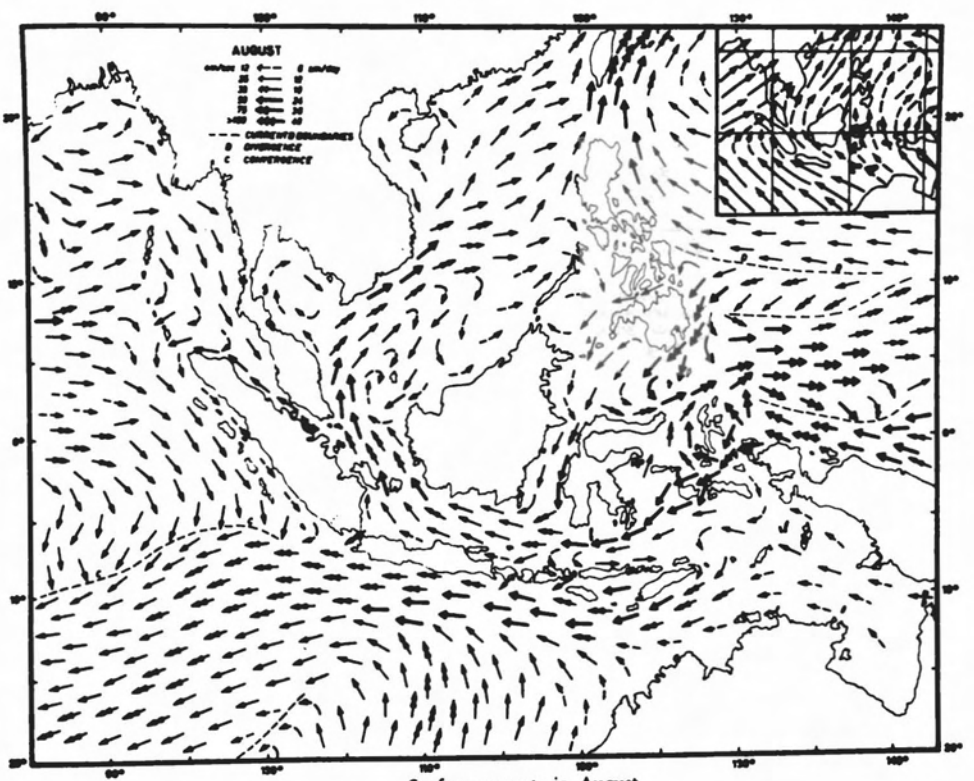
Water Type	Characteristic	T (°C)	S (°/₀₀)
Northern subtropical lower water	S maximum	23-15	34.60-35.10
Southern subtropical lower water	S maximum	24-13	34.60-35.30
Upper salinity minimum	S minimum	12-9	34.40-34.60
Upper oxygen minimum	O_2 minimum	9-7	34.45-34.65
Deep and bottom water	T minimum	4	34.65-34.75

NOTE: T = temperature
S = salinity

SOURCE: Abstracted from Wyrtki (1961).



Surface currents in February.



Surface currents in August.

FIGURE 1 Seasonal changes in surface currents and wind flows (inset) in February and August (Source: Wyrtki 1961).

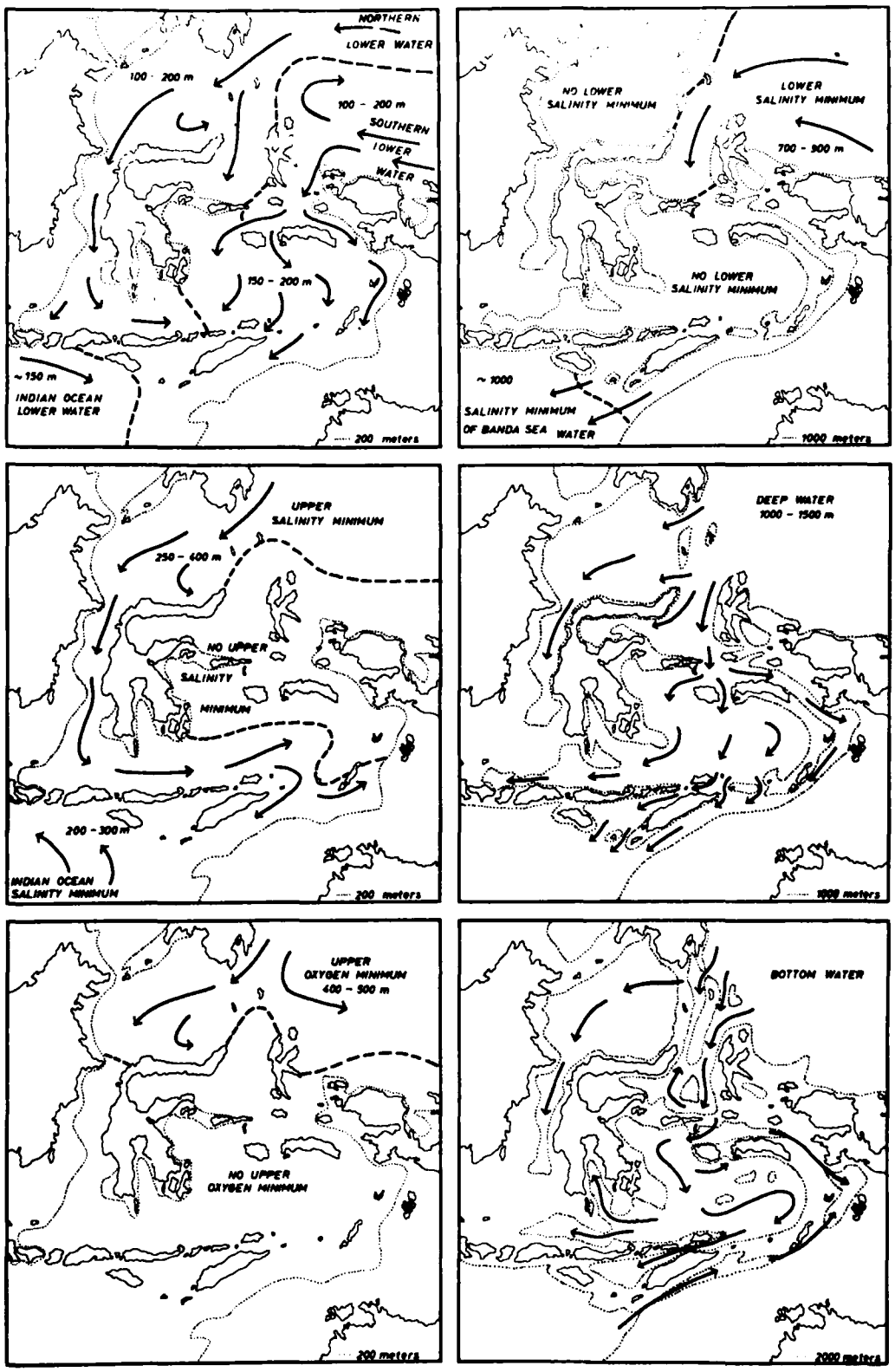


FIGURE 2 Deep-water circulation in eastern Indonesian (Source: Wyrtki 1961).

BIOLOGY

The biology of Indonesian marine waters has been studied more extensively than other aspects of marine science because of the importance of fisheries to Indonesia's economy and protein supply. Thirteen types of Indonesian fisheries yield more than 20,000 tons of harvest annually (anonymous 1979a). These include anchovies, mackerel, scad, sardines, oil sardines, tuna, trevally, ponyfish, cockles, skipjack, drum fish, prawns, and catfish. It is estimated that annual per capita consumption of marine fish falls between 8.5 and 10 kg and accounts for 30-50 percent of Indonesians' intake of dietary protein (Sujustani 1980). About 4.5 percent of the Indonesian population (11.7 million people) derive their livelihood from marine fisheries, although fishery products make up less than 2 percent of total export revenue, 80 percent of which is from prawns (Soegiarto and Polunin 1981).

Indonesian marine biology has focused on systematic studies of the diverse biota, fishery statistics and techniques, and coastal habitat ecology. Relatively little study of offshore waters and benthos has been conducted, although useful information is available from early expeditions (Snellius, Meteor, Galathea, etc.). Some information on offshore waters and coastal habitats is summarized below.

Offshore Waters

Waters off the shore of Indonesia appear to be biologically divisible into (1) productive coastal waters in which nutrients regenerated from bottom sediments, supplied in land runoff, or seasonally upwelled from below the photic zone support rates of primary production of about 100 gC m^{-2} yr^{-1} (grams of carbon per square meter per year), and (2) low-productivity offshore waters with primary production rates less than half that high (Wyrtki 1961, Soegiarto and Polunin 1981). The phosphate content of Indonesian surface waters without nutrient supplementation is less than 0.2 mg at $.1^{-1}$ (milligram atoms per liter), but reaches 2.5-3.0 mg at 1^{-1} in layers beneath the discontinuity layer (Delsman 1939). Values for nutrient concentration in coastal waters appear to vary greatly, ranging from lows of 0.03-0.12 mg at 1^{-1} at the surface (Delsman 1939) to much higher levels in areas enriched by runoff, regeneration, or upwelling (Nontji and Supangat 1977). Not surprisingly, these waters support levels of primary productivity that also vary widely. In most offshore waters and in coastal waters not supplemented with nutrients, primary production rates range from 0.1 to 0.5 gC m^{-2} day $^{-1}$, whereas in areas influenced by upwelling, land runoff, or regeneration, rates as high as 3.6 gC m^{-2} day $^{-1}$ have been measured--the average high productivity values are about 1.2 gC m^{-2} day^{-1} (Steeman and Jensen 1957). The monsoon-driven, seasonally reversing surface circulation of enclosed Indonesian waters creates areas of seasonal upwelling on the east and west sides of many islands. These upwellings involve a doming

of the discontinuity layer which rarely, if ever, reaches the surface (Wyrtki 1961; National Institute of Oceanology, Jakarta, internal data, 1982).

The animal ecology of Indonesian offshore waters is very poorly known. A few observations of benthos suggest that communities on the continental shelf are less diverse and show more even species distributions than those in shallow water, and that species distributions generally show distinctive zonation patterns (Soegiarto and Polunin 1981). The pelagic copepods have been observed to have two diversity peaks, one at 750 m and one at 1,000 m (Sewell 1948). Observations of nekton and birds suggest highly patchy distributions, although as a whole the communities are diverse, and some populations (e.g., skipjack on the Indian Ocean side of Sumatra) are locally dense (Soegiarto and Polunin 1981).

Coastal Habitats

Coastal habitats in Indonesia have been studied more extensively than offshore waters because of their relative accessibility and obvious relation to the human use of marine resources. Scientific information about Indonesian coastal ecosystems has been summarized extensively by Soegiarto and Polunin (1981). These authors provide data on the structure and ecological functioning of and human impact on Indonesian beaches, mangroves, estuaries, sea grass and algal beds, coral reefs, brackish-water fish ponds (tambaks), and islands. The information on ecosystem structure includes expedition descriptions extending back to the botanical work of Raumphius in the 1700s. The information on ecological functioning relies heavily on studies of similar ecosystems in temperate and other tropical regions because little, if any, scientific study of functional ecology has been conducted in Indonesia. Without attempting to repeat the valuable work of Soegiarto and Polunin, some aspects of Indonesian coastal habitats are summarized below.

Coastal habitats in Indonesia comprise those facing the open ocean--including beaches, lagoons, coral reefs, and sometimes sea grass or algal beds--and those facing estuaries--including mangroves and brackish-water fish ponds.

Open Ocean Coastlines

Open ocean coastlines show a range of wave energy conditions nicely illustrated by the northern and southern coasts of central Java. The northern coast faces the low wave energy waters of the Java Sea, and its low-energy beach deepens gradually offshore to heavily fished shallow waters in which wooden fishing platforms all but cover the horizon. The southern coast, on the other hand, faces the high wave energy waters of the Indian Ocean and is a complex mix of carbonate and volcanic rock headlands separated by sections of steep beach fronted by coral reefs and lagoons. Human use of this coast is largely limited to

those with large or strong power boats. A similar range of conditions occurs on most Indonesian islands, making generalization about open ocean coastlines difficult.

Beaches in Indonesia show the same seasonal variation in profile as those elsewhere (Soegiarto and Polunin 1981), although sand dunes rarely occur landward of the beach (Backer and van der Brink 1965). Low-energy beaches commonly support well-developed plant communities at their upper reaches. These include a herb/grass/sedge community (usually termed the pes caprae community after its concomitant species Ipomoea pes caprae), grading into a tree-dominated community (Barringtonia community) in the deeper soils behind the beach (Backer and van der Brink 1965). These two beach-associated plant communities rarely occupy a band more than 50 m wide, and in many places the communities are greatly disturbed by human activity (Soegiarto and Polunin 1981). The exposed beach itself supports a well-zoned community that includes ghost crabs (Ocypode) and beach hoppers (Amphipoda-Talitridae) in its upper reaches; small surf clams (Donax) and isopods such as Exocarolanus in the middle; and snails (Ombonium), hippid crabs, and sea urchins (Echinodiscus) at the lower end (Soegiarto and Polunin 1981). Beaches are also important nesting sites for the five species of sea turtles that inhabit Indonesia.

Open ocean coastlines often have lagoons and a fringing coral reef offshore from the beaches, although reefs are more extensively developed on small islands in the eastern part of the country than along the runoff-generating larger islands (Kalimantan, Java, Sumatra) in the western part (Soegiarto and Polunin 1981). Indonesian coral reefs are thought to be biologically diverse (Briggs 1974), although Chuang (1977) reported only 45 genera of corals from the Malacca Straits. Few specific studies of Indonesian coral communities have been completed (Soegiarto and Polunin 1981), although work currently under way in Sabang and Ambon should provide much new and needed information. Reef lagoons sometimes have high phytoplanktonic productivity, but the few measurements made so far in Indonesia (the Seriba Islands) show values of only 39-97 gC m^{-2} yr^{-1} (Nontji and Setiapermana 1982). Sea grass and algal flats, which have much greater primary productivity (about 1,000 gC m^{-2} yr^{-1}), are also found in the lagoons fringing islands (Soegiarto and Polunin 1981). Together, the phytoplankton and benthic plants support a coral reef biota of great importance to Indonesian coastal fishermen. This biota includes 32 of the 132 marine species listed by the Indonesian director-general of fisheries as economic (Anonymous 1979a), and includes eels, snapper, jack, trevally, sea bass, grouper, parrot fish, triggerfish, angelfish, and scad. Unfortunately, capture of these fish by use of submarine explosives remains common and is a major cause of reef destruction in some parts of Indonesia.

Estuarine Coastlines

Seasonally heavy rainfall in Indonesia creates several large rivers that drain to the sea on Sumatra, Kalimantan, Java, and Irian Jaya, and

many smaller rivers on smaller islands. These rivers create estuaries at their juncture with the sea. Many of Indonesia's important early settlements were located at these estuaries, and today they are the site of many important cities (e.g., Jakarta) and nearshore fisheries (Soegiarto and Polunin 1981). The heavy rainfall (more than 4,000 mm in some areas) also creates runoff that measurably dilutes seawater over areas extending as far as 200 km off the coast of Kalimantan and helps create annual surface salinity variations of more than 1.5 parts per thousand over most of the Java Sea (Wyrtki 1961).

Indonesian estuaries are as variable physically as those in other parts of the world, although many seem to be poorly stratified as a result of turbulence formed by currents flowing over sand bars at the river mouths (Soegiarto and Polunin 1981). The estuaries support endemic species of fish, copepods, and other fauna as well as high rates of primary production. As a result, they are the major sources of marine fish (Soegiarto and Polunin 1981), four of which are of great economic value in Indonesia: the Chinese herring (Hilsa toli), the anchovy (Setipinna taty), the sea perch (Lutjanus lutjanus), and Hisha elongata (Anonymous 1979a). Indonesian estuaries also serve as nursery areas for many marine species.

Mangrove forests and man-made fish ponds border Indonesian estuaries. The mangrove community includes more than 40 tree species (Kartawinata et al. 1979) and is a direct source of organic products including fuelwood, charcoal (with an export value of over US$1 million from Sumatra alone), chip wood, pulpwood, tannin, vegetables, roof thatching, medicinals, fish poisons, goat food, sugar, honey, and even wine (Soegiarto and Polunin 1981). Indonesia's annual production of mangrove wood is approximately 250,000 m^3 with a value of over US$3 million (Burbridge and Koesoebiono 1980). Mangrove production also appears to support estuarine fisheries through a detritus food chain, although specific details of this linkage have not been described for Indonesian waters. There is a relationship between mangrove forests and shrimp production in Indonesia. Although not all prawn species conform to this relationship, the general correlation holds (Martosubroto 1979). Indonesia's prawn catch generates over US$150 million in export income annually (Anonymous 1979a). Many other commercially important estuarine species are also associated with mangroves, including crabs (Scylla serrata), sergestid shrimp (Acetes), and fish such as mullet (Mugil), milkfish (Chanos chanos), and Lates (MacNae 1974).

The highest nutrient concentrations and primary production rates of Indonesian estuaries have been used for many generations to support aquaculture in brackish-water ponds known as tambaks. These man-made ecosystems cover about 146,000 hectares in coastal Indonesia and support the growth of prawns, milkfish, and Pantius based on larvae taken from wild stocks (Birowo 1977). The secondary production rates for these ponds range from 250 to about 1,000 kg per hectare per year, with only 10 percent falling in the upper third of that range. Thus research and extension activities could substantially increase protein yield from these systems.

CHEMISTRY

Marine chemistry is undoubtedly the least studied major subdiscipline of marine science in Indonesia. It appears that no modern, process-oriented marine chemistry studies have been carried out in Indonesian waters. Chemical knowledge of these waters is based on hydrographic measurements made by expeditions and the National Institute of Oceanology, nutrient measurements made in conjunction with studies of biological productivity, and pollution studies.

Early hydrographic studies were largely synthesized by Wyrtki (1961), but additional measurements made by the National Institute of Oceanology are available as data reports. Nutrient studies associated with early expeditions were also summarized briefly by Wyrtki (1961), and more recent observations are generally published in Oseanologi di Indonesia or Marine Research of Indonesia (see Nontji 1974, Nontji and Supangat 1977).

Studies of marine pollution are in their infancy in Indonesia, although pollution is a matter of major concern to the government. Observations have been reported for eight types of marine pollutants including synthetic organics (phenols from wood treatment), chlorinated hydrocarbons, trace metals, fossil fuels, coliform and other digestive tract bacteria, agricultural nutrient fertilizers, litter, and sediments (Soegiarto and Polunin 1981). In most cases, however, the reports are anecdotal or without documented techniques or intercalibration. None of the universities or laboratories visited by the seven members of the NRC marine science exchange possesses a modern, clean instrument room for marine pollution measurements. The situation may be slightly better with respect to oil pollution since both international agencies (Bilal and Kuhnhold 1980) and the Indonesian agency Lemigas have financial support for and an interest in this problem.

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APPENDIX B

Trip Reports of Participants
in the 1982-83 Marine Science Exchange Program

LECTURER: Dr. Hans W. Paerl, Institute of Marine Sciences, University of North Carolina

TOPIC: Primary Production Resource Limitation: Research Needs vs. Current Technology

DATE OF VISIT: September 2-19, 1982

My trip to Indonesia was the first of a series of visits by seven U.S. marine scientists to assess current priorities and technological needs facing the development of research programs in marine sciences in Indonesia. A main objective of my visit was to evaluate research activities in the areas of primary production, both with respect to recognizing environmental factors regulating this process and gaining an understanding of the role of primary production as a resource supporting marine food chains, and ultimately commercially important crustacean, fish, and shellfish species.

While visiting several universities in Java and Sulawesi (Celebes) during September 1982, I established relationships with seven leading Indonesian marine scientists concerned with marine biological productivity: Professor Sumardi Sastrakusumah (Professor of Physiological Ecology) at the Fisheries and Biology Faculty of the Bogor Agricultural University (West Java); Dr. Aprilani Soegiarto (Director) and Dr. Anugerah Nontji (Head of Ecological Research Department) of the National Institute of Oceanology, Jakarta (Java); Rector Professor Amiruddin, of Hasanuddin University, Ujung Pandang (Sulawesi); Rector Ir. Baskoro Winasno of Brawijaya University, Malang (East Java); and Dri Tri Sumarli, fisheries scientist, at the Fisheries Faculty of Gadjah Mada University, Yogyakarta (Central Java). These scientists, as well as affiliated staff members, expressed a strong desire to host the establishment of cooperative research projects. They welcomed the opportunity to pursue joint research efforts as a mechanism for the development of (1) research programs designed to address and answer key questions related to a better understanding of factors regulating biological production of marine environments, (2) development of essential technological knowledge needed for executing research projects designed to answer the above questions, and (3) continued consultation on appropriate procurement of equipment (both laboratory and field) in order to conduct scientific work in a productive and effective manner.

THE GENERAL IMPORTANCE OF MARINE SCIENCE TO INDONESIA

Indonesia is the world's fifth most populous nation, having a heavy reliance on fish, shellfish, and mariculture as a basic source of

protein and exportable commodities. Despite the obvious importance of marine and freshwater fisheries with respect to the general welfare and economic growth of this island nation, potential food resources and diversification of fishing regions and techniques have remained largely unexplored in recent decades (Bilal et al. 1975, Nontji and Supangat 1977, Bird and Soegiarto 1980). Meanwhile Indonesia's population stands at near 200 million, with an annual growth rate of approximately 3 percent. Because of the vast areas of marine coastal and pelagic waters (approximately 2.3 million km^2) bordering the island archipelagos of Indonesia, the government (particularly the Minister of State for Research and Technology, Dr. B. J. Habibie) recognizes the need to identify, manage, and properly utilize marine food resources in order to support the diverse and ever-pressing food needs of the country. This is not a simple task, since qualitative and quantitative research on resources present in Indonesia's diverse marine environments is in its infancy.

After visiting five universities and government research facilities with marine science programs, it became clear that even the most basic factors supporting trophic potentials of Indonesia's marine environments have remained largely unidentified (Bird and Soegiarto 1980). One of those factors is the primary production of organic matter of photosynthetic microorganisms (phytoplankton) supporting a bulk of marine food chains. It is important to assess marine fertility at the primary producer level of food chains, since numerous worldwide studies in both temperate and tropical waters have revealed a direct relationship between production potentials at this level and higher ranked herbivore, detritivore, and carnivore levels representing commercially important fish and shellfish species (see Mann 1982 for a summary). Basic information on the geographic distribution of primary productivity (over time and depth) and factors regulating (limiting) primary productivity rates urgently needs to be obtained in order to properly identify and assess overall production potentials of Indonesia's numerous fishing grounds; some of these grounds remain to be discovered, let alone properly managed.

ENVIRONMENTAL FACTORS POTENTIALLY INFLUENCING MARINE PRIMARY PRODUCTIVITY IN INDONESIAN WATERS: AN OVERVIEW

Prior to designing the research proposed here, I traveled to Indonesia to identify and evaluate known hydrological and chemical factors constituting potential influences on marine primary productivity. In general, very little is known of hydrological and chemical conditions in Indonesian marine waters. From both literature searches (of papers lodged in Indonesian and U.S. libraries) as well as direct consultations with Indonesian marine scientists, the following general characteristics can be ascertained:

- Known upwelling regions exist in the Southern Java Sea, Strait of Bali, Indian Ocean regions bordering Southern Java, and the Banda

Sea bordering the Molluccan Island Group (Weel 1923, Berlage 1927, Wyrtki 1961, Ilahude 1970, Nontji and Arinardi 1975).

- Significant freshwater inputs (large rivers, estuarine environments, and surface runoff) exist in the Java Sea bordering the major islands of Sumatra, Borneo, and Java, resulting in depressed salinity regimes (Weel 1923, Veen 1953, Soeriaatmadja 1956, Doty and Oguri 1956, Nontji and Arinardi 1975).
- Nutrient inputs from municipal, agricultural, and industrial sources may constitute an important component of nutrient enrichment in the vicinity of Java, Borneo, and Sumatra (Verstappen 1953, PUTL and DKI 1973, Bilal et al. 1975, Nontji and Supangat 1977).
- Preliminary surveys of biologically available nutrient concentrations point to the possibility of nitrogen limitation of phytoplankton production in the Java and Banda Seas (Nontji 1974, Nontji and Ilahude 1975, Nontji and Supangat 1977).

Physical regions in Indonesia's marine waters are poorly understood. Initial survey work on salinity, temperature and dissolved oxygen regimes was conducted during the latter stages of the Dutch Colonial Period (1920-1940) (see Weel 1923; Verstappen 1953; Veen 1953 for example). The results of these surveys point to several important physical characteristics of Indonesia's best-studied waters, the Java and Banda Seas, the Straits of Bali and Macassar as well as regions of the Indian Ocean bordering southern Java, and Bali. Several regions of upwelling have been reported (1) in the Indian Ocean, bordering the Bali Strait approximately 50 km south of Java (Nontji and Ilahude 1975); (2) in the eastern regions of the Java Sea, bordering the Banda Sea (Berlage 1927, Rahardjo and Ilahude 1965, Ilahude 1970); and (3) in regions of the Banda Sea bordering the Molluccan Island Group (Nontji 1974). Virtually nothing is known of the chemical constituency of these upwelling regions; presumably surface waters are enriched with deep-sea and bottom-water nutrients, including nitrate and ammonia nitrogen, phosphate-phosphorus, and a variety of trace metals as in other tropical and semitropical upwelling systems (Cushing 1975). There is some evidence that in the Molluccan Sea, Java Sea, and Bali Strait, nutrient enhancement occurs on a regular basis and that this enhancement is related in time and space to monsoon-driven upwelling events. Parallel increases in the standing crop of phytoplankton (recorded as chlorophyll a) have also been reported during such events (Nontji and Ilahude 1975). Hence, nutrient enhancement of phytoplankton growth appears to be an important factor in regulating and maintaining phytoplankton fertility. Furthermore, the direct relationships reported between upwelling events and increases in phytoplankton biomass can be regarded as evidence that nutrient limitation of phytoplankton growth must be a common occurrence in unaffected (by upwelling) regions of Indonesia's pelagic environments. Accordingly, it would prove fruitful to identify types and quantities of nutrients restricting primary productivity in such regions.

The terrestrial environment may potentially play an additional role in regulating primary productivity patterns and magnitudes in Indonesian waters, particularly those waters bordering the large islands of Java, Sumatra, Kalimantan (Borneo), and Sulawesi (Celebes). Noticeable decreases in salinity in the Java and Banda Seas as well as in the Indian Ocean bordering these large islands have repeatedly been observed along coastal regions (Veen 1953; Rahardjo and Ilahude 1965). In the Java Sea alone, Veen (1953) and Soeriaatmadja (1956) reported a consistent depression of salinity of from 2-5 ppt as far as 100 km away from the south coast of Kalimantan. Similar depressions in salinity are evident off Java and Sumatra (50-100 km offshore) (Nontji and Supangat 1977). These data serve as evidence of the influence that Java, Kalimantan, and Sumatra's large freshwater rivers and estuaries have on the hydrological characteristics of the Java Sea. Average yearly rainfall in Java alone varies from 50 to 300 cm, a majority of which is transported northward via large rivers emptying into the Java Sea. Similarly, the southwestern region of Kalimantan, which harbors extensive rainforests (average yearly rainfall is from 200-600 cm per year) and large rivers, has a profound effect on the salinity of the northeastern Java Sea (Soeriaatmadja 1956). Clearly, both the hydrological and chemical quantities and qualities of freshwater runoff are of potential importance in dictating primary productivity patterns of the Java Sea, and possibly the Banda Sea (no definitive data exist from this sea). Furthermore, man's activities in the watershed regions of these seas are relevant, since land disturbance due to logging, clear-cutting, vegetation removal by burning and mechanical means, generation of hydroelectric impoundments (including dam construction), as well as municipal, industrial, and agricultural use of catchments could potentially play a role in dictating nutrient enhancement (and hence qualitative and quantitative characteristics of primary productivity) of bordering seas and oceans.

Industrial development is a prime goal of Indonesia. The country intends to utilize its petroleum, coal, and natural gas reserves for industrial development and expansion. Chemical (industrial and agricultural chemicals) as well as light and heavy industry (steel mills, aluminum smelting plants, wood and pulp processing plants, and mineral processing--bauxite, iron, copper, and nickel--plants) are slated for future development, expansion, and modernization by the Indonesian government. Many of the existing and projected plants are being developed near major urban centers, including Jakarta, Surabaya, Semarang (Java), and Ujung Pandang (Sulawesi). Nutrient export from existing as well as developing industries is expected to be highly significant in light of extensive freshwater inputs transported through major metropolitan areas. Furthermore, logging activities, including clear-cutting, are known to have an appreciable impact on nutrient loading in a number of riverine watersheds emptying into the Java and Banda Seas.

Lastly, man's impact on the terrestrial/aquatic environment is nowhere as noticeable as in agriculture. In a majority of regions of

Java and Sumatra supporting rice as a main food staple, chemical fertilizers are commonly used. These include urea (a side product of petroleum distillation) and superphosphate. Both fertilizers are applied on a year-round basis. There is little doubt that an appreciable proportion of agricultural fertilizers ends up in domestic water supplies, rivers, and estuaries (estimates range from 20 to 50 percent according to LON-LIPI) which eventually empty into the marine environment. In Jakarta alone, nutrients find ready access to the Java Sea, where the combined influences of agricultural, municipal and industrial nutrient input, and nutrient loading from the large harbor (Tandjung Priok), have a significant effect on nutrient enrichment (Nontji and Supangat 1977) and presumably phytoplankton productivity in Jakarta Bay (Java Sea) as far as 50 km offshore.

My visit took me to several government-operated as well as university facilities currently having interest in either production or pollution-related aspects of marine science. Largely due to the role that my Indonesian host and contact, Professor Sumardi, plays in coordinating marine research as an advisor to the Ministry of State for Research and Technology, I was guided to one of the more established (in terms of basic research efforts and implementation of applied research projects) as well as developing facilities in Indonesia. During my various visits to facilities in Java and Sulawesi, I was able to observe teaching facilities, research facilities (including laboratories, field equipment, and field stations), and some aspects of the administrative operation of such facilities. The following paragraphs describe the specific facilities visited, their ongoing activities, and potentials in terms of primary and secondary production research in marine and estuarine environments. Included in facilities visited were the National Institute of Oceanology, Jakarta, Java; the University of Brawijaya, Malang, East Java; Gadjah Mada University, Yogyakarta, Central Java; and Hasanuddin University, Ujung Pandang, Sulawesi.

National Institute of Oceanology

Located in Jakarta, approximately 4 km from the harbor of Tandjung Priok, this is Indonesia's main oceanographic research institute. It is staffed by 10 faculty-level (either M.Sc. or Ph.D.) members, with an 80-member support staff of technicians, students, and secretaries. The Institute is departmentalized largely along classical lines, such as zoology/invertebrate taxonomy systematics, mollusc taxonomy, and crustacean taxonomy. Collection and identification of taxa appears to be an important component of daily activities. Botanical research runs along similar lines. Marine chemistry is a division of the Institute, but during my 3-day visit there I saw little active chemical (either analytical or developmental) work in progress. On the other hand, there is a great deal of administrative activity in all areas of the Institute. There are outstanding individuals, however, such as the director of ecological research, Dr. A. Nontji. These individuals have

largely gained this expertise and directiveness from having either been involved in research activities in conjunction with European or U.S. scientists or having experienced research activities in overseas laboratories.

In my opinion, the Institute, as well as the following research facilities, need a great deal of direction and stimulus (in that order) as well as relevant and necessary instrumentation. Clearly, the lack of instrumentation consistently hampers the fostering of relevant research directions, as well as the initiation of basic and applied research projects. Also, expertise needs to be developed in both running and properly maintaining such instrumentation. Even an instrument as basic as a field oxygen meter can at present not be properly maintained, and hence operated in virtually all research institutes visited. I believe that the installation of expertise, project management and involvement as well as equipping should occur simultaneously, not sequentially, in developing research facilities such as the National Institute of Oceanology. The development of scientific expertise without concurrent instrumentation, and vice versa, would prove to be counterproductive, since the utilization of experience and ideas depends to a large extent on having the basic research tools at hand.

Several areas of research priorities in the area of primary productivity were identified during discussions with the Institute staff as well as through personal observations.

NEAR-SHORE ACTIVITIES

I. Pollution studies of Jakarta Bay in the Java Sea

A. Nutrient enrichment problems (eutrophication)

1. Due to untreated sewage, wastes from municipal sources
2. Agricultural runoff of applied nutrient sources
3. Internal processing and nutrient formation (N_2 fixation, denitrification, periods of bottom-water anoxia leading to nutrient release from sediments)

B. Pollution by organic toxic substances and heavy metals

1. Toxic organics known to originate from industrial processes, agricultural and municipal sources
2. Heavy metals originating from agricultural sources and/or industry

Pollution studies should be carried out at several levels of marine food chains.

1. Primary producers (phytoplankton as well as attached at benthic plant communities)
2. Invertebrate grazers (planktonic and benthic)
   a. Crustacean zooplankton
   b. Benthic crustaceans and molluscs
3. Fish

A regular chemical sampling program should be instituted in Jakarta Bay, including the following measurements:

1. Routine analyses of the following heavy metals in total and particulate fractions (by atomic absorption spectroscopy, which is available): Pb, Cd, Hg, Cu, Zn, As
2. Routine analyses of pesticides and potentially harmful (to humans) organics

A screening of toxic organics known to be produced and discharged by industries and agriculture should be initiated. This screening program will take a serious and comprehensive effort. Perhaps technical advice and help from the U.S. Environmental Protection Agency and the National Oceanic and Atmospheric Administration pollution assessment office (OMPA) will be necessary. Such a program is badly needed in Indonesia, however, as there is virtually no idea how (if any) toxic materials may end up in aquatic environments and in man's food sources. Considering the large population of Indonesia, and the heavy dependence on seafood, it would seem crucial for the Indonesian government to initiate a program (with U.S. assistance) to assess the presence and potential impacts of toxic materials in its marine and freshwater habitats. Such substances may have a significant impact on the welfare and general health of the population.

Incidentally, no laws governing restrictions on discharges of either heavy metals or toxic substances exist in Indonesia. To my best knowledge, no active consideration is being given to such regulations; it is of obvious importance to dovetail the desire for technical and industrial development with awareness of the impacts of such development on aquatic environments.

II. Assessments of factors regulating fertility and productivity of Indonesian marine environment

A. Understanding the potential fertility of Indonesian marine habitats currently being utilized or under consideration for fishing purposes (which constitutes a majority of the waters of the Java Sea, Straits of Macassar and Bali, Banda and Mollucca Seas). Assessments of fertility should be made on:

1. Primary production--including nutrient production relationships
2. Zooplankton population and distributional studies

3. Relationships of phytoplankton and zooplankton production fertility to fish yields and potentials
4. Relationships of chemical stakes (nutrient levels and upwelling events) to primary production

Currently the National Institute of Oceanology is chiefly concerned with taxonomic studies. While these are useful in gaining an understanding of the occurrence of ecologically and commercially important fish species, they have yielded little insight into the dynamics of fish production and the relationships between primary production and fish production in Indonesian waters.

With regard to geographic studies, emphasis should be placed on:

1. Location of sites of active as well as periodic upwelling
2. Relationships between terrigenous processes (including nutrient generating and stripping activities, runoff, erosion, impoundment, and channelization) and coastal fertility of marine waters
3. Mapping areas of major nutrient deficiencies (limitations) and abundances, with respect to primary productivity patterns
4. Compatibility of geological exploitation and ecological stability in marine environments

UNIVERSITY OF BRAWIJAYA, MALANG, EAST JAVA

This very small university (approximately 3,000 students) is located in a heavily agricultural area of Java. The main ties between this university and the marine environment are in the areas of marine industrial and organic pollution (sugar processing plants near Surabaya on the Java Sea) and aquaculture in brackish-water ponds. A potentially important link between agriculture and aquaculture is of interest to the small (4 staff members) fisheries faculty. This is the use of manure to fertilize fish and shrimp and aquaculture ponds. In order to achieve both goals the university will need to be equipped with the most basic of limnological and oceanographic gear, including field oxygen, salinity, temperature and pH meters, nutrient chemistry facilities (including glassware, reagents, and spectrophotometric abilities), and microscopic equipment. Potential specialties in which this university can provide valuable research contributions include (1) study of the impacts of agriculture on water quality, (2) study of the impact of light industry on water quality, and (3) experimental pond (either brackish or freshwater) work designed to assess factors leading to and eliminating nuisance algal bloom problem in such ponds.

Pollution assessment studies of organic loading (BOD problems) due to sugar processing plants east of Surabaya have been proposed. However, the staff will need technological and directional assistance as to which parameters are of relevance in assessing such loading effects in the marine environment. Dissolved oxygen monitoring is

obviously of key importance, but specific nutrient analyses must accompany such monitoring activities in order to pinpoint the main source of BOD in this environment. In general, and this can be said of all laboratories visited, water chemistry has not been adequately recognized as an important tool in identifying and ultimately resolving water quality and the eutrophication problems. Additional useful (and considered standard in the United States) parameters include chlorophyll a levels, coliform counts, hardness, and conductivity. This facility needs to be given the information and technical assistance to recognize such factors while developing a basic set of equipment to conduct training.

GADJAH MADA UNIVERSITY, YOGYAKARTA

This well-established university has a fisheries-oriented faculty, with a basic recognition of relevant and necessary parameters for assessments of water quality and production at the primary and secondary producer levels. Measurement of the above parameters are necessary for the faculty to (1) conduct feasibility studies on aquaculture sites at several estuarine locations bordering the Indian Ocean near Yogyakarta, (2) develop acceptable water chemistry facilities, and (3) understand the relationships between agriculture and water quality in the central Java area. As with Brawijaya University in Malang, eastern Java, it is necessary to understand the relationships between man's activities on land and potential environmental impacts in adjacent waters.

The most promising potential projects I observed at this university are the development of brackish-water ponds and estuarine lagoons for shrimp and (potentially) crayfish and catfish culture. A promising brackish-water environment exists directly south of Yogyakarta, emptying into the Indian Ocean. The construction of a marine harbor has been proposed in this region; in order to construct this harbor site, inlets must be cut to allow saltwater intrusion into oligohaline and mesohaline environments which appear to be vitally important shrimp hatching and rearing areas. Careful consideration should be given to preserving the delicate brackish-water habitats that serve as shrimping grounds supporting the local economy.

Projects on brackish-water ponds should emphasize the potential for rearing exotic species such as crayfish, eels, crabs, and perhaps mixed-culture systems of shrimp-fish or fish-crayfish. Studies to be undertaken here should include assessments of panel fertilization techniques, use of agricultural waste for panel fertilization, and formulation of proper N:P ratios for fertilization. This university (although similar to others in Indonesia in having little equipment of relevance--and what does appear to be relevant is largely inoperational), does have a dean who is very interested in developing technological knowledge including high-quality basic and applied research. Gadjah Mada University struck me as a good place for

cooperative U.S.-Indonesian work in the future. Other interests expressed to me by various members of the faculty included water chemistry, food chain research, and pond management and manipulation. This university is well established and perhaps the most autonomous from government bureaucratic involvement with respect to conducting independent high-quality marine science projects. I was most impressed (of any university visit) by the faculty assembled here.

HASANUDDIN UNIVERSITY, UJUNG PANDANG, SULAWESI

Hasanuddin University is a large (approximately 10,000 students) sprawling university near the center of Ujung Pandang, Sulawesi. Both the Rector and Dean of Fisheries were very receptive. They were obviously eager to develop bridges with other universities in Indonesia (particularly in Java) as well as with U.S. and foreign experts who could be instrumental in helping them develop their marine science status. This university gives the appearance of having been left out of the mainstream of government funding and development, until recently. A new campus is being built outside Ujung Pandang. The fisheries faculty expects to move into the new facility in late 1983.

Regarding the current state of marine science, it appears almost nonexistent. There is an obvious interest (repeated to me on numerous occasions by faculty members) in fisheries ecology and technological development of aquaculture, fishing methods, and management of coastal resources. No laboratories exist specifically for marine science research. The only laboratory "materials" I was able to recognize during my visit were unstoppered reagent bottles, some nonfunctional sampling gear, and a few (approximately 50) preserved specimens of fish and invertebrates native to the region. Accordingly, this university is at a "ground-floor" state with respect to development of marine science as a discipline.

Despite the "facilities" presented to me at the university, I did see several large aquaculture (milkfish and shrimp) pond projects near Ujung Pandang which were government-funded (directly funded by the ministerial office in charge). It seems there are several such projects throughout Indonesia. While these projects appear to be receiving adequate funding, there is little interest in stimulating academic research through similar projects on campuses. There was mention of several students from Hasanuddin University becoming involved in future (government-supported) pond projects, but the role these students would play and their contributions to research were not defined (despite my inquiries) and were left rather open-ended. It would seem fruitful for the Indonesian government to direct more efforts to using such pond systems as training grounds for student development. The pond systems outside Ujung Pandang are large, impressive by most standards, and could be the focal point of more university-oriented research. There appears to be a large void between development of such ambitious government-supported projects and parallel university development.

RESEARCH POTENTIALS IN SULAWESI

There is definitely room for expansion of brackish-water aquaculture (pond and natural estuarine systems) in Southern Sulawesi. I observed numerous potential brackish-water sites on the coastal region bordering the Strait of Macassar, approximately 30 km north of Ujung Pandang. Recycling of agricultural wastes (through fertilization of brackish-water ponds) could also be investigated in this area. There appears to be little recognition of potential expansion of marine habitats for food production. I am under the impression that such resources exist. Included are the following suggested areas:

1. Development of offshore fisheries and decreased dependence on "fish houses," which are platforms constructed in coastal regions supporting intense and suspected overfishing.
2. Diversification of shellfish industry. There appears to be an abundance of systems in coastal environments of Southern Sulawesi but almost no use of this resource. Clams and scallops are also plentiful.
3. Recognition of upwelling areas and potential pelagic fishing grounds currently ineffectively exploited.
4. Supporting studies on the effect of pollutants and sedimentation on the marine environment.
5. Development of marketable products for fish being caught. There exists a very high diversity of fish currently being caught. Diversification of fish-based products (such as extracts, paste, oils, etc.) could make use of such diverse fish sources.

The fisheries faculty at Hasanuddin University also expressed interest in addressing freshwater eutrophication problems facing some of Sulawesi's large lakes. Serious eutrophication problems (combined with an extensive drought) in Lake Tempe in central South Sulawesi is threatening the diverse fisheries there. The cause of the problem has not been investigated, but it appears that excessive nutrient loading from agricultural sources is the likely causative factor. There is an urgent need to know the relationships between amounts and ratios of nitrogen and phosphorus loading with respect to eutrophication potentials. Periodic blue-green algal blooms (Microcystis aeruginosa) have been blamed for catastrophic fish kills in Lake Tempe. Food chain alterations due to undesirable primary producers (blue-green algae in particular) should be investigated in this and other lakes in agricultural catchments. Lake Tempe also supports a large (30,000) fisheries community. Freshwater fisheries such as this one are of surprising economic importance, especially in the face of underutilization of marine fisheries in Sulawesi.

In summary, Sulawesi appears to have potential for diversification of marine fisheries, particularly among pelagic fishing grounds as well as specialized coastal habitats (brackish-water estuaries, for example). The development of a marine science program at Hasanuddin

University will be a necessary step in order to foster recognition and evaluation of marine resources and potentials. Such a step, however, is a "ground-floor" proposition, since the current fisheries faculty is in dire need of training (with respect to both technological and directional aspects of marine science) and even the simplest analytical tools (oxygen, pH and conductivity meters, chemical analyses equipment, for example) are missing at Hasanuddin University. Despite such extremely low scientific standards, there exists a definite desire on the part of faculty members, technicians, and students to learn and utilize technology and research directions if they were to be supplied by counterparts from technologically developed countries such as the United States, our European allies, and Japan. It would seem wise to develop the potential for research, diversification, and the carefully guided exploitation of Indonesia's vast marine environments, for these are positive and beneficial steps to improving the general standard of living and welfare of the Indonesian populace.

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LECTURER: Dr. James A. Marsh, Jr., University of Guam

TOPIC: Coral Reef Ecology, with an Emphasis on Indonesian Coral Reefs

DATES OF VISIT: November 1-20, 1982

My trip to Indonesia was the second in a series of visits by U.S. marine scientists. I gave single lectures on coral reef ecosystems at four institutions, visited several research sites and other areas of marine activity, made observations related to the present state and future potential of coral reef research in the country, and participated in the joint U.S.-Indonesia Panel Discussions on Science and Technology Planning and Forecasting for Indonesia with Special Emphasis on Manpower Development.

After arrival in Jakarta on 31 October, I spent the next day at the National Institute of Oceanology (LON). I met with Dr. Aprilani Soegiarto, Director of LON and my Indonesian host, to discuss objectives and scheduling of my visit; met with a number of staff members to discuss their and my research interests; and worked with several staff members to prepare materials and assemble equipment for field studies at LON's Pulau Pari research station. Appropriate contacts were also made with personnel of LON's parent organization, the Indonesian Institute for Sciences (LIPI), to ensure that they were advised of my activities.

The next four days were devoted to a trip to Pulau Pari Research Station, in the Thousand Islands group extending into the Java Sea northwest of Jakarta. Working primarily with LON staff members Mr. Deddy Setiapermana and Mr. Husni, I selected several potential sites for reef community productivity studies utilizing either flowing-water or standing-water techniques. This involved observations of temporal and spatial changes in dissolved oxygen concentrations in conjunction with measurements of water movement and calculations of water budgets for shallow reef-flat areas. We made daytime and nighttime field observations, collected water samples, and carried out laboratory analyses. A significant amount of time was spent in step-by-step calculations of the raw data generated. The objective was to follow through on the whole procedure from start to finish as an instructional exercise, rather than generating data per se. One evening was also devoted to assembling and testing a respirometer set-up for metabolic measurements of individual organisms. The set-up was necessarily rather crude because of equipment and materials limitations, but I believe that the demonstration was worthwhile and

provided the necessary background for further development of apparatus. In general, I believe that the Pulau Pari facility is satisfactory to support studies of reef community productivity and metabolism of individual populations and organisms; however, doing so will require a certain level of resourcefulness on the part of individual investigators.

The reef at Pulau Pari, like the other Indonesian reefs where I made brief observations, appears to have a high coral diversity but a notable lack of algal diversity and biomass (except for the alga Caulerpa, with a remarkably high standing crop in certain reef zones). There was also a notable lack of consolidated reef pavements, with their associated algal turfs, as compared with other reef flats where productivity measurements have been made; and areas of loose sand with a relative dearth of algae were much more extensive on the Indonesian reef flats than other regions with which I am familiar. These impressions, if supported by more extensive and quantitative observations, would be significant for productivity studies, but I emphasize that they are only general impressions at this point and that they require further documentation.

Phytoplankton blooms were quite evident in the waters around Pulau Pari, and this necessitated some adjustments in the productivity methodology for reef community studies. Plankton productivity in the waters overlying most reef communities that have been studied so far is negligible in comparison with benthic productivity. This is clearly not the case at Pulau Pari, but the plankton metabolism is easily corrected in estimating benthic productivity.

There had been a major kill of reef organisms within the few days prior to our arrival at Pulau Pari, and the shallow waters near shore were anaerobic and foul-smelling. Apparently this was an unusual occurrence. The cause of the kill was not immediately obvious, but there was some speculation that it may have been detergents from a passing oil tanker. The likelihood of such kills, as well as the incidence of oil slicks and washed-up tar balls, should be a matter of some concern in evaluating long-term research potentials at Pulau Pari.

After my return to Jakarta I presented a Saturday-morning research seminar at LON on coral reef ecology. The following week I participated in the first 2 days of the U.S.-Indonesia Panel Discussions on Science and Technology Planning and Forecasting for Indonesia with Special Emphasis on Manpower Development. The first day was spent in the plenary session and the second day in the working group on marine sciences and underwater technology. I was one of two U.S. marine scientists participating in this session and one of 12 scientists in the overall U.S. delegation.

I spent 10 days traveling to various universities and potential research sites in several areas of Indonesia. I was accompanied by Mr. Harsono from LON, whose logistic assistance was invaluable and greatly appreciated.

At Hasanuddin University in Ujung Pandang, South Sulawesi, I met with a group of faculty members, with the newly appointed rector, and with a UNDP ecological adviser in residence to review marine programs and discuss plans for research. I also visited several field sites and gave an evening lecture. Dr. A. S. Kumanireng, Head of Marine Resources Development, was my local host and was most cordial.

Hasanuddin University is clearly at a low level of development with respect to marine sciences. There are obvious financial constraints (as at the other places I visited) and apparently very little in the way of equipment and supplies. Clearly, a major effort will be required if the present situation is to be turned around. A project funded by the United Nations Development Program may be able to lay the groundwork for such a turnaround. The conservation area of Samalona Island is an accessible site with a relatively unaltered natural community (although there is some damage apparently caused by dynamiting); a variety of worthwhile research projects could probably be carried out there.

From Ujung Pandang I went to Ambon, Moluccas Islands, for one day. I gave a lecture at Pattimura University, met with staff members of the university and LON's Ambon Research Station, met briefly with the on-site coordinator of the USAID project there (and saw the shrimp hatchery his group is developing), and briefly visited one field site. There was an atmosphere of interest and activity and some obviously motivated individuals. While Ambon is hardly a well-developed center of marine science, the sense of activity there was in marked contrast to Hasanuddin University. There appears to be a good working relationship between Pattimura University and the LON research station. Mr. Ono Sumadhiharga of LON was a very helpful and informative host; and Dr. Wairisal, Dean of Animal Husbandry and Fisheries at the university, also impressed me as having a sincere interest in the development of marine sciences at Ambon.

I next went to Bali, where I devoted one day to surveying a reef site at Padangbai, including travel to and from the site. As at other reef areas visited, I was struck by the high coral diversity and low algal diversity and biomass. I did not personally observe areas where limestone was being removed from reef areas but did visit several operations where truckloads of coral were being burned in kilns to produce lime. It is clear that large quantities of coral are being so consumed, and there is the potential for a significant impact on local reefs.

I next traveled to Semarang in north-central Java, to visit Diponegoro University. This is a major university with a real atmosphere of activity and apparently a motivated faculty and student body. Professor Sapardi Brodjohudoyo, Head of the Biology Department, was an extremely knowledgeable and stimulating host. I also had the pleasure of briefly meeting the rector, Prof. Sudarto, and the Deputy Rector for Academic Affairs, Prof. Moeljono Trastotenojo, and was impressed by their interest and awareness.

From Semarang I traveled by university vehicle to a field teaching station at Jepara. This is an excellent physical facility that has been recently completed and is just coming into use. Its minimum laboratory equipment and supplies need to be upgraded; a consignment of books and other materials for its empty library building is apparently being held temporarily on the main campus of Diponegoro University. Biologists from a British University, Newcastle-on-Tyne, recently taught a field course focusing on local flora and fauna which resulted in the beginnings of a potentially valuable reference collection to be developed for future teaching. This field facility has great potential as a teaching center and, secondarily, as a research center. It is to be used as a teaching facility for classes from all of Java and from some other Indonesian islands. I examined a local reef area and visited a local fishing village with large areas of greatly modified mangrove swamps, another local fish market, a district public health facility, and the National Brackishwater Aquaculture Development Center at Jepara.

Upon my return from Jepara to the main campus of Diponegoro University, I presented a lecture attended by more than a hundred people. I found the faculty and students to be interested and motivated; we spent almost an hour in questions and discussion after the formal lecture. Overall, I found Diponegoro to be the most active and best developed of the universities I visited.

After completing the lecture, I returned to Jakarta for two nights. My final meeting was with Dr. Aprilani Soegiarto to review my activities and impressions. I also followed up on several items of unfinished business with other LON staff members. I departed Jakarta on 20 November.

One general impression that I formed during my tour concerns the need for a careful evaluation of future plans for marine research in Indonesia, especially as these require a high-technology approach. Certainly, much modern marine research requires large inputs of money, highly trained scientists, and expensive, hard-to-maintain equipment. Indonesia should try to develop major research centers where these can be brought together in a carefully planned facility. However, I wonder if it is realistic for the near future to think that this can be done in more than a few research centers or universities. In many of the more remote locations and developing institutions, it might be more reasonable to focus on a low-technology approach that can yield basic information and provide a meaningful framework for education and training. Hence, in several places I found myself emphasizing the possibilities for floral and faunal studies and field surveys (which can admittedly be overemphasized at the expense of more in-depth studies where such studies are feasible), documentation of traditional utilization and conservation of marine resources, and population studies of important species. Such studies still require trained manpower, even if they minimize the need for sophisticated equipment and facilities; and I believe that they can often provide effective

educational opportunities. Considering the present state of marine science at some of the institutions I visited, I believe that the low-technology approach would be a step forward, would help to generate interest in marine systems, could provide the basis for more effective management of reef resources, and could provide a foundation for more sophisticated studies as these become feasible. So little is known about the reef systems of Indonesia now that almost any activity would be a step in the right direction.

I believe there is a need for better coordination between various national and international agencies funding activities in Indonesia. At every place I visited I heard about completed or ongoing projects being carried out by agencies or institutions from several developed countries or by United Nations agencies. All were apparently being done in a context limited to one agency or government's viewpoint. Better coordination, if possible, might result in more synergisms which would increase the impact of all such programs in Indonesia. Perhaps more realistically, such coordination might be better left to the Indonesians themselves.

Finally, it is clear that visiting scientists provide a certain amount of stimulation to Indonesian colleagues and students merely by their visits, lectures, and consultations. This may be especially true of students, who are still at an age when their energies need direction. The first step in developing marine science in Indonesia is creating awareness and motivation for marine research and education. It is to be hoped that such short-term visits as mine are helpful in this regard.

LECTURER: Dr. Joseph R. Curray, Scripps Institution of Oceanography, University of California, San Diego

TOPIC: Marine Geology of Indonesia

DATES OF VISIT: December 6-12, 1982

I was a participant in the marine sciences exchange program with Indonesia in late 1982. This is a very brief report on my activities.

I first went to Jakarta and Bandung in late October, to meet with my Indonesian hosts and finalize a schedule for my visit. Arrangements were made for me to return to Indonesia on 6 December to start my official lecture and discussion tour.

I then went to other parts of Asia for official and personal business and returned to Jakarta as scheduled on 6 December. I was met in Jakarta by Mr. Bambang Dwiyanto, of the Geological Research and Development Center, Bandung, Indonesia, who was to act as my official escort for the duration of my visit. He accompanied me throughout my tour, set up arrangements for all my visits and lectures, arranged for my housing reservations in advance, and coordinated my travel plans. Having a personal escort who was also a professional geologist greatly facilitated my tour. It made all travel and living arrangements convenient for me, so that I could devote my whole attention to the professional aspects of my tour.

We spent the first two days in Jakarta, visiting the National Institute of Oceanology and some oil company geologists. We attempted to see Mr. Joe Widartoyo of the Ministry of Mines, but he was out of the country at the time. On 8 December we traveled by automobile with our personal driver to Bandung, where we spent the next several days. During our stay, we met and had discussions with a large number of geologists from the Indonesian Institute of Technology at Bandung, from oil companies, and with various foreign visitors. We visited the site of the future Marine Geology Laboratory on the coast at Cirebon; we visited the active volcano, Galunggung; and I gave formal lectures for most of three mornings on various aspects of marine geology, plate tectonics, and the geology of the Indonesian region.

On the evening of 13 December, we took the train to Yogyakarta. Because of torrential rains on the flanks of the active volcano, Galunggung, floods and mud slides delayed our arrival until early morning on 14 December. I lectured that morning at the University of Gadjah Mada. During the morning of 15 December, we visited some classical geological localities at Karangsambung, near Yogyakarta. Late that afternoon, we flew to Denpasar and stayed overnight.

Early in the morning of 16 December, we flew to Ujung Pandang, where we were the official guests of Hasanuddin University. I gave formal lectures on marine geology, plate tectonics, and the geology of the northeastern Indian Ocean on 16 and 17 December. On 18 December, a geologist from the university took us to the field to see a classical ophiolite locality.

On the afternoon of 19 December we returned to Jakarta, and I departed Jakarta to go on with other portions of my trip on 20 December, thereby terminating my official visit to Indonesia.

My general impressions of the tour are very good. The arrangements were made in a manner to be most convenient to me, and to make available as much time as possible for lectures and discussions with other geologists. The general level of geological background in Indonesia is quite variable. Industry geologists are very much up-to-date. Most of the geologists I met and talked with in Bandung were similarly very much up-to-date, especially with the geological problems of this complex region of the world. At the universities in Yogyakarta and Ujung Pandang, however, I was somewhat disappointed in the level of background knowledge of the students. An exchange program like this must be of some help, but it can be only a token effort. Much more is needed to help those universities reach an adequate level of understanding of modern geology. Indonesia, on the other hand, is far more advanced in this endeavor than are most other countries in Southeast Asia. My own personal experience from working in the seas of that region during the past 15 years is that we have had the best international cooperation with Indonesia of any other country in that part of the world. The Indonesians are anxious to participate in research projects in marine geology and geophysics; they have contributed significantly to these research projects; and they have in turn benefited in bringing their geologists up to modern world standards.

LECTURER: Dr. Kenneth R. Tenore, Skidaway Institute of Oceanography

TOPIC: Mollusc Aquaculture and Environmental Monitoring

DATES OF VISIT: January-February 1983

The main objective of my visit was to evaluate ongoing and potential research in the area of shellfish culture, especially the green mussel (Mytilus virens).

My principal contact was Dr. Aprilani Soegiarto, Director of the National Institute of Oceanology (LON). Several members of his staff are interested in mussel culture, and we traveled to several laboratories.

1. The staff at LON in Jakarta are involved in a joint study of the feasibility of pole culture of the green mussel with several staff of ANCOL, the large public aquarium-park in Jakarta. They have had success during the past year but are worried about polluted conditions in Jakarta Bay.

2. Several of the faculty at Bogor University (Mr. Sutomo Ahmad and Mr. Mohammad Raswin) are involved primarily with shrimp culture but are interested in growing mussels as food for shrimp.

3. The Indonesian laboratory at Serang in West Java (LIPI) and the associated JICA Shellfish Lab funded from the Indonesia-Japan Mariculture Research and Development Project have an experimental study of raft culture of mussels under way. The JICA is staffed in part by Japanese scientists interested in developing shellfish culture techniques.

4. Other places were examined for potential sites for mussel culture:

   a. Ambon, the Moluccas Islands, with the LON laboratory and Pattimura University facilities and the ongoing AID-funded University of Washington program on mollusc culture

   b. Embayment sites on the island of Bali

There is a small, energetic group of scientists of varied expertise who are interested in developing a mussel culture program. The group is fortunate in that it includes phytoplankton, mollusc, and pollution

chemistry experts (from LON) along with those capable of both pilot-scale and mass-scale culture efforts (LIPI and JICA) and those with theoretical interests in designing polyculture systems (BOGOR). Various aspects of mussel culture are already being attempted. I was impressed by their interest and degree of success given difficult research conditions.

The main difficulties that I see hampering their efforts are:

1. Lack of effective intercommunication and coordination in research efforts and dissemination of results.

2. Difficulty in getting administrators to see value in trying to develop new food resources (as opposed to "tried and true" shrimp and fish) and thus in receiving research funds.

After my visits to the various laboratories we had a small workshop meeting in Jakarta (LON) of scientists interested in developing an Indonesian program in the introduction and development of mussel culture methods. The following research outline and aims were developed as an organizational tool.

I. The need to identify, monitor, and characterize potential mussel mariculture sites in Indonesian waters

   A. Potential sites should provide:

      1. Appropriate salinity regimes (including data from rainy season)

      2. Protection from rough weather

      3. Oceanographic conditions providing adequate nutrient and phytoplankton supply (e.g., upwelling sites along Java, Straits of Bali, Mollucas)

   B. Potential sites should be free of unacceptable levels of pollution or turbidity.

II. Introduction of technology at public and fisherman levels

   A. Culture techniques

      1. Development of dependable seed supply

      2. Raft design and handling of mussels

   B. Market development

      1. Overcoming introduction of a new product into diet by adapting cooking methods to Indonesian tastes

2. Developing regional shipping and marketing strategies (local; export--dried or canned).

III. Possible effects of mussel culture in developing polyculture systems and minimizing eutrophication

A. Mussels for use as food for shrimp

B. Nutrient excretion of mussels used for seaweed growth

C. Shrimp feeding on mussel feces

I have offered to work with the Mussel Group in their attempts to develop an Indonesian program. I rate their chances of success high if they receive encouragement and funding from their institutions.

I also visited the Center for Environmental Studies at the University of North Sumatera in Medan and was quite impressed with their earnestness and interest in developing marine science studies at their university. Dr. Ir. Abu Dardak, Dean of the Faculty of Agriculture, and Prof. Jazanul Anwar have developed the interest of other scientists from various disciplines in studies of the runoff effect on coastal marine environments. Lack of facilities is severely retarding their development, and this institute would benefit immensely from some form of collaboration with LON, especially in ship time and marine and coastal sampling techniques. I spent a morning with the group discussing development and areas of expertise and equipment needs. Their questions were incisive and well thought out. I would pick this university as a sure bet in responding to development aid. Their location on the Singapore Strait would be a logical place to develop a coastal oceanographic sampling program.

I want to thank all (National Academy Staff, USAID Staff, LON and other Indonesian hosts) who made my trip so enjoyable.

LECTURER: Dr. Robert Corell, University of New Hampshire

TOPIC: Ocean Engineering and Technology

DATES OF VISIT: May 2-21, 1983

During the period May 2-21, 1983, I was privileged to visit the country of Indonesia under the 1982-83 U.S. marine science exchange program, coordinated by the government of Indonesia's Ministry of State for Research and Technology and the Board on Science and Technology for International Development of the National Research Council. The central purpose of this visit was to explore a wide variety of ocean technology and ocean engineering interests that could potentially develop between the United States and the Indonesian institutions and agencies. The host for this meeting was Dr. Achmad Amiruddin, then Deputy Director of the Agency for Assessment and Application of Technology (BPPT), a deputy directorship that he held for the basic and applied sciences including ocean director at the technology directorate, the basic science directorate, and the life sciences directorate. Dr. Amiruddin at that time reported directly to Dr. B. J. Habibie, Minister of State for Science and Technology, as well as the chairman of the Agency for Assessment and Application of Technology.

I was also hosted by Dr. Rahman Djay at the BPPT, a nuclear physicist, who spent 18 years at the Swedish nuclear laboratory at Upsala. He was a major source of conversations and insights during my entire visit to Indonesia.

BPPT does not have a direct analogy in the United States though it is an amalgamation of a number of federal agencies interested in technology, research and assessment, and the application of such technologies to national priorities and needs. The agency has four major areas of development, one of which is the basic and applied sciences, chaired and directed by Dr. Amiruddin. The others include industrial development, natural resources development, and technology development. My host for the entire time was Dr. Amiruddin and his staff. Key individuals were Mr. Rys Bamdang Suharbiyanto--a naval architect and graduate of the Institute of Technology at Surabaya; Mr. Idwan Suhadi--a graduate of the Institute of Technology at Bandung and responsible for geological activities within the Agency for Basic and Applied Sciences; and Dr. Rahman Djay, Director of the Basic Sciences.

The itinerary was as follows:

May 2, 3, 4--Meetings with a variety of individuals and leaders within the BPPT and the National Institute of Oceanology.

May 5, 6, 7--Meetings and lectures at the Institute of Technology at Bandung.

May 8, 9, 10, 11--Lectures and meetings with the faculty and others interested in research and education in Surabaya, all located at the Institute of Technology in Surabaya, and meetings with individuals from government and industry.

May 12, 13, 14, 15, 16--Meetings and lectures at Hasanuddin University in Ujung Pandang.

May 17, 18, 19, 20, 21--Meetings and briefings with the key leadership in Jakarta on technological and engineering interests in the ocean. Meetings were with the National Ocean Technology Committee, many elements of the Agency for the Assessment and Application of Technology, the AID Office, etc.

The format of the visit had three major components:

1. Formal lectures on a variety of topics were offered at all locations. About 15 lectures were given.
2. Meetings with formal groups such as faculty, committees of the federal government, etc.
3. Meetings with a wide variety of individuals, academic, industrial, governmental, and institutional agencies.

Highlights of my impressions and thoughts are summarized below:

1. The initial visit was in Jakarta, with meetings at BPPT and other agencies with interests in ocean science and technology in Jakarta. These meetings were largely briefings, intended to bring me up to date and provide a background for my trips throughout Indonesia. Several themes emerged from these sessions:

- There is a major interest in environmental technology, particularly as it relates to the needs for laboratories and activities in environmental quality control, pollution, etc. They are in desperate need of technical data journals, the whole range of written materials to assist in water quality, air quality, and health engineering. They are eager for training of engineers in the sciences and technology of environmental matters.

- There is an interest in building a stronger hydrodynamic base to their shipbuilding industry with the potential of building a hydrodynamics laboratory at Surabaya.

- Water quality and chemistry appear to be a major interest related to the environmental technology interest identified above, but has been identified as a special interest because of both its applied and basic implications. The water chemistry is largely located at the technical institute in Bandung, but there will be broader interests throughout the country as the pollution issue grows in importance.

- There are major interests in shipbuilding, marine engineering, naval architecture, and the broader aspects of ocean engineering, such as offshore structures development.

- There is a strong interest, particularly by the Director of Basic Science and its application, in the development of a technical information center. He feels, as do many others, that their library holdings and their technical information is substantially below that which is required. This includes not only the classical literature available as a standard in virtually every American university and major ocean institution, but a strong interest in the gray literature (publications that have a life of several years, such as technical reports, memoranda, and technical data documents).

In all cases, the Indonesians have expressed a strong interest in true cooperation, a partnership in the development of any of these activities wherein they feel that they can bring together some resources--fiscal, personnel, and physical. They lack a great deal to develop the necessary momentum to undertake some of these projects and, therefore, seek the cooperation of U.S. and other institutions. They are extraordinarily eager to reach out to the United States, for they are determined to develop their marine and coastal resources wisely and appropriately.

2. The visit to the Institute of Technology in Bandung focused largely on a lecture series, as the faculty at the Institute of Technology at Bandung is not organized around its ocean technology interests as much as are faculties elsewhere. A number of substantive discussions with individuals and small groups of faculty there focused on pollution technology, hydrodynamics, and hydraulic engineering. The faculty expressed a strong interest in evolving a program, not a department, in ocean engineering. They would hope that U.S. cooperation might lead to some assistance in the development of such activities at their institution.

3. The faculty at the Institute of Technology at Surabaya, led by their dean, is incredibly committed and eager to expand their conventional shipbuilding, marine engineering, and naval architecture activity into a broad-based ocean technology faculty. Their interest is keen: in one case, having asked me to a lecture for about four hours, they pressed me to continue for almost 10 hours nonstop. In all

cases, the individuals asked pertinent questions and engaged in significant discussions relating to their wants and needs to develop a broad ocean technology program and faculty.

4. Activities during visits to Hasanuddin University in Ujung Pandung surrounded a series of lectures with small and large groups of faculty and students, but the essence was a strong commitment on the part of this institution to expand its ocean science and technology program. My host, Professor A. Amiruddin, was previously rector at Hasanuddin University. During his tenure, the institution made substantial commitments to expand its activities in ocean science and technology. These interests remains. They have had some difficulty in doing that as a substantial number of their faculty of 157 are off at foreign universities studying. A small portion of these faculty are in the ocean sciences field: virtually none were trained in the United States; many were trained in Japan.

That commitment to ocean science and technology resulted in a meeting with all the key leadership of the institution in the evening to explore concepts and topics related to marine science education and research. It was an excellent meeting. Their interests ranged from fish farming, aquaculture and marine environmental issues to interests in the technological areas.

5. The return visit to Jakarta and BPPT, which lasted four days, was focused on discussions with a variety of individuals within government and industry, who have responsibilities in ocean science and technology. A major effort was devoted to a meeting with the National Ocean Technology Committee (NOTC), chaired by Dr. Zen. The focus was on marine resources development, marine science activity, and potential cooperative efforts. It was a fascinating discussion, and I had the opportunity to speak at some length about my views on the topic.

The scope of the meeting (NOTC) was extremely broad, ranging from some fundamental questions about the role of the federal government in marine resources development, industrial development, and economic development of coastal margins to very specific questions about how we can improve the quality of water in our urban industrial centers; and how we can protect our offshore waters from pollution. They were eager to explore U.S. concepts such as the Sea Grant Program, the way in which the National Science Foundation supports marine research, and the way the military primarily through the Office of Naval Research interacts with U.S. institutions in the support of fundamental and applied research.

The lectures during the entire visit to Indonesia were, in all cases, keyed to the audience, were designed after discussions with the individuals within the universities and agencies, and were generally in one of the several following areas:

1. Advanced technology in electronics as it applies to the ocean sciences and technology

2. Undersea manned and unmanned vehicle systems for marine resource development and basic science
3. Aquaculture and fisheries technology
4. Pollution and environmental science and technology
5. Basic oceanography, with particular emphasis on the physical and biological deep ocean, such as aspects of programs of science aboard the ALVIN submarine.
6. Education for ocean technology and engineering.

Conclusions: I found the visit well received. The individual institutions and agencies in Indonesia are extremely eager to engage in cooperative and joint venture efforts with the United States. I was continually confronted with the fact and the perception that the United States has not expressed itself effectively in international cooperative efforts with Indonesia. Their past cooperative efforts have been with Japan, Germany, Holland, and to some extent the Scandinavian countries. The French have been active in some of the offshore work, particularly in geology.

I was overwhelmed on several occasions by the lack of evidence of U.S. interests in Indonesia. We clearly have the technology, and we have the capability. We have not expressed well our interests to a nation that ranks number five in population, has unbelievable natural resources, including oil, gas and minerals, and is a nation well schooled in what we might call the "Puritan ethic"; that is, a devotion to hard work and loyalty to cause. These ingredients seem to me to herald a nation that is going to grow fairly rapidly and, if one observes the current administration, is dedicated to major economic growth and development. It is clearly a nation of contrasts; one where some individuals spend their entire lives nursing small rice paddies while others deal with the most advanced technology such as the new telephone system launched by the space shuttle to serve the 13,600-plus islands in the Indonesian archipelago. My impressions are that the sciences and technology have the potential for growth and development through two major mechanisms:

1. Direct cooperation with the universities and science institutions that are funded through various patterns, but primarily the federal government.
2. The Agency for Assessment and Application of Technology (BPPT), which is committed to technology development but does so within the basic and applied sciences.

The real benefit from the U.S. marine science exchange program is that we are developing a group of individuals in the United States, small though it may be, who have had direct access to some fundamental resources within the Indonesian society and federal infrastructure. It is extraordinarily difficult to place on paper the substance of our collective understanding. I endorse and encourage the kind of activity that is planned for the fall of 1983--the symposium on Indonesia--and continued efforts to build cooperative efforts within Indonesia.

If I have any frustration at this moment, it is a lack of understanding about how we can initiate programs and attract the interest of the appropriate individuals in the United States, for cooperative ventures. The central problem is not going to be interests on the part of the U.S. scientists, engineers, and personnel or on the part of interests within Indonesia. I think the central problem for us is going to be the raising of funds to complement those within Indonesia for research and development activities. That difficulty exists both in Indonesia and the United States, though I have some optimism that on approved projects, the Indonesian government will come forth. The four major areas of potential cooperation identified by the National Ocean Technology Committee are:

1. Food from the sea
2. Energy from the sea
3. Raw mineral resource extraction from the sea
4. Marine pollution

Finally, I want to thank the National Academy of Sciences, Dr. Dirk Frankenberg, and my many new colleagues and friends in Indonesia for one of the most outstanding experiences of my life. I am convinced that I learned substantially more than I ever contributed during the visit, and that that learning and understanding provide a context for a continued personal commitment on my part to encourage the concepts and thoughts inherent in the U.S. marine science exchange program during 1982 and 1983. I will do all I can to continue to enhance the concepts inherent in that exchange effort and to encourage U.S.-Indonesian joint and cooperative research and development programs in marine resources development and in the fundamental and basic sciences of oceanography.

LECTURER: Dr. Dirk Frankenberg, Marine Sciences Program, University of North Carolina

TOPIC: Coastal Zone Management in the United States, Major Oceanographic Research Projects

DATES OF VISIT: May 17-June 5, 1983

I traveled to Indonesia to discuss the NRC-sponsored marine science exchange program with U.S. and Indonesian colleagues and to give a series of lectures on the U.S. Coastal Zone Management Program. During the trip, I visited Jakarta twice, Samarang, Yogyakarta, Ambon, Ujung Pandang, and Medan.

During my first visit to Jakarta, I discussed the U.S.-Indonesian marine science exchange program with Dr. Jerome Bosken at USAID, Robin Harger at UNESCO-Jakarta, and Dr. A. B. Van Rennes, U.S. Advisor to the Indonesian Ministry of Science and Technology. These discussions on May 16 indicated continuing enthusiasm for an enhanced U.S.-Indonesian program in marine science but few specific suggestions of the direction such a program should follow. There was great interest expressed in suggestions that might be generated in a report on the 1982-83 marine science exchange project funded by the U.S. National Research Council.

On May 17, I traveled to Samarang to visit the University of Diponegoro (UNDIP). After some confusion about scheduling and making contacts, I arrived at about noon. I was welcomed by the Rector, Professor Sudarto; the head of UNDIP's Jepara Marine Laboratory, Dr. Gatot; the head of the University of Newcastle on Tyne/UNDIP fisheries development project, Professor Separdi of the Biology Department; and two staff members of the Newcastle/UNDIP project, Dr. Nick Willoughby and Dr. Janet Brown. After a brief conversation and lunch, Gatot, Willoughby, and I left for Jepara to visit the UNDIP marine laboratory.

UNDIP has a Department of Fisheries that includes "departments" of oceanography and marine biology. This is a separate unit from the Biology Department although it appears to be primarily biological/fisheries in focus. UNDIP operates a marine laboratory at Jepara about 80 km (2 hours by car) from Samarang. Dr. Gatot told me that UNDIP had been "given responsibility" for coastal resource management by the Ministry of Education. The UNDIP marine laboratory consists of 6 buildings, a wet lab, a dry lab, a general lab, 2 small houses, and a long library, conference room, sleeping quarters, storage building. There is also a short concrete pier, and a tower for a saltwater system (currently used to store brackish water from a

groundwater well, i.e., there is no non-brackish, potable water on site at present). The laboratory buildings are ready to function. All have been built since 1977, but there is no permanent staff so no full-time work is in progress. A team of biologists from the University of Newcastle operated a field course for UNDIP faculty in the summer of 1982, and "specialized groups" from UNDIP have used the facility for course work. Gatot told us that this was to be a laboratory for all universities to use and that its support was to come from the Ministry of Education. Additional charges to user groups are anticipated. The laboratory is equipped with 2 small boats (one inflatable, one aluminum, both 25-HP motors), running brackish water, and electricity. There is little scientific equipment in evidence (3 dissecting microscopes, a drying oven), but equipment is brought from the UNDIP main campus as necessary.

On May 18 I visited the main campus of UNDIP, gave a two-hour lecture and discussion on coastal zone management in the United States, and discussed the future of marine science at UNDIP with senior administrative officials. The UNDIP campus is flourishing; about 10,000 students are enrolled in 19 departments, including the Fisheries Department where marine science is located. My lecture was attended by about 75 people, about 20 of whom were faculty. The discussions with administrators demonstrated their enthusiasm and interest in developing marine science. Both the Rector, Professor Sudarto, and the Vice Rector, Professor Modjono, expressed great interest in developing student exchanges with the University of North Carolina and/or other U.S. institutions and in sending staff to the United States for further training. Both responded positively to a suggestion of a U.S.-Indonesia marine science consortium which might coordinate such exchanges. Professor Sudarto urged me to discuss this concept with Professor Pramutadi in the Ministry of Education in Jakarta. After this meeting I met for lunch with Professor Sapardi, head of the Biology Department; Professor Sidarta, Director of the Center for Coastal Area Ecodevelopment; and Professor Lachmuddin, a young UNDIP faculty member who has just completed his Ph.D. in coral systematics at the University of Newcastle. Professor Sidarta, an architect, has been given responsibility by the Minister of Higher Education to coordinate coastal resource management in north-central Java.

On May 18 and 19, I visited Gadjah Mada University in Yogyakarta. Gadjah Mada is a large modern university located on an impressive new campus on the north side of Yogyakarta. It is one of three "national" universities in Indonesia in that it accepts students without regard to their place of residence. Acceptance is based on competitive examination, with 1 in 10 applicants being admitted. My visit was complicated by the fact that May 18 was graduation day and most of the faculty were involved in activities other than my visit. I was shown the campus and met faculty in the departments (faculties) of geography and biology. On May 19, I was shown laboratories in these two departments, gave a lecture, discussed possible academic exchanges with the heads of these two departments, and visited the south coast of Java

at Baron and Kracal where a new fishery is being developed (Baron) and planning for a new national park and international hotel is progressing (Kracal).

Gadjah Mada is clearly a place in which mutually beneficial cooperative research could be conducted by U.S. marine scientists. The faculty is intelligent, well trained, and ambitious. The laboratory facilities I was shown compare favorably with those of U.S. institutions. There are state-of-the-art instruments already in place and operational, and there is widespread interest in developing competence in marine science. The Geography Department seems a particularly good place to focus such cooperative work. The faculty is divided into "departments" of Human Geography, Physical Geography, and Research Technology. Laboratories include those for hydrochemistry, cartography, and remote sensing. The faculty has obtained support from international aid groups (The Netherlands, Japan, Australia), private foundations (Rockefeller), and fees from contract analyses to equip these laboratories with spectrophotometers, colorimeters, fathometers, flame photometers, pH meters, conductivity meters, BOD analysis equipment, wet chemistry technology, etc. Their field equipment includes water level recorders, boats with outboards, sediment analysis equipment (screens/rotap and pipette techniques), coring (3 types), and a 4-wheel drive vehicle. The cartography laboratory has large and giant (21 X 6 m) cameras and a flat press for mapmaking. The products of this laboratory rely heavily on aerial photographs and Landsat imagery analyzed in a separate remote-sensing facility.

I spoke with the Dean of the Geography faculty, Professor Surastopo, and with two geomorphologists on his faculty, Professors Karmono and Sunardi, in specific terms about possibilities of a young faculty member from Gadjah Mada being trained at the University of North Carolina in carbonate bank geomorphology. This prospect will be explored further by correspondence. I also spoke with the Dean of the Biology faculty, Professor Muso, and the Geography faculty about prospects for a U.S. scientist spending 2 to 4 months at Gadjah Mada developing and teaching a course in coastal zone management. Faculty members interested in this prospect included Professors Anthon (fish larval ecology), Tandjung (fish gill tissue as pollution indicator), and Sugeng (head of the Center for Environmental Research and Studies).

The visit to the south coast provided a convincing demonstration that the commonsense principles of coastal zone management are well understood by some development-minded Indonesians. The new fishery is based on fiberglass copies of traditional Indonesian canoes (the fiberglass is better able to withstand the high surf of the south coast) equipped with outboard motors. The fishery has grown from 4 boats in 1982 to 41 boats in 1983; the income is said to average 6,000 Rp (US$1 = 970 Rp) per boat per day (up from ca 1,000 Rp for the rod fishery that preceded it). Harvest is variable but includes at least 8 species and is sufficient to justify sending a refrigerated

truck 80 km to pick up the catch each day. The fishery is run by a cooperative that is said to keep records. Analysis of these records and the Baron fishery would provide valuable insight into catch/unit effort changes during development of a tropical marine fishery and help determine the effect of current intense fishing in other tropical areas including the north coast of Java. After visiting Baron we drove around a headland to the sites of a regional park, a planned tourist hotel, and a national park. The planned use of different parts of this coast for commercial fishing, recreation, and tourism demonstrates that commonsense coastal zone development planning is already being practiced in some parts of Indonesia.

On May 23-25, I visited Ambon, capital of the Molucca Island Province of Indonesia. I met with staff of the University of Pattimura, the Indonesia National Institute of Science (LIPI) laboratory of the National Institute of Oceanology (LON), and the USAID-funded aquaculture project of the University of Washington. The functional part of my visit was delayed half a day by failure of communication within the University of Pattimura and between the units I was to visit.

The University of Pattimura is a growing provincial university of about 5,000 students. It has faculties (departments) of Agriculture, Animal Husbandry and Fisheries (soon to be split), Shipbuilding, and is currently organizing a Faculty of Mathematical Science. Marine science activity is included in the fisheries unit. Pattimura has marine science "responsibilities" that far exceed its current capabilities. Its fisheries staff has only 2 senior faculty, yet it has responsibility for fisheries research as well as marine aspects of an environmental center focused on island ecology (this center is headed by the Dean of Agriculture), a nationally assigned focus on deep-sea research, and marine aspects of a newly developed Indonesia-Australia project on South Pacific studies. Efforts to increase Pattimura's capabilities in fisheries are under way as 15 young staff members are currently being trained at the University of Bogor, and plans exist to increase quality of staff by sending young faculty abroad for further training. Short-term staff training has already occurred at the universities of Washington and Guam. Marine fisheries and coral reef ecology will remain the focus of the University of Pattimura program. The Washington and Guam links need to be maintained if the institution is to keep its momentum in developing capabilities to match its responsibilities. The University of Washington link is not assured of formal continuance after the end of the USAID-funded aquaculture training program in April 1984.

The Ambon laboratory of LON-LIPI is growing rapidly. Its professional staff has doubled from 7 to 14 since my last visit in January 1982. The 20,000 square-foot laboratory, which had its cornerstone laid during that visit, was essentially complete and needed only water and electrical connections before occupancy. A new 90-foot research vessel is under construction and will be delivered in 1984.

The new staff is not yet fully functional because equipment purchases lag behind staff development; however, the physical oceanography laboratory of Luke Weinno is equipped for hydrography and wet chemistry measurements of NO_3, PO_4, SiO_2, etc.; the marine ecology laboratory of Daniel Sapulete is equipped for measurements of chlorophyll, zooplankton displacement volume, and (in cooperation/ competition with the physical oceanography laboratory) fish distribution by Simrad echo sounding; the biological laboratory of Mr. Sam Wouthuyzen is equipped for and is conducting an inventory of biological resources of Ambon and nearby islands. This group is also involved in a mangrove assessment study with the National Biological Institute (LBN) at Bogor. Through contacts and cooperation with the USAID-funded University of Washington project, the LON-LIPI laboratory has obtained sophisticated instrumentation such as the Simrad, a Hewlett Packard 85 microcomputer with floppy disk drive and printer (no plotter), Turner fluorometer for chlorophyll measurements, etc., as well as the technical expertise to operate these instruments. Several staff members have been to Seattle for short-course training, but continued involvement with University of Washington or other faculty seems needed to maintain the momentum gained by USAID funding.

The USAID-funded aquaculture training project run by the University of Washington has clearly been a major success. This outcome was not obvious when I visited in January 1982 but has become so since. One project, establishment of a marine science library, had been completed in early 1982, but there was little evidence of its use by Indonesians. In May 1983, when I visited unexpectedly, there were 34 Indonesian students using the facility, the books are becoming soiled and dog-eared from use, and the library gives every evidence of being a great success. Numerous faculty at LON and Pattimura described use of this library and results of research contained in papers therein. The collection has been extremely well chosen to meet Indonesian needs with emphasis on general texts, fisheries specialties, and Pacific Rim marine biota.

The central project of the University of Washington program, the aquaculture training project is also obviously successful. In early 1982 the Director, Dr. Charles Angell, was waiting for equipment to clear Indonesian customs; in May, 1983, the equipment is operational in an established laboratory equipped with a running seawater system and tanks and culture facilities suitable for spawning and raising 2 types of shrimp (Macrobrachium rosenbergii and Panaeus monodon), 2 types of fish, the rabbit fish (both Seganus lineatus and S. aurium), and a potential tuna bait fish, the molly Poccilia reticulata. In addition, this laboratory has cooperated with LON-Ambon to develop a successful culture technique for the black-lipped oyster, Saccrostrea echinata. Some of this technology is derived from results elsewhere, but about half these species are being raised in the laboratory for the first time. All have important uses in marine fisheries. The shrimps have potential for growth in pond culture, the rabbit fish are important food fish throughout eastern Indonesia, and the oyster has already been

raised and sold in Ambon markets. The techniques developed and in use have been taught to several Indonesian students--some as laboratory helpers, many more in formal classes. Thus the technology has already begun to be transferred to users. In addition the project has fostered short-course training of several Indonesian scientists at the University of Washington. These people are unanimously enthusiastic about the experience, and they provide a corps of well-trained staff that provides momentum to the whole marine science community in Ambon. I don't know the outcome of many USAID projects, but as a self-admitted cynical and independent observer, I would have to give this program very high marks. It is a success in which all Americans can take pride. Momentum in areas important to Indonesia has been generated that would have been impossible otherwise. It is not clear that this momentum is sufficient to maintain forward progress without some continued involvement with the University of Washington and University of Guam faculty, but modest funds spent to maintain such involvement will keep forward progress under way. This investment seems needed to reap the full potential of funds already spent.

On May 26-28, I visited Hasanuddin University (Un Has) at Ujung Pandang on the island of Sulawesi. Hasanuddin is a growing provincial university of 10,000 students. Administration and faculty at Un Has have had an interest in marine science since the mid-1970s when a workshop encouraged by former rector Achmad Amiruddin recommended that oceanology become the "main scientific theme" of the university. This recommendation has been incorporated into administrative planning and thinking about the university's development but has not shown much tangible result to date. This is easily explained by other pressures created by moving the campus from a central city location to a new suburban location north of town. This move occupied most of the attention of former rector Amiruddin and is taking a significant portion of the time of the current rector as well. Faculty and administration enthusiasm for marine science at Un Has remains strong, however, and renewed progress toward its developments is expected soon.

The faculty and administration of Hasanuddin were very hospitable and interested in my visit. I had three appointments with Rector Hasan Walinono, and two with Vice Rector Hardjoeno. Both attended my coastal zone management lecture and joined to host a dinner for me. The faculty was also cordial; Dr. Kumarineng, nominal head of the Programs in Marine Resource Development took me to the site of a new laboratory 80 km north of Ujung Pandang and to the site of a central government/ local government cooperative project to increase productivity of brackish-water fish ponds (tambaks). The new laboratory site is on the berm of a low-energy beach facing Macassar Strait. The site is 14 hectares in area and has 8 experimental ponds. There is no scientific laboratory development at this time, although there are 4 currently occupied houses on the site. The tambak project at Pangkajene was described as having increased the harvest of shrimp (Panaeus monodon) from 600 to 1,200 kg/ha/yr through use of fertilizer and modest amounts of pesticides. The layout of the experimental ponds

with nursery transition and rearing ponds appears logical and will be emulated at the new university site. The university, local government, and Ministry of State for Research and Technology have signed a contract to develop a shrimp nursery to provide juveniles for increasingly productive tambaks. I described the work of the USAID-funded University of Washington project, which has achieved spawning of this species at Ambon, and I encouraged Un Has staff to visit Charles Angell before he leaves Ambon in July. In summary, Un Has is an institution that seems anxious to develop marine science, but they have had that enthusiasm since the mid-1970s without developing a tangible program. The advice given Un Has by Grant Gross of the National Science Foundation in 1977 is equally applicable today. I urged them, as he had, to make a plan for program development to help them obtain external support and place their needs in priority order. The faculty and vice rector assured me that this was a good idea and said they would do so soon. I had the feeling that they had said the same thing to Dr. Gross 6 years earlier.

On May 30, I visited with Dr. Aprilani at the National Institute of Oceanology. We discussed the NRC report on Scientific Manpower Development in Indonesia, my interim report on the NRC-supported marine science exchange program, plans for the final report on this program, and development of the LON program since last November. This conversation was a useful precursor to the meeting planned for October 1983 in Washington in which opportunities for research and technology in Indonesia will be discussed. Also on May 30, I talked with Professor Sukadji and gave him my initial reactions about marine science in Indonesian universities. We discussed further the idea of an Indonesian-U.S. consortium-to-consortium arrangement in which U.S. marine science institutions interested in training Indonesian staff and students would be made known to Indonesian universities interested in having such training. Sukadji and the rectors or faculty of Diponegoro, Gadjah Mada, and Hasanuddin universities had expressed interest in such an arrangement. Sukadji indicated he would discuss this idea with the Minister of Higher Education as well as with the universities potentially involved to see if Indonesian interest justified efforts to form a U.S. consortium to interface with academic marine science programs in Indonesia. Later in the day I had discussions with Drs. Jerome Bosken and A. B. Van Rennes on my impressions of the Indonesian institutions I had visited and the potential future for U.S.-Indonesian cooperation in marine science.

On May 31, I returned to the National Institute of Oceanography (LON) to give two well-attended lectures; one on U.S. coastal zone management, one on modern U.S. research in oceanography. I also visited the laboratories in LON and found them to be modestly equipped and apparently functional. LON impressed me as a place where useful marine science is now being done and where additional work could be well supported with space and interested colleagues, and modestly supported with technical staff and instruments.

On June 1, I traveled to Medan, North Sumatra, to visit the University of Northern Sumatra. Unfortunately, I seemed to have been scheduled at a poor time to visit. No one expected my arrival on June 1, there having been correspondence suggesting my visit be deferred until Friday, June 3. As a result there was no program on June 1 or 2. I visited the campus briefly on the evening of June 2 and talked with the Dean of the School of Agriculture, Professor Abu Dardak, and with a British employee of a UNDP-funded project on plantation ecology, Dr. Tony Whitten. On June 3, I visited the campus and gave a sparsely attended lecture on the U.S. coastal zone management program and met the Assistant Director of the Center for Environmental Studies, Dr. Jazanul Anwar. It was unfortunate that the press of other responsibilities (specifically, administering the university admission examination to 27,000 applicants and preparing for an upcoming Regional Conference on Plantation Environments) kept my visit from being fully functional. Dr. Ken Tenore found the staff at the University of North Sumatra to be active, enthusiastic, and interested in further work.

LECTURER: Dr. Nelson Marshall, University of Rhode Island

TOPIC: Tropical and Coral Reef Fisheries

DATE OF VISIT: May 1983

UNIVERSITY OF INDONESIA

This university has about 10,000 students. The marine interests are concentrated in the Biology Department which reopened in 1978 (biology had lapsed for a while) and has 150± students with 20 faculty members. Five or six of the students are in marine biology. The Biology Department is headed by Dr. Indrawati Gandjar, very capable with a Ph.D. from The Netherlands and an interest in industrial microbiology. She stressed the need for growth in the marine biology faculty group (there are now only three) and for advanced education for the faculty members.

Three faculty members have some direct interest in marine work. S. Hadidjah Parsono is interested in phytoplankton and marine algae. Her master's thesis was on Stenophara. B. H. McConnahey of the University of Oregon was her major professor, and she earned her degree at the Institute Pertanian Bogor where McConnahey served with the University of Kentucky team. Sundowo Harminto is interested in echinodermata. Phil Aburrahman is interested in malacology. The marine group enjoys (jointly with IPB) a new marine lab in the complex at Ancol. The building is very impressive but almost bare at present. Running seawater is to be arranged, I understand, by pumping it over from the nearby oceanarium. They do not have a boat at present.

At the time of my visit, a faculty member (Sundowo, I believe) was leading a group of students on a 3-day field trip to Pari Island. The Ancol lab referred to it as a joint project of University of Indonesia and IPB, currently relying heavily on LON, the National Institute of Oceanology, for help with instruction. The Biology Department is inviting Professor Maria Best of the University of The Netherlands for a 6-month stay to help them get started on coral work. University of Indonesia also has a Center for Studies of the Environment and Human Resources headed by Dr. Mohamad Soerjani. One member of his staff, who joined in our discussions, has an interest and some advanced knowledge of law of the sea. Environmental concerns with a marine slant fall in the center's domain, but they do not seem to be stressing this area. There was little or no sense of the scope of marine work outside the domain of biology.

Cooperative research was not discussed much since the priority is to upgrade the educational background of the faculty. They talked a great deal about what they called "sandwich" graduate programs: faculty members are degree candidates in Indonesia and their thesis research focuses on Indonesia problems, but they do their course work abroad, perhaps for a year. Such arrangements have worked out thus far, and they would like more of them, typically involving some participation by overseas university professors. "Sandwiching" seemed to be regarded as far more workable and useful than sending students abroad for years of study for the Ph.D.

FISHERIES RESEARCH INSTITUTE STATION AT ANCOL

As I understand, FRI focuses on three areas: marine fisheries, inland fisheries, and fishery technology. The unit at Ancol is apparently part of the marine fisheries activity and seems to include the work at FRI's Pari Island Field Station. The staff of six scientists at Ancol is essentially a bachelors' level group, and the work is pitched accordingly. There is a great deal of interest in further education. In fact, whenever I tried to talk about cooperative research, the conversation was soon directed toward further education. The head of the FRI work at Ancol is Wardana Ismail. The overall head of FRI is Unar Mohammed. I came away puzzled as to why FRI had not been brought more actively into the U.S.-Indonesia marine science exchange program.

INSTITUTE PERTANIAN BOGOR

This is a rather large, relatively "mature" university. Its fisheries faculty has close working ties with the fisheries staff of the Indonesian Department of Agriculture. There are about 80 faculty members in fisheries (about 10 percent of whom have a Ph.D.), and there are about 500 students. Some members of the faculty and some students are interested in marine work, but there is apparently a greater emphasis on freshwater interests.

Faculty members include Prof. Sumardi Sastrakusumah, Dr. Eidman (Dean of Faculty of Fisheries), and Geoffrey B. Deitriech, who is interested in coral reefs and does fish community work.

BIOTROP, the SEAMEO Regional Center for Tropical Biology, is located in Bogor and has functional ties with the Institute Pertanian Bogor. BIOTROP plans to launch a mangrove production ecology study that will include a section on hydrobiological observations. They would be very receptive to cooperative research in this area. Key people to contact are Prof. Ishemat Soerianegara, BIOTROP Director with an active interest in mangroves, and Dr. Zahrial Coto, a key worker on mangroves. In the absence of others the mangrove plans were presented by Dr. Soetikno Slamet, who is associated with the pesticide program.

Both the fisheries faculty and BIOTROP expressed interest in overseas education, liked the "sandwich" method, and said the French government was offering a substantial program patterned in this way.

UNIVERSITY OF PADJADJARIN IN BANDUNG

The Fisheries Department is in the Faculty of Agriculture but is working toward becoming a separate faculty. There are about 30 students and 17 faculty members in fisheries. At present only about five faculty members are in residence. Several are studying abroad for the Ph.D. (three are in Australia--two at the University of New England, one at the University of Queensland).

The department gives both the M.S. and Ph.D. but likes to encourage overseas education, either as a straight degree program in foreign universities or in some form of "sandwich" program. Faculty members include Dr. Ir. Hasbi Tirtapradja, Dean, Faculty of Agriculture (not in fisheries himself but promotes the department); Professor G. Satari, Professor of Agronomy (serving for the time being as Chairman for Fisheries, was formerly Rector, and before that was Dean of Fisheries at IPBO); Dr. Ir. D. Iriana, whose interest is in shrimp; Ir. A. R. Syamasudin, who is working on cage culture as a Ph.D. candidate at his university and is also on the faculty; and Dr. Otto Soemarwoto, a first-class ecologist and conservationist and member of the board of ICLARM (he was in Jakarta so I was unable to meet with him).

UNIVERSITY OF HASANUDDIN IN UJUNG PANDANG

The university has about 10,000 students. In the Department of Fisheries, marine interests seem to be lodged in the Faculty of Animal Husbandry; in the Department of Biology, they are in the Faculty of Science. There seemed to be more cross-campus interest than noted at other places.

There are about 150 majors in fisheries and perhaps less than 20 in biology. A large percentage (147 people) of the faculties (all fields) is currently away studying. Nine of the 21 faculty members in fisheries are away. The chief fisheries interest is in aquaculture, especially shrimp at present.* More attention may be paid to finfish and to algae (probably Euchuma) in the future. At a University Senate meeting it was noted that the University of Hasanuddin had decided to focus on shallow water problems for the time being.

There are good coral reefs around the offshore islands, some as close in as 6-8 km. Dr. Best of The Netherlands has been involved here in reef studies, probably largely taxonomic. Dynamics of reefs did not seem to interest anyone. At a University Senate meeting the former rector, Dr. Achmad Amiruddin, challenged the university to come forward with some imaginative planning for marine research.

I met with the following key people: Professor Dr. Hasan Walinono, Rector, a sociologist; Professor Dr. Hardjoeno, Deputy Rector, a clinical pathologist, School of Medicine; A. S. Kumanireng, a chemist, head of Department of Fisheries; Dr. Masud Sikong, head of the shrimp project; Hendarko S. Sardjono, Chairman, Department of Biology, M.S. in limnology from Technical Institute in Bandung; Muhamad Sahrul, Department of Chemistry, interested in pollution chemistry, received M.S. in Japan; Willem Moka, faculty member studying coral taxonomy under Dr. Best, University of Leiden, The Netherlands.

UNIVERSITY OF SAM RATULANGI IN MENADO

This relatively small university has about 6,000 students. There is a separate Faculty of Fisheries with a dean who is a veterinarian, not a marine scientist. There are about 200 students in fisheries and 30 faculty members, half of whom are away studying. Interest in marine science extends somewhat into other faculties. There is also a fishing technology training program in Menado with a 3-month offering. This is run by the government fisheries staff, I believe, and includes training in motors, boats, and fishing gear.

Fisheries interests focus on close-to-shore artisan fisheries and tuna fishing. Batung is apparently the center for tuna. The boats there are mainly 30 tons; a new one is 300 tons. They stay out about a week. Foreign tuna vessels fish their waters, mostly illegally. To some extent this is a Sulawesi Sea-Pacific Ocean marine orientation. There are some truly great coral gardens on the offshore islands.

The university is interested in becoming involved in a project in the Sangir Taland Islands where a group of Protestant churches in North Sulawesi, with support from the SOAM Church in Switzerland, has a program to upgrade the well-being of the islands. The churches want the university to supplement their work with biologist/fisheries expertise, and the university thinks this is one area in which cooperative marine science might be pursued. There are close to 80 islands, 56 of which are inhabited. They depend on coconuts and fisheries. There is one airport on the island, reached from Menado. There is a shortage of live bait for the tuna fishery--they depend largely on mangrove and reef areas to supply this. FAO has some sort of tuna fisheries project in Batung that is headed by Robert Lee, from Hawaii.

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*Much was made of the fact that they were signing a memo of agreement for a shrimp culture development site about 80 km to the north. The province will provide the land, the Ministry of Research and Technology will provide facilities, and the University of Hasanuddin will provide research input. They are building a new campus in a far more attractive setting north of the city. Some groups have moved in.

Robert Haggerty from Washington State University, stationed in Menado to coordinate an AID project on graduate-level training in agriculture, was present at our final briefing. He said the project is under the Office of Education and Human Resources of the AID Mission, is a 5-year project, and may be extended another 5 years. We learned the following about support services for reef work: the Nusantara Diving Center, Malaylayang, Menado, North Sulawesi, is operated by Loky Herlambag, a professional diver, who is ecologically oriented and conservation-minded. He has three cottages for rent near his base of operation, which is near the university. Although faculty members repeatedly expressed interest in both mangroves and reefs, I had a strong feeling that the area is readily surpassed with respect to mangroves but superb with respect to reefs. Key people met with include Dr. P. E. A. Pangalila, Vice Rector; Ir. Lucky Sondakh, head of the research section, an agricultural economist; Dr. S. W. D. Sabroto, Dean of the Faculty of Fisheries, a veterinarian; Marthen Rondo, M.S., Faculty of Fisheries, interested in coral reefs; Dantji (Dan Sambell), faculty member, interested in entomology.

UNIVERSITY OF UDAYANA IN DENPASAR

This university has about 13,000 students. There are eight faculties: Letters, Medicine, Law, Economics, Agriculture, Animal Husbandry (including Veterinarian Medicine), Engineering, Education. There is no faculty for fisheries. There is a small Subcenter for Environmental Studies which is mostly interested in human ecology and law. Members from such faculties as Law, Letters, Medicine, and Animal Husbandry participate. University workers have done some work hatching and rearing marine turtles.

A representative from the World Wildlife Fund, with offices with the Director General of Conservation (of Indonesia), met with us and discussed their reef conservation efforts and also mentioned that the directorate has a school--primarily to train workers, I assume. At the local office of the Indonesian Division of Fisheries it was learned that this had been the headquarters of the recently completed Joint Eastern Tropical Indian Ocean Survey (participating groups were the Food and Agriculture Organization, Indonesia, West Germany, and Australia).

After my lecture the head of the Subcenter for Environmental Studies introduced the idea of having a short course as an orientation to marine resources so that diverse faculty members could get a better idea of the scope of interests and opportunities.

Key people met with were Dr. Sutewan, Vice Rector, an agricultural economist interested in irrigation; Putra Sastrawan, Fakultas Peternakan, in charge of the subcenter on the environment and interested in terrestrial ecology and specifically the giant lizard; Graham F. Usher, World Wildlife Fund, P.O. Box 133, Jl, Juanda 9,

Bogor, Indonesia; and Ir. A. A. S. Pt. Karteni, M. App. Sci., Department of Food Technology.

UNIVERSITY OF BRAWIJAYA IN MALANG

This university has about 10,000 students. There is a Department of Fisheries now in the Faculty of Animal Husbandry but slated to become a separate faculty soon. Programs under fisheries include aquaculture, fishing techniques, fishing technology (apparently food technology), socioeconomics, and hydrobiology. They plan a fisheries field station near Probolingo, about 2 hours away.

As a U.S.-Indonesian marine science exchange activity, they said they would be most interested in graduate training. The Dean Designate repeatedly stressed the need for textbooks for her classes.

Key people met with included Koentjoko, D.V.M., Dean, Faculty of Animal Husbandry; Iman Soestrini, Head, Environmental Studies Centre and formerly Dean of Animal Husbandry; L. Sutini, selected to be Dean of the Faculty of Fisheries when formed, interested in marine algae; Murachman and D. Syamsudin, faculty members in fisheries interested in reefs; and M. Rasyid Fadholi.

GADJAH MADA UNIVERSITY IN YOGYAKARTA

This is a very large university with about 22,000 students and many different faculties. There are seven departments in the agriculture complex, and fisheries is one of them. There are nine faculty members in fisheries, with five now away studying. About 45 students are in the upper S1 level in fisheries. In the agriculture complex the M.S. is offered with courses; the Ph.D. is offered on more of an apprenticeship basis. Fisheries has a brackish-water research station in Kalimantan, plans to have a freshwater station nearby, and would like to have a station on the south coast.

Other units noted include the Center for Environmental Studies; a central laboratory for sophisticated scientific instrumentation; and an oceanography laboratory (apparently this is a facility for the Civil Engineering Department but I was unable to find out what is done there); and the Faculty of Geography which has the following divisions:

Human	--Hydrology
	--Geomorphology
Physical	--Oceanography
Techniques	

The Satellite Center, which uses the Difix Computer System, comes under this heading. The Dean of the Faculty of Geography, was very

interested in the multiple aspect of marine resources and seemed to want to start a cross-campus program to encompass this.

In spite of the major role of the university, perhaps next to IPB in prestige in the country, it did not come across as a potential leader in the marine area unless, as could well happen, this should unfold through leadership outside of fisheries, for example, in geography. Somehow I felt there was more to the university than I was able to see. My visit was hindered by a lack of preplanning by university officials and the holiday which fell on Friday morning of the second day of my visit.

Key people met with included Joedoro Soedarsano, Dean, Faculty of Agriculture, a soil microbiologist; Dr. Ir. Bambang Soebiontoro, Secretary for Fisheries, an aquaculturist; Surastopo Hadisumarno, Dean, Faculty of Geography, a geomorphologist; and S. D. Supardio.

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