WORKSHOP ON THE DEVELOPMENT, MANAGEMENT, AND UTILIZATION OF INDONESIAN MARINE RESOURCES

Summary Report

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WORKSHOP ON THE DEVELOPMENT, MANAGEMENT, AND UTILIZATION OF INDONESIAN MARINE RESOURCES

Summary Report

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June 23-26, 1987

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PREFACE

In 1986 the National Research Council of Indonesia (DRN) invited the Board on Science and Technology for International Development (BOSTID) to join it in sponsoring a workshop on the development, management, and utilization of Indonesian marine resources. As a first step a small steering committee representing both the United States and Indonesia met in Jakarta, November 18-19, 1986 to draft an agenda for the workshop and to determine the appropriate U.S. and Indonesian participation, presentations, and background materials.

The workshop summarized in this report was held in Jakarta, June 23-26, 1987. It was designed to facilitate the exchange of information and experience pertinent to developing, managing, and utilizing Indonesian marine resources; to identify short- and long-term commercial products to serve as nonpetroleum exports or import substitutes; and to develop a plan of action in three areas: oceanography, living resources, and mineral resources. Natural resources--both renewable and nonrenewable--can be recovered from Indonesia's vast expanse of seas (62 percent of its territory) and used to increase the prosperity of the Indonesian people. Particular attention was given in this workshop to the industrial potential of these underutilized marine resources. These resources range from the information needed to predict climatic change and basic ocean productivity in Indonesia, to increased harvests of such commodities as tuna and shrimp, to the gold and other valuable minerals that could be recovered from offshore deposits.

In preparation for these discussions a background paper was prepared by Dr. Dirk Frankenberg, director of the Marine Sciences Program at the University of North Carolina at Chapel Hill and chairman of the U.S. National Research Council (NRC) panel (Appendix A). This paper was circulated to all members of both the U.S. and Indonesian panels.

These activities were one activity in a larger program of cooperation between BOSTID and the Indonesian government. Begun in 1968, this program has featured a series of workshops on food policy, industrial and technological research, natural resources, rural productivity, manpower planning, marine algae biotechnology, role of biotechnology in agricultural development, steroid compounds as contraceptives and drugs, and development of a science and technology information system. 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 current

two-year program with BOSTID calls for a number of activities (panel discussions, workshops, follow-up activities, or small advisory groups) to be organized each year.

ORGANIZATION OF THE WORKSHOP

The organizing committee for this workshop was chaired by Dr. Kasijan Romimohtarto, head of the Center for Oceanological Research and Development, Indonesian Institute of Sciences. His welcoming remarks, which were made at the workshop's opening session on June 23, are found in Appendix B.

Dr. Didin S. Sastrapradja, chairman of the workshop steering committee, and vice-chairman of the Indonesian Institute of Sciences and assistant (II) to the Minister of State for Research and Technology, then formally convened the workshop in plenary session (Appendix C), following remarks by Dr. Dirk Frankenberg. The Honorable Paul Wolfowitz, U.S. ambassador to Indonesia, commented on the importance of marine resources to any country with an ocean boundary, and to Indonesia in particular (Appendix D).

In his keynote address at the opening session, Minister of State for Population and the Environment Emil Salim stressed that although the role of marine resources is of strategic importance to Indonesia, use of these resources must be based on the concept of sustainability (Appendix E). He urged that recommendations produced by the workshop focus on program priorities, research and development needs, and manpower development.

Part I of this report summarizes the conclusions and recommendations that emerged during the four-day workshop. Papers prepared for the workshop are found in Part II. During the workshop, participants broke into three working groups, which addressed (1) oceanography as a key to environment and resource prediction, (2) living resources, and (3) mineral resources. The reports of these working groups are included in Part III of this report. Following the working group sessions, a special plenary session was convened to concentrate on management issues that emerged during these sessions.

On June 26 the conclusions of the three working groups were presented by the chairman of each group. The workshop was then officially closed by Dr. Sastrapradja. The workshop agenda and a list of participants are included as Appendixes F and G of this report, respectively.

This workshop report was prepared by Rose Bannigan of the BOSTID staff using papers written by the Indonesian and NRC workshop participants. The papers, edited to eliminate duplication, accurately reflect the discussions. The final draft was reviewed and approved by the members of the NRC panel and the Indonesian organizing and steering committees. Sabra Bissette Ledent, BOSTID consultant, edited the report.

Participants would like to acknowledge the valuable contributions of the workshop's organizing committee and its chairman, Dr. Kasijan Romimohtarto, to the final arrangements for the workshop. They would also like to thank the members of the workshop secretariat for the excellent organization of the workshop. The secretariat was under the supervision of Dr. Kasim Moosa.

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PART I

Executive Summary

EXECUTIVE SUMMARY

Indonesia is an archipelagic country composed of more than 13,000 islands, with a land area of about 1.9 million km^2. The ocean area controlled by Indonesia as a result of the extended jurisdiction provided by the Law of the Sea Convention is over 3.1 million km^2, or 62 percent of Indonesia's total area. Marine resources are a major contributor to the nation's development. Indeed, offshore deposits of petroleum hydrocarbons and tin have already made such a contribution. Other marine resources such as fisheries and sand and gravel aggregates provide small export earnings as well as local food and building materials.

The full potential of Indonesian marine resources is not yet known. Thus, this workshop was designed to assess how much is presently known about marine resources, identify those with the greatest potential for development, point out constraints that might limit their development, and recommend actions that might overcome these constraints.

The level of knowledge of Indonesia's seas differs greatly among fields. The enormous biological diversity and productivity of these seas has supported both scientific study and fisheries for more than 300 years. Consequently, the biological resources are best known. Exploitation of offshore petroleum and tin resources, as well as recent academic interest generated by recognition that Indonesia's geological setting was created by the interaction of six lithospheric plates, has resulted in a growing national and international emphasis on Indonesian geology. Knowledge about the physical and chemical characteristics of Indonesia's seas has lagged behind biology and geology, however.

In the late 1950s, Klaus Wyrtki conducted pioneering studies that demonstrated the reversing seasonal flows of surface currents associated with monsoonal winds, the strong density discontinuity across a permanent thermocline at a depth of 100-300 m, and a complex pattern of deeper water mass distribution apparently originating from different areas of the southwestern Pacific Ocean. This general picture has been filled in since Wyrtki's studies, but it has not changed greatly.

The two days of discussions by the three working groups--oceanography, living resources, and mineral resources--resulted in summaries of present knowledge about Indonesia's seas as well as

conclusions and recommendations about the potential of specific resources. Two kinds of conclusions and recommendations were produced by the working groups: (1) general conclusions and recommendations with which all the working groups concurred, and (2) resource-specific conclusions and recommendations that differed for various commodities.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

All three working groups concluded that Indonesia's Exclusive Economic Zone (EEZ) contains resources that could be developed to the benefit of Indonesia and its people. These resources range from the information needed to predict climatic change and basic ocean productivity in Indonesia, to increased harvests of such commodities as tuna and shrimp, to the gold and other valuable minerals that could be recovered from offshore deposits.

In all cases the groups pointed to the lack of knowledge about Indonesia's ocean phenomena as a constraint to realizing the potential of these resources. It was thus recommended that ocean research continue to be expanded both within Indonesia and through cooperative projects with Indonesian scientists and those of other nations. The working groups also agreed that manpower development programs should continue to be emphasized. The living resources group, however, felt that this should occur more at the high school and technical levels, while the mineral resources and oceanography groups felt the focus should be at the college and postgraduate levels. All groups agreed that Indonesian scientists should continue to be sent abroad for advanced training. This was particularly recommended for those undertaking physical and chemical oceanographic studies.

SPECIFIC CONCLUSIONS AND RECOMMENDATIONS

Working Group on Oceanography

The oceanography working group concluded that knowledge of the physical and chemical aspects of Indonesia's seas would be of significant economic value, especially to agriculture, fisheries, and tourism. This value would be realized by developing the ability to predict climatic change (particularly droughts) and the photosynthetic production rates that support marine fishery food chains. These goals can be achieved by

- Obtaining full Indonesian collaboration in international scientific efforts relevant to Indonesia's seas.
- Monitoring features of Indonesia's seas that are relevant to climate and its prediction.

- o Conducting research on the physical basis for photosynthetic production.
- o Studying the physical and chemical processes involved in the dispersion of waste materials in nearshore areas.

The plan of action for achieving these objectives was developed in terms of Repelitas IV and V (Indonesia's five-year national development plans). For the remainder of Repelita IV (1984-1989) the group recommended full Indonesian participation in the Indonesian Seas Throughflow Experiment (INSTEP) and development of a plan for experimental study of the physical basis for photosynthetic production in Indonesia's eastern seas. The group also recommended that five activities be undertaken during Repelita V:

1. Monitoring the flow between the Pacific and Indian oceans through Indonesia.
2. Monitoring the heat content and thermocline depth in Indonesia's seas.
3. Monitoring the sea surface temperature of Indonesia's seas through satellite technology to be developed by the National Aeronautics and Space Institute (LAPAN).
4. Monitoring pollution levels and dispersion patterns in selected coastal regions.
5. Developing a capability within the staffs and facilities of at least one Indonesian oceanographic center for modeling mathematically physical oceanographic features.

The working group identified three key features of this plan of action:

1. Indonesian scientists should be sent abroad for doctorate-level study of physical and chemical oceanography.
2. An infrastructure of technically skilled electronic technicians and data processors must be developed to support the effort.
3. Collaboration between government research institutes and academic institutions in operational field programs and modeling efforts must be enhanced.

Working Group on Living Resources

After reviewing the potential resources found in Indonesia's seas, the living resources working group concluded that five commodity groups rate further development: shrimp, tuna, unexploited species (squid, deepwater shrimp, small pelagic fish, and deepwater sharks), species that are currently cultured (shrimp, grouper, bass, snapper, oysters, sea cucumbers, and algae), and coastal living resources. A number of constraints may limit, however, larger harvests for each of these groups. They include inadequate knowledge of harvestable stocks, insufficient manpower (particularly at the technical level), and

commodity-specific problems such as legal and licensing barriers to shrimp fishing, the limited availability of bait fish for tuna fishing, the limited ability to identify the fishing techniques needed for unexploited species, the high food costs and limited availability of young for culture fisheries, and the current overexploitation of many coastal fisheries.

Because the steps needed to overcome these constraints are also largely commodity specific, the working group recommended that task forces be formed for each commodity requiring development or management. These task forces should include representatives of government research and regulatory agencies, universities, and both the foreign and domestic fishing industries. Regional subgroups may be needed for some commodities. All task forces should be responsible for developing management plans that include annual catch targets, which could be adjusted each year to assure sustainable levels of harvest. This task force approach should be adopted quickly for coastal resources because they appear to be overexploited in many areas of Indonesia. Thus, this working group recommended development of a coastal resources management plan for Indonesia.

This working group also recommended increased research on living marine resources. This research should address identification of resources and their potential for exploitation, fishing technology, and the socioeconomic aspects of fisheries and mariculture. Development of the needed fisheries research is hampered by lack of funds and personnel as well as by the low level of education and training of existing fisheries personnel.

Working Group on Mineral Resources

This working group reviewed all minerals that might occur in economically exploitable concentrations within Indonesia's EEZ. Petroleum and currently exploited tin resources were not included because these commodities are administered by specialized agencies of the Indonesian government. The mineral resources of the Indonesian EEZ were then grouped into five mineral families:

1. Placers (tin, gold, diamonds, chromite sands, etc.)
2. Aggregates (sand and gravel, shell, etc.)
3. Industrial minerals (clay, bentonite, glass sands, barite, etc.)
4. Hydrogenetic minerals (cobalt-rich crusts, phosphorites, manganese nodules, etc.)
5. Hydrothermal muds (polymetallic sulfides containing copper, zinc, silver, gold, and platinum).

These mineral families were analyzed in terms of their occurrence, the likelihood of commercially significant concentrations, the availability of mining technology, the existence of processing technology, the existence of a handling and distribution infrastructure, the location

and size of markets, and the likelihood that recovery operations would have an adverse environmental impact. The working group then assigned priority to certain minerals for development, taking into account the constraints likely encountered. Highest priority was given to tin recovery through delineation of the Indonesian tin belt south and east of currently exploited areas. Gold recovery from offshore placer deposits was given second priority, and sand and gravel exploitation, particularly near Singapore where a market exists, was found to be of third priority. Finally, fourth priority was accorded to the glass sands used by industry both in Indonesia and abroad.

The major constraint to developing these high-priority minerals as well as others is the low quality of knowledge about the distribution and extent of the mineral bodies containing these resources. This group thus recommended support of a focused program of research on the marine geology and geophysics of Indonesia's seas. This program should be continued and accelerated during Repelita IV by training scientists and technicians in the methodology of modern mineral body delineation so that actual at-sea research on minerals can be conducted in the early 1990s.

PART II

Overview

PART II

Overview

THE LAW OF THE SEA CONVENTION AND INDONESIAN RESPONSES

Hasjim Djalal
Head, Agency for Research and Development
and
Boer Mauna
Head, Center for Political Action
Department of Foreign Affairs

THE LAW OF THE SEA CONVENTION

For Indonesia the Law of the Sea Convention (LOSC) recognizes the following:

- Archipelagic Waters. Indonesia's sovereignty over its water column, air space, seabed, and subsoil, and all the resources contained therein, is recognized. The archipelagic waters include the seas between the Indonesian islands drawn in accordance with the provisions of the Convention. This is the most important achievement of Indonesia's struggle with the Law of the Sea since 1957.

- Territorial Seas. Indonesia also exercises territorial sovereignty over a 12-mile space drawn around the archipelago or archipelagic waters as well as its resources.

- Contiguous Zone. Indonesia can exercise control over customs, financial, immigration, and sanitary matters of a 12-mile zone drawn around the territorial seas of 12 miles. The contiguous zone could also be drawn 24 miles from the baselines from which the territorial seas are measured.

- Exclusive Economic Zone (EEZ). This zone extends 200 miles from the baselines from which the territorial seas are measured. In this zone Indonesia exercises sovereign rights over all the natural resources contained therein, and has jurisdiction over installations, artificial islands and structures, regulation of marine scientific research, and protection and conservation of the marine environment, in accordance with the provisions of the LOSC.

- Continental Shelf. This area extends 200 miles from the baselines or to the outer edge of the country's continental margin. The continental margin can extend either to 350 miles from the baselines or to 100 miles beyond the 2,500-m isobath. The continental margin is considered to be the limit

of the natural prolongation of the land territory of the coastal states. This prolongation is determined by a concept based on the thickness of sedimentation in relation to a certain distance from the coastline. Within the continental shelf Indonesia exercises sovereign rights over the natural resources. Exploitation of natural resources beyond 200 miles from the baselines is subject to revenue sharing.

Based on the above, Indonesia's marine resources base far exceeds its land resources base. Prior to recognition of the archipelagic state and other concepts by the LOSC, Indonesia's land-based resources covered an area of about 1.9 million km^2. Under the 1982 Law of the Sea Convention, however, Indonesia's resource base covers an area of about 8 million km^2.

This tremendous expansion of Indonesia's marine resources base is accompanied by certain obligations, however:

- In its archipelagic waters Indonesia must recognize the traditional fishing rights as well as the other legitimate interests and activities of its most immediate neighboring states. This recognition must be negotiated and regulated in bilateral agreements with these neighbors. Such an agreement is now in effect between Indonesia and Malaysia, but further negotiations are still to be undertaken, particularly with Singapore, another neighboring state.

- In the EEZ Indonesia must allow other countries, especially the land-locked and geographically disadvantaged states, access to surpluses of its living resources. Indonesia has yet to determine the maximum allowable catch of these resources, to determine its capacity to harvest, and to allow others access to surpluses. This could be undertaken through a specific agreement or agreements. Determination of the allowable catch will be based on scientific findings that are still not available. Indonesia has not yet assessed the nature, quality, and quantity of the living resources in its EEZ.

- Within the continental shelf Indonesia has an obligation to contribute to an international authority a percentage, as defined in the Convention, of the yield of the resources recovered from the continental shelf beyond 200 miles of the baselines. Indonesia has not yet determined, however, the outer limits of its continental shelf beyond 200 miles, based on the provisions of the LOSC.

INDONESIA'S RESPONSES

Indonesia is pleased with the results of the LOSC of 1982, and it has therefore ratified the Convention and deposited its instruments of ratification with the Secretary-General of the United Nations. Thus far 32 countries have ratified the Convention. Because the LOSC of 1982 will become effective ons year after the sixtieth ratification, Indonesia is trying to persuade other countries to ratify the Convention so that it can take effect promptly.

Indonesia, in cooperation with other developing and signatory states, is also working to advance the work of the Preparatory Commission aimed at establishing the International Authority and the International Law of the Sea Tribunal. It is hoped that these institutions will begin their work the moment the Convention takes effect, thereby assuring the viability of the LOSC regime. Implementation of the International Authority is important for Indonesia's resource management because it will regulate the exploitation of resources in the international seabed area. Some of these resources are also land based, particularly nickel and copper. The regulated and well-managed resources of the international seabed area will have a definite impact on the development and management of Indonesia's land-based mineral resources.

IMPLEMENTATION STAGE

Domestically, a great deal must be done by Indonesia to implement the LOSC. The Agency for Research and Development of the Department of Foreign Affairs has enumerated about 50 follow-up actions that Indonesia must undertake to implement the LOSC. These actions are described in the following sections.

Boundary Fixing

Indonesia must amend its legislation on baselines to conform to the provisions of the LOSC. Indonesia's baselines, as stipulated in Law No. 4, 1960, must be reexamined and adjusted to the provisions of the LOSC. A special committee has been studying this matter for some time, but the results will depend on further surveys and scientific investigations. The charts as well as the coordinates will be deposited with the U.N. Secretariat.

Indonesia will also have to redefine the regime of passage and navigation through the archipelagic waters and relevant territorial seas. For this purpose archipelagic sea lanes must be designated. Moreover, the waters inside the archipelagic waters must be defined to determine where the regime of innocent passage will not apply. The LOSC recognizes the right of innocent passage through archipelagic waters (but not through the waters within the archipelagic waters) and recognizes the regime of archipelagic sea lanes passage. A committee

has been addressing this matter for a number of years and much has been achieved. In light of the new Convention the activities of this committee should be revived.

Once the baselines of the archipelagic waters have been redefined or reaffirmed, the outer limit of the territorial sea will be readjusted accordingly. This is relatively simple, but problems will arise in delimiting the boundary of Indonesia's territorial sea in areas where it may overlap with the territorial sea of neighboring countries. These boundaries will have to be negotiated with these states. So far, agreements have been reached with Malaysia and Singapore.

Once the archipelagic baselines have been redefined or reaffirmed, the outer limit of Indonesia's contiguous zone will also have to be defined. Indonesia has not enacted legislation on this outer limit. If and when it does so the delimitation of its boundaries with neighboring countries in areas where they may overlap will also have to be negotiated. Indonesia has thus far taken no steps in this direction.

Equally, Indonesia must determine the outer limits of its EEZ once the baselines of the archipelagic waters have been redefined and clarified. Again, problems will arise in delimiting the boundaries of Indonesia's EEZ where it may overlap with these of its neighbors. No agreement on the delimitation of the EEZ has been concluded between Indonesia and its neighbors, although they have already enacted their respective legislation dealing with this.

The EEZ boundaries may or may not coincide with the continental shelf boundaries because the two concepts (EEZ and continental shelf) differ totally. Delimitation of the EEZ applies basically to the water column and its resources; it is not affected by the topography or geomorphology of the seabed. Delimitation of the continental shelf, on the other hand, applies basically to the seabed area and its subsoil. Thus, it depends upon the natural prolongation of the land territory. The seabed geology and geomorphology, as well as topography, are important in determining the outer limit of the legal continental shelf, which can extend far beyond the 200-mile limit of the EEZ. A great deal of work has to be undertaken in this area.

A committee has been established to deal with the boundary negotiations of the continental shelf, but there is no committee dealing with boundary negotiations in the EEZ. The outer limit of Indonesia's continental shelf to the open ocean has also not been studied properly. It is conceivable that the committee on the continental shelf could be entrusted to study the delimitation of the EEZ as well, provided that the EEZ elements within this zone, primarily fisheries, are included.

Delimitation of the outer limits of Indonesia's shelf requires:

- Further negotiations with the relevant neighboring countries to complete the delimitation of the boundaries, which thus far has been determined by agreement. This work is essential in

view of the expanding exploration and development of marine resources from the continental shelf, which are primarily, but not exclusively, oil and gas.

- Determination of the outer limit of Indonesia's continental margin where Indonesia does not immediately face other countries, especially in the Indian Ocean. This determination must conform with the provisions of the LOSC, particularly Article 76, and it is essential for the development and management of Indonesia's resources in view of the discovery of some manganese nodules and sulfide within the limits of national jurisdiction, especially in the eastern Pacific. It is not known whether these resources also exist on the outer edge of Indonesia's continental margin in the Indian and Pacific oceans.

Since Indonesia's legislation dealing with the EEZ and the continental shelf was enacted prior to ratification of the LOSC by Indonesia, the provisions of this legislation will have to be restudied and adjusted to conform with the provisions of the LOSC. Accordingly, development programs for the management and utilization of marine resources recovered from the EEZ and continental shelf will have to take into account the provisions of the LOSC of 1982.

Development of Resources

Abundant marine resources are found in the waters over which Indonesia has sovereignty, sovereign rights, or jurisdiction.

Living Resources

Some Indonesian waters are populated by species similar to those found in the South China Sea. Large-scale fishing industries may thus be difficult to develop. Some resources--such as those found in the Strait of Malacca, Java Sea, and Flores Sea--are mainly harvested by local fishermen. Here their protection is perhaps more important than developing large-scale fishing industries. Areas that are largely populated by one species, such as the Banda and Molucca seas, could support large-scale fishing industries such as tuna.

It is estimated that less than 2 percent of Indonesia's fishery resources in the EEZ has been exploited. Further exploitation will require research and surveys as well as development and management efforts.

The master plan for the development of fisheries is devised and implemented by the Office of the Directorate-General of Fisheries. Given this central planning, the input of the local and provincial

governments and of the private sector are channeled through the Directorate-General of Fisheries. It is not clear, however, how the exploitation of fishery resources is coordinated with other uses of marine space such as mining, navigation, and environmental protection, and how the benefits of the resources are used by the central and local governments.

Nonliving Resources

Two of Indonesia's most important nonliving marine resources are oil and gas, which constitute an important portion of its overall oil and gas production. Although these resources account for less of Indonesia's gross national product than previously, they are nevertheless very important to the national economy.

Exploitation of these marine resources is still limited to the relatively shallow waters of Indonesia's archipelago and continental shelf. They will remain important to Indonesia's economy in the future, however, leading to exploration of the deeper waters. Determination of the outer limits of Indonesia's continental margin will therefore become more important in the near future.

Other nonliving resources present in Indonesia's waters, particularly the various hard minerals, have not been properly and sufficiently investigated.

Management of mineral resources is handled by the Department of Mining, and especially by the directorate-generals of oil and gas and of general mining. Coordination of the exploitation of offshore oil and gas resources is highly developed, although this should be further improved.

Other Resources

With recognition of the archipelagic state concept, Indonesia's air space has also expanded over the archipelagic waters. Although the right of overflight in the air space above the sea lanes is recognized, this right is not recognizes above the archipelagic waters as a whole. Use of this air space is important for international aviation and could be advantageous to Indonesia's development. This has been taken into account in various agreements negotiated or concluded by Indonesia's Directorate-General for Air Communications.

Other resources within Indonesia's marine areas—such as the production of energy from the water, currents, and winds—have not been properly explored or exploited. Some studies have been made, however, on how to produce energy from the temperature differentials that exist between the surface water and the water at lower depths.

National Planning

The Indonesian government is now promoting the export of non-oil and gas products, and the president of Indonesia has indicated that the country's large marine area and its resources should be explored to support this promotion.

The development and exploitation of marine resources could also benefit the population, primarily by increasing its intake of protein through the increased consumption of fishery resources. Increased consumption would benefit local fishermen as well.

Per capita fish consumption in Indonesia is still the lowest among the peoples of Asia (it is only about one-fourth that of Hong Kong, for example). Although cultural or traditional patterns of food intake will influence fish consumption, an increase is still possible. People will have to be encouraged to consume more fish and will have to be educated about its benefits for their health and welfare. Specific programs should be developed in this direction.

The development, management, and utilization of marine resources, especially living resources, must take into account the national, regional, and international situations. The exploitation of marine resources in Indonesia may affect or be affected by the exploration and exploitation of marine resources by neighboring countries or regions.

Management of the Marine Environment

A polluted marine environment may harm marine resources, especially living ones. For this reason a policy addressing protection of the marine environment must be closely coordinated with a policy on the exploration and exploitation of marine resources.

The development and management of marine resources must also be coordinated with other legitimate uses of the sea such as scientific, recreational, and defense. This calls for an integrative approach—a sectoral approach would not be effective.

Marine Scientific Research

The development and management of the marine environment must be supported by scientific findings. Marine scientific research is essential to determine the natural phenomena of the sea, and to act as a basis for further surveys and exploration. This research should be coordinated with and geared to support the national master plan for the development, management, and utilization of marine resources.

It should be cautioned, however, that marine scientific research is closely linked to security matters, especially those dealing with topography, hydrography, oceanography, oceanology, underwater feasibility, salinity, etc. Specific knowledge of these fields is important for navigation and defense purposes, as well as for resource exploitation. Proper coordination will be needed so that scientific research undertaken in one area is not detrimental to other areas.

Regional and International Cooperation

The development of living marine resources, especially the highly migratory species such as tuna, requires cooperation with neighboring countries or regions. The exploitation of shared stocks that are found in two or more neighboring countries requires similar cooperation. For example, the countries of the South Pacific Forum have developed a successful form of regional cooperation in managing their living resources--the Forum Fisheries Agency (FFA). Indonesia's tuna resources are known to migrate through some Pacific island countries, especially Papua New Guinea and the Philippines. To understand the migratory patterns of such species research and development programs such as tagging should be conducted jointly with the relevant countries or regions.

Indonesia and some neighboring countries, especially in the South Pacific, have gained enormous marine resources as a result of the Law of the Sea Convention. Particularly for the South Pacific countries, fishery resources have become the major, and perhaps the only, alternative for sustaining economic development. Yet exploitation of these resources depends to a large extent on export markets--especially in Japan, the United States, and other distant fishing nations--and will require large-scale foreign investments. Because Indonesia may compete with its neighbors in seeking investments and markets, it is essential that it coordinate its efforts to exploit its living marine resources with them, thereby avoiding as much as possible competition in attracting foreign investors or in seeking foreign markets in the industrial countries.

Institutional Problems

Since 1957 Indonesia has been struggling to achieve a number of objectives in relation to the Law of the Sea Convention, especially (1) the promotion of national unity given its archipelagic, multiethnic situation, (2) political stability given its various political trends, and (3) economic development given its varied resource base. Over the past 30 years Indonesia has developed the concept of the archipelagic state, and within the last several years it has also supported other concepts that would strengthen its objectives.

The first stage of the struggle for the Law of the Sea occurred during the first decade of Indonesia's independence, and it was basically internal in nature. During this period, Indonesia paid a great deal of attention to developing and instilling the notion of archipelagic unity in the country. It declared the archipelagic principle in 1957, enacted archipelagic legislation in 1960, passed regulations on archipelagic navigation in 1962, and regarded all of Indonesia's maritime areas as a single maritime unit for law enforcement purposes in 1963. Yet in view of the strong international

opposition to the archipelagic concept, Indonesia has been extremely cautious in promoting this concept in the international forums. Management of Indonesia's thinking on the Law of the Sea was largely handled by the Maritime Council (Dewan maritim) under the chairmanship of Prime Minister Djuanda. Its legal aspects were handled by its legal committee under the chairmanship of the Naval Chief of Staff, Admiral Martadinata. This institutional arrangement was upset, however, after the abortive communist coup in 1965 when the Maritime Council was abrogated, perhaps accidentally.

When international efforts were made to solve many LOSC issues--particularly navigation, exploitation of resources on the continental shelf, fisheries jurisdiction, and environmental pollution arising from the birth of super tankers--various committees came into being in Indonesia. In the late 1960s the Continental Shelf Committee was established in the Department of Mining, the Fishery Committee in the Department of Agriculture and Fisheries, the Strait of Malacca Committee in the Department of Communications, and the LOSC Committee in the Department of Foreign Affairs, among others. By 1971, when Indonesia was attempting to promote its interest in the LOSC Conference, scheduled for 1973, intensified coordination among the activities of the various committees was strongly needed. The Coordinating Committee for the National Territory (Panitia Koordinasi Wilayah Nasional) was established in 1971 by Presidential Decision No. 36. During the second stage of Indonesia's struggle for the Law of the Sea (encompassing most of the second and third decades of independence), this committee played an important and successful role in advancing Indonesia's interests. It was able to coordinate effectively the various activities of the many committees in the many departments.

With the adoption of the LOSC in 1982, Indonesia entered the third stage of its struggle for the Law of the Sea. With its very large maritime base for its natural resources, Indonesia is now in a position to claim the full status of a maritime power. It is also in a position to enter the implementation stage vigorously and with full confidence. Since 1982, many countries have begun to devise new institutional mechanisms for implementing the new convention. An institution with executive power, rather than a coordinating agency, is felt to be more suitable for implementing the complex and vast spectrum of Convention issues comprehensively and in an integrative manner. Some countries such as India immediately established a department for ocean development, which not only coordinates the implementation activities but also implements them itself. Other countries such as Canada expanded their existing department to handle activities related to the implementation of other LOSC provisions as well.

Although it may prove useful to establish an independent executing agency or department to carry out a well-thought out implementation program for the LOSC, there is no harm in continuing to rely on the Coordinating Committee for the National Territory for some time to

come, provided that this committee is given the proper attention it deserves and is managed on a full-time basis by sufficiently senior officials. This will enable it to concentrate on the many implementation problems and issues and to interest the various departments in the implementation activities. This committee must also be provided with the manpower, materials, funds, and expertise needed to deal with the implementation stages of Indonesia's Law of the Sea objectives.

U.S. MANAGEMENT OF MARINE AND COASTAL RESOURCES

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INTRODUCTION AND BACKGROUND

This paper focuses on the U.S. experience in managing marine and coastal resources since the late 1960s. This is not an arbitrary time frame; most of the major U.S. marine and coastal resources management legislation and programs were enacted or established during this period, and this aspect of the U.S. experience should not be overlooked. Although the United States may have a more fully developed marine resources management regime than other countries, the U.S. management experience is of recent vintage and serious marine resources management problems remain unsolved.

Three sectors of the U.S. management regime are dealt with here: fisheries, offshore oil and gas, and offshore minerals. One important and controversial use of the oceans—as a "sink" for dumping and incinerating waste materials—is also mentioned.

The management regimes for fisheries and for offshore oil and gas are well developed in the United States. The regime for offshore minerals exists in rudimentary form, which is perhaps to be expected given the somewhat distant prospects for offshore minerals development. The dumping of toxic materials is prohibited by U.S. law, while at-sea incineration remains controversial and unavailable in the United States as a means of disposing of large quantities of liquid wastes. The dumping of solid wastes at designated ocean sites continues, but this too is controversial. The proposal several years ago that decommissioned nuclear submarines be sunk in ocean areas near the west coast of the United States provoked serious opposition, and the proposal was eventually dropped.

U.S. FEDERALIST SYSTEM OF GOVERNMENT

To understand the U.S. approach to management of its marine and coastal resources, it is necessary to understand generally how the U.S. legal system works. The United States has a federalist system of government, which means that both the federal and state governments are sovereign powers that have separate political, legal, and administrative jurisdictions. One extraordinary feature of the U.S.

marine resources management regime is that it often involves serious issues of constitutional law and interpretation. For example, because conflicts have emerged between the states and the federal government over the management of offshore fisheries and hydrocarbon resources, questions continually arise over whether federal law should take precedence over state and local laws (involving the supremacy clause of the U.S. Constitution) and whether federal agencies must adhere to state and local requirements in carrying out activities that affect state and local interests (that is, whether the federal government should "waive" its sovereign immunity from the authority of state and local governments). There are no clear guidelines for answering many of these questions, and the answers provided by the Congress and the federal courts have alternately favored the states and then the federal government.

The Reagan administration has put forth the not-so-new doctrine of "New Federalism" which calls for limits on the exercise of federal authority and promotes the interests of state and local governments. But this doctrine has not been applied consistently. In fisheries management the administration has supported the system of shared federal-state authority that was established by the Congress in the mid-1970s. In the area of offshore oil and gas development, however, the administration has sought to reduce state and local control over these resources, granted to them in the late 1970s, and to reassert federal authority.

The cyclical nature of U.S. politics must also be acknowledged to understand the U.S. marine resources management experience. The political history of the United States abounds with periods of intensive federal government action (increased legislative activity, more laws, expanding federal agencies, etc.), followed by periods of efforts to restrict or contain the growth of central government's power. Most of the current U.S. management programs for marine and coastal resources were established during a period of vast expansion of federal government activities. The current administration has opposed federal action, and, indeed, it has asserted that "the federal government itself is the problem." Its "new federalist" program is thus aimed at limiting or reducing the size of the federal establishment. In short, the U.S. marine resources management regime has developed in response to these political forces, and, for better or worse, has been shaped by them.

One particularly troublesome feature of the U.S. regime arises solely from the federalist system of government: the necessity to resolve intergovernmental conflicts and to find a means or mechanism that will enable separate jurisdictions to cooperate in the management of shared resources. This problem will be mentioned later in this paper.

SECTORAL APPROACH TO MARINE AND COASTAL RESOURCES MANAGEMENT

A striking characteristic of the U.S. regime is its sectoral nature. Each of the major ocean and coastal resources or uses (fisheries, oil and gas, minerals, coastal resources, ocean dumping, etc.) is managed separately, under different laws, by different agencies and bureaucracies, answering to different congressional committees and to different constituencies. The reason: the U.S. marine and coastal resources management regime developed in a piecemeal and ad hoc fashion. Efforts to "rationalize" this system meet with substantial resistance largely because of inertial bureaucratic forces.

The problems and issues associated with this sectoral management approach may be clustered around the following themes:

- Matching the management regime to the marine ecosystem rather than to the political system
- Resolving jurisdictional problems
- Coordinating among sectors.

Matching the Management Regime to the Marine Ecosystem

The disparities between the U.S. marine and coastal resources management regime and the underlying marine and coastal ecosystem are compared below:

Marine ecosystem	Management regime
Vastness	Prescribed zones of authority
Mobility	Single-resource management
Interdependence of resources and processes	Segmented programs

These disparities arise, of course, from political and legal reasons, or from the piecemeal development of the U.S. system. Nevertheless, as shown above, the mismatch between resources to be managed and the existing management system is pronounced.

Jurisdictional Problems

The jurisdictional problems that arise in the management of U.S. marine and coastal resources are presented below for the coastal zone (shorelands and territorial sea), the outer continental shelf (OCS)/fishery conservation zone (FCZ)/Exclusive Economic Zone (EEZ), and the high seas/deep seabed.

Coastal zone		OCS/FCZ/EEZ	High seas/deep seabed
Shorelands	Territorial sea	3-200 miles	>200 miles
	J U R I S D I C T I O N		
Local	State	Federal	Federal
State	Federal	State	
Federal	Local	Local	

The hierarchy of authority differs according to the resource management zone. Between the shorelands of the coastal zone and the territorial sea there is a marked change in authority, not easily understood if one only considers the nature of the resources to be managed. But regardless of how persuasive the political and legal reasons are for this division of authority, both the necessity and the difficulty of cooperation between different jursidictions in managing marine and coastal resources should be apparent.

Coordination Among Sectors

Not only is each sector of the U.S. system governed by different authorities; each sector also has policies and goals that differ substantially from those of other sectors. Thus, the policy of maximizing oil and gas production from the OCS often runs counter to policies governing other sectors, such as the protection of coastal and living marine resources that may be threatened by such development.

It is true that many of the authorities governing the separate sectors contain coordinative mechanisms. For example, before an action can be taken that potentially affects a species listed as "endangered" under the Endangered Species Act, the federal authorities responsible for protecting that species must be consulted. Under this consultative scheme, oil and gas drilling and production activities in the Beaufort Sea have been modified or restricted because of their effects on the "endangered" humpback whales that visit this area.

But many conflicts have proved difficult if not impossible to resolve through consultation, and substantial litigation has resulted from such conflicts. Thus, federal judges have been the ultimate decision makers in the U.S. marine resources management system, however ill-equipped they may be to make such decisions. Typically, litigation in the United States is a costly, time-consuming, and often divisive means of settling disputes. The "winners versus losers" structure of the U.S. legal system is not suited to reaching complex resource management decisions that must balance diverse and competing interests. Rather, a system of bargaining and conciliation appears to be appropriate for marine resource management decision making.

U.S. EEZ Proclamation (March 1983)

Against this background of sectoral marine resource management, we may examine the proclamation by the President in March 1983 of the U.S. Exclusive Economic Zone, in which the United States asserted ownership of and sovereign rights over the resources of its 200-nautical mile offshore zone. This zone includes more than 2 million square nautical miles and exceeds the continental U.S. land area. Importantly, the zone has a uniform boundary which includes all marine resources (except tuna). The U.S. EEZ is therefore a common, multipurpose zone that presents a unique opportunity to devise a management structure governing all its uses and resources.

No specific EEZ legislation has been enacted since 1983, however, primarily because the current administration has taken the position that the separate marine and coastal resources management programs already in place are sufficient to manage EEZ resources.

Congress recently indicated its interest in examining whether these programs are suitable for exploring, surveying, and managing the development of EEZ resources. Bills have been introduced to establish a regime for managing EEZ hard minerals, and these bills incorporate major changes in the federal regulatory structure (permits rather than leases) and in the role of state and local governments in resource management decisions affecting their jurisdictions. Major changes have also been suggested for existing programs (such as the program to manage OCS oil and gas development) that address some of the sectoral and jurisdictional problems described earlier. Although the EEZ proclamation has not yet led to new marine and coastal resources management programs, it has sparked considerable debate about the problems of the current system and has generated some interesting management proposals.

U.S. MARINE AND COASTAL PROGRAMS

Fisheries: The Fishery Conservation and Management Act

The goals of the Fishery Conservation and Management Act are to assure a fair allocation and full domestic utilization of fishery resources, to maintain recreational fishing, and to protect fishery habitats as well as endangered species.

This act establishes a fishery conservation zone of 3-200 miles and regional fishery management councils, and sets forth requirements for fishery management plans and regulations. It also sets national fishery management standards and provides for the control of foreign fishing.

Passage of this act has resulted in the setting of fishery standards, the development of fishery management plans, the control of overfishing by foreign fishermen, and the encouragement of a high level of state and federal cooperation. Other results have been greater opportunities for domestic fishermen and recognition of the need for scientific information in fishery management.

Offshore Oil and Gas: The Outer Continental Shelf Lands Act

The Outer Continental Shelf Lands Act seeks to foster the "balanced" development of offshore energy resources and to minimize conflicts between energy development and fisheries. It is also designed to obtain a fair and equitable return on the sale of public resources and to encourage state and local participation in decisions.

This act authorizes leasing of the outer continental shelf, and it sets forth four stages of development: (1) development of a five-year leasing schedule, (2) lease sales, (3) exploration, and (4) development. State review of stages 3 and 4 are permitted under the Coastal Zone Management Act (see below). This act also provides for an environmental studies program.

The Outer Continental Shelf Lands Act increased the amount of acreage leased to industry, but it also created conflicts among the oil and gas, fishing, and tourism industries; between industry and environmentalists; and among the federal, state, and local governments. There is considerable congressional dissatisfaction with the OCS development program.

Coastal Resources: The Coastal Zone Management Act

The goals of the Coastal Zone Management Act are to preserve and protect important coastal resources that are at risk and to encourage state and local governments to use their "full authority" to protect such resources. This act requires the development of state coastal management plans, and it requires federal agencies and federal permittees to act consistently with state plans.

The Coastal Zone Management Act establishes a "coastal zone" (shorelands and territorial sea), and it provides states with the federal funds to develop coastal management plans. State plans must meet the minimum federal standards for approval. It also includes the federal consistency doctrine which states that both federal agency actions and federally permitted activities must be consistent with state coastal management policies. Under this act the states are given the lead in coastal management, and they have authority over the onshore effects of offshore development.

As a result of this act coastal management plans have been approved in 29 of 35 coastal states and territories. A wide range of state laws have been enacted to meet federal standards. These states are thus asserting a measure of control over coastal development. Conflicts have arisen, however, between states and federal agencies over application of the federal consistency doctrine.

Ocean Minerals: The Outer Continental Shelf Lands Act

The Outer Continental Shelf Lands Act requires balanced development of the mineral resources of the outer continental shelf and allows state and local governments to participate in decisions affecting such

development. Under this act leases to outer continental shelf areas are based upon terms set by the secretary of the interior.

The results of this act have been very limited thus far. Regulations to govern prelease prospecting for ocean minerals are being developed, but there is widespread dissatisfaction among the coastal states, industry, and environmentalists over the proposed regime for hard minerals. Legislation has been introduced to establish a new EEZ hard minerals regime.

CURRENT ISSUES AND PROBLEMS

The issues and problems affecting the U.S. marine and coastal resources management regime may be summarized as a set of tasks:

- To resolve intergovernmental conflicts
- To provide integrated, nonsectoral management
- To resolve user conflicts and establish use priorities
- To set a coherent marine and coastal resources management policy.

The first three tasks are evident from the characterization given above of the U.S. regime and its problems. The last task is the most important and the most difficult because it requires agreement on basic resource management principles, and such agreement is lacking. The United States is, however, progressing slowly toward a majority view that conservation of renewable living marine resources must have priority over the development of other marine and coastal uses and resources (minerals, oil and gas, tourism, etc.).

Improvement of the existing U.S. marine and coastal resources management system dictates an incremental approach to breaking down jurisdictional and sectoral boundaries, or overcoming the problems they create. Indonesia may choose a different path, however, and determine an overall marine resources management policy before creating a number of separate marine and coastal resources management programs. Whatever path is chosen the U.S. experience will be directly relevant to Indonesia's task of organizing a marine and coastal resources management program.

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OCEAN SCIENCE AS THE BASIS FOR THE DEVELOPMENT, MANAGEMENT, AND UTILIZATION OF MARINE RESOURCES

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Marine resources are materials that occur in the sea in such a form that their economic extraction is partly or potentially feasible. It is axiomatic that economically extractable materials occur in the sea as a result of features of the marine environment itself. For example, fisheries occur as a result of the nutrient chemicals (phosphorus, nitrogen, silicon, etc.) that are found in abundance in lighted surface waters so that plants can carry out photosynthesis. This process converts the sun's energy into plant tissue, which provides the basis for the food chain that leads to fishery harvests. On a longer time scale environmental processes cause the formation of mineral resources in economically exploitable concentrations. This is best exemplified in Indonesia by the submarine tin deposits that formed as tin-containing granitic rocks, decomposed through weathering to form tin-rich sedimentary particles. They then flowed seaward in rivers and were concentrated by ocean currents to form the tin belt of northwestern Indonesia.

Because the ocean environment is so important in the formation of marine resource concentrations, one must study the ocean for help in the search for such resources. Even more important, one must understand how the ocean forms economically exploitable concentrations of materials. Maritime countries can then devise effective policies for managing exploitation of these materials and can avoid, or at least control, their depletion. Because the need for resources has unfortunately almost always exceeded our knowledge about the ocean features that form them, man has often used marine resources unwisely, particularly living ones. To correct this problem, the resources and the processes that form them must be studied both before and during the period that the resources are being utilized.

The science that focuses on ocean phenomena and processes is oceanography. This field commonly has four subdivisions according to the basic science being applied to the ocean. Biological oceanography applies biology to study life in the ocean and its relationship to the marine environment. Chemical oceanography applies chemistry and geochemistry to chemical distributions and reactions in the ocean. Geological oceanography applies geology and geophysics to seafloor features. Physical oceanography applies basic physics and some methods of meteorology to understand how and why seawater moves. A complete

understanding of ocean phenomena usually requires applying several of these subdisciplines at the same time. For example, knowledge of seawater movement is essential to understanding fully the formation processes of living matter as well as the distribution of fish, plankton, chemicals, and sediments in the sea.

KNOWLEDGE: A RESOURCE IN ITSELF

Knowledge of the marine environment itself can be a resource of vast economic value to Indonesia. Examples from marine physics and geophysics are used to develop this thesis because these subdisciplines usually seem further removed from resource issues than marine biology with its linkage to fisheries, marine geology with its linkage to mineral resources, and marine chemistry with its linkage to chemical extraction from seawater.

Because the density of seawater is greater than that of air, the ocean responds more slowly to changes in heating and wind stress than does the atmosphere. The ocean also has a very large capacity to store heat energy and nutrient chemicals. Thus, once the ocean has started moving it can transfer great quantities of energy across the earth's surface. Such transfers, if observed early enough and with enough understanding of their environmental implications, can be used to predict future climatic and oceanographic events. When such events include droughts and forest fires, such as these that plagued Indonesia in 1982-1983, the economic impact of oceanographic knowledge and observations can be significant. Such predictions are now possible through the growing knowledge of the physics of the El Nino-Southern Oscillation (ENSO) that periodically disrupts the stability of the equatorial Pacific.

Major oceanographic studies since the mid-1970s have focused on understanding the processes involved in the El Nino-Southern Oscillation. These studies gained special attention when the 1982-1983 ENSO turned out to be more extreme than any in recorded history. It was marked by droughts and forest fires in Indonesia and Australia; property damage and human lives lost from floods and landslides in Peru, Chile, Ecuador, and the United States; collapse of the sardine fisheries off Peru; unusual sea surface temperatures and sea levels all across the Pacific; and depressed thermocline depths in the eastern Pacific (Cane, 1983; Rasmussen and Wallace, 1983; Barber and Chavez, 1983). These events now appear to be linked to abnormal distributions of atmospheric pressure, sea surface temperature, and sea levels that developed across the tropical Pacific about six months prior to the adverse climatic and biological events that affected human population. Because the environmental linkages between these events are now well enough known, major efforts are being made to predict events with catastrophic human consequences from the earlier, non-life threatening events that occurred in the ocean (Walsh, 1987).

The oceanic signal for the onset of ENSO phenomena is not known for Indonesian seas, although according to one theory there are changes in both sea level and thermocline depths. Another signal may also occur in the sea since surface temperature distribution changed over much of the western Pacific in 1982-1983 (Kubota, 1987). It is reasonable to assume that increased study of the physics of Indonesia's seas will identify an ENSO signal, thereby providing early warning of droughts with their adverse effects on agriculture in general and rice culture in particular. Such a warning would be a resource of inestimable social value potentially obtainable from Indonesia's seas. The same measurements used to detect these changes can also be used to determine upwelling areas in Indonesia.

Sedimentary mineral resources, including petroleum, are distributed within or between distinct strata of sediments. Recognition of the age, relative position, and resource potential of these strata is central to exploration for sedimentary minerals. Over the last several years a revolutionary geophysical approach to sedimentary minerals has been developed by Peter Vail and associates. Correlated seismic and stratigraphic data are used to determine the distribution of sediments bounded by specific past sea-level events. This technique appears to have widespread applicability because major sea-level events affect sediments all around the globe. It allows seismic reflections from sub-bottom profiling to be used as time lines to provide regional and global chronostratigraphic correlations. Haq et al. (1987) assert that the technique "has been particularly valuable in frontier areas where it aids in the predrill determination of geological exploration parameters from seismic profiles."

Use of the sequence stratigraphy technique has been limited because control correlations to magnetostratigraphy, chronostratigraphy, and biostratigraphy have been based on proprietary data of the Exxon Corporation. This limitation was recently removed by the Haq et al. (1987) article in Science in which "an effort has been made to develop a realistic and accurate time scale and widely applicable chronostratigraphy and to integrate depositional sequences documented in public domain outcrop sections from various basins with this chronostratigraphic framework."

This new technique could now be applied to Indonesian continental margins. The Sunda Shelf seems particularly well suited to such an approach, since clear evidence of ancient sea-level fluctuations are well preserved on its surface and presumably occur in its interior strata as well. Other Indonesian continental margins may be equally well suited to sequence stratigraphic analysis, although the tectonically active plate boundary areas may require local modification of sea-level curves. Thus, basic knowledge of seafloor stratigraphy can be used to predict the distribution of new petroleum and other sedimentary mineral resources in Indonesia's offshore seas. These predictions will need to be tested.

Predicting climatic change from knowledge of ocean physics and the occurrence of mineral resources from knowledge of seafloor stratigraphy are only two ways in which basic oceanographic information could be of value to Indonesia. Other obvious examples include using remotely sensed data on the distribution of thermal discontinuities as a key to the distribution of pelagic fish such as tuna, mackerel, and skipjack, and using knowledge from meteorology, physical oceanography, and biological oceanography to predict the fishery implications of ocean upwelling created around islands by monsoonal and local winds. Many other examples could be mentioned because it is axiomatic that knowledge of an environment enhances human use of it. This is as true of the oceans as it is of the land.

The English philosopher Francis Bacon is most often credited with saying "Knowledge is power." This old maxim is worth remembering as Indonesia enters an era of exploiting its marine resources. Basic knowledge of ocean phenomena can provide the power to use these resources--and wisely enough to sustain their use into the future.

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POTENTIAL COLLABORATION IN OCEAN SCIENCES

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The participation of Indonesian ocean scientists and engineers in international collaborative projects is essential to accelerate the rate of development of Indonesia's marine resources. The world oceans--and indeed the Indonesian waters--are immense. No one country possesses enough resources to understand fully the processes that control the abundance of living resources and the distribution of nonliving resources in the ocean. Collaboration with scientists from other countries will help Indonesian oceanographers obtain access to ships and to the rapidly changing technology needed to evaluate, manage, and protect the nation's enormous ocean resource heritage.

REMOTE SENSING

The technology for observing the ocean surface and depths is changing rapidly. The use of remote sensing to view the ocean as a whole and computers to process the data have dramatically altered how the ocean is studied. Ocean-observing satellites have also radically changed the ability to observe the ocean as a whole. For example, SEASAT, the first ocean-observing satellite, was launched in 1978. During its 100 days of operation it provided a picture of seamounts and mid-ocean ridges on the ocean bottom that is far more detailed than maps made from data collected from ships over the past 100 years. Furthermore, SEASAT obtained data about deep ocean floor structures that are improving our understanding of how those features form.

Another example of the results of remote sensing are monthly maps of the distribution of chlorophyll (plant pigment) in nearsurface waters. The Coastal Zone Color Scanner (CZCS), also launched in 1978, collected data about the distribution and abundance of chlorophyll. Because areas rich in chlorophyll normally support large fish populations, knowing where chlorophyll is abundant suggests where potentially exploitable fish populations are located. It would be impossible to match the data, even using many ships operating full time. The CZCS data provide a snapshot of chlorophyll distribution over the entire ocean.

Remote sensing techniques generate vast quantities of data. Computers and highly trained people are needed, however, to turn the

data into useful products such as maps. The utility of such data is greatly increased by combining different types of observations for the same ocean area. For instance, combining data on the topography of the seafloor and variations in the earth's gravity at the same point helped answer fundamental questions about the processes forming the ocean floor and various mineral deposits.

These techniques are now used in many countries. Japan, for example, regularly issues maps and predictions of ocean conditions derived from satellites and their data sources. By collaborating with other countries, Indonesian scientists and engineers can get access to the data and learn how to apply them to Indonesian waters. Many of the remote sensing techniques require modification, however, to cope with the complexity of ocean and seafloor conditions in Indonesia.

Combining the new remote sensing capabilities with measurements of currents and water properties permits detailed mapping of water flows and studies of the origins of subsurface water masses. The proposed Indonesian Seas Throughflow Experiment (INSTEP) will include use of the most modern satellite techniques combined with one of the oldest and still powerful techniques, measurement of sea level changes. The intensive observation period (1988-1989) will provide the basic framework for long-term monitoring of the water flows in Indonesia during a second several year period. During the start-up phase, U.S. scientists will provide extensive training for technicians, engineers, and scientists. During the longer term monitoring phase, Indonesian scientists will carry out most of the field observations and data analysis.

New techniques are now also available to sample below the ocean floor. The International Ocean Drilling Program operates a state-of-the-art drill ship to collect samples and scientific information from the ocean floor. Modern laboratories on the ship permit at-sea study of samples. The involvement of Indonesian scientists in the proposed drilling operations in the Indian and western Pacific Ocean in the late 1980s will acquaint them with that technology, which promises to be extremely important in answering many unanswered questions about the history of the archipelago and potential mineral resources on the deep ocean floor.

CONCLUSIONS

Since the ocean is global and knowledge about it is international and changing rapidly, it is important that Indonesian oceanographers have access to the worldwide data and the scientific and engineering techniques needed to evaluate, manage, and protect its marine resources--both living and nonliving.

The ocean is immense, and scientific resources of all nations are limited. Only by working together will the many important questions about Indonesia's marine resources be answered. In understanding and exploiting the ocean, all countries are developing countries. Much can be gained from working together.

PART III

Working Group Reports

WORKING GROUP ON OCEANOGRAPHY

Oceanographic Features of the Indonesian Waters

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INTRODUCTION

The Indonesian archipelago is situated between Asia and Australia and between the Pacific and the Indian oceans. Its waters occupy most of the Southeast Asian region and form a geographical unit with complex structures and characteristics.

In oceanographic terms Indonesia's seas are part of the Pacific Ocean which is separated from the Indian Ocean by the islands of Sumatra, Java, Bali, Lombok, Sumbawa, Sumba, Timor, and Melville. They are filled primarily with water from the Pacific Ocean. The numerous large and small islands of Indonesia separate its many seas, which are connected by channels and passages of varying widths and depths (see Figure 1).

Indonesia's seas are under the strong influence of the monsoon blowing between Asia and Australia. The effect of the monsoon on the oceanographic characteristics of the Indonesian waters can be seen clearly, especially in the upper layer. From October to March the so-called northwest monsoon blows mainly from west to east in most parts of Indonesia. From April to September the southeast monsoon blows from east to west. The northwest monsoon is normally characterized by relatively heavy winds and rains, while the southeast monsoon is characterized by light winds and dry months.

Almost all types of bottom topography are found in the Indonesian waters, including continental shelves (the Sunda Shelf in the west and the Sahul Shelf in the east), continental and insular slopes, deep-sea basins, troughs, and trenches. Volcanic and coral islands are also found in this area. In its distribution of water and land, Indonesia is considered to be one of the most complex structures on earth.

The uniqueness and complexity of the Indonesian waters have attracted scientists from many countries. Major international oceanographic expeditions have included the Challenger (1872-1875), Gazelle (1875), Valdivia (1899), Siboga (1899-1900), Planet (1906-1907), Snellius I (1929-1930), Albatross (1948), Spencer F. Bird (1947-1950), and Galathea (1981). In recent years Indonesia has participated in several international oceanographic cruises carried out in the Indian and Pacific oceans, such as the International Indian Ocean Expedition (1958-1963) and the Cooperative Study of the Kuroshio

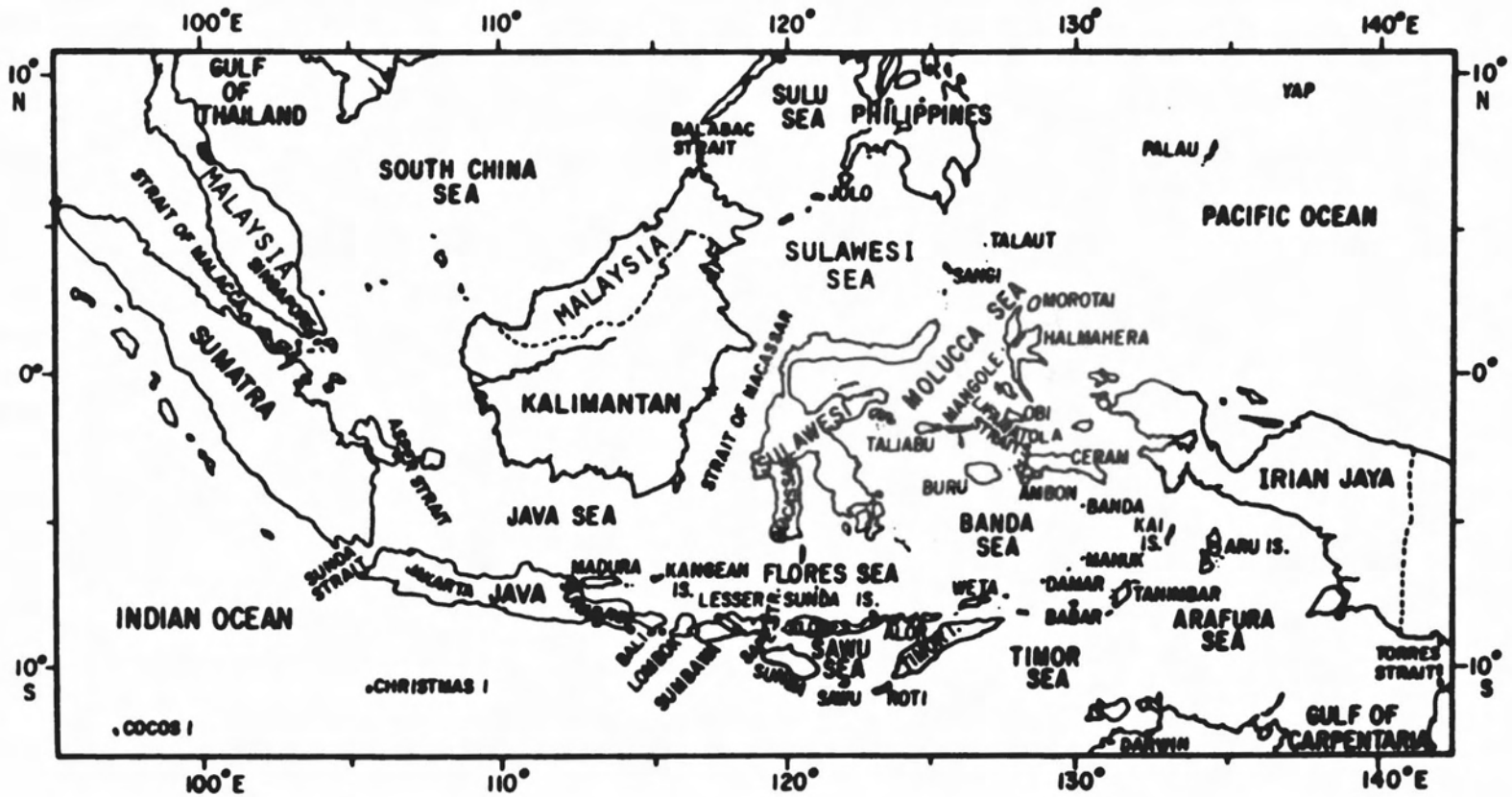

FIGURE 1 Indonesia and its surrounding waters.

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Current (1970-1974). Since 1970, Indonesia has been carrying out oceanographic cruises in its own waters on the basis of a five-year program. These cruises are designed to study the water characteristics of the pelagic system. About 30 cruises have been carried out thus far.

From June 1984 to July 1985 the Snellius II expedition was conducted jointly by the Indonesian and Dutch governments in the eastern Indonesian waters. The results of the expedition will be presented at a symposium to be held in November 1987 in Jakarta.

Valuable information on the oceanographic characteristics of the Indonesian waters has appeared in several publications (Wyrtki, 1961; Soegiarto and Birowo, 1975; Soegiarto, 1978).

EFFECTS OF MONSOONS ON OCEANOGRAPHIC FEATURES

Because its waters are strongly influenced by the monsoons, Indonesia is an excellent site for studying the effects of monsoons on water circulation and the physical, chemical, and biological properties of water masses.

During the northern summer a low-pressure area develops over Asia and a high-pressure area develops over Australia. These high- and low-pressure systems cause the monsoon to develop over the Indonesian archipelago. Because the pressure distribution is stationary, the winds are rather constant, especially over the sea.

The peak of the low-pressure area over Asia and the high-pressure area over Australia occurs from June to August, when the stable monsoon winds blow from southeast to northwest (southeast monsoon). The high-pressure area over Asia and the low-pressure area over Australia occur from December to February, when the stable monsoon winds in most of Indonesia blow mainly from northwest to southeast (northwest monsoon). The northwest and southeast monsoons are only true for the area south of the equator. The area north of equator experiences a northeast wind from December to February and a southwest wind from July to September. The area close to the equator experiences the north and south monsoons, respectively.

In the transition months from the northwest to the southeast monsoon--March, April, and May--the winds are extremely variable. In November and October, the transition period from the southeast to the northwest monsoon, the winds are also variable and weak.

The monsoons strongly influence the surface currents in the Indonesian waters. The relationship between the monsoon and the water circulation affects in turn the seasonal distribution of the water properties at the surface.

Monsoon Currents

The monsoons, owing to their constancy and regularity, are capable of generating and sustaining surface currents in the Indonesian

waters. Furthermore, the geographic layout of these seas favors this development. The line connecting the South China Sea, Natuna Sea, Karimata Strait, Java Sea, Flores Sea, Banda Sea, and Arafura Sea is parallel to the axis of the monsoons. Thus, as the monsoons change direction twice a year, the surface water circulation is also reversed over a large area. This is typical of the current system in the Southeast Asian waters.

In the beginning of the southeast monsoon (in May and June) a wide and uniform drift current develops in the northern China Sea. The larger part of these water masses passes through the Formosa Strait into the East China Sea, while a smaller part flows through the Bashi Channel to form the root of the Kuroshio Current. Because the supply from the Java Sea is not sufficient, the flow within the Strait of Macassar is directed toward the south, and in the region of the Natuna Islands it turns back to the north. The water making up this current comes partly from the Sulu Sea and partly from a countercurrent formed in the central part of the China Sea. In August, when the southwest monsoon is strongest, the water movements are considerably stronger than in September and October when they lessen. In October the northeast monsoon is already blowing with considerable strength. Influenced by the winds, the water masses of the North Equatorial Current south of Formosa are deflected south into the China Sea and other water flows toward the north through the Formosa Strait. In the center of the China Sea a countercurrent is formed. Because the southeast monsoon is still blowing over the Java Sea, not all of the water in the China Sea can flow into it (Figure 2). Thus, a current is formed along the coast of Sarawak flowing northeastward. In December the northeast monsoon reaches its full development and the currents are strong, often exceeding 100 cm/sec off the shore of Vietnam. A new countercurrent is formed in the center of the China Sea. In February the main current is almost the same as in December, and by April the whole current system of the northeast monsoon has dissolved into two eddies, one northeast and the other southeast of Vietnam.

The Java Sea is small compared to the South China Sea, and the currents developed there occupy its full width. From May to September the currents flow to the west, and from November to March they flow to the east. In April and October the direction of the flow changes and eddies occur.

In the Makassar Strait the southward flow is observed during the whole year, and the velocities are normally small. The strongest currents occur from February to March and from July to September. The lowest velocities are formed in December/January and in May. In the southern part of the strait the water mass flows into the Java Sea during the southeast monsoon and into the Flores Sea during the northwest monsoon (Figure 3).

Over the Flores Sea west winds prevail from December to March and east winds during all other months. Accordingly, from December to March the uniform current that is formed to the east is intensified along the northern coast of the Nusa Tenggara Islands. With the disappearance of the west winds in April, a weak current to the west is

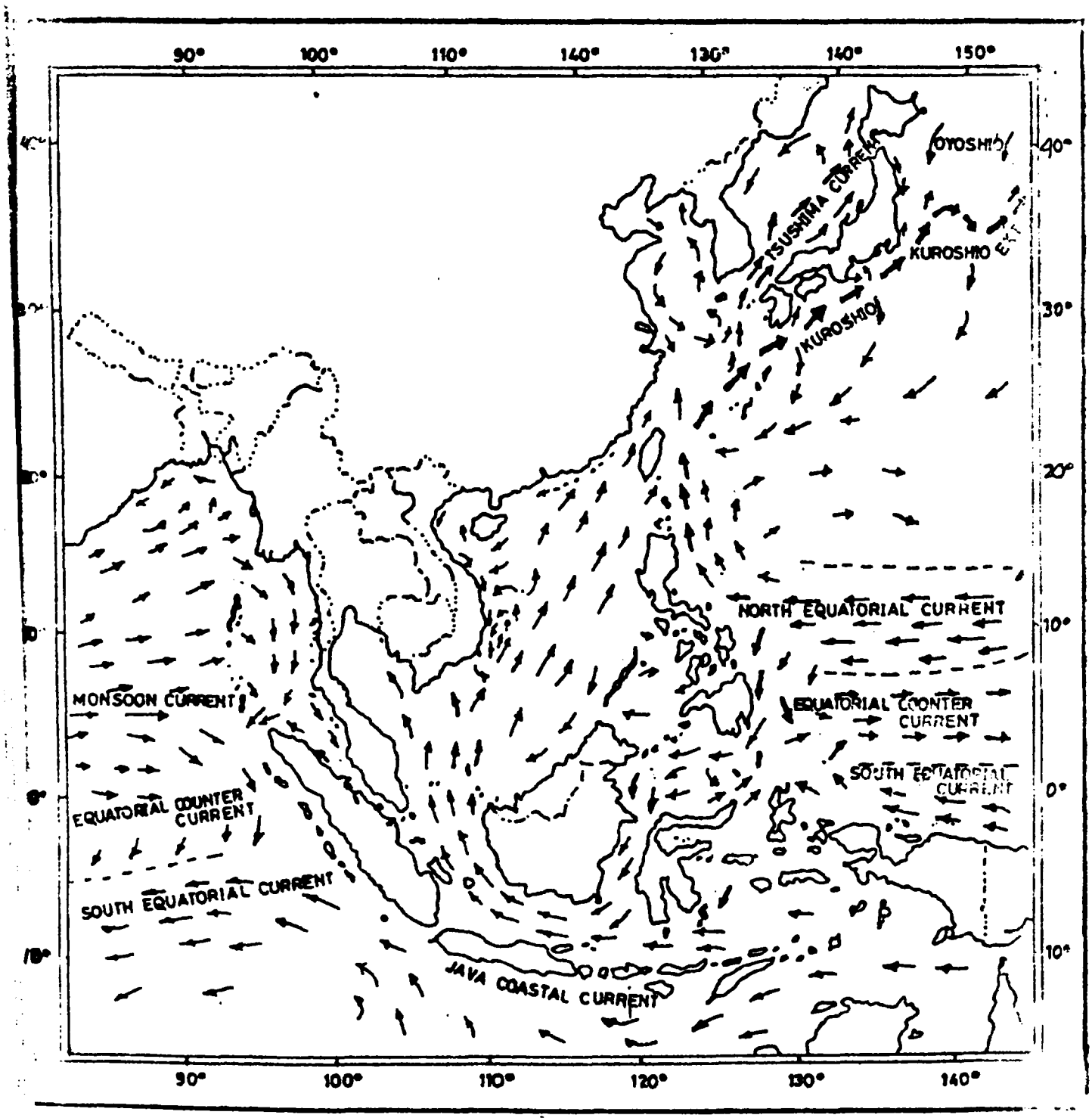

FIGURE 2 Surface currents during the southeast monsoon.

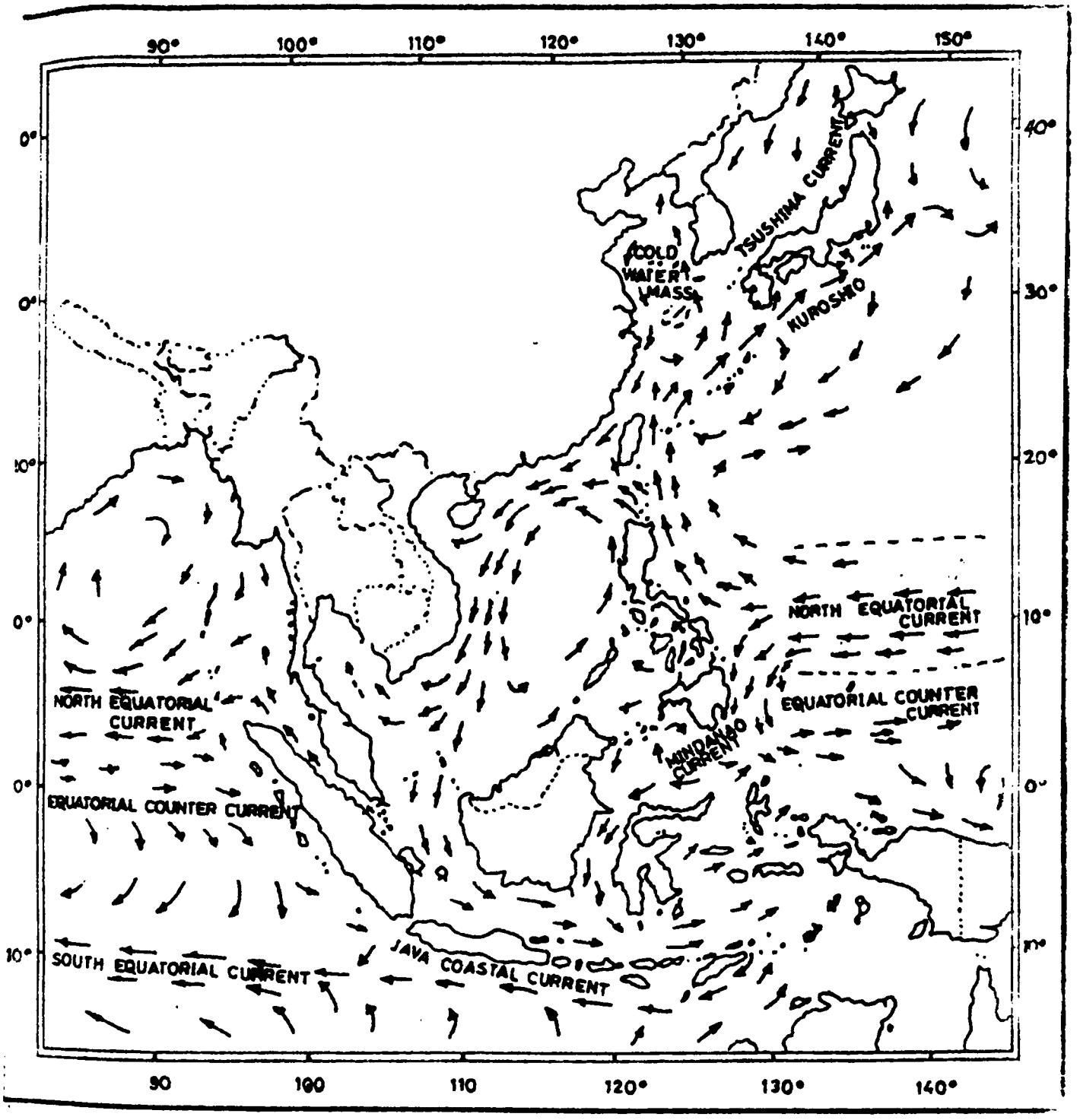

FIGURE 3 Surface currents during the northwest monsoon.

formed south of the Sulawesi coast, while north of Nusa Tenggara a strong current to the east still prevails. During the full southeast monsoon in July and August the westward flowing drift current in the northern part of the Flores Sea occupies most of its width, and in August it reaches a velocity of about 7 cm/sec. With the waning of the southeast monsoon the coastal current north of the Nusa Tenggara Islands is again intensified, and in October only a weak drift current is observed south of Sulawesi.

During the northwest monsoon water from the Flores Sea enters the Banda Sea. Part of this water flows north of Buru Island into the Ceram Sea and from there through the Halmahera Sea into the Pacific Ocean. Another part flows as a wide drift south of Ceram into the Arafura Sea. In April, at the time of the changing monsoon, the currents are variable. During the southeast monsoon the water out of the Pacific flows through the Halmahera and Ceram seas into the Banda Sea and passes in a southwestward direction into the Flores Sea. In the eastern part of the Banda and Arafura seas only a weak drift current develops over the entire year. The drift current over the shallow parts of the Arafura Sea follows the direction of the wind.

In the Timor Sea a southwestward current with its axis close to the coast of Timor prevails during the entire year. From April to September the Timor Current reaches the Australian coast, although its velocity decreases. From October to April the current takes its water out of the current flowing along the coast of the Nusa Tenggara Islands to the east, which then turns around the eastern end of Timor. During the full development of the southeast monsoon the Timor Current is supplied by water from the Arafura and the eastern Banda seas, where upwelling occurs.

The Sulawesi Sea is open wide to the Pacific Ocean. A branch of the Mindanao Current flows south of Mindanao southwestward into the Sulawesi Sea. Its water is deflected to the south and later to the east along the northern coast of Sulawesi. In the region northwest of Halmahera this coastal current joins the branch of the Mindanao Current coming directly from the north between the islands of Talaud and Sangihe. Together they receive the water coming out of the Molucca Sea, forming the root of the Pacific equatorial countercurrent. This system of circulation is maintained throughout the year, even though its extension to the west may vary.

The current in the Makassar Strait is supported from February to September almost exclusively by water from this current system. But from October to January, when north winds prevail over the Sulawesi Sea, the eddy in which the Mindanao Current turns back to the east is displaced to the east, and water from the Sulu Sea flows through the western part of the Sulawesi Sea into the Makassar Strait. In the northern part of the Sulawesi Sea the water movement is normally weak and irregular, but from March to July movement into the Sulu Sea prevails and during the other months water movements are toward the southwest.

A small exchange of water occurs between the Indian Ocean and the Sunda Shelf through the Malacca and Sunda straits. In both straits the

water moves generally toward the Indian Ocean, and this movement is strongly related to the surface gradient of the sea level through the strait. In the Sunda Strait the flow reaches a maximum in August during the southeast monsoon and a second maximum in December/January when the northwest monsoon is fully developed. In the Malacca Strait the strongest movement is from January to April during the northeast monsoon. This is chiefly caused by the low sea level in the Andaman Sea during this season.

The water circulation of Indonesia's seas thus primarily originates from the Pacific Ocean. The waters of the Pacific Ocean enter these seas through the South China Sea in the west and the Sulawesi, Molucca, and Halmahera seas in the east. The flow from the Indian Ocean into Indonesia's seas is possible through the Malacca and Sunda straits and the straits between the Nusa Tenggara Islands. The Malacca and Sunda straits are narrow and the waters exchanged there flow normally toward the Indian Ocean. The same applies for several straits between the Nusa Tenggara Islands. Of greater importance is the flow of water through the Timor Sea into the Indian Ocean.

Transport of Water Masses

The circulation of the Indonesian waters varies considerably under the influence of the changing monsoons. Thus, their annual variations, circulation, and transport are of the greatest interest. Wyrtki (1961) has calculated the transport of the various current branches in the Southeast Asian waters, including the Indonesian waters (Table 1). These dynamic calculations are based on observed data related to winds, sea levels, and currents. They are restricted to the upper layer above and within the discontinuity layer (the upper 150-200 m) because information about movement in the deep layer is too scarce. The monsoon current develops mainly along a line connecting the South China, Java, Flores, and Banda seas, because this line almost coincides with the axis of the winds during both monsoons. Other regions, such as the Molucca Sea, Makassar Strait, Sulawesi Sea, and Halmahera Sea are less favorably situated with respect to the direction of the winds. Throughout these regions compensating currents occur between the Pacific current and the monsoon current.

When the northeast monsoon is fully developed, the transport of the monsoon current through the Java Sea is about 4 million m^3/sec. During this period the water masses of the monsoon current leave the North Equatorial Current and enter the China Sea mainly through the Luzon Strait. The water masses leaving the Java Sea to the east join with those leaving the Makassar Strait and flow to the east as a strong current in the Flores Sea. When entering the Banda Sea the monsoon current splits into three parts. One part flows through the Molucca and Halmahera seas into the Pacific Ocean and ends in the Irian Coastal Current. Another part ends in the Banda and Arafura seas, where during this period sinking water occurs. A third part turns to the southeast of the Nusa Tenggara Islands and forms the Timor Current. Through this current an exchange of surface water with the Indian Ocean occurs.

TABLE 1 Transport of Currents in the Southeast Asian Waters (Million Cubic Meters per Second)

Current	Feb.	Apr.	June	Aug.	Oct.	Dec.
Pacific Ocean						
North Equatorial Current	41.0	32.0	41.0	39.0	37.0	37.0
Mindanao Current	12.0	8.0	9.0	10.0	9.0	12.0
Formosa Current	24.5	37.5	35.0	30.5	27.0	21.5
Countercurrent	9.0	-	15.0	16.5	14.5	9.0
Irian Coastal Current	5.0	-	-	-	-	5.0
South Equatorial Current	-	8.0	10.0	10.0	6.0	-
Southeast Asian Waters						
Luzon Strait, westward positive	+2.5	0.0	-3.0	-2.5	+0.5	+3.0
Makassar Strait, southward	1.5	1.0	1.0	1.5	1.0	0.5
China Sea off Vietnam, southward positive	+5.0	+1.5	-3.5	-3.0	+2.0	+5.0
Java Sea, eastward positive	+4.5	+0.5	-3.0	-3.0	+0.5	+4.0
Flores Sea, eastward positive	+6.0	+2.0	-2.5	-2.0	+1.0	+4.5
Banda Sea, upwelling positive, sinking negative	-2.0	-0.5	+2.0	+1.5	-0.5	-1.0
Timor Current, westward	1.0	1.5	1.0	1.5	1.5	1.5
Halmahera Sea, southward positive	-2.0	+1.0	+3.0	+3.5	+2.0	-1.5
Indian Ocean						
Source of the South Equatorial Current	16.0	12.0	8.0	10.0	14.0	14.0
Java Coastal Current	4.0	3.0	1.0	-	-	2.0
Upwelling off Australia	-	3.0	5.0	4.0	-	-
South Equatorial Current Southwest of the Sunda Strait	20.5	19.5	16.0	16.5	16.0	17.0
Resultant flow from the Indonesian waters to the Indian Ocean	1.0	1.5	2.0	2.5	2.0	1.0
Torres Strait, eastward positive	+0.8	0.0	-0.6	-0.4	-0.3	+0.5

Source: Wyrtki (1961).

During the change of monsoon in April the circulation becomes very weak. The eastward current still flows in the Java Sea and transports only 0.5 million m^3/sec. It joins the water coming out of the Makassar Strait and forms a rather strong current in the Flores Sea of 2 million m^3/sec. From the Pacific Ocean a weak transport occurs through the Philippines and the Sulu Sea into the China Sea. Another branch splits off from the Mindanao Current and flows through the Sulawesi Sea into the Makassar Strait. From the South Equatorial Current of the Pacific Ocean about 1 million m^3/sec penetrates southward through the Halmahera Sea. The larger part of the monsoon current flows through the Timor Sea into the Indian Ocean.

During the southeast monsoon conditions are nearly the inverse of these during the northwest monsoon, with the average transport of the current smaller. The transport of the monsoon current through the Java Sea is only 3 million m^3/sec. The monsoon current is almost completely supplied by water masses of the Pacific Ocean penetrating between Mindanao and Irian. One branch of about 2 million m^3/sec splits off from the South Equatorial Current and passes through the Halmahera Sea into the Banda Sea. Another branch splits off from the Mindanao Current and flows southward through the Makassar Strait. When entering the Java Sea the two branches join and together transport 3 million m^3/sec of water through the Java and China seas. The monsoon current finally leaves the China Sea through the Luzon and Formosa straits and joins the water of the Formosa Current.

During the south monsoon upwelling develops in the Banda and Arafura seas. Almost all the ascending water masses flows through the passages of the Nusa Tenggara Islands and through the Timor Sea into the Indian Ocean.

In October the south monsoon changes to the north monsoon. Over the China Sea the south monsoon has already started with considerable strength. The monsoon current along the coast of Vietnam is already developed and is transporting 2 million m^3/sec of water southward, but the larger part of this water turns northward before entering the South China Sea (and is transported back along the coast of Kalimantan). In the Java Sea the water movements are still variable, and the eastward flowing monsoon current has not yet started. From the Sulu Sea the water masses flow southward through the western part of the Sulawesi Sea and through the Makassar Strait to join in the Flores Sea with the current along the Nusa Tenggara. In the eastern parts of Indonesia the water movements are still weak. Only through the Timor Sea does a considerable current flow into the Indian Ocean.

GENERAL PROPERTIES OF THE WATER

The Pelagic System

Because Indonesia's seas are located in the equatorial region, their surface water is characterized by high temperatures. These high

temperatures and low salinity reduce the density of the surface water rather markedly. The large excess of rainfall over evaporation causes an average surface salinity of less than 34°/oo. The density of this water always remains below Sigma-t 22.0 (specific gravity of about 1.022). This light tropical surface water contrasts strongly with the cold water masses in the deeper layers with a Sigma-t of 27.7-27.8. The transition layer between these two water masses, defined as the discontinuity layer, is found between 200 and 300 m. This stable layer practically prevents any vertical exchange of water masses. Only in a few places and in certain seasons is the stable stratification disrupted either by extremely strong winds or the upwelling processes.

The physicochemical properties of the warm water at the surface normally extend downward to a certain depth before the properties of the colder water are encountered. The homogeneity of the surface layer is maintained by the action of winds, and in some cases by currents and tides. Beneath the homogeneous layer the change in water properties, especially an increase in the density, begins gradually at first. Later the density increases rather rapidly until a maximal density gradient is reached at a depth of between 150 and 200 m, which is the center of the discontinuity layer. Below this the density of the water continues to increase until a depth of about 300-400 m with a Sigma-t of 26.0. After this level the density increases only slightly to Sigma-t 27.7 in the intermediate layer and remains constant at about 27.7-27.8 in the deep cold layer.

The depth of the homogeneous layer is of interest in dynamic oceanography and in marine productivity. Over the Sunda and Sahul shelves the homogeneous layer reaches the bottom of the shallow parts. In the deeper parts high-density water is found below the homogeneous layer in the discontinuity layer. In some places, such as in the Sulawesi and Flores seas, the lower boundary of the homogeneous layer is found at about the same depth throughout the year. In the eastern Indonesia seas, however, the seasonal variation is more pronounced. In the Banada and Arafura seas the depth of the homogeneous layer is about 20-50 m in October and about 200 m in March. A similar range of variation is recorded for the deeper part of the South China Sea, where the homogeneous layer, which is about 30-40 m deep during the south monsoon, increases to 70-90 m deep during the strong north monsoon.

The thickness of the discontinuity layer is affected primarily by dynamic processes. In a large eddy the warm water masses are pressed downward, causing a thick discontinuity layer. In the eastern Indonesian seas this layer maintains a uniform thickness of about 100 m throughout the year.

Temperature

Like the other physicochemical properties of the surface water, the temperature varies seasonally, although the annual variation is small.

During the northwest monsoon, generally high surface temperatures of 29-30°C prevail along the western coast of Sumatra and in the eastern Indonesian waters. Because of the inflow of water masses from the higher latitudes, however, colder water (26-27°C) is found in the South China Sea. Very different conditions occur during the southeast monsoon. High surface temperatures (29-30°C) are found in the Natuna Sea (the shallow part of the South China Sea) and lower temperatures (26-27°C) prevail in the Arafura Sea and along the southern coast of Java. In other waters temperatures range between 27°C and 29°C (Figure 4).

The average annual range of sea surface temperatures in the equatorial region is less than 2°C. Slightly higher values, by 3-4°C, are found in the Banda, Arafura, and Timor seas as well as south of Java. In the South China Sea the annual temperature range increases as one goes northward, owing to the increased inflow of cold Pacific water through the Strait of Formosa during the north monsoon. Over the shallow parts of the Sunda and Sahul shelves the temperature is uniform throughout the water column.

Salinity

In contrast to the uniform surface temperatures, the salinity at the surface is extremely variable. The high rainfall, the runoff of many large rivers, and the geographical subdivision of the seas are responsible for this characteristic. The rainy and dry seasons caused by the monsoon, as well as the seasonal water circulation also governed by the monsoon, affect the annual variation in salinity. The high rainfall and discharge of freshwater from the land lower the salinity.

Figure 5 shows the average distribution of surface salinity in the Southeast Asian waters during the north monsoon (December-May). In general, low salinity prevails over the Sunda Shelf and the coastal areas, largely as a result of the heavy rainfall and river discharge. During the south monsoon (June-November), however, high salinity prevails in almost all the Southeast Asian waters (Figure 5).

The Java Sea is a good example of how the monsoon affects surface circulation and salinity (Doty and Soegiarto, 1970). During the north monsoon heavy rainfall occurs throughout the western parts of the Indonesian archipelago. The heavy rainfall, combined with the large runoff of the many rivers of Sumatra, Java, and Kalimantan, result in a general lowering of the salinity level near the shore. In some cases water with a salinity of less than 30°/oo extends far toward the open sea. At the same time the surface current from the South China Sea brings the low-salinity water into the western Java Sea and pushes the high-salinity water eastward. With the onset of the south monsoon this low-salinity water is pushed back westward and replaced by water masses of higher salinity from the Makassar Strait and the Flores Sea. By September the high-salinity water masses reach their maximal westward penetration.

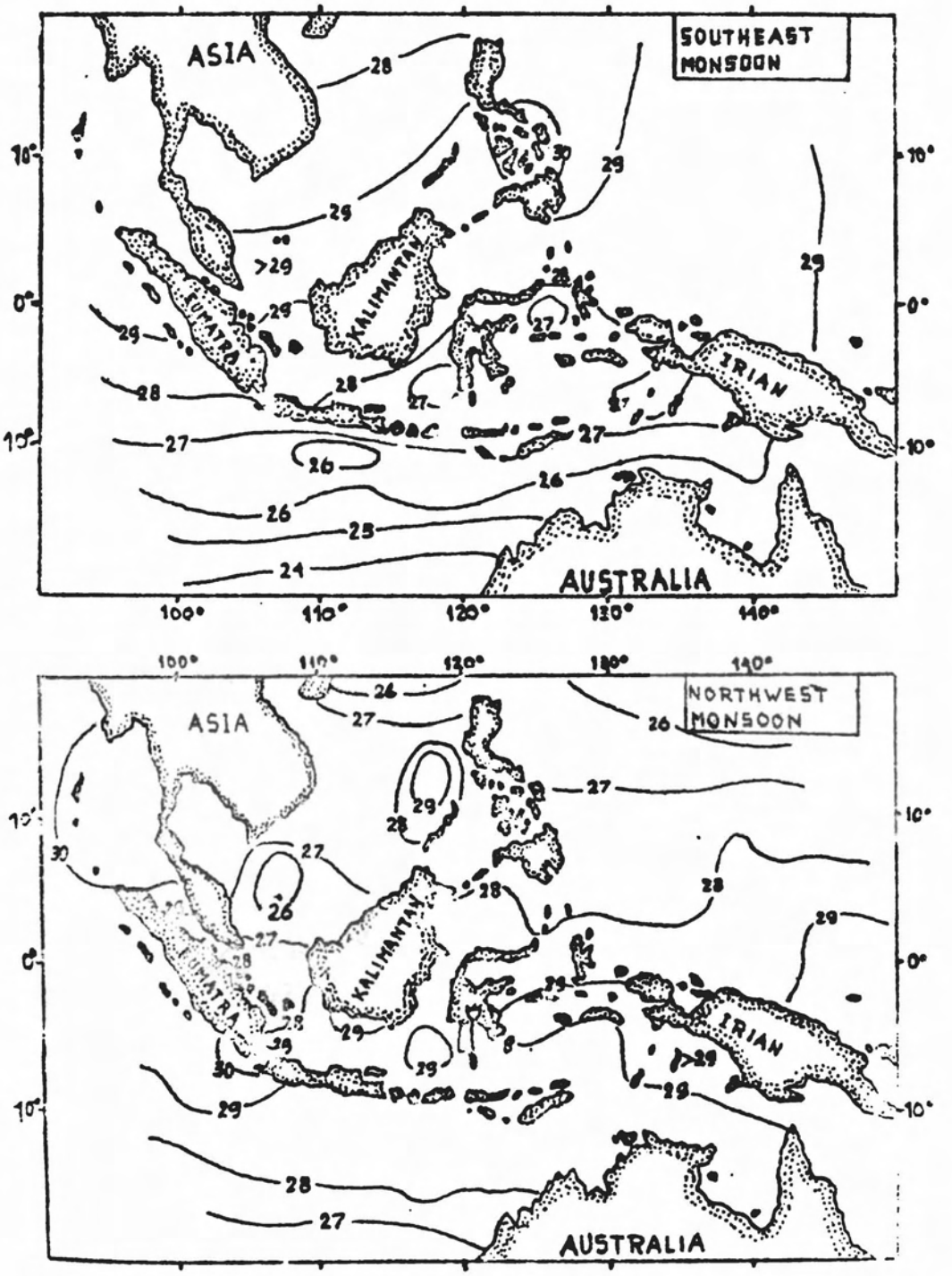

FIGURE 4 Surface temperature (degrees Centigrade) distribution of Indonesia's waters, southeast and northwest monsoons.

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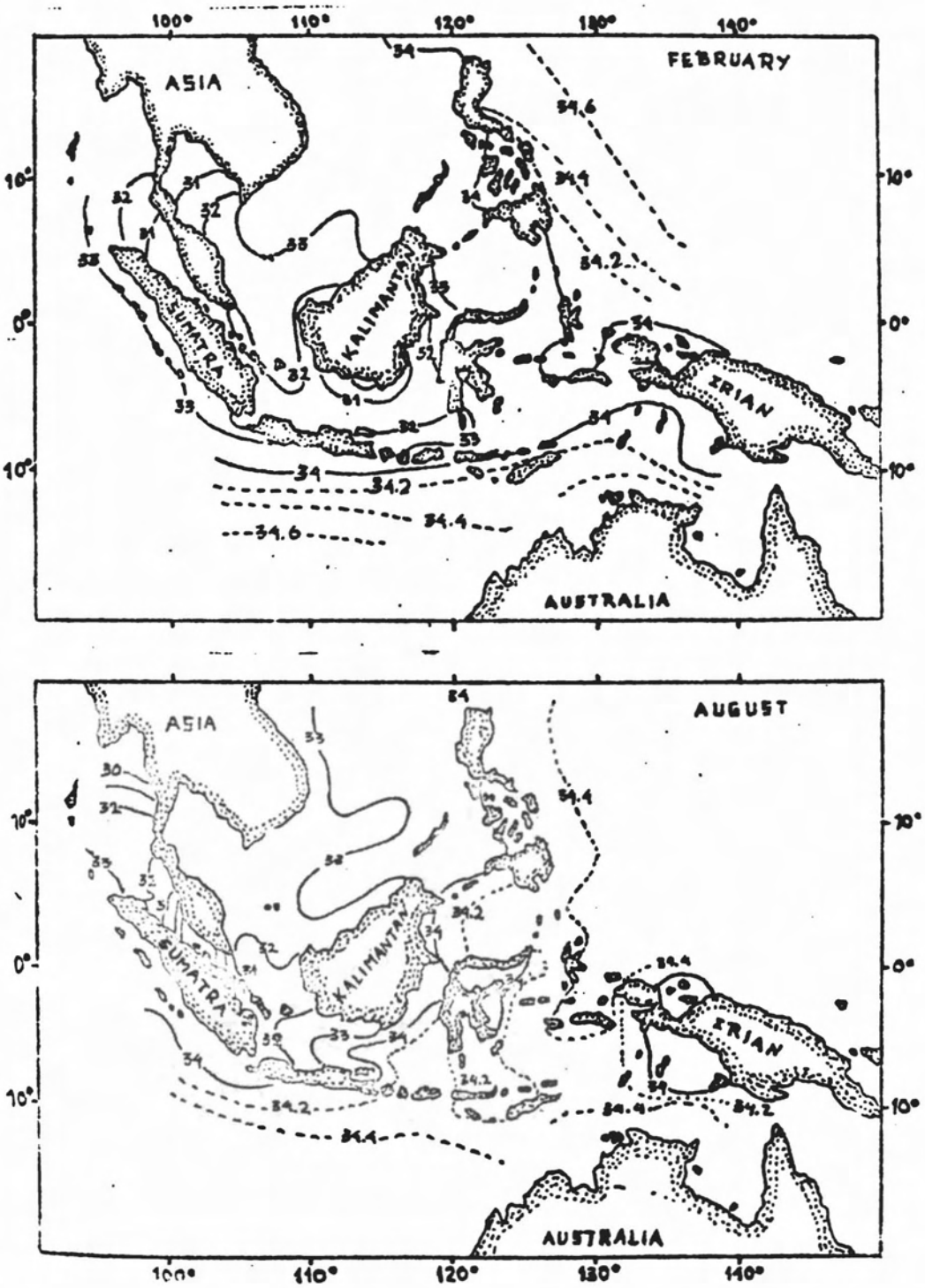

FIGURE 5 Surface salinity (°/oo) of the Indonesian waters, February and August.

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Dissolved Oxygen

The surface distribution of dissolved oxygen (DO) does not generally show a strong seasonal variation. In the eastern Indonesian seas the surface distribution of DO ranges from 4.0 to 4.5 ml/l, whereas on the Sunda Shelf the value is somewhat lower, between 3.5 and 4.0 ml/l. At 100-150 m, however, the DO distribution has some interesting features. In the eastern Indonesian waters, for example, the amount of dissolved oxygen is relatively low, between 2.5 and 3.0 ml/l, with no apparent seasonal variation. Toward the Indian and Pacific oceans it increases, and in the area of the Mindanao Current, DO values of 4.5 ml/l are common. Along the southern coast of Java the DO tends to increase as one moves from the coastal area (2.5-3.0 ml/l) toward the open water (over 4.0 ml/l). In the South China Sea the DO concentration varies between 2.5 and 3.0 ml/l, and it increases toward the northern part owing to the influence of the Pacific Ocean water masses.

Water Transparency

The transparency of the water is generally measured by lowering a white secchi disc. The point at which the disc disappears visually is recorded as a measure of transparency. Many factors influence water transparency, including, for example, its silt content and the plankton and other particulate matter found in the water. Low water transparencies (secchi disk readings of less than 10 m deep) are found off the mouths of rivers and in the coastal waters around Sumatra and Kalimantan. In general, transparency is high in deep water (10-20 m) and in open seas (20-30 m). Water transparency does not show a strong seasonal variation between the north and south monsoons (Soegiarto and Birowo, 1975).

Nutrients and Primary Productivity

Basic to an understanding of the geographic, seasonal, and other types of biological variation is an understanding of the related variation in primary productivity—the conversion rate of inorganic matter to organic form. Knowledge of this aspect of the Indonesian waters is still limited, and investigators have only recently begun to gather data. A number of authors have summarized how much is known about the nutrients and primary productivity in Indonesia's seas (Wyrtki, 1961; Soegiarto and Birowo, 1975).

The nutrients in the deeper Indonesian waters have a distribution pattern typical of tropical waters. The surface layer is poor in nutrients with a phosphate content of less than 0.2 ug/l. Within the discontinuity layer the phosphate content increases rather markedly and reaches 1.5 ug/l at the lower boundary. A phosphate content of 2.5-3.0 ug/l is usual in the deeper layer. Over the shelves the phosphate

content varies considerably, depending on the proximity to the river mouths and the strength of the mixing processes. In the vicinity of the river mouths the water is normally rich in nutrient salts, particularly during the wet monsoon. In addition, in the shallow waters vertical mixing can bring the mineral at the bottom to the upper layer. Thus, there is a continual supply of nutrients to the water column, enabling a high production of organic matters.

Replenishment of the nutrient salts of the surface layer over the deeper waters is achieved either by upwelling or by the divergent movements of water at the surface, where more fertile water from the discontinuity layer can ascend and enter the euphotic zone. These mechanisms occur only locally, however, and during certain seasons. The presence of such upwelling in the Indonesian waters has been summarized elsewhere (Soegiarto, 1965, 1975). In 1957 Wyrtki described the upwelling found in the Banda and Arafura seas and in the northwestern Australian waters. In 1962 he detailed the upwelling found along the southern coast of Java up to the entrances to the Sawu Sea. In both areas upwelling occurs during the winter monsoon, but in the Banda and Arafura seas it takes place somewhat earlier in August. A few smaller upwellings in other waters, such as off the southern coast of Sulawesi, have also been reported (Wyrtki, 1962; Ilahude, 1970).

Regions of upwelling are characterized by large amounts of plankton biomass, high rates of organic matter production, low water transparency, and a high concentration of inorganic phosphorus, especially at the bottom of the euphotic layer. In general, the surface phosphate content of the water is slightly higher during the south monsoon than during the north monsoon. There is also a gradual decrease in content as one moves from the Indonesian waters toward the Pacific Ocean. In the eastern Indonesian waters the average phosphate content varies from 0.2 to 0.3 ug A/1 during the northwest monsoon, partly owing to the upwelling processes in the Banda Sea. In both the Java and South China seas the average phosphate content is between 0.1 and 0.2 ug A/1 in the north monsoon, increasing to 0.3-0.4 ug A/1 in the south monsoon.

Figure 6 shows the average surface primary productivity or the rates of organic carbon production of the Indonesian waters during the northwest and southeast monsoons. Because the charts shown in Figure 6 are constructed from rather limited and unevenly distributed data, the results shown should be considered preliminary. Generally, the coastal and shallow waters show high rates of organic production (over 1.0 $ug/m^3/h$), mainly owing to nutrient enrichment from rivers and from the bottom. In deep seas high rates can only be attributed to upwelling processes such as those occurring during the south monsoon in the Banda and Arafura seas, the Indian Ocean south of Java, and the Lesser Sunda islands.

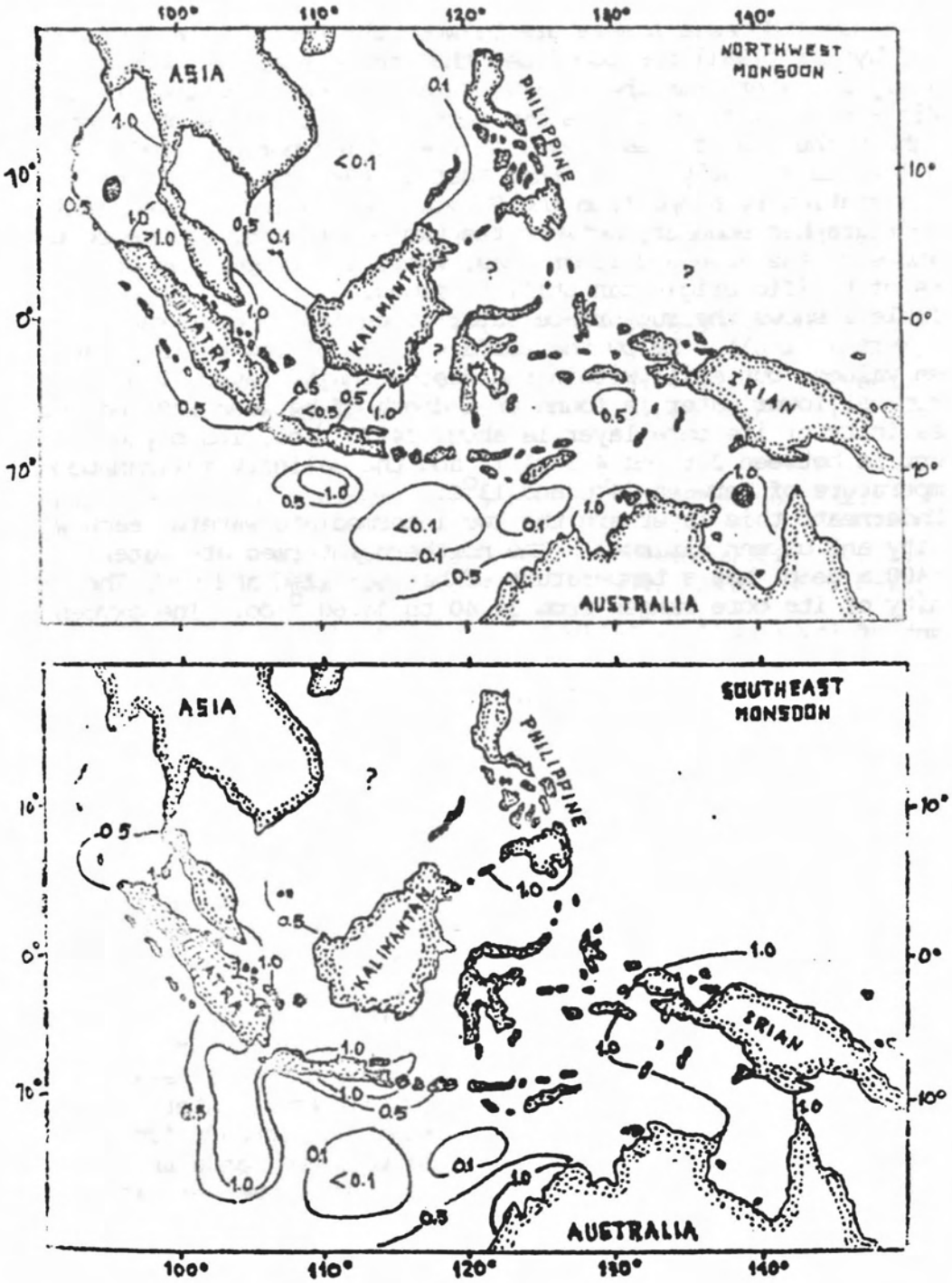

FIGURE 6 Primary productivity (milligrams per cubic meter per hour) in Indonesian waters, northwest and southeast monsoons.

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Water Masses in the Depths

Although Indonesia's seas are between the Pacific and Indian oceans, Wyrtki (1961) has concluded that these seas are occupied primarily by water from the Pacific Ocean. Both accessibility to the Pacific and dynamic conditions are responsible for this phenomenon. Throughout the year the sea level in the region north of Halmahera and Irian Jaya is slightly higher than that in the region south of Java. Thus, a stationary slope from the Pacific to the Indian Ocean exists. The hydrographic boundary between the two oceans lies at the southern entrances of the Sawu and Timor seas, where the properties of the water masses of Pacific origin can still be found.

Table 2 shows the subsurface water types in the eastern Indonesian seas (Wyrtki, 1961). Below the surface layer of low salinity and high oxygen values, but still within the discontinuity layer, the subtropical lower water is found at a depth of between 120 and 200 m. The salinity of its core layer is about 34.70 $^{o}/oo$, its oxygen content is between 2.6 and 4.3 ml/l, and the salinity maximum occurs at a temperature of between 24°C and 13°C.

Underneath this layer are the two intermediate waters, each with a salinity and oxygen minimum. The northern intermediate water (250-400 m deep) has a temperature of between 12°C and 9°C. The salinity of its core ranges from 34.40 to 34.60 $^{o}/oo$. The oxygen content of its core is relatively high, and is in every case higher than that of the oxygen minimum below it. This indicates that the water mass had a high oxygen content at its formation. At the lower boundary of the intermediate water (350-500 m deep) is a second oxygen minimum. The salinity of its core is higher than that of the intermediate water, and throughout the oxygen content is lower than 2.5 ml/l.

Between the depths of 600 and 800 m is the southern intermediate water with a temperature of between 8°C and 5°C. Its salinity varies between 34.45 and 34.65 $^{o}/oo$, a little higher than that of the core of the northern intermediate water. The oxygen content of the core of this water type is between 2.2 and 2.6 ml/l, which is higher than the oxygen minimums above and below it.

The subtropical lower water in Indonesia's seas can be divided into three types. The northern subtropical lower water spreads over the Sulawesi and Molucca seas and penetrates through the Makassar Strait into the Flores Sea. The southern subtropical lower water penetrates through the Halmahera Sea into the Ceram Sea and spreads from there down both sides of Buru and Ceram islands into the Banda and Arafura seas and further on to the Timor Sea. These two types of water masses meet in the Flores Sea. The subtropical lower water of the Indian Ocean is restricted to a small region southeast of Timor.

TABLE 2 Properties of Subsurface Water Masses in the Eastern Archipelago

Water Type	Characteristic	Temperature (°C)	Salinity (°/oo)	Dissolved O^2 (ml/l)
Northern subtropical lower water	S maximum	23-15	34.6-35.1	3.3-4.3
Southern subtropical lower water	S maximum	24-13	34.6-35.3	2.6-3.6
Northern intermediate water	S minimum	12-9	34.4-34.6	2.0-3.3
	O_2 minimum	9-7	34.45-34.65	1.8-2.5
Indian Ocean oxygen minimum	O_2 minimum	8.5-6	34.50-34.65	<2.3
Southern intermediate water	S minimum	8-5	34.45-34.65	2.2-2.6
	O_2 minimum	6-4	34.5-34.6	1.8-2.5
Deep water	T minimum	<4	34.65-34.75	different

Source: Wyrtki (1961).

The northern intermediate water, which is situated below the discontinuity layer, enters the Sulawesi Sea with the Mindanao Current and penetrates through the Makassar Strait into the Flores Sea. It spreads farther than the subtropical lower water into the Banda Sea, and its last traces can be found in the Timor Sea. It does not penetrate into the Molucca Sea and the northern part of the Banda Sea, however. The oxygen minimum, which is situated in the lowest part of the northern intermediate water, immediately below the salinity minimum, is found only in the Sulawesi Sea.

The salinity minimum of the southern intermediate water of the Pacific Ocean is well developed in the region north of Irian, but it penetrates only slightly into the Molucca Sea. In the Sulawesi Sea it is not found as a salinity minimum. An oxygen minimum is usually found below the salinity minimum of the southern intermediate water. No lower salinity minimum is found in the Banda Sea, however, but it is found again in the Indian Ocean, from which water masses of low salinity penetrate the Sawu and Timor seas and form a minimum at a depth of 1,000 m.

The oxygen minimums of the southern intermediate water of the Pacific and Indian oceans have different features. The oxygen minimum of the Pacific Ocean lies in the lower parts of the southern intermediate water at a low temperature, and together they penetrate the Molucca Sea. The oxygen minimum of the Indian Ocean, on the other hand, is found at a higher temperature, and it is questionable whether this water spreads in a permanent direction.

The deep water between 1,000 and 1,500 m in depth is a water mass that spreads very slowly from the Pacific into the Indonesian basins and then on to the Indian Ocean. It carries away simultaneously the water masses ascending out of the deep Indonesian basins. The passages between the deep basins are so small that this spreading must be extremely slow, especially over the large basins. One branch of the deep water enters the Sulawesi Sea on both sides of the Sangihe Islands and penetrates further into the Makassar Strait. At the southern end it ascends and passes the ridge connecting Sulawesi and the Sunda Shelf. Another branch enters the Molucca Sea and passes through the Lifomatola Strait, the only connection available, into the Buru Basin. There it splits off through three sides of Buru and Ceram into the Banda and Arafura seas. The deep water then spreads through the narrow passages east of Wetar into the Sawu and Timor seas and on to Indian Ocean.

The bottom water enters the Sulawesi Sea north of the Sangihe Islands (and probably flows along the northern side of the basin). In the Molucca Sea the bottom water spreads within the trough along the western coast of Halmahera to the south, turns off the Lifomatola Ridge to the west, and enters the Gorontalo Basin from the south. The bottom water mass passing over the Lifomatola sill penetrates the Buru and Banda basins. From there it spreads in all directions, including the Manipa Basin, the Weber Deep, the Flores Basin, and the Salayar Trough. From the Weber Deep the bottom water penetrates the sill northeast of Timor into the Wetar and Sawu basins. Another branch of bottom water spreads from the Buru Basin into the Aru Basin. From the Indian Ocean the Timor Trough is supplied with the bottom water that penetrates further into the Aru Basin.

The deep and bottom water masses passing over the different sills sink to the bottom of the basin and there spread further along the bottom. In other parts of the basin water must ascend to compensate for the sinking water. This ascending water is carried away horizontally as soon as it comes into the range of the deep current at the level of the sill. Naturally, all of these movements are extremely slow--water is replaced in the deep-sea basins only at the rate of 0.2 m^3/sec.

At the surface the monsoon circulation brings water from the Pacific Ocean, which is subjected to strong annual variations. One branch, however, the Timor Current, continuously gives off water to the Indian Ocean. Below this layer the subtropical lower water and the northern intermediate water spread according to the general surface gradient from the Pacific to the Indian Ocean, but with decreasing intensity with depth. Below them, and especially in the southern part

of the region, a nearly motionless layer seems to exist in which the oxygen minimum is situated. In the deep layer the Pacific again spreads to the Indian Ocean, which simultaneously replaces the water of the deep-sea basin. Thus in all layers, with the exception of that of the oxygen minimum, movement from the Pacific to the Indian Ocean predominates.

TIDES AND CURRENTS

Tides

Indonesia's tides are affected by the Pacific and Indian oceans. Wyrtki (1961) has characterized the four kinds of tides in the Southeast Asian waters:

1. Semidiurnal tide, two high and two low waters of almost equal height daily.
2. Mixed tide, semidiurnal prevailing; two high and two low waters daily, but they are different in both height and the time of high water.
3. Mixed tide, diurnal prevailing; only one high and one low water daily. There are also regimes with two high and two low waters that differ appreciably in height and the time of high water.
4. Diurnal tide, only one high and one low water daily.

Because the semidiurnal tide predominates in the Indian Ocean, the northern coast of Sumatra and the Malacca Strait have semidiurnal tides. Elsewhere in the Indian Ocean--such as the western and southern coasts of Sumatra, the southern coast of Java, and the Nusa Tenggara Islands--there are mixed tides with semidiurnal prevailing. In the western Pacific Ocean the diurnal tide dominates. It changes, however, as soon as tides enter the Southeast Asian waters. Almost the entire South China Sea experiences the mixed tide with diurnal prevailing. In other waters the diurnal tide is strengthened. In the waters between Sumatra and Kalimantan and the Java Sea, for example, an almost purely diurnal tide is observed. In contrast, over the eastern part of the Indonesian waters the mixed tide with semidiurnal prevailing is dominant.

INTERESTING PHENOMENA FOR FURTHER INVESTIGATION

Interesting oceanographic phenomena--such as upwelling, water mass exchange, and sea-level dynamics--can be found in the Indonesian waters. Upwelling is important from a biological as well as an oceanographic point of view. Marine biologists are interested in the high productivity of the upwelling area, which is usually accompanied by high fish production. Oceanographers consider the upwelling area to

be an important link between subsurface and surface circulation. Water circulation and sea-level dynamics are important to oceanographers as well because of their role in controlling other physical processes such as currents and water renewal.

Upwelling

Upwelling in the Banda and Arafura seas develops under the influence of the southeast monsoon and occurs from May to August. The upward velocity is 0.6 10^{-3} cm/sec, and the average upwelling is 2 million m^3/sec. In June the ascending water masses pass partly over into the monsoon current to the Flores Sea and partly into the Timor Current. In August almost all the ascending water flows with the Timor Current into the Indian Ocean.

In contrast, from January to March of the northwest monsoon the water masses from the Java and Flores seas are piled up in the eastern part of the Banda and Arafura seas. Consequently, descending movement occurs in this area. These movements are balanced by an outflow of water from the Banda Sea into the Indian Ocean at a depth of 1,000 m. The amount of the descending water mass is at most about 2 million m^3/sec in February, and it seems to compensate approximately for the upwelling.

During the southeast monsoon an inflow of the Pacific water at the level of the intermediate layers into the eastern Indonesian seas usually occurs, together with the upwelling and outflow at the surface into the Java Sea and the Indian Ocean. During the northwest monsoon an inflow of surface water from the Java Sea into the eastern Indonesian seas occurs, together with sinking in this area and an outflow into the Indian Ocean at the intermediate depth. This clearly indicates the role of the upwelling and sinking in the Banda and Arafura seas in the water exchange between the Pacific and Indian oceans. It also demonstrates the close relationship between the circulation at the surface and the depth of the water exchange between the two oceans.

Upwelling and sinking affect the biological productivity in the area by influencing the supply of nutrients to the euphotic zone. Productivity is high during upwelling and low during downwelling. Rochford (1962) and Nontji (1975) have described an increased plankton biomass and high rates of primary productivity in the region during July, August, and September owing to the nutrient enrichment during upwelling. During the northwest monsoon, on the other hand, when stratification is established, low productivity and biomass are expected because of nutrient depletion in the surface layer. As a result of changes in the hydrographic condition, both the structure and function of the biological system are altered completely following the changing monsoonal wind. Important unanswered questions are how will the pelagic ecosystem react to hydrographic and chemical change in the Banda and Arafura seas and what will happen to the fish production of the region?

Upwelling is not limited to the Banda and Arafura seas. Reportedly it also occurs in the other areas such as the Makassar Strait (Ilahude, 1970, 1978), and in the Molucca, Halmahera, and Ceram seas (Birowo and Ilahude, 1977; Ilahude et al., 1975). In Indonesia's Exclusive Economic Zone, upwelling has been reported south of Java-Nusa Tenggara (Wyrtki, 1962) and north of Irian Jaya. Further investigation of these regions is needed.

Water Mass Exchange

Pacific Ocean water spreads through the eastern Indonesia seas into the Indian Ocean. This spreading is found in all layers with the exception of that of the oxygen minimum. Thus, the movement of water from the Pacific to the Indian Ocean predominates. The very slow replacement or renewal of water masses in the deep basins through sills is a feature of the eastern Indonesian seas. Between 0 and 500 m in depth the flow from the Pacific into the Indian Ocean is more substantial, and the entire water exchange at the surface is practically carried away by the Timor Current.

A number of investigators have estimated the magnitude of the Pacific-to-Indian Ocean transport. According to Wyrtki (1961), the transport at the upper 150-200 m of water from Indonesia to the Indian Ocean ranges from a low of 1 million m^3/sec (1 Sv) from December to February to 2.5 Sv in August. The annual range is estimated to be 1.7 Sv. More recent estimates based on a variety of methods are larger than Wyrtki's figure. The average of all estimates of the Pacific to Indian throughflow is 9.2 Sv (Gordon, 1986). It seems that all investigators agree about the direction of the throughflow, but there is a wide range of estimates of its magnitude. More investigation is needed.

On the first Snellius expedition the ventilation of the Indonesian deep basins was also studied. Why is it that these basins, separated from each other and from the Pacific and Indian oceans by sills of various depths, did not stagnate as, for example, the Black Sea, which is completely anoxic below a depth of a few hundred meters? The oxygen content in the eastern Indonesian basins is not exceptionally low. Current measurements in the Lifomatola Strait on the main sill of the Banda Basin and a geological investigation of the sill have indicated that there is strong water movement from the Pacific Ocean into the Banda Basin. The rate of water renewal of the basin was estimated to be 200-3,000 years. Possible ventilation mechanisms were also discussed, such as warming up of the bottom water by the earth or by vertical mixing as a result of tidal movement. A final conclusion was not reached, however. More recent measurements of currents in the Lifomatola Strait by American investigators indicate even faster water renewal, on the order of tens of years, for the Banda Basin.

Long-term measurements of currents in selected straits and sills connecting the basins and the Pacific and Indian oceans are essential for providing better insight into the total transport from one ocean to

the other. Such measurements should be accompanied by sea level measurements and the collection of data on temperature and salinity in the upper 1,500 m. Knowledge of variations in water transport through Indonesia could be of practical application to studies of periodic and aperiodic changes in the world climate, such as the southern oscillation and the El Nino phenomenon, as well as to studies of physical processes in the other regions of the earth's oceans.

The Second Snellius Expedition

One of the research themes of the second Snellius expedition was the study of the pelagic system. The hydrographic element of this theme included the collection of data on salinity, temperature, nutrient concentration, and water transparency. The biological element of the theme included a survey of the horizontal and vertical distribution of microbial organisms, phytoplankton, zooplankton, meroplankton, and other nekton animals, as well as an analysis of the food chain components and measurements of their growth and activity. Organisms at the end of the food chain (bottom-living animals and fish) were also studied. The flow of organic matter between the various ecosystem compartments was assessed by measuring the concentration of particulate and dissolved organic matter at different depths, and by estimating the sedimentation flux at selected stations. Assessments of fish stock abundance and composition were also carried out. Such a combined approach would permit a comparison of estimates of fish resources using direct estimates (acoustic and fishing methods) and productivity and general food web structure analysis.

Investigations of basin ventilation were another research theme of the second Snellius expedition. Of the approaches applied in these investigations, the first was the direct measurement of the current on the sill, especially in the Lifomatola Strait. The second approach was determination of the age of water masses using C_{13} and C_{14} tracers and the uranium-radium-radon series. With these methods the age of the inflowing water and the length of time the water stays in the basin can be estimated. The third approach was estimation of the residence time of the water in the basin by measuring the concentration of nonconservative elements such as dissolved oxygen, calcium carbonate, and nutrients. The results of these investigations are expected to reveal much about the rate of water transport through the ventilation of the deep-sea basins.

Other themes covered by the second Snellius expedition were geology and geophysics, coral islands, and river inputs to the ocean system. All of these themes were designed to advance knowledge about the oceanography of the deep eastern Indonesia seas.

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Comments by U.S. Participant

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The large pool of hot, low-salinity surface water of the western tropical Pacific stands 10-15 cm higher than the water of the eastern Indian Ocean, and acts as a pressure head, driving a flow from the Pacific to the Indian Ocean. Estimates of the interoceanic transport vary widely, from 1.7 to 18 million m^3/sec. Potentially, it can accomplish an enormous flux of heat and salinity, which is the basis of its global-scale impact.

While it was their global-scale impact that drew this workshop participant to Indonesia's seas, I am also increasingly fascinated by various oceanographic features of these seas, including:

- The response of the ocean stratification and circulation, specifically the throughflow component, to the strong seasonal atmospheric facing. The interannual variability of ENSO (El Nino-Southern Oscillation) events can also be expected to influence the oceanography.
- The higher degree dynamics within the various passages and straits, which impede the throughflow. This retardation effect would not necessarily have a linear relationship to the pressure head. These passages may be a focus of intense cross-isopycnal mixing.
- The lateral and vertical mixing within the Indonesian waters, including the passages (as mentioned above) and the broad continental shelves. This mixing is likely induced by the strong tidal currents.
- The physical processes responsible for the high levels of primary productivity (the basis of fishery stocks). In some areas (eastern Banda Sea, south of Java) wind-induced upwelling is significant; in others vertical mixing, driven by tidal currents or strait dynamics, may be significant to the vertical nutrient fluxes.

Several U.S. and Indonesian oceanographers have joined together to propose the establishment of INSTEP (Indonesian Seas Throughflow

Experiment), which would address fundamental questions about the interoceanic transport within Indonesia's seas. The intensive observation period proposed is from February 1988 to October 1989, would utilize moorings of current meters, pressure sensors, and CTD oceanographic stations, and would determine chemically the presence of oxygen, nutrients, and various tracers (freon, tritium, helium, and radium-226). A plan to set out a network of tide gauges during INSTEP was also proposed and discussed.

The objectives of INSTEP are:

- To determine the magnitude and variability of the throughflow during the intensive observation period.
- To relate transport to simple monitoring indicators such as sea level variability so that the throughflow magnitude and variability can be determined after the intensive observation period.
- To resolve the primary water masses and pathways as well as the mixing associated with the throughflow.
- To determine the ventilation time scales of the subsill basins.

INSTEP represents an excellent opportunity for initiating related programs. The INSTEP data will provide more complete environmental information for different kinds of oceanographic research.

Knowledge of the physics of the local ocean contributes to understanding economically important aspects of the ocean such as the climate system and its variability, nutrient fluxes and associated primary productivity, and perhaps dispersion of pollutants introduced into the ocean by, for example, mining activities.

CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

Ocean sciences research includes gaining a quantitative understanding of ocean circulation and mixing, and both the mean and variable components over a wide range of spatial and temporal scales are of interest. According to the oceanography working group, physical and chemical oceanography are the primary means of studying ocean circulation and mixing.

With a knowledge of the ocean sciences one can predict the condition of the ocean's physical environment, and this is the basis of the effective development, utilization, and management of marine resources. This ability has a direct bearing on three sectors of direct economic concern to Indonesia: agriculture, fisheries, and tourism. It is also relevant to the mineral ore industry.

Agriculture

The oceanic processes within Indonesia's seas are a significant part of the complex global oceanic and climatic system. Reliable predictive models for climate variability, including the ENSO events that bring drought and forest fires to Indonesia, would be most important to the management of agriculture in Indonesia. Study of the relevant oceanic processes at work within Indonesia's seas is an important requirement for the development of climatic models.

Fisheries

The distribution of fish stocks depends on the spatial and temporal distribution of primary productivity, the beginning of the marine food chain. Primary production depends on the oceanic processes that bring nutrients into the euphotic layer of the ocean. These processes include wind-induced circulation as well as turbulence or mixing driven by the interaction of ocean currents with the complex bottom bathymetry. Knowledge of the causes of high primary productivity and how they are modified seasonally and internally would provide the basis for understanding fish stocks and how to manage them.

Another link between fisheries and ocean sciences is the distribution of pollution in the ocean, which involves coastal ocean circulation and mixing characteristics. It is essential that we understand what levels of human and industrial waste disposal are safe for coastal waters.

Tourism

Tourism is an important industry in Indonesia. Its continued growth depends on clean beaches and clean coastal waters, which in turn depend on pollution levels (discussed above).

GENERAL OBJECTIVES OF OCEAN SCIENCES RESEARCH

Fulfillment of a few key objectives for ocean sciences research will provide the knowledge needed to develop, utilize, and manage marine resources. These objectives are: (1) study of the Pacific-Indian Ocean exchange, (2) study of mixing within Indonesian waters, (3) determination of changes in heat content and thermocline depth, (4) understanding of the physical basis for primary production patterns, and (5) determination of pollution flushing rates in near coastal waters.

Achievement of these objectives, however, depends on a strategy that relies heavily on cooperation between Indonesian oceanographers and those of other nations. This is particularly the case for climate system research which is clearly an international issue. The proposed U.S.-Indonesia INSTEP (Indonesian Seas Throughflow Experiment) program, for example, is directly related to climate research.

PLAN OF ACTION

During Repelita IV (1984-1989) an experimental plan for the study of the physical basis of primary productivity should be prepared. Furthermore, the proposed INSTEP program, which will establish the basis for the long-term monitoring of the throughflow, should be realized.

During Repelita V (1989-1994) Indonesia's ocean sciences program should

- Maintain a water-level (or tide) gauge network for monitoring throughflow and other variables.
- Establish a temperature profile observation program, using ships of opportunity, to monitor variations in heat content and thermocline depth.
- Implement image processing software on the LAPAN (National Aeronautics and Space Institute) computer system and adjust algorithms for local conditions. This will be needed to monitor sea surface temperatures in support of ENSO and upwelling studies.

- Monitor pollution levels at select coastal sites.
- Maintain water-level gauges at these select coastal sites as a basis for understanding the flushing rates of the pollutants.
- Study the physical basis for primary productivity using the experimental design developed during Repelita IV.
- Carry out ocean modeling studies during Repelita V, in collaboration with the observation programs, to achieve the predictive ability that is the ultimate objective.

The following issues must also be addressed for the further development of Indonesia's ocean sciences capability.

- It is not recommended at this time that Indonesia develop its own Ph.D. program. Rather, it should continue to take advantage of existing programs in foreign countries. Since the primary language in the scientific field is English, future scientists should receive training in English language skills to meet the entrance requirements of foreign universities.

- Training and job opportunities are also required for technical personnel so that they are able to operate scientific apparatus and equipment both in the laboratories and in research vessels at sea. A good mix of technologically skilled and scientifically trained personnel is required. Special emphasis on data processing and analytic skills is recommended to facilitate the exchange of data and information with national and international data centers.

- Collaboration between research institutions and the university community is required to form closer links between these conducting theoretical studies in the field of ocean sciences and those actually performing operational tasks such as data collection and operational data analyses.

WORKING GROUP ON LIVING RESOURCES

Development and Management of Indonesian Marine Fishery Resources

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INTRODUCTION

Because seas constitute about 60 percent of Indonesia's territory, it is not surprising that Indonesians view the exploitation of marine resources with great expectations. Greater access to these resources was gained when Indonesia laid claim to its Exclusive Economic Zone (EEZ) in 1980, which was later manifested in Law No. 5/1983 and further elaborated in Government Regulation No. 15/1984.

Historically, Indonesia has depended on the exploitation of land resources through various agricultural activities. Exploitation of marine fishery resources has only been stepped up since the instigation of the five-year national development plans. The 1967 Law on Foreign Investment opened up opportunities for foreign investors to seek investment opportunities in Indonesia.

Indonesia's seas are dominated by the shallow water of the continental shelves which are mostly found in the western seas. About 1.7 million km^2 of seas, or about 50 percent of the entire territory, have a depth of less than 100 m. Some parts of the Indonesian EEZ are even shallower than 100 m as they are part of the shelves. As biological processes are largely found in shallow water, it is not surprising that most of the Indonesian waters are rich with living resources.

Indonesian marine fisheries are dominated by small-scale operations in which most of the fishermen still use simple fishing gear. Marine fishery production has risen from only 600,000 tons in 1969 to 1.8 million tons in 1985, a threefold increase in 17 years. The number of fishermen has increased accordingly, and was 1.2 million in 1985.

Marine fishery resources in Indonesia, as in other tropical waters of Southeast Asia, consist of many species. Most catches are consumed locally, but some of the highly valued species are exported to other countries. In recent years exports have risen through a special arrangement in which licensed foreign fleets are allowed to fish in the EEZ and to export their catch directly.

The exploitation of marine resources has benefited the country and its people. Some resources are still underutilized, while others have been exploited to the point that management is needed. The question raised most frequently about the development and management of fishery

resources is: Can Indonesia exploit these resources in such a way that their sustainability is ensured, keeping in mind the open access principle?

FISHERIES

The western Indonesian waters belonging to the Sunda Shelf are shallow. They include the Malacca Strait, South China Sea, and Java Sea. The eastern waters are generally deep except the Arafura Sea which is part of the Sahul Shelf. Resources found in the two areas are quite similar; the difference between the areas stems from the variation in depth and salinity of the water. The demersal resources of the Sunda and Sahul shelves are similar in kind; the difference, if any, is of little significance. Tuna are distributed in the waters having high salinity such as the Indian Ocean, Pacific Ocean, Sulawesi Sea, and some internal waters such as the Banda, Molucca, and Flores seas.

The sea condition in Indonesia is very much governed by the monsoon. The two monsoonal periods and their intermission more or less undermine the dynamics of marine waters. To some extent the availability of marine resources is also influenced by the monsoon.

The multispecies nature of the resources in Indonesia and other parts of the Southeast Asian region has been addressed by Martosubroto (1976), Pauly (1979), and Pope (1979), while problems associated with multispecies resources, especially their assessment, have been addressed by Pauly (1979) and Pope (1979). Forty-five species of fish, eight species of crustaceans, and eight species of molluscs are listed in the fisheries statistics published by the Directorate-General of Fisheries.

Small-scale Fisheries

The small-scale fisheries, which use small boats and simple fishing gear, remain labor intensive and continue to confine their operations to coastal waters. Their total catch represents about 90 percent of overall marine fisheries production (Table 1).

The number of fishermen in each area varies (Table 2). The high concentration of fishermen along the Sumatra coast of the Malacca Strait and on the northern coast of Java is to some extent related to the availability of infrastructure and markets. The high pressure of fishing in these waters has led in the past to the overexploitation of some demersal resources, which then led to social unrest when unfair competition occurred in the fishing area. This situation resulted in the 1980 ban on trawling.

The data on catch landings and the respective number of fishermen reflect the different levels of fishing pressure on resources found in various coastal waters (see Table 2).

TABLE 1 Marine Fisheries Production (Tons) by Type of Fishery, 1980-1985

Year	Small-scale Fisheries	Large-scale Fisheries	Total
1980	1,362,646	32,164	1,394,810
1981	1,375,295	32,977	1,408,272
1982	1,462,582	28,137	1,490,719
1983	1,662,446	29,573	1,682,019
1984	1,684,354	28,450	1,712,804
1985	1,789,942	31,783	1,821,725

Industrial Fisheries

Most industrial fisheries seek the highly valued commodities, shrimp and tuna. Of the 63 registered fishing companies, 27 are fishing for shrimp and 31 for tuna; the rest are fishing for other species. The catches of industrial fisheries are relatively smaller than these of the small-scale fisheries (Table 1).

Most industrial fisheries operate in the eastern Indonesian waters. Shrimp fishing is found in the Arafura Sea, and tuna fishing is widely scattered in the Pacific Ocean and Molucca, Banda, Sulawesi, and Seram seas.

Industrial fisheries are capital intensive, except for some tuna companies which on occasion still use labor-intensive poles and lines. A new development--fish aggregating devices (FAD)--has made pole and line fishing more efficient, however. This device was initially adopted by a state company, Usaha Mina.

Following the formulation of Law No. 5/1983 on the EEZ and the introduction of Government Regulation No. 15/1984, foreign fishermen were invited to exploit tuna and other pelagic and demersal fish in Indonesia's EEZ. Only fleets employing long lines, purse seines, fish nets, and gill nets were allowed to participate. Licensed fleets from Taiwan, Thailand, the United States, and Australia are presently taking advantage of this offer, and other countries have shown an interest in joining them.

TABLE 2 Marine Fisheries Landings and Number of Fishermen by Area, 1985

Area	Catch (tons)	Number of Fishermen
Western coast of Sumatra	95,239	86,996
Southern coast of Java	52,814	56,689
Malacca Strait	315,946	163,121
East of Sumatra	126,647	55,559
Northern coast of Java	403,712	292,560
Bali/Nusa Tenggara	164,378	97,256
Western and southern coasts of Kalimantan	88,230	47,358
Eastern coast of Kalimantan	89,179	78,395
Southern coast of Sulawesi	261,390	168,324
Northern coast of Sulawesi	87,612	123,345
Molucca-Irian	136,578	116,845
TOTAL	1,821,725	1,286,448

DEVELOPMENT, MANAGEMENT, AND CONSTRAINTS

Over the 19 years of Indonesia's national development plans, the Indonesian government has financed various fishery development projects. These projects have addressed infrastructure, research, training, extension, and credits to fishermen. During this period the fisheries have increased production, thereby also increasing the supply of protein. Export earnings increased from less than $100,000* in 1969 to more than $250,000 in 1985. The resulting increase in fishing boats and the availability of more landing sites, processing facilities, and other infrastructure have generated a large number of employment opportunities. Although the fisheries labor force represents only

*U.S. dollars are used throughout this report.

5 percent of Indonesia's total labor force (Sujastani, 1980), and although fisheries represent only 2.6 percent of the total gross domestic product (1984), the increased protein supply, earnings, and development that fisheries also represent cannot be understated.

The development of marine fisheries in Indonesia has varied from area to area. This development can be examined from the standpoint of trends in fisheries production (Table 3). If the Makassar and Lombok straits were used arbitrarily to delineate the western and eastern parts of the Indonesian waters, one would observe that marine fisheries production in the western part is from 1.8 to 2.2 times that of the eastern part. In terms of increase, however, the average annual rate of increase of the western part is 6.1 percent (1975-1985), while that of the eastern part is 10.7 percent. Although this difference could be attributed to the development of more industrial fisheries in the eastern Indonesian waters, it could also indicate that resources are more abundant in the eastern part of Indonesia than in the western part. An exception is the shrimp resources of the Arafura Sea, which have been highly exploited (Naamin, 1984).

TABLE 3 Trends in Marine Fisheries Production (Tons) by Major Area, 1976-1985

Year	Western Indonesia	Eastern Indonesia	Total
1976	750,163	334,531	1,084,694
1977	808,802	345,841	1,154,643
1978	834,832	392,554	1,227,386
1979	887,178	430,566	1,317,744
1980	953,582	441,228	1,394,810
1981	880,540	527,732	1,408,272
1982	979,394	511,325	1,490,719
1983	1,074,672	607,347	1,682,019
1984	1,117,719	595,085	1,712,804
1985	1,165,008	656,717	1,821,725

The level of exploitation of marine resources in the western part of Indonesia is also variable. The concentration of fishermen along the northern coast of Java and in the Strait of Malacca has meant extensive exploitation of marine resources, especially shrimp and demersal species prior to the trawl ban in 1980. The round-scad (Decapterus spp.) fishery off the northern coast of Java has been exploited to an alarming degree (Naamin, 1987). The exploitation of marine resources off Kalimantan, on the other hand, has in general been at low levels, not only after the trawl ban but prior to it as well. This was learned from a monitoring survey conducted by the Research Institute of Marine Fisheries on the R.V. Mutiara IV. This situation is attributed to the relatively low number of fishermen in Kalimantan as opposed to the high number of fishermen along the northern coast of Java. Lack of infrastructure and marketing problems have hindered the development of the fishery off Kalimantan. It is possible that Kalimantan, with its small population, is adequately supplied by the freshwater fish that abound in its rivers and other freshwater bodies. Future development in this area should be geared to developing a transport system that would allow the shipment of fish from Kalimantan to Java without loss of quality.

Marine resources in the deep waters of the Indian Ocean and other parts of Indonesia are even less exploited. Resource surveys conducted in various parts of the Indian Ocean indicate that the density of demersal stock in the Indian Ocean is lower than that in the Java Sea, and that the density of fish tends to increase toward the coast (Anonymous, 1972; Aglen et al., 1981; Lohmeyer, 1982).

A concentration of crustaceans (Solenosera prominentis) was detected at a depth of 200 m south of central Java by the R.V. OH DAE SAN. Lohmeyer (1982) found relatively large amounts of shrimp (no identification) at a depth of 200-300 m. The concentration of deepwater shrimp (scampi, Metanephrops spp.) detected at a depth of 300-500 m off northwest Australia by Australian scientists has become a commercial operation, although in limited amounts (Anonymous, 1985).

Resources in Indonesia's EEZ have been exploited for less than a year, so total catch data are still not available. Thus far 148 boats are licensed to fish in the EEZ extending into the Pacific, South China Sea, and Arafura Sea. The tendency of license applicants to seek permission to fish in the Arafura Sea stems from the likelihood that the area is rich in resources.

The development and management of fishery resources should go hand in hand, since resource exploitation is confined by the limited amounts of resources available and the common property factor. Gulland (1974) has indicated that development and management are two sides of the same coin. Thus, even in the early stages of development a management strategy should already be integrated with the development strategy.

Experience in Indonesia has shown that management of small-scale fisheries is not as easy as that of industrial fisheries. The average small-scale fishermen are poor and their lives very much depend on day-to-day operations. A management measure such as a closed season could therefore endanger their lives, unless other job opportunities are available for them.

The difficulty of managing coastal resources has led many to believe that property rights should be given to a group of fishermen or a community or cooperatives, so that management will be the responsibility of the fishermen concerned. Such a system has been developed successfully in Japan (Yamamoto, 1983).

In 1983 and prior to the fourth five-year national development plan the Asian Development Bank (ADB), in association with the International Bank for Reconstruction and Development (IBRD), studied the fisheries sector in Indonesia. One proposal of this study was that the Indonesian government, in an effort to reach the development target in the fourth five-year development plan, enhance credit mobilization and private sector mobilization. In the three years that have elapsed since that suggestion, some of the ADB proposal has been adopted and implemented in the form of a project. The government has recognized, however, that credit mobilization faces various problems, and this project has suffered from the delays in credit repayment by fishermen. Because the government has faced financial difficulty in recent years, an effort has been made to reschedule projects, especially those funded by loans. To mobilize the private sector the government created such incentives as simplified export procedures and restructured license procedures.

Because trawl fishing is still banned in all Indonesia except in the Arafura Sea, shrimp culture is attracting greater investment. The shrimp produced in brackishwater ponds has partially served as export substitutes. Tuna fisheries are also attracting increased investments in the form of private companies with national capital or in the form of joint ventures.

The private sector seems to be more interested in investing its money in export commodities such as shrimp, tuna, shark (for oil), and oyster (for pearl), and this situation may not change much in the coming years. A government committee is devoted to increasing the future role of the private sector in the development of fisheries.

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Comments by U.S. Participants

Earl J. Conrad, Chairman of the Board, Port Clyde Foods Inc.

For over 35 years I have been involved in the catching, processing, and marketing of fish in the United States, Canada, Mexico, Costa Rica, and Panama. Throughout this period I worked closely with the university and government scientists of these countries to ensure that the harvest of fish could be sustained and would not destroy the resource for future generations.

The offshore waters of Indonesia can play a significant and rewarding role in helping satisfy the growing demand for fish and shellfish throughout the world. To extract the greatest long-term value from these waters, however, expanded utilization must be supported by scientific evidence and not undertaken because of short-term market opportunities.

It is important to have a system of technology transfer that will encourage fishermen to improve their harvesting and processing methods. It is equally important, however, that harvesting and processing technologies be part of the research on marine resources and that there is clear evidence of their impact on resource populations. They must also contribute to the data base of information, both statistically and biologically. A system that promotes mutual respect between fishermen and scientists is essential to any resource management plan. Such a plan--developed by the national government, utilizing university facilities and researchers, and supported by the leaders of fishing associations and industry--is needed to ensure the orderly expansion of underdeveloped fishery resources.

David M. Checkley, Jr., North Carolina State University

These comments address the role of eggs and larvae in the recruitment of pelagic fish and the potential for an eel fishery in Indonesia.

The eggs and larvae of fish are useful to fisheries in three ways. First, egg and larva surveys can be used to assess the abundance and distribution of the spawning biomass of fish populations. This is useful in discovering new populations as well as assessing and managing

known ones. Second, investigations of eggs and larvae and their environment are useful in understanding the dynamics of fish populations, especially recruitment. Managers can therefore determine whether the decline of a fishery is the result of natural causes or overfishing. Finally, fish eggs and larvae are themselves potential fisheries. The larvae of several species of fish, including the Japanese sardine (Sardinops melanosticta) and anchovy (Engraulis japonica), are fished for human consumption (shirasu) in Japan.

The eggs and larvae of fish provide therefore information for both the short-term management and longer-term understanding and prediction of fish resources. Indonesia's development and management of its fish resources, especially the small pelagic species (for example, Sardinella spp., sardines; Stolephorus spp., anchovies; Rastrelliger spp., Indo-Pacific mackerels; and Selar spp., jack-like mackerels), would benefit from studies of the eggs, larvae, and environments of these species.

Anguillid eels, found off Indonesia, may be a valuable fishery resource. Anguilla celebensis (A. bicolor bicolor) and A. marmorata are the dominant species. Spawning occurs in the deep water southwest of Sumatra and Java, northwest of Irian Jaya, east of Kalimantan, and around Sulawesi. Fisheries could consist of the capture of migrating eels prior to entering freshwater or the capture and pond culture of young eels, as in Japan. Potential markets include Japan and Europe.

Conclusions and Recommendations

These working group discussions concentrated on living resources that could benefit Indonesia economically, both as import substitutes and as export commodities. The following resources were given priority for improvement and development.

SHRIMP

Shrimp plays an important role in Indonesian fisheries, and the value of shrimp exports has increased yearly. The shrimp fishery has developed rapidly since trawling for shrimp began in 1966. The steady rise in both the demand for and the price of shrimp products have stimulated national and foreign capital investment in the shrimp trawl fishery. Shrimp production increased from 8,000 tons in 1968 to 96,000 tons in 1979, and shrimp exports increased from 2,002 tons ($824,000) in 1969 to 34,621 tons ($200.5 million) in 1979. In 1968 the value of shrimp exports constituted just 29 percent of the total value of exported fisheries products. It had increased to 90.6 percent by 1979, but it fell during the five years following the initiation of the trawl ban in 1980.

Indonesia has many good shrimp fishing grounds, such as the western and eastern coasts of Sumatra, northern and southern coasts of Java, off Kalimantan, and south Sulawesi and the Arafura Sea off Irian Jaya. The most important species supporting the Indonesian shrimp fishery are of the family Penaeidae, including those of exportable size of the genera Penaeus and Metapenaeus. It has been estimated that of the approximately 180,000 tons of shrimp available each year in Indonesian waters, 50 percent could be harvested on a sustainable basis. Overall shrimp production in 1985 was 53,429 tons with a level of utilization of about 59.8 percent. Thus, there is the potential for further development, especially in the western Indonesian waters where trawl fishing is prohibited. In the eastern waters, especially in the Arafura Sea, the only area in which trawling is permitted, the level of utilization is near the maximum sustainable yield.

Constraints to Fully Utilizing Indonesia's Shrimp Resources

The two main constraints to achieving the potential yield of Indonesia's shrimp resources are technological and legal.

Technological constraints occur primarily in the western waters of Indonesia, where trawl fishing, the most effective method, is banned. The trammel net has largely replaced the trawl in these waters, but it is very selective, immobile, and limited to shallow water. An estimated 20-30 percent of the total sustainable shrimp resources are caught with the trammel net. Despite evidence that the shrimp stock has recovered and is presently underutilized following the trawl ban, reintroduction of the trawl has not been considered for political reasons. The trawl was associated with problems that concerned the traditional fishermen of shrimp and overfishing in some areas.

Legal constraints to exploitation of shrimp stocks include the export of gravid females as brood stock, which is illegal but lucrative, and the efforts required to obtain a shrimp fishing permit.

Recommendations

- Preharvest stage. Improved management is needed to preserve the Arafura shrimp fishery for three reasons: (1) the present level of exploitation is near the maximum sustainable yield; (2) there is evidence of decreasing catch per unit effort; and (3) there has been a decline in the size of shrimp caught. Simplification of the licensing procedure is also needed to encourage investment in shrimp fishing.

- Harvest stage. For western Indonesia gear other than the trammel net should be found to replace the trawl, and the trammel net fishery should be better regulated to avoid conflict between fishermen in coastal waters.

- Postharvest stage. The by-catch of the shrimp fishery should be investigated as a source of fish meal or silage.

TUNA

Indonesia possesses large tuna resources, some of which can sustain increased exploitation. The present catch of tuna is dominated by skipjack (*Katsuwonus pelamsis*) and to a lesser degree by the yellowfin (*Thunnus albacares*). Other species of potential value include the bigeye tuna (*Thunnus obesus*) and numerous smaller tunas.

Most tuna are caught with poles and lines and fewer with purse seines, trolling, long lines, and gill nets. Pole and line fishing is labor intensive and thus may be less efficient than the purse seine.

Because tuna are perhaps the most highly migratory fish, they are among the most difficult for assessing population size. Although the resource size is largely unknown, most agree that it would sustain increased exploitation and thus deserves attention.

Recommendations

- Preharvest stage. More information about the available resources is needed. For example, it is uncertain whether bigeye tuna is available in other parts of the Indian Ocean; it is now caught off Lombok and especially in the Banda Sea. Bigeye is more valuable than yellowfin and skipjack and is usually caught with long lines. It is uncertain whether purse seines can be used for its capture.

- Harvest stage. Because bait availability is a problem for pole and line fishing, bait rearing, holding, and transportation should be studied. Further development of purse seine fishing should also be considered, as well as the legal constraints associated with its use in the vicinity of porpoise.

- Postharvest stage, processing, and marketing. Many possibilities exist for tuna export marketing, ranging from *katsuo bushi* (dried skipjack) to *sashimi* (fresh or frozen tuna). Domestic handling and distribution should be improved.

NEW RESOURCES

Small Pelagics

Indonesia's seas have extensive populations of underutilized small pelagic fish, including anchovies, sardines, sardinellas, herring, mackerel, and trevallies. The Directorate-General of Fisheries has estimated that only 23 percent of a total potential production of 931,000 tons of pelagic species was harvested in 1981. Thus, a considerable amount of pelagic production remained available for harvest. Some of this unexploited potential was tuna and other large pelagics, but most consisted of a mix of small pelagic species.

Small pelagic species are consumed directly as human food in Indonesia, although their relative sensitivity to storage and transport limits human consumption to fish caught close to the consuming population. Small pelagics can be canned, but the sale price of this product is lower than that of canned tuna and limits the economic potential of canning operations. Small pelagic fish are most commonly used as a raw material for producing fish meal, and as such they offer Indonesia a real hope as an import substitute.

An economically viable fishery for small pelagics would have to consist of concentrations of a combination of species that would allow catches of about 200,000 tons over a period of six months. Such concentrations are likely to occur in eastern Indonesia because of probable upwelling in this area and the natural migratory patterns of the species involved. A small pelagic fishery could produce fish both for human consumption nationally and for export and fish meal to replace that currently imported.

Recommendations

- Preharvest stage. The low level of knowledge about the distribution, migration patterns, and areas of concentration of small pelagic species could be overcome with the help of an aerial survey conducted by a fishing company interested in Indonesian resources. Alternatively, such a survey could be conducted by Indonesian agencies. The size and widespread occurrence of pelagic species require the use of aerial assessment techniques and experienced observers, however. Egg and larva surveys in productive regions would be useful as well. Indonesian scientists must therefore be trained to carry out such surveys effectively.

- Harvest stage. Methods for harvesting small pelagics are well established worldwide. They could be easily adopted by Indonesian fishermen and used from modest-sized motorized vessels.

- Postharvest stage. The postharvest technology for handling small pelagics is already operational in Indonesia. Thus, trained personnel are available to staff a new operation for small pelagic resources.

- Distribution and marketing. Systems for the distribution and marketing of all three products potentially producible from small pelagic resources already exist in Indonesia and worldwide.

Squid

A valuable commodity on the world fish market, the squid in Indonesia's seas are presently underexploited. Previous survey and fishing efforts have indicated that squid resources exist near Lombok and throughout eastern Indonesia.

Capture is primarily by small seine, and by trawl, jigging, and long line as well.

The present small catch of squid in Indonesia is salted and consumed locally. Significant export markets exist, however, especially in Japan, for chilled and frozen squid at prices of more than $2,000 a ton. Although squid is used primarily for human consumption, it is also valuable as an additive to cultured fish feed.

Recommendations

- Preharvest stage. Abundant squid stocks appear to exist in eastern Indonesia and near Lombok. Other stocks should be identified and all stocks assessed.

- Harvest stage. Gear and fishing methods should be investigated. Because the technology for squid fisheries exists in other countries, use of this technology in Indonesia will not require great capital investment.

- Postharvest stage. To maximize value the catch should be iced, frozen, or dried.

- Distribution and marketing. Market demand must be explored. Japan would be a likely export market.

Deepwater Sharks

Sharks are presently harvested from the shallow waters, yet significant populations exist in the deep water of the Exclusive Economic Zone, as indicated by the large catches made on tuna long lines. Nearly all parts of a shark are valuable, including its fin, skin, muscle, and, especially, oil (squaline), which is rich in vitamins A and D and valuable for cosmetics. Squaline from deepwater sharks is more valuable than that from shallow-water sharks. Indonesia exported $5-6 million in shark oil in 1986, at a value of $7-10 a kilogram.

Recommendations

- Preharvest stage. Deepwater stocks are apparent from the tuna long line by-catch. Thus, additional stock assessments would be useful. Because shark populations are easily overfished, careful management is needed.

- Harvest stage. The long line is the preferred method of capture and is available to Indonesian fishermen with little additional technology.

- Postharvest stage. The technology available for shallow-water sharks is appropriate for deepwater sharks, including storage and squaline production.

- Distribution and marketing. Strong export markets exist for shallow-water sharks.

Deepwater Shrimp

Past fishing has indicated that stocks of pelagic and demersal shrimp exist in Indonesian waters deeper than approximately 250 m. The status of these stocks is largely unknown, however. In Australia scampi shrimp have been harvested from as deep as 500 m.

Recommendations

- o Preharvest stage. Little is known of either the pelagic or demersal shrimp stocks. Both must be assessed for abundance, availability, and sustainability.

- o Harvest stage. Trawling in deep water should be feasible using the large trawlers now available in Indonesia, with modifications. A potential constraint to harvesting the demersal shrimp of the Indian Ocean is the rough bottom strewn with rock and coral.

- o Postharvest stage, distribution, and marketing. The practices now in use for shallow-water shrimp should be applicable to deepwater shrimp. Strong export markets exist.

MARICULTURE

The culture of marine organisms is a relatively new venture in Indonesia. The culture of fresh- and brackishwater organisms is highly successful, and thus mariculture is perceived to have great potential. Marine organisms presently being cultured in Indonesia include fin fish such as grouper (*Epinephelus* spp.), sea bass or barramundi (*Lates calcarifer*), and snappers (*Lutjanus* spp.); invertebrates such as shrimp, crabs, pearl oysters, and sea cucumbers; and seaweeds. Cultures of most of these organisms are begun with young stages collected from nature, which at times are limited in availability. The United Nations Development Program has funded research that has led to the controlled spawning of sea bass, an important step in its complete culture.

Constraints to the development of mariculture in Indonesia are primarily the cost of food and the availability of young. Food, which is imported as fish meal, is often the major expense of mariculture. Thus, the availability of a less costly supply of food, such as fish meal from shrimp by-catch, would reduce production costs. The supply of young for stocking is also important. Efforts should be made to both optimize the acquisition of naturally produced young and produce young in captivity. Because the culture technology, processing, distribution, and marketing are well developed, there is significant potential for mariculture in Indonesia.

COASTAL RESOURCES

The living resources of Indonesia's coastal regions are not necessarily undeveloped, but they require proper management to ensure sustained yields. In some regions such as parts of Java exploitation is heavy, while in other places such as Kalimantan and Irian Jaya resource use is low. The management of Indonesia's coastal waters is

complicated by the high density of its resources and how they are exploited.

It is recommended that a coastal resources management plan be initiated to place the ownership, use, and management of resources in local cooperatives or fisheries. Such a method has worked successfully in Japan and in a small region of Indonesia in the Moluccas Islands for a riverine fishery. This plan should include a central body to advise and study the local units, particularly stock assessment and research. Full implementation of such a plan should be a long-term goal (perhaps 10 years), but a cost-benefit analysis and its implementation should begin within a year.

FISHERIES RESEARCH

Research is needed at all stages of the development, use, and management of Indonesia's living marine resources. For example, to attract capital for fisheries development, information on the distribution, abundance, and production of the resource in question is needed to predict a return on investment, be it by government or the private sector. Gear development and technology must also be analyzed. At present, only $60,000 is devoted to fisheries research, while fisheries exports alone exceed $300 million annually.

First, and most important, resources must be identified and their potential assessed. Both conventional means—such as sampling from ships, aerial surveys, and questioning of local fishermen—and novel methods, especially remote sensing (for sea surface temperature and phytoplankton), should be considered. The optimal strategy for discovering and assessing fish stocks would use oceanographic (physical, chemical, and biological), satellite (sea surface temperature and chlorophyll), and fishery (egg, larva, and acoustic) investigations. It is necessary to know, for example, what level of exploitation can be sustained by a resource and whether variations in the size of that resource are natural or a result of human activities. Such knowledge cannot be acquired elsewhere and thus it is of high priority. This is a goal shared by fishery scientists of all nations.

Second, research on fisheries technology is needed, including gear and design, fishing methods, and postharvest storage and processing. Much of this technology exists elsewhere in the world and need only be adapted to both the small-scale and larger fisheries in Indonesia.

Third, research on the socioeconomics of Indonesia's fisheries—artisanal and industrial, coastal and offshore, developed and developing—is recommended. The economics of fisheries includes the cost of resource assessment and management, capitalization, marketing, sales, local income, and export revenue. Sociological factors include employment and protein production. Evaluation of a potential fishery and management of existing fisheries require a basic knowledge of these and other factors. Principles established elsewhere should be applicable, with modification, to Indonesia.

Finally, research on mariculture is required. Particular areas needing attention are the development of food for cultured organisms and the production of or access to young for stocking and sustaining cultured populations. The socioeconomics of mariculture also deserves attention.

Funding for fisheries research is a major constraint. It is essential that significant financial support be committed to research if Indonesia's fisheries are to sustain exploitation.

HUMAN RESOURCES

The development, use, and management of Indonesian living marine resources also requires educated and trained personnel. The vocational schools, academies, and universities must therefore train the artisanal and industrial personnel (including fishermen, gear and boat builders, ships' crews and officers, processors, and marketing persons) and research and extension personnel (including fisheries managers, scientists, and extension workers) needed for jobs associated with the fisheries. The latter persons are important because they provide for the transfer of both technology from research institutions to users (for example, fishermen and processors) and problems from users to research institutions.

The development of human resources is hindered by the current shortage of funds, low quality of education, and lack of training appropriate to Indonesia's needs. Thus, it is recommended that increased funding be expended for the education and training of fisheries personnel, including facilities such as training vessels and equipment. It is also recommended that the quality of the present educational and training institutions be improved, rather than creating new institutions or programs. It may be useful to strengthen one institution of each type as a center of excellence in Indonesia. Finally, it is recommended that the education and training be appropriate to Indonesia's needs, including such diverse elements as artisanal fishermen and multispecies and multi-island fisheries.

INSTITUTIONAL CONSIDERATIONS

The Coordinating Committee for the National Territory (Panitia Koordinas Wilayah Nasional), which was established in 1971, has continued to coordinate activities pertaining to Indonesia's seas, even after 1982 and the Law of the Sea Convention (LOSC). It was decided then that there was no need to establish a separate agency to implement the provisions of the LOSC. It was somehow believed that the various departments in Indonesia would adjust to the situation, which has drastically changed since 1982.

MANAGEMENT

Management of fishery resources to ensure fulfillment of the long-term social and economic needs of Indonesia is complicated by the number of species and types of fisheries in Indonesia. It is not possible therefore to develop a management program that can be applied universally to all fishery stocks.

It is recommended that a task force made up of policymakers, researchers, and industry representatives be assigned to each resource in need of management. These task forces would establish, perhaps regionally, goals and objectives for each of the fisheries, including target catches to be accomplished over time. In view of the likelihood of future exports from the new fisheries, a program of quality assurance will be essential for commercial success.

TIMETABLE

A possible timetable for the recommendations made in this section is shown in Table 1.

TABLE 1 Possible Timetable for Implementation of the Recommendations of the Working Group on Living Resources

Topic	Repelita IV (1984-1989)	Repelita V (1989-1994)	Repelita VI (1994-1999)
SHRIMP			
Preharvest			
Arafura fishery mgmt.	X		
Licensing simplification	X		
Harvest			
Alternative gear to trammel net		X	
Regulation to reduce coastal fishermen conflicts	X		
Postharvest			
By-catch for meal or silage		X	
TUNA			
Preharvest			
Resource assessment		X	
Harvest			
Bait availability		X	
Purse seine fishery development		X	

TABLE 1 Continued

Topic	Repelita IV (1984-1989)	Repelita V (1989-1994)	Repelita VI (1994-1999)
Postharvest			
Processing and marketing		X	
NEW RESOURCES			
Small pelagics		X	
Squid		X	
Deepwater sharks		X	
Deepwater shrimp		X	
MARICULTURE			
Food (fish meal) production		X	
Young for stocking			
Improved collection from nature		X	
Artificial propagation			X
COASTAL RESOURCES			
Coastal management plan			
Cost-benefit analysis	X		
Initial implementation	X		
Full implementation			X
FISHERIES RESEARCH			
Resource assessment		X	X
Technology research		X	X
Socioeconomics		X	X
Mariculture		X	X
HUMAN RESOURCES			
Increased funding for education, training, and facilities		X	X
Improvement in quality of education and training		X	X
Improvement in appropriateness of education and training		X	X
MANAGEMENT			
Implementation of task forces		X	

WORKING GROUP ON MINERAL RESOURCES

Indonesian Offshore Mineral Deposits

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Marine Geological Institute

INTRODUCTION

The available information on the occurrence of marine mineral deposits in Indonesia is generally poor, except for oil, gas, and tin, which are already being exploited and exported (Table 1). Other minerals (e.g., manganese nodules, cobalt-rich ferromanganese crusts, phosphorite) with resource potential have been found in Indonesian waters, but their abundance relative to quantities necessary for commercial exploitation are unknown because only a small portion of the seabed has been explored. Geologic reasoning also suggests that conditions are favorable for the occurrence of other mineral resources. For example, the oceanic crustal rocks in some Indonesian seas have magnetic properties that some scientists believe originated from spreading centers where the rocks were formed by high-temperature volcanic processes. Mineral deposits related to present or former spreading centers, found in similar geologic settings elsewhere, are therefore likely to occur in Indonesian waters.

The potential for mineral resources in Indonesian seas can be determined through a program of reconnaissance geological surveying, mapping, and sampling followed by detailed exploration of specific areas of promise.

GEOLOGIC ENVIRONMENT OF MARINE MINERAL RESOURCES

Hydrocarbons

World offshore oil production is now about 20 percent of total production, but it will probably increase in the future. Offshore oil production in Indonesia is now about 41 percent of total production, and it too is likely to increase in the future and possibly exceed onshore production (Figure 1).

Oil is found in sedimentary basins, and geologically Indonesia's basins can be classified into four types:

1. Fore arc basins
2. Back arc basins (inner arc basins)
3. Intracratonic basins (median basins)
4. Passive continental margin basins.

TABLE 1 Stage of Beneficiation and Occurrence of Indonesian Marine Mineral Resources

	Stage of Beneficiation			Occurrence	
Type of Resource	Exploration	Exploitation	Export	Coastal	Offshore
Tin	X	X	X	X	X
Iron sand	X	X	X	X	X
Quartz sand	-	X	-	X	X
Sand and gravel	X	X	X	X	X
Mud	-	-	-	X	X
Coral	-	X	-	X	X
Manganese nodules	-	-	-	-	X
Metalliferous muds	-	-	-	-	X
Chromite	-	-	-	X	X
Oil and gas	X	X	X	X	X
Radioactive minerals	-	X	-	X	X
Coal	-	X	X	X	X
Geothermal energy	-	-	-	X	X
Phosphate	-	-	-	-	X

FIGURE 1 Oil fields in Indonesia.

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Fore Arc Basins

This type of basin is formed directly from subduction, when subsidence occurs between the zones of accretion and volcanism. Such basins are found in western Sumatra, southern Java, the Sawu Sea, and the Weber Deep. They are all located at similar positions in an island arc setting between a subduction trench and magmatic arc. The thickness of the sediments may reach up to 7 km, but until now no oil has been taken from these basins. Offshore exploration west of Sumatra has indicated the presence of gas. The absence of oil is probably caused by a low heat flow. Thus, the process of hydrocarbonaceous maturation could not have taken place. The occurrence of a large quantity of volcanoclastic constituents in the basin may also be hindering the accumulation of hydrocarbonaceous sustances.

Back Arc Basins

This kind of basin is the most productive because (1) substances are present for the generation of hydrocarbon, (2) its sedimentary layers are favorable for the accumulation of hydrocarbon in the clastic as well as carbonate facies, (3) the deep-sea shale acts as seal, (4) sufficient heat flow is present for maturation during deposition and subsidence, and (5) favorable tectonic conditions are present for the construction of structural traps.

In Sumatra the back arc basin is bounded on the southwest by the Semangko fault and on the northeast by the tin belt. Stratigraphically, it is resting on the Sunda craton which includes permo-carboniferous layers rich in hydrocarbonaceous substances. The basin opened during the Paleogene period and was supplied by materials from neighboring areas. The sediments are rich in carbonaceous materials derived from favorable environmental conditions: terrestrial with alluvial fans, fluviatile, lacustrine, and swampy.

During the Early Miocene period a transgression occurred in which sediments were deposited that later developed into reservoir rocks. Deposits of shale in a deep-sea environment act as trap layers.

The uplift that occurred during the Middle Miocene period raised the Barisan Mountains. This was accompanied by subduction, volcanism, and transcurrent dextral Semangko faulting. The back arc basins were then compressed, creating structures favorable for hydrocarbonaceous accumulation.

Such back arc basins extend the whole length of Sumatra on the eastern part of the Barisan Mountains, especially the foothills and coastal plains. The basins extend to the northern part of Java.

Intracratonic Basins

The Tarakan, Kutai, Barito, and Makassar (intracratonic) basins are found in eastern Kalimantan and the Makassar Strait. They are located

between the core of the craton in Kalimantan and the Tertiary volcanic front in West Sulawesi. The basins of this volcanic front, which is actually a magmatic arc, are in a back arc position.

The formation of these basins began during the Paleogene period through the processes of extension, thinning of the continental crust, and subsidence. Subsidence continued during the Middle Tertiary period with the deposition of transgressive sediments, followed by regression with compressive movements related to the uplift of the Meratus Range. It could have also been related to the Tertiary West Sulawesi Arc development. These conditions facilitate the deposition of carbonaceous material, its maturation, and the accumulation of hydrocarbon. The heat necessary for maturation comes from the extension process.

Passive Continental Margin Basins

This type of basin is confined to a passive continental margin and is related to the extension of the Australian continental crust to the Indonesian area. It is a passive margin as it does not have an island arc system at its margin.

The basin between Timor and northwestern Australia has been explored for its hydrocarbon potential with favorable results. Since the basin extends substantially into Indonesian areas, it should be considered a potential area for hydrocarbon exploration.

The sediments overlying the basement have shown a horst and graben structure. A regressive phase of sedimentation was followed by transgressive sediments and followed again by regressive sediments. This cycle continues during geologic history. Layers containing oil and gas occur in sediments that are Permian, Triassic, Jurassic, and Cretaceous in age.

When the northwestern extreme of the basin collided with the Banda Island Arc system, a complicated structure resulted. Important structural features associated with the collison are a trench, where the Australian shelf collided with the Banda Island Arc, and an accretionary wedge, which is occupied by the outer nonvolcanic Banda Arc. The complicated structures of the accretionary wedge are caused by the buoyancy properties of crusts, where it is not possible for a continental crust to be subducted under the arc continuously. Consequently, a mixing of arc and shelf components occurs, resulting in overthrusting, shearing, and faulting.

An exciting geological discovery was recently announced by Pertamina from the Tomori Block, Tiaka Well No. 1, located offshore east of Sulawesi. A delineation well (Tiaka No. 2) confirmed the presence of oil, derived from Miocene carbonates, at a depth of over 2,218 m. The Tomori Block is located within the Sula Microcontinent. It is thought that oil from such an environment originates in the Triassic-Mesozoic layers and is trapped in younger layers. Further study is needed of the Miocene carbonate layers in which the oil is reported to be and of how they relate to the underlying Mesozoic basement.

Tin

It is mostly secondary deposits (placers) of tin that are being mined in offshore areas. Tin particles with a high specific gravity are scattered from the disintegrating mother rock (tin-bearing granite), and they become concentrated by sorting. The processes responsible for this disintegration and concentration process are rock weathering, river erosion, sea abrasion, and sorting by repetition of transgression and regression caused by sea level changes during the Quaternary. These processes facilitate the sorting of minerals, while the high specific gravity of tin facilities the concentration of tin ore. Sorting may also be caused by the action of river water.

Tin occurs in the areas surrounding Bangka, Singkep, Karimun, Kundur, and Belitung, which are located in the tin-granite belt. This belt extends to the Malay Peninsula and Thailand, and there is possibly an eastern extension to Kalimantan. The age of the tin granite is Triassic.

Based on technical data furnished by the dredge vessels owned by PT Tambang Timah, the maximum depth at which tin ore can be dredged is 21 m. Two dredge pontoons are in operation: a Surabaya dredge pontoon with a maximum dredge depth of 21 m and a Rayah dredge pontoon with a maximum dredge depth of 12 m (Ministry of Mines and Energy, 1984).

Radioactive Minerals (Th)

Tin-bearing granites also contain monazite, radioactive minerals in which thorium is an important element. Monazite is therefore a by-product of tin mining and may be found off Bangka, Belitung, and the other tin islands (IAGI, 1985).

Chromite

Chromite deposits have reportedly been found in eastern Sulawesi, and it has also been reported that offshore deposits occur near the known onshore deposits (McKelvey et al., 1970). Details about the deposits are not given.

Geologically, chromite is associated with ophiolite-ultrabasic rocks, which are known extensively in eastern Sulawesi. Thus, it is highly likely that chromite occurs in the offshore areas of eastern Sulawesi. Because chromite is in high demand, exploration should be pursued.

Phosphorite

Phosphorite deposits on the sea floor south of Timor have also been reported (McKelvey et al., 1970), but again no details about the deposits are available.

Based on the geologic conditions of known deposits, marine phosphorites can be formed in both deep and shallow seas at depths of from 30 to 300 m, where slow clastic sedimentation takes place.

Offshore Metalliferous Muds

Metalliferous muds have been discovered on the Sangihe Islands near Awu volcano (McKelvey et al., 1970). Further details are not known.

Offshore metalliferous mud is formed by hydrothermal processes at a temperature of about 350°C. This process usually occurs at zones of seafloor spreading, at undersea flanks of an active volcano where fumarolic/hydrothermal activities are taking place, or at the summit of a submarine active volcano.

Iron, manganese, copper, and nickel commonly occur as sulfides. These elements are derived from magma with a basaltic composition.

Hydrothermal processes take place at depths that vary from several hundred meters in the Red Sea to over 5,000 m at spreading centers in the Atlantic and Pacific oceans. Metalliferous mud has been collected from the volcanoes Banu Wuhu and Manupi in the Pacific and Santo Rini from the Mediterranean Sea. The metalliferous mud at offshore areas near the Gunung Awu-Sangihe Islands may come from the flank of the underwater Awu volcano where fumarolic or hydrothermal activities are taking place.

Active spreading centers are not present in Indonesia. The spreading magmatic lineations on the floor of the Banda Sea and south of Sumba are the result of seafloor spreading that began during the Jurassic period and ceased during the Cretaceous period. Thus, it is likely that the seafloor contains hydrothermal mineral deposits.

Iron Sand

Iron sand is found along almost all the shore line south of Java, and reportedly along the western coast of Sumatra. Iron sand from some of the deposits mined at Cilacap and south of Yogyakarta has been exported.

Concentrations of ore are formed by the direct abrasion of sea waves on coasts where volcanic effusive rocks occur. Iron sand is composed mainly of magnetite and ilmenite, the parent rock from which volcanics are derived. The volcanics are known as the Old Andesite Formation, which is Paleogene in age. Derivation from younger volcanics may also be possible as these are also found along the southern coast of Java.

Manganese Nodules/Crusts

Manganese nodules are found at the bottom of the world's oceans. Manganese also occurs as oxide pavements, or crusts. Reportedly, manganese has been found west of Sumatra, south of Lombok, in the Banda Sea, near the islands of Damar and Misool, north of Sula, north of Manada, north of Halmahera, and north of the Birds Head.

Manganese modules are generally discovered in deep seas between 4 and 5 km deep. They have, however, also been reported in relatively shallow seas. Nodule size varies from microscopic to 1 m in diameter. Although this resource probably occurs in large quantities, mining is still risky and not economical.

Coal

Geologically, coal deposits can extend to offshore areas, as is the case with hydrocarbon. Hydrocarbon can be easily mined, however, because of its liquid nature, but this is not the case with coal. Thus far industry has shown no indication of undertaking offshore coal mining in Indonesia.

Coral

In offshore remote areas coral has been excavated for building materials, and on a small scale excavation is permitted. Large-scale excavation, however, should be prohibited because it creates an imbalance of the ecosystem and generates unfavorable environmental conditions.

Geothermal

Indonesia is an island arc which has a magmatic belt with volcanoes as a surface manifestation. Geothermal energy has therefore great potential for Indonesia.

Because on-land geothermal energy has already been modestly exploited and can still be developed and extended, it is doubtful that exploitation will take place offshore in the coming decade.

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Conclusions and Recommendations

INTRODUCTION

Mineral resources play an important role in Indonesia's development. In the last decade offshore oil and gas production have gained a larger share of total oil production--it presently represents 41 percent of total production and will exceed 50 percent in the near future.

These conclusions and recommendations do not address the potential of oil and gas. They concentrate instead on other commodities that are known to have potential but are underdeveloped. The following sections identify these commodities, arrange them according to short- and long-term development, identify constraints to their development, propose a development program, and give a plan for short-term action during Repelitas V and VI.

ANALYSIS OF MINERAL COMMODITIES

Table 1 shows the mineral commodities known to occur in Indonesia's seas. Of these commodities, the nine listed in Table 2 were judged to have the most promise and were the subject of further discussion. Table 2 also lists factors that must be taken into account before placing priority on the development of one mineral over another. Known occurrence ranges from the wealth of information on Indonesian offshore tin placers to the scattered reports of manganese nodules and crusts. A probable occurrence is one suggested strongly by the geologic setting, such as the likelihood of gold placers being found off areas of known onshore gold deposits. In most cases the quantities of resource minerals present in Indonesian waters are totally unknown.

In Table 2 technology is considered developed if it is available anywhere in the world. The working group assumed that a technology could be acquired, for a fee, if needed. In some cases mining techniques have been tested and proven workable, although the particular commodity is not being mined commercially. In two instances in Table 2 processing technology is shown as commercial even though mining has not passed the test phase. The reason for this apparent paradox is that metallurgical processes have been developed for the onshore equivalents of these marine commodities.

TABLE 1 Examples of Mineral Commodities for Future Development

Placers	Aggregates	Industrial Minerals
Tin	Sand	Clay/kaolin
Gold	Gravel	Bentonite
Diamond	Pumice	Wolframite
Monazite	Shell	Quartz sand
Iron sand	Coral	Barite
Ilmenite		
Garnet		
Chromite sand		
Zircon		

Hydrogenetic	Hydrothermal Muds
Cobalt-rich manganese crust	PMS (polymetallic sulfides)
Manganese nodules	Copper
Aragonite	Zinc
Phosphorite	Lead
	Gold
	Platinum
	Silver

The infrastructure cost indicated in Table 2 includes the cost of providing services such as power, water, roads, schools, and housing to accommodate the people and materials involved in the mining steps that lead to a marketable product. For example, a mining firm would have to invest about $1.7 billion to begin a manganese nodule venture. This investment would provide for two mining ships, a fleet of ore carriers, a marine terminal, a processing plant, a waste disposal facility, and a transportation net. In the case of sand and gravel a mining company would build a shoreside facility for washing and sizing, and it would have to locate the plant near sources of water and power and near a rail track leading to market.

The environmental impacts shown in Table 2 are of general concern. Their relative ranking, however, reflects the extent to which research--conducted mainly in Europe, Japan, and the United States--makes it possible for a regulator to ensure that commercial recovery activities will be carried out in a manner that is reasonably safe environmentally. Sand and gravel mining is of special concern in Indonesia because it would probably be conducted close to metropolitan areas and fisheries. Although this situation is found in Japan and Europe without apparent pollution, this working group recognized the potential for damage to fisheries in Indonesia if the proper regulations are not imposed.

TABLE 2 Potential Development of Marine Mineral Resources in Indonesia

Mineral Family	Occurrence/ Quantity	Mining/ Processing Technology Developed	Infrastructure Cost	Environmental Impact	Priority Research Needs	Market Potential: Within 10 Years	Market Potential: Beyond
SHALLOW SEAS							
Placers							
Gold	Probable/ ?	C/C	Low	Low	Exploration	High	High
Tin	Known/ abundant	CS/C	Low	Low	Deeper water mining	Medium	Medium
Aggregates (sand and gravel)	Known/ abundant	C/C	Low	Medium	Environmental effects	High	High
Industrial (glass sands)	Known/ abundant	C/C	Low	Low	Exploration	Medium	Medium
DEEP SEA							
Hydrogenetic							
Manganese nodules	Known/ ?	T/T	High	Low	Exploration	Low	Medium
Manganese crust	Known/ ?	None/T	High	Low	Exploration & mining	High	High
Phosphorite	Known/ ?	T/C	Medium	Low	Exploration	High	High
HYDROTHERMAL MUDS	Probable/ ?	T/None	High	?	Exploration	High	High
Polymetallic sulfides	Probable/ ?	None/C	High	?	Exploration & mining	Low	Low

Note: ? = Unknown
C = Commercial
CS = Commercial in very shallow water
T = Tested successfully

The research issues included in Table 2 are those over which Indonesia has some control. In most cases the need for exploration data is clear. In some cases mining technology needs to be developed and, in the case of tin, improved to permit deeper dredging. The potential impact of sand and gravel mining led the working group to recommend an environmental assessment, followed by a government-level decision on the suitability of each mining site proposed by industry.

PRIORITIES FOR DEVELOPMENT

The working group concluded that the nearshore and shallow-water commodities in the Exclusive Economic Zone (EEZ) are of higher priority for near-term development in Indonesia than the commodities in deep water. The reasons for placing a high priority on shallow-water marine minerals are:

- o A market presently exists for the nearshore commodities and two commodities (tin and sand and gravel) are known to occur in commercial quantities.
- o The Marine Geological Institute has the personnel and equipment to conduct the necessary studies and to provide within a short time frame the maps and reports needed to evaluate the potential for exploitation.

The group also agreed that priorities for nearshore investigations and development, in descending order, are:

1. Tin
2. Gold
3. Sand and gravel
4. Industrial minerals (for example, glass sands).

Deepwater resources within the EEZ for later development include phosphorites, manganese nodules, cobalt-rich ferromanganese crusts, metalliferous muds, and polymetallic sulfides.

RESEARCH PLAN

Table 2 shows the importance of bathymetric, geophysical, and geological mapping being conducted in a sequence that takes into account both the priorities of certain mineral commodities and their probable locations.

Planning Strategy

A combination of Indonesian and U.S. experience suggests the following flow of activities:

- o Inventory of existing data on Indonesian waters and resources (both Indonesian and foreign)
- o Development of trained manpower and acquisition of required equipment
- o Field work (at sea):
  - — Reconnaissance scale mapping (for example, GLORIA, high-resolution seismic reflection)
  - — Framework geology (for example, multichannel, seismic, magnetic, gravity)

- Sedimentary deposits and processes
- Marine minerals
- Coastal processes (for example, erosion, pollution, resources).

Procedurally, seafloor mapping would be conducted first. Then areas of interest, identified through geophysical techniques, would be sampled.

The training of professionals and technicians is well along for these tasks. Funding is the primary constraint at this time.

Repelita IV (Present to 1989)

Activities will center on four goals:

1. Inventory of existing data
2. Continuation of training of personnel for nearshore studies
3. Preparation for field work in nearshore areas
4. Pragmatic studies to encourage foreign participation.

Repelita V (1989-1994)

Top priority would be placed on implementation of a marine mapping program. This could lead to exploration and evaluation of shallow-water areas for tin, gold, and sand and gravel. Tin is already important to the Indonesian economy. Thus, the emphasis now should be on locating additional tin in known areas through detailed mapping and exploration in deeper water. In the future the emphasis should extend to deeper water dredging and a search for potential geographic extensions of the tin-granite belt to seek new reserves.

On-land gold deposits are known and mapped on Kalimantan and Sulawesi, but possible offshore deposits should be explored as well, such as south of Kalimantan. Concentrated offshore gold deposits also possibly exist near the mouths of rivers that drain the on-land gold-bearing region. Seafloor mapping and sampling will show the extent and concentration of offshore gold.

Aggregates such as sand and gravel can be used as building materials on the free market island of Batam. Sand and gravel should be sought to serve as aggregate in concrete for construction and as landfill. For the former, surveys should be conducted near major cities so that as onshore resources becoame depleted in that area, and if environmental and land-use concerns preclude their use, there is a possible marine solution to a city's aggregate shortage. South Irian Jaya, for example, needs sand and gravel because there is no onshore supply. Other areas such as Singapore should be explored as possible markets for exports. Deposits not suitable for construction aggregate may be suitable for landfill and for dike construction for shrimp farming, for example.

Beyond 1994

Beyond Repelita V the emphasis will be on exploring and evaluating the deepwater resources shown in Table 2. This will involve sophisticated equipment such as deep-tows and a larger ship capable of seafloor studies at depths to 5,000 m. It may also include using a research submersible or other advanced technologies.

MANAGEMENT ISSUES AND RECOMMENDATIONS

It is recommended that international cooperative projects be continued and encouraged to supplement the development of Indonesia's marine resources programs. Such cooperative projects provide economical access to data, training, and advanced technology that might not be immediately available otherwise.

It is recommended that the development of the infrastructure supporting marine resources programs be expanded by:

- Providing opportunities and support for graduate student training and operational training abroad, the latter in such technological fields as ocean engineering and mining
- Broadening and strengthening the marine curricula in Indonesian universities beyond the current emphasis on biology to include more courses on, for example, geology, geophysics, geochemistry, ocean engineering, resource evaluation and exploitation, and protected land management
- Increasing the marine geoscience component within the present geology curriculum offered at Indonesian universities.

It is recommended that communication be expanded among the many university departments, research institutes, and government agencies having marine resources programs. This becomes increasingly important as new intellectual and operational resources become available within Indonesia.

It is recommended that marine mineral resources be developed in a manner sensitive to and considerate of possible changes to the environment and social structure of the region.

APPENDIXES

APPENDIX A

Background Paper on Oceanography and the Marine Resources of Indonesia's Offshore Seas

Dirk Frankenberg
Chairman, NRC Panel

INTRODUCTION

Indonesia is an archipelagic state made up of over 13,000 islands distributed across 5 million km^2 of the earth's surface. Territorial land makes up 1.9 million km^2 and is surrounded by over 3.1 million km^2 of ocean. The nation extends for about 2,300 nautical miles along the equator from south of Malaysia to north of Australia (Figure 1).

Indonesia's islands are situated in a complex geologic setting created by the interaction of six lithospheric plates: the Eurasian, South China Sea, Indian, Australian, Philippine, and Pacific (Hamilton, 1979). This region is tectonically active and rich in mineral resources. The islands of eastern Indonesia appear to be a product of the ongoing collision of the Pacific and Indo-Australian plates, which have formed two concentric island arc systems. One bears the islands of the Lesser Sunda group (Lombok, Sumbawa, Flores), as well as Wetar, Damar, Manuk, Banda, and the western part of Ceram. The other arc bears the islands of Sawu, Roti, Timor, Babar, Tanimbar, Kai, and the eastern part of Ceram. The complex tectonics of this area has also produced seafloor topography characterized by deep-sea trenches and basins north, south, and between the two island arcs (Figure 2). The western Indonesian seafloor includes the broad Sunda Shelf north of Sumatra and Java, extending across the Sunda Sea to Kalimantan. The Sunda Shelf is incised by two major systems of submerged river valleys, indicating earlier periods when the sea level was lower than at present. The Indian Ocean shelf is narrow along Sumatra, Java, Bali, and the Lesser Sunda islands, and this narrow shelf is characteristic of those that occur where two tectonic plates collide. Katili and Hartono describe the geology of this area in detail in this report.

Surface ocean circulation in the 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 axis lies parallel to the major winds flowing to the equatorial low-pressure trough. In the northern hemisphere winter, high pressure over Asia created by seasonal cooling combines with relatively low pressure over Australia to displace the equatorial low-pressure trough to about

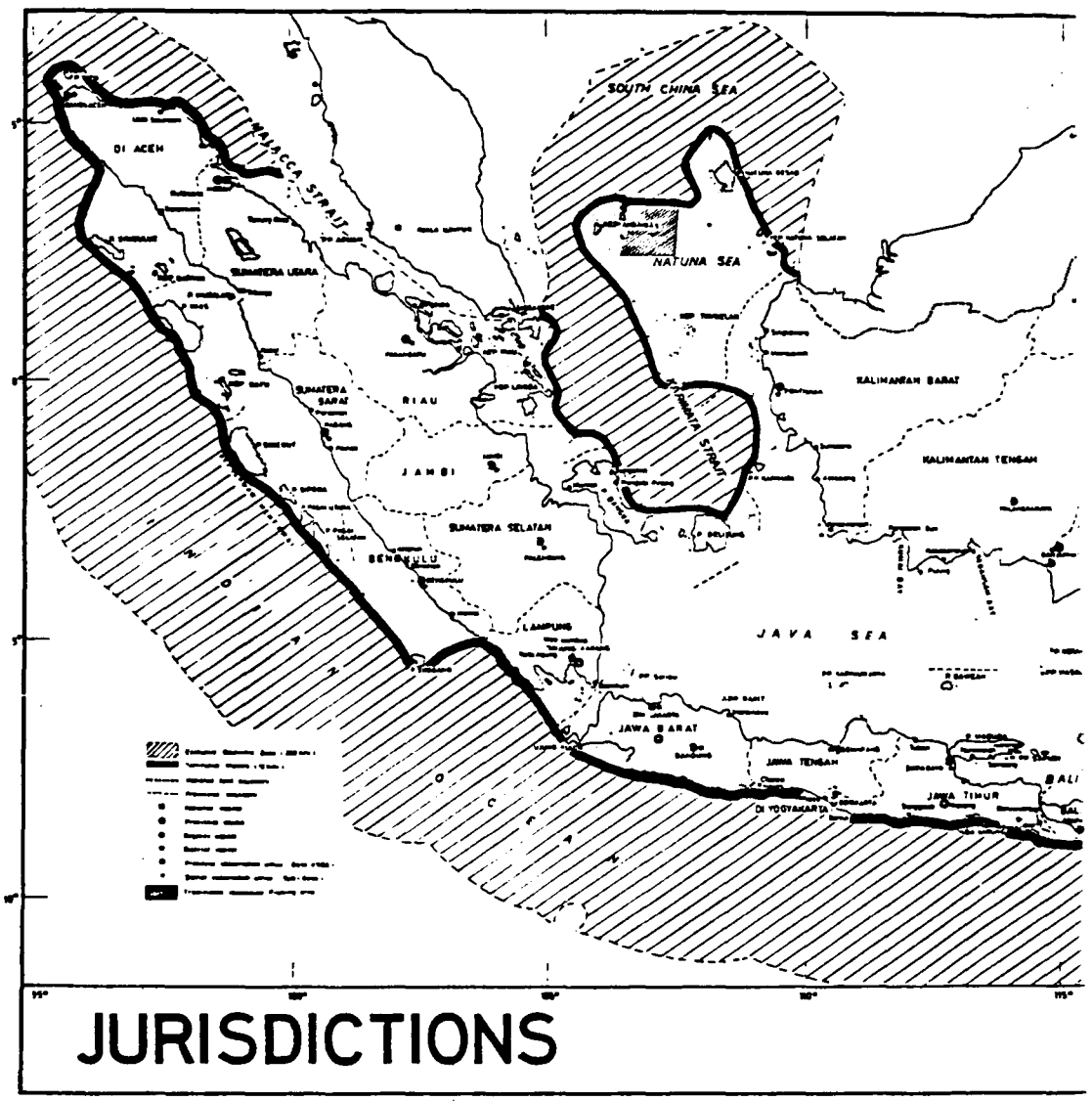
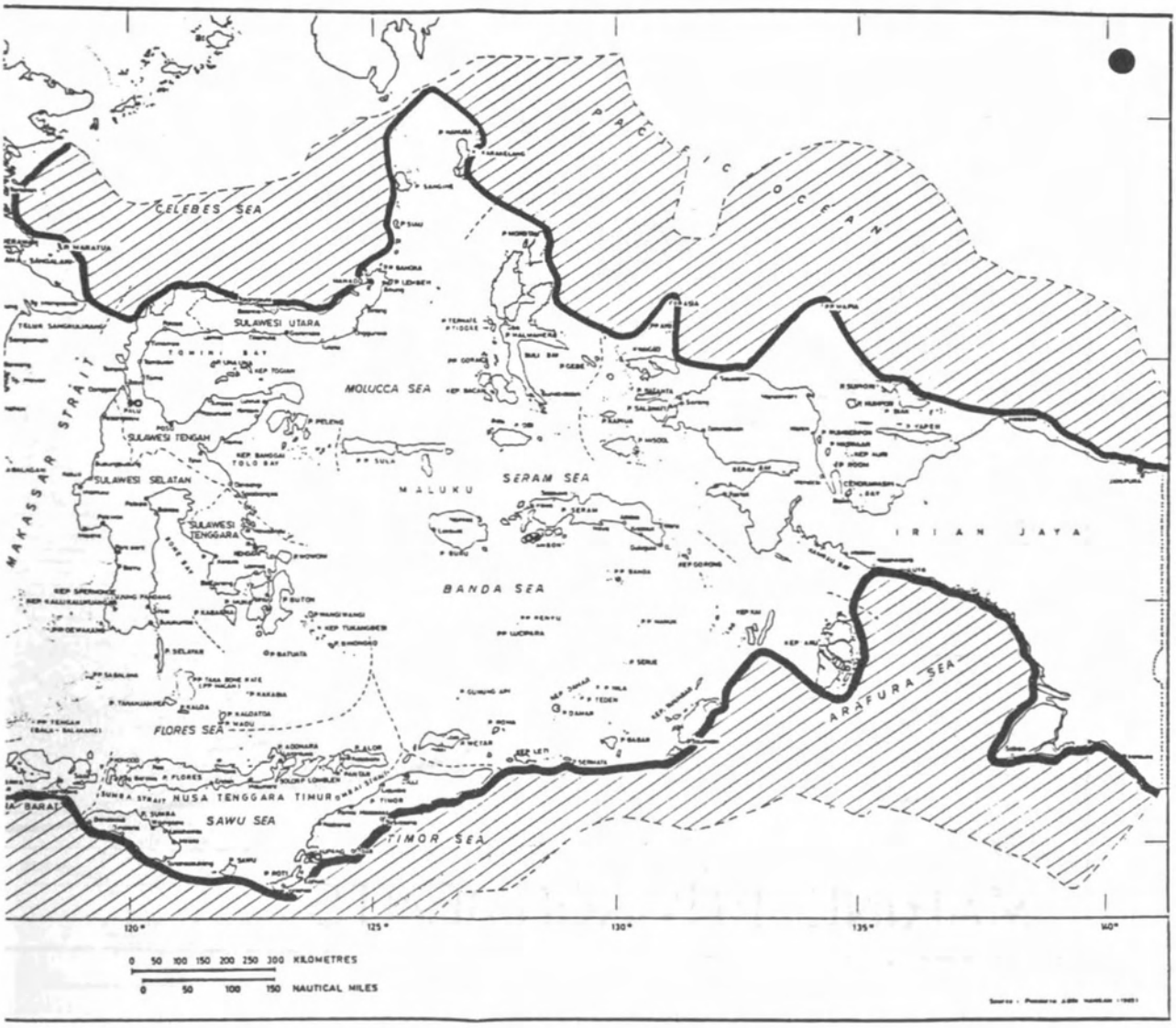


FIGURE 1 Indonesia and its territorial waters and Exclusive Economic Zone.



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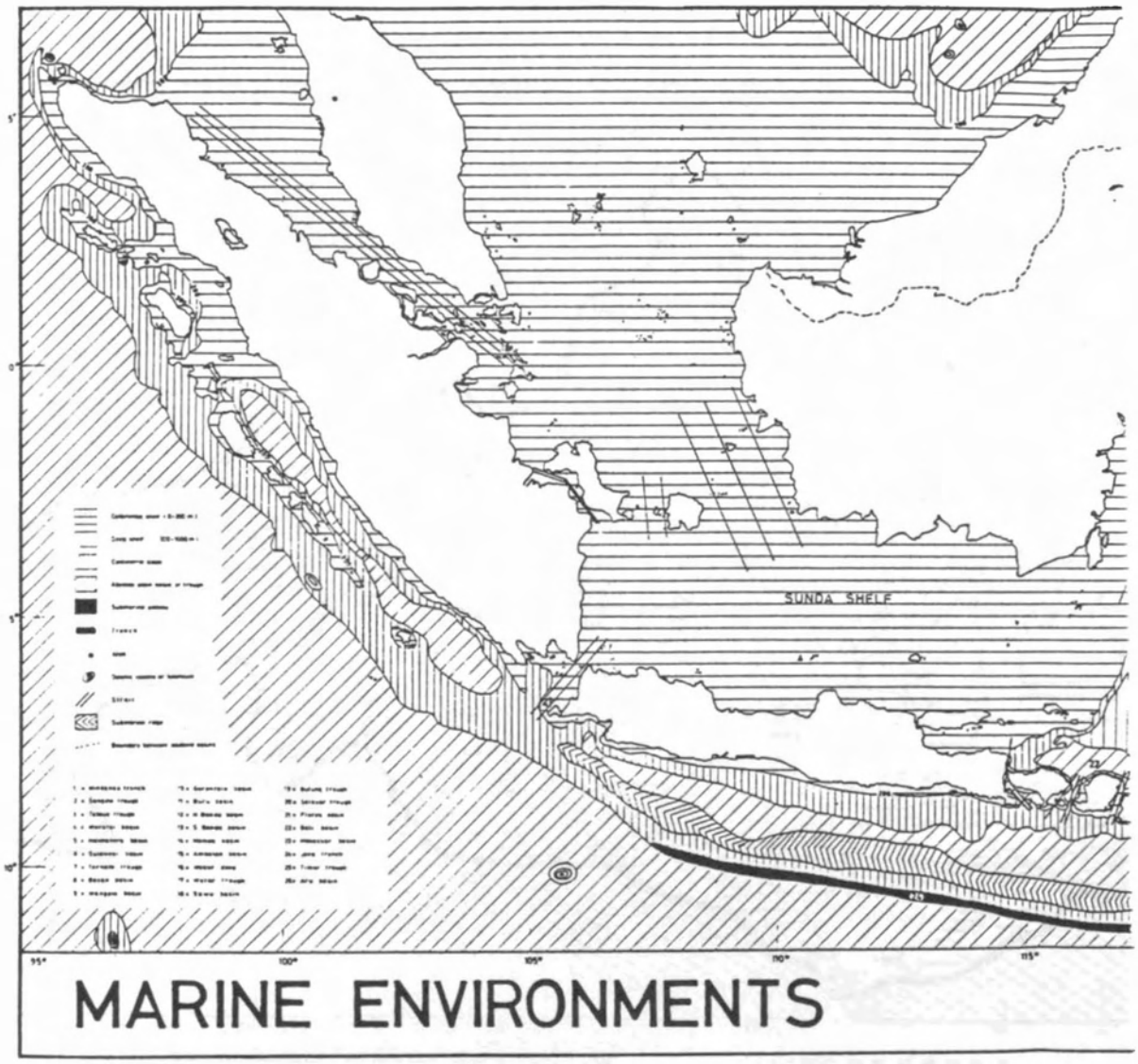

FIGURE 2 Marine environments of Indonesia.

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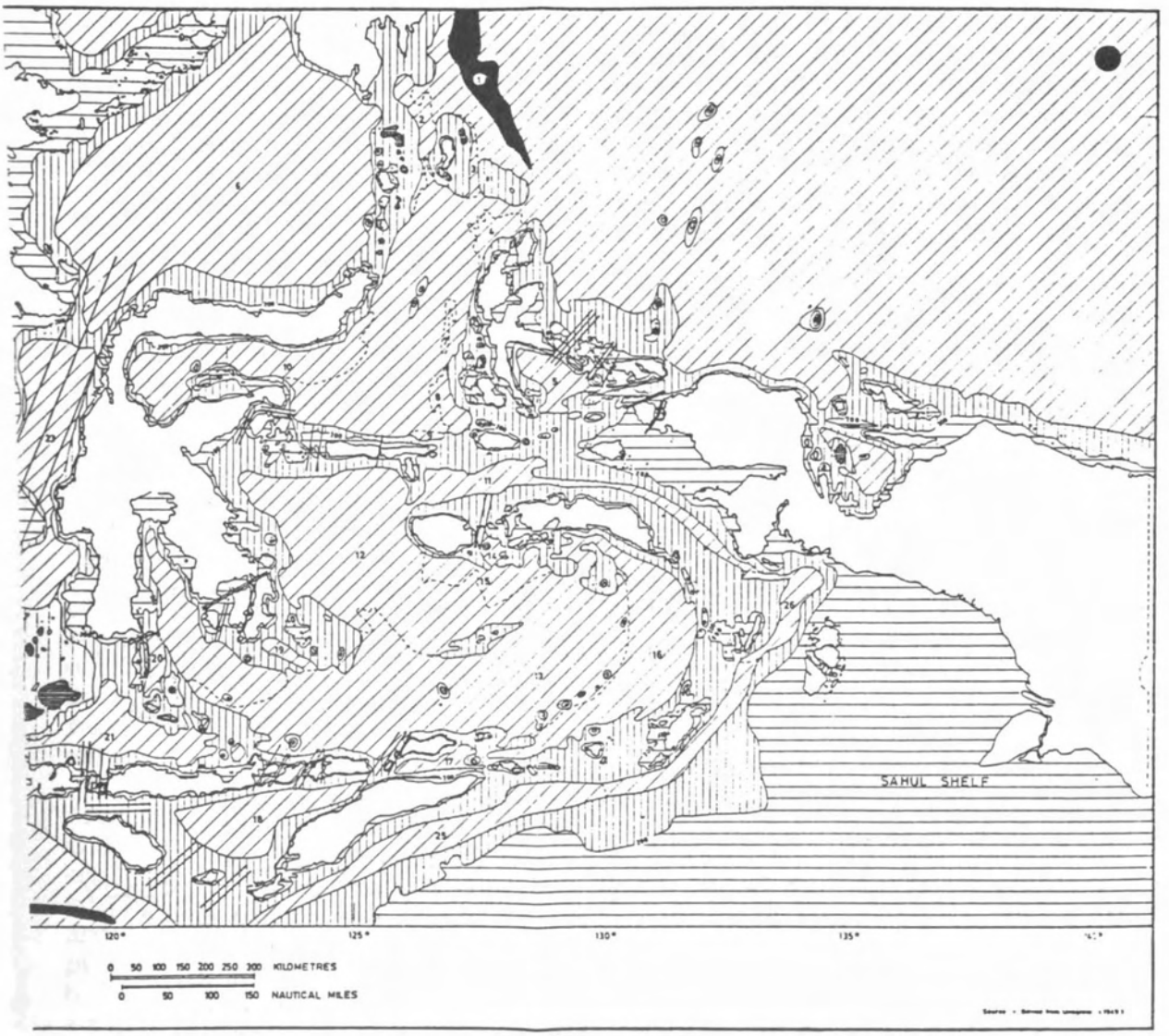

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10°S. The resulting pressure differentials lead to a strong wind flow from the northeast over the South China Sea. This flow turns to the east along the equatorial trough. The resulting strong west-to-east winds over the enclosed waters of Indonesia produce west-to-east surface currents that reach 75 cm/sec (Wyrtki, 1961). In the northern hemisphere 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 waters, creating east-to-west surface currents with speeds of 40-50 cm/sec (Wyrtki, 1961). Ilahude and Birowo describe in detail in this report how monsoon winds affect water movement in Indonesia's seas.

The biology of Indonesia's marine waters has been studied extensively because of the importance of fisheries to Indonesia's protein supply and economy. Thirteen types of fisheries yield more than 20,000 tons of harvest annually (Anonymous, 1979). They include anchovies, mackerel, scad, sardines, oil sardines, tuna, trevally, ponyfish, cockles, skipjack, drum fish, prawns, and catfish. It is estimated that the 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 (11.7 million people) of Indonesia's population 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 (Polunin, 1983).

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

Waters off the shores 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; Polunin, 1983). The monsoon-driven circulation of the enclosed Indonesian waters creates areas of seasonal upwelling on the eastern and western sides of many islands. These upwellings involve a doming of the discontinuity layer, which rarely, if ever, reaches the surface (Wyrtki, 1961; internal data, National Institute of Oceanology, Jakarta, 1982).

The animal ecology of Indonesian offshore waters is 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 (Polunin, 1983). Observations of nekton and birds suggest highly patchy distributions, although as a whole the communities are diverse, and

some populations (for example, skipjack on the Indian Ocean side of Sumatra) are locally dense (Polunin, 1983).

LIVING RESOURCES

Marine fish have been harvested in Indonesia's seas since long before the founding of the nation in 1945. Traditionally, fishermmen have used trawling, hook and line, and traps, and these methods are still employed today in coastal waters, although there has been a steady increase in the number of motorized vessels and production per vessel over time. Both trends increased steeply in the late 1970s.

Government policy toward marine fishing has evolved during a succession of five-year development plans. The first five-year plan (1969-1973) was aimed at improving economic and marketing conditions in the fisheries sector (Zachman, 1973), and it focused on increasing fish production and improving fish marketing. Incentives were offered to fishing industry entrepreneurs, and by 1975, 14 joint venture companies, 27 domestic companies, and 5 state fishery enterprises were operating in Indonesia (Comitini and Hardjolukito, 1983). Total investment in these activities in 1975 was over $100 million (Anonymous, 1979).

The second five-year plan (1974-1978) focused on increasing fisheries production, and it exceeded its 4 percent annual targets by 1.5 percent per year. This period also saw attention given to creating (1) a nonphysical infrastructure through training, education, research, management, and administration; (2) a physical infrastructure through establishment of fishing ports, piers, breakwaters, market halls, dockyards, and slipways; and (3) production, processing, and marketing facilities such as fishing boats, gear, cold storage, and credit and extension services (Comitini and Hardjolukito, 1983).

The third five-year plan (1979-1983) was aimed at (1) increasing fish production to meet domestic demand and for exports; (2) improving the living standards of fishermen and fish farmers; (2) providing employment opportunities through diversification and development of supporting industries; and (3) improving fishery resource conservation and management. The quantitative target for increased fishery production was met in 1980, but by 1981 and 1982 a partial trawl ban had limited harvest fishery growth. Increased production from aquaculture partially offset the decline and brought total production to within 3 percent of the 1983 target (World Bank, December 1983).

The current five-year plan retains the same general goals: resource sustainability, occupational opportunity, and equality of income. Increased production remains an important objective to be achieved through effective resource management and programs to improve the income and living standards of small fishermen. The 1985 harvest of marine fisheries was 1.8 million metric tons, a threefold increase since 1969.

The fishing areas of Indonesia have been subdivided into four regions based on types of fishing grounds and the national system of fishery statistics. These regions are shown in Figure 3, and their size is summarized by jurisdiction in Table 1.

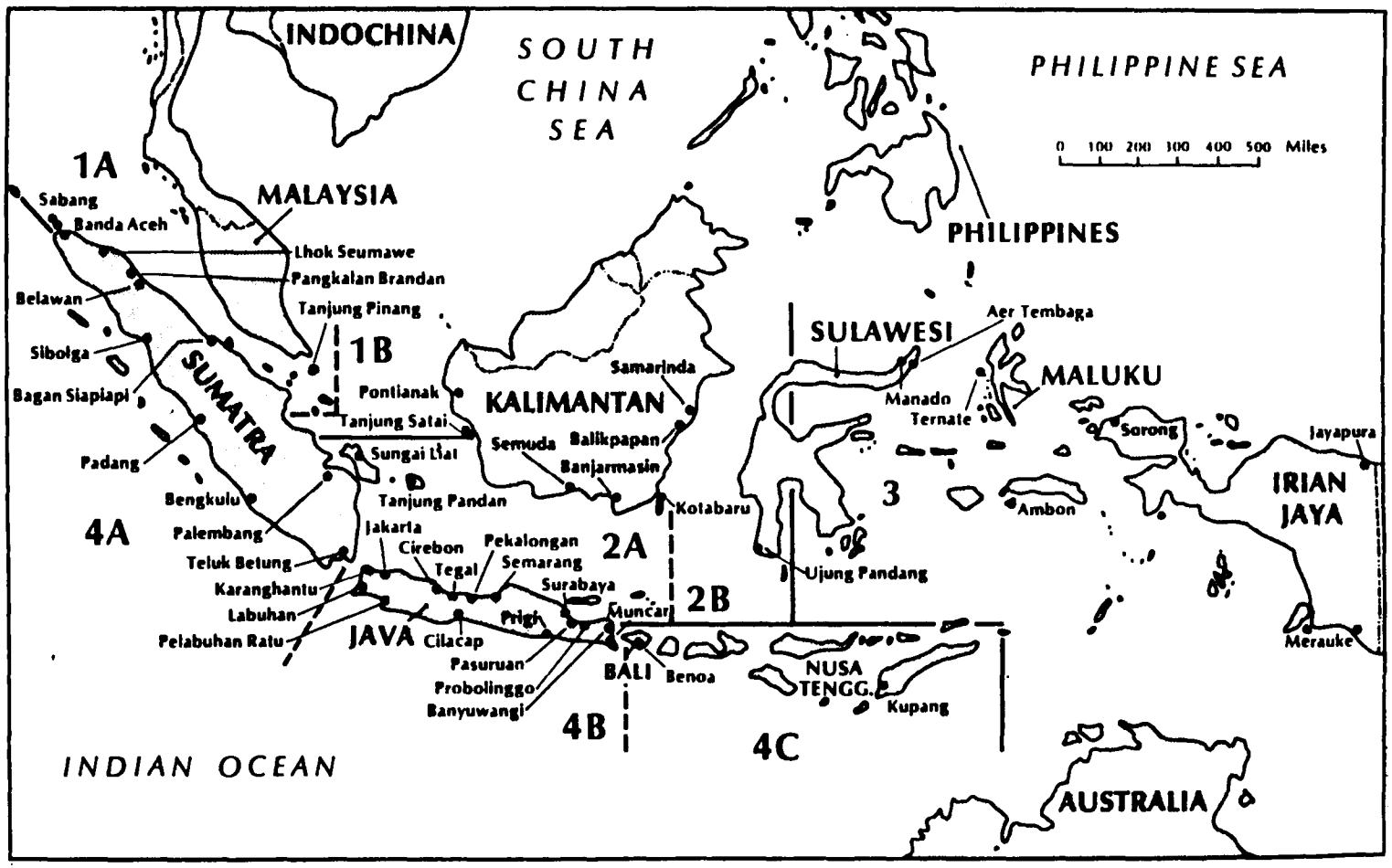

FIGURE 3 Fishing regions and selected fishing bases in Indonesia, 1977.
(Source: Indonesian Directorate-General of Fisheries)

TABLE 1 Jurisdictional Fishing Regions (Thousand Square Miles)

Regional Jurisdiction	Archipelagic Jurisdiction	Extended Jurisdiction[a]	Total
Region 1			
1A (Malacca Strait)	30.1	36.5	66.6
1B (South China Sea)	105.0	66.0	171.0
Subtotal	135.1	102.5	237.6
Region 2			
2A (Java Sea)	186.4	30.0	216.4
2B (Makassar Strait)	141.5	23.6	165.1
Subtotal	327.9	53.6	381.5
Region 2 (East Indonesia)	539.7	371.5	911.2
Region 4			
4A (West of Sumatra)	81.4	214.7	296.1
4B (South of Java)	17.1	112.1	129.2
4C (Bali and Nusa Tenggara)	106.2	126.7	232.9
Subtotal	204.7	453.5	658.2
TOTAL	1,207.4	981.1	2,188.5

[a]Based on the calculations of Comitini and Hardjolukito (1983).

Sources: Prescott (1981). Indonesian Department of Mines and Energy, 1984; Indonesian Mining Yearbook, Bandung, Indonesia, 1983.

Comitini and Hardjolukito (1983) have described these regions in considerable detail on pages 32-35 of their report on Indonesian marine fisheries. A representative catch rate by species group is summarized in Table 2 for each region. The 30 species groups listed in Table 2 represent only one way of summarizing data on the multispecies fishery of Indonesia. Actually, over 100 separate species make up the fisheries production, and the Food and Agriculture Organization of the United

TABLE 2 Popular[a] Species Caught in Each Region and Level of Production by Region[b]

Species	1A	1B	2A	2B	3	4A	4B	4C
Marine catfish	4	1	4	2	1	1	2	1
Ponyfish	2	1	7	2	1	2	3	2
Red snapper	2	1	5	2	2	2	2	2
Grouper	2	0	2	1	2	2	0	1
Barramundi and threadfin bream	2	1	3	2	2	3	2	2
Yellowtail fusilier	3	0	3	0	2	1	2	2
Croaker and drum	6	1	3	2	0	1	1	1
Shark and ray	2	2	6	1	2	2	2	2
Black and silver pomfret	3	1	2	2	1	1	2	1
Scad	2	0	8	2	6	2	2	3
Yellowstrip trevally	3	0	6	2	6	3	2	2
Jack and trevally	1	0	1	2	3	2	1	0
Flying fish	0	0	6	1	2	1	0	1
Mullet	2	1	2	2	2	1	1	2
Threadfin	3	1	2	3	1	1	1	0
Anchovy	5	1	8	2	6	5	5	5
Fringescale sardinella	5	1	7	2	4	2	2	2
Indian oil sardinella	4	0	7	1	2	2	3	6
Wolf herrings	5	1	3	1	1	1	1	1
Indo-Pacific mackerel	6	2	7	2	3	6	2	2
Spanish mackerel	5	1	5	2	2	2	2	2
Hairtail	2	1	4	1	1	1	1	1
Tuna	1	0	0	1	4	2	1	2
Skipjack	2	0	1	1	7	2	2	2
Eastern little tuna	6	2	6	1	5	5	5	4
Tiger prawn	3	0	2	2	2	1	1	0
Banana prawn	6	0	4	2	2	1	2	1
Endeavour	3	0	2	1	2	1	2	0
Blood cockle	8	0	2	1	1	0	0	1
Common squid	2	0	3	1	1	1	2	2

[a]In terms of the quantity caught.
[b]The numbers indicate the level of production per year:
0 = less than 15 tons
1 = 15-500 tons
2 = 500-2,500 tons
3 = 2,500-4,500 tons
4 = 4,500-6,500 tons
5 = 6,500-8,500 tons
6 = 8,500-15,000 tons
7 = 15,000-30,000 tons
8 = greater than 30,000 tons

Source: Indonesian Directorate-General of Fisheries.

Nations (1980) has grouped these into four categories: crustaceans (primarily shrimp); demersals (for example, ponyfish, groupers, and snappers); small pelagics (for example, mackerels, scads, pomfret, sardines, and anchovies); and large pelagics (for example, tunas).

The practical difficulties of managing and even collecting meaningful statistics on multispecies tropical fisheries is described by Purwito in this report. Despite these difficulties, there is generally thought to be substantial unexploited production in some Indonesian fisheries. The Indonesian Directorate-General of Fisheries has estimated the maximum sustained yield for pelagic, demersal, and shrimp resources by province and has compared these estimates with current levels of production. Table 3 shows this comparison for 1981.

TABLE 3 Utilization of Marine Fisheries Resources, 1981

	Production[a] (1,000 tons)			Level of Utilization		
Coastal Zone Area	Pelagic	Demersal[b]	Shrimp[c]	Pelagic	Demersal[b]	Shrimp[c]
West Sumatra Coast	38.2	18.1	0.33	22.2	10.7	36.9
South Java Coast	30.0	12.4	1.2	18.0	11.0	21.4
Malacca Strait	91.1	34.0	8.8	68.2	43.5	43.9
East Sumatra	82.6	43.7	5.8	20.0	6.9	100.0
North Java	233.8	58.7	4.3	64.3	18.2	36.6
Bali-Nusa Tenggara	64.5	10.6	0.34	24.9	4.9	68.8
Southwest Kalimantan	39.2	20.9	5.9	25.1	8.5	100.0
East Kalimantan	42.9	23.0	5.3	27.8	11.5	100.0
South Sulawesi	161.0	38.5	4.0	100.0	55.9	-
North Sulawesi	65.3	9.6	0.01	17.7	12.0	-
Moluccas/Irian Jaya	62.4	15.6	7.4	4.1	3.3	40.9
TOTAL	930.9	285.2	43.3	23.5	11.0	62.8

[a]Includes the Exclusive Economic Zone.
[b]Excludes penaeid shrimp but includes coral reef fish.
[c]Only penaeid shrimp.

Source: Indonesian Directorate-General of Fisheries, November 1984.

MINERAL RESOURCES

Known offshore resources of nonfuel minerals in Indonesia include tin, sand and gravel, phosphorite (Broadus, 1987) and barite (Mero, 1965). Other minerals of potential significance include nickel, cobalt, copper, and manganese from manganese nodules and crusts, as well as coal, molybdenum, gold, silver, lead, mercury, titanium, tungsten, uranium, zinc, and zirconium (Dorian et al., 1985). The information provided by Katili and Hartono in this report on specific mineral resources can be usefully compared with a world perspective on seabed mineral recovery; see Table 4 (from Broadus, 1987).

Present Indonesian mineral production is from terrestrial sources except for offshore petroleum, tin, and some locally recovered sand, gravel, and coral rubble. Total Indonesian production of major minerals from 1979 through 1983 is summarized in Table 5 (Dorian et al., 1985). Dorian et al. (1985) applied a revised version of the Unit Regional Value (URV) method (Griffiths, 1978) to assess the mineral resource potential of Indonesia. The methodology involved three major steps:

1. Selection of U.S. states having geology most similar to that of major Indonesian provinces
2. Estimation of the area of each province occupied by specific rock types
3. Multiplication of these areas by the areal production value of 33 minerals recovered from similar rock types in the United States.

Using only terrestrial rocks this effort was able to identify nine minerals currently not produced in the provinces identified (Table 6). Six of these nine minerals--coal, gold, silver, phosphate, zinc, and nickel--potentially occur in offshore areas of Indonesia (see paper by Katili and Hartono). Thus, it is likely that Indonesia's mineral resources potential has an offshore as well as onshore manifestation. Defining priorities for exploration of offshore deposits was a major activity of this workshop.

TABLE 4 Seabed Materials in World Perspective (MT=Metric Tons)

Seabed deposits	Material commodity	Seabed production (10^3 MT)	World mine production (10^3 MT)	Estimated average price ($ per MT)	Seabed revenues* ($ in millions)	World revenues† ($ in millions)	Seabed share of world revenues‡ (%)	Seabed reported potential resources (10^3 MT)	World onshore resources (10^3 MT)	Seabed comparison to world resources§ (%)	"Resource life" index‖ (years)	Projected onshore depletion by year 2030¶ (%)
Hydrocarbons#	Crude oil	788,834	2,788,913	70	55,218	195,224	28	>61,429,000	181,857,000	34	65	185
	Natural gas	246,670	1,296,405	95	23,434	123,158	19	>60,000,000	228,214,000	26	176	45
Sand and gravel	Sand and gravel	112,300	7,620,480	3	334	22,861	1	665,778,000	Very large	Small	Long	
	Industrial sand		181,440	14		2,540		Large	Very large	Small	Long	
Shell	Calcium carbonate	16,667	1,666,667	6	100	10,000	1	90,000,000	Very large	Small	Long	
Sulfur	Sulfur	381	54,000	105	40	5,670	<1	27,125**	5,000,000	<1	93	120
Barite	Barite		5,652	31		175		2,087**	453,600	<1	80	
Phosphorite	Phosphate rock		159,000	24		3,816		7,939,000	129,500,000	6	814	12
Mineral placers	Tin	28	201	6,614	185	1,329	14	2,500	34,500	7	172	105
	Rutile		356	364		130		13,060	181,440	7	510	
	Ilmenite		4,187	49		205		230,500	907,200	25	217	
	Titanium††		90	12,236		1,101						40
	Zirconium		709	182		129		29,040	54,432	53	77	
	Hafnium		<<1	231,483		17		290	544	53	7,452	
	Yttrium		<1	35,020		14		{3,450**}	172		430	
	Thorium		2	35,850		72			5,168		2,584	
	Chromite		9,616	42		404		30,158**	32,659,200	<1	3,396	1
	Gold		1	10,600,000		10,600		<1**	72	<1	72	443
	Silver		12	206,667		2,480			743		62	295
	Platinum		<<1	9,000,000		1,980		<<1**	99	<<1	446	13
Nodules and crusts	Platinum§§							2–3		2–3		
	Cobalt		32	25,353		811		6,000–24,000	10,886	55–220	340	
	Nickel		745	5,026		3,744		35,000–131,000	129,730	27–101	174	77
	Manganese		23,406	141		3,300		706,000–2,600,000	10,886,400	6–24	465	17
	Copper		7,805	1,475		11,512		29,000–108,000	1,600,000	2–7	205	86
Massive sulfides	Copper‖‖							5,000–216,000		<1–14		
	Zinc		6,560	893		5,858		11,000–518,000	1,800,000	<1–29	274	47
	Lead		3,350	419		1,404			1,400,000		418	46

*Seabed production times estimated average price. †World mine production times estimated average price. ‡Seabed revenues times 100, divided by world revenues. §Seabed reported potential resources times 100, divided by world onshore resources. ‖World onshore resources divided by world mine production. ¶From (32), based on low growth case for developing economies. #Hydrocarbons in metric tons of oil equivalent. **Seabed estimate for the United States only; the number in braces (3,450) is for U.S. seabed monazite deposits containing yttrium and thorium. ††Titanium resources are included in rutile and ilmenite resources. §§See numbers directly above in mineral placers for platinum. ‖‖See numbers directly above in nodules and crusts for copper.

Source: Broadus (1987). Reprinted with the permission of Science.

TABLE 5 Selected Mineral Production of Indonesia, 1979-1983 (MT = Metric Ton)

Mineral	1979	1980	1981	1982	1983
Petroleum (10^6 barrels)	580.446	577.015	584.838	488.109	490.483
LNG (10^6 m^3)	13.821	18.923	19.372	20.165	21.179
Natural gas (10^{15} ft^3)	0.998	1.045	1.123	1.111	1.186
Coal (10^6 MT)	0.278	0.303	0.350	0.480	0.485
Bauxite (10^6 MT)	1.051	1.249	1.203	0.700	0.777
Gold[b] (kg)	164.9	247.9	183.1	222.7	259.5
Manganese (MT)	5,909	4,299	2,587	17,894	8,317
Nickel ore (10^6 MT)	1.552	1.537	1.543	1.640	1.270
Ferronickel (10^6 MT)	0.017	0.010	0.019	0.021	0.020
Silver[b] (kg)	1,644	2,195	2,000	3,057	1,794
Copper concentrate (10^6 MT)	0.188	0.186	0.188	0.223	0.205
Tin (MT)	29,535	32,527	35,391	33,806	26,553

[a]Excludes coal production by private companies, estimated at 162,610 metric tons.
[b]Not including gold and silver production by Freeport Indonesia.

Source: Indonesian Department of Mines and Energy, 1984.

TABLE 6 Mineral Resources of Highest Potential in Indonesia[1]

Province	Minerals Currently Under Production [a,b]	Minerals Predicted to Occur Based on Geologic Analogy
Kalimantan	Petroleum, natural gas, coal	_____
Timor	_____	Copper, coal, molybdenum, gold, silver
Sumatra	Coal, bauxite, silver, tin, petroleum, natural gas	Gold, copper
Nusa Tenggara	_____	Silver, phosphate, lead, gold, silver
Irian Jaya	Petroleum, copper, gold, silver	Tungsten, lead
Moluccas	Petroleum, ferronickel	Gold, copper, silver, tungsten, lead
Sulawesi	Nickel/ferronickel	Coal, gold, uranium, zinc, silver
Java	Petroleum, natural gas, coal, gold, silver	Nickel, mercury

Note: _____ indicates that minerals likely to exist, based on geologic analogy, are currently being produced.

[a]Refers only to 33 mineral resources assessed by the URV technique.
[b]From Indonesian Department of Mines and Energy, 1984; Prijono (1984); U.S. Bureau of Mines (1983). Indonesian Mining Yearbook, Bandung, Indonesia, 1983.

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APPENDIX B

Opening Remarks

Kasijan Romimohtarto
Chairman, Workshop Organizing Committee

Members of the organizing committee would like to welcome you to the opening ceremony of the Workshop on the Development, Management, and Utilization of Indonesian Marine Resources, and to thank you for attending the ceremony and participating in the workshop.

This workshop is organized by the Indonesian National Research Council (DRN) and the Indonesian Institute of Sciences. The workshop will consist of four consecutive plenary sessions and three parallel group sessions. The plenary sessions will feature presentations by four Indonesian participants and two U.S. participants as well as comments by the U.S. participants on aspects of management, oceanography, fisheries, and mineral resources. The group sessions will discuss these aspects separately.

Approximately 13 U.S. participants and 46 Indonesian participants will meet. This represents Indonesian participation from 18 different research and similar institutions and 10 universities and other educational institutions in nine cities of Indonesia.

All members of the organizing committee wish all the participants good luck in your deliberations, and we hope you have a pleasant stay in Jakarta.

APPENDIX C

Opening Remarks

Didin S. Sastrapradja
Chairman, Workshop Steering Committee

On behalf of the steering committee, I join the previous speakers in welcoming you to the opening ceremony of the Workshop on the Development, Management, and Utilization of Indonesian Marine Resources. We are indeed honored by your presence at the opening session and by your participation in the discussions that will follow. Therefore, let me avail myself of this opportunity to express my sincere gratitude and highest appreciation.

Since time immemorial the Indonesian seas have been an integral part of the life of Indonesian people, particularly these who inhabit the coastal regions. To our people the seas serve as media for transportation, produce vast amount of food products, provide housing materials, and serve in many other ways. In the meantime there is a strong belief that with the presently fast-growing world population the seas and oceans will be the last resorts for mankind on earth in the future. In view of all that Indonesia should praise the Lord for blessing our country with so large an extent of the rich watery territery. It is our duty then to manage the resources wisely for the benefit of the present as well as the future generations.

For centuries the seas and oceans have been considered a common garbage disposal into which unlimited human wastes could be dumped without fear of igniting negative impacts. The tremendous amount of water contained in the seas and oceans was believed to be capable of digesting--through natural processes--any amount of waste materials man could dump into it. Of course, we now realize that such a belief is completely unfounded.

Marine resources are one of Indonesia's highly valued assets, but they must be properly managed and wisely utilized for the benefit of the greatest majority of the people. Attaining this objective, however, is not a simple matter. Experience, expertise, technology, and money are among the basic ingredients necessary for its success. Thus, it is crucial to keep in mind before we meddle with our seas and oceans that whatever we do, we have to do it professionally and with great care. Otherwise we may end up living in the middle of a hostile

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Members of the workshop steering committee were Didin S. Sastrapradja (Chairman), J. A. Katili, Sediono M. P. Tjondronegoro, Aprilani Soegiarto, Hasjam Djalal, R. Soeprapto, Benny Soeparno, Dirk Frankenberg, M. Grant Gross, and Rose Bannigan.

ocean of human waste and with a degraded environment.

Taking into consideration the rationales stated above, the initiative taken by the Indonesian National Research Council (DRN), in cooperation with the Indonesian Institute of Sciences (LIPI) and the U.S. National Academy of Sciences, to convene this workshop is absolutely important and very timely.

Through such a scientific gathering, knowledge, expertise, experience, and technology on marine management and utilization can be transferred. Therefore, it is very appropriate for me, on behalf of Minister Habibie as the Chairman of the Indonesian National Research Council, to convey the Council's strong commitment to a comprehensive and continuing discussion of marine resources as a priority topic of the highest order. From the very inception of the DRN-NRC collaboration, and the signing of the agreement with Dr. Keyworth, then the U.S. president's science advisor, in April 1984, marine sciences and marine biotechnology have been put high on the list of such priorities.

Seen from the overall picture of the Indonesian national development program, the timing of this workshop seems to be very accurate. Indonesia is now preparing to enter the fifth five-year development program. In anticipation of this event, it is only appropriate to expect that deliberations on the management, development, and utilization of marine resources in Indonesia's territory will result in an implementable plan of action, which I hope will also provide broad directions for future research.

Realizing that much work has yet to be started, I hope that collaboration between the Indonesian National Research Council and the U.S. National Academy of Sciences can be extended beyond 1987. A sequence of activities in which Indonesian and American researchers will cooperate and exchange knowledge in a particular field and related sciences is what our development needs require.

To conclude my remarks, I wish to express my sincere gratitude and appreciation to the U.S. National Academy of Sciences for joining DRN and LIPI in sponsoring this workshop. My thanks are also extended to all participants whose hard work have made this scientific exercise possible. Lastly, I wish you all successful deliberations and an enjoyable stay here in Jakarta.

APPENDIX D

Remarks

Paul F. Wolfowitz
Ambassador of the United States to Indonesia

This is the second occasion that I have had the opportunity to address senior members of the Indonesian scientific community; the first was almost exactly a year ago. At that time we discussed the development of information services. Now we are concentrating on a user of such services, the field of marine resources.

I am proud that we in the U.S. government have been able to help develop the excellent relationship between the National Academy of Sciences and the Indonesian science and technology community over the past 10 years. I am particularly proud to be associated with the current project, which I see as the springboard for major developments in the future, not only in marine resources but in biotechnology and information services as well. From all reports I have received, the project has been successful far beyond the anticipation of those who designed it. Congratulations are certainly in order for Professor Sediono M. P. Tjondronegoro and the staff of the Indonesian National Research Council Secretariat for their role in initiating, organizing, and following up on the activities of previous workshops. On the U.S. side, I think that congratulations are due to the National Academy of Sciences for a creative and sensitive job done in support of the development goals of the government of Indonesia in the field of science and technology.

In this workshop you are concerned with marine resources in Indonesia's offshore seas. This would be a subject of major importance to any country with an ocean boundary; however, in Indonesia the importance extends far beyond Indonesia itself because Indonesia straddles one of the most important trade routes in the world. Its boundaries enclose several seas and even changes to its environment have effects far beyond Asia to the Pacific shores of the Americas. Most of us are used to thinking of the land masses of our own countries. It is difficult to realize that the greater part of Indonesia is water (62 percent). Marine resources are the biggest portion of the country, yet they have received the least amount of sustained attention. Clearly, to use it productively, this resource must be better understood.

As laymen and as tourists we wonder at the sea, enjoy it, and are often afraid of it. It is an unknown. We probably know and understand as little about this "inner space" as we do about "outer space," but we

take it more for granted. As experts in biology, environmental science, and oceanography, you probe the complexities of this close but strange environment. You can assess the human resource needs that Indonesia must develop for her to reap the benefits of this extensive part of her national area. Over the years, the United States has provided assistance to Indonesia in the field of marine fisheries and currently is supporting a fisheries research and development project, which will develop a capability for research and training. However, the need is immense and our resources small.

From the time of the first pelita the government of Indonesia has recognized the importance of marine resources to the welfare of this nation. Over time it has developed Indonesian experts and modern laboratories and has taken advantage of opportunities of assistance offered by other countries. Major advances have been made. That this high-level workshop can be convened is evidence of that. I expect that this progress will continue to develop. It has also been very encouraging to see the increasing collaboration between the government of Indonesia and the business community, because I believe that good relationships between government and business result in better products faster than would be the result of either going it alone.

Clearly, significant advances in marine research and resource development will need the interest and support of entrepreneurs and the private sector who can mobilize greater resources on a more sustainable basis. This is not only true for the oceans as a resource for food, but also for the development of mineral resources, in addition to oil and gas. Unless private resources can be mobilized to develop Indonesia's minerals for the benefit of its population, necessary growth may be delayed. The immense sums needed are beyond the resources of donor agencies and of the government of Indonesia itself.

I am happy to be with you today because I believe that this workshop can help draw a clearer picture of potential Indonesian marine resources than we now have. It can focus on a set of priorities and give Indonesian decision makers estimates of resources needed to begin lasting and environmentally sound development of the seas.

One significant related project is already under active consideration, involving the participation of a number of leading Indonesian and U.S. oceanographers—the major Indonesian Seas Throughflow Experiment or INSTEP. As many of you are already aware, INSTEP is designed to examine the dynamics of the exchange of waters between the Pacific and Indian oceans and the effects of that exchange on regional and global weather patterns, including the infamous El Nino phenomenon. The benefits from this project could extend not only to Indonesia and the United States, but also to the international community at large by helping us achieve a better understanding of world climate interrelationships. The project could also help Indonesia gain a broader understanding of ocean currents and movements as these factors affect domestic fish resources. Several of the Indonesian and U.S. scientists at this workshop will be staying on to participate in the INSTEP meetings to be held in Jakarta, June 29-30, and to finalize preparations for this extremely impressive joint endeavor.

I understand that the workshop we are opening here today is the last in this series of workshops. I wish again to congratulate everyone who has contributed to their success. I hope that ways will be found to continue this relationship, which fosters close cooperation between our two countries.

APPENDIX E

Keynote Address

Emil Salim
Minister of State for Population and the Environment

On behalf of the Indonesian government, the Indonesian National Research Council, and myself, allow me to extend a warm welcome to all of you, especially our colleagues from the U.S. National Academy of Sciences, for attending the Workshop on the Development, Management, and Utilization of Indonesian Marine Resources. The purpose of this workshop is to exchange information and experience pertinent to developing, managing, and utilizing Indonesian marine resources; to determine potential short- and long-term projects that can be developed for commercial purposes such as non-oil experts or as import substitutes; and to develop action programs to exploit Indonesia's marine resources.

The role of marine resources is of strategic importance in Indonesia's national development because of their size, their contents, and their capabilities. Seas cover about 3.1 million km^2 or approximately 62 percent of the total Indonesian territory. Indonesia's Exclusive Economic Zone adds another 2.7 million km^2 of valuable oceanic area. Not less that 13,000 islands are scattered in this area with about 81,000 km of coastline. These islands stretch between two continents--Asia and Australia--and two oceans--the Pacific and the Indian--making it an ideal place to study monsoons which determine the wet and dry seasons within a year. These monsoonal changes affect activities on land and in the sea, and thus determine the behavior of marine organisms. The water mass exchange between the Pacific and Indian oceans through the Indonesian waters plays an important role in understanding the global ocean circulation and the weather and climate of the Indo-Pacific region.

This brings me to the rich content of our marine resources. Fish, shrimp, crustaceans, mollusks, and seaweeds are a few examples. In addition, minerals and hydrocarbon resources can be and have been tapped from the shallower Indonesian waters. For a nation with a current population of 167 million people--moving toward 212 million by the year 2000--living on a limited and crowded land area, the availability of these resources are of crucial importance and may well affect our survival. It is therefore understandable why Indonesia attaches such great importance to the sea and all elements related to it, such as the Law of the Sea. The industrialized nations may look upon the seas as any other resource that may enhance their welfare.

For developing countries like Indonesia which has to cope with high population pressure on limited land resources, it may become necessary to consider our seas as the Achilles heel for our survival. For developing countries like Indonesia there is no new continent or new land area that can absorb the millions of people who are added each year, as was the case with Europe which gave birth to the new world of America.

It is this crucial role of the sea in our survival that leads us to attach such great importance to all aspects of the seas. Because of their importance, the seas can be the cause of conflict between nations, but also the cause of unity among nations.

As intellectuals we share a common trait--namely, use of our intellectual capabilities to serve not only our respective nations, but the human race as well. Building our world with fewer hungry people and less inequality will benefit humanity. God has created men equal. If there are differences among men of nations, especially in terms of wealth and income, then these differences are caused mainly by differences in when development was begun. Give these late starters, the developing nations, the opportunity to build their intellectual capabilities, and those nations will prove that men are created equal.

It is with this frame of mind that this workshop may become a different entity. We can make it not only a vehicle for intellectual exercise and an exchange of ideas, which is still useful, but also enhance its quality in the direction of closing the gap of inequality among nations.

In this context the sea may well serve as a strategic unifying and integrating factor among the scientists of the United States and Indonesia. We need to explore the full capabilities of the sea that might unite our experts. And it is here that I see the various avenues that are concealed in the capabilities of the sea, which we need to explore together to strengthen our cooperation.

The sea provides us with the opportunity to cooperate in training and research in mining, deep-sea fishing, conservation of coral reefs, development of our coastal zone, mitigation of sea- and land-based pollution, and development of technology for sustainable fishing. All these refer to the capabilities of marine resources that can and need to be developed.

It is in these fields that the transfer of skill and know-how becomes necessary to make full use of our marine resources. Use of these resources needs to be based on the concept of sustainability--that is, to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.

This concept implies that the technologies needed satisfy the following conditions. First, they should not harm the function of these resources. Marine resources may be exploited but within the constraints of not jeopardizing their role as a life-supporting system. We must treat marine resources as "capital," using the benefits of its interest without consuming it. Second, they should not pollute the biosphere and reduce mankind's quality of life. Third,

they should support a system in which the poor are enhanced in their effort to obtain a humane quality of life.

To achieve these objectives it is important that ways and means be identified for training, institution building, and law making, as well as various other institutional arrangements, so that long-term, continuous development can take place. If this workshop is put in this context, it becomes clear that this meeting today may well be a small step toward making the sea a unifying factor, not only between the intellectuals and experts of the United States and Indonesia, but between our two nations as well.

It is with this spirit that I heartedly welcome all of you and pray to God the Almighty that He may give us the strength, friendship, understanding, and cooperation that we hope will be established between United States and Indonesia through the unifying sea.

APPENDIX F

Workshop Agenda

Tuesday, June 23, 1987

Morning — Registration

Opening

Report by the Organizing Committee
Dr. Kasijan Romimohtarto

Remarks by the U.S. NRC Panel
Dr. Dirk Frankenberg

Remarks by the Steering Committee
Prof. Dr. Didin S. Sastrapradja

Address by the U.S. Ambassador
Dr. Paul F. Wolfowitz

Keynote Address and Opening of the Workshop by the Minister of State for Population and the Environment
Prof. Dr. Emil Salim

Coffee

Plenary Session

Chairman: Prof. Dr. Didin S. Sastrapradja
Rapporteur: Dr. M. Kasim Moosa

The Law of the Sea Convention and Indonesian Responses
Dr. Hasyim Djalal and Dr. Boer Mauna

U.S. Management of Marine and Coastal Resources
Dr. Jack Archer

Ocean Science as a Basis for the Development, Management, and Utilization of Marine Resources
Dr. Dirk Frankenberg

Lunch

Afternoon

Plenary Session (continued)

Chairman: Dr. Dirk Frankenberg
Rapporteur: Dr. Otto Ongkosongo

I. OCEANOGRAPHY

Oceanographic Features of the Indonesian Waters
Dr. Abdul Gani Ilahude
Suyatno Birowo

Comments by U.S. Participants
Dr. Arnold L. Gordon and Dr. Klaus Wyrtki

Coffee

Plenary Session

Chairman: Dr. Kasijan Romimohtarto
Rapporteur: Ir. Gede Sedana Merta

II. LIVING RESOURCES

Indonesian Development and Management of Fishery Resources
Dr. Purwito Martosubroto

Comments by U.S. Participants
Dr. Brian Rothschild, Dr. Earl Conrad, and Dr. David M. Checkley, Jr.

Wednesday, June 24

Morning

Plenary Session (continued)

Chairman: Dr. Grant Gross
Rapporteur: Dr. Nafrizal Sikumbang

III. MINERAL RESOURCES

Indonesian Offshore Mineral Deposits
Dr. H. M. S. Hartono

	Comments by U.S. Participants Dr. Monty Hampton, Dr. Gary Hill, and Dr. John Padan
Coffee	
	Directives to Chairman and Rapporteurs of Working Groups Prof. Dr. Didin S. Sastrapradja
Lunch	
Afternoon	Working Group Sessions

Thursday, June 25

Morning	Working Group Sessions
Coffee	
	Working Group Sessions
Lunch	
Afternoon	Working Group Sessions
	Plenary Session: Report of Working Groups with Special Reference to Management Problems
	Chairman: Ir. Henk Uktolseja Co-chairman: Dr. Dirk Frankenberg Rapporteur: Dr. Otto Ongkosongo

Friday, June 26

Morning	Discussion of Recommendations and Conclusions
	Chairman: Dr. Suyatno Birowo Co-chairman: Dr. Dirk Frankenberg
Coffee	
	Continuation of Discussion
Lunch	
Afternoon	Summary of Conclusions and Recommendations Dr. Suyatno Birowo and Dr. Dirk Frankenberg
	Closing Remarks Prof. Dr. Didin S. Sastrapradja

APPENDIX G

Workshop Participants

Steering Committee

Prof. Dr. Didin S. Sastrapradja, Vice-Chairman, Indonesian Institute of Sciences, and Assistant (II) Minister of State for Research and Technology (Chairman)

Prof. Dr. J. A. Katili, Director-General of Geology and Mineral Resources, Ministry of Mines and Energy (Vice-Chairman)

Prof. Dr. Sediono M. P. Tjondronegoro, Secretary, Indonesian National Research Council (DRN), and Assistant (V) Minister of State for Research and Technology (Secretary)

Dr. Aprilani Soegiarto, Deputy for Natural Sciences, Indonesian Institute of Sciences (LIPI)

Dr. Hasjim Djalal, Head, Agency for Research and Development, Department of Foreign Affairs

Dr. R. Soeprapto, Director-General of Fisheries, Department of Agriculture

Drs. Benny Soeparno, Head, Survey and Mapping, Center of the Armed Forces

Organizing Committee

Dr. Kasijan Romimohtarto, Head, Center for Oceanological Research and Development, LIPI (Chairman)

Dr. Anugerah Nontji, Indonesian Association of Oceanologists, LIPI (Vice-Chairman)

Dr. Kasim Moosa, Center for Oceanological Research and Development, LIPI (Secretary)

Ms. Titi Marpaung, LIPI

Ms. Ratna Wulan Karang, DRN

Dr. Aznam Azis, Center for Oceanological Research and Development, LIPI

Mr. Tatang Bardjah, Secretariat, Ministry of State for Research and Technology

U.S. Participants

Dr. Dirk Frankenberg, Director, Marine Sciences Program, University of North Carolina at Chapel Hill (Chairman, NRC Panel)

Dr. Jack Archer, Senior Fellow, Woods Hole Oceanographic Institution

Dr. David M. Checkley, Jr., Assistant Professor, Department of Marine, Earth and Atmospheric Sciences, North Carolina State University

Dr. Earl Conrad, Chairman of the Board, Port Clyde Foods Inc.

Dr. Arnold L. Gordon, Oceanographer, Lamont-Doherty Geological Observatory, Columbia University

Dr. M. Grant Gross, Director, Division of Ocean Sciences, National Science Foundation

Dr. Gary W. Hill, Chief, Office of Energy and Marine Geology, U.S. Geological Survey

Dr. John Padan, Program Director, Deep Seabed Mining, National Oceanic and Atmospheric Administration (NOAA)

Dr. Brian Rothschild, Professor, University of Maryland Center for Environmental & Estuarine Studies, Chesapeake Biological Laboratory

Dr. Klaus Wyrtki, Professor, Department of Oceanography, University of Hawaii

Mrs. Rose Bannigan, Senior Program Officer, BOSTID

Resource Persons

Dr. Monty Hampton, Chief of the Branch of Pacific Marine Geology, U.S. Geological Survey (USGS)

Dr. John C. Hathaway, USGA-PGK, Bandung

Dr. Wolfgang Scherer, Chief, Technical Applications Group, Office of Oceanography and Marine Assessment, NOAA

Working Groups

Oceanography

A. G. Ilahude (Chairman)
Arnold L. Gordon (Co-chairman)
Wolfgang Scherer (Rapporteur)
Mulia Purba (Rapporteur)
Sujatno Birowo
Salem Gemping
M. Grant Gross
Safwan Hadi
Punjanan Jacob
Mahdi Kartasasmita
Adolfientje Kasenda
Mochtar Machful
John Pariwono
Sofyan Rawi
Sem Saimima
Benny Soeparno
L. F. Wenno
Klaus Wyrtki

Living Resources

Purwito Martosubroto (Chairman)
Brian Rotschild (Co-chairman)
David M. Checkley, Jr. (Rapporteur)
Nurzali Naamin (Rapporteur)
Jusdy Achmad
Rose Bannigan
Kee Chai Chong
Earl Conrad
Mohd. Eidman
Dirk Frankenberg
Harry P. Haryono
Sofyan Ilyas
Mahsum Irsyam
Gede Sedana Merta
Bonar P. Pasaribu
Rys Bambang S.
Edi Setianto
Syabandi

Mineral Resources

H. M. S. Hartono (Chairman)
M. Grant Gross (Co-chairman)
John Padan (Rapporteur)
Peter Hehanussa (Rapporteur)

Mawardi Anwar
Jack Archer
John C. Hathaway
Monty Hampton
Gary Hill
Iskandar
Haruna Mappa
Otto S. R. Ongkosongo
Djoko Prajitno
Nafrizal Sikumbang
Soegiono

Other Attendees

Drs. Fred Hehuwat
Ismail Usna
Prof. de Neve
Prof. Dr. M. T. Zen
Dr. Pulunggono
Prof. Dr. Wahyudi Wicaksono
Dr. Mulia Purba
Drio Utomo
Dr. L. M. Panggabean
D. U. Martoyo
Dr. Lachmuddin Sya'rani
Dr. Muchtar Achmad
Ir. Martin Rondo
Ir. Zalbawi Suyuti
Nugroho Wismumurti
Ir. Untung Wahyono
Ir. Kusno Rahardjo
Ir. Henk Uktolseja
Ir. Latif Hasyim
Ir. Augus Syukur Nasution
Ir. Ris Bambang
Dr. Zuhal
Marskal Madya
Kepala Dishidros
Brigjen
Utaryo Surodirono
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