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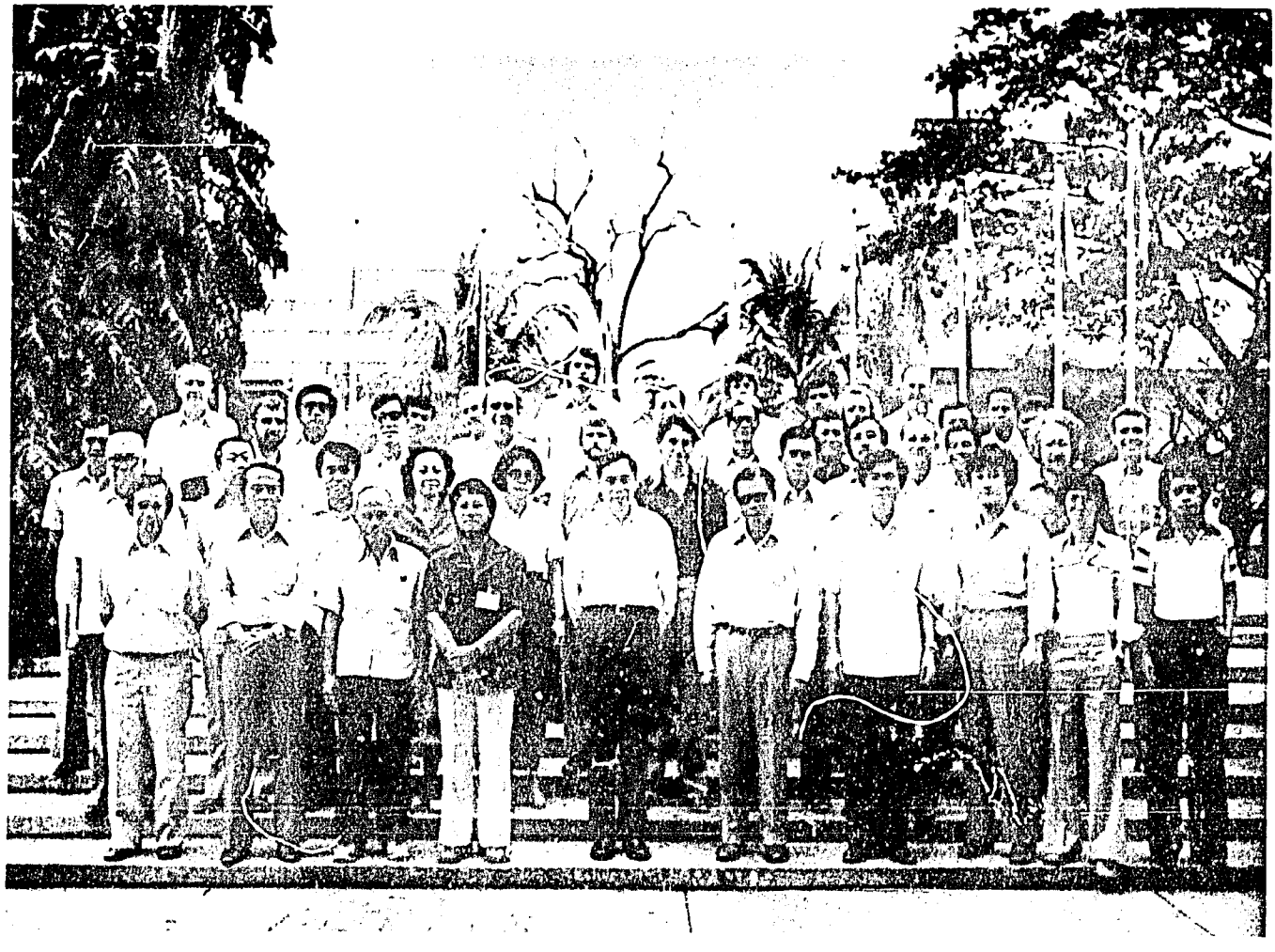
PROCEEDINGS OF THE WORKSHOP ON COASTAL AREA DEVELOPMENT AND MANAGEMENT IN ASIA AND THE PACIFIC

Manila, Philippines
3 to 12 December 1979

Mark J. Valencia, Editor
Lawrence Neuman, Workshop Organizer



Participants in the Workshop on Coastal Area Development and Management in Asia and the Pacific, Manila, Philippines, 3 to 12 December 1979.

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PREFACE

The United Nations (UN) Economic and Social Council has acknowledged* that the rational development of coastal areas--capitalizing on the growth opportunities inherent in marine resources and ocean space--could add a new dimension to the development of many developing countries and thus constitutes an important factor in national development planning.

Responding to the specific concerns and directives of UN Member States for positive action in this field, the Department of Economic and Social Affairs, through its Ocean Economics and Technology Branch (OETB), is implementing a program of activities aimed at assisting developing coastal states to harness the potential of their coastal areas to the overall development effort.

A large number of significant regional projects has followed this initiative. Of primary importance is the Regional Seas Programme organized by the United Nations Environment Programme (UNEP). Although this regional approach has emphasized environmental concerns in areas such as the Mediterranean region, the Programme recognizes the primacy of rational development concerns in the Kuwait, West African, Greater Caribbean, and Southeast Asian regions, among others.

In 1976, in West Berlin, the German Foundation for International Development (DSE) and OETB cosponsored a major interregional seminar on Development and Management of Coastal Areas. Recommendations at that Workshop for regional follow-up meetings prompted UN-assisted Workshops in Mexico and West Africa, and in Manila.

The Manila Workshop reported herein was a tribute to cooperation within the UN system and between UN specialized agencies and national and regional bodies. The UN (OETB), together with UNEP, ESCAP (the Economic and Social Commission for Asia and the Pacific), CCOP (the Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas), and CCOP-SOPAC (the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas) co-sponsored this Workshop and supported the participation of consultants and national experts. DSE and EWC/EAPI (the East-West Center's Environment and Policy Institute) joined the UN in cosponsoring this Workshop and in supporting the participation of consultants and national experts. The Philippine Bureau of Mines and Geosciences under the Ministry of Natural Resources of the Government of the Philippines served as host of the Workshop supplying all meeting facilities and logistical support, as well as gracious hospitality.

EWC/EAPI was pleased to be able to cosponsor and contribute substantively to this Workshop and to publish this Proceedings on behalf of the other cosponsors. This Proceedings comprises the edited manuscripts of presentations

*Economic and Social Council Resolutions 1802 (LV) and 1970 (LIX).

made at the meeting. These papers have not been reviewed beyond the discussions at the Workshop, and the responsibility for their substantive content rests with each individual author.

EWC/EAPI would like to acknowledge the financial contributions of the UNEP and DSE for publication of this Proceedings. The editor would like to acknowledge the EWC and Dr. William H. Matthews, Director, EAPI, for his support of this work, as well as the logistical support of EAPI's Publications Office including specifically Sherry Bryson and Helen Takeuchi.

Mark J. Valencia
Environment and Policy Institute
East-West Center

ACRONYMS

ASEAN	Association of Southeast Asian Nations
CCOP	Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas
CCOP-SOPAC	Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas
DSE	Deutsche Stiftung für Internationale Entwicklung (German Foundation for International Development), Berlin (W)
ESCAP	Economic and Social Commission for Asia and the Pacific
EWC	East-West Center, Honolulu, Hawaii
FAO	Food and Agriculture Organization
IMCO	Intergovernmental Maritime Consultative Organization
IOC	Intergovernmental Oceanographic Commission
OETB	Ocean Economics and Technology Branch of the United Nations
SEAFDEC	Southeast Asian Fisheries Development Center
SPC	South Pacific Commission
SPEC	South Pacific Bureau of Economic Cooperation
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNU	United Nations University, Tokyo
WHO	World Health Organization

KEYNOTE ADDRESS

—His Excellency Jose J. Leido, Jr.*

On behalf of the Philippine Government, and of the Ministry of Natural Resources in particular, I have the honor again to welcome most of you to our country. And as your humble host, we in the Ministry would like to express our sincere thanks to the distinguished organizers and co-sponsors of this very important workshop, namely, the Economic and Social Commission for Asia and the Pacific, the United Nations Office of Technical Cooperation for Development, the United Nations Ocean Economics and Technology Branch, the Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP), the Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (SOPAC), the United Nations Environment Programme, and the Environment and Policy Institute of the East-West Center. I would like to acknowledge their efforts in bringing to this gathering the presence of the equally distinguished representatives of the member countries of CCOP and SOPAC.

You are gathered here to discuss and assess the basic guidelines and methodologies for the management and development of coastal areas in our respective countries. For the Philippines, the task you seek to delineate is of primordial interest and concern to our national leadership. Geographical imperatives necessitate it since our extensive coastline is even longer than that of the United States.

Within the terrestrial, marine, brackish-water, and atmospheric confines of the country's coastal zone, we aim to apply more enlightened management schemes and better control measures. We are contemplating, or otherwise already implementing, some of these steps with due consideration of course to possible effects and repercussions on the neighboring archipelagic and coastal countries.

We deem this international workshop as highly significant, therefore, because here we may gain valuable insights into the transnational character of space, resources, and environmental facets of each country's coastal zone management and development program. Through this workshop, perhaps we can evolve guidelines and procedures on coastal zone management that are of mutual benefit to the countries represented here.

You could throw light and illumine such cases as the problems concerning migratory species of fish (like tuna), offshore oil exploration, mining of underwater nodules, the protection of mangrove and coral areas, and the strategies for controlling oil spills and other pollutants of the marine environment that we all share.

The marine space within our region should be of particular interest since it

*His Excellency Jose J. Leido, Jr., is Minister of Natural Resources, Republic of the Philippines.

links the coastal zones of our individual countries. Hence, our coastal policies are or should be intrinsically interdependent and interwoven with each other. I am very confident that with the experts in attendance in this workshop, we can translate our interdependent coastal policies into common programs and projects for our mutual advantage.

Now, allow me to digress a little on the Philippine experience in coastal zone management.

We are an archipelago and therefore our population and economic activities are highly concentrated in our coastal zones. Major human settlement areas in the country, like Metropolitan Manila and Cebu, thrive in their coastal locations because of the obvious economic advantages which the terrestrial and marine interface offers.

Economic activities within our coastal zones include fisheries and aquatic resources exploitation, beach mining, offshore oil exploration, mangrove utilization, salt production, agriculture, and the like, which are not necessarily compatible with each other or suited for multiple use management.

Other nonresource extractive activities, such as transportation, infrastructure development, recreation, waste and sewage disposal, and land reclamation also are exerting considerable impact on our coastal zones. This complicates the schemes for rational use and management of these areas.

I am aware that the concentration of people and human activities in coastal areas is also true with respect to similar archipelagic or coastal countries like Indonesia, Malaysia, and Thailand. I suppose we can, for one thing, credit this to the historical fact that our forefathers were seafarers and built their original settlements on the shores of our countries.

Environmental degradation and resource depletion can result in our coastal zone if we cannot properly manage the activities of people in these areas. Already, signs of environmental and resource stresses are evident in our dwindling mangrove and coral resources, which may directly affect the productivity of our fishing grounds.

Pollution and sedimentation are likewise becoming serious environmental issues in our major coastal human settlements, like Metropolitan Manila. Here, although coastal zones can be used as ecological units for management purposes, this approach is still in its infancy. Management activities are still carried out by many national and local agencies. But in the future, an integrated approach to the management of these zones should include a better management setup that will coordinate and rationalize all activities in the coastal areas.

For its part, our Ministry has started and is continuing with a package of development programs for improved management of natural resources in the country's coastal zones. For the conservation and rational management of resources in these areas, the Ministry, through its bureaus and attached agencies, is at present undertaking three major programs. These are the mangrove, coral, and marine park programs.

Our mangrove programs accelerated with the creation of a National Mangrove Committee sometime in 1977, composed of representatives from the Ministry's bureaus and consultants of the Office of the Minister. Soon, the Natural Resources Management Center (NRMC) became the Secretariat of this committee. Using satellite remote sensing technology supported by ancillary data, the center allocated the country's total mangrove areas into forest preserves, forest conservation zones, and areas that can be converted into fishponds.

Now, with mangrove areas and their associated fishing grounds already delineated using a set of ecological criteria, our Ministry is working on a proclamation regulating and controlling the exploitation activities within the identified forest preserve and conservation zones.

The coral management program is being done by the Ministry in cooperation with the Marine Science Center of the University of the Philippines. The program has finished intensive investigations on the state of coral resources in the country in about 370 sites. These sites showed signs of unwise use or over-

exploitation in spite of a standing ban on coral gathering which took effect as early as 1973. The Ministry is now formulating stronger strategies to implement the intent of Presidential Decree 1219, which prohibits the gathering, harvesting, collecting and/or exportation of ordinary corals. For the precious and semiprecious species, we want their utilization to be less destructive. We will not allow the traditional tangle net method of harvesting which is nonselective.

The coral and mangrove management programs are geared toward increasing the productivity of our municipal fishermen. Of course, there are ecological and other economic reasons to be considered in conserving these invaluable marine areas.

To protect and conserve the numerous habitats and ecosystems in the marine environment without necessarily hindering the country's industrialization, our Ministry has launched a marine park and reserve management program. The task force on marine parks implementing this program has prepared plans and projects for marine parks and reserve management. The task force has also identified possible marine park sites in the country which include Apo Island and Reef in Mindoro, Sumilon Island in Cebu, Panglao-Balicasag Area in Bohol, and Sombrero in Batangas.

I wish to emphasize that our Ministry, aside from implementing the major programs on the coastal zones I have described, has also formulated policies expressed in various Legislations, Administrative Orders, and the like, which seek to protect, conserve, and regulate activities related to the utilization of natural resources and the environment in these coastal areas.

Through the National Environmental Protection Council (NEPC), the Ministry also started environmental programs in our coastal zones. The Council was formerly an agency attached to the Ministry when it was created three years ago. However, it is now under the jurisdiction of the Ministry of Human Settlements.

One of the first interagency programs implemented by the NEPC was a Coastal Zone Management Program. This program sought to rationalize the uses and activities in these areas through interagency efforts involving all government institutions doing related work for our coastal zones.

I am pleased to note that one of the topics to be discussed in this international workshop is the methodological approaches to surveying and monitoring of our coastal resources. Indeed, a basic problem usually confronting planners and resource managers is the dearth of comprehensive baseline information.

At this juncture, I am glad to mention that the Natural Resources Management Center (NRMC) of our Ministry has been using satellite remote sensing technology for quite sometime now in surveying and monitoring the country's natural resources. The Center has facilities for computer-assisted analysis of digital data being fed by LANDSAT.

In fact, a major ongoing project of the NRMC is a coastal resources and environment survey using MSS LANDSAT data. This project is being supported by the National Science Development Board and has as its main objective the conduct and actual resource inventory, mapping, and multidisciplinary environmental analysis of a selected pilot area in northwestern Luzon, using computer processing of satellite images and ground surveys. We aim to utilize our experience in the pursuit of this project in evolving an operational procedure for a nationwide satellite-based monitoring of our coastal areas.

In closing, I wish to commend everyone in this hall for participating in a dialogue on coastal zone management. Our common task is urgent, but it is certainly not too late for us to repair past damages or build or plan new approaches to our problems before the dangers posed by increasing population and industrialization become critical. I am heartened that countries of Asia and the South Pacific are here to evaluate each other's coastal zone policies and programs, which definitely are linked to each other by a common marine environment.

Again, I welcome you all. May your stay be pleasant as well as productive.

Thank you.

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MESSAGE FROM J. B. P. MARAMIS*

Dr. Roque, Dr. Fernandez, Distinguished Participants, Ladies and Gentlemen:

It is with a great sense of trepidation that I venture to address this important workshop on a subject on which considerable research is still needed and about which ESCAP has no activity covering the whole gamut of the problems involved.

It is surprising that interest in coastal area development and management is relatively new, considering that since antiquity human settlements, trade, and industry have flourished in coastal areas where at present approximately two-thirds of the world's people live. It was only as recent as 1974 that a meeting of a group of experts on Coastal Area Development was held in New York. The conclusion of the subgroup dealing with East Asia included recommendations that criteria be developed for complementary use of land and near-shore resources and that a regional meeting be held to provide information on coastal area planning and resources development. The interregional seminar on Coastal Area Resources Development held in West Berlin recommended a focus on specific local problems.

It is encouraging to note that the Ocean Economics and Technology Branch of the United Nations Headquarters has been able to organize this Workshop on Coastal Area Development and Management with the co-sponsorship of several other United Nations, international and national organizations, including ESCAP. I should like to take this opportunity to thank all the Governments and International Agencies whose financial and other contributions made this important workshop possible.

Coastal areas have a number of favorable features and unique physical characteristics which have made them focal points for settlement and economic activities. Coastal climates are more moderate than those of the continental interiors and are usually associated with sufficient rainfall to sustain agriculture. Large, meandering rivers and estuaries deposit silt and mud in flood plains and deltas, producing fertile agricultural land. It is believed that a large percentage of the world's recoverable hydrocarbon resources lie in coastal waters less than 200 meters deep. The handling of marine cargo is also an important activity in coastal areas. The coastal area is furthermore a focal point for national and international tourism since swimming, sailing, sport fishing, and sunbathing are important activities in coastal areas. It may therefore be seen that coastal areas satisfy diverse human needs like food, energy, transport, and recreation.

Having said this, it may be worth considering that, for the purpose of planning the use of coastal areas and development of its resources, a thorough knowledge should be gathered of: coastal systems; their historical evolution; and the components, processes, and functions of

*J.B.P. Maramis is Executive Secretary of the United Nations Economic and Social Commission for Asia and the Pacific.

natural coastal systems, such as the biological and geomorphological characteristics of coastal areas, phenomena of erosion and deposition, floods, subsidence and uplift, seismic characteristics, etc.

We have to bear in mind that man's activities, especially in the light of the rapid advancement of technology, have a very great impact on coastal systems. If man formerly depended much more on biological resources, lately mineral resources such as offshore oil and gas, tin, and sand and gravel are increasingly becoming more important, and their exploitation could affect the coastal environment.

Obviously coastal areas are not without disadvantages. They are hosts to a number of difficult problems: poor drainage due to their flat topography, frequent flooding because of their low elevation, salt-water intrusion, and prevalence of water-borne diseases and parasites. Man has also found the coastal zone a convenient place to dump both industrial and domestic wastes. The degradation of coastal areas through pollution by oil spills is becoming a serious problem. Coastal areas also are vulnerable to natural disasters like typhoons and accompanying storm surges as well as tsunamis. Some of the world's greatest tragedies have occurred along coastal areas as a result of such phenomena.

Studies reveal that the global trend in the development and use of coastal areas is towards large-scale urbanization along coastal belts with attendant concentration of trade and industry around the major port cities, the concentration and intensification of the extraction of marine resources--both living and nonliving--in shallow near-shore coastal areas, and increasing international tourism as well as domestic demand for recreation in these areas. These trends, however, will exacerbate the growing problems already being faced in these areas, if not properly planned and managed.

Thus, the rapid growth of large-scale economic activities in the relatively narrow and limited coastal strips cannot continue indefinitely without some degree of control and management. Competition between industrial, residential, and recreational uses will intensify as the available coastal space decreases. Moreover, the transformation of the coastal area resulting from man's activities may adversely alter natural coastal processes whose long-term effects cannot as yet be determined.

For example, little is known about the processes of transport of sand along coastal areas. The construction of a harbor without taking into account the sand transport may result in failure or excessive remedial measures. On the other hand, some adverse effects can be predicted. For example, unregulated pumping of groundwater supplies in coastal areas will definitely cause the fresh and salt water interface to move upstream and render many wells useless.

In view, therefore, of the need for the rational development and management of coastal areas, the subject of this workshop is a very important and topical one for the countries of this region. The coastal environment constitutes a complex ecosystem but is an important and unique resource that must be maintained for the benefit and gainful use of the countries in the region. Neither complete destruction of the natural environment nor complete prohibition of development and exploitation are acceptable goals as a national policy on coastal zone management. A balance of use, conservation, and preservation of the coastal zone should be maintained so as to optimize man's use of coastal resources. Thus, maximum rational use of coastal resources consistent with the retention of life-support systems and amenities of the coastal zone for the enjoyment of future generations should be the objectives of coastal zone management.

Distinguished participants, it is not usual for an opening address to end with a problem. In this particular case, however, it might be appropriate and useful to pose to the workshop the question as to what exactly constitutes the coastal zone. While I stand to be corrected, I must admit that I am not aware of a generally agreed upon and acceptable definition, in a legal sense. The seaward limits of the coastal zone are particularly ambiguous or arbitrary. It may, therefore, perhaps be worthwhile for the workshop to start with a precise definition of the coastal zone.

I wish you every success in the workshop.

STATEMENT FROM MARK J. VALENCIA*

The East-West Environment and Policy Institute (EAPI) is very pleased to be a co-sponsor of this workshop. EAPI was organized in October 1977 to increase understanding about the vital relationship between the policies that direct a society's activities, and the physical environment within which these activities take place and upon which they depend. Without such understanding, policies developed within one sector of a society can have unanticipated, undesirable impacts in other sectors of the society. For example, a policy designed to increase foreign exchange through the export of timber products may adversely affect the society's agricultural productivity through erosion resulting from deforestation. Further, a policy designed to fill a critical short-range need may inadvertently create even more critical problems in the longer-term future.

To assure that activities designed to meet human needs are not counter-productive among various sectors and over time, consideration of environmental and natural resource factors should be integrated into the formulation and implementation of a broad range of policies. This must be achieved on an international basis when a common environment is involved or when interdependencies such as finance or resource flows link nations.

EAPI contributes to the required international understanding of these issues through the study and synthesis of environmental knowledge from a perspective of policy concerns. Its efforts are undertaken through the cooperation of competent and experienced scholars and professionals from many societies in the independent institutional setting provided by the East-West Center.

Institute activities include staff studies, awards to scholars, experts, and advanced degree students in relevant fields; workshops; and conferences that bring together professionals from different sectors and many countries to identify and examine important problems and to work toward their solutions. The products of these activities include issue papers, research reports, state-of-the-art surveys, policy aids, and instructional materials.

Two major five-year projects in EAPI are "Natural Systems Assessment for Development" and "Marine Environment and Extended Maritime Jurisdictions: Transnational Environment and Resource Management Issues."

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*Mark J. Valencia is a Research Associate at the East-West Environment and Policy Institute, East-West Center, Honolulu, Hawaii, and Coordinator of the Institute's project "Marine Environment and Extended Maritime Jurisdictions."

The mandates and terms of reference of the Environment and Policy Institute make coastal zone management issues a particular area of interest for the Institute and we are indeed pleased to co-sponsor this workshop.

We extend our thanks to the Bureau of Mines for their organization and hospitality.

Thank you.

II. REGIONAL PERSPECTIVES

SOUTHEAST ASIA: AN OVERVIEW

—Mark J. Valencia*

This paper attempts to provide a general overview of the status and trends in use of the South China Sea's coastal area. As used here, the term coastal area includes the coastal waters, the continental shelf, and the waters above it, as well as the adjacent shorelands and water bodies strongly influenced by each other and in proximity to the shoreline. For management purposes, the area can be considered as extending seaward to the limits of the exclusive economic zone and landward to the extent necessary to control uses and impacts on shorelands which have a direct influence on coastal water quality and resources.

NATURAL ENVIRONMENTAL SETTING[1]

Geography and Climate

Ninety percent of the $3.5 \times 10^6 km^2$ marine area[2] known as the South China Sea is bordered by land. The South China Sea is situated between the Pacific and Indian Oceans and separates the Asian mainland in the northwest from an archipelagic rim to the southeast. There are two deep embayments on its northwestern margin, the Gulf of Tonkin and the Gulf of Siam. The Sea is directly connected with the Andaman Sea and the Indian Ocean to the southwest through the Singapore-Malacca Straits bordered by Indonesia, Malaysia, and Singapore. The direct connection with the Pacific Ocean in the northeast is through the Taiwan Strait and Bashi Channel and several channels in the Batan and Babuyan Islands of the Philippines. Numerous indirect interoceanic connections exist via the archipelagic rim. The Philippines, Indonesia, Singapore, and the heavily populated area of Hong Kong are island entities. Malaysia consists of a peninsula and a portion of a large island, separated from each other by the South China Sea. Thailand consists partially of a long isthmus truncated by the international border with Malaysia. Cambodia, Vietnam, Laos, and part of Thailand together comprise a peninsula.

The South China Sea itself is bathymetrically divided into the deep China Sea Basin in the northeastern portion extending over 52 percent of the total area, and extensive continental shelf areas comprising 48 percent of the total area. The China Sea Basin has a maximum depth of 5,016 m off Palawan and a central abyssal plain at about 4,300 m.[3] Within the deep basin area are submerged banks, e.g., Macclesfield Bank, and island groups, e.g., the Paracels and the Dangerous Ground extending in the south to the Spratly Islands. The continental shelf areas include the Mainland Shelf extending from the Taiwan Strait through the Gulf of Tonkin, the great shallow Sunda Shelf underlying the southwestern South China Sea including the Gulf of Thailand, and the narrow shelves off western Palawan and Luzon.

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*Mark J. Valencia is a Research Associate at the East-West Environment and Policy Institute, East-West Center, Honolulu, Hawaii, and Coordinator of the Institute's project "Marine Environment and Extended Maritime Jurisdictions."

The South China Sea region is situated almost entirely between the Equator and the Tropic of Cancer and is under the influence of a monsoonal climatic regime. North of the Equator, the dry monsoon with northeasterly winds extends from October to April, and the wet monsoon with southwesterly winds lasts from May to September.[4] Precipitation in the region varies with the distribution of land and sea and mountain chains, but 2,500 mm a year is common in the coastal area.[5] Typhoons spawned in the western Pacific frequently pass through the northeastern sector of the region.

Surface currents in the South China Sea are greatly influenced by the monsoon regime. During the southwest monsoon, northeasterly currents, intensified in the western portion of the sea, dominate the surface flow. A weaker southwesterly return flow develops in the central eastern portion off Borneo, however, producing an anticyclonic circulation pattern. The northeast monsoon produces the reverse pattern.[6] Since the surface flow reverses direction twice each year and there is a counter current producing a circulatory gyre even at the peak of each monsoon, it is possible that flushing rates of surface layer pollutants deposited in the South China Sea are quite low. Surface water movement in the Gulf of Thailand is weakly anticyclonic during both monsoons. Here surface flushing rates are certainly low, and deeper horizontal circulation is retarded by a shallow sill across the mouth of the Gulf. In the Philippine and Indonesian archipelagoes, deep circulation is inhibited by sills dividing the numerous separate deep basins, thus retarding replenishment and ventilation.

Salinities are generally less than 35 percent throughout the region due to an excess of precipitation and runoff over evaporation, and nearshore or restricted areas can become brackish at times. The temperature structure of the surface waters is fairly uniform, varying only about 4°C annually.

Nutrient enrichment of the surface layers is through vertical mixing over the shelf, river discharge, and upwelling. Upwelling occurs during the southwest monsoon in the South China Sea northeast of the Malay Peninsula, along the edge of the shelf southeast of Vietnam, on the edge of the Mainland Shelf, west of Luzon and Palawan, and in the Timor and Banda Seas. During the northeast monsoon, upwelling occurs along the edge of the Mainland Shelf, east of Vietnam, and off Sarawak. Production is relatively high (1.0g C m^{-2} day^{-1}) over the Sunda Shelf such as in the Gulf of Thailand, along the east coast of the Malay Peninsula, and between Sumatra and Borneo, and low (<0.5g C m^{-2} day^{-1}) over the deep ocean areas.[7] Production of fish, crustaceans, and molluscs is thus high in the shelf areas. Tropical marine ecosystems generally consist of large numbers of species with fewer individuals of shorter life cycles, as compared with higher latitude ecosystems. Fisheries in the South China Sea are based on large numbers of short-lived species containing fewer individuals, and catches are thus "mixed."[8]

Littoral Types

Maximum tidal ranges are greater than 3 m along the coasts of the Andaman Sea and Malacca Straits, as well as at the head of the Gulf of Thailand, along southern Sarawak, the head of the Gulf of Tonkin, and farther east along the China coast. Tidal ranges reach more than 6 m in the Taiwan Straits and at the head of the Gulf of Martaban. Coastal plains and mountains and hills are predominant coastal land types. Extensive coastal plains are found along the Chinese mainland opposite Hainan, in central and extreme southern Vietnam, the eastern and western Malay Peninsula, the entire northeast coast of Sumatra and north Java, the southern Celebes, and almost all of Borneo. Deltas with mud flats and adjacent nutrient-rich, turbid coastal waters generally are located where the region's major rivers discharge into the sea, e.g., China's Si, Vietnam's Red and Mekong, Thailand's Mae Klong-Chao Phya, Burma's Irrawaddy, and Indonesian Borneo's Kapuas. Mangrove forests are a predominant coastal feature in northern and extreme southern Vietnam, Kampuchea, Thailand, Burma, the Malay Peninsula, Sumatra, north Java, Borneo, and the Philippines. Although patches of fringing coral occur along the land-water interface of virtually all the political entities of the region, extensive fringing reefs are limited to the eastern Indonesian archipelago and the

Philippines. Coral fringed islands, atolls, and isolated reefs abound in the Gulf of Thailand, the eastern central South China Sea, and throughout the Indonesian and Philippine archipelagoes wherever sufficiently clear waters and geological factors permit growth. Sandy beach is not a common coastal type in Southeast Asia. Extensive stretches of sandy beach do occur in southwest and northeast Taiwan, central Vietnam, and along the east coast of the Thai Isthmus and the Malay Peninsula; smaller stretches of sandy beach are scattered throughout the region. Earthquakes and volcanic eruptions are common throughout the Indonesian and Philippine island arcs and have generated destructive tsunamis.

The coastal climates and hence the coastal landforms, biological systems, and the very way of life of the inhabitants are thus monsoonal tropical throughout most of the region. Tropical ecosystems have evolved and flourished under relatively stable environmental conditions as compared with temperate regions and are thus possibly more vulnerable to geologically abrupt, man-induced impacts. The rate of environmental degeneration due to human impact appears to be greater than the rate of natural recovery or readjustment.

Just as it is apparent that some coastal area uses are related to certain natural environmental associations, it is also apparent that these natural environmental associations are limited and unevenly distributed. This basic condition sets the numerical constraint and eventual limit on choices for compatible uses by each national entity.

PRESENT AND POTENTIAL COASTAL AREA RESOURCE USES AND CONFLICTS

There are basically four categories of coastal area resource use conflicts: competition for coastal space itself, synchronic competing uses of the same resource, present dedicated use versus future use of the same resource, and uses at some distance away affected by uses that modify the coastal environment.[9] These categories should be borne in mind during the following discussions of use status and trends in the region.

More than a quarter of humanity resides in the political entities bordering the South China Sea, and 75 percent of Southeast Asia's population lives on islands. The average national rate of population increase is 2.7 percent per year.[10] Due to infertile or rugged, forested hinterlands, much of the population is crowded into arable river valleys and available coastal plains.

The population in the coastal area of the South China Sea is concentrated around coastal cities such as Taipei, Manila, Jakarta, Singapore, Bangkok, Ho Chi Minh, Hanoi-Haiphong, and Hong Kong. Population densities are greater than 200 km^2 and increasing as rural inhabitants migrate to these areas, placing severe strains upon facilities, services, and living space itself. With an increasing population and the lack of success, so far, in attempts to stem coastal and urban immigration from rural areas, this demand upon coastal space, as well as attendant conflicts, will be intensified.

Urbanization in the region also is accompanied by commercial/industrial growth, which serves as an attractant for the employment-seeking populace. Since most of the political entities of the region are in a "developing" economic status, industrial activity is not as advanced or widespread as in the "developed" world and is predominantly confined to extraction and primary processing of indigenous raw materials prior to export. Primary processing industries in the region often are established on the coast or adjacent to rivers and estuaries due to the need for a ready water supply and a ready waste-disposal system; in any event, the waste often eventually reaches the sea.

Many of the South China Sea's coastal urban concentrations are associated with major ports. Most of these ports are highly congested, have antiquated facilities, and are shallow and subject to heavy siltation. Moreover, those nations bordering on the shallow Sunda and Mainland Shelf have few naturally suitable areas available for port construction. Expansion of existing ports and construction of deep-water facilities are planned by many nations of the region. Port expansion and maintenance entails almost constant construction and dredging of channels and berths to meet the demands of increased and deeper draft traffic, while new port establishment is inevitably

accompanied by, and indeed may be designed to attract, a concentration of coastal commercial and industrial activity, human habitation, and eventually, pollution.

Because of the relative scarcity of permanently dry, level land in the South China Sea coastal region, and the ensuing conflicts over use of that resource, land reclamation is widely practiced and advocated as a short-term solution. It is usually achieved by infilling of mangrove dominated intertidal regions with sanitary and, occasionally, unsanitary fill. Reclamation projects have been completed or are under way in many coastal areas, including Hong Kong, Singapore, Java, Penang, Kota Kinabalu, and Manila; a large land reclamation project for agriculture also is ongoing in southeast Sumatra. With increasing pressure for suitable land for industrial and agricultural development, land reclamation will become an even more attractive option.

Hydrocarbons

Two major hydrocarbon-bearing sedimentary basins underlie a portion of the Gulf of Thailand and the outer edge of the Sunda Shelf from northwest Borneo to Indochina. Smaller petroliferous basins are scattered along the Mainland Shelf and the coastal areas of the Indonesian and the Philippine archipelagoes.[11]

Probably all of the continental shelf has been explored by the oil and gas industry, and most of it has been leased. Important non-Indonesian producing areas include offshore the east coast of West Malaysia, west Sabah (East Malaysia), and adjacent Sarawak waters.[12] Important offshore Indonesian producing areas include the Java Sea, east Kalimantan, and the Vogelkop. Two recent offshore discoveries in the Philippines are Nido No. 1 off northwest Palawan, and Sampaguita on the Reed Bank in the disputed Dangerous Ground.[13] Further, new discoveries have been reported off southern Vietnam, in the Gulf of Tonkin west and south of Hainan Island, in the Pearl River estuary, and in the Paracel Islands.[14]

Continental shelf areas that appear to have the highest potential for new discoveries or expansion of recent discoveries include the western Malacca Straits-Andaman Sea, the western and eastern Gulf of Thailand, the Sunda Shelf north and northwest of the Natuna Islands, the Gulf of Tonkin, the Mainland Shelf area between Canton and Taiwan, northwest and west of Palawan, the southern Sulu Sea, the Kalimantan side of the Makassar Straits, and the Vogelkop.

Deeper water, i.e., the continental slope (including inter-arc troughs and sediment-filled trenches), the continental rise, and small ocean basins, also are receiving exploration and lease attention although the exploitation technology is not yet available for these water depths.[15]

Examples of deep-water leases in Southeast Asia include the southeastern Andaman Sea continental slope and rise, the southeast Sumatra inter-arc trough and trench, the Makassar Straits continental slope and rise, and the east Timor trench. Although the geology of the seabed provinces beyond the upper continental slopes has been little investigated with respect to petroleum potential, in general, the small ocean basins such as the Andaman, South China, Sulu, Celebes, and Banda Seas appear to be promising. In any event, long-range coastal area development planning should consider the probability of deeper-water hydrocarbon exploitation in the next decade.

Bottom Mining

Bottom mining for tin or sand and gravel involves dredging and disposal of tailings. The Southeast Asian "tinbelt" extends southward from the Malay Peninsula to the "tin islands" of Indonesia, i.e., Singkep, Bangka, and Billiton, and to the west and possibly east of the Peninsula.[16] Tin exploitation in Indonesian waters is concentrated in several localities around the "tin islands."

An area enclosing these islands and extending to the northwest to the international boundaries with Singapore and Malaysia and including the islands of Lingga, Karimun, Kundur, and Riau is considered of good potential. Although no systematic exploitation of tin is being undertaken in Malaysian waters, small areas off Lumut and Malacca have been systematically test-drilled, and the entire west, south, and southeast West

Malaysian state and federal territorial waters are considered as having potential, especially the Johore estuary.[17] In Thai waters, mining is ongoing off southeast Phuket and in portions of a coastal strip extending from southwest of Phuket to the Thai-Burma border. Some tin is being won from beach deposits near Rayong in southeast Thailand, and there is good potential in Phang-nga Bay, and some offshore exploration interest north and south of Songkla, and west and east of Rayong. The southeast appendage of Burma, on the basis of geology and occasional independent operators, has long been considered to harbor significant tin resources.

The easy-to-find terrestrial tin deposits have already been discovered, particularly in Malaysia and Indonesia, and offshore possibilities and prospects are receiving increased interest. Maximum subsea mining depth of detrital minerals feasible with present conventional technology is approximately 50 m, although skin deposits might be mineable to depths of 65 m. The 50 m isobath includes a large portion of the continental shelf in Southeast Asia. However, geologic considerations such as an 8 km maximum transport distance from source for economic deposits of placer tin,[18] the presence or absence of coastal or offshore granitic exposures, or shallowly buried granites or ultra-basic rocks, and the presence or absence of a large coastal plain significantly narrow the prospecting area. The occurrence of basins containing hydrocarbons is also a general indication of low potential for tin and other detrital mineral deposits.

Other principal coastal mining activities in the region include sand and gravel, silica sand, iron sands, and coral.

Energy Material Transportation, Storage, and Refining

The major transportation route for oil imported into the region is from the Middle East and Africa through the Straits of Malacca to Japan with offshoots to Thailand and the Philippines, including transshipment in Singapore.[19] The 920-km-long, 15- to 232-km-wide Straits of Malacca is the world's second most busiest seaway; more than 100 vessels transit the Straits every day, including six greater than 30 x 10^3 dtw (27.2-10^3 metric tons), and 10 VLCC's per day are expected in 1980. From within the region, Indonesian production is exported to Japan, the United States, the Philippines, Thailand, and Australia, whereas Brunei's production is exported to Japan and Thailand. Thailand and the Philippines also import oil from China. A recent tanker-safety scheme proposed by Malaysia, Indonesia, and Singapore to regulate tanker traffic in the congested Malacca and Singapore Straits may encourage a detour by VLCC's over 220 x 10^3 dwt (227-10^3 metric tons) through the deeper Lombok and Makassar Straits and the Sulu or Celebes Seas to Japan.[20]

Petroleum discharge during tank cleaning and from transfer operations at wells, terminals, storage tanks and refineries, as well as from nonpoint sources, also contributes significant petroleum to the region's coastal environment. Liquefied natural gas (LNG) will soon start moving from Arun in Sumatra and Bintulu in Sarawak to Japan and the United States. Nuclear spent fuel is apparently now being transported from Japan through the South China Sea to the United Kingdom and France.

Tourism/Recreation

Tourism/recreation has two main components relevant to coastal resource use conflicts; aesthetics and water contact activities. The perception of aesthetic beauty is a relative concept: local, intra- and extraregional tourists flock to such coastal resorts as Pattaya in Thailand and Penang in Malaysia; others consider these turbid and polluted waters and debris-laden beaches unattractive. Tourism/recreation is a rapidly growing industry and source of foreign exchange in the region, but extensive beach areas suitable for tourism/recreation, especially those readily accessible but not adversely impacted by man, are rare commodities. Initial efforts have been made to establish coastal preserves, such as Pulau Gaya National Park in Sabah, Muka Head State Park in Penang, and several small areas in the Philippines. Other coastal areas in the region have been nominated for conservation status by indigenous environmental organizations (Table 1).

TABLE 1. Coastal areas suggested for preservation/conservation status in Thailand and Malaysia

Thailand[a]

Preservation areas

- Entire northern coastal arc of the upper Gulf from Petchaburi around to Chon Buri
- Areas of coral habitat off the coast at Bang Lamung
- Important coastal and estuarine sections and corals between Rayong and Trat
- Reefs off Phuket Island
- Northern section of Songkhla Lake

Conservation areas

- The sea area from Laem Chabang, out to Kho Pai, and back into Leam Kham above Sattahip
- The sea and islands of Sattahip
- The channel and coasts around Kho Samet in Rayong Province
- The area of Trat and the offshore islands including Kho Chang
- The coastal strip of Hua Hin as far south as Khao Krat Lat
- Most of the coast and minor islands at Phuket
- Almost all of Songkhla Lake

Malaysia[b]

Marine nature reserves

- Four islands off Kuala Kedah
- Pulau Lallang in the Sembilan Islands
- Pulau Lang Tengah
- Tanjong Genting
- Tanjong Tokong, Penang[c]

[a] D. Michaels. Is the water fit to drink? *Bangkok Post Special Feature*, 28 May 1976, pp. 2-3.
[b] P.R. Wycherley. Conservation of coral reefs in West Malaysia, *Biol. Conserv.*, 1:3, 1969, pp. 259-260.
[c] Ong Jin Eong. Personal communication, 1973.

Commercial Fisheries

Important fishing areas include the western Malacca Straits, the Gulf of Thailand, the southern South China Sea, off southern Vietnam, the Gulf of Tonkin, northwest of Palawan, and the north central South China Sea.

It is interesting to note the correspondence of some major fishing grounds with areas of high petroleum exploration interest and/or recent discoveries. Such areas of potential use conflict include that off northwest Palawan, the Gulf of Thailand, the northern Malacca Straits, and possibly the Gulf of Tonkin and off southern Vietnam. Some of these fishing grounds also straddle major and minor petroleum tanker routes. Spatial interference of rigs with trawling runs, fouling of nets, and tainting of the catch are the major potential short-term problems for the fishing industry.

Aquaculture, an ancient practice in the region, is being modernized and expanded through intensive national and international efforts with the hope of providing protein to Asia's expanding and increasingly undernourished populace. The developed and potential aquaculture areas in the region generally coincide with the extensive stretches of mangrove-fringed coasts. Areas of expected major expansion include northwest Sumatra, both the Andaman Sea and Gulf of Thailand coasts of Thailand, and Luzon, the Visayas, Palawan, and Mindanao in the Philippines.

MARITIME JURISDICTIONS AND THEIR IMPLICATIONS FOR COASTAL AREA USE

Most of the littoral countries in the South China Sea have extended their resource sovereignty in the marine sphere and the rest will eventually follow suit. Indonesia and the Philippines have promulgated the archipelagic principle that extends national resource sovereignty to include the marine area within straight baselines connecting the outermost points of the archipelagoes. Further, almost all the littoral states have laid claim to the resources of their respective continental shelves, which, by present legal definition, extend to the depth of exploitability. Burma, Indonesia, Malaysia, Thailand, the Philippines, Vietnam, and Kampuchea also have declared exclusive economic zones (EEZs) which include, with minor exceptions, exclusive resource sovereignty in the marine sphere up to 200 nm from shore. China, Vietnam, Malaysia, and the Philippines also claim

small islands in the South China Sea, each of which may have its own continental shelf and EEZ. Given the eventual resolution of conflicting claims, the end result will be the accrual of enormous marine areas and any contained resources to national control.

Nations of the region have high expectations for the contribution of resources of these areas to national economic development. Indeed, this resurgence of "marine awareness" is beginning to be reflected in national economic development plans. Also, hydrocarbon and fishing companies from the major resource consumer nations such as Japan and the United States are increasing their interest in "joint-venture" exploration and exploitation of marine resources in the region, providing added impetus to short-term extraction and profit objectives. Further, as marine "awareness" and the concomitant severity of environmental regulations increase in developed countries, shifts of pollution intensive industries to less environmentally strict developing countries may become attractive. Also, national action may not be sufficient because the ocean is a fluid medium, and pollution or its impacts may be carried across national boundaries.

As the littoral South China Sea nations and their extraregional partners gear up their efforts to exploit this perceived windfall of resources, the numbers, as well as the placing, planning, and transnational impact of pre- and postharvest coastal bases may become significant.

For example, support bases for offshore oil development have sprung up in Trengganu on the east coast of Peninsula Malaysia, on Hainan, at Vung Tau in southern Vietnam, in Sabah, in eastern Kalimantan, and in northwest Palawan. The geographic location of these initial developments may be viewed as fortunate because of the economic infusion into rural, economically backward sectors. However, a rapid uncontrolled proliferation of such facilities and their ancillary industries may quickly preclude other planning options and bring new problems, such as population migration and overcrowding. Because the new areas of hydrocarbon interest, e.g., east coast Peninsula Malaysia, northwest Palawan, and the Gulf of Tonkin, are also major fishing grounds for both artisanal and commercial fishermen, direct conflict between uses and users is a possibility.

There are other indirect implications for coastal management of extended maritime jurisdiction. Promulgation of environmental or other regulations, in claimed areas with respect to oil tankers, may, as in the case of the Straits of Malacca, result in a shift of transportation routes. If these new routes, or increased frequencies of tanker traffic along formerly little-used routes, appear to be stable, governments may soon perceive that it would be to their economic advantage to tap these "energy pipelines" for economic stimulation of rural and remote border areas. This may result in major refineries and storage areas, including floating storage and even "superports" for developed country interests, with concomitant industrialization. Also, increased environmental awareness in developed countries may result in prohibition of the landing of certain hazardous cargo shipments, e.g., LNG and nuclear spent fuel in certain ports, thus further affecting transportation routes in developing country marine areas as well.

Some countries such as Thailand and others will find that their fishing grounds fall within the claims of other countries whose terms for foreign access are restrictive. One effect of this may be the forcing of large-scale and small-scale fishing and fishermen into competition and conflict over already stressed nearshore resources. Also, for some nations that will find their distant-water fleets banned from former fishing grounds, aquaculture would then no longer be a convenient minor supplement to marine fishing, but an imperative. Suitable sites for major aquaculture enterprises are not plentiful, and the pressure for this use of precious coastal areas will increase. Mariculture may remain a long-range dream, if suitable marine areas are allocated to other uncomplementary uses, including waste disposal from industrial development. Further, with the realization of the value of migratory, shared resources such as tuna, sardines, and mackerel in zones of newly extended jurisdictions, the attendant value of coastal spawning and nursery areas for these stocks takes on a new, transnational importance.

There are probably other indirect implications of extended jurisdictions for coastal area use conflicts that will become apparent as developments proceed. However, there may be a delay engendered by the conflicting jurisdictional claims and such delay could be a benefit if it is used for careful analysis of trade-offs in coastal area resource use.

CONCLUSIONS

Based on the foregoing survey of coastal area use and use trends in Southeast Asia, priority areas of concern may be delineated as urgently requiring coastal area planning for the most efficient utilization of the available resources.[21] Certainly the coastal areas enveloping the region's major cities are of concern due to the concentration of many resource users in a small area: dense human habitation, commerce and industry, highways, airports, ports, land reclamation, unrestricted domestic and industrial waste disposal, power facilities, pest control, and logging, terrestrial mining, and agriculture in the hinterland. Priority urban areas would include Manila, Jakarta and all of north Java, and Bangkok. Although controls on existing coastal resource uses may be difficult to implement due mainly to nontechnical reasons, new or additional uses might be regulated or at least planned for, especially in new "development" areas. The upper Gulf of Thailand, particularly the Bight of Bangkok, is a case in point. Circulation is extremely weak, and Sattahip may be converted to a civilian deep-water port, with attendant domestic and industrial/commercial activity, adding further stress to the coastal resources in this area. Areas of potential conflict in coastal and offshore resource use include northwest Palawan, where aquaculture, petroleum exploitation and offshore fisheries may coincide, and the greater Gulf of Thailand.

The constricted, shallow Malacca Straits is a priority area for a coordinated international approach by the four bordering nations: Thailand, Malaysia, Indonesia, and Singapore. This area is a microcosm of the coastal activities and conflicts of the region. The Straits are a major transport route for petroleum tankers. Coastal petroleum exploitation is ongoing in north Sumatra, with exploration off southwest Thailand, and coastal depots and refineries are situated in Port Dickson and Singapore. Bottom mining is ongoing from Phuket northward and exploration is under way off Malacca and Penang. Terrestrial tin mining is scattered throughout the Thai Isthmus and the Malay Peninsula. Logging activity is significant on Sumatra, generating much sediment and contributing to coastal accretion. In addition to Singapore, the west coast of the Malay Peninsula is rapidly becoming urbanized and much of Malaysia'a population and industrial/agricultural processing activity is concentrated there, discharging wastes into the Straits, including those from pest control. The ports of Penang, Port Swettenham, Port Dickson, and Singapore are situated on the Straits. Aquaculture is being expanded in North Sumatra and may be expanded in suitable locations along Malaysia's west coast, and mangrove harvesting is locally significant throughout the coastal area of the Straits. Much of the West Malaysian coastal plain above the high-tide mark is under cultivation, and an agricultural scheme utilizing reclaimed land is planned for southeast Sumatra. Artisanal fishing including shellfish harvesting is widespread in the nearshore areas and significant offshore fishing is conducted in the northern Straits. Tourism/recreation centers bordering the Straits include Phuket, Penang, and Singapore.

From a realistic politico-economic perspective, it is clear that certain activities in the region will have national economic priority, such as extraction of hydrocarbons and minerals. However, such activities might be planned and managed so as to minimize adverse impacts on other coastal resources and uses. Also other uses, such as tourism/recreation may be geographically situated in areas less likely to be exploited for other uncomplementary purposes. The name of the game is complementary multiple use where possible and judicious, far-sighted trade-offs where not. However, it remains to be seen if and when governmental planning philosophies, so geared to growth development on the Western model, also will incorporate the concept of long-term planned growth and optimum allocation of coastal resources, belatedly, and thus so painfully attempted by the West.

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INVESTIGATION OF MINERAL POTENTIAL IN THE SOUTH PACIFIC (CCOP/SOPAC)

—Natural Resources Division, ESCAP

The Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC, which was established under the aegis of ESCAP in 1972), Eighth Session at Suva, Fiji, in September 1979 was attended by representatives from all the member countries--Cook Islands, Fiji, Kiribati, New Hebrides, New Zealand, Papua New Guinea, Samoa, Solomon Islands, and the Kingdom of Tonga. Technical advisers from the Governments of Australia, France, Japan, the United Kingdom of Great Britain and Northern Ireland, the Union of Soviet Socialist Republics, and the United States of America also attended.

BACKGROUND

As the South Pacific is dominated by the ocean, the peoples there have traditionally depended on it as a means of communication and food. Therefore, for a long time there has been an emphasis on, and an interest in, marine resources.

However, limited financial resources coupled with the lack of facilities, equipment, and trained personnel have precluded the development of appropriate and necessary capabilities to properly assess those resources without substantial support from external sources.

Consequently, due to strong efforts by ESCAP, a project was started on January 1, 1979. This project, Investigation of Mineral Potential of the South Pacific, involved a commitment by UNDP of more than US $2.5 million and member country contributions in kind and cash of over US $1.4 million for a three-year period.

As set out in the project document, the long-term development objective is the discovery and development of mineral and hydrocarbon deposits within offshore areas of interest to CCOP/SOPAC member states so that those states and their people can benefit from the increased revenues, employment, industrial activity, and other downstream activities that would attend their exploitation.

WORK PROGRAM

The major activities of the UNDP Project are centered on a chartered, small, coastal-type vessel with which it is planned to carry out coordinated geological/geophysical surveys of member country offshore and oceanic areas for six months of each year. CCOP/SOPAC's work program, which it should be pointed out is not synonymous with the work plan of the UNDP Project, is reviewed and formulated at annual sessions. The work program is designed, among other things, to foster technical cooperation among the member countries. There are 74 country projects and 20 regional projects in the current program.

Additionally, the UNDP staff undertake:

(1) to train member country personnel in mineral exploration techniques through on-the-job and specialized training courses;

(2) to collate and reinterpret the available, relevant data from previous work;

(3) to publish and disseminate the results derived from these activities;

(4) to coordinate all offshore mineral resources surveys being carried out in the region;

(5) to provide advice to member governments on minerals exploration and exploitation;

(6) to select areas of interest for investigation;

(7) to establish a data repository;

(8) to provide equipment through loan and exchange; and

(9) to strengthen existing marine science institutions of the region.

GEOLOGY AND MINERAL RESOURCES OF CCOP/SOPAC

The principal geological features of the CCOP/SOPAC region include:

(1) active basins such as the Lau, North Fiji, Woodlark, Bismarck, and Solomon;

(2) inactive basins such as the Coral Sea, New Caledonia, South Fiji and Norfolk; and

(3) island arc systems such as the Solomon, New Hebrides and Tonga.

Considering the offshore regions within 200 miles from the coasts of the individual countries, the potential mineral resources that might occur from shallow to intermediate depths, e.g., from 0 to 2,000 m are indicated in Table 1. Other potential resources of the member countries include geothermal and marine energy sources, and lagoonal, freshwater springs.

TABLE 1. CCOP/SOPAC countries: potential marine mineral resources

Country/ Mineral	Industrial Minerals	Precious Metal Placers	Heavy Metal Placers	Phos-phates	Pre-cious Coral	Metal-liferous Muds	Ferro-man-ganese Nodules	Hydro-carbons
Cook Islands	X			X	X		X	X
Fiji	X	gold	titaniferous magnetite	X	X	X	X	X
Kiribati	X			X	X		X	
New Hebrides	X (also bauxite)			X	X	X	X	X
Papua New Guinea	X	gold platinum		X	X	X		X
Samoa	X			X	X			
Solomon Islands	X (also bauxite)	gold	titaniferous magnetite; chromite	X	X	X		X
Tonga	X			X		X		X

COASTAL AND NEAR-SHORE SURVEYS

Recognizing that coastal and offshore area development will become increasingly important to the island countries in the future, the project will pay special attention to the environment, particularly where near or onshore exploration work is concerned and, in general, will examine the ecological consequences attending the exploitation of any mineral substance of potential found by its surveys. Provision has been made also to render advice to member governments on ecological matters and to carry out surveys of onshore construction projects that may have ecological consequences for the offshore area. Oceanographic environmental baseline data and information on the geology and characteristics of the sea floor will be collected during the course of the near-shore surveys.

CONCLUSIONS

A considerable amount of on-the-job (aboard ship) and shore-based training of member country technicians has been accomplished to date. This training has enabled offshore survey units to be set up in Fiji, Cook Islands, New Hebrides, Solomon Islands, Samoa, and Tonga.

Furthermore, the data obtained by the project are contributing to a better understanding of the regional geological features and processes in the region. As those features and processes control the distribution of minerals and hydrocarbon resources on and below the surface of the seabed, it is hoped that the knowledge gained would in turn be used in local, more detailed geological exploration and provide a firm basis for the evaluation of the economic resources potential.

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OFFSHORE AND ONSHORE MINING OVERVIEW

—Michael J. Cruickshank*

INTRODUCTION

The following notes are intended to give a brief overview of the type of mining operations that might be expected to be located in the area of the coastal zone. Offshore and onshore mining activities should for the most part be considered separately because the techniques employed are generally different.

OFFSHORE MINING

From a recovery perspective, there are basically three types of offshore mineral deposits: (1) those which are amenable to dredging methods for their recovery; (2) those which may be recovered through bore holes in a manner similar to the recovery of petroleum; and (3) those which may be recovered by underground mining methods utilizing shaft or tunnel access from land.

Only the first type will be considered here. These deposits are composed very generally of two types of materials: (1) construction materials such as sands, gravels, refractory muds, shells, and corals, all of which are bulk materials of generally low value; and (2) heavy minerals, gems, and metal sands such as those containing tin, titanium, iron and chromium minerals, diamonds, gold, and platinum. These materials are of high value but constitute at the most only a few percent of the volume of the deposit.

Most of these deposits are found in proximity to the coast within 100 m of water depth, whereas others such as nodules of phosphorite, metalliferous muds, or precious corals are found farther from the coast and in water depths up to 1,000 m.

The most common of the deposits are the construction materials. For example, sand and gravel are mined very extensively in Japan, the United Kingdom, and northern Europe.

Japan mines 60 to 70 million m^3 of sand each year utilizing about 1,000 small dredges. Most of the operations take place in the Sea of Japan and in the Inland Sea near Hiroshima. These operations, which take place mostly within 2 km of shore in water less than 20 m deep, supply almost 20 percent of Japan's construction requirements. In the North Sea area of northern Europe about 100 dredges are operated by 10 different nations, particularly the United Kingdom, Sweden, and France, to mine about 30 million tons each year of sand and gravel aggregates.

Tin mining offshore has been a major industry for many years in Thailand and Indonesia. As many as 16 major dredges have operated in the coastal areas of islands, generally in water depths of less than 15 m with total digging depths of less than 30 m. In Thailand, small dredges

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operated by tin poachers have numbered as many as 3,000 at one time.

Diamonds were mined for several years off southwestern Africa, close to shore. Technical problems due to rough sea conditions resulted in the closure of the operations pending further research on the problem, but much of the area is still of interest. Other operations for iron-sands and titanium sands are found in Japan near shore and in Australia and New Zealand in beach areas.

ONSHORE MINING

Mining in the coastal zone onshore is quite common throughout the world, because historically there have been immediate advantages in such a location due to easy accessibility. Use of the coastal wetlands and waters has been made for disposal of mine waters and dumping of waste materials from the mine and processing plants. With large operations, significant adverse effects may result.

SOUTHEAST ASIA AND THE PACIFIC REGION

Present or potential offshore and coastal mineral activities in Southeast Asia and the Pacific are reviewed in Table 1.

CHARACTERISTICS OF OFFSHORE MINING ACTIVITIES

Some relevant characteristics of offshore mining activities for construction materials, tin and heavy minerals are given in Table 2. Other notes on limitations of mining depth and breakeven

TABLE 1. Overview of offshore mining and mineral deposits in Asia and the Pacific

Country	Active Mining	Potential
China	Sand, iron, nickel, titanium & other detrital minerals, coral	Gold, diamonds
Fiji	Coral sand	Gold, iron, copper, phosphates
Indonesia	Tin, titanium, sand	Tin
Malaysia	Tin (onshore), iron, bauxite	Tin (offshore)
Papua New Guinea	Limestone, gravel	Construction sands, chromite sand, limestone for cement, precious coral, gold, phosphate, corals
Philippines	None	Gold, iron, chromite, silica sand, precious coral, coral sand
Singapore	None	Sand
Solomon Islands	Construction materials	Chromite, gold, bauxite, precious coral
South Korea	Silica sand (onshore)	Titanium, thorium, garnet
Thailand	Tin	Rock salt, coal, fluorite, limestone for cement
Trust Territories	Coral sand, basalt rock	Phosphates
Vietnam	Coal, silica sand, kaolin, limestone, gravel	Coal, iron, titanium, coral
Western Samoa	Coral sand	Sand, precious coral

TABLE 2. Some characteristics of offshore mining activities

Characteristic	Construction Materials	Tin	Heavy Minerals
Ore mineral	Rock, shells, silica, coral	Cassiterite	Iron (Magnetite), titanium (Ilmenite, Rutile), Gold (Native Metal), Thorium (Monazite)
Percentage ore mineral in deposit	60%-100% depending on sand/gravel ratio and local construction needs	1/100 of 1%	3-5% or less
Normal annual through-put	Dependent on local need; 30,000-300,000 m^3	Limited by dredge capability; 2 million m^3/yr	Limited by dredge capability; 1-3 million m^3/yr
Average life of deposit or field	10-100 yrs	70 yrs	10-50 yrs
Thickness of typical deposit	3-20 m	1-30 m	1-15m
Water depths	0-100 m	0-100 m	0-100 m
Type of dredge	Clamshell, plain suction, drag suction	Bucket ladder, suction cutter	Bucket ladder, suction cutter, bulkhead with dry loaders
Amount of ore mineral transported to shore per 5,000 m^3/day excavated	4,000-5,000 m^3	0.6 m^3	0.1-250 m^3

grade are written specifically for tin mining but are applicable also to other heavy minerals.

MINING METHODS

There are two basic methods of dredging: mechanical dredging using a bucket-ladder or clamshell dredge, and hydraulic dredging using a suction pipe which may be assisted by a mechanical cutting or digging device at the intake. Dredges used for mining construction materials may be quite mobile, but generally the dredges for mining heavy minerals are large, more or less stationary digging units with a complete processing plant for concentration of the minerals on-board.

LIMITATIONS ON MINING DEPTH

Bucket-ladder dredges are most commonly used for tin mining. In the past their digging depth has been generally limited to less than 33 m, but in most cases this limit has been governed by the depth of the deposits explored. Deposits over 33 m deep have been worked on land in many areas. In 1978, Billiton Corporation Maatschappj Indonesia B. V. commissioned a dredge to work offshore to a depth of 45 m. There are structural limitations in going beyond this depth with a bucket-ladder dredge, although those limitations may be overcome by new materials and modified design.

Hydraulic dredges utilize a much lighter ladder or lifting system than the bucket-ladder dredge and are not so limited structurally in their depth capabilities. Extended-ladder hydraulic dredges have been used for mining sand and gravel from depths of over 61 m in West Africa. Deep-seabed hydraulic dredges have been utilized at depths of 5,486 m, a fact that indicates no technical limits to the depth of hydraulic dredging.

Bucket-wheel excavators are widely used on land and provide a high torque continuous bucket rotation similar to the bucket ladder but of much lighter and simpler configuration. In combination with a suction dredge, the bucket-wheel dredge can be designed to give bucket-ladder capabilities at depths to 65 m and beyond depending on the design capacity of the dredge. Both IHC Holland in the Netherlands and Ellicot Machinery, Inc., in the United States have designed bucket-wheel hydraulic dredges for mining deep alluvial deposits

TABLE 3. Offshore dredge operating statistics, Thailand, 1977-78[a]

Company & Dredge	Operating Days/yr	Cubic Meters Treated	Value US $	Costs US $	Excess of Value Over Cost	Original Capital Cost[b]	Average Grade Dredged kg/m^3 (Sn Metal)	Break-even Grade kg/m^3 (Sn Metal)
AOKAM TIN								
NO 2 (14 cubic feet capacity)	278	2,161,000	6,894,000	1,453,000	5,441,000	2,560,000	0.23	0.048
NO 3 (15 cubic feet capacity)	304	2,853,000	9,101,000	1,523,000	7,578,000	Not known	0.23	0.048
SOUTHERN KINTA								
Takuapa 16 inch suction	305	912,000	6,074,000	1,352,000	4,722,000	1,650,000	0.48	0.107
TONGKAH HARBOR								
NO 1 (15 cubic feet capacity)	282	1,842,000	4,605,000	1,284,000	3,321,000	Not known	0.18	0.050
AVERAGE	292	1,942,000	6,669,000	1,403,000	5,266,000	-	0.25	0.052

[a]Data adapted from data given in World Mining (March 1979), p. 79.

[b]The dredges listed were built in the 1960s or before. Examples of new dredges, their cubic foot capacity and their capital cost are:

1.	Billiton International Metals	30 cubic feet capacity	"BIMA"	$25 million (1979)
2.	P. T. Timah	24 cubic feet capacity	"BELITUNG 1"	
3.	O. M. O. (Thailand)	16 cubic feet capacity		$15 million (1980)
4.	Heinze Basin Proposed	12 cubic feet capacity		$ 4.6 million (1975)

offshore. The Indonesian State Mining Co., P. T. Timah, has explored and is evaluating a tin deposit offshore of Bangka Island, at a depth of 70 m.

It may be concluded that exploration for tin deposits offshore may usefully be carried out to water depths of 70 m and that there is no technical limitation to the mining of deposits at that depth if evaluation shows them to be otherwise economic.

BREAK-EVEN GRADE AND DREDGE PERFORMANCE

The data displayed in Table 3 emphasize the favorable economics of offshore tin mining at the present time. These are very rough figures and do not take into account various contingencies that might be applicable to other areas, or any changes in the price of tin. It may be concluded, however, that values of 50 g/m^3 or higher are of possible economic significance.

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ANALYZING THE IMPACT OF OFFSHORE MINING OF CONSTRUCTION AGGREGATES

—Joseph A. Dehais and William A. Wallace*

INTRODUCTION

Urbanization and industrialization create strong demands for mineral resources. The best known are those for metallic ores and petrochemical feedstocks. Less publicized, but still very important for future growth and development, are the demands for construction minerals: sand, gravel, crushed stone, and fill.[1]

As an illustration of the importance of these resources in the United States, construction of the concrete basement for a 10 by 15 m house requires 80 tons of aggregates; 1.6 km of four-lane highway requires from 60,000 to 100,000 tons; and the Verranzano Narrows Bridge connecting Brooklyn and Staten Island contains over 1 million tons.

Volume demand for construction minerals in the United States is greater than that for all other nonfuel and nonmetal resources combined. In 1972, the United States consumed 913 million short tons of sand and gravel and 792 million tons of crushed stone.

The mineral aggregates industry produces a product with a low intrinsic value and a relatively high unit weight. Dry gravel weighs 100-120 lb/ft^3, while bituminous coal weighs approximately 84 lb/ft^3 and white pine 27 lb/ft^3. Both of these other materials have higher intrinsic values per ton than construction aggregates. Thus, even when hauled considerably farther, they can still be economically competitive. Current U.S. estimates indicate that hauling aggregates 32 km by truck doubles delivered costs and that distances of 64 km to 96 km become prohibitive. Longer distances are feasible by barge if a suitable route and docking and unloading facilities exist. Such routes and facilities are limited and often involve unloading in congested urban areas which increases the time involved in subsequent movement of the product by truck to the eventual use site and hence increases overall costs.

Construction aggregate resources are common and plentiful. The total onshore resource, however, is not available for exploitation. Reserves--resources available for extraction--are severely limited by a number of economic and noneconomic factors. Some of these are urban sprawl, highway construction, land use regulation, restrictive zoning, increased land values, and environmental regulation. These factors have forced producers to seek new extraction sites which are progressively

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farther from demand sites. The ultimate impact of this situation is in economic terms--increased delivered costs reflecting, most strongly, increases in hauling costs. This fact, coupled with the economies of scale associated with dredging, indicates the possibility for economically viable offshore extraction where major sites of development are near shore.

We have developed an analysis procedure by which we are able to consider the various parameters associated with the establishment of an offshore mining operation and to evaluate its economic viability. The purpose of this paper is to describe the procedure we have developed and to present, in summary, the results we have obtained in our study of the Greater New York Metropolitan Areas. We believe that our procedure is portable; that it can be adapted to the analysis of offshore mineral aggregate mining in any part of the world.

THE ANALYSIS PROCESS

The analysis process which we propose involves six steps and each will be considered in turn. While the information developed at each step is essential to a viable development plan, we believe that the process will be most fruitful if the order of steps presented here is followed. Our goal is to reduce significantly the number of alternatives to be considered as the process proceeds from one step to the next.[2]

It should be noted that each step of the process we outline requires a different type of expertise. As such, the administrative resources required to conduct the analysis might best be organized as a task force. The temptation to split the analysis into a series of independent and simultaneous substudies should be avoided, however.

Step 1: Market Analysis

The first step of the process is to consider the current nature of the marketplace for construction aggregates. Of primary importance is the determination of the market area to be studied. While a current threat of shortage may seem to affect only a small urban area or a single construction project, long range future development of adjacent areas may also be at stake. The fundamental guidelines should be this: all areas which are either presently supplying or have the potential to economically supply the area or single project under consideration should be included in the study.

The second consideration should be that of the material itself. The types of material which are or will be in demand should be surveyed. This involves the consideration of particle size and size distribution (sorting) needed to provide an acceptable finished product. Inherent in this is a realistic technical consideration of material standards currently in force as these may be less a function of technical requirements than of the types of material which have traditionally been available.

Past and current price data should then be gathered. This provides first, a means of viewing the dynamics of the aggregate market and second, a benchmark against which to compare the results of an economic analysis of offshore mining.

Finally it is imperative that some measure of past and current supply and demand be made. Since transportation costs are a key factor in the delivered price of aggregates, it is desirable to incorporate as much detail in these data as is practicable.

At this point, the region under study should begin to divide itself into zones which share or have shared some commonality of price, demand, or supply. The interrelationship between these zones can then be studied through formal analysis, such as the transportation algorithm.[3] In addition, relative inequities between zones can also be considered.

Finally, some estimate of future trends in supply, demand, and price must be made. While this will of course involve the past and present data gathered, it should also consider potential new supplies, new demands, and externally motivated changes in price.

Step 2: Geological Analysis

Having obtained a knowledge of the types and amounts of material which will be needed, it is now necessary to determine where, and in what amounts, suitable offshore resources are to be found. This will generally involve ocean survey work of two types: first, seismic profiling to

determine the depth and extent of geologic layers beneath the ocean floor; and second, core sampling to determine the content of those layers.

While such surveys are generally quite expensive and it is certainly possible to begin mining more or less at random, moving from site to site, such preliminary work is desirable for two reasons. First, economical offshore mining of mineral aggregates is largely dependent upon economies of scale and thus the ability to locate a site or sites with enough reserves to maintain a production rate that minimizes idle time. Second, environmental analysis of even fairly small areas is both expensive and time consuming and limitation of the study area can achieve significant savings in research.

Included in the geological analysis should also be a consideration of oceanographic and meteorological conditions. Data on winds, storms, visibility, currents, tidal motion, and wave heights should be obtained in order to later assist in the determination of appropriate technological configurations for offshore mining equipment. In addition, seasonal factors which may make mining hazardous should be noted. Based upon this step of the analysis, the most likely sites for offshore mining should be determined.

Step 3: Environmental Analysis

The analysis of potential environmental effects due to offshore mining must be considered both with regard to onshore and offshore impacts. Onshore impacts will most generally be evidenced in changes in tidal motion, wave heights, and wave refraction patterns. The impact of these changes will be in the form of increased or decreased erosion. The prediction of these effects is a fairly new science, but some assessment of their impacts should be made.

Offshore impacts, too, have physical aspects. The mining operation in itself may involve the release and spread of fine materials and an increase in turbidity. Pits in the ocean floor may cause the creation or erosion of underwater structures. In addition, they may cause a concentration of undesirable materials or create local anoxic conditions. Adverse chemical effects may result from this concentration or creation of anoxic conditions. Also, material released during mining may in itself cause undesirable concentrations of some substances in the water.

These effects have the potential to significantly alter the composition of undersea life, especially those species living on or near the sea floor. In particular, the quantity and quality of food resources may be affected and so particular attention must be paid to avoiding spawning areas. It should be noted that mining will, at least temporarily, destroy the habitat of the specific mining area. This is probably the single most important argument against unplanned or random mining.

Part of the environmental analysis must concern itself with the impact of offshore mining on other human uses of the marine environment. Study in this area should consider, at least, the impacts on commercial fishing, recreation, navigation, potential oil exploration or production, and waste disposal.

Step 4: Hazard Analysis

At this step in the process, a careful delineation is made of the hazards inherent in the mining operation. These hazards can be chronic or episodic in nature. Chronic hazards are typically due to the mining operations and are pervasive in their impact on the environment. Episodic events are accidental and intensive in their effects.

Public policies can be designed to reduce the frequency of the hazardous events or their potential impact. Policies can focus on reducing the impact before the event or after it occurs. Examples are the requirement for safety equipment on the mining site or establishment of public programs to assist the fishing industry in the case of damage to their fishing grounds.

Step 5: Technological Analysis

Having established a set of economically viable and otherwise acceptable sites for offshore mining, it is now necessary to determine an appropriate technological configuration for mining at each site. We must emphasize that the technology suitable to one of a group of sites may be suitable to all, some, or none of the other sites.

The choice of technology will be a direct result of the parameters already established: amount of material needed (Step 1); characteristics of the site or sites considered (Step 2); environmental concerns (Step 3); and potential hazards (Step 4).

There are many types of equipment available, each of which has its own unique and individual characteristics. Such equipment may be leased (with crew), bought, or purchased new and designed to particular specifications. All of the available alternatives, both as to type of equipment and as to lease or purchase, should be considered.

Involved in the choice of a technological configuration are two components external to the mining operation itself. First, some means must be determined for moving the material mined to shore, and onshore surge sites will need to be established. Second, the material required may require washing, sorting, or blending with onshore or other offshore material to produce an acceptable product. The result of this analysis should be a range of technological choices with associated costs.

Step 6: Economic Analysis

Economic analysis of the various acceptable alternative locations and configurations must be considered both from the point of view of the economic success of the enterprise itself and from consideration of the broader economic impacts of such an operation.

The viability of the enterprise can be measured by its return on investment given certain price and/or profit levels. Thus it is necessary to again perform the market analysis of Step 1 incorporating a site or group of sites. By means of the transportation algorithm, it is possible to estimate total sales from offshore production as a function of the price of the product and thus to determine annual return and hence profitability.

The problems of a broader economic analysis can best be illustrated by two contrasting examples, each considered under the assumption of projected, or actual, shortage of supply. If it is found that onshore sources are and will be less expensive than offshore production, an essentially uneconomic offshore operation may require subsidies to provide for desired development. If onshore sources are more costly, onshore producers will quickly be forced out of the market unless countermeasures of an opposite effect are taken.

CASE ANALYSIS: THE GREATER NEW YORK METROPOLITAN AREA (GNYMA)

For the past three years, we have been engaged in a research project concerned with analyzing "The Impact of Offshore Mining on the Costs and Availability of Construction Mineral Aggregates in the Greater New York Metropolitan Area in the USA."[4] While our particular focus has been on the economic impacts of offshore mining, other researchers have been studying the environmental and geological aspects of offshore mining. The analysis procedure described above has been derived as a result of this work. As an illustration of this procedure, the results of the GNYMA study are summarized below. It is considered that the general methodology may be applicable to similar situations in Asia and the Pacific. However, we must emphasize that while our conclusions, as presented in brief form, may appear unambiguous and definitive we are convinced that there are many questions still unanswered.

Market Analysis

The GNYMA has been established as an area including twenty-five counties in the states of New York, Connecticut, and New Jersey centering around the city of New York, U.S.A. While the focus of any shortage will be upon the metropolis itself, the region as a whole is relatively selfsufficient in construction minerals with limited amounts of material crossing its borders in either direction.

The type of material most in demand, and in which a shortage is most imminent, is coarse sand. This is the type of material which makes up the majority of the sand used in concrete and in asphaltic paving mixtures. The price of this material has been rising rapidly in recent years and averaged about US $2.40 per ton in 1978 at a mine, exclusive of transportation to sites of demand.

Available supplies are declining rapidly with some sections of the region

anticipating no production at all within two years. A study of production data for the period 1970 to 1975 indicated that the area's maximum potential production of sand and gravel was 25 million tons per year; current estimates by producers indicate that only 16 million tons per year can be produced, and that rate is declining.

Regional demand was estimated for the years 1970 to 1975 on the basis of end use, employing technical coefficients which have been derived on the basis of input-output analysis to relate the dollar volume of construction activity to the amount of aggregate required. During that period, annual demand ranged from 7 million to 16 million tons. On the basis of this data, annual demand for the period 1980 to 2000 is projected to average 13 million tons per year.

The region was divided into nine zones, each with an associated supply and demand. Transportation costs, both within and between zones, were estimated and the resulting figures incorporated into a transportation algorithm. Reserves were estimated in consultation with producers and incorporated into the transportation algorithm on an annual decremental basis. This analysis indicates that the region will experience critical shortages between 1982 and 1986; that is, demand will exceed supply.

Geological Analysis

A survey of existing data was made which indicated a potentially large number of economically feasible sites. These include sites along the eastern shore of New Jersey, in New York Bay, along the south shore of Long Island, and in Long Island Sound. The total number of such sites, all of which appear oceanographically and meteorologically suitable, is on the order of 100. It was noted that sites close to shore, in general, would require less seaworthy dredges. We have limited ourselves to the study of five offshore "areas" which on the basis of the data available appeared to offer the most commercially desirable material. One of these is off the coast of New Jersey, one in New York Bay, one off south shore Long Island, and two in Long Island Sound.

Environmental Analysis

This substantive area poses the most unanswered questions. Since offshore mining of any duration has not been performed, most environmental impacts remain unknown. An operation which was begun in Long Island Sound in the 1960s was halted because of inadequate environmental information. Significant research effort has been expended in trying to understand the physical effects of offshore mining, and it appears that mining may be able to prevent erosion in some cases. We believe that a pilot operation, with coordinated monitoring and study, may pose the best means of obtaining relevant information.

Hazard Analysis

Delineation of the hazards associated with offshore mining operations is just commencing. Initial work has focused on the environmental impacts of chronic turbidity in the area surrounding the mining operations. Data for episodic events, including barge accidents and on-site hazards, are being developed. This information will be used to develop a risk profile for each prospective site.

Technological Analysis

On the basis of public data on dredging bids maintained by the U.S. Army Corps of Engineers, and with significant assistance from their staff, we were able to establish representative costs and production rates for the various types of dredges which have been used for harbor activities, fill production, and beach replenishment in our study area.

Whereas it is felt that sophisticated ocean-going dredges will probably be required off New Jersey and the south shore of Long Island, simpler or less expensive technologies should be appropriate for other sites. We anticipate that hydraulic dredges, which pump material from the ocean floor, will be more environmentally acceptable for all sites than mechanical dredges which lift material in some configuration of open container.

We anticipate that dredged material will be washed and sorted onboard or alongside the dredging vessel as a means of minimizing transportation costs to shore and eliminating the need for onshore disposal

of silt and fines. Transportation to shore may be either by a selfcontained dredge or by barge. The surge site will process the material only to the extent of blending material from the mining operation with other material to form an acceptable product. As such it will be a temporary storage facility of relative small size and cost.

Economic Analysis

Incorporating the results of our technological analysis in the transportation formulation described above by allowing each offshore site to act as a supply zone, we have estimated total potential sales for each of the technological configurations identified. We estimate that, depending upon configuration and permitting unlimited mining at all sites, offshore operations would provide 70 to 90 percent of all fine aggregates consumed in the GNYMA. Allowing our highest estimated costs to double reduces this figure to approximately 50 percent. Similarly, the average delivered cost of material in the region would be reduced by approximately 40, 25, and 20 percent respectively.

We have undertaken a detailed rate of return analysis on only one site-configuration alternative to date. We have considered a large (27-inch hydraulic) selfcontained hopper dredge with an effective production rate of 4.5 million tons per year operating off the south shore of Long Island. We assumed that the dredge would be purchased new in 1978 with all necessary supplemental equipment at a cost of US $15.2 million. The anticipated price of mined material at surge was set at US $3.48 per ton, the average of the 1978 at mine prices in the four onshore zones where such surges could be located. On a 20-year basis this investment would yield a rate of return of 13 to 14 percent.

In all of these analyses, a royalty of US $.25 per ton to Government was assumed. In addition, it was assumed that the 1978 production limit of 16 million tons from onshore producers was available, i.e., that no shortage had occurred. We must also note that for the rate of return analysis we chose essentially the most expensive technological configuration which we could contemplate with costs far higher than those currently applicable to leases of other configurations or to the purchase of older equipment with the same configuration.

Recommendations

Our analysis has indicated the following: that offshore material will be needed to meet future demand; that suitable material exists offshore; and that such material can be mined economically subject to the satisfying of environmental concerns. We have recommended that at least one pilot operation be established with rigorous monitoring for environmental effects.

Conclusion

By means of the analysis procedure outlined herein, it is possible to evaluate the possibility of establishing an offshore mineral aggregate mining operation to serve any area of demand. By means of this stepwise method, the number of alternatives is, or can arbitrarily be, limited for succeeding steps. In addition, and perhaps more importantly, the necessary policy and/or regulatory concerns associated with each alternative will be implicitly brought forward for consideration and a well-planned and coordinated result can be obtained.

Although we do not purport to have extensive expertise with developing economic systems, we offer the following considerations:

- Given the economies of scale associated with offshore mining of construction mineral aggregates, it is likely that any franchise tendered for offshore operations will eventually confer upon its holder some measure of market control within a free market system. Depending upon the amount of production desired or allowed, this power could range from market leadership to market dominance especially if onshore production is more costly. Therefore, the public value of such a franchise must be considered and appropriate taxation policies developed.[5]

- Modern dredging equipment ranges technologically from the simple to the exceedingly complex. For example, a clamshell dredge is little more than a crane with a bucket on a floating platform while

a large hydrobarge may include sophisticated automatic process control equipment. Considerations of local employment goals or economic independence may indicate that a somewhat more expensive but simpler technology is more appropriate to broader developmental aims.

- Given the transportation costs of mineral aggregates, it is rarely possible to export the finished product although the possibility should be investigated.[6] However, it may be possible to utilize mining equipment in various areas of a country or in other countries on a scheduled basis. This essentially requires a commitment to onboard processing of dredged material and an appropriate increase in the level of inventories maintained at each surge. Thus it may be appropriate to investigate more than one area of demand before considering technological configurations.

- Mineral aggregate mining equipment, i.e., dredges, can also be used to provide fill. In addition, the simpler technologies are often appropriate for such tasks as harbor or river channel maintenance and for the redistribution of silts to aid in agriculture. It may thus be useful to consider such equipment for multiple uses.

- Increasing attention is being paid to the multiple use of the resource site. Research is being conducted on the environmental feasibility of using the borrow pits resulting from these mining operations as sites for the disposal of wastes from channel maintenance. Economically, the concept of mining the aggregate, filling with dredge spoils, and capping with fine material is extremely viable.

NOTES

1. An extensive discussion of the industry can be found in F. Earney. Mining, planning, and the urban environment, *CRC Critical Reviews in Environmental Context*, April 1977, pp. 1-88.

2. This process has been described in detail in D. Bishko, J.R. Dunn, and W.A. Wallace. *Planning for Non-renewable Common Mineral Resources in Urban-Suburban Environs*. U.S. Department of Interior, Bureau of Mines, Open File Report No. 25-69, 1969; and L. Bronitsky. The economics of construction mineral aggregates with an analysis of the industry in the Greater New York Metropolitan Area (Ph.D. thesis, Rensselaer Polytechnic Institute, Troy, New York, 1973). Abridged versions of the above are D. Bishko and W.A. Wallace. A planning model for construction minerals, *Management Science*, no. 10 (1972), pp. 502-518; and L. Bronitsky and W.A. Wallace. The economic impact of urbanization on the mineral aggregate industry, *Economic Geography*, no. 2 (1974), pp. 130-140.

3. This methodology is described in F.S. Hillier and G.J. Lieberman. *Operations Research* (2nd ed.) (San Francisco, California: Holden-Day, Inc., 1974). Its application to the problem on hand is given in L. Bronitsky and W.A. Wallace, supra n. 2.

4. The following reports on this work are available from New York Sea Grant Institute, 411 State Street, Albany, New York 12246:

   D. Carlisle and W.A. Wallace. Sand and gravel offshore in the Greater New York Metropolitan Area.

   K. Courtney, J. Dehais, and W.A. Wallace. The demand for construction minerals in the Greater New York Metropolitan Area.

   J. Dehais and W.A. Wallace. The economic viability of offshore mining of construction minerals in the Greater New York Metropolitan Area.

C.R. Jones, C.T. Fray, and J.R. Schubel. Textural prospects of surficial sediments of Lower Bay of New York Harbor.

P. Guyette and W.A. Wallace. A cost analysis of offshore mining operations of mineral aggregate in the Greater New York Metropolitan Area.

K.A. Kastens, C.T. Fray, and J.R. Schubel. Environmental effects of sand mining in the Lower Bay of New York Harbor: phase one.

S.M. Swartz and B.H. Brinkhuis. The impact of dredged holes on oxygen demand in the Lower Bay.

Kuo-Chuin Wong and R.E. Wilson. Gravel mining on tidal circulation in the Lower Bay of New York Harbor.

5. An excellent analysis of this problem for developing economic systems is found in Malcolm Gillis. *Taxation and Mining: Nonfuel Minerals in Bolivia and Other Countries* (Cambridge, Massachusetts: Ballinger Publishing Company, 1978).

6. We must remark that the possibility of one site serving more than one metropolitan area on the East Coast of the United States is being investigated. The ability of large hydrobarges to mine extensive quantities of material and the relatively cheaper costs of water transportation make the concept of a large regional market being served by a single hydrobarge with multiple offshore mining sites worthy of study.

THE IMPACT OF OFFSHORE PETROLEUM EXPLOITATION ON THE COASTAL REGION: AN OVERVIEW

—Volkmar J. Hartje*

INTRODUCTION

An overview on offshore petroleum can focus on a number of different problems and points of view, but because of time constraints one has to make choices. This paper will try to put offshore petroleum development in its wider economic context from a producer country's point of view. The paper will touch upon the problems that arise during the phases of offshore development, outline the impacts of these phases of development, and indicate how these impacts can be dealt with in terms of public policy.

DEPLETION POLICY AND THE ECONOMIC CONTEXT OF OFFSHORE DEVELOPMENT

The central question for any natural resource development is the rate of use, be they minerals, fossil fuels or forests. For nonreproducible natural resources, it means that the amount used this year will not be available next year. For some natural resources, such as air and water (in some regions at least), we do not worry about this year's versus next year's use because they are not scarce. The concept of scarcity has a variety of meanings for different persons. Economists tend to define scarcity in relation to demand. In their thinking, the indicator for scarcity is the price of a natural resource.

The economist's concern is the behavior of privately owned companies and the questions of whether and how their profit motive in extracting resources coincides with the public interest. Although the days when private oil companies owned the oil resources or held oil licenses have long since vanished for most of the countries in the Third World, the concept developed for analyzing the behavior of private companies can be useful for publicly owned oil companies and for public policy as well.

An optimal oil depletion policy maximizes the net present value of profits or some other indicator of surplus for different exploitation paths. Critical in this context are the costs that are included in this net present value calculation. They consist not only of the capital and operating costs of finding and producing the oil, but include the user cost as well.[1] These user costs are the opportunity cost for producing this year or for this generation instead of next year or for the next generation.

The application of the user cost principle implies that the price of natural

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resources will rise, independent of actual extraction costs, as the stock of the resource becomes more and more depleted. The user cost, and thus the price, are assumed to be dependent upon the real interest rates or the time preference rate of a society. This concept can be broadened to look at natural resources as a capital asset with similar qualities as the man-made capital stocks of a society. The question of depletion policy thus becomes the question of: "What is the best composition of a capital (natural and man-made) stock that we should use and leave for the next generation?" The user costs are reflected in resource rents and these rents can be invested in man-made capital assets. Thus the depletion of natural resource stocks can be compensated by increasing the man-made capital stock.

If one country owns resource stocks and must make decisions concerning the depletion of these stocks, it must first make decisions concerning the time preference rate, the use of the rents, the type of surplus to be maximized (taxes, company profits, or foreign exchange), and the alternative investment opportunities.

The time preference rate will largely depend on the macroeconomic impact of the rents and the alternative investment opportunity. Since the small producer will most likely be a price-taker, relatively large rents will accrue due to OPEC prices, and these revenues will have a critical impact on a country's economy. For the macroeconomic impact, the balance of payments effect and the absorptive capacity of a country for capital projects are most important.[2] Using North Sea examples, Great Britain decided on an expansionary development path for balance of payments reasons,[3] while Norway decided on a go-slow policy for absorptive capacity reasons.[4] Such different depletion policies can be achieved by two mechanisms--licensing and regulation, and/or taxation[5]--if one decides to work with private companies as Britain and Norway did. A restrictive licensing policy and a severe tax policy will slow down the depletion process while generous licensing and tax policies will speed it up.

A second question is: "What happens to the tax revenues?" The temptation to use these revenues for income transfer purposes seems to be very high. In the Netherlands, the government used a large share of its revenues derived from the offshore gas for income support for private households.[6] When the gas production declines, the government will face the problem of finding other revenues or cutting these expenditures. In Britain, the government is planning to invest the revenues in capital improvements, but has to make a series of decisions as to which type of capital improvements. The private industrial capital stock needs the most upgrading. Thus the question becomes: "How can we channel the money for these purposes into the private sector?"

A third question is: "Who controls the exploration and production process?" In the Third World, the days of concessions are over and nationalization, participation, and service contracts have taken their place.[7] These contractual arrangements mean a larger national and usually governmental control over production. However, control of exploration, processing, and marketing is limited by the advantages of the major oil companies in these areas.

The present dependence of any country on the expertise of the oil majors to operate an oil industry, and the necessity to maintain the oil pricing cartel, limit the control of government and necessitate arrangements that allow what is considered a fair return by the major oil companies whether the costs for their fair return are borne by producer or consumer countries. Britain is as dependent as any other country outside the United States and centrally planned economies on the import of technology, thus also limiting national control. These factors--time preference rate, absorptive capacity of a country, and ability to control--will shape the overall depletion policy, but it might be modified by factors that are present on a microlevel during the various phases of offshore development.

THE OFFSHORE DEVELOPMENT PROCESS

The offshore development process consists of four phases: exploration, field development and production, transport, and processing and refining (Table 1). The geology of an area, licensing conditions, and information about the area determine how and where offshore exploratory drilling and subsequent production occur. Several activities take place onshore, however,

TABLE 1. The stages of offshore petroleum development

Stages	Issues	National Participation	Regional Policy Aspects	Environment	Safety
I. Exploration					
-surveys	quality of data	low	little	negligible	-
-drilling	-licensing -cost -success rate	high for platform construction and services	control of boomtown development, infrastructure	blow-out	
II. Field development	-licensing -platform type				
-construction	-sites -cost	high	transport bottlenecks	wetlands workover	
-operation	-rate of production	medium		chronic discharges	fire ramming
-support	location	high	growth pole concept		
III. Transport	mode				
pipeline	minimum field size; welding quality; cost;	low to medium	little	breakage coating accidents	
tanker	technical feasibility	high	none	chronic discharges;	
terminals	sites costs	employment low supply medium	harbor siting	operational discharges	collision ramming
IV. Processing	market sites	medium	growth pole	water & air pollution	fire explosion

such as construction of equipment, servicing of offshore activities, storage, processing, housing of manpower, and so forth.

The off- and onshore activities have impact on other areas on land, on sea, and on the sea floor. It should be ensured beforehand that these impacts are coordinated with other goals of a society and are compatible with other sectors of the economy. This coordination must be timed so that the sequence of steps in the development process itself avoids delays when high capital costs are involved. The process of planning the offshore development itself is usually performed by the contracting oil company and involves highly sophisticated planning techniques such as PERT, model simulation, and detailed engineering analyses.[8] However, the coordination of these activities with other competing uses of space, and with other sectors of an economy, remains the function of a producer country's government.

Spatial planning onshore implies coordination with regional policy, in particular with respect to the siting of the necessary infrastructure, transport, housing, other services, energy, and selection of sites for onshore support facilities for offshore development. Spatial planning offshore might sound far-fetched, but possible conflicts with other marine uses, mainly fisheries and shipping, may make planning necessary, particularly in coastal areas where these conflicts are most likely to be frequent.

Coordination with other sectors of the economy will have to be undertaken to ensure maximum participation of the national economy in the development process itself and to avoid shortages in other sectors that compete with the development project for goods, services, and manpower. Increased participation in the national

economy can be required by contractual arrangements or by regulations. The extent of such participation will depend on the capacity and experience of the industries concerned, if costs are not to increase disproportionately.

Surveying the capacity and experience of the national industry, planning for their improvement, and the promotion of these industries are instruments used to increase national participation. For example, the Department of Trade and Industry in Great Britain commissioned a study on the present status of the contracting industry and on the need for the improvement of their market position, including training, education, and research.[9] In addition to the involvement of the national supply industry, the training and recruitment of national labor should be studied and planned.

The huge amount of supply necessary might create shortages in a small country or in a peripheral region in a larger country so that goods and manpower have to be imported, creating bottlenecks in the transport sector and in storage facilities. Thus, the potential impact should be studied and plans made to avoid or mitigate such shortages. The size of these microimpacts will depend mainly on the depletion policy but also on the capacity of a national economy and the region to handle these impacts. Here, on the impact level, might be the place for arguments for a slow depletion policy.

Furthermore, the offshore development process must be coordinated with other societal goals, most important, safety and environmental protection. Here, the development of regulations and their enforcement are necessary. Offshore rigs, pipelines, storage facilities, terminals, and tankers are accident prone. These accidents will involve a loss of capital, a loss of production and revenues, and of lives, as well as environmental quality.

All offshore activities have a potential for quite a sizeable operational discharge. Today, a number of technologies are available to reduce these discharges. However, the application of these technologies has to be required and their proper use by companies and their work force must be insured. Regulations must be developed, equipment certified, manpower trained, treatment facilities provided for, contingency plans developed, and contingency equipment deployed.

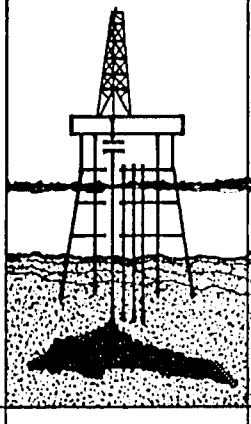
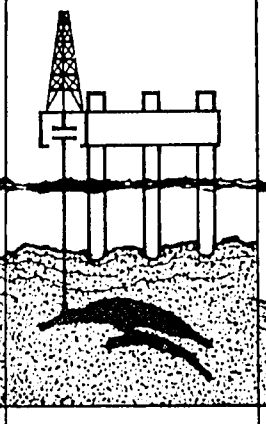
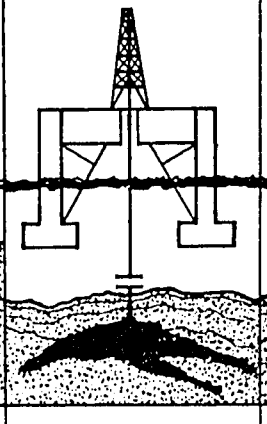
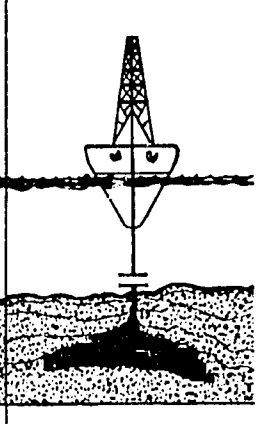
THE EXPLORATION PHASE

The exploration phase can be divided into the survey phase and the exploratory drilling phase.[10] The survey period involves aerial magnetic and gravity surveys and shipborne seismic surveys. The information generated by these activities is used to identify promising tracts and to bid for exploratory drilling. These surveys usually do not involve high onshore or offshore impact except for the use of explosives in seismic surveys. To avoid this impact, the use of explosives has been abandoned and a propane oxygen gun is now in use.

Exploratory drilling to determine if there is actually a reservoir present has a sizeable impact since it involves the construction and operation of platforms. With a success rate varying from 1 in 4 to 1 in 20 in offshore wildcats,[11] the number of exploratory wells drilled can be quite high before a field is found that is worth developing. Oil development in the North Sea under severe weather conditions contributed to a number of innovations in platform technology so that an operator now has a choice between a number of platform types (Table 2). The cost of drilling one exploration well varies between US $3 and 15 million,[12] whereas the cost of the drilling platform can be up to US $80 million.

Drilling services, which include the operation and building of drilling platforms and drilling vessels,[13] provide an opportunity for participation by the national economy. These drilling activities need onshore support structures for transport, repair, housing, and health services, which must be planned and provided. The drilling process always involves blow-out risk. Although the industry has developed a number of technological devices to reduce this risk,[14] there remains a blow-out risk due to human error. Thus, emergency plans and equipment to protect the crew and the environment are urgently needed. In the North Sea, both the governments involved and the oil companies developed plans and deployed equipment.[15]

TABLE 2. Platforms in offshore development

Type	Fixed		Floating	
	Stationary	Mobile	Mobile	
	Fixed	Jack-up	Semi-submers.	Vessel
				
Max. water depth (m) — Conventional anchoring	130	100	300	300
Max. water depth (m) — Dynamic positioning			600	600
Construction cost 10^6	up to 200	up to 40	up to 70	up to 40
Operating cost/day 1000 $	--	25 - 50	45 - 85	35 - 50

Source: Commerzbank, Oil and Gas from the North Sea, supra n. 12, p. 12.

FIELD DEVELOPMENT AND PRODUCTION

When exploratory drilling is successful, it has to be decided whether the reservoir is economically viable and, if so, how it should be developed, how the oil should be transported, and where it should be marketed. To determine the size and extent of the field, further exploratory wells must be drilled while the preparation for development itself begins. If the field extends beyond a licensed block, arrangements are necessary to avoid common pool problems. In the North Sea, one field, FRIGG, crosses national boundaries, and a special committee between No way and Great Britain was established to deal with the common pool problems involved (Figure 1).[16]

The type of platform most appropriate for the field must be identified, constructed, assembled, put in place and erected. For deeper waters, the platforms are so large that normal shipyards are not adequate and special flatsites have to be identified and prepared. For example, the platform for the Thistle field is about 295 m high and weighs about 30,000 tons.[17] The cost for such a platform varies between US $150 and 300 million.[18] In the North Sea, the investment costs per barrel daily capacity went up to US $6,000 and $7,000 compared to US $200 in the Middle East and US $1,800 in the Gulf of Mexico.[19] These figures indicate the size of the market for a national economy in offshore development supply ranging from drilling services to steel and cement production. In Britain, the value of orders by offshore operating companies was around US $2 billion in 1976, with the British share at 57 percent.[20] The employment effect is not as impressive; e.g., for Scotland, 60,000 jobs have been calculated.[21]

During the development phase, onshore impact will speed up as a construction site and service centers are built and become operational. Unplanned, this process will result in a boomtown phenomenon with all its undesirable consequences. The Scottish Development Department issued guidelines for the planning of onshore

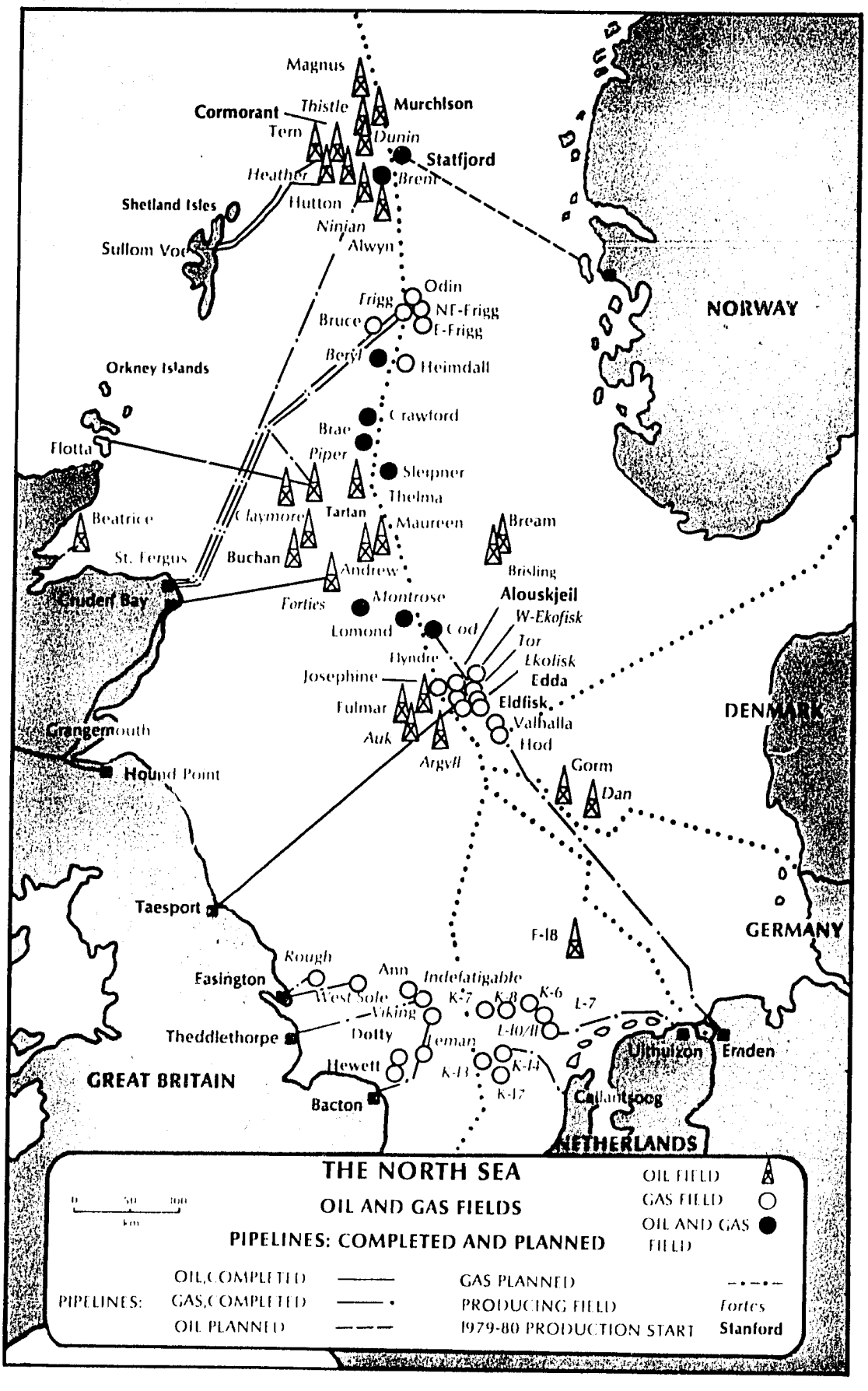


FIGURE 1. North Sea offshore development

activities, emphasizing a growth pole type of approach, with the following advantages:[22] avoidance of scatter development, fuller use of existing support services, economic provision of additional services, and greater likelihood of diversification after decline of offshore activities.

As far as the major service centers are concerned, the clustering of activities is desired by the oil companies because they require a sizeable manufacturing base, a diversified labor market, certain transportation facilities, a large housing stock, and the provision of other services. In Britain, Great Yarmouth and Aberdeen--both medium-sized towns with an ocean-related but declining economy[23]--developed into the major service centers.

If such towns do not exist in the area to be developed, they will have to be constructed with the necessary infrastructure, housing, and other community services. The time horizon for offshore development from first exploration to production is between five and eight years, quite long for a private investment, but not so long for the building of a new town, particularly if the development exceeds the capacity of the local construction industry. In Aberdeen, it has been calculated that offshore development has provided about 4,000 employment opportunities.[24] If one assumes a multiplier of 1.5, about 6,000 jobs could be created and, with a dependence rate of 3, there would be an influx of a new population of about 24,000.

During production, oily water discharges occur including production water, displacement water, and water run-off. Before treatment, production water contains up to 3,000 parts per million (ppm) of oil. Unless treatment is required, pollution will be significant. For example, for 100 million tons of production per year, 66,000 tons of oil will be discharged, assuming 10 percent displacement water. If maximum oil content is 50 ppm, discharge of oil will be reduced to 1,100 tons annually. In Britain, the discharge standard is 50 ppm, an attainable standard, given present treatment technologies.[25]

In addition, the platforms have an associated accident risk due to, e.g., fire, explosion, blow-out (during workover) and ramming.[26] To reduce these risks, traffic regulations should be devised, and the platform should be inspected and licensed for safety aspects by classification societies, including, e.g., operational plans and alarm plans. Furthermore, prior to production, oil spill contingency plans should be developed and the requisite equipment should be purchased and strategically situated.

THE TRANSPORT PHASE

The next phase is the construction and operation of the transport system. For oil, there is a choice between pipelines and tanker systems. Although there are safety problems in handling of liquefied gas at sea in rough weather, handling and loading systems have already been developed. The alternative mode of transport is chosen depending on costs, safety, and environmental conditions such as the water depth, characteristics of the sea floor, and wind conditions.[27]

The use of tankers makes offshore storage necessary as a buffer between the continuous process of production and the discontinuities of tanker operations. Pipelines are generally preferable to a tanker system because of tanker vulnerability in adverse weather. However, if a tanker transport system is cheaper than a pipeline, the tanker system will prevail. In the British sector, approximately 60 percent of production is transported by pipeline[28] while this method services 98 percent of US offshore production.[29]

The cost of a pipeline is a function of distance, volume transported, water depth, and bottom characteristics. In the North Sea, 1 km of offshore pipeline costs between US $2 and 3 million.[30] The size of the investments and the economy of scale make the pipeline mode uneconomical for small outlying fields. The length of a pipeline depends on the market that the oil will serve, which also determines if a terminal on the nearest suitable point on land is sufficient, or if the pipeline must be connected to the next refinery.

These marketing considerations involve the overall depletion policy as well and choices have to be made between an emphasis on the national market, e.g., such as the servicing of a petrochemical industry, and the international export market. In Britain, marketing was planned to meet domestic consumption, but the low sulphur

TABLE 3. North Sea reserves and production

Countries	Oil			Gas		
	Reserves 10^6 tons		Production 10^6 tons	Reserves 10^9 m^3		Production 10^9 m^3
Denmark	39	1976: 1980:	0.2 1.5	20	1976: 1980:	- 1 to 1.5
West Germany	-		-	-		-
Great Britain	2,308	1976: 1980:	10.6 100.0	850	1976: 1980:	40.0 45 to 50
Netherlands	13	1976: 1980:	- 2.0	300	1976: 1980:	2.0 24.0
Norway	760	1976: 1980:	13.7 50.0	525	1976: 1980:	- 35.0
Total North Sea	ca. 3,120	1976: 1980:	24.5 150.0	2,550	1976: 1980:	42.0 105 to 110

Source: Commerzbank, Oil and Gas from the North Sea, supra n. 12.

TABLE 4. Impact on the British economy

Oil production in 1978	53 X 10^6 tons
Domestic oil consumption in 1978	59 X 10^6 tons
Investments in 1977	US $3,450X$10^6$
Balance of payments contribution in 1977	US $3,450X$10^6$
Taxes 1977	US $89,672X$10^6$
Taxes (estimated) 1980	US $9,706X$10^6$
Gross National Product 1976..	US $21,890X$10^6$

Source: United Kingdom Department of Energy, Development of Oil and Gas Resources in the U.K. 1978, supra n. 3.

content of the oil commands a premium of approximately US $1 per barrel so that about 40 percent of production is exported. The export market will usually be served by crude oil since product marketing without the distribution systems of the oil majors is rather difficult. In this case, a loading terminal will be adequate, providing the flexibility to serve both the national and the international markets. Once the transport mode is chosen, regulations and regional planning for the transport phase can be implemented.

The siting of the pipeline, although usually a straight line between the field and land terminals, has to be made compatible with existing and potential fishing grounds, particularly if bottom-feeding fish or spawning grounds are involved. Usually, this is not accomplished by routing the pipeline around the fisheries area, but by burying the pipeline with a cement coat to prevent damages from and to trawl nets and so trawling will not be interrupted.[31] If the bottom is sandy, the sea floor usually will not be stable and the pipeline may move, thus introducing a risk of breakage. To avoid such an accident, permanent surveillance is necessary. Present surveillance and monitoring techniques are not adequate since they cannot detect the outflow of 5,000 to 10,000 tons of oil along a 100 km pipeline.

Other than accidents, the pollution risks with a pipeline are comparatively small. Pipelaying is performed by specially equipped ships and the sections of the

pipes are welded onboard. The weld is tested by ultrasound and X-ray methods.[32] Debris from the construction of platforms and pipelines may be left on the ocean floor causing damage to fishing nets and raising issues concerning compensation. Aside from the actual pipelaying and construction of pipe sections, the market and employment opportunities for this type of transportation are not very significant.

For a tanker-based transport system, offshore storage tanks and mooring systems are required. The transfer of oil involves accident and pollution risks, particularly in adverse weather conditions. Very often, the storage tanks are integrated into the platform structure, but separate systems have also been developed and used. There are obviously accident risks with tankers. Given the experience of the last 12 years, such accidents not only result in loss of vessel, life, and cargo, but they cause significant environmental damage as well. To reduce these risks, IMCO has organized a series of international agreements concerning ship safety.[33] In addition, traffic safety schemes with traffic separation and radar control can be introduced. There is chronic pollution from tankers in the form of discharged ballast water. The present standard treatment methods--load on top and segregated ballast tanks--are not universally employed. Short haul voyages do not technically allow for load on top, and segregated ballast tanks are required only for vessels above 40,000 dtw. Smaller vessels might be economical for the platform-land-terminal voyages. Thus, the installation of reception facilities and regulation of their use are necessary to avoid this source of pollution. These facilities should be available before production and transport begins. The lack of such a facility in the Shetland Isles at one terminal caused considerable harm to the environment during a six-month period.

The tanker operations provide an excellent opportunity for national participation in this part of the offshore development process. The terminal usually consists of treatment facilities, gas separators, storage tanks, mooring and loading facilities, and the ancillary support system. One terminal in the North Sea, Sullum Voe on the Shetland Isles, is capable of handling 70 million tons of oil per year from pipelines and vessels, and costs US $1.4 billion.[34] On the other hand, another terminal, at Cruden Bay, consists only of a pumping station because the pipeline continues to a refinery on land at Grangemouth.

The economic impact of terminals, even for one such as that in Sullum Voe, is, aside from the construction period, quite small, particularly in terms of employment. The visual impact of the terminal in Sullum Voe was considered very significant, given the pristine characteristics of the Shetland Isles, and a special commission was set up to minimize the visual impact.[35]

THE PROCESSING PHASE

From a regional point of view, refining, the final phase of offshore petroleum development, is only loosely connected to the offshore areas. The location of refineries was, at least in the past, determined by market proximity.[36] The attempts of producer countries to increase the value-added of oil exports by refining have so far been successful to a limited extent because of the marketing advantages of the oil majors. The surplus capacity of refineries in northwestern Europe prevented the construction of additional refineries around the onshore terminals in the North Sea.[37]

The economics of market proximity probably work in Southeast Asia as well, but regional development objectives might override economics, particularly if there is no surplus refining capacity. The extent of refining and processing there will depend on the national market and export opportunities for refined products and chemicals. Refining tends to be capital intensive and not very employment intensive so that investment in this sector for export purposes will involve a trade-off between balance of payments considerations and employment objectives.

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SUMMARY OF DISCUSSION ON REGIONAL PERSPECTIVES

The Secretary reviewed the preceding day's presentations, which included overviews of coastal activities in the South China Sea, the southwest Pacific, and the North Sea. The North Sea situation was viewed as a useful example of management techniques. For example, when fishermen opposed the siting of an oil pipeline, an opportunity was provided for representatives of the fishing community to participate in the site surveys and analysis of the data. Consequently, the representatives chose the same site for the pipeline as the companies' technical personnel. Further, when fishermen complained that it was exceedingly difficult under the existing legal regime to obtain compensation for damage to nets by oil company debris left on the sea bottom, several techniques were employed to solve the problem. First, the oil companies were required to undertake a side-scan sonar survey to prove that no debris had been left on the sea bottom. Second, special changes in the legal regime were introduced, making it easier to prove that a net was damaged by metal left on the seafloor and, finally, regulations were promulgated requiring oil companies to label all equipment used in the fields so that responsibility for abandoned debris could be more easily demonstrated.

It was considered that these management techniques might be relevant to parts of the Southeast Asian region where trawling grounds and oil exploration/exploitation coincide, such as in the shallow bays of the Philippines, the Gulf of Thailand, and the Java Sea.

A discussion ensued concerning the influences of oil platforms and activities on productivity of fish stocks and on fishing itself. It was noted that platforms may only increase the physical concentration of fish by providing shelter but that long-term effects on productivity itself were unknown. On the other hand, evidence was presented that productivity of benthic foraminifera increased in the vicinity of a pipeline in Indonesia. It was considered that a major problem of platforms was the resultant navigational conflicts when platforms were situated in the path of usual trawling runs. In addition, work boats moving to and from oil platforms often stir up the bottom and also physically interfere with trawling runs.

The discussion of onshore impacts of offshore petroleum development focused on the examples of development of large hydrocarbon resources in Alaska and near the Shetland Islands in the North Sea. The attendant social and economic problems due to the influx of large numbers of workers were reviewed. It was noted that although it was difficult to assess these problems in advance, it was important for public officials to recognize their existence and to study similar situations in order to gain a better understanding of their complexity. It was recognized that local authorities must become intimately involved in resolving these problems, and that the national governments should take into consideration the needs and particular requirements of local officials.

III. NATIONAL PERSPECTIVES

CHINA: BRIEF COMMENTS

— Wang Daxiong and Chen Degong*

The workshop was informed of the development of exploration programs for offshore and onshore hydrocarbon and other mineral resources in China since the 1950s. Many basins with good petroleum potential had been discovered, as well as a number of heavy detrital and other mineral resources. Steps were being taken to prevent coastal pollution and to pass appropriate laws and regulations. It was considered, however, that the government agencies lacked experience and in this context the opportunity to learn from this Workshop was appreciated.

In regard to coastal area development and management on the national level, it was felt that an organization should be established to deal exclusively with the coastal areas, and that a comprehensive study should be made of natural resource uses in the coastal area and of priorities for their development and management.

Regarding coastal area management and development on the international level, it was suggested that the United Nations should organize workshops on more specific subjects such as remote sensing techniques, protection from pollution of the coastal area, and mineral resources. Further, the relevant United Nations agencies should provide experts as requested by the countries, organize extended training courses to be held both in-country and in the United Nations University or other international organizations, and publish a newsletter which would disseminate relevant information and experiences of various countries.

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FIJI

—Ronald N. Richmond*

COASTAL ACTIVITIES AND EFFECTS IN FIJI

The Fiji Islands are subjected to a number of natural and man-made events which can have significant effects on coastal areas. The most important of these are described below.

Natural Effects

Hurricanes are regular events and particularly severe hurricanes occur about three times in a decade. Apart from normal wind waves and resultant damage along the coastline, the occasional passage of the very low pressure hurricane center coincident with high tides has resulted in waves in excess of 10 m sweeping destructively over small islands. This phenomenon can be particularly difficult to combat where the islands are low-lying.

Lokas are the Fijian term for a series of persistent high waves emanating from oceanic storms thousands of kilometers away to the south in the Tasman Sea area. These waves affect southern coastlines for a few days damaging jetties and beach property.

Heavy rainfall introduces much silt and clay into the major rivers, and the resultant turbidity is clearly visible in the barrier reef lagoons for several days afterwards.

Earthquakes and related tsunamis are natural hazards along two active seismic zones which have been delineated in the coastal areas of the two largest islands in Fiji. Earthquakes in these zones occasionally result in landslides and slumping which can damage jetties. In 1953 an earthquake of 6.7 magnitude resulted in a tsunami well over 10 m high which affected a wide area in the Fiji group. Fortunately in many areas the force of the wave was broken by the barrier and fringing reefs so that only a weaker 1-2 m wave traveled across the lagoon to the coasts.

Man-made Effects

Mangrove reclamation for public use has recently been the focus of government attention because of the complex land tenure system in Fiji and the need for more farmland. This practice has now been suspended--not because of environmental issues--but because no reasonable approach has been found so far for fair and just compensation for loss of fishing to the owners of native fishing rights.

Dredging of coral sand in the barrier reef lagoon is the sole method of supply for the cement industry because of the lack of suitable limestone deposits close to the cement factory. This practice has been going on for some years

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with the company moving from site to site after exhausting each one. Only recently has the company been required to carry out baseline studies to determine the sediment transport within the lagoon and the rate of recharge to areas already mined.

Tourism is the second largest foreign exchange earner in Fiji next to sugar. This has resulted in many hotel developments along the coasts, many of which desire their own jetties and marinas. Early developments of jetties were done in a haphazard manner with no requirements for coastal studies. This has now been corrected with a requirement for detailed studies of coastal currents, sediment transport, and prediction of the effects of structures on these systems.

The method of disposal of tailings is one of the problems facing a large low-grade porphyry copper prospect that is undergoing a pre-feasibility study. Because of a seismicity hazard and heavy rainfall on land, the possibility of offshore disposal of tailings is being seriously considered. The site would have to be in deep water beyond the reefs and below the thermocline. Marine baseline data are being gathered at present in an area which is also near a major tourist resort area. Other disposal site alternatives that can also be considered are the reclamation of mangrove areas and the infilling of swampy coastal lowlands.

Wildcat petroleum exploration drilling will begin in March 1980 in the Bligh Water area north of the largest island, Viti Levu. Prior to drilling, the company will have to gather baseline marine data and submit contingency plans to combat possible oil spills. The drilling area is expected to be surrounded by coral reefs and be within 20 km of major mangrove forests and some of the best tourist beach resorts in Fiji. One problem that could be critical would be the great distance to the nearest dense exploration area in Australia and therefore the distance from readily available oil-spill combatting equipment.

Data are also presently being gathered to locate areas where OTEC and "Blue Wave" energy systems might be feasible. Likely sites appear to be concentrated along the southern coast of Viti Levu.

In general, while there is no dedicated coastal zone management authority, powers for various coastal zone controls are provided for in the Lands Act, Town and Country Planning Act, Marine Act, Fisheries Act, Mines Act, and the Petroleum (Exploration and Exploitation) Act. Thus activities concerning mining and petroleum development come under the control of the Director of Mineral Development whose powers also include the ability to require Comprehensive Environmental Impact Studies for activities in these fields. This is the only activity area where environmental impact studies are required in Fiji at present. One major present problem is the total lack of a responsible authority to collect these data. With the recent formation of an offshore section, the Mineral Resources Department plans to take on these activities in the near future.

CURRENT ACTIVITIES IN COASTAL AREA DEVELOPMENT AND MANAGEMENT IN THE REPUBLIC OF KOREA

— Sung-Woo Kim*

The Korean Peninsula is about 220,000 km^2 in area with a total coastline length of about 17,361 km. The eastern shoreline is about 1,823 km; the western, 8,950 km; and the southern, 6,588 km. The western and southern coastlines are of the ria type with more than 3,000 islands dotting the southern and western offshore. The southern and western intertidal zone is wide, having been expanded by land reclamation to approximately 480 km^2 between 1946 and 1978.

Resorts and regions of cultural assets established by the government include 32 regions of historical remains and cultural assets, 59 temple sites, 70 areas of swimming beaches, 60 natural monument sites, 100 fishing areas, and various parks. The government has also established 12 reservations for marine products. The total area comprises 4,597 km^2 with 1,834 km^2 on land and 2,763 km^2 offshore. The marine area under aquaculture is about 820 km^2. The important organisms being cultured are oysters, clams, and seaweed. Salt ponds are found mainly along the western coastline, occupying an area of 12,861 ha and producing about 794,710 tons of salt in 1978.

There are 14 coastal industrial complexes with 521 factories comprising 83 percent of the entire industrial component of Korea. There are two areas delineated on the western coast for future tidal power plants--the Garorim Bay and the Cheonsoo Bay. The mean tidal range in the Garorim Bay, apparently the more economically profitable region, is 4.7 m and the theoretical latent tidal power is 7,487 gigawatts per hour, and the technical latent tidal power is 1,572 gigawatts per hour. The mean tidal range in the Cheonsoo Bay is 4.5 m with a theoretical latent tidal power of 4,829 gigawatts per hour, and a technical latent tidal power of 5,214 gigawatts per hour.

About ten regions have been selected for steam power plants and four steam power plants are under construction (three on the western coast and one on the southern coast). On the eastern coast of Korea, a nuclear power plant is already in operation and another plant has almost been completed, while another plant is under construction on the western coast. In addition, several sites on the southwestern coast are being investigated for their suitability for nuclear plants.

Recently, the Korea Research Institute of Human Settlements completed a planning map and a general plan for use of the west coast of South Korea. The investigation delineated possible areas for land expansion by reclamation. Such reclamation is needed

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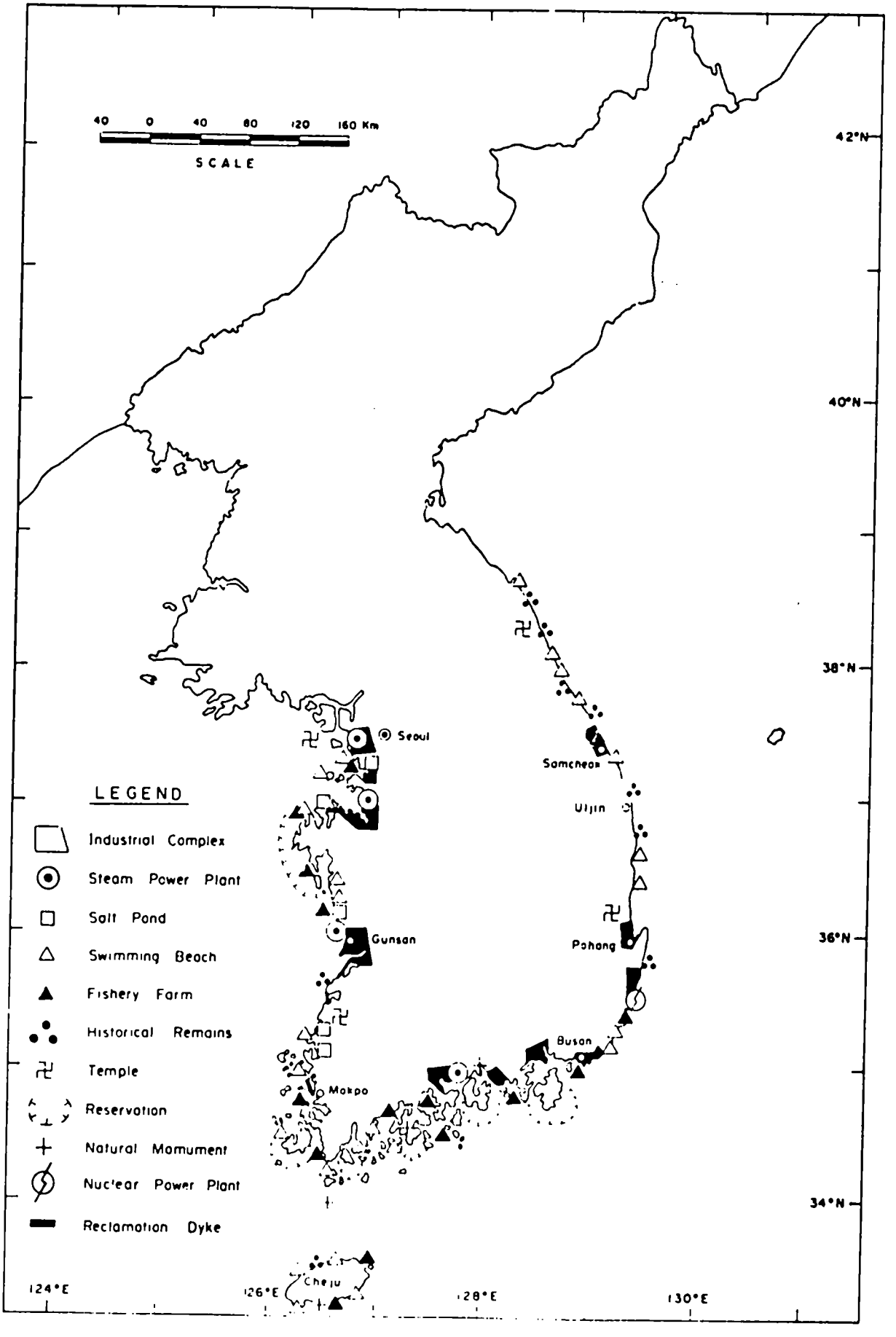

FIGURE 1. Current activities in the coastal area of the Republic of Korea

to satisfy the increase in demand for land resulting from population growth. The investigation also delineated future land demand and appropriate land use with a view to minimizing land use conflicts. In this manner, some of the resources may be used effectively and gradually while those resources requiring preservation are maintained. Specifically, in addition to a focus on areas for land reclamation, the study delineates tidal power plant sites, areas for aquaculture, nature reservations, coastal industrial complexes, harbor and harbor estates, agriculture, atomic power and steam power plants, and a tourist resort.

Marine geological investigations in the nearshore area of the Yellow Sea, especially in the major bays and estuaries along the coast have been conducted over the last ten years by the Korea Research Institute of Geoscience and Mineral Resources. These investigations are particularly aimed at making base maps of subsea geology on a scale of 1:250,000. A small quantity of sand and gravel is being exploited on the southern coast as is silica sand in beaches.

An Office of Environment will begin functioning in 1980. It will have air pollution and water pollution bureaus and is expected to play an important role in protecting the environment of the coastal areas from pollution.

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COASTAL ZONE MANAGEMENT IN INDONESIA

—P. E. Hehanussa*

Coastlines experience frequent physical changes. These changes may be caused by both natural and human factors. Natural factors include sedimentation, erosion, tectonism, volcanism, and tsunamis, whereas human factors comprise such activities as waste disposal, brackish water fish culture, and natural salt extraction. Since both natural and human factors may bring about significant alterations of the coastal area, the management of coastal resources deserves special attention.

With a coastline of approximately 81,000 km (Table 1) and with 75 percent of the cities greater than 100,000 people located in coastal areas, the role of coastal resources in Indonesia is clearly important. There is a substantial amount of activities and resources within the Indonesian coastal area. Such activities and resources comprise, among others, the settlements, brackish water fishponds, natural coastal forests, paddy fields, salt extraction, industries, recreation and tourism, harbors, commerce, communication/shipping, algae, fish, minerals, and construction materials. Also, 90 percent of pollution in Indonesian waters is derived from land-based sources. Only a small portion is derived from the air, direct outfalls, or dumping. The pollutants consist of sediment, rubbish, oil and its derivatives, pesticides and fertilizers. In the future there will be pollutants from industry and power plants.

TABLE 1. The Indonesian coastal zone: some statistics

Total islands:	13,667
Land area:	2,027,083 km^2
Land area + 12 n. mile sea:	3,166,163 km^2
Shelf area:	210,000,000 km^2
Length of coastline:	80,791 km
Area of brackish forest:	10,000,000 ha
Area of mangrove forest:	3,100,000 ha
Tambak area:	183,000 ha
Fishponds:	40,000 ha

The Indonesian Constitution, which is the basis for the management and utilization of Indonesia's natural resources, provides that the:

> . . . land and water, and the natural resources contained therein, shall be controlled by the state and utilized for the greatest feasible prosperity of the people.

The most challenging problem for Indonesia is the need to support its rapidly growing population. This is a strong incentive to manage its limited natural resources efficiently. In this regard, a comprehensive yet realistic plan for integrated management and utilization of coastal zone resources is required. For this purpose an inventory of basic data should be made at the very outset. A

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series of special training courses would undoubtedly help to enhance the achievement of these objectives. Also of importance would be efforts to create a greater public awareness of, and interest in, problems of coastal resources management.

A five-year program for coastal area resource use management should have among its objectives the establishment of:

- environmental quality standards;
- national laws implementing international conventions for the protection of the environment;
- marine parks;
- a national contingency plan for oil spill cleanup;
- a research program on maximum sustainable yield of mangrove forests;
- a monitoring program for environmental quality; and
- more employment possibilities in the coastal zone.

HUMAN ACTIVITIES AND THEIR ENVIRONMENTAL IMPACTS ON THE COASTS OF INDONESIA

—Otto S. R. Ongkosongo*

INTRODUCTION

Indonesia is an archipelagic country whose geographic extent is embodied in the national state concept of *Wawasan Nusantara*. It has more than 13,000 islands and 81,000 km of coastline, and more than 140 million people. More than 75 percent of towns of 100,000 people or more are located in the coastal area.[1] This paper discusses those prominent aspects of human activities in the coastal area which need more attention for better utilization, management and development of coastal area resources.

The western part of Indonesia was separated into islands by the rise in sealevel after the last glacial advance of the Pleistocene. *Homo erectus* has lived in Java for about 2 million years, and there is some indication that man began to live on the coast about 1.2 million years ago.[2,3] Tools and ceramics are scattered along the coast at Jakarta and other coastal areas in Indonesia. These artifacts not only reveal the human culture at that time, but also the possible impacts of their activities. For example, a rock inscription at Tugu, Jakarta, describes the making of a water canal by Purnawarman, a king of the fifth century Tarumanegara period, to connect his palace and the sea. Reliefs of sea ships are portrayed on the famous eighth century Borobudur temple in central Java, and old seaports have recently been found by an Indonesian archeological expedition team at Gresik, Lamongan, and Sedayu. Historical data also recorded the sea trade and expeditions in the middle centuries. Medan, Jakarta, Indramayu, Semarang, and Surabaya, for example, were embryonic towns 390, 453, 453, 465 and 687 years ago respectively. Thus man began to use and influence the coast directly many centuries ago.

RESULTS OF HUMAN ACTIVITIES

Coastal Erosion

Coastal changes in Indonesia as well as the factors influencing these changes have been described elsewhere.[4,5,6] Most of the erosion caused by human activities is due to river mouth changes with new canal construction, or to coastal deforestation.

All rivers flowing into the Straits of Malacca, the Java Sea, and the South China Sea form deltas. However, only big rivers form lobate or even elongate deltas which jut far out into the sea. Shoaling, river mouth closing, and river mouth changes are very frequent in these types of deltas due to the high silt content of the river water, flooding, and ocean tides, waves and currents. To alleviate problems from flooding and to regulate river flow, flood

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canals are dug. The usual end result is sedimentation in the new canal and erosion at the abandoned natural river mouth or its adjacent coastal sectors; almost all deltas in Java show this pattern. For example, after the digging of an irrigation canal in 1927, the new Cidurian delta 4.5 km west of the old river mouth grew 2.5 km in 18 years, while the shoreline 2 km east of the former mouth was eroded.[7] This phenomenon also occurred on the Padang coast at the Cimanuk and Kedung-Semat deltas.[8]

Population pressure produces very significant coastal impacts in Indonesia, especially in Java. In big cities this impact is even more pronounced due not only to the greater number of people but also to more advanced technology. Coastal deforestation has occurred in many places, e.g., in Jakarta, Cimanuk Delta, and Segara Anakan, and the land has been used for fish ponds, rice fields, settlement, industry, or other human activity. Mangrove deforestation has increased the rate of erosion along the eastern coast of Jakarta at Eretan and at Balongan in the north coast of west Java and at many other places.

Coastal erosion may also result from the dredging of fringing or barrier reef corals. This phenomenon has been recorded at Sengkidu,[9] Sanur and Kuta,[10] and in Balikpapan.[11] The coral islands Ubi Besar and Nirwana have been decreased to about half their original size by coral mining. Although there are now regulations to forbid any kind of mining of coastal sands and corals in the Jakarta area, similar activities still occur in many other places, e.g., in the Seribu coral island area and in the Komodo Islands. Some mining occurs in proposed nature reserves at Pombo and Papagaran Islands in eastern Indonesia, where about 30 percent and 80 percent of these islands respectively have been destroyed by irresponsible fishermen using dynamite.[12,13]

During the period 1873 to 1938, Cilincing Beach in Jakarta retreated about 50 m at an average annual rate of 0.76 m. From 1951 to 1975 the retreat of the strandline totaled 600 m, or an average of 24 m per annum. The changes were especially obvious in the period 1972 to 1975, with a total retreat of about 260 m, or an annual recession rate of about 87 m. The main cause of shoreline recession was mining of about 200 to 300 truckloads of sand per day by the local people, and sedimentation from rivers was not sufficient to balance this loss.[14] Local people also mine mollusc shells, e.g., *Ostrea sp.* on the eastern coast of Jakarta, and collect giant clam shells *Tridacna sp.* in the Seribu Islands. Although careful investigations are still needed, these activities probably have played a role in local coastal erosion. Such mining may have also influenced the fishery resources of that region.

Since 1970 PN Aneka Tambang has been mining iron sands in beach ridges by removing the dune sand overburden along the coast from Cilacap to Selok Hill. The mined area is about 16 km long and averages about 200 m wide. By 1979, some 2,398,773 tons of concentrate had been mined. In theory, the mining activities would have lowered the coastal topography an average of about 0.28 m. However, the mining has lowered the topography by much more in some places and has left mining ponds which can be used directly by villagers for agriculture. On the other hand, the topography has been raised above the original level in some places due to accumulation of the tailings and overburden.

Shore protection systems will usually stabilize a particular area of coast, but they can also affect the adjacent shoreline by changing the mode of longshore current and modifying the sedimentation-erosion balance. Improper shore protection systems at reclaimed land areas of Muara Karang and Pluit have generated scouring and great parts of the wall have been eroded. Construction of an oil seaport at Balongan was one of the main factors resulting in erosion of the surrounding coast.[15]

COASTAL ACCRETION

As a result of coastal accretion during the past 6,000 years and minor oscillations of sea level, coastal plains are well developed on Sumatera, Kalimantan, Java, and Irian Jaya where there are large rivers. Human activities which directly or indirectly result in coastal accretion include coastal reclamation, shore protection, upstream deforestation, coastal afforestation and new canal construction.

Coastal reclamation usually occurs only in large towns or cities where there is more need for land and interest in better coastal area management and development. Coastal reclamation in remote areas is for special purposes such as the airport extension at Ngurah Rai in Bali and at Arun gas field in North Sumatera. Former fishponds at Ancol, Jakarta, at Sunda Kelapa, and at Muura Angke were reclaimed for a recreation park, industry and housing, and housing and a steam power electric plant respectively. At Pluitt, reclamation was also extended into the sea about 200 m from the former shorelines. In short, reclamation progrades the shoreline in a short time and reduces the rate of erosion but does not prevent it.

Shore protection can stabilize the coast and promote sedimentation. The construction of Sunda Kelapa and Angke jetties in Jakarta have increased accretion in the western coastal sector by 1 km compared to 100 m in the eastern sector. At present about half of the Jakarta coast is protected by seawalls, jetties, breakwaters, groins, and bulkheads.

Indonesia has more than 3.6 million ha of mangrove forest. Coastal mangroves will at least reduce the rate of erosion. Mangrove afforestation at the coast from Angke to Kamal in Jakarta, for example, has not only protected the shoreline from the effects of surf erosion, but has also resulted in a progradation of several meters per annum. Mangroves also play an important role in fisheries. For example, there appears to be a close relationship between tidal mangrove forests and commercial shrimp production in Indonesia.

Deforestation along the drainage system will increase sediment yield downstream. For example, growth rates of some deltas in Java have increased considerably in the last decade due to deforestation[16] with increasing population pressure. Even in the Barito River drainage system in Kalimantan, a remote jungle area with few people, the rate of sedimentation has been surprisingly very great. In 1974, the Barito River was dredged to an average of about 6 m for transportation purposes. Four years later the average depth was only 2.9 m. It has been suggested that logging activities have contributed to this increased sedimentation rate. In comparison, Mahakam delta in Kalimantan has a width of about 67 km and protrudes into the sea up to 42 km. Increased sedimentation may cause shoaling and closing of river mouths resulting in floods upstream as demonstrated annually in Jakarta, Indramayu, along the southern coast of central Java, and at Pekan Baru in Sumatera. Thousands of hectares between Cilacap and Karangbolong on the south coast of central Java are also subject to annual flooding.[17]

Sediment yield is greater in watersheds underlain by sedimentary rocks than in those underlain by volcanic rocks.[18] Areas underlain by sedimentary rocks may also be influenced more by human activities in comparison with volcanic regions. Births of new deltas like Cimanuk, Cipunegara and Wulan in Java, and the relatively extensive turbid water along the coast of northern Java and eastern Sumatera in general as viewed in air photographs or LANDSAT images support the conclusion of intensive coastal dynamics in those regions. In general, land use, notably rice farming, plays great roles in these changes.

In the period 1873 to 1938, the Citarum River in its Tanjung Gembong estuary and the Pecah accreted about 45 m and 46 m per annum respectively.[19] After the Jatiluhur Dam was constructed upstream, the annual accretion rate from 1950 to 1975 decreased to 40 and 44 m respectively.[20] The silting of the dammed-up water in the reservoir is clearly visible on the 1976 LANDSAT photographs. In contrast, in the neighboring Bekasi and Cikarang Rivers, catchments with no dam construction upstream, the annual accretion rate increased from 15 to 50 m during the same period.[21] This comparison indicates that human activities and high technology upstream can influence and create considerable changes on the coast. As an extreme example, the edge of the coastal plain at Air Melik, Indragiri on Sumatera was originally about 150 km further inland.[22]

To summarize, the calculated annual changes of coastline in Indonesia are on the order of +500 to -330 m and accretion is more prevalent than erosion.[23] A portion of these coastal morphological changes has been caused, directly or indirectly, by human activities.

POLLUTION

The interest of government in pollution problems is increasing, particularly since the establishment of a State Minister of Development Supervision and Environment in 1978. The status of marine pollution and marine pollution studies in Indonesia have been summarized elsewhere.[24,25,26] Pollution is a problem in some coastal waters, including riverine and groundwater, and on the shore in the form of garbage including nonbiodegradable wastes. There is very little information on negative effects of such pollution regarding fishery or other environmental resources. Extensive and detailed studies are still needed to learn the distribution of pollution and methods for its prevention. It should be remembered that due to limited offshore technology, most fishery activities are concentrated at the coast.

Oil pollution on the coast occurs mostly in harbors and rivers adjacent to large cities and at sites of oil exploitation and transportation. The areas and resources in Indonesia vulnerable to oil pollution include coastal, marine and estuarine zones, offshore marine fisheries, intertidal zones and reef flats, brackish fish ponds, fresh water, and tourism and recreational resources.[27] Although, in general, pollution by oil in offshore waters is not yet a serious problem in Indonesia, hydrocarbon concentrations of 100 ppm and 200 ppm have been detected locally at Tanjung Priok Harbor and in the Malacca Straits respectively. On many of the coral islands of Seribu, tarballs are widely distributed. At the north coast of Lancang Island, for example, mangroves cannot survive due to oil pollution. Similar surveys are being carried out in other areas, such as in the Cilacap region. The status of tarball pollution at Pari Island is now being monitored by the National Institute of Oceanology.

Sea water encroachment is a common feature in coastal lowlands. The saline water, however, only affects surface and shallow subsurface water. Intense exploitation of surface and subsurface water such as in Jakarta will lower the piezometric surface. The number of people in Jakarta has increased from about 1.4 million in 1950 to about 6 million in 1980. Before World War II, salt water encroachment was only encountered at the surface less than 60 m from the coast and at depth less than about 2 km from the present coastline, but in 1979 the piezometric surface was present up to 150 m from the shoreline and at depth as far as about 10 km inland.[28]

Specific examples of marine pollution follow. The effluent of a petrochemical fertilizer plant at Gresik, east Java, coated the mud bottom of fishponds in the vicinity. Although the mangroves were alive and apparently not adhered to by the sludge, the associated benthic fauna was almost absent. During the early stages of the plant operation, there was mortality of fish in the ponds.[29] Pollution of water wastes produced by a sugar factory has been noted in Pati and hectares of fishponds and many of the surrounding drinking water wells cannot be utilized.

In the rivers and streams of Jakarta, heavy metal and bacterial concentrations surpass the water quality standards.[30] Wastes carried by rivers are deposited in many coastal areas, especially around large towns and cities like Muara Karang in Jakarta. Beaches are traditionally used for waste disposal directly, or indirectly, through rivers. Bacteria has contaminated seawater, sediments and some fish, clams, and oysters in Jakarta Bay[31,32] and in Citarum watershed,[33] to such a degree as to endanger the consumers. Some fish and shrimp in both marine and brackish ponds on the north coast of Java are contaminated by agricultural pesticides.[34]

Thermal pollution from the steam power electric project at Tanjung Priok has been detected by the thermal infrared scanner technique. It has been reported that *Ambassis gymnocephalus*, a species of fish, was dying at a temperature of about 39°C in the discharged water of the Tanjung Priok power plant.[35] Similar power plants have also been constructed at Muara Karang, Surabaya and others.

In 1976 LANDSAT images, the turbid water area along the north coast of west Java is mostly limited to about 4 km offshore, notably around big deltas. However, these images were made in the dry season and turbidity should extend much farther offshore in the rainy season. About 80 to 90 percent of the river

sediment load is carried to the sea in this area during the rainy season. There is no doubt that man has influenced the offshore extensions of coastal water turbidity and that this turbidity adversely impacts the coastal resources, notably fishery production, environmental quality, and mariculture.[36] Only by careful monitoring and great efforts of government, institutions, and people can this problem be solved.

SOCIOECONOMIC PROBLEMS

There are many conflicts of interests and needs which occur during the utilization, management, and development of coastal regions. Coastal changes will create land tenure and economic problems. In many new deltas like Cipunegara, Cimanuk, Wulan and Solo, the newly accreted land has created problems not only of land ownership, but also among the government agencies over the right of management. Such agencies include local government, the Department of Home Affairs, the Department of Agriculture, and the Department of Public Works. Land loss due to erosion as in Cidurian, eastern Jakarta, and Kedung-Semat has affected the fishpond areas and salt farms at Eretan, west Java.

Conflicts between traditional fishermen and trawlers over coastal fishery resource utilization have been noted in many places. In Medan and Cilacap, these conflicts have led to physical violence. The government limits the operation area of trawlers larger than 25 gross tons to greater than seven miles offshore, and limits the size of the trawl mesh to not less than 55 mm for the wing side and not less than 25 mm for the bunt.[37]

Pollution by industry has also created conflicts. In Pati, for example, waste water from a sugar plant polluted fishponds, rice fields and drinking water wells of the surrounding villages. In Jakarta, many industrial wastes like detergents, waste water, garbage, pesticides, and solid wastes such as plastics and woods have polluted rivers, beaches, and coastal waters. Battery and detergent industries, and shrimp processing have polluted the surrounding environment and created socioeconomic problems.

Coastal land ownership and use management issues are still great problems to be solved. For instance, certain coastal areas at Anyer are owned by rich private companies and individuals, and such ownership may present obstacles to plans for coastal area development for the welfare of the greater number of people. Regulations, customs, habits or traditional laws for coastal area management do exist but they are not very detailed, and due to demographic pressure and the social status of the people, have not been widely used. For example, in Jakarta where there are regulations to protect the environment from sand and coral dredging in the coastal region, people still deliberately violate the restrictions.

TOWARDS COASTAL PROBLEM SOLVING

Since small, isolated coastal problems accumulate and integrate to become bigger and more serious problems, the human response will usually also keep pace. Since the establishment of a State Ministry of Development Supervision and Environment, coastal resource utilization and coastal area management and development has become more systematic and integrated.

Establishment of new institutions and activities to deal with coastal problems began in the 1960s. The government institutions and universities involved in coastal studies are the National Institute of Oceanology, the Marine Fisheries Research Institute, the Indonesian Petroleum Institute, the Naval Hydrographic Office, the Directorate of Swamps, the Directorate of Rivers, the Directorate of Environmental Geology, the Institute of Hydraulic Engineering, and the Center for Natural Resources Management and Environmental Studies of Bogor Agricultural University. Subjects of interest include pollution, environment, resources, management, institutional cooperation, and legal aspects. A National Committee on Marine Research (PPLI) was established in 1978 to coordinate marine research activities, including coastal studies, in Indonesia.

Efforts have been made through seminars, workshops, symposia, courses and training to exchange ideas, discuss problems and increase institutional relations. Areas of focus include marine pollution, mangroves, corals, coastal

resources, ecology and management of tropical shallow water communities, management of coastal areas, laws and regulations, implementation of the *Wawasan Nusantara* concept, marine data management, and environmental protection and preservation.

A data inventory and collection is one of the activities which will increase the knowledge of human activities and their negative impacts on the environment. Information on fisheries resources, marine environment and pollution, coastal geology, and marine law and regulations has been compiled through annotated bibliographies and a library for marine sciences. Monitoring in certain priority areas like Jakarta Bay has been initiated, and other coastal regions such as Segara Anakan in central Java are being investigated quarterly. Environmental assessments are now being carried out widely by several institutions and universities.

In recent years, training courses such as a course on coastal sedimentation problems by the Institute of Hydraulic Engineering have been initiated to increase technical capabilities for comprehensive coastal area research. In 1979, the United Nations University, in association with the Indonesian Institute of Sciences, initiated a graduate training course in coastal resources management. The course includes workshops, training, and research programs. The 1979 to 1980 research program focuses on Cimanuk Delta as a study area; the following year, the focus will be on the Cilacap region. Some state universities such as Hasanuddin University have marine sciences as their main area of emphasis. It is expected that the lack of well-educated, trained and skilled personnel for comprehensive coastal area research, planning, management, and control will be partly alleviated by the above programs.

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MALAYSIA: BRIEF COMMENTS

— Choong Tet Foong and Khoo Han Peng*

Malaysia produces over one-half of the world's supply of tin, which is one of that country's largest foreign currency earners. The tin is located mostly on the west coast in alluvium and is mined by dredges and gravel pump methods. As the known deposits are depleted, exploration will be directed upstream for lodes, downstream for more deeply buried alluvial deposits and offshore. Exploration of a part of southern peninsular Malaysia's west coast by the Geological Survey of Malaysia and the Federal Republic of Germany, DGR, in 1979 discovered tin resources near one of the best beach resort areas. The use of pegmatite boulders on some beaches for the ceramic industry has been studied, and silica sand and heavy mineral deposits along the east coast of the Peninsula have been evaluated. Production of petroleum resources off the east coast is expected to start soon.

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COASTAL RESOURCES AND ENVIRONMENT: TRUST TERRITORY OF THE PACIFIC ISLANDS

— Division of Lands*

The Trust Territory of the Pacific Islands (TTPI) covers some 7.5 million km^2 of the western Pacific Ocean just above the Equator, ranging from about 1° to 22° N latitude and 130° to 172° E longitude. The Territory embraces more than 2,000 islands and islets, lying in three major archipelagoes: the Carolines, the Marshalls and the Marianas. Politically, the Trust Territory of the Pacific Islands is composed of three entities and the Northern Mariana Islands. The Northern Mariana Islands was separated administratively in 1976 and became known as the Government of the Northern Marianas. Palau, Yap, Truk, Ponape, and Kosrae lie within the Carolines archipelago. The Marianas and the Marshall Islands lie in separate archipelagoes of the same names. The entire area is called Micronesia, or "Tiny Islands." Guam in the Marianas, however, is not part of the Trust Territory.

The Territory's more than 2,000 islands range from large volcanic islands to tiny coral islets linking the circular chain of rock and vegetation which forms a coral atoll. Most islands in the Eastern Carolines and the Marianas are coral atolls, and the Eastern Carolines and all of the Marshall Islands rest on a series of submarine elevations. The largest islands are Babelthuap, Palau District, and Ponape Island, Ponape State. Elevations range from about 1.9 m on a coral atoll to 959 m on Agrihan Island, Northern Mariana Islands. Land area for each island group is given in Table 1.

TABLE 1. Land area of island groups

Island Group	Land Area (km^2)
Northern Marianas	454.8
Palau	444
Ponape	363.8
Marshalls	150.8
Yap	117
Truk	113.5
Kosrae	102.5

All islands in the TTPI have a tropical marine climate characterized by uniform air pressure, temperature, and humidity. Average monthly temperatures range from 79° to 83°F. Usually there is a greater range in daily temperature (approximately 10°F) than in seasonal average temperatures. Relative humidity is usually about 75 percent, but ranges from 55 to 100 percent. Seasonal changes in wind direction and strength and in precipitation are the main variables in climate. Most of the TTPI lies within the northeast trade wind zone, with steady winds over 70 percent of the time. These winds typically persist from October to June with average speeds over

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17 km per hour. The rest of the year, weaker trade winds, slight winds from the east, southeast, southwest, and west, and calm periods are frequent.

The atolls of the northern Marshall Islands have the lowest rainfall of any island in TTPI. For example, Enewetak averages only 138 cm of rain per year. Humidity, as well as precipitation, tends to be less on low atolls than on high islands. Low islands have the same climatic features as atolls except for the absence of lagoons and reefs which protect the backshore from waves and salt spray.

The high islands of Palau, Yap and Truk do not have mountains tall enough to produce rain shadows or to generate heavy clouds and rainfall. Nor are there noticeable temperature differences at different altitudes on these islands. Dry seasons occur most commonly from January through April. Average yearly rainfall in centimeters is as follows: Palau, 365; Yap, 305; and Truk, 342.5.

Extremely heavy rains are experienced on Ponape due to the high mountains. Rainfall at higher altitudes averages 750 to 1,000 cm per year, while in the low coastal area of Kolonia Town the average is 480 cm per year. Kosrae also experiences heavy rain due to its mountains. Records of maximum and minimum annual rainfalls are 590 and 305 cm on Kosrae's east coast. Inland areas would register much higher amounts of precipitation, if measured. Because of the extremely high rainfall and humidity in all months, cloud forest occurs on the peaks of Ponape and Kosrae. There are no significant dry areas resulting from an orographic rain shadow on these two high islands.

Any part of the TTPI may experience devastating typhoons with winds occasionally reaching over 250 km per hour, but Truk, Yap, and Palau have the highest frequency of these storms, with an average of two passing somewhere through these entities each year. The eastern entities only have a fully developed typhoon approximately once every 5 years.

CENTER OF ACTIVITIES

Each entire island is considered to be part of the coastal zone. The islands of Koror, Yap, Moen, Ponape, Kosrae, and Majuro are the central loci of sea communications, legislative seats, hospitals, commerce, urbanization, etc. The limited coastal land area has been developed without adequate attention to either appropriateness of location or related uses.

The government should take steps to manage this delicate and limited resource and develop guidelines for authorities managing the property. Policies are necessary to resolve conflicts between land uses competing for the same area, to give orderly and prudent direction to development, and to protect coastal resources from degradation. The regulations must be specific, comprehensive, and enforceable. Key elements of the program will be the definition of its objectives and policies, its geographic boundaries, and the management system.

Perhaps one of the most significant administrative developments for coastal zone management in Micronesia is the creation of the three new entities: Palau, Marshalls and the Federated States of Micronesia (States of Yap, Truk, Ponape, and Kosrae). It is the hope of the TTPI that these respective governments will establish mechanisms to consider coastal area aspects in the early stages of their overall development planning process, in order to: 1) enhance productive and enjoyable relationships between the people of the islands and their coastal zone, 2) to promote efforts which will prevent or eliminate damage to the terrestrial and marine environment and stimulate its use for the welfare of the people, 3) enrich the understanding of the coastal resources important to Micronesia, and 4) protect the public trust for the benefit of all Micronesians.

Micronesia, like most developing countries, is experiencing coastal problems that reflect both a lack of development and the course of development. These problems are compounded by rapid population growth in an area of low income. Examples of misuse of coastal area resources commonly experienced in Micronesia include: 1) litter, e.g., tin cans and abandoned vehicles, 2) reef damage from silt caused by dredging or runoff from earth-moving activities, 3) use of dynamite, bleach, and other destructive means to catch fish.

At the same time, coastal lands are used for sightseeing, general recreation,

construction of tourist facilities, as well as for seaports and industrial needs. Certain developments such as port facilities and industries often render these locations dangerous and unsuitable for recreation and tourism. In the future, as economic development progresses along with the growing population, these uses and the demands for coastal area are expected to increase. The public is becoming aware of the fact that there is not enough space to accommodate indefinite expansion.

Until recently, little consideration has been given to the preservation of the delicate seashore area, or to its potential for recreation, open-space or aesthetics. Unplanned landfill reclamation projects, unprotected fill, dredging activities and restriction of water circulation by man-made structures have resulted in heavy sedimentation of the immediate lagoon. Shorelines surrounding scenic bays and hillsides of the coastal area are resources of aesthetic, economic, and ecological importance. Past land use patterns have not emphasized preservation of these sensitive and scenic sites. Homes and businesses have been built on landfill along shorelines or over the water on pilings. Improper dredging and landfill, allowing loose sediments to be exposed to waves and land runoff have resulted in unnecessary siltation of bay water. Present dredging still does not provide sufficient means for sedimentation control. This seashore, overgrown with mangrove, is a sanctuary and breeding ground for marine life.

LAND TENURE

Traditional Micronesian land tenure patterns present a significant problem for the installation and improvement of public facilities. To Micronesians in a subsistence economy, land is not a commodity to be traded, but is deeply linked to personal and family identity and social status. Land tenure patterns vary between entities, but generally involve communal ownership of a single plot, single ownership of several small and separate plots, or commercial use rights to land owned by traditional leadership.

Land records prior to and from the Japanese Administration have been substantially destroyed; however, most people know their traditional boundaries and these boundaries do not always agree with government surveys. While a land cadastral program is currently being carried out by the Division of Lands and Surveys of the Trust Territory Government, the program is regarded with suspicion by some Micronesians and its progress has been delayed by many local disagreements.

The communal land ownership and the ill-defined land status resulting from overlapping boundaries and disputed surveys have caused problems which have plagued past construction projects and will cause more difficulties in future projects. In some instances, the projects were built without easements; however, there are many projects for which the government has actually obtained the signatures of all the landowners involved in a land dispute in order to proceed legally.

The Trust Territory Government is empowered with the right of eminent domain, but has encountered sizable resistance to a rumber of public facilities projects involving land condemnation. The former Congress of Micronesia has determined that decisions regarding land matters should be made at the state/entity level.

ENVIRONMENTAL CONTROL ACTIVITIES

Legislative Background

TTPI Environmental Enabling Act and Policy

In 1972 the former Congress of Micronesia enacted an act to provide for the protection and enhancement of environmental quality of the air, land and water of the TTPI, and to provide for establishment of a Trust Territory Environmental Protection Board (TTEPB). By amendment to this law, state/entity Environmental Protection Advisory Boards (EPABs) were established as agents of the TTEPB.

Under this law, the following public policy was promulgated:

> The people of the Trust Territory of the Pacific Islands are dependent upon the air, land, and water resources of the islands for public and private water supply, for agricultural, industrial, and recreational uses, and as a basis for tourism. Therefore, it is declared to be the purpose of this act to achieve and maintain such levels of air,

land and water quality as will protect human health, welfare and safety and to the greatest degree practicable prevent injury to plant and animal life and property, as foster the comfort and convenience of its people and their enjoyment of health, life and property and will promote the economic and social development of the Trust Territory of the Pacific Islands and facilitate enjoyment of its attractions.

Implementation of the policy is undertaken through:

1. Coordination and integration of TTPI development planning and environmental policy and laws with the TTPI Territorial, Federal, and local governments and agencies, and the general public;

2. Education by the TTEPB and their staff of both government agencies and the general public on environmental problems, policies, and programs through such activities as village meetings, public hearings, and announcements through the local media; and

3. Participation of the people through public meetings on proposed development projects, and proposed environmental rules and regulations.

More importantly, the TTEPB and other related agencies are making efforts to incorporate the environmental dimension into development planning at the Territorial, state, and local levels by policies requiring preparation of Environmental Impact Assessments and facility plans of new major development projects.

It should be noted, however, that even with the above requirement, implementation is difficult because the decision makers are very reluctant to accept this concept. Like any other country's decision makers, they hold the view that incorporating environmental aspects in development planning would raise the cost of development. This view arose out of identifying environment with "pollution control" and "conservation." Therefore, the Board's effort is to convince the decision makers that wise environmental use means concern for the totality of resource use over time.

TTEPB Rules and Regulations

Public Water Supply Systems Regulations. This regulation requires any person planning to build or modify a public water supply system to submit a Notice of Intent to the TTEPB through the local EPA Board for the TTEPB's approval. It also requires the supplier of this water to perform routine bacterial and chemical analyses of the water and to report the results to the TTEPB. If the bacterial or chemical standards are exceeded, the supplier (in the case of the TTPI, the local Department of Public Works) must also inform the public using the water, and explain how to make the water safe for drinking.

This regulation has allowed the TTEPB the opportunity to assure that all public water supply systems are properly constructed and monitored. However, because of inadequately trained local Public Works manpower and inadequate funding, none of the public water supply systems in the TTPI are able to produce safe drinking water. The TTEPB is working with the TTPI Bureau of Public Works to obtain the necessary funds to improve these systems, and is assisting the Bureau of Public Works in training of the water operators through an EPA grant used to hire an operator trainer.

Earth-moving and Sedimentation Control Regulation. This regulation requires anyone doing any earth-moving activity (except small agricultural cultivation and construction of a family home) to apply for a permit from the TTEPB through the local EPA Board. The application includes an erosion and sedimentation control plan to minimize the environmental impact of the project. Public hearings are held on all significant earth-moving projects to obtain the public's comments.

A US $100 application fee is required with applications from private applicants (no fee is required from government agencies). This has caused some complaints, but it is explained that such projects can have a great impact on the environment and should be carefully planned and carried out. Some questions have also arisen as to why the TTEPB should control earth-moving activities on private lands.

It is explained that the impact of such project is not limited to the immediate area, but can affect areas far removed from the project site through runoff and other impacts. Through this permit system, the control of earth-moving activities in the TTPI and the protection of the environment are being carried out very effectively.

The U.S. Army Corps of Engineers also requires a permit for any filling of water and wet-land areas in the TTPI, under Section 404 of the U.S. Federal Water Pollution Control Act (as amended). This permit is not issued until the applicants have received a TTEPB Earth-moving Permit, and all other locally required approvals. The TTEPB and the Army work closely together in administering these permit programs. The TTEPB informs the Army of proposed projects requiring the Army's permit, and assists the Army in follow-up inspections on these projects, as the Army has no staff assigned to the TTPI.

Fish and Wildlife Coordination Act As Amended (P.L. 85-624)

This law, administered by the U.S. Fish and Wildlife Service, in the Department of Interior, provides information and technical assistance to public and private agencies and organizations for the improvement of conditions for the management of wildlife resources.

All Army Corps of Engineers Section 404 (U.S. Clean Water Act of 1977) permit applications for all major TTPI projects, such as for docks, airports, etc., are reviewed by the Fish and Wildlife Service for impact of the project on the marine environment. No permit can be issued by the Army without the concurrence of the Fish and Wildlife Service. The Service also has conducted several marine surveys in the TTPI to determine possible impacts of proposed projects on the marine environment.

National Environmental Policy Act

This law requires all U.S. Federal agencies, before reaching a decision on a proposed major action which may have a significant effect on the human environment, to analyze in detail the likely environmental consequences of the action, and make the analysis available to the public. All U.S. federally funded projects in the TTPI must comply with this law. An Environmental Impact Assessment (EIA) is first developed on these projects, and a public hearing is then held. If the assessment and the results of the hearing indicate that no major impact is expected, the requirement for a more detailed Environmental Impact Statement (EIS) may not be necessary. Environmental Impact Statements have been made on airport projects for Kosrae, Truk, and Yap. Environmental Impact Assessments on other construction projects in the TTPI have shown there is no necessity for EISs.

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PAPUA NEW GUINEA: BRIEF COMMENTS

—Greg Anderson*

Papua New Guinea's extensive potential offshore and onshore resources coupled with a small population are considered favorable for development. Nevertheless, minor conflicts between commercial and local fisheries operations were being encountered as well as concern for possible environmental effects on the Gulf of Papua should development of the large Oktedi porphyry copper deposit and the Wabu hydroelectric scheme proceed. The Port Authority is the responsible agency controlling the development of Port Moresby, but there is no agency responsible for the overall development of the country's coastal areas.

On the national level, a coastal authority should be organized to be responsible for coastal management of specific areas where development is occurring. This authority could be incorporated into the present governmental system, or the authority could be composed of personnel from all governmental departments concerned with coastal development. In the latter situation, these personnel would be responsible for informing their parent departments and making them aware of planning requirements. Coordination and exchange of information between departments is lacking at present. Also, some provinces are attempting to carry out general resource evaluation of their particular province. This evaluation should include a very general management proposal for coastal resources.

On the regional level, interchange of personnel working on similar coastal development projects within the region would be helpful. Also, there should be cooperation between the Pacific nations to pool knowledge and expertise on coastal resources and management problems common to all or shared by all such as management of migratory tuna. On the international level, the United Nations should provide appropriate consultant services for extended periods for specific projects or areas, and access to data when required on a specific coastal development, particularly when problems faced in new developments can be related to projects already established in other nations. The United Nations should also assist in the dissemination of information on available training programs at the UN University, East-West Center, and other institutions. Further workshops should also be organized to deal with both general and specific issues, and to include specific case studies from countries in the region presented by teams representing several disciplines.

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THE COASTAL ZONE MANAGEMENT PROGRAM OF THE PHILIPPINES

—Prescillano M. Zamora*

BACKGROUND

The coastal zone is of immense value to the economic and ecologic life of the Philippines. The country's archipelagic configuration, its 18,417 km of shoreline and the fact that 82 percent of the country's provinces have coastlines highlight the coastal zone's importance. However, due to increasing demands for fish production, recreation, transportation, and waste disposal sites, the problems of environmental degradation and overexploitation of natural resources have begun to pose a considerable threat to the ecological integrity of not a few coastal areas, especially in such urban centers as Metro Manila, Cebu City, and others. The national interest requires sound policies and strategies with regard to the proper management and protection of the coastal zone.

The *Letter of Instruction 549* dated June 17, 1977 recognized the coastal zone as a vulnerable ecosystem presently being subjected to environmental degradation and, with these considerations in mind, mandated the National Environmental Protection Council (NEPC)[1] to organize and coordinate an interagency task force to conduct research on vulnerable ecosystems including the country's coastal areas.[2] To that effect, the Ministry of Natural Resources (MNR) issued *Special Order 180* on June 6, 1977 creating a Coastal Zone Management Committee (CZMC).[3] (The NEPC was under the supervision of the MNR until its transfer to the Ministry of Human Settlements [MHS] by virtue of *Presidential Decree 1846* dated June 2, 1978;[4] this transfer automatically placed the CZMC under the MHS.)

The Committee is a technical group and has the following functions as specified in *Special Order 180*:

- To conduct a nationwide survey, in cooperation with the Natural Resources Management Center, to identify and assess the existing status of resources, the manner of utilization, and attendant environmental problems in the coastal zone,
- To formulate a master plan to ensure optimal utilization of coastal areas with attention to ecological and environmental conditions,
- To conceptualize and initiate plans, programs and projects to effect wise and efficient utilization of the coastal areas, and

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- To draft and recommend policies, based on the findings of the Committee, to Dr. Celso R. Roque, Executive Director of the NEPC.

Thus, in late 1978, a Coastal Zone Management Task Force (CZMTF) was formed through a *Memorandum of Understanding* among the member agencies to coordinate all activities on coastal management and to properly enforce all policies and guidelines related to it. The CZMTF is composed of 22 government agencies (Table 1).

Prior to the creation of the CZMC, several goals had been established for the protection and enhancement of the country's coastal area. These goals are expressed in various *Presidential Decrees (PD)*, *Letters of Instruction (LOI)*, *Special Orders (SO)*, and *Administrative Orders (AO)*. Some of the more important edicts are listed in Table 2.

Recently, on June 11, 1978, the President issued *PD 1586* establishing an Environmental Impact Statement (EIS) System[5] founded and based on the environmental impact statement required under Section 4 of *PD 1151*. Section 9 of this new decree provides for the imposition of penalties for noncompliance with the EIS requirement.

PROGRAM COMPONENTS AND PROJECTS

The Philippine Coastal Zone Management Program is tentatively divided into five phases as follows:[6]

1. Gathering of baseline information on coastal zone resources and utilization,
2. Organization and coordination of an interagency task force on coastal zone management,
3. Survey of coastal zone resources and utilization,
4. Project implementation and policy formulation, and
5. Monitoring of the coastal zone and enforcement of rules and regulations.

Phases 1 and 4 are presently being implemented with the cooperation of the NRMC[7] under its Director-General, Dr. Celso R. Roque. Of particular interest

TABLE 1. Member agencies of the coastal zone management task force

1	Bureau of Coast and Geodetic Survey
2	Bureau of Fisheries and Aquatic Resources
3	Bureau of Forest Development
4	Bureau of Lands
5	Bureau of Mines
6	Bureau of Soils
7	Environmental Center of the Philippines
8	Fertilizer and Pesticide Authority
9	Fisheries Industries Development Council
10	Forest Research Institute
11	Ministry of Human Settlements
12	Ministry of Local Government and Community Development
13	Ministry of Tourism
14	Ministry of Public Works
15	National Pollution Control Commission
16	Natural Resources Management Center
17	Philippine Atomic Energy Commission
18	Philippine Coast Guard
19	University of the Philippines, College of Fisheries
20	Philippine Atmospheric Geophysical and Astronomical Services Administration
21	National Water Resources Council
22	University of the Philippines, Marine Sciences Center

TABLE 2. Some important presidential decrees relevant to coastal zone management

1	*Presidential Decree 463:* Mineral Resources Development Decree of 1974, containing provisions regarding the control of pollution due to mine waste and tailings.
2	*Presidential Decree 552:* Marine Pollution Decree: Protection of Coastal Zones from Pollution.
3	*Presidential Decree 705:* Forestry Reform Code of 1975: Management of Foreshore Areas.
4	*Presidential Decree 704:* Fisheries Decree of 1975: Regulation of Fishery Exploitation.
5	*Presidential Decree 354:* Preservation of Marine Parks, Sanctuaries, Natural Habitats and Wildlife Refuges, including a specific ban on beach mining of magnetite and silica sand, and on coral exploitation and export.
6	*Presidential Decree 1151: Philippine Environmental Policy* dated 6 June 1977 requiring "All agencies and instrumentalities of the national government, including government-owned and -controlled corporations, as well as private corporations, firms, and entities" to "prepare, file and include in every action, project or undertaking which significantly affects the quality of the environment," an ENVIRONMENTAL IMPACT STATEMENT.

is the ongoing project of the NRMC-National Science Development Board (NSDB), "Coastal Resource and Environment Survey Using LANDSAT Multispectral Scanner Data." The project began on January 1, 1979 and has as its objectives the actual resource inventories, mapping, and multidisciplinary environmental analysis of selected areas for coastal zone management through computer-processing of setellite (LANDSAT) images and ground-truth surveys.[8] The project includes the following sectoral activities: (1) geological and hydrological studies, (2) botanical studies, (3) marine resource and oceanographic studies, (4) agricultural and land use studies, and (5) software development. Ricardo T. Biña is the project director. Major completed and proposed projects of the NRMC that have direct bearing on Philippine coastal resource management and environmental problems are reviewed in the Country Report, "Remote Sensing Program of the Philippines."[9]

Phase 3 is being implemented through the Coastal Zone Management Study Project. This project consists of a nationwide survey of the present status of utilization of the coastal resources, both extractive and nonextractive, and associated environmental problems as a basis for the conceptualization, formulation and implementation of a master plan for management and protection of the coastal zone. The output of the project will include:

Volume 1:	Inventory of Philippine Coastal Resources
Volume 2:	Coastal Zone Utilization and Environmental Problems in the Philippines
Volume 3:	Coastal Zone Manpower and Institutional Resources in the Philippines
Volume 4:	Philippine Coastal Zone Policies and Decision-Making Processes

Volume 1 has been completed and is now in press; volumes 2, 3, and 4 are under preparation. Dr. Celso R. Roque is the Project Director; Dr. Prescillano M. Zamora is the Project Coordinator for Volume 2; Dr. Edgardo D. Gomez, Project Coordinator for Volume 3; and Dr. Jorge de las Alas, Project Coordinator for Volume 4.

As terms of reference for the foregoing undertaking, the CZMC adopted the definition of the Philippine Coastal Zone as developed by an interdisciplinary group of experts.[10] The definition is as follows:

> The Coastal Zone is the strip of land and adjacent lake or ocean space (water and submerged land) in which the land ecology and land use directly affect lake and ocean space ecology and vice versa. Functionally, it is

a broad interface between land and water where production, consumption and exchange processes occur at high rates of intensity. Ecologically, it is an area of dynamic biochemical activity but with limited capacity of supporting various forms of human use. Geographically, the outermost boundary is defined as the extent to which land-based activities have a measurable influence on the chemistry of the water or on the ecology of biota.

In determining the geographic boundaries of the Philippine coastal zone, the point of reference used is the zero mark or mean sea level on 1:50,000 topographic maps and the following limits. The outermost limit is the 200 m (100 fathom) isobath except at embayments in which case the 200 m isobath at the mouth of the bay, gulf or cove is extended across. Where the 200 m isobath is less than 3 km from the shoreline, the outermost limit is 3 km. The innermost boundary is 1 km from the shoreline except at places where recognizable indicators for maritime influences exist like mangroves, nipa swamps, beach vegetation, sand dunes, salt beds, marshlands, bayous, recent marine deposits, beach sand deposits, and deltaic deposits. At such places the 1 km distance will be reckoned from the innermost edges of such features.

The foregoing definition will not always be adequate and will be revised when and if necessary. However, the definition is practical and can serve present needs. Evolving a coastal zone management system for the Philippines will not be easy because, as in all countries, the coastal areas are used by everyone, yet owned by no one.

NOTES

1. *Presidential Decree 1121:* Creating the National Environmental Protection Council, 18 April 1977.

2. *Letter of Instruction 549:* Mandating the NEPC to organize and coordinate an interagency task force to conduct research on vulnerable ecosystems such as the coastal areas, 17 June 1977.

3. *MNR Special Order 180:* Creating the Coastal Zone Management Committee, 6 June 1977.

4. *Presidential Decree 1396:* Creating the Department of Human Settlements, 2 June 1978.

5. *Presidential Decree 1586:* Establishing an Environmental Impact Statement System, 11 June 1978.

6. NEPC Subgroup on Coastal Zone Management. *Proceedings of the Workshop on Identification and Planning in Environmental Management, 24-28 October 1977* (Covelandia Resort Hotel, Kawit, Cavite, Philippines, 1978); NEPC. *Proceedings of the Planning Workshop for Coastal Zone Management, 7-10 December 1978* (1979); Center for Development Studies. Initial Reports, Coastal Zone Management in the Philippines Project (Quezon City, Philippines, 4 October 1979).

7. *Presidential Decree 1041:* Creating the Natural Resources Management Center, 25 October 1976; *Presidential Decree 1531:* Declaring NRMC as an autonomous agency, November 1978.

8. NRMC. *Coastal Resources and Environmental Survey Using MSS LANDSAT Data: Detailed Project Plan and Accomplishment Report, 1 January-30 June 1979* (Quezon City, Philippines, 1979).

9. *Proceedings of the Twelfth International Symposium on Remote Sensing of the Environment, 20-26 April 1978* (Philippine Plaza Hotel, Manila, Philippines, 1979).

10. NEPC. *Proceedings of the Workshop to Define the Philippine Coastal Zone, 13-14 September 1979* (AIT House, Diliman, Quezon City, Philippines, 1979).

COASTAL DEVELOPMENT IN SINGAPORE

—Lim Joo Ngee*

THE COUNTRY

Singapore consists of the island of Singapore and some fifty-odd islets within its territorial waters. It is situated between latitude 1° 09'N and 1° 29'N and longitude 103° 38'E and 104° 06'E approximately 136.8 km north of the Equator. The main island is about 41.84 km in length, 22.53 km in breadth, and 571.6 km^2 in area. It has a coastline of 193.7 km. Total land area including the islets is now more than 616.3 km^2; some of the islets are reclaimed land. The city, with an area of approximately 97.4 km^2, is situated in the southern part of the island, at latitude 1° 18'N and longitude 103° 50'E.

About two dozen of the islets are inhabited and economically important. The major ones are Pulau (P.) Tekong Besar, 7,792.4 ha; P. Ubin, 1,014.1 ha; Sentosa, 301 ha; P. Bukom Besar, 120 ha; P. Ayer Merlimau, 125 ha; and P. Ayer Chawan, 223 ha. P. Seburus Dalam and Luar were merged by reclamation with P. Seraya which has a land area of 188 ha (Figure 1).

PHYSICAL FEATURES

The island is low-lying and flat, with an average elevation of 10 m above sea level. Only about 56 km^2, or roughly 9 percent of the area of Singapore is over 31 m above sea level. Geologically, the island can be divided into three distinct parts. The central part is hilly with massive deposits of granite in Bukit Timah (height 166 m), Bukit Gombak (133 m), Bukit Panjang (166 m), and Bukit Mandai (88 m). The western and southern part consists of sedimentary rocks forming a succession of scarps and vales, and the eastern part consists of unconsolidated sand and gravel, extending from Katong to Bedok and Changi.

There are few rivers and these are mostly short and sluggish. The longest one, Sungei Seletar, is about 12 km from its source through Seletar Reservoir to the sea. The coasts are generally flat. The coasts on the western part of the island extending from Changi to Pasir Panjang are low. About 8 km west of the city, the coast becomes more or less regular with extensive sandy beaches and some traces of mangrove.

The natural vegetation of the island is the dipterocarp type with patches of mangrove forests inside tidal river mouths and occasionally along the coast. The indigenous higher plants number over 2,000 species. Although much of the primary forest has given way to massive housing development (Table 1), some of the island's original vegetation survives in 2,797 ha of nature reserves. The Bukit Timah Nature Reserve, occupying 66 ha is the only place in Singapore where many indigenous plant species can still be

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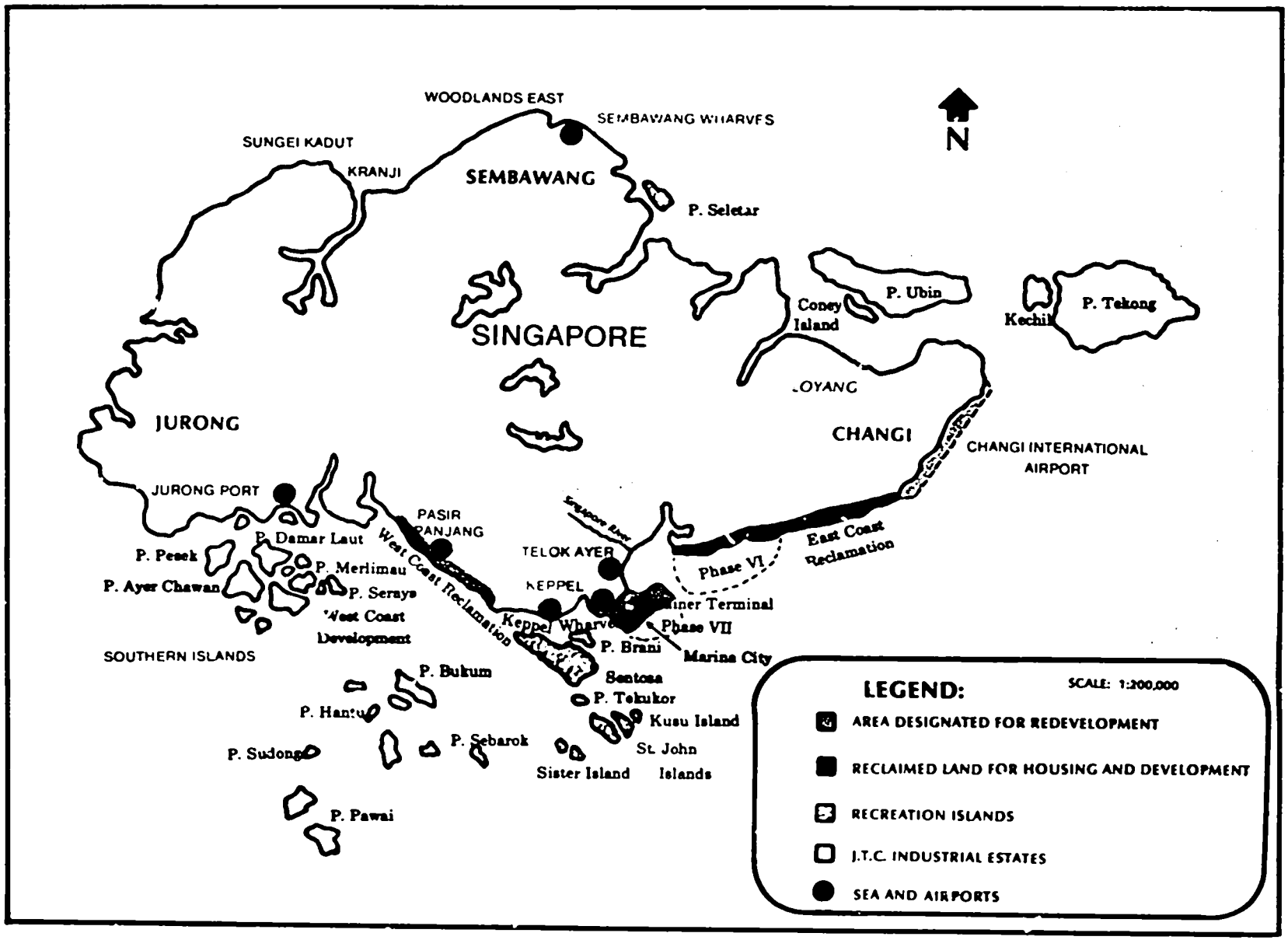

FIGURE 5. Coastal land use in Singapore

found. The water catchment area, consisting of some 2,717 ha, has been protected since 1951. The Kranji Nature Reserve of 14 ha contains remnants of secondary mangrove forests.

TABLE 1. Land use 1978

Built-up area	266.5 km^2
Farm holdings	100.6 km^2
Cultivatable waste	95.8 km^2
Forest	32.4 km^2
Marshes	26.7 km^2
Other	94.3 km^2

The waters surrounding Singapore and the islets teem with various species of fish. The electric ray, ikan tamban bulat (sardine), ikan tamban sisek (sprat), ikan terubok (shad), ikan bilis (anchovy), pike eels, ikan alu-alu (barracuda), ikan renyau (silver-sides), ikan parang (dorab), ikan kerapu (groupers) and ikan selar (horse mackeral) are still plentiful.

AGRICULTURE

The major farming activities are livestock rearing, horticulture, and fishing. In 1978, there were 13,307 licensed farms of all categories occupying a total of some 10,056 ha. The gross agriculture output for the year amounted to US $239.03 million at ex-farm value. Pig rearing is the most important farming activity with an output of 1,173,000 porkers in 1978 with an ex-farm value of US $97.92 million. Poultry farming is next in importance, attaining outputs valued at US $84.57 million in 1978. Production of vegetables in 1978 was 40,665 tons valued at about US $11.06 million, meeting about one-fifth of the local requirement. In 1978, 2,084 licensed fishermen and 719 licensed fishing vessels caught a total of 15,634 tons of fish worth approximately US $17.59 million, meeting about a quarter of the local demand for fish.

ORGANIZATIONAL STRUCTURE FOR COASTAL DEVELOPMENT AND MANAGEMENT IN SINGAPORE

Coastal development and management in Singapore is undertaken mainly by the Ministries of Communications, National Development, and Trade and Industry. The Ministry of Communications directs, coordinates and promotes the communications services both domestically and internationally. It exercises responsibilities for the development of maritime and port services and international air services, telecommunications and postal services. The Port of Singapore Authority (PSA) is under this Ministry.

The Ministry of National Development is responsible for public housing, public works, urban renewal, primary production, parks and recreation, state and city planning, middle-income housing, the control of land use and buildings, and car parks. Its other responsibilities include the maintenance and management of buildings and common properties, the control of private housing developers, and the development of public facilities in urban and rural areas. The Housing Development Board (HDB), the Public Works Department (PWD), and the Urban Renewal Authority (URA) are under this Ministry.

The Ministry of Trade and Industry is responsible for economic and manpower planning, public sector development, regional and international economics, domestic and external trade policies, and supply and control of essential commodities, export promotion, shipping and freight, tariffs, industrial policies, investment promotion, investment guarantee agreements, and tourism and statistical development. The Departments and Statutory Boards under its direction include the Jurong Town Corporation (JTC), Singapore Tourist Promotion Board (STPB), and the Sentosa Development Corporation (SDC).

TRANSPORTATION (Figure 1)

The Sea Port

Singapore is the focal point of more than 150 major shipping lines covering

services to different parts of the world. Anchorage facilities are available for supertankers, cargo freighters, bulk carriers and cargo boats. The Port of Singapore Authority (PSA) operates 6 fully mechanized gates with a total of 5 third-generation container berths, 44 ocean berths and 26 coastal berths for a total area of approximately 561,000 m^2 including warehouses and back-up facilities within the port.

Reclamation of about 37 ha of land and construction of 1,360 m-long wharves consisting of both coastal and lighter berths was included under Phase I of the west coast development initiated in early 1972, and was completed in stages by 1976. The Phase II expansion program consists of reclamation of another 14 ha of foreshore land beginning in April 1977 and would include the construction of 540 m of deep-water berths, 250 m of coastal berths and 65,000 m^2 of covered warehousing space. The whole project is due to be completed by mid-1981.

Plans are now being prepared for the reclamation of another 20 ha of foreshore land, and construction of 1,100 m of wharves under the Phase III west coast development project. Lighter facilities are also being planned to accommodate the resettlement of lighters necessitated by the redevelopment programs of the Singapore River. Also, the planning of the sixth container berth is underway and alternative sites in the coastal area are being studied in detail for the expansion of the container terminal.

The Airport

The PSA was the agent for the Government in the major reclamation of some 650 ha of foreshore at Changi for the development of Singapore's new international airport. The project commenced in February 1976 and was completed in February 1979 at a cost of around US $250 million.

INDUSTRY (Figure 1)

The development of the coastal region for industry is undertaken mainly by the Jurong Town Corporation (JTC). In Jurong Town, development of seafront land continues at the western section of Jurong Town and at the eastern part abutting the Pandan River. This site is allocated to high technology industries, e.g., manufacturing of high-precision milling machines, plastic moulding machines, patented oil field equipment, electronic and electrical components and accessories such as color TV tubes and miniature batteries.

In Sungei Kadut, a total of 217.3 ha of land houses the largest number of wood product and rattan processing establishments in the Republic. The strong demand for sawn timber products has made the development of sawmills in Sungei Kadut very successful. Kranji Estate with a total area of about 78 ha also consists mainly of timber-based industries. Woodlands East has a total area of about 160 ha. However, there are at present only 13 factories there occupying a land area of 7.54 ha. This site is being actively promoted by relaxation of investment requirements. In addition, a "food zone" has also been created there. Planning for the development of Sembawang as the largest industrial estate in the northern portion of the island is in an advanced stage. Reclamation and construction of two channels in the estate produced more marine land with sea frontage for allocation to the shipbuilding/repairing and other marine industries.

A total of 140 ha of land has been prepared in Loyang and another 32 ha are under preparation. Earthwork at Loyang is expected to be completed by mid-1980. In view of its proximity to the new Changi International Airport, part of the estate has been earmarked for aircraft servicing and related aviation industries. Land sites are also earmarked for offshore exploration and marine-oriented industries. This will complete the services of the offshore marine base presently operated by the Singapore Offshore Petroleum Services Pte, Ltd.

Development of the major islands in the Southern Islands group continues with large-scale reclamation work being carried out on P. Merbau, marking the start of physical implementation of the US $2 billion Sumitomo-Singapore petrochemical project. Reclamation work on P. Damar Laut was also carried out during the preparation of 22.3 ha of industrial land on the island. This reclamation and preparation were undertaken bearing in mind future expansion of Jurong Port. Similarly,

development work on P. Pesek was undertaken considering the expected expansion of the storage and refining capacity of the existing petroleum refinery in P. Ayer Chawan. Work on P. Serayen was completed in 1979 and the island will be allocated to the Public Utilities Board (PUB) for the development of a power station.

Area around P. Sebarok was reclaimed and developed by PSA to provide a comprehensive range of slop reception and treatment facilities. P. Brani is earmarked for future port development. In late 1976, reclamation and shore protection works at P. Sudong began and were completed by the end of 1978. The reclamation yielded about 24.3 ha of land for development purposes. In addition, Kuchin Creek and other parts of the northern foreshore of P. Sentosa were reclaimed providing an additional 17.3 ha of land for the development of a ferry terminal and central landing plaza. Tenders have been invited for the reclamation of some 760 ha of land around P. Tekong Besar; however, the project has been temporarily halted. P. Bukom is leased to Shell Oil Company as a refinery site while P. Pawai is reserved for military purposes.

HOUSING AND URBAN REDEVELOPMENT (Figure 1)

The development of coastal areas for housing is undertaken mainly by the Housing Development Board of Singapore. The Board has reclaimed a total of 1,165 ha of land under the first five phases of the East Coast Reclamation Scheme, and 66 ha of land were reclaimed along the west coast for the development of Clementi New Town and the coastal highway linking Jurong to the city. In 1978, the Board awarded its largest single contract amounting to US $352 million to reclaim 360 ha of land under Phases VI and VII of the East Coast Reclamation Scheme.

The Urban Redevelopment Authority (URA), in cooperation with other authorities, prepared land use and development plans for Marina City. The area consists of about 640 ha of reclaimed land. The principal development objectives are to counterbalance deficient cultural/recreational and social facilities in the Central Area with the creation of public open spaces, parks, cultural and recreational facilities and schools. The project will also provide complementary development such as good quality housing and commercial facilities, including hotels, offices and shops. When fully developed, Marina City will form the southern end of a 4.5 km tourist belt stretching from Tanglin Circus to Orchard Road, Bras Basah Road and Raffles City.

Many of the offshore islands are being developed into recreational resorts. The PSA, in undertaking development of recreational resorts in the Southern Islands on behalf of Sentosa Development Corporation (SDC), had, by 1976, reclaimed a total of 75 ha forming 10 km of beaches in the Southern Islands from material obtained from the navigational channels and sealanes in the port. These developments include P. Hantu, Sister Islands (P. Suban Darat and P. Suban Laut), Kusu Island, St. John's Islands (P. Sakijang Bendera and P. Sakijang Pelepah). To the north, Coney Island (P. Serangoon), owned and developed by PSA, and P. Seletar were enlarged to provide a total of 50 ha and 4.3 km of beaches.

geothermal power potential is sufficient, industrial development could take place in the area. Pulp or paper making, fish processing, cement manufacture, and aluminum smelting have been suggested as possible uses of the power. The population of Vella Lavella is small and development of the field for domestic use would not be economically justified.

FISHERIES

On January 1, 1978, Solomon Islands declared a 200-mile fishing limit. Within this limit there is a large and not yet fully exploited fish resource.

Solomon Taiyo, a joint venture company between the Solomon Islands government and Taiyo Fishing Company of Japan, is currently engaged in fishing for skipjack tuna using pole and line catching methods. Longline fishing is also under development, the target in this case being yellow-fin tuna. Two fish processing plants are run by Solomon Taiyo. At Tulagi in the Florida Group (Figure 1), a cannery, freezing plant and smoke factory is in operation, and at Noro in the Western Solomons there is a freezing and smoking plant. A second canning factory is planned at Noro. Agreements have been made with the governments of the New Hebrides and Japan to allow vessels from these countries to fish within the 200-mile limit. However, only Solomon Taiyo and local Solomon Islands ships are allowed to operate within the archipelagic and territorial waters. In order to reduce the revenue lost by Solomon Taiyo in charter charges for Okinawan fishing boats, another government Taiyo joint venture company, National Fisheries Development Ltd., has been set up to construct ferro-cement skipjack vessels. This company is also based in the Florida Group.

Local fisheries development has been aided by a government-established fish collection and marketing scheme. Twelve ice-making plants--two in Honiara, the capital, and the rest in outstations--supply ice to local fishermen who can then store their catch in ice boxes to await collection by a refrigerated vessel. This vessel provides a regular weekly service between the more productive fishing groups in the islands and Honiara, where the fish are marketed chiefly through a public company, SIACO, formed under the direction of the Fisheries Division of the Ministry of Natural Resources. A number of private collection and marketing schemes are also functioning, although these schemes also utilize the government ice plants. Crayfish, oysters, crabs, prawns, and fish are now all exploited commercially.

FORESTRY

Forests cover the major part of the land surface of Solomon Islands. Logging operations are carried out exclusively by the private sector, the main areas worked being in the New Georgia Group, Guadalcanal, and the Shortland Islands (Figure 1). Logs are exported in preference to sawn timber, most of which is sold locally. The Forestry Division of the Ministry of Natural Resources has a substantial forest regeneration program underway and planting is currently taking place in the New Georgia Group and Santa Cruz, and was previously undertaken on Santa Isabel (Figure 1).

MINERALS AND PETROLEUM

Panning for gold on Guadalcanal is the only mining operation taking place at the moment. There are, however, a number of prospects which are attracting interest. A program of reconnaissance geological mapping and geochemical exploration aimed at completing a preliminary geological survey of the Solomons is currently being carried out by the Institute of Geological Sciences supported by British Aid funds. Guadalcanal, Choiseul, the Shortland Islands, Eastern Outer Islands, the Russells and Ulawa have all been mapped at reconnaissance level, and work on the New Georgia Group is in progress. Parts of other islands have also been surveyed.

Gold panning is restricted to the rivers draining the Gold Ridge area of Guadalcanal. The increase in the price of gold during 1979 led to renewed interest in the Gold Ridge prospect and also in the Suta gold field eight miles farther inland (Figure 1). An offshore gold prospect has been found where the rivers draining Gold Ridge enter the sea on the north coast of Guadalcanal. The chief interest here is in a submerged buried river channel, which was investigated under a CCOP/SOPAC project.

Chromite-rich beach sands on San Jorge are being examined as a possible small-scale mining prospect and it is hoped that the bauxite deposits on Rennell, Waghena and

New Georgia will soon be the subject of further work. Tests are being carried out to determine whether the particular properties of the Solomons bauxites will allow them to be mixed with other major bauxites in the Bayer process.

A number of other mineral prospects exist particularly for copper, nickel, phosphate, and manganese. Petroleum legislation is expected to be put before Parliament in the first quarter of 1980. It is hoped that this will stimulate prospecting in offshore areas. Complicated land ownership systems and resistance from landowners to prospecting could hinder the development of mineral resources in some areas.

URBAN, INDUSTRIAL, AND PORT DEVELOPMENT

Honiara, the capital of Solomon Islands on Guadalcanal, is the only center with a population of over 5,000, the latest figure being just under 15,000. New housing and light industrial developments are taking place, but the proliferation of large hotels usually associated with the tourist industry has been resisted. Proposed extensions to the wharf are at the tender stage.

At Noro, in the Western Solomons, a new port is being developed. The previous main port for the west, at Ghizo, had difficult access and the large international shipping lines, which carry copra for export, have refused to call there. It is possible that the new port will become the administrative center for the Western Solomons and its population may eventually rise to the level of that of Honiara.

MANAGEMENT PROBLEMS

Most of the developments in Solomon Islands' coastal zone give little cause for concern but prospective activities may produce problems.

Honiara has a water supply problem and recent tests have shown evidence of sewage pollution in the coastal waters. Similar problems are likely to exist at the new port site at Noro where investigation of the water resources is taking place and the fish processing plant may give rise to some pollution. Alternative sites for the new port had to be ruled out for a variety of reasons, among which were poor access and communications, land tenure, and existing timber operations. Sources of sand and gravel for construction purposes are being sought and extraction will need to be monitored if erosion problems are to be avoided.

In the fisheries sector, one current problem is that of illegal fishing within the 200-mile limit. One patrol boat is already operating, another is needed, and an air surveillance program has been allotted budget funds.

Mining ventures invariably produce environmental problems. If mining were to take place in the Gold Ridge area of Guadalcanal, care would have to be taken that waste material did not pollute rivers flowing across the agricultural development area of the coastal plains because some of these rivers are used for irrigating rice paddies. Pollution effects in the region of river mouths might also have a deleterious effect on fish stocks. The chief bauxite reserves lie on the islands of Rennell and Waghena (Figure 1) and the environmental impact of mining and the possible processing of bauxite on either island would be substantial.

A dormant volcano, Savo, lies offshore some 22 miles to the northwest of Honiara. The last recorded eruption of this volcano, in the middle of the last century, was of Pelean type. A teleseismic link between the island and Honiara has been established to monitor earth motions which may herald an eruption. The form the next volcanic activity will take cannot be predicted at this stage but, if sufficiently violent, Honiara and the agricultural plains area could be affected by tidal wave and ash fall. An evacuation plan for the population of Savo has been prepared but no steps have been taken to protect Honiara from the possible consequences of an eruption. It is in fact very difficult to say what could be done to protect the town and also justify it economically.

Finally it can be pointed out that all the activities mentioned affect shipping and, as development goes ahead, the volume of sea traffic can be expected to increase. Shipping lanes are not crowded and port facilities not yet overloaded, but the prospects of a collision, possibly involving an oil tanker, are not negligible and must be planned for.

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COASTAL AREA DEVELOPMENT AND MANAGEMENT IN SOLOMON ISLANDS

—John Ridgway*

Solomon Islands is a recently independent (1978) developing nation comprised of six major and numerous smaller islands (Figure 1). Because of the relatively small size of even the major islands, the whole of the Solomons can be regarded as "coastal area." Most major development is taking place in the immediate coastal zones, but inland projects inevitably have some impact at the coast, if only because of shipping, which is the chief form of transport between the islands.

There is at present no specific body responsible for all aspects of coastal management, although the Central Planning Office, a unit within the Prime Minister's Office, acts as an economic coordinator for the nation. Environmental problems, mining, forestry and fisheries are normally the responsibility of the Ministry of Natural Resources, while the Ministry of Agriculture and Lands takes care of agricultural developments and urban planning. Transport is the concern of the Ministry of Transport and Communications, and water supply that of the Ministry of Works and Public Utilities with some assistance from the Ministry of Natural Resources. In order to facilitate better communications between the various Ministries, para-state bodies and private companies involved in coastal area developments, the Solomon Islands government is examining the possibility of designating one office, or individual, to act as a national coordinator and also as a focal point for overseas communications.

Current and prospective developments are shown on Figure 1 and can be summarized under a number of headings.

AGRICULTURE

The main agricultural developments are on the coastal plains of north Guadalcanal where extensive areas are given over to palm oil, rice, copra, and cocoa production. The area under cultivation extends eastward away from the outlet port of Honiara, which is situated at the extreme western end of the plains. One major road serves the plains area and increasing volumes of traffic have necessitated tar sealing of its surface. Coconut plantations are found in coastal regions throughout the islands, and projects are under way to rear cattle under trees in both coconut and forest areas.

ENERGY

The island of Vella Lavella in the New Georgia Group of the Western Solomons has a geothermal field which has potential as an energy source (Figure 1). Investigation of the field is under way and, if the

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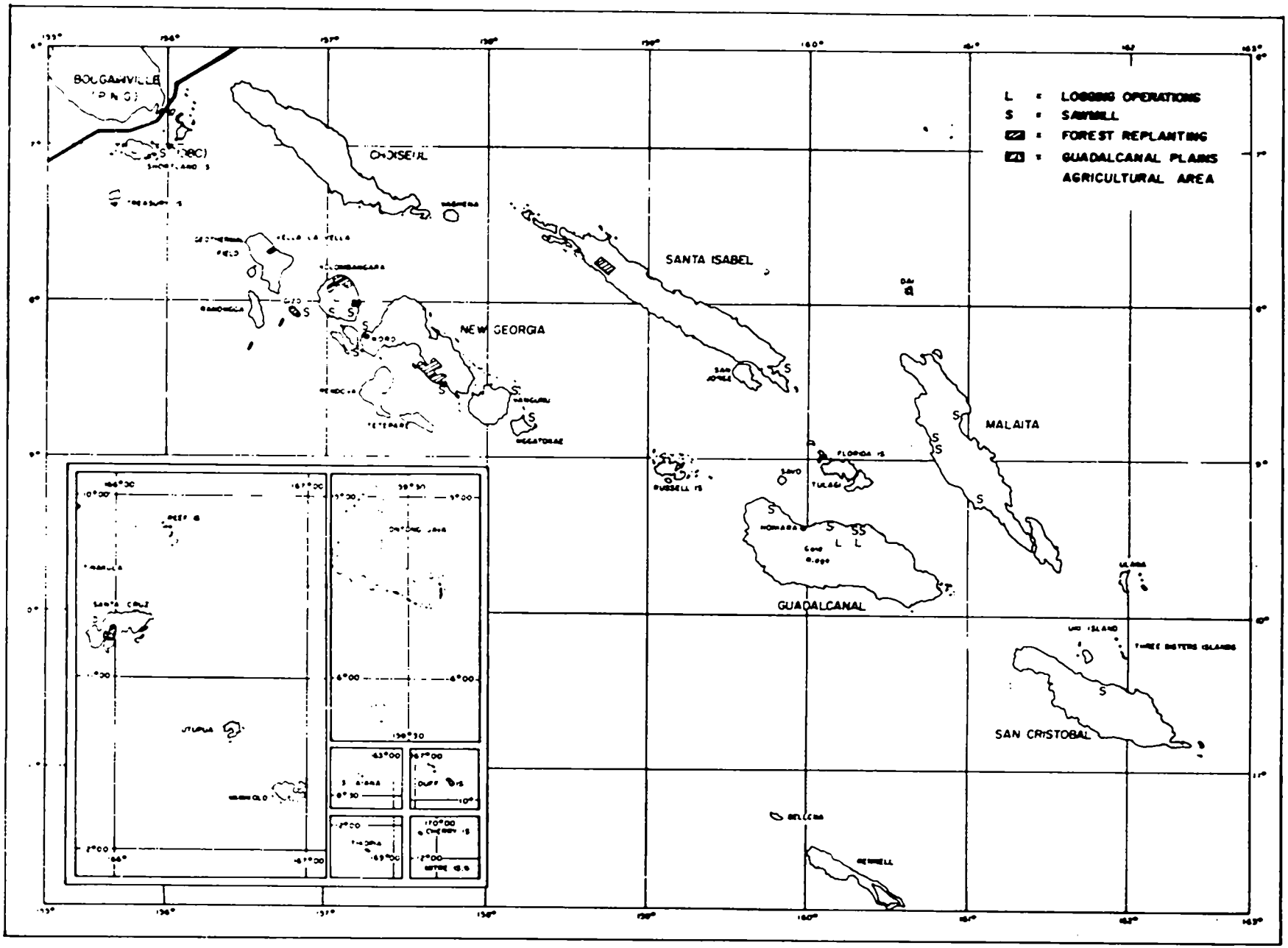

FIGURE 1. Solomon Islands: major coastal area developments

ACKNOWLEDGMENTS

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A COASTAL LAND DEVELOPMENT PROJECT

—Tip Ruangchotivit*

HISTORICAL BACKGROUND

In 1970, a team of economists and agronomists was sent by the Land Development Department to gather facts and figures on coastal land use, vacant land, and ways and means for development in seven provinces along the Gulf of Siam. From ground surveys and field interviews, the team determined that vast areas of coastal land were not utilized or were economically underutilized. This poor utilization was due to lack of technical know-how, funds and, especially, to well-trained extension workers.

At the same time, it was determined that research on agriculture, fisheries, and mangrove forests had been undertaken by different departments, and that the results were scattered and unused. For example, research on agriculture in saline soil had been carried out for many years and, although a large sum of money had been spent, no positive results had yet been confirmed. No central organization existed where the results of all fields of research on the coastal area were assembled and applied.

Finally, a fundless, isolated project on coastal development was established with a few personnel in the Land Policy Division. The project leader spent almost a year studying ways and means to bring vacant coastal land into economic use. By 1976, it was determined that more than 28 species of fruit trees and vegetables could be grown in saline soil. Other activities were shown to have potential high income, such as shrimp farming and animal husbandry. Then a group of researchers consisting of economists, agronomists, and agricultural engineers found a mutual interest in coastal area development. As more research was accomplished, the group began writing an overall coastal development plan for submission to the National Economic and Social Development Board (NESDB) and the government for approval. At the same time, this group prepared to establish a permanent office to execute the plan after approval. Thus on August 31, 1977, the Office of Coastal Land Development was approved and recognized by the National Cabinet and also endorsed by the National Social and Economic Plan (1977 to 1981). The Office started its operations with four staff members.

OBJECTIVES

The main objective of the Office is the full utilization of coastal land to create income and employment among the people who live in these areas. If this development project is well planned and successfully implemented, migration of the population from rural to urban areas may be reduced. In this manner, money that would have been spent on slum clearance, housing projects,

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an improved bus system, schools, and energy and water supply would be saved. Also, within the next four years, Thailand will experience a serious shortage of suitable land for agriculture, and the development of coastal land may reduce the impact of this shortage in the short-term.

Many countries are now extending their marine jurisdiction to 200 nm. Thailand will thus lose fishing grounds in a marine area of approximately 600,000 km^2. Unemployment of fishermen will result. The rising price of fuel is also contributing to unemployment among fishermen, especially artisanal fishermen. The costs of operation are increasing with the increase in the price of oil, and the profit is dwindling to a point where government attention will become necessary. A possible solution to this problem is the provision of new occupations in the coastal area. This will bring new hope and new opportunities to the unemployed fishermen. At present, the total acreage of coastal land and its potential are unknown. The coastal land surveys will provide the information from which the master plan can be drawn.

PROJECT AREAS

The project will cover the entire sea coast of 25 provinces; 19 on the Gulf of Siam and 6 on the Andaman Sea. The total area to be surveyed is approximately twelve million rais or six million acres.

STAGES OF DEVELOPMENT

The Survey Stage

To determine the potential of each province, surveys must be carried out in the following fields: sociology, economics, ecology, soil science, water resources, land tenure, land capabilities and physical land use.

Planning Stage

The compilation of data from the field surveys in each province will be accomplished within three years. Following the completion of field surveys and data processing, the development plan will be drawn. The finished plan will be presented to the Coastal Land Development Committee for final decisions and approval. The Committee, usually appointed by the Cabinet, will consist of director-level officers from the following specialized departments: Land Development, Fisheries, Forestry, Animal Husbandry, Cooperatives, Budget, and the NESDB.

The Implementation Stage

At this stage all 25 provinces will be grouped into six zones for the sake of simplicity in administering the project. Each zone will comprise four to five provinces. Zone I will include four provinces on the east coast--Trat, Chantaburi, Chonburi, and Rayong--with a project office for Coastal Land Development in Chantaburi. Zone II will cover the four provinces in the middle part of Thailand--Chachengsao, Samut-Prakarn, Bangkok, and Samut-Sakorn--with an office in Samut-Sakorn. Zone III covers the four provinces immediately south of Bangkok--Rajburi, Samut-Songkram, Petchaburi, and Prachurb--with an office in Petchaburi. Zone IV covers the four provinces in southern Thailand--Chumporn, Surattani, Nakorn Srithamarat, and Pattalung--with an office in Surattani. Zone V covers the five provinces on the Andaman Sea--Ranong, Pangna, Krabee, Phuket, and Trang. The project office will be in Phuket province. Zone VI covers the four southernmost provinces in Thailand--Songkla, Pattani, Stul, and Narathivat. The project office will be in Songkla.

As soon as the surveys and planning are completed, the implementation stage will follow immediately. In particular, programs for Zones I to IV will be implemented at the beginning of fiscal year 1980 (October 1980), as the surveys and planning conducted by the Institute of Scientific and Technological Research are expected to be completed in June 1980.

ESTABLISHMENT OF A TECHNOLOGICAL RESEARCH CENTER FOR COASTAL LAND DEVELOPMENT AND MANAGEMENT IN THAILAND

– Office of Coastal Land Development (OOCLD)*

BACKGROUND INFORMATION AND PROJECT JUSTIFICATION

Coastal Land and Rural People

About 35 percent of the total land area of Thailand is coastal land. This coastal land comprises 1.6 million ha in 25 provinces along the Gulf of Thailand and the Andaman Sea. Of this total area, only 10 percent has been utilized for, e.g., crop cultivation, fisheries, shrimp/salt farming, forestry, industrial estates, recreation, harbors and harborage; 90 percent is unused.

Although the resource potential in coastal regions tends to be higher than in other parts of Thailand, these resources are wasted and poorly used, ultimately contributing to an increase in rural poverty. Such problems arise from four main factors.

1. Rural people are mostly engaged and experienced in agriculture. In recent years costs of production have been significantly increased and rural people have been unable to make profits at their occupations. The growth rate of agricultural business is less than 5 percent per annum, causing substantial rural to urban migration and career changing.

2. Rural people not only lack funds for investment but also lack technological know-how. Therefore they are unable to modify primitive practices and tools for more efficient applications.

3. The administrative structure of most government institutions is highly centralized. There is also functional duplication and inadequate coordination among government agencies, reflecting inadequate planning, implementation, and monitoring capacity for both development projects and general supporting services.

4. Rural people have not received clear technological recommendations from government officials. Appropriate technology research and technology extension projects have rarely been carried out due either to a lack of experienced officials in such work or to a lack of funds.

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Government Policy

The fourth National Economic and Social Development Plan, 1977-81, stated that "several basic policy reforms are considered necessary for promoting greater economic security for the nation and creating a more equitable economic and social order which would mean an eventual eradication of poverty among large segments of the population." National development objectives in the Plan include accelerated economic growth, reduced income disparities, reduced population growth, expanded employment, improved management of natural resources, greater national cohesion and expanded decentralization of development management.

In order to achieve these objectives, the Office of Coastal Land Development (OOCLD) has designed decentralized systems of integrated development in coastal provinces with the initial effort focused on improving production technologies, implementation, and marketing.

DETAILS OF THE PROJECT

Program goals are to:

- Improve the living conditions of the poorer sectors of the coastal population by increasing and stabilizing local family income and providing minimal social services in coastal poor sectors;
- Develop extensive use of local materials, energy sources and capabilities;
- Raise the rural population's level of technical competence in order to familiarize coastal farmers with improved cultivation methods, machineries, and irrigation and drainage technologies; and
- Assist the government in its program to decentralize planning and implementation activities, and accelerate rural development.

Project objectives are to:

- Provide the guidance for overall management of coastal land development;
- Strengthen environmental and socioeconomic controls over coastal land;
- Increase production through mechanization;
- Recommend and assist on transferring technical know-how to the coastal poor; and
- Accelerate development and promotion of appropriate technology for coastal occupations such as coastal agribusiness.

Anticipated End-of-Project Status

It is expected that at the end of the project, a regional research center will be a component of each zonal office for coastal land development. Each center will consist of a laboratory, plant nursery, machinery shop, and data base system. A schematic diagram of each zonal office for coastal land development is shown in Figure 1.

The laboratory will provide qualitative and quantitative analysis for soil-plant-water systems, production of mineral resources, and pollution control. The nursery will provide experiments for seed production, plant growth, and coastal aquaculture. The machinery shop will work to mechanize agriculture by developing and manufacturing motor-driven pumps for irrigation and drainage.

A data base system will provide services in processing economic and agricultural statistical data. Data will be organized into suitable record segments and sets of relationships for planning development in the coastal areas.

As a unit of operational research, the center will organize research activities focused on multiple coastal area use and forward the results to a committee which will be responsible for making decisions on planning policy and development that will meet the basic needs of low-income groups in rural areas. In addition, the rural population in coastal areas will be able to conveniently obtain assistance on the development of their technical skills for their business operations.

It is expected that the number of rural people in coastal provinces who use this

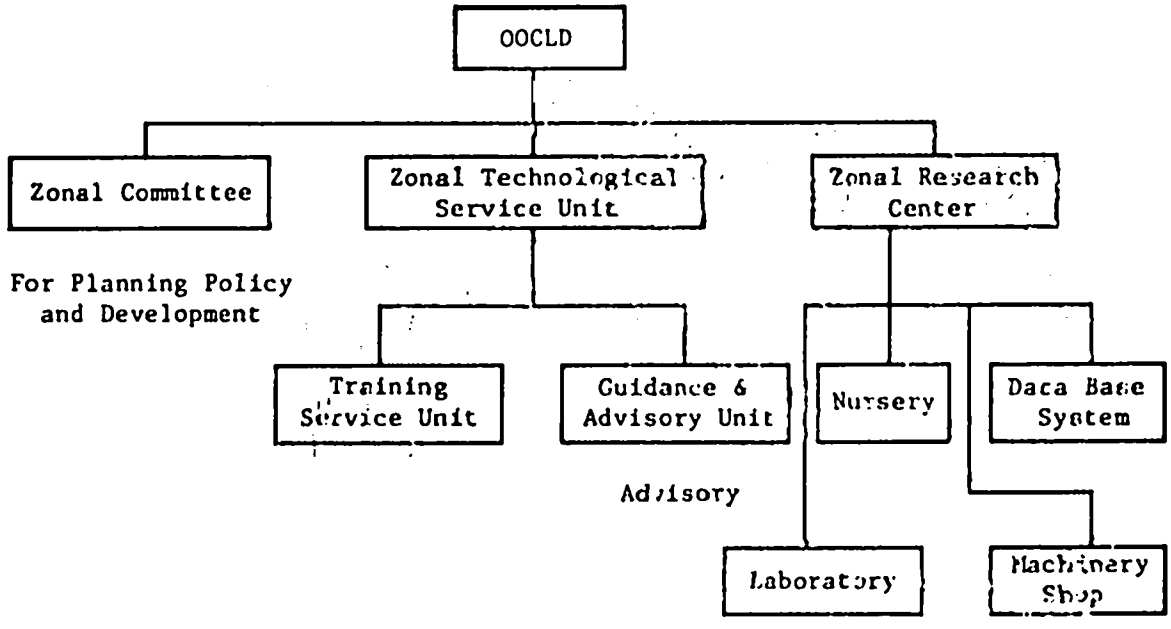


FIGURE 1. Organization of zonal office for coastal land development

center will increase because of its value and convenience for technical training and multipurpose advisory services.

Project Work Plan and Activities

Building Construction

For each zonal research center, buildings must be constructed with space for offices, training halls, laboratories, nurseries, and shops well equipped with essential equipment, tools and facilities for scientific and technological experiments.

Research Training and Activities

A search for research officers will be undertaken, and training programs for research staff by requested experts will be implemented. Research activities and services will be carried out in a way that develop links between agricultural and nonagricultural sectors so that growth in these sectors will become mutually reinforcing.

The center will collect and process relevant information on farm commodities, estate and plantation-scale farming and biological, technological and socio-economic aspects of various stages of development from preinvestment to post harvest, through its research activities and from other sources. This information will serve as the basis for advice given to various interested parties and investors in coastal agribusiness. The center will also store information on agrisupport measures such as fertilizers, insecticides, costs and prices, infrastructure, and legal and institutional relationships.

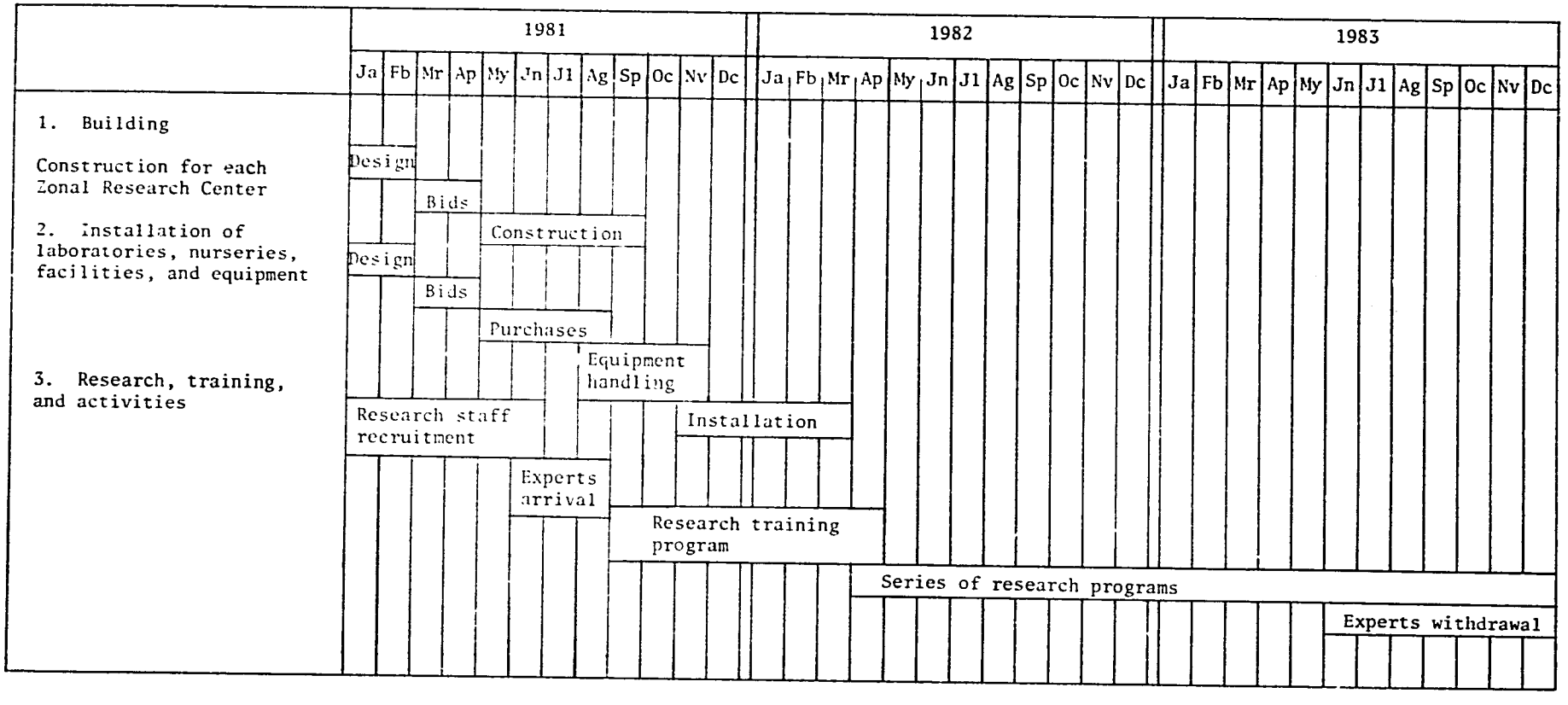
The center will conduct research on its own initiative based on identified opportunities and problems. The center will also respond to requests for research by business parties or will conduct joint research with other institutions. Such research would focus on preinvestment, prefeasibility, and feasibility surveys and on various development policy studies with particular emphasis on coastal agribusiness and rural development.

Finally, in its efforts to accelerate coastal agribusiness development, the center will also cooperate with the Zonal Technological Service Unit in conducting technical training and managerial courses, in performing adaptive tests and demonstration plots, and in encouraging various socioeconomic development programs.

INSTITUTIONAL FRAMEWORK AND LAND USE CHARACTERISTICS AND PROBLEMS

The Office of Coastal Land Development is the component of the Land Development Department that will carry out the Coastal Land Development Project. Structurally

TABLE 1. Schedule of project activities



the Office consists of two sectors--central and provincial. The central sector is responsible for general administration, including planning policy, communication, and coordination with other government agencies relating to coastal land development and the rural sector. The provincial sector implements socioeconomic coastal land classification, conservation of coastal resources, land management, and development.

Areas under provincial administration are divided into six zones and the utilized lands in these areas are classified as agricultural land, forest, nonagricultural activities, and grassland (marsh and swamp). Agricultural lands include those used for horticultural crops, perennial crops, field crops, and rice paddies. Horticultural crops include all types of vegetables grown in minor plantations in the limited low-lying areas between rice fields. Perennial crops are scattered through the region and include mixed orchard, coconut, rubber tree, banana tree, and sugar palm. Field crops include cassava, sugar cane, castor bean, and sorghum. Paddies are situated in former tidal flats and in more inland areas whereas forest is found in mountainous areas and in tidal lands.

Important nonagricultural land use includes salt production in salt evaporating beds or "pans," fish-shrimp culture in ponds, inland fisheries, and tin mining. The salt farming and shrimp-fish farming operations are commonly located next to each other, and sometimes a farmer will shift from one type of use to the other. Usually, these salt farms and shrimp ponds are operated only during the dry cycle extending from November/December through April.

Tin mining is the main industry in the southern coastal provinces. The productivity of the industry is relatively high. Historically, tin production in Thailand rose from about 4,000 tons per year around the year 1900 to 30,000 tons per year at present. However, it appears most of the richer and more accessible land deposits have been or are being exploited.

The number and range of occupations in coastal provinces are limited due to four main problems: shortage of water supply, water pollution, poor operational techniques, and lack of investment funds. About 78 percent of salt-fish-shrimp farms have experienced shortages of fresh seawater supply and inability to retain water in the farms. In addition to the annual variability of water quality, cyclic intrusion of seawater results in salt-affected soils.

The main contributors to water pollution at present are believed to be turbidity from tin mining and effluents from rubber and cassava processing factories, and other industries. In addition, effluents from palm oil processing are a potential pollution threat as is the increasing use of fertilizers, herbicides, and pesticides.

Lack of technical know-how is a major problem in the coastal area. For example, shrimp farmers still use primitive farming techniques for production. Most farms use shrimp larvae naturally present in seawater drawn to the farms, not from hatcheries. Also, the shrimp in some farms are not fed with supplementary food. Another example is the abandonment of croplands by many farmers because of salt-affected and water-logged soils. In order to increase production rates, farmers must buy essential inputs such as fertilizer, insecticide, tools, machines, fuel, and repairs. But, in general, these items are so expensive that they cannot be purchased.

PROJECT STAGES

The Coastal Land Development Project will be carried out in three stages in each zone. Stage 1 will consist of a land classification survey designed to divide the zones into regions suitable for agricultural management, mangrove forest reservation, industrial estates, and recreation. In addition, a socio-economic survey will also be undertaken to identify Project beneficiaries and to generate baseline data for the monitoring and evaluation activities. Stage 2 will focus on the development of a land map for utilization and advisory services. Stage 3 will be the establishment of the technological research center for coastal land development. The first two stages of this Project will be undertaken by the Institute of National Applied Scientific Research under contract to OOCLD, whereas the last stage will be carried out by OOCLD itself.

TABLE 2. Staff/personnel participating in project implementation

Numbers: In Each Center	Numbers: Total	Qualifications	Role
1	6	M.S. (Systems Engineer)	Project managers to carry out systems analysis of multiobjective or conflicting uses.
2	12	M.S. (Computer Science)	Programers and operators for data base systems.
2	12	B.S. (Economics)	Economists to analyze farm economics, marketing problems and funding.
2	12	B.S. (Agricultural Engineering)	Engineers to implement farm mechanization and agricultural design and drainage control projects focusing on waterlogging, salinity and pollution problems.
1	6	B.S. (General Science)	Technologists to undertake field experiments and laboratory analyses.
1	6	B.S. (Soils Science)	Technologists to undertake field experiments and laboratory analyses.
1	6	B.S. (Agronomics)	Technologists to undertake field and greenhouse experiments relating to crop protection, plant breeding and seed.
1	6	B.S. (Animal Science)	Technologists to undertake farm experiments relating to animal breeding.
1	6	B.S. (Marine Science)	Technologists to undertake aquaculture experiments.
3	18	Certificate in Agricultural Engineering	Technicians for agricultural mechanics' shops.
10	60	Certificate in Applied Science	Technicians for laboratories, nurseries and field work.
8	18	Certificate in Secretarial Skills and Typing	Typists and secretaries.

TABLE 3. Assistance requested

Field	Total		1981		1982		1983	
	No.	m/m	No.	m/m	No.	m/m	No.	m/m
1. Project Manager	6	144	6	36	(6)	72	(6)	36
2. Economics	6	144	6	36	(6)	72	(6)	36
3. Agricultural Engineering	6	144	6	36	(6)	72	(6)	36
TOTAL	18	432	18	108	-	216	-	108

EXPERTISE, EQUIPMENT, AND FACILITIES REQUIRED FOR THE PROJECT

There is a need for a project manager in each zonal center to train and supervise Thai counterparts in the establishment of research programs for multiobjective utility and development. Systems engineering has the appropriate methodology and applications for addressing conflicting uses and reaching optimum adjustments.

Because Thai researchers dealing with these problems are in general not familiar with such techniques, their research is focused on sectoral problems rather than on aspects of sectoral integration. Hence the results are nearly inapplicable to rural conditions and socioeconomic development.

Experts in economics are needed to train and supervise Thai counterparts in the promotion of opportunities for present and future agribusiness. Experts in agricultural engineering are needed to train and supervise Thai counterparts in the development and promotion of appropriate technology for farm mechanization, irrigation and drainage systems and to raise the rural population's level of technical competence.

The project manager will manage development research focused principally on the use of alternative renewable sources of energy and better use of agricultural raw and waste materials, improvement of living conditions, creation of jobs, and increasing of productivity in coastal poor sectors.

The economists will research aspects of coastal agribusiness, particularly purchase, processing, storage, and marketing of agricultural products. Such research will involve collection and compilation of economic and agricultural data for planning development in coastal poor areas.

The agricultural engineering experts will analyze and estimate the demand for tools and very simple power tools and will plan and implement research on the development, adaptation, transfer, and propagation of appropriate technology on environmental protection and on agricultural technology such as irrigation and cultivation techniques.

Before agricultural technologies can be improved, the nature of the soil-plant-water systems and the productivity of natural resources must be analyzed. Laboratory work with the requested equipment is an indispensable part of such analysis. For instance, a spectro-flame-photometer is necessary for mineral and nutrient analysis, whereas Kjeldahl kits are required for sample digestion and distillation.

Because each coastal research center must work with complex problems in agricultural production, agribusiness, and agricultural technologies, alternative development models have to be formulated. For systems analysis, data programing and processing, a minicomputer is necessary.

Both the laboratory and the nursery are structural components of the coastal research centers. Their function is to provide working space for analysis of agricultural raw and waste materials and for feasibility studies of production, environmental protection, and irrigation control. As such, the structures are indispensable to the research effort. The OOCLD yearly budget is inadequate for new construction; therefore, funds from other sources are necessary.

TABLE 4. Equipment required

Description of Equipment Items	No. Requested	Unit Price (US $)	Total Cost (US $)	1981 (US $)	1982 (US $)	1983 (US $)
1. Spectroflame Photometer	2	10,000	20,000	10,000	10,000	-
2. Kjeldahl Kits	4	2,000	8,000	4,000	4,000	-
3. Minicomputer	1	10,000	10,000	10,000	-	-

TABLE 5. Facilities required

Item Requested	Total Cost (US $)	1981	1982	1983
1. Laboratory Construction Cost	100,000	100,000		
2. Nursery Construction Cost	50,000	50,000		

TABLE 6. Thai government counterpart contribution to the project

Component	Total Budget US $ Million	Government		Colombo Plan		Total
		Amt.	%	Amt.	%	%
1. Experts	0.432	-	-	0.432	15.94	15.94
2. Salary of Staff	0.324	0.324	11.96	-	-	11.96
3. Labor	0.054	0.054	1.99	-	-	1.99
4. Construction	0.35	0.20	7.38	0.15	5.54	12.92
5. Equipment	1.280	0.60	22.14	0.68	25.09	47.23
6. Miscellaneous	0.270	0.27	9.96	-	-	9.96
TOTAL	2.71	1.45	53.44	1.262	46.57	100.00

FUTURE PLANS

Plans for the future include a continuation of development research in the fields of shrimp-fish production, animal breeding, and plant production related to coastal agribusiness in rural poor sectors. Also considered relevant are planning and execution of projects to promote seed multiplication, seed production, and evaluation of cultivation potential for coastal lands, support for forest management and erosion control, research on animal breeding and cattle raising in coastal inlands, operational research on coastal and inland fisheries, and research on integrated promotion of coastal agrimarkets and market organization in rural poor sectors.

VIETNAM: BRIEF COMMENTS

— Dao Duy Chu and
Le Thac Xinh*

The workshop was informed that no single institute was in charge of the development and management of coastal regions in Vietnam, although a number of institutes and ministry research units were carrying out activities in that area. It was noted that Vietnam had a large coastal area and was rich in hard mineral deposits as well as energy resources and recreational sites. Hydrocarbons were of particular importance to the economy and in this context development of auxiliary service and training facilities was being undertaken.

It was felt that on the national level, a state institution for coastal zone development and management should be organized with objectives to include utilization of idle land, coastal erosion and hazard protection, and development of agriculture and fisheries. The first step should be the organization of a national workshop to exchange information and ideas and to determine further steps.

Regarding coastal area development and management on the regional and international level, it was suggested that a specific item focusing on Southeast Asia be incorporated into the CCOP program. It was also suggested that more workshops be organized and focused on specific subjects relating to coastal area management and development such as mining and petroleum exploration, ecosystems, fisheries and protection from oil spills and pollution in Southeast Asian seas. More United Nations-sponsored training courses on these subjects were requested.

*Dao Duy Chu is with the Department of Oil and Gas, and Le Thac Xinh is with the General Department of Geology in Hanoi, Vietnam.

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COASTAL AREA MANAGEMENT IN WESTERN SAMOA

—C. A. Y. Hewson,
F. Malele, and
P. D. Muller*

GEOGRAPHY OF WESTERN SAMOA

The independent State of Western Samoa consists of two major islands, Upolu (1,075 km^2) and Savaii (1,825 km^2), and eight small adjacent islets. Western Samoa lies between 171° 20'/172° 50'W longitude and 13° 20'/14° 10'S latitude. It is part of the 500-km long Samoan archipelago, the other five islands being the Territory of American Samoa. Upolu is narrow and elliptical in outline (77 km by 27 km) with a rugged chain of volcanic cones rising to 1,091 m forming the crestal ridge. Savaii Island (78 km by 45 km) consists of broad coalescing domes topped by numerous cones, the highest of which rises to over 1,818 m. The climate is tropical with two distinct seasons, a wet summer and a drier winter. Temperature ranges are slight, both daily and seasonally, with the mean daily temperature remaining at about 80°F. Although Samoa lies outside the normal track of hurricanes, occasional severe storms are experienced. The drier parts of the country receive an annual rainfall of 210 to 250 cm, the wetter parts more than 500 cm on Upolu, and more than 625 cm on Savaii.

Savaii and Upolu have a well-developed road system focused on the capital of Apia, the only city and main harbor, situated on the north coast of central Upolu. On Savaii, Asau is the main town and export harbor for timber products. Physical communication between the two islands is by ferry which runs from Mulifanua (Upolu) and Salelologa (Savaii), and local airlines which service Apia via Faleolo (the International Airport) on Upolu, and Salelologa and Asau on Savaii.

The 1976 indigenous Polynesian population of 151,982 was divided geographically between 109,764 living on Upolu and 42,218 on Savaii. Most villages are located on the coastal strip and plantations of coconuts, cocoa, taro, bananas, coffee and other crops extend up the slopes of the high volcanic cone-studded, central ridges. Away from the cultivated coastal strip, the islands are covered with moderately dense tropical forest.

The industries are few in number and mostly agriculturally based. The greatest number of people are employed on plantations. The chief exports in 1979 were copra (16,643 tons), cocoa (1,473 tons), bananas (34,343 cases), and timber (1,602,727 super feet).

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*C.A.Y. Hewson is Superintendent of the Apia Observatory; F. Malele is with the Apia Observatory; P.D. Muller is a UNDP/OTC Hydrologist attached to the Apia Observatory, Apia, Western Samoa.

EXISTING COASTAL FEATURES

The major ports are Apia on Upolu and Asau on Savaii. The present port of Apia was constructed in 1964. The port is located inside a gap in the island's fringing coral reef, which is maintained by the freshwater flow from the Vaisigano River. The harbor is open to the north, thus leaving the port area unprotected from weather from that direction; all shipments must leave the port prior to the onset of severe storms.

During the hurricane season (December to March), surges are frequently experienced by ships when berthed alongside the wharf. This phenomenon is a result of the lack of shelter from the adjoining reef when the wind and swell are from the northwest, and changes in the underwater contours created by the reclamation of areas to the east and west of the port. As one direct result of these phenomena, tourist ships no longer call at Apia at the height of the southern hemisphere tourist season, and cargo ships are held up and sometimes have to bypass Apia.

Asau Harbor is the main timber export port from which small interisland vessels carry timber to other Pacific countries. However, the existing harbor facilities are too small and need to be upgraded to facilitate the handling of larger ships, if the timber export industry and the island of Savaii are to be developed. The long-shore current in the area is a major hazard for shipping and this current, together with the hard rocky nature of the present dredged channel, retards efforts to upgrade the port facilities. Formerly, Asau Harbor had a natural channel. However, because of coral heads within the channel, a new shorter channel was blasted and dredged when the harbor was first developed in the mid-1960s. The hardness of the rock and the long-shore current were not taken into consideration in this decision.

LEGAL FRAMEWORK FOR COASTAL AREA USE AND MANAGEMENT

An exclusive economic zone was created by the Exclusive Economic Zone Act of 1977. This is "an act to establish an exclusive economic zone of Western Samoa adjacent to the territorial sea, and in the exercise of the sovereign rights of Western Samoa to make provision for the exploration and exploitation, and conservation and management, of the resources of the zone, and for matters connected with these purposes."

The Head of State under the advice of Cabinet may, from time to time, make regulations for the following purposes:

- To regulate the conduct of scientific research within the exclusive economic zone;
- To prescribe measures for the protection and preservation of the marine environment of the zone;
- To regulate the construction, operation and use of artificial islands (whether permanent or temporary) and of other installations and structures within the zone; and
- To regulate the exploration and exploitation of the zone for the production of energy from the water, currents, and winds and for any other economic purposes.

The Exclusive Economic Zone Act of 1977 is administered by the Department of Agriculture, Forest and Fisheries, and the Agriculture, Forest and Fisheries Ordinance of 1959 is applicable to the zone.

COASTAL USE CONFLICTS

Present significant coastal uses and their geographic locations include Apia, Aleipata, Asau, Salelologa, and Mulifanua wharfs; the proposed Salamumu-Matautu Seawave Energy Project; lagoonal and near-shore fishing; manganese and precious coral prospecting; lagoonal and near-shore black sand and coral-fill mining; and land reclamation near populated centers.

Plans are being made for the future development of all the harbors listed. For example, the port of Apia is to be resited at Vaiusu Bay, the channel at Asau may be resited, and redredging and upgrading of the interisland wharfs at Aleipata, Salelologa and Mulifanua are envisioned. The present dredging of coral sand for roadfill and building material at Vaiusu Bay is dredging out an area of the proposed new port which will have to be refilled. The development of Vaiusu Bay will interrupt the tidal seawater

flow to mangrove swamps which are the breeding ground for fish, the staple diet of a large proportion of the Upolu population. The mining of black beach sand for construction purposes has caused serious foreshore erosion. Although this practice has been stopped, future development pressure could result in its resumption. Dredging of coral fill material is causing changes in the lagoonal currents and ecology.

OPTIMAL DEVELOPMENT AND MANAGEMENT OF COASTAL RESOURCES

While there is an existing framework within the newly formed Ministry of Transport for the development of harbor facilities, the comprehensive management of Western Samoa's coastal environment and resources may have to await the formation of a department of natural resources. In the meantime, plans and planners should consider all impacts of new harbor development, e.g., the physical impact on currents, thus avoiding the recurrence of Apia's surge problem, ecological impact on marine life within the reef, and population shifts and resultant requirements such as housing and sewerage and their effect on the coastal environment.

In summary, any new harbor improvement or coastal development should be planned not just as an engineering project, but as a project that embraces industry, town planning and social aspects. Any such development would have associated with it marine industries such as small shipways or dry-dock facilities with marine engineering facilities. We would envisage that the construction costs could be offset by these small industries. Also, mining operations should be undertaken with regard for their environmental impacts and the recharge of the resource. The legal framework exists and needs to be applied.

IV. GENERAL INFORMATION PAPERS

POLICY ISSUES FOR COASTAL AREA DEVELOPMENT/ MANAGEMENT: LEGISLATION, AGENCIES, PROGRAMS

—Robert W. Knecht*

INTRODUCTION

The objective of this paper is to explain the Coastal Zone Management (CZM) program as it has developed in the United States and to indicate how some of the lessons learned in that program might be applicable to coastal development problems in this region. These observations, based on the author's experience as Director of the U.S. CZM program since it began seven years ago, will be directed principally at three points:

1. What is CZM and how does it work?
2. What arguments can be used when discussing the desirability of implementing a CZM program with a national government?
3. What are the major problems that have complicated implementation of the CZM program in the United States?

WHAT IS CZM AND HOW DOES IT WORK?

Some papers have emphasized technical aspects of coastal management whereas the following observations pertain almost exclusively to such nontechnical issues as problem definition, policy formulation, public participation, options for implementation, and laws and regulations. In this section, I will discuss the coastal problems that gave rise to the CZM program in the United States, the principal characteristics of the U.S. program, and its current status, and the steps undertaken in the development of the coastal management program.

Problems Giving Rise to the CZM Program in the United States

The late 1950s and early 1960s saw increasing concern in the United States with regard to pollution of the nation's estuaries, shellfish beds, and coastal waters. By the mid-60s, for instance, one-fifth of the nation's shellfish beds were closed due to pollution. Similarly, more than one-third of the coastal wetlands of the country had been "reclaimed" by dredge and fill operations, destroying their important contribution to the biological productivity of the estuaries. On the development side, needed coastal development often faced nearly endless delays as major disagreements on use of the coast moved from court to court. Such coastal development as did occur, often in connection with second-home vacation needs, saw people locating in low-lying

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coastal areas and on barrier islands, greatly increasing the risk of a large hurricane-related disaster.

In addition to these conflicts in use, a second kind of conflict was emerging--this involved a conflict in decision making. In the United States, the decisions of all three levels of government--local, state, and national--often can have important implications on the use and conservation of coastal land and water. Local authorities typically have zoning and planning powers, and thus the most comprehensive role with regard to land and water use in the coastal zone. State governments exercise control over air and water pollution and thus have an important impact on the location of major facilities or developments and the extent to which important natural systems such as wetlands are modified. State governments also have jurisdiction over the resources of the three-mile territorial sea. Finally, the national government controls the resources of the Outer Continental Shelf (beyond the three-mile territorial sea) and, as well, numerous federal programs affect many aspects of the development of the coastal zone itself. For example, the location of federal interstate highways, federal grants for the water and sewer treatment plants, federal guarantees for home mortgages, and the Federal Flood Insurance Program all have a direct and immediate impact on coastal development patterns.

Approach Taken

After receiving a report containing recommendations for a national CZM program in January of 1969, the U.S. Congress debated the matter for about three years. The debate centered around the desirability of a program concentrating only on the coastal areas of the nation versus one that dealt with land-use problems comprehensively throughout the entire geography of the United States. In October of 1972, the Congress decided on and enacted the Coastal Zone Management Act of 1972. To date, Congress has yet to enact the comprehensive national land-use program.

The Coastal Zone Management Act called for a program that was voluntary in nature with the leadership at the state level of government. Federal incentives (funding) were provided to encourage and assist states in developing and implementing comprehensive coastal management programs that would provide a policy and procedural framework for local, state, and national decisions affecting coastal resources. The resulting state CZM programs were to be balanced, that is, they were to be concerned with protecting the sensitive natural areas of the shoreline (beaches, dunes, wetlands), but also with accommodating coastal facilities needed to meet requirements that were more than local in nature.

In addition to the financial incentives provided in the Act (financial grants for both program development and implementation), the Act contained an important "federal consistency" provision which also was seen as an important incentive to coastal states. Under this provision, once the states had completed and implemented a coastal management program, actions by the national government (except those involving national security) were to be consistent with the policies of the state coastal program.

States were promised up to four years of financial assistance to develop a coastal management program. Thereafter, federal financial assistance was limited to aiding those states whose coastal program had met the requirements of the CZM Act and who had put their programs into operation.

Current Status

All 35 eligible coastal entities (22 ocean coastal states, 8 Great Lakes states, and 5 territories) applied for program development grants and initiated a CZM effort. To date, 19 states and territories have had their CZM programs approved by the federal government and are now receiving financial aid for operating those programs. It is expected that six to eight additional states and territories will receive federal program approval and implementation funding during the next twelve months.

Currently, the national CZM program within the United States is undergoing a period of evaluation and scrutiny because the initial legislation expires in 1979, and Congress is now considering

extending the lifetime of the program. As part of this consideration, both the administration and the legislative branch are undertaking a fairly extensive review of the achievements of the CZM programs of the various states up to the present time. While substantial differences of opinion exist with regard to the relative effectiveness of the CZM in the United States, most interests seem to want the program to continue. Environmentalists would prefer to see a more protectionist approach taken, and energy and development interests, of course, would like to see the program facilitate coastal development. Nonetheless, all seem to agree that the program is moving in the right direction and, in balance, is aiding in the more rational development and conservation of the coastal zones of this country.

President Carter, in an environmental message in August of 1979, recommended that the legislation authorizing the CZM program be extended for an additional five years but that, in the process, more definitive coastal policy goals be written into the law and program. The coastal policy goals he recommended are as follows:

- Protect significant natural resources such as wetlands, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife;
- Manage coastal development to minimize loss of life and property from floods, erosion, saltwater intrusion, and subsidence;
- Provide predictable siting processes for major defense, energy, recreation, and transportation facilities;
- Increase public access to the coast for recreation purposes;
- Preserve and restore historic, cultural and aesthetic coastal resources; and
- Coordinate and simplify government decision making to ensure proper and expedited management of the coastal zone.

ELEMENTS OF CZM

CZM Goal

The overall goal of CZM is to obtain maximum long-term benefits from coastal resources. The key to the achievement of this goal is the recognition of the "inter-connectedness" of most coastal uses, and hence the planning and management of the coastal zone in as comprehensive a fashion as possible. Another way to state the CZM goal would be as follows:

> The development of a management system permitting conscious and informed choices among development alternatives.

Principal Elements of CZM

CZM has three principal elements: problem definition, policy formulation, and implementation.

Problem Definition

Obviously, to be successful, a CZM program must address the real coastal problems of a region. Hence, the initial task is to define the coastal problems that exist or are expected to exist in the future in a particular region or coastal jurisdiction.

- What are the coastal problems and opportunities of a region?
- What issues should a coastal management program address?

Clearly, there is a need to tailor the CZM programs to fit the particular situation. There is no cut-and-dried CZM program to fit all situations. However, most CZM programs will be designed to address the following kinds of problems:

Substantive--erosion, coastal flooding, development of offshore oil and minerals, lack of recreational access and facilities, low level of economic development, need for fisheries development.

Institutional/Legal--lack of long-range plans, lack of governmental authority, lack of

appropriate laws and regulations, lack of adequate enforcement.

Technical--lack of data or information on resource potential, lack of adequate know-how, lack of trained people.

Economic--lack of funds to conduct studies to develop plans, etc.

Certain types of coastal systems have common problems. Clearly, defining the problem or problems that a coastal management program is to address is a fundamentally important first step. In a generic and rather general sense, the problem will often be defined as follows:

> How can we bring about increased economic development of our coastal resources without jeopardizing the economic activities that depend upon biological productivity (fisheries), and physical attractiveness (tourism)?

In many coastal regions, the goal is to maximize the long-term economic return from three sectors simultaneously--fisheries, tourism, and industrial development. The extent to which this is possible will depend upon the potential for each sector (the resource base, the market, and other factors), the impacts of the development of one sector on the well-being of another, and a number of other factors. Developing the right mix in terms of development emphasis is, therefore, a crucially important element of CZM.

Policy Formulation

The second important element in CZM involves the development of a policy framework to guide private and public decisions with respect to the use and conservation of coastal zone resources. Obviously, the policy framework will closely parallel the problems delineated above. This policy framework will generally involve determining the development potential of various resources, determining the impacts (environmental, social, economic) of such development, determining the costs and benefits of development alternatives, and ultimately, determining the setting of priorities between development alternatives, and agreement on safeguards to reduce adverse impacts of preferred development.

Typically, three kinds of policies seem to be needed in the typical coastal area:

- Policies related to coastal development;
- Policies related to marine resource development; and
- Policies related to natural systems protection.

The kinds of individual policies and issues that will usually need to be dealt with under each major policy area are outlined below.

Coastal Development (Shoreland and Nearshore)

Natural hazards policies (coastal flooding, typhoon, tsunami, tide action, erosion)

Tourism (hotel siting policy, public facilities, aesthetic policies)

Industrial siting (ports and harbors, aquaculture, water dependency policies)

Marine Resource Development

Fisheries development

Offshore petroleum development

Hard minerals development

Ocean energy sources (OTEC, etc.)

Natural Systems Protection

Wetlands

Coral reefs

Lagoons, estuaries, shellfish beds

Beaches, dunes

In addition to policies for development and protection, often policies are also needed to deal with

improved intergovernmental coordination. Such policies would encourage, facilitate, and streamline permit processes and other governmental procedures in order to ensure that fragmented decision making of various levels of government does not frustrate the achievement of coastal policy goals.

To be effective, coastal policy should be as specific and as concrete as possible. It should provide a clear statement of what the future should hold for various portions of the region's shoreline and coastal waters. It should provide clear-cut information to all concerned as to what kinds of development will be approved, on what basis, and in what locations. It should also indicate clearly what areas of the coastal zone are "off limits" for developments of various kinds.

Implementation Approaches

The final element in CZM relates, of course, to implementation of these policies. How can we enforce them? How do we make them stick? How do we achieve the policy goals we have developed to address the coastal problems we have delimited?

In general, the different implementation approaches listed below will be used in connection with each of the three sets of policies: protection, development, and improved governmental coordination.

Implementation of Protected Policies

Laws, regulations, and permits

Development of guidelines and standards for coastal development near sensitive natural systems

Tax policies giving relief for nondevelopment in sensitive area

National government financial and technical help (leading to improved development policies, nonpolluting facilities, etc.)

Implementation of Development Policies

Laws and regulations regarding hazardous areas (e.g., building prohibition in flood or tsunami zones)

Laws and regulations regarding setback lines to deal with eroding areas

Laws and regulations regarding preservation of scenic views

Technical assistance regarding aesthetics and design

Laws and regulations giving priority to water dependent uses of the shoreline

Infrastructure funding policies of government which guide development into certain areas and/or away from other areas

Taxing policies (e.g., which disallow writing off certain losses in hazardous areas)

Laws and regulations regarding the siting of major facilities (e.g., regarding discharges, appearance, public access)

Licensing and leasing schemes for shoreland and water areas for resource extraction purposes (e.g., oil, sand, and gravel)

Government support (loans, guarantees, grants) for needed shoreside support facilities (e.g., fish processing facilities, storage, harbor improvements)

ROLE OF NATIONAL GOVERNMENTS IN CZM DEVELOPMENT

The national government role typically has three aspects to it:

1. to provide general policy direction;
2. to provide technical and financial assistance to local jurisdictions; and
3. to provide implementation help (often shared with local authorities).

In a typical situation, the national government would encourage a coastal area (either a governmental jurisdiction or a natural coastal unit) to develop a coastal management program. The national government would be expected to provide general policy direction, technical assistance and, if possible, financial help to the local authority to assist in the planning and program development phase. In due course, the local and national government would agree on a final plan which meets both local and national needs in terms of coastal development and protection. Furthermore, these entities would agree to use both local and federal authorities (in the legal sense) to achieve the policy goals agreed upon in the coastal plan. They might also agree on dividing the costs of implementing and operating such a coastal program.

In conclusion, I should like to address two final points: How do you convince your national government that coastal zone management will be beneficial to your situation? And, what are the principal problems in making a CZM program work?

Convincing Your National Government of the Merit of CZM

The following five points would be useful in discussing the merits of CZM with a national government:

1. Emphasizing the development aspects of coastal management is a positive approach. Hence, the terminology "coastal area development" or "coastal resources development" are far preferable to "coastal zone management."

2. The "balanced" nature of the coastal management approach should be emphasized. The emphasis in the program also should be on management, that is, the prudent use and development of resources, and not on preservation per se. Of course, protection of sensitive coastal areas is a key objective of CZM.

3. Determine early who is potentially opposed to CZM and develop arguments particularly aimed at that sector.

   - Energy and industrial interests can be convinced that CZM will facilitate rational development and increase the predictability of the coastal situation.

   - Local authorities should realize that they can increase their impact on national government coastal policies through a partnership involving local CZM programs.

   - Rival governmental agencies should be incorporated into the CZM planning process early on and made partners in the program.

4. Clearly, one needs to argue the logic and reasonableness of rational coastal planning and management and obtain a maximum number of allies for this point of view.

5. Governments about to embark upon the planning for new 200-mile exclusive economic zones should easily understand that this work should be based on a foundation of rational coastal planning and management.

Some of the Problems in Making CZM Work

Based on the U.S. experience, several kinds of problems occur in the CZM programs.

Initially, it was difficult to convince the federal government to provide adequate funding to get the program started on a proper basis. Similarly, a sustained effort has been needed to keep enough funding available during a 4- to 5-year period so that adequately comprehensive CZM programs could be developed.

Another problem has to do with data and information. Clearly, the right information must be available at the right time if well-founded CZM programs are to be created and implemented. Certain kinds of information are needed as input into the policy formulation phase. Different kinds of information are needed later when laws and detailed regulations are developed to implement these policies. It is fundamentally important that data

and information collection programs produce the right kind of information at the right time in the program development process.

Surprisingly enough, one problem has to do with the kinds of issues that CZM programs sometimes try to avoid. Unless the work is carefully supervised, planners and others connected with the development of the CZM programs sometimes, understandably, try to avoid the hard coastal problems of a region, preferring to put them off to a later day. The benefits of coastal management will be lost unless the real and urgent problems of the region are faced honestly and openly.

Unless public support and understanding exists for the coastal management program, the long-term goals of such an effort will not be achieved. Successful CZM requires a long period of public education and awareness. This educational activity must continue throughout the lifetime of the effort.

CONCLUSION

This paper has reviewed the "essence" of coastal zone management, at least as it has developed in the United States. There has been an attempt to dissect CZM into its principal elements and to discuss how each would relate to the situation typically found in this region. The coastal management approach has much to offer to coastal nations of Southeast Asia as they begin serious development of their coastal resources.

SUMMARY OF DISCUSSION ON POLICY ISSUES FOR COASTAL AREA DEVELOPMENT/MANAGEMENT: LEGISLATION, AGENCIES, PROGRAMS

A question was raised as to the role of economic and budget aspects in the planning process being discussed in this Workshop. It was recognized that although the process being discussed was that of management of the natural environment after decisions on development projects had been made, fiscal matters and economic and social trade-offs were indeed an important part of the coastal area use planning process.

In response to a question regarding definition of the boundaries of the coastal area, and thus the relationship of inland environmental protection policy and water quality control to coastal area management, it was noted that coordination of various national programs is usually a problem because of overlapping and conflicting agency jurisdictions. However, it was also noted that in the United States, water quality control laws had been incorporated into the coastal zone management programs as minimum standards with exceptions for special areas requiring higher standards. Whereas it was recognized that the definition of the coastal area will vary between and within countries depending on physical geography, specific types of activities, and planning objectives, it was considered that a general working definition, e.g., "coastal area," might include those areas on land and in the water which are sites of activities affecting the coastal area proper.

The degree of detail contained in United States' state CZM programs was elaborated. The example used was the broad range of objectives and policies contained in the CZM program developed by the island of Guam. Furthermore, it was indicated that state CZM programs typically set specific policy goals and directions for important geographic areas of their coastal zones.

In elaborating the need for policies to protect the important natural systems of the coastal area (e.g., coral reefs, wetlands, beaches, and dunes), the importance of focusing on the economic value of these protection policies was stressed. The example used was the once very beautiful lagoon in front of Guam's best tourist beach that is now filled with unsightly green algae due to neglect of the natural system, coupled with inadequate pollution controls. Other examples served to illustrate the concept that by modifying the development proposal slightly (e.g., moving a hotel site back behind the front row of dunes), or by adopting more environmentally sensitive techniques (e.g., laying oil pipelines in a wetland so as not to modify the circulation of the water), it was possible to have both a new development project and retain the natural systems in functioning order.

Several questions focused on the method of determining appropriate management strategies. It was suggested that the

actions taken should try to capitalize on the natural processes and not alter them. Where beach erosion is a problem, for example, a solution that uses sand instead of introducing foreign materials such as rock is preferred unless a crisis situation is present. If mining of the beach is required due to lack of other sources of sand, one should mine where there is excess sand or where the sand can be replaced, and in such a way that erosion will not be accelerated. The plant life in the dunes should be preserved since they act as sediment traps.

The topic of regulations on setback distance was discussed in detail. It was recognized that regulations should be designed with an understanding of the historical record on erosion. All pertinent data should be collected and reviewed. In this connection, it was felt that mathematical models such as those describing flushing phenomenon were important but did not provide guidance for beach erosion. An empirical approach on a site-by-site basis was considered more appropriate and useful.

The discussion then turned to the relationship between a state CZM program and environmental impact statements (EISs). It was indicated that in the United States, an EIS was required in connection with the national government's approval of a state CZM program. For convenience, these documents are typically combined into a single volume, as in the case of Guam. Whereas individual EISs were still required on specific projects even after the state CZM program was fully approved and implemented, it was noted that EISs on projects that were consistent with the state's CZM program could be considerably shorter and were likely to be less controversial as well.

The discussion then focused on the need for generating public support for CZM if it is to succeed over the long term. The meeting noted the difficulty of doing this in countries where jobs, economic development, and improvements in living standards are the highest priority. However, it was recognized that good coastal management makes good economic sense as well, and that this message, in hard economic terms and with examples, must be communicated to the interested officials and the public. For example, protected wetlands and mangroves have been shown to mean more fish and, hence, more money to the fishing industry. Also, unspoiled beaches and clean coastal water means more tourist dollars. It was noted that Coastal Zone Management does not mean no use of the coastal zone--but prudent use in order to maximize benefits over the long term.

In connection with this agenda item, several additional documents* were referred to or made available to the meeting, viz.:

Coastal Zone Management (CZM)

1. Educational report on CZM by League of Women Voters.

2. Excerpts from the Guam CZM program document (policies only).

3. Coastal Mapping Handbook (general information and techniques for mapping the coastal zone).

4. "Our Nation's Wetlands" (an educational document dealing with the value of wetlands).

5. "The Coastal Zone Development Dilemma of Islands" (an article by E. Towle).

6. Guam CZM Program (the full program document).

7. Rules and Regulations of the U.S. CZM program.

8. Natural Hazard Management in Coastal areas (issued by U.S. Department of Commerce, Office of Coastal Zone Management).

Onshore Impacts of Offshore Oil

1. Educational report on onshore impacts of oil by League of Women Voters.

2. "The Shetlanders Accept the Challenge" (a report of how these remote islands in northern Scotland faced the onshore impacts of offshore oil).

*Additional copies are available from the Office of Coastal Zone Management, NOAA, 3300 Whitehaven St., Wash., D.C. 20235.

APPLICATION OF INFORMATION AND DATA TO COASTAL DEVELOPMENT AND MANAGEMENT

—Ronald B. Linsky*

Civilizations have been associated with coastal margins of the world since time immemorial. However, it is only in recent decades that man has categorized and organized this part of his environment causing what appears to be a sudden awakening to the significance of this thin strip where land and sea merge at the shoreline.

The coastal area complex, an extremely important resource in Southeast Asia because of the archipelagic nations and extensive national coastlines, includes the coastal waters, the continental shelf, adjacent shorelands, and water bodies influenced by and in proximity to the shoreline. These coastal areas are recognized as the most productive ecological units in the world in terms of biomass (the amount of extant living matter) and are also one of the most desirable areas for human habitation. Inevitable conflicts will continue to arise in this area because of the competing uses for its resources, including space.

Worldwide coastal areas can be classified according to their geomorphology or biological characteristics, e.g., mangroves, sandy beach, lagoon, rocky shore, embayment, delta, or estuary. These are all familiar classifications. Today, however, the term coastal area or coastal zone is commonly used to imply that what was formerly the simple shoreline area is now a complex system frought with interactions that are difficult to comprehend. What at one time was the province of biologists and geologists has now become the territory of the socioeconomists, politicians, and lawyers.

With these changing perspectives has come a redefinition of the area now depicted as extending several kilometers landward and seaward of the shoreline itself. With this expanded view of the area have come new requirements for data and information. Of equal significance has been the problem of defining the coastal area in management terms, of determining if such an area is manageable, and, if so, what the management unit should be. All these considerations and more have been the focus of coastal management programs around the world.

Coastal management involves the ability to make decisions based on the best available information regarding resource allocations. These decisions are data and information dependent and require the input of scientists, planners, and administrators. Although not particularly a new concept, the integration of these perspectives into a systems approach to decision making is new. This is not an easy task as one can see by reviewing the many attempts throughout the world in coastal management activities. Some have been successful

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while others have failed. Sometimes failure resulted when the popularity of coastal area management demanded administrative action before adequate descriptions of baseline conditions were determined. In many instances, it was determined that indeed a knowledge of basic natural laws as well as principles of socioeconomics are prerequisites for coastal management.

Coastal planning suggests a wide range of questions requiring scientific and technical information and data. Development activity anywhere in the coastal area, offshore or onshore, is a potential source of stress to the coastal environment. There are many critical natural components to this environment: fringing wetlands, estuarine bottoms, shellfish beds, coral reefs, mangroves that provide important habitats for coastal species including nesting and breeding areas. For purposes of planning and development, each such area should be analyzed and designated for protection or limited use. In addition, the basic environmental processes such as water circulation, nutrient input, and sunlight penetration of the water column must also be considered.

In general, the paucity of systematically collected information and data regarding either resources or the actual and potential modifications upon those resources hinder the ability of institutions to implement environmental policies. There is not only a need for better data and information but for applied research on specific environments and factors regarding their modification potentials. Modification potentials are also referred to as impacts. However, the term impact has a negative connotation and does not correctly express what some consider as environmental enhancement. The marine environment can absorb considerable modifications without causing negative impacts. For example, in some highly developed coastal areas, the only source of nutrients for the nearshore marine environment is the adjacent urban discharges that emanate from primary or secondary sewerage treatment facilities. Data regarding fish populations in such areas indicate a very abundant and viable population.

The amount of damage that may result from any disturbance depends on the characteristics and vulnerabilities of the specific ecosystem; this is where the expertise of the natural scientist is so vitally needed. To use the term pollution, one must be able to define the term damage, for that is what pollution should mean. Unfortunately, the term has come to mean practically anything found in the ocean or coastal waters that is normally not found there even though it may not be detrimental to the ecosystem or physical integrity of the environment. If the scientist can define damage, then he must also have some way of measuring damage to human or marine life or aesthetics. Therefore, it is most important that coastal areas have some baseline information and data program established simultaneously with the planning process. It is unfortunate that these types of information and data are sorely lacking from the majority of coastal areas of the world.

Potential environmental problems from production activities at sea are of three general types: alteration of the shape of the seafloor, interference with other users of the area, and disturbance of marine ecosystems.

Dredging, for instance, may change the shape of the seabed sufficiently to alter local wave and current patterns. This could lead to changes in coastal erosion or deposition and could cause destruction of beaches, siltation of harbors, removal of offshore banks, and disruption of longshore and transport systems Experience in Europe and elsewhere has shown that mining operations can be hazardous to other marine activities or emplacements, causing collisions in shipping channels, disturbance of navigational buoys or anchorages, and cutting or displacement of buried cables or pipelines.

The potential impact of marine mining on ecosystems is one of the least known areas of environmental concern and one of the most difficult to assess. For the most part, effects are secondary and due to some alteration in the existing physical, chemical, or trophic equilibrium. Impacts on the coast tend to be more significant than those on the outer continental shelf because of the higher physical and biological energy levels found there and because of the proximity of the coast to population centers. Physical changes that may induce biological effects include variations in temperature, current patterns, amount of suspended

particulates, nature of the seafloor and substrate, light penetration and photosynthesis, and the introduction of new habitats. Significant chemical changes may occur through the introduction of nutrients, trace elements, or toxics. Possible changes include selective removal of, or influence on, existing species by their involvement in the operation.

Criteria by which to judge pollution or significant environmental change are often arbitrary and, where given, may err on the side of safety, based mostly on the assumption that no change is the preferred state. This assumption is open to argument, and much more data are required before generalizations can be made--if, in fact, they ever can be made for such a varied and dynamic environment. Effects of operations on living marine resources can be judged beneficial, insignificant, or adverse. To date, some beneficial effects have been recorded or discussed, such as the attraction of fish to offshore structures, the enhancement of substrate habitats and biomass productivity by alteration of the texture of the seabed, the enhancement of substrate habitats due to introduction of new nutrients through mixing and replacement of the seabed material, thermal stimulation of plant and animal growth, introduction of nutrients by mixing of water masses, and enhancement of phytoplankton growth through an increase in turbidity in ultraclear waters.

The list of potentially adverse effects is much longer. For example, the direct effects of pollutants on individual organisms include abnormal growth, decreased productivity, behavioral changes, accumulation effects in the trophic chain, restriction of motor functions, erosion of gill filaments, suffocation by burial, retardation of metabolic efficiency in filter-feeding animals, pressure shock, embolism, and thermal shock. Changes in diversity and abundance and other secondary effects on the community and ecosystem structures may be caused by disruption of food webs, changes in predator-prey relationships, reduced community stability in response to environmental fluctuations, changes in age structure of populations by selective mortality, changes in dynamic behavioral patterns, concentration of toxic fractions through food chain transfers, loss of bottom habitat, provision of new habitat, migration of population, and introduction of dormant species from bottom to surface waters.

Analyses of the potential impacts require a knowledge of the undisturbed populations and their natural cycles so that changes can be predicted, verified, and controlled. At the present time there is little agreement within the scientific community about what constitutes an adequate knowledge of preoperating conditions or baselines. Difficulties arise in the selection of indicator species that will adequately represent the biotic community and its reaction to the disturbances. The idea of measuring baselines is still so new that the effect on local biological communities of long-term regional cycles, for which there are no data, may be overlooked or unsuspected. Conversely, the effect of local impacts on regional or global communities may be underestimated or overestimated with no change of immediate verification of disproof.

From the foregoing considerations, it can be generally concluded that potential disturbances from marine offshore operations are dependent on both the methodology of the operation and the environmental conditions of the area. Apart from some broad guidelines, conclusions on potential impacts should be operation- and site-specific. Most physical and chemical changes can be measured, but assessment of the effects of biological perturbations requires intensive and long-term study.[1]

Planners and scientists should concurrently participate in the process of planning for coastal area development. Whether making recommendations or passively reviewing the documents generated by nonscientists, the role of a scientist is not an easy one. The ecological consequences of coastal development are so complex and so imperfectly understood that it is often extremely difficult to formulate specific development standards for protection of natural environments and conservation of resources. Scientific research has provided a general awareness of the values of natural systems and of the effects that development can have on these values. Coastal areas can have either or both a natural and economic value placed upon them.

A natural value is determined after a substantial study accurately quantifies

an area's resources and their relative abundance. For example, after intensive study, if a particular coastal estuarine environment facing potential modification is known to serve as a nursery for a particular coastal fishery, the area will gain a certain natural value. If the estuary is also the habitat of a rare species, its natural value will increase.

The monetary economic value of an estuary can be derived from the estimated value of its harvestable shellfish or fish and other economic species. Nonmonetary values may be derived from, e.g., the number of people deriving recreational value from the estuary or the innate aesthetic qualities of the estuary.

Once the value of the environment has been measured, the next step is to estimate how the values may change under the influence of future development activity. If a potential offshore fishery has been estimated to be worth so many millions of dollars, what will be the value impact if offshore hydrocarbon production or hard mineral mining is undertaken? Will one operation reduce the economic value of the fishery resource significantly? Will the hydrocarbon exploration and potential recovery have a greater economic value than the fishery and will there be more socioeconomic benefits to people? A country should be able to determine these kinds of answers in order to understand the relative value and costs of managing coastal environments.

In the absence of standards, analysis of area-specific scientific data for natural systems may be necessary for each planning program in order to determine the range of environment modification potentials. Guiding principles such as "protect wetlands" or "preserve water quality" are meaningless terms unless translated into specific decision-making strategies. Although scientists can state the optimum conditions for the maintenance of an ecosystem, with few exceptions they are not able to determine what constitutes socially acceptable or unacceptable levels of resource protection. Scientists can establish criteria upon which decision making can proceed, but they are not qualified as scientists to make those decisions.

The special role of science in coastal planning can be uncomfortable for a scientist. The role does not involve basic research with which many scientists are familiar, but information transfer, including data interpretation, prediction, and consultative services, a role which many, if not most, scientists scorn.[2] Planners do not necessarily need new research results but often require more application of what scientists already know to the problems of planning and management. The collection of raw data is the beginning of the process of planning and management, but if nothing is done with the data, it is of little help to the planning process.

Without knowledge of the environmental baseline conditions, prediction of how a project will interact with natural and socioeconomic systems is exceedingly difficult. In general, the commodity of time is the most critical element in securing information and data prior to the decision-making process. For coastal area development, the period between planning and implementation is usually not adequate to gather sufficient baseline data and information. Nevertheless, data and information collection must be undertaken in order to provide decision makers the opportunity to gain some insight, even though limited, into the environmental modification potentials of a project. In the final analysis, piecemeal data and information collection without an overall planning strategy are not adequate for coastal area planning purposes. Regional or national schemes, on the other hand, are longer in duration and can provide a synoptic view of conditions, trends, and potentials.

The second most critical problem is cost. The cost of the information collection and research necessary to conduct a thorough analysis related to a particular project may well be greater than the potential costs of the adverse impacts identified.[3] It is advantageous in certain circumstances to undertake a comparison of the costs of impact analysis with the anticipated societal costs of the adverse impacts. Obviously, the costs of data and information collection related to the project are justified if they are less than the costs of the socio-environmental impacts. It might be prudent for the technical and professional staff to make an estimate prior to undertaking projects that appear beforehand to meet this criterion.

Historically, coastal marine data and information have been accumulated by the standard practice of marine surveys. It has also been standard practice as a part of the survey to list all the species collected; in some cases with 4,500 or more species, the skill of a highly trained taxonomist is required for identification. Generally, there are substantial numbers of a few species and one apiece of the rare kinds. The result of each survey station is a species list of Latin names several pages long. No person or computer, to my knowledge, makes very effective use of such a list at present. Because the list does not characterize the environment in terms of, e.g., trophic levels or population densities, the value of such data is doubtful at best to those whose responsibility it is to interpret and make recommendations in the coastal planning and development process. And the costs involved in obtaining such information increase and thus become more prohibitive with time.

As an alternative to the lengthy and expensive marine survey, the technique of the Infaunal Trophic Index (ITI) developed by Dr. Jack Q. Word of the Southern California Coastal Water Research Project (SCCWRP) might be considered.[4] The ITI utilizes a simple number, from 0-100, to describe the mix of feeding strategies of the animals on, in, and above the bottom. The high values represent regions where animals feed on suspended material in the water, the intermediate values represent animals feeding on the surface of the bottom, and low values indicate the areas where the animals feed on subsurface materials. The ITI indicates the condition of the benthic animals.

The virtues of the ITI are numerous. Each sample can be assigned a value in a few hours, replicates are not required, and all species in a sample need not be identified. In addition, equal results can be obtained by different biologists using a wide variety of equipment. Old data can often be compared with new data, and the results can be readily plotted on a chart. The ITI method greatly reduces the effort that must be made at any one station, thus permitting many more stations to be covered with the same effort. Complex reports, involving long lists of organisms and complicated analyses, can be replaced with simple numbers on a synoptic chart.

As another alternative, it might be appropriate to consider a regional approach strategy that will distribute the cost among those entities in the public and private sectors responsible for planning, implementing, and monitoring a particular project. As an example, a joint effort may be formed between all interested parties to collect data and information common to all parties. Such a joint effort would dilute the cost burden to any single party and provide a mechanism for cost sharing the collection process. The result would be cost savings in ship time, equipment, and manpower.

When one considers that the fisheries of Asia are a major and highly productive source of protein for the region's residents and that the annual consumption of fish in Southeast Asia is two to four times the world average, the maintenance of this resource takes on more significance in relation to the region's further development.[5]

The productivity of nearshore fisheries has been threatened in many countries by overexploitation and environmental impacts of sewerage, chemical wastes, and siltation. Fishermen continue to use outmoded technology which limits them to intensive fishing in shallow coastal waters. In addition to overfishing, coral reef environments, which are essential for the maintenance of coral reef fisheries, are being destroyed by fishermen using not only dynamite but toxic chemicals as well. For example, a recent survey in the Philippines indicated that more than three quarters of the country's coral reef resources have been heavily damaged by such practices.

Some offshore fisheries, on the other hand, have not yet been exploited nor fully utilized in Southeast Asia because of a lack of technology and equipment. This potentially important resource could be adversely affected by offshore exploration for petroleum and hard minerals. It is imperative, therefore, that natural and economic values of offshore fisheries be seriously considered as a major management problem in coastal area development. These problems are not problems of one sector, but indeed are multisectoral. If all parties involved with fisheries

problems, both directly and indirectly, could coordinate their information and data requirements, the problems of information cost could be reduced.

A coastal environment consists of fundamental natural processes and systems. Only when these processes are deciphered can management data and information requirements be formulated. A starting point as well as a primary focus for comprehensive understanding of coastal environments is an understanding of the physical processes; all other systems are contingent upon these processes. Physical processes important to coastal systems include waves, tides, currents, temperatures, density, pressure, mixing, light and light transmission, and wind. Atmospheric conditions produce large effects in the coastal area through wind, rain, and storms. The wind-driven currents and waves are an ever present factor modulating the other systems. Hurricanes are effective agents of change, especially when large storms are associated with high tides in the coastal area.

Biological systems, today often referred to as ecosystems, have a fundamental quality of balance of "ecolibrium" among their components. An understanding of the interactions of these components is a most important step in gaining insight into the dynamics of an ecosystem. Examples of some of the information required to gain this understanding would be species types and frequencies, seasonal migrants and permanent residents, relative positions in the food web (trophic levels), and physical location of the organism (i.e., on the bottom, sub-bottom, in mid-water, at the surface).

Water chemistry of the coastal area is the most complex of all major aquatic systems. It is here that the fresh water of the rivers mixes with the saline water of the sea yielding a range of chemical concentrations and chemical reactions. Also, waters of different coastal environments such as mangrove swamps, marshes, or urban areas have different chemical characteristics. Over time, urban coastal waters have become very different than nonurban waters and are often characterized by the organic and chemical wastes from urban runoff or effluent disposal. These various source pathways can be predicted with sufficient data over time. Coastal waters, because of their proximity to sources of natural and man-made nutrients, are high in organic productivity, especially planktonic species.

The chemical structure of coastal sea is dependent upon the importance of various sources such as rivers, local surface runoff, ground water seepage, rain, wind-borne materials, and coastal upwelling from deep nutrient rich oceanic waters.

Coastal geologic systems can be considered to be in a short-term state of dynamic equilibrium; changes in one part of the system will cause an imbalance in another, requiring a new state of balance to be achieved. Nowhere has this been demonstrated more dramatically than in a coastal area which is undergoing beach or foreshore alterations. In many locations, the improper placement of groynes constructed for beach protection have caused major damage. These structures were emplaced without the benefit of a fundamental understanding of simple shore processes such as littoral drift.

Natural systems are not independent but are indeed interdependent. For example, consider the town of Hikkaduwa on the southwest coast of Sri Lanka where the mining of the coral reefs for building materials has gone on for decades. The subsequent loss of beach from direct wave action has been estimated at 300 m over 50 years with a net dollar loss of over US $3 million. This cost might have been avoided with a simple and fundamental knowledge of the significance of reefs to shoreline protection.

With this brief background of physical, geological, and biological systems, it becomes obvious that a thorough review of the available information concerning the marine and terrestrial environments must be made at a very early stage in coastal planning. Following this review, a survey should be undertaken to define the coastal area within a more regional context. After conducting a comparative analysis, the resultant data and information gaps will indicate what kinds of research and surveys should be undertaken to supplement available information and data.

Generally speaking, coastal and offshore planning focuses upon a group of activities, but each activity requires specific information and data regarding its

potential impact on the environment and natural systems. The identification of information gaps will require an interaction of engineers, scientists, and planners. A research program must be established to acquire the data and information required for determining the environmental modification potential of the project. Surveys will be required to delineate the resources in question. Applied research will have priority even though a well-thought out plan of research will have definite basic research components. In some countries where the knowledge base may be small, such research will assist later coastal and offshore development projects. An initial, careful, and thorough analysis of the area will save time, money, and effort during later implementation phases.

Significant elements which must not be overlooked are the requirements for trained manpower and data and information processing facilities. Generally speaking, these are limited in many countries and therefore reasonable expectation factors for analysis should be applied to any program.

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NATURAL HAZARD MANAGEMENT IN THE COASTAL ZONE: AN OVERVIEW

—James K. Mitchell*

Natural hazards are of increasing concern to coastal managers and industrial firms engaged in offshore continental shelf (OCS) development activities.[1] For example, on July 1, 1979 an earthquake caused US $2 million in damages to petroleum loading facilities on the coast of Panama.[2] Elsewhere, special precautions have been taken to insure the safety of seafloor pipelines and cables and coastal storage tanks against seismic shocks. Massive evacuation of workers from offshore oil and gas platforms precedes the threatened arrival of hurricanes in the Gulf of Mexico, and many firms operate elaborate shutdown and evacuation plans for onshore support facilities.[3] These responses are but one part of the much larger pattern of adjustments made by coastal populations.

TYPES OF HAZARD IN COASTAL AREAS OF THE SOUTHWEST PACIFIC AND ADJACENT SEAS

The shores of Southeast Asia and the islands of the southwest Pacific are beset by a variety of serious natural hazards (Table 1). It is estimated by some sources that the region is the most naturally hazardous on earth.[4] Two major sets of processes account for this situation. As a result of its location on the circum-Pacific "ring of fire" and its associated tectonic plate convergence zones, the entire region is affected by serious earthquakes, tsunamis, volcanic eruptions, and the secondary hazards which these phenomena generate (e.g., landslides, lahars). Much of the region also lies in the path of tropical typhoons. These bring storm surges, floods and high winds to shore areas, and they trigger additional problems such as hill slope failures and serious coastal erosion. In the western Pacific the annual number of typhoons varies between 19 and 45.[5] However, without the addition of typhoon generated rains, many small low-lying Pacific islands can also experience serious droughts. Inasmuch as coastal deltas often tend to support heavy agricultural population densities, their susceptibility to riverine flooding also contributes to the natural hazard burden.

HAZARD TRENDS AND THEIR CAUSES

The creation of hazard is a direct outgrowth of society's attempts to inhabit or use areas affected by extreme natural processes. If such places remained empty or unused, no property damage or loss of human life would occur. However, hazardous areas frequently offer superior economic advantages over other locations. These may be in the form of fertile soils (e.g., volcano slopes), flat, easily irrigated or developed land (e.g., flood plains), or scenic vistas and recreational resources (e.g., steep slopes or sandy beaches). As

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TABLE 1. Selected recent natural hazard events in coastal areas of Southeast Asia and the Western Pacific

Location	Year	Event	Effects
1) Mt. Lamington,* New Guinea	1951	Volcanic eruption	3,000-5,000 dead; destruction of sugar plantations
2) Japanese coast	1959	Typhoon	4,640 dead; 537 missing
3) Bali, Indonesia	1963	Volcanic eruption	1,500 dead; 85,000 homeless; one third of agricultural land damaged
4) Vietnam	1964	Typhoons	5,000 dead in Mekong Delta
5) Luzon, Philippines	1968	Earthquakes	500 dead or injured
6) Shantung, China	1969	Coastal storm	Estimated several hundred thousand dead
7) Hong Kong	1972	Typhoon and landslides	180 dead
8) Bougainville, Solomon Islands	1975	Earthquake	US $420,000 damage to roads, villages, missions, and mining works
9) Luzon, Philippines	1976	Floods	60 dead; 630,000 homeless
10) Bali, Indonesia	1976	Earthquake	573 dead; 2,900 injured; 85,500 homeless
11) Mindanao, Philippines	1976	Earthquake/ tsunami	5,000 dead; heavy losses of houses, boats and fishing equipment
12) East Java, Indonesia	1976	Floods	136 dead
13) Lombok and Sumbawa, Indonesia	1977	Tsunami	180 dead; 3,900 homeless; US $1.4 million damage to houses, boats, and fishing equipment
14) Vietnam	1977	Typhoons	3.2 million people in need of assistance
15) Karkar, Papua New Guinea	1979	Volcanic eruption	Research volcanologists killed
16) Lombok, Indonesia	1979	Earthquake	22 dead; 100 buildings destroyed
17) Lomblein, Indonesia	1979	Tsunami	150 dead; 350 missing; many landslides

*Believed extinct.

new industries and development projects spring up in coastal areas, the attractions of shore zones increase. New paddy fields on reclaimed land and new OCS-related industrial shore facilities bring more people. These influences help to account for the striking worldwide increase in coastal populations. They also result in major growth of coastal hazard potential.

On a world scale, natural hazards are causing steadily increasing losses of life and property. Further, the number of very large disasters appears to be increasing.[6] However, the worst problems occur in poorer, developing nations.[7] This is, in part, a function of agricultural development, urbanization, and industrialization of hazard prone areas. For example, it is

estimated that approximately 21 percent of the Philippines' population and US $7.56 billion worth of its property are located in flood prone areas.[8] The greater part of these are to be found near the coast. In Singapore the figures are 15 percent and US $4.4 billion respectively, while in Fiji, approximately 9.4 percent of the population is so located.

Population growth and the accompanying tendency to occupy hazardous areas when safe locations are fully developed account for much of the increase in natural hazard costs. However, it has also been observed that--especially among the poorer and more vulnerable nations--investment in appropriate hazard protection measures has failed to keep pace with growth in potential losses. For example, Malaysia, the Philippines, and Korea spend approximately 10 percent of the value of flood losses for flood protection, whereas New Zealand, Singapore, Japan, and Australia spend between 100 and 200 percent of the value of flood losses for flood protection.[9] Sometimes a specific adjustment is simply not known by those responsible for hazard mitigation. Sometimes the knowledge, skills and technology necessary to establish or manage particular protection systems are not available in a given nation. To some extent this may be a function of the heavy costs of such undertakings as weather modification. Often, however, the failure of governments to adopt appropriate protection strategies stems from other causes such as misperception of their effectiveness, commitment to familiar "solutions," lack of enabling legislation or institutions to develop, supervise or regulate such activities, interagency competition, and many additional influences.

Since rising hazard potential is both a function of increasing occupancy of hazard areas and failure to make the best use of available adjustments, coastal management agencies which confront hazard constraints must direct their attention toward adjustments which affect both of these causes. Before discussing such specific responses, it is worthwhile to establish some general principles of coastal hazard management.

PRINCIPLES OF HAZARD MANAGEMENT IN COASTAL AREAS[10]

Mapping Hazards

If natural hazards are to be managed, the areas which they affect must be identified and delineated and the risks assessed. Thus hazard mapping forms a first stage in most management programs. Alternative ways of measuring hazard produce different types of maps. For example, a map of earthquake frequency may be quite different from one which shows earthquake intensity or damage potential. The coastal manager must be aware of the advantages and limitations of each and must select the type of map which is most useful for his purposes. Thus, if the intent is to regulate the use of earthquake prone areas that are not presently built up, frequency and intensity maps may be helpful. A damage potential map may shed more light on the problems of managing already built-up areas.

In similar fashion, there are contrasts between risk zone maps based on actual historic events (e.g., record floods or worst tsunami inundation zones), and those which describe the probability of expected future events (e.g., 100-year floods or landslide probability). Sometimes probabilities may be measured by directly projecting present trends (e.g., shoreline recessions), but the choice of hazard index will influence the size and configuration of the hazard zone, and may affect public comprehension of risk. Hence, it is easier for most people to appreciate that a specific tsunami reached a particular location than it is to realize the meaning of a probability statistic such as a "5 percent chance" of flooding. However, the coastal manager may find that historic tsunamis are imperfect guides to likely consequences of future waves because of changes in land use, coastal defenses, or the possibility that a different type of earthquake may generate a different type of event.

To be useful, hazard maps in the coastal zone must be kept up to date.[11] New information on natural processes or new types of data analyses may indicate the need to revise hazard zone delimitations. Changes in the form and use of such areas may also necessitate revisions. Thus, a map which shows flood plains before they--or the watershed of which they are a part--became urbanized is not a satisfactory management tool. Since new river basin development invariably affects hydrological characteristics, changes in flood potential must be reflected on new maps.

Accepting Appropriate Levels of Risk

Since natural hazards are an inevitable accompaniment of life on many coasts, society must decide what level of risk it is willing to accept and how much it wishes to invest in protection adjustments to offset excessive risks. This is essentially a political choice which involves balancing the benefits of hazard zone occupance against their attendant costs. If governments choose to ignore hazard mitigation as a public policy objective, individual citizens may have to make their own adjustments, and the nation as a whole may become the object of foreign disaster assistance programs sponsored by other countries. However, it needs to be remembered that so long as we continue to occupy hazard areas, no type of protection is entirely reliable. Even the best designed and operated warning networks or levee systems may fail and populations which believed they were "safe" can suffer catastrophic losses.[12]

Choosing Among Alternative Strategies

The central guidelines for coping with natural hazards are to assess the full range of possible measures and to consider the possibilities of mixing several types of adjustments rather than relying on a single response.

The range of choice includes warning systems, control and protection works, weather modification, modification of building construction practices (e.g., "floodproofing"), land use management, insurance, and disaster relief and rehabilitation. The most generally compatible combinations of adjustments include warning and floodproofing or earthquake proofing, warning and land use controls, warning and insurance, insurance and land use controls, and protection works and disaster relief and rehabilitation.

Monitoring the Changing Consequences of Protection Strategies

Many adjustments to coastal hazards are best regarded as interim measures which require periodic review to avoid creating new and more complex problems than those they were designed to solve. For example, the natural protection afforded by wide beaches can diminish when seawalls, groins and bulkheads are installed. As more people move into exposed locations, evacuation plans and routes which were designed for smaller populations may become overburdened and incapable of functioning. Habitually safe "islands" of higher ground on coastal flood plains may become heavily built up, thus sowing the seeds of ever greater disasters in the event of storm surges of a magnitude never before recorded.

Further, adoption of one type of adjustment affects the likelihood that others will also be adopted and directly or indirectly influences the level of protection which is made available to populations at risk. If, for example, a community invests heavily in engineering works to prevent tidal inundation, it is less likely to consider large scale land use controls. Conversly, if hazard insurance programs are developed, they may promote consideration of supporting land use controls.

RESPONSES TO HAZARD: A SUMMARY

Preventing Occupance of Hazard Zones

Increased occupance of hazardous areas is a major factor in the rising toll of losses. Hence, a primary function of coastal management should be to discourage occupance of exposed coasts by uses other than those which require such a location. If alternative safe sites exist for manufacturing industries, utilities or residential developments, for example, such areas should be preferred and those uses precluded from coastal zones. Conversely, fishing harbors, commercial ports, coastal aquaculture, salt farms, coastal tourism and recreation, marine parks and offshore mineral mining are examples of uses whose existence depends on their ability to utilize shore areas. They exemplify, but do not exhaust, the range of coastal uses which may require protection against natural hazards.

Coastal managers may draw on various techniques to discourage coastal occupance. Publication of information about hazards is sometimes sufficient to deter the unwary. Leaflets can be distributed, films screened, posters exhibited and school children educated about local hazard problems. Clearly visible markers indicating past flood heights or other indices of hazard can be erected. Through the medium of a land register, potential buyers of hazard

land can be contacted directly by public agencies and made aware of the dangers. Explicit recognition of hazards may be written into mortgage documents or property titles.

Beyond these measures, managers can create disincentives for coastal occupance and provide incentives for development to move elsewhere. They may lobby for enactment of outright legislative prohibitions on certain uses. All developers may be required to apply for permits to build on coastal sites. These may be granted only after potential users meet appropriate criteria for hazard mitigation. Variable property taxation rates can be used to penalize hazard zone users and to provide revenue for public mitigation programs. Perhaps most important, public agencies can exert a strong influence on the future course of urban growth by approving the construction of infrastructure in hazard free locations (e.g., wells, water pipes, sewers, electricity, gas, telephone lines, etc.). If this incentive is employed, care must be taken not to inadvertently stimulate development in adjacent hazard zones. This can happen, for example, when utility lines cross flood plains to service developments on higher ground. Admittedly, by themselves infrastructure controls do little to affect the growth of poor, squatter settlements. These are one of the worst casualties of natural hazards. To be effective in this regard, infrastructure policies must be integrated within broad campaigns to provide adequate, low-income housing near appropriate employment on safe sites elsewhere.

Hazard Adjustments for Developed Areas

If a hazardous area is already extensively occupied, the preceding measures can do relatively little to reduce potential losses. Managers must turn to other adjustments. These can be classified into four basic groupings:

1. Measures designed to cope with the consequences of hazard losses (e.g., disaster relief or insurance);

2. Measures aimed at reducing potential losses (e.g., land use controls, prediction, or warning and evacuation programs);

3. Modifications of the natural hazard process (e.g., control and protection works); and

4. Attempts to affect the physical causes of hazard (e.g., weather modification).

Six measures within these four groupings are described below.

Disaster Relief

Disaster relief is probably the most widely practiced response to serious coastal hazards. A vast range of international, national, and local organizations stand ready to provide assistance to disaster stricken communities. It includes the United Nations Disaster Relief Office (UNDRO), the International Red Cross, the World Food Program, national emergency response groups (e.g., civil defense agencies), and the foreign disaster assistance institutions of major national governments. In addition, a wealth of private nongovernmental groups also provides relief supplies and services (e.g., OXFAM, CARE, and various churches).

Obviously, it is important to rescue the injured, feed the hungry and house the homeless. Therefore, some measure of relief will always be necessary. However, relief cannot prevent disasters and, in some cases, maladministered relief may inadvertently make them worse.[13] There is often a mismatch of relief supplies with community needs. There may be confusion in the assessment of damages and inequities in the allocation of resources. The influx of free relief goods may seriously disrupt the local economy. Donor nations may also try to exert political influence through the relief allocation system. In order to reduce the likelihood of such problems arising, coastal managers should encourage the adoption of predisaster or emergency preparedness programs; these set out procedures to be followed by public officials and private citizens prior to, during, and immediately following a major disaster.[14] They may involve training programs for emergency workers, construction of emergency operations centers, stockpiling of communications equipment, rescue vehicles and relief supplies, designation of evacuation routes, and preparation of emergency plans for closing roads and other facilities and for evacuating and housing impacted populations. In low-lying coastal areas the existence of a known and practiced

emergency preparedness plan can significantly reduce loss of life. It is estimated that if what is now known about emergency planning and other improved relief procedures were carefully and comprehensively applied throughout the globe, a 20 percent reduction in deaths and a 5 percent reduction in property losses could be achieved.[15]

Insurance

By itself, hazard insurance provides a mechanism for spreading hazard-related property losses incurred by victims among a much larger population that is potentially at risk. It has no direct effect on injuries or loss of life. Therefore, it may be useful only in substantially built-up shores containing high-value investments.

Privately sponsored hazard insurance has not been successful because only those who are exposed to extreme hazard purchase protection. Government subsidized coastal flood, erosion, and landslide insurance is offered for sale in the United States. Through this scheme, the national population provides a subsidy to coastal residents and thus premium costs are kep relatively low. However, the program is t ed directly to mandatory land use controls in communities where flood insurance is on sale. These regulations are designed to reduce new construction in the hazard zone and to prevent reoccupation of sites which have been devastated by serious floods. Such a scheme theoretically offers hope of long-term reductions in hazard losses, but it depends for success on careful monitoring of compliance and vigorous enforcement of penalties. Poorly conceived coastal hazard insurance may well attract more people to the coast and increase eventual losses.

Prediction, Warning, and Evacuation Systems

A warning system possesses several components. First, a hazard must be predicted, forecast or detected. A warning must then be issued. This message has to be transmitted via a communications system. Members of the target population must receive the message, they must interpret its meaning, and, finally, they must take appropriate protective action (e.g., evacuation). If any of these components is missing or malfunctions, the warning system may fail.[16] Nonetheless, effective warning systems probably hold the greatest potential for reducing fatalities and injuries caused by natural hazards. It is estimated that 75 percent of the global casualties and 10 percent of the damages caused by hazards could be eliminated by use of proper warning systems.[17]

Different types of hazard pose special warning problems and separate systems may be necessary for each. We still lack the capacity to predict and, therefore, to warn of some events. For example, despite recent advances in China, Japan, the United States, and the Soviet Union, earthquake prediction is far from perfected and it is doubtful that most nations are now in a position to develop effective earthquake warning programs.[18] However, earthquake prediction may become a viable prospect in the next decade. Likewise, predictions of volcanic eruptions are confined to a few well researched areas and they too are still experimental for most nations.[19] Landslide and coastal erosion predictions are also at a relatively primitive level. In contrast, there is now a high level of ability to predict, forecast and detect typhoons, tsunamis and other types of weather systems.

Nine western Pacific states now belong to the 18-member International Coordination Group for the Tsunami Warning System in the Pacific.[20] This system operates from a headquarters in Hawaii and makes use of 21 seismic stations, 51 tide gauges and 55 warning dissemination points throughout the Pacific basin. Within one to two hours after a serious underwater earthquake is detected, warnings have been sent to all participating countries. This leaves some areas vulnerable to locally generated earthquakes in adjacent waters and regional warning systems may be established in those areas. The most sophisticated systems at present are in Japan and Alaska. However, much of Southeast Asia still remains vulnerable to local tsunamis, and coastal managers should be aware that improvement of the warning system is very desirable. The Pacific Tsunami Warning System is effective in the dissemination of warnings but the affected public's failure to heed such warnings sometimes causes casualties. Therefore, additional effort needs to be devoted to educating user populations.

A similar situation exists with respect to typhoon warnings. Pacific tropical storms are usually first detected by space satellites, and this information is

transmitted to the World Meteorological Organization's (WMO) World Weather Watch system via a complex global telecommunications network. Thus there is ample warning of the existence of an approaching storm although the marginal error of predicted landfalls is still 167 to 250 km, 24 hours before the expected impact. In 1968, the United Nations Economic Commission for Asia and the Far East (ECAFE), in collaboration with WMO, initiated a joint program for mitigating typhoon damage in the western Pacific. This program continues to improve forecasting and warning capabilities. It also supports disaster preparedness planning and supplies data on potential typhoon losses to development agencies and governments.[21]

Land Use Regulation and Building Controls

Land use and building controls are effective methods of reducing property damage. It is estimated that, if soundly applied, such practices could reduce global property losses by about 20 percent and deaths by approximately 10 percent.[22] The array of possible controls is impressive although little is known about the performance of some of them (Table 2).

Zoning controls are the most widely used adjustment. Areas exposed to high risk are delimited and uses specified. For example, a flood risk zone might be barred to further construction of buildings and provisions made for the removal of those damaged by future floods. Exceptions might be made for specific structures which utilized floodproofing design features such as elevated ground floors, localization of vital equipment on upper stories, watertight doors, movable machinery and automatic utility line shut-off valves. Low density uses like parks or recreational facilities could be permitted. Some forms of agriculture might also be allowed.

TABLE 2. Land use regulations and building controls

Legal	Economic
Zoning	Taxes
Building codes	Bonding requirements
Subdivision regulations	Subsidies
Land registers	Public purchase (fee simple)
Planned unit developments	Purchase of development rights
Open space controls	Matching funds for approved land use practices
Master plans	
Setback or encroachment lines	
Access controls	
Environmental impact regulations	
Permits	
Licenses	
Scheduled development programs	
Preemption and expropriation rights	
Utilities hook-up authorizations	

In 1973, under the auspices of the United Nations Development Programme, a Regional Seismological Network was initiated among five cooperating countries in Southeast Asia (i.e., Indonesia, Malaysia, the Philippines, Thailand, and Hong Kong). Data gathered by this network may make possible seismic regionalization for construction purposes. Thus seismic building zones and earthquake resistant construction standards could be established for prospective buildings. Sample maps of flood and earthquake hazard zones have recently been developed for the Metropolitan Manila area by UNDRO.[23]

Building codes and standards are as important as zoning regulations and the two should be closely coordinated. Codes prescribe how, rather than where, a development is built. This usually involves specification of minimum standards of design construction and materials to enable the structure to withstand hazard forces. In already built-up areas, codes should apply retroactively through the application of performance standards for preexisting structures. In North America and elsewhere, the additional costs expended to bring houses and other buildings up to hazard-"proof" standards are relatively modest--perhaps adding 5 percent to total construction expenses. However, the light materials from which houses in many Asian coastal areas are constructed suggest the need for developing low cost alternatives. The United States Agency for International Development has sponsored research on improved typhoon resistant design standards and construction practices for low-rise buildings in the Philippines, Bangladesh, and Jamaica.[24]

Given the vast range of land use control choices potentially available to coastal managers, it is impossible to treat each in detail. Their benefits are clearly large, especially in terms of potential losses avoided and savings in money that might have been spent on more costly control works. Because regulations are intangible and abstract responses to hazard, they may appear less impressive than direct engineering adjustments, and they may require more diligent application of managerial skills to prevent them from being flaunted or becoming outdated by changing technology or other factors.

It has been widely observed that when disasters strike, destroyed facilities are often reconstructed on the same hazard prone sites that they previously occupied. This merely recreates the conditions for repeated, and larger, future disasters. To avoid this vicious cycle, high priority should be accorded to the early development of post-disaster recovery plans before such events occur. These should make it possible to rebuild in a more orderly manner that reduces the future loss potential.

Coastal Hazard Control and Protection Structures

Seawalls, dikes, levees, typhoon shelters, breakwaters, beach nourishment schemes, tunnels for draining crater lakes in volcanos and lava diversion barriers are representative of engineering responses to hazard. Where densely settled populations occupy hazard areas and have established high value investments, such structures may afford some protection, however at great cost. Massive coastal walls, for example, are expensive to design, build and maintain. They tend to encourage still more development of nominally protected areas. More important, they are effective, at best, only up to their design specifications. Events of an unexpected type or an unanticipated scale generally produce structural failures. Clearly, engineering protection schemes are a mixed blessing. They have an unhappy record of failure during extreme natural events. Equally, for example, they make possible the reclamation of high value land or the occupation of steep slopes in places where flat building land is scarce.

In general, the disadvantages of technological responses to hazard are in proportion to their scale. The use of small-scale technologies is thus to be preferred. Many societies make use of a number of such technologies but tend to ignore them if presented with the possibility of "solving" all problems through a few large-scale projects. Nonetheless, the traditional technologies should not be overlooked. Flood refuge mounds, emergency dikes made of local materials, vegetation screens, houses on stilts or on boats, and terraces on steep slopes are examples of relatively simple responses which are often admirably suited to local needs.

Weather and Earthquake Modification

Experimental data indicate that some

geological faults may be mobilized by the injection of fluids at depth or stabilized by the withdrawal of such fluids. This has led to speculation that it may eventually be possible to reduce the frequency of some types of earthquake or to release potentially large tectonic forces in a series of small shocks. Such techniques are now at the outer limits of practicability and they are unlikely to prove useful on a large scale in the foreseeable future. However, the prospects of modifying tropical storms are somewhat greater.

Experiments off the east coast of the United States indicate that peak hurricane wind speeds may be reduced by seeding them with ice-forming nuclei. While complete dissipation of hurricanes or typhoons is probably impossible, a significant decrease in their destructive power may be possible. Whether that is desirable through seeding is difficult to answer. Quite apart from its technical aspects, the subject of weather modification raises vast social, economic, and political issues. For example, if typhoons were reduced, would islands be deprived of necessary rainfall? Who would pay for losses if a seeded storm veered into a coastline which would not otherwise have been affected? Until the global society is better able to answer such questions, typhoon modification seems best regarded as an adjustment to hazard which has some distant, future potential for realization.

CHOICES AND PROSPECTS

It would be unwise to set forth universal prescriptions for coastal protection against natural hazards. Each area presents unique problems which necessitate different mixes of responses. Nonetheless, some general priorities can be suggested.

The most direct and immediate steps for better hazard mitigation involve improved emergency preparedness planning and superior application of traditional local adjustments. When combined with anticipatory post-disaster reconstruction planning, these measures provide a basic level of relatively inexpensive responses and they necessitate no major innovations. Thereafter, improvement of hazard warning systems will probably yield the greatest savings in lives. All components of warning systems must be involved. It is pointless to perfect prediction capabilities and leave warning dissemination or evacuation to uninformed private initiative.

Strengthening buildings will help to reduce property losses from wind storms and earthquakes. Floodproofing can also offset hazard losses. Each of these adjustments requires an investment of public funds and time for research and development of improved designs. Land use regulations are potentially the most effective tools for holding down property losses, but they are also likely to raise administrative difficulties and to stimulate policy debates about a broad range of associated community issues. Nonetheless, they should be employed wherever possible.

The remaining adjustments are best thought of as suitable for special selected use. Hazard insurance might be developed for built-up urban areas which have significant buildings in hazard zones. It seems best avoided, and is probably unworkable, in rural areas with poor, uneducated populations. Control and protection works require such heavy financial investments and may produce such undesirable ecological, aesthetic, social and other consequences that they should only be considered after other alternatives have been fully explored. Weather and earthquake modification are so experimental that coastal managers should do no more than keep a watchful eye on their development and await further information.

There is no panacea for coping with natural hazards. As inevitable products of human occupance and natural processes, they will continue to persist. Each society must choose the set of adjustments that best meets its needs. Different combinations of adjustments will involve different groups of people and will have different results. The number of alternatives is large and expanding. The scope for creative use of various mixes of adjustments remains wide.

SUMMARY OF DISCUSSION ON NATURAL HAZARD MANAGEMENT IN THE COASTAL ZONE: AN OVERVIEW

It was emphasized that natural hazards are only a problem if humans inhabit a hazardous area. Conflicts arise because hazardous areas such as volcanic soils and flood plains are attractive to settlement. In this region natural hazards cause more important direct human losses than indirect material losses, and better communications

have resulted in better reporting of losses.

Problems of hazard management were discussed in relation to examples drawn from the overlay mapping exercises. Seismic zones, landslides, flooding of coastal and riverine flood plains and forest fires were identified and analyzed. Filled coastal land was singled out as a high risk area for structures. Because earthquakes and volcanos are of general concern, it was suggested that monitoring programs should be encouraged. Participants reported that pumping of underground fluids such as gas and water can induce earthquakes and cause coastal subsidence. It was also noted that the release of volcanic gases from a drill hole had caused losses in Java.

Lack of application of basic research programs to practical needs and the high cost of seismic and volcano monitoring programs were cited as constraints to the improvement of protection against hazards. Most of the major hazards in the region were not regarded as being susceptible to modification. Insurance and regulations generally were thought to neglect the possibility of losses to onshore structures. The discussion of earthquake protection measures highlighted the use of information and education programs, modification of hazardous buildings, adoption of earthquake engineering codes, and land use controls.

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ENERGY: NONCONVENTIONAL OCEAN SOURCES

—Lawrence D. Neuman*

OCEAN ENERGY

Three primary sources of renewable energy from the ocean have been identified and are currently in different stages of development, namely, ocean thermal energy conversion (OTEC), waves, and tides. In addition, five other sources are also being investigated--offshore winds, ocean currents, marine biomass, ocean geothermal, and salinity gradients. Of these five, only offshore winds and marine biomass are capable of commercial realization before the year 2000. Concentrating on the primary sources, the basic principles will be discussed together with the potential for their applications in Southeast Asia and the Pacific.

Ocean Thermal Energy Conversion (OTEC)

The warm surface waters of tropical and subtropical regions are separated from the cold, deep ocean waters by a thin boundary, the thermocline, at a depth of 500-1,000 m. The temperature difference between these waters can be used to generate power. There is general agreement that a temperature difference of at least 17°C should be available, and both Southeast Asia and the Southwest Pacific are well endowed with this criteria.

The concept of solar sea power dates back to 1881 when a French scientist, Jacques d' Arsonval, suggested operating a closed system in which a working fluid, such as ammonia, would be vaporized by warm water and then condensed by cold water. The scheme was tested by a student of d' Arsonval, Georges Claude, in 1930 off the coast of Cuba and was briefly successful but uneconomic.

The next successful working system was installed on a barge 2 km off the coast of Hawaii and dubbed "Mini-OTEC" because of the small size of the power generated (about 50 kw of which 15 was net energy). This demonstration project underscored the conclusion that OTEC shows the most promise for the early development of commercial quantities of power.

Several options are available for open or closed cycle operation, floating or shore-based plants, and end product. The open cycle uses water instead of ammonia and can produce fresh water as a normal part of its operation. Floating plants can follow the greatest gradients and might be designed as seagoing factories producing energy intensive products such as aluminum from alumina, and ammonia, hydrogen or chemicals from seawater. Shore-based plants can be designed to use the upwelled, nutrient-rich seawater for mariculture whereas the fresh water from an open cycle plant may be particularly valuable in many islands having small water supplies.

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Recent French studies indicate that a 5 Mw plant could be built now which would be competitive with a diesel generator on a South Pacific island. Studies in the United States for a 10 Mw plant confirm this conclusion while others indicate that a 200 Mw plant would be competitive with coal or nuclear energy sources in Puerto Rico by 1985. Cost ranges were US $1,650 to $2,420 per kilowatt and US $60 to $80 million per kilowatt hour. As technology evolves and fossil fuel costs continue to rise, OTEC viability will increase. Such factors as financing, ownership, and taxation will greatly affect costs and it is necessary to consider social benefits and environmental effects as well.

Developing countries have large resources and may well take an active role in OTEC development. It is not too early to begin site identification studies and preliminary evaluations which could lead to financially viable OTEC projects. The priority needs of developing countries may in certain respects be different from those of developed countries and hence they should be involved from the beginning in such studies. The most useful approach would be to take baseline reference studies from countries developing the OTEC technology and adapt these to local needs.

The United Nations General Assembly in Resolution 33/148 has called for a Conference in New and Renewable Sources of Energy to be held in 1981. As part of the preparatory activities, a Technical Panel on Ocean Energy has been organized and met for the first time from November 5 to 9, 1979. The second and final meeting convened from September 22 to 26, 1980. The panel will assist in creating guidelines to assist governments in the assessment of their resources and the evaluation of sites involving the following series of steps.

1. Establish criteria of evaluation, e.g.,
   - temperature differential greater than 18°C
   - 1,000 m isobath within 5 km of the coastline
   - proximity to a coastal energy demand of 10 Mw or more.
2. Establish data needs.
3. Determine availability of archival data.
4. Determine what data can be acquired by computer simulation.
5. Define the remaining data gaps after steps 3 and 4.
6. Specify the instrumentation and field program to supply the missing data.
7. Implement if appropriate.

Given the advantages of different configurations, an initial determination should be made of which option is appropriate for a particular set of circumstances. Multiple-use benefits should be considered as should the base load electric production resulting from the continuous nature of OTEC operation.

Wave Energy

The development of wave energy converters is still in the early stages. Finding ways to capture the enormous power of waves (5 to 200 kw per meter) has occupied the imaginations, efforts, and resources of inventors for many years. Though conversion systems are relatively simple "in concept," they are not always straightforward in engineering design and implementation.

Converters may be activated by vertical movement, rolling, pitching or rearing, or focused waves, such as the U.S. Dam Atoll. Although only tested on a 1:100 diameter bench scale in a wave tank, there appears to be great promise for a 100 m diameter unit capable of operating at 25 percent efficiency and extracting 1 Mw of power from a standard 10 second, 2 m amplitude wave regime (40 kw per meter wave energy density). The cost was projected at US $5,000 per kilowatt which appeared to be marginally viable, and continuing work is concentrating on cost reduction.

Energy storage is likely to be a major problem in wave energy converters. The economics of wave generators might be improved if they were used for coastal defense and land reclamation taking advantage of the fact that they absorb

wave energy in order to convert it. Economics may also be improved by combining wave energy to improve tidal systems. The use of small wave generators in offshore oil drilling rigs and at isolated islands and coastal sites will probably be the first applications to become economically viable.

Tidal Energy

The only major installation is the plant at La Rance, France, which has been operating since 1966 with a capacity of 240 Mw. In the Soviet Union a 400 kw plant is operating using a very low head. A 1,500 Mw plant has been proposed for South Korea. The major questions for tidal energy applications are economic in nature. Cost figures range from US $800 to $3,470 per kilowatt and US $25 to $106 million per kilowatt hour, depending on site characteristics.

Tidal plants have long lifetimes and low maintenance and can be constructed by traditional means. The application of small-scale tidal energy plants may be important in developing countries, especially if they could be combined with aquaculture possibilities. Tidal energy is an attractive technology which has proven its feasibility. Closely related to hydroelectric power generation, it poses no serious technical problems. Environmental effects may, however, be more significant, in part because the location of the installation would be in sensitive coastal areas such as estuaries and bays.

CONCLUSION

Ocean energy is still under development even in advanced countries, yet developing countries are likely to be the main beneficiaries of the technology. Developing countries should participate in the early stages of its development and the ESCAP countries are well-endowed to benefit greatly. Although ocean energy technologies are, to some extent, advanced technologies, there are major segments that lie within the capabilities of the more industrially advanced developing countries. For example, much of OTEC technology is closely related to shipbuilding whereas tidal power is similar in requirements to hydropower.

SUMMARY OF DISCUSSION ON ENERGY: NONCONVENTIONAL OCEAN SOURCES

The initial discussion was mainly concerned with the practicality of the system. Questions concerned the appropriateness of the nutrients contributed to the surface water, whether food sources other than kelp could be raised, and the economics of the biomass system in general. It was noted that experiments have demonstrated that various food sources could be produced but that the cost of raising the bottom water makes the system uneconomical at the present time. One suggestion was that the size of areas under cultivation could be increased. However, it was recognized that concentration of the nutrients was required for better control of kelp growth and management of urchin proliferation.

Details of the operating characteristics of OTEC were discussed. It was understood that an increase in the temperature difference (over the required minimum of 18°C) does increase efficiency. Suggestions as to how to increase this temperature difference and thus OTEC efficiency included using power plant effluent, cold water springs in lagoons and the water surrounding an iceberg (icebergs have been proposed as a source of fresh water in the Middle East). The problem of biofouling was raised and it was felt that progress was being made. Also the usefulness of OTEC in an area with a shallow shelf was questioned, and it was concluded that a decision of feasibility was partly a function of the distance from shore to the edge of the shelf. The possible impact of OTEC on fisheries resources was discussed, in particular the relative coolness of the discharge water. It was felt that the fish would probably avoid the area, but that it was a subject for continued research.

In regards to wave energy, it was noted that promising sites for such systems were to be found in Sri Lanka, Fiji, Australia, and Oceania. It was reported that a French firm was considering the use of an atoll for a wave energy device.

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MULTIPLE USE APPLICATIONS OF OTEC

—Ronald B. Linsky*

The concept of Ocean Thermal Energy Conversion (OTEC) was conceived in 1880 by French scientist Jacques D'Arsonval. In 1930, D'Arsonval's protege, George Claude, field tested the concept by building a successful plant off the coast of Cuba. Systems now being developed apply modern technology to the basic principles formulated by the Frenchman. Briefly, warm surface water is pumped through evaporators, vaporizing a working fluid such as ammonia. The vapor then powers a turbine generator, passes into a condenser, and is cooled by near-freezing water pumped from depths as great as 4,000 feet. The liquefied ammonia is returned to the evaporator, beginning the closed-loop cycle again. OTEC works most effectively when the upper and lower water temperatures vary by at least 40°F.

As a nonconventional energy source, OTEC provides some interesting multiple use applications potentials. An OTEC feature that has been examined for multiple use application is the cold water pipe (CWP). Marine biologists have for many years been aware that the cold, deep waters of the ocean are high in nutrients. This accounts for the abundance of marine life in areas of "upwelling" such as off the west coasts of South America and Africa. Since an OTEC plant creates just such an upwelling by pumping cold, deep water up through its CWP and then discharging it, slightly warmed, at the surface, it is logical to consider using this available nutrient resource for commercial applications. Of singular importance in this regard is mariculture/aquaculture systems.

However, there are several problems connected with this concept, particularly as applied to mariculture. A method for containing the cold water discharge in the desired area without interfering with the operation of the OTEC power plant has not been proven. Not until extensive experience with full-scale OTEC plants has been acquired will it become practical to examine the possibilities in any detail. Nevertheless, some preliminary analyses have indicated that the conversion of the upwelled nutrients into protein in the form of shellfish would be a very efficient process. Indications are that it would require only a few OTEC-mariculture plants to saturate the world markets for shellfish.

On the other hand, the cultivation of kelp as a commercial crop to be used as a biomass energy source is quite feasible. There have been a number of proposals for floating "energy farms" of kelp, since kelp is relatively efficient at storing energy in a form that can be converted to fuel (biomass conversion) and has the added attraction of using no land area in doing so. It has been demonstrated by Dr. Wheeler North of the California Institute of Technology that cold, deep, nutrient-laden waters can accelerate growth of the kelp (Macrocystis sp.).

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Other applications of OTEC plants include energy-intensive manufacturing processes, e.g., aluminum refining, ammonia manufacture, hydrogen production, and freshwater production through desalination. Aluminum refining consumes very large quantities of electrical power, and if the process can be carried on at OTEC plants far from shore, the power now used for that process can be released for other purposes. Tropical islands are special cases where OTEC might be used for the production of fresh water. These islands frequently lack sufficient freshwater supplies but are situated in prime waters for OTEC. Global Marine Development Inc. of Newport Beach, California, has calculated that the economics of such an OTEC/desalination system are favorable. The resultant numbers indicate that for each net megawatt generated. 1,100 m^3/day of fresh water can be produced.

Ammonia (NH_3) production would require no extraneous raw materials at all, since it can be manufactured from the nitrogen in the air and the hydrogen in the water. Ammonia is now manufactured from natural gas, a depletable and diminishing resource. Hydrogen can be produced from water by electrolysis, and if the hydrogen economy predicted by some futurists should some day come about, it may be attractive to use OTEC plants to produce hydrogen. Thus, multiple use depends upon human imagination, and it appears to this writer that concepts such as OTEC provide a fertile field for just such imagineering.

V. PLANNING TECHNIQUES AND EXERCISES

METHODOLOGIES FOR COASTAL AREA MANAGEMENT: MATRIX APPROACHES

—Lawrence D. Neuman*

MATRIX METHODS IN COASTAL AREA DEVELOPMENT AND MANAGEMENT

Introduction

The purpose of an integrated coastal management approach to marine resource development is to derive the greatest benefit from the total range of activities in the area. Since decisions will have to be made involving priorities for the allocation of scarce resources, the decision maker should be presented with the full range of possibilities as well as their short-term and long-term consequences. The process of coastal area development and planning is multidisciplinary in nature and should be designed as a basic strategy for choosing between alternatives and reducing adverse environmental and other effects. Although the need for a rational approach to development incorporating environmental factors and assessing their importance can be justified on both economic and political grounds, strong arguments for preservation of coastal ecosystems need to be presented in the face of pressure for development. Preservation as an end in itself, whether for the sake of aesthetics or to maintain existing amenities, is not necessarily a compelling argument. However, short-term gains from development should always be weighed against the long-term value of renewable resources as well as future development.

The tasks and methods presented for coastal area planning and management should provide an indication of the consequences of a given action including assessment of the particular coastal areas which will be affected and may require protection or preservation. The aim of a basic strategy should be to supply quantitative evidence and evaluation. For example, the assignment of values to mangroves which may be affected by a coastal area development project may differ from country to country or locality to locality. Yet, because the trees often serve as a source of renewable energy to local inhabitants and provide such renewable living resources as oysters, crustacea and fish for subsistence, these values should be carefully assessed in order to be adequately taken into account when weighing the losses against the benefits of development.

The Place of Matrices in Coastal Area Development Planning

The process of coastal resource development planning incorporates an evaluation of resource potential and methods of exploitation together with

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conflict analysis and environmental impact assessment. The matrix method is one of the techniques to be applied at an early stage in the process of assessment and planning. The environmental assessment is being increasingly recognized as a necessary stage in development planning where such planning incorporates a determination of the nature and degree of interaction between an economic activity and the physical environment. The assessment examines interactions in economic, social and ecological terms and is multidisciplinary in nature. When properly undertaken, the assessment should not only indicate likely environmental consequences, but also consider alternatives and mitigating measures to eliminate or minimize adverse effects.

Information gathering, compilation, and evaluation is an essential component of the coastal area development and environmental assessment program. The decision-making process, however, depends more on a careful statement of the objectives of the particular planning process and the problems to be addressed, than on data acquisition.

The Coastal Planning Process

Figure 1 indicates the steps to be taken in reaching a decision on project implementation in a coastal area. Once the project has been conceived, the decision-making process should include a comparison of alternative ways of meeting the objectives of the project. Performance standards will vary according to local conditions and requirements. In order to set performance standards, it may be necessary to seek the opinions of those not directly engaged in the project but affected by it, including local inhabitants of the area. For example, in evaluating the development of a particular coastal or offshore mineral deposit, alternative ways of producing the mineral might include use of other sites, increased production onshore or different exploitation techniques. The evaluation of alternative actions must be carried out in light of those legal, political, financial and cultural factors which are external to the project but put limits on the options available.

After possible sites and development methods have been proposed and adequate information has been gathered, it is possible to estimate the potential impact of the development activity on the marine and coastal environment. To gain a preliminary appreciation of these effects, a matrix method may be employed.

Once the consequences of each alternative have been identified, a point is reached where a decision can be taken on the acceptability of those impacts. The choice ranges from rejecting the project to implementing it with or without measures to mitigate the environmental effects or modify other factors in the decision-making process. The process is iterative and several paths are open for changing the elements in order to produce an acceptable project. The "trade-offs" which usually must be made result from the fact that ideal solutions are not obtainable and that some adverse environmental impacts cannot be avoided.

The coastal planning process and environmental impact assessment should help the decision maker appreciate the benefits and costs of his actions both in the short-term and in the long-term. By avoiding irrevocable mistakes early in the planning stage, future remedial actions will be feasible and may be less costly. Where funds are insufficient for immediate provision of any or all measures to reduce adverse effects, the planning process may still allow scheduling of future activities to minimize impacts.

Matrix Techniques

Matrix methods are employed within the process of coastal planning and assist in evaluating alternatives. The matrices described here[1] lead logically from the changes caused by the activity, to the effects such changes have on the marine environment, and to the implications of these environmental alternatives for other uses of the coastal area. The matrices were developed to direct attention to considerations which might otherwise be overlooked. This "checklist" function is valuable because it helps assure that a multidisciplinary approach is incorporated in determining environmental effects and potential conflicts.

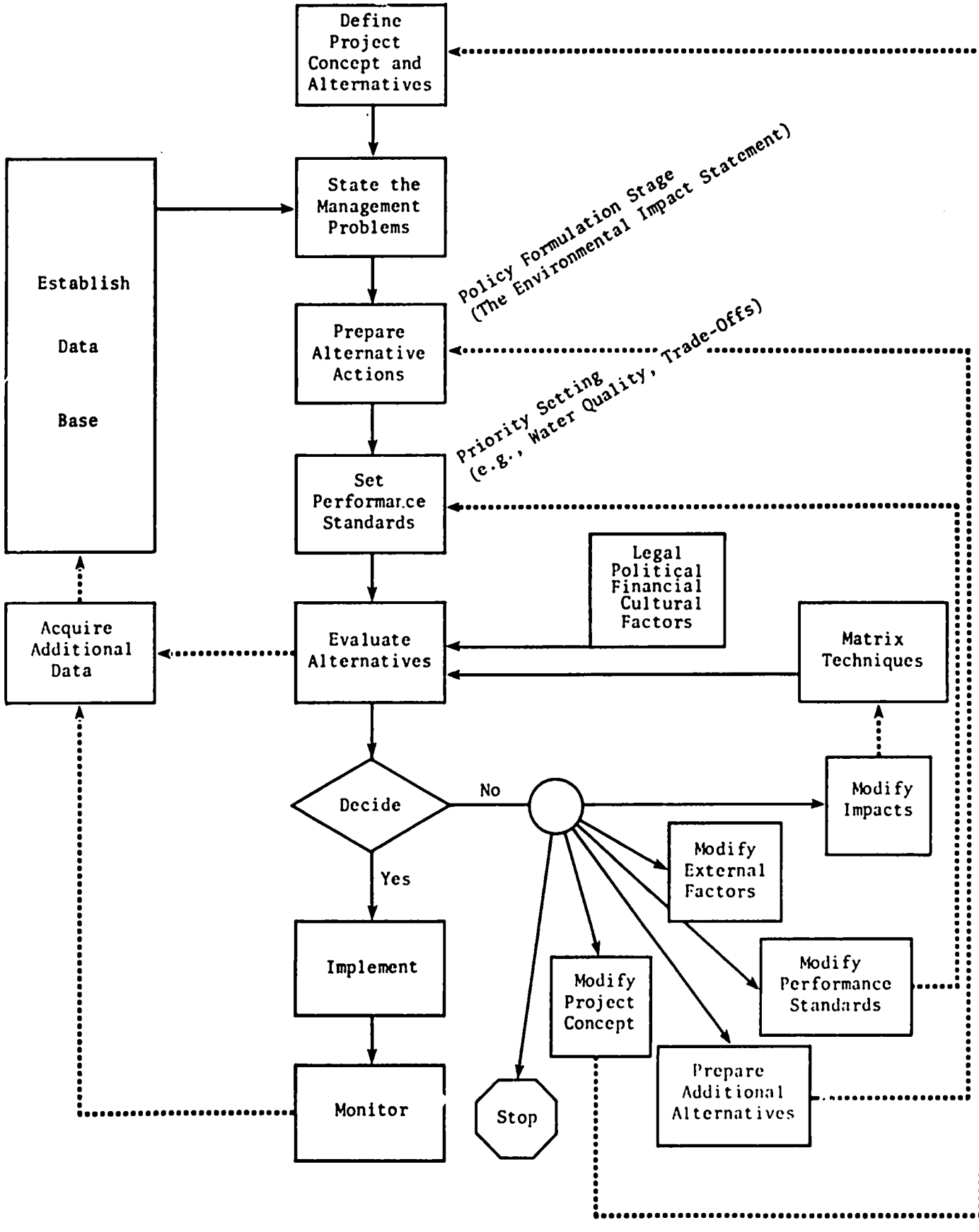

FIGURE 1. The coastal planning process

The list of uses, residuals (wastes) and effects given in these matrices is not exhaustive. The effects listed are, however, considered to be the most important and, once they are identified, appropriate effort can be allocated to determine their quantitative significance. Matrix 1 (Table 1) relates selected coastal area activities to the residuals (wastes) they produce and to direct changes in the physical environment resulting from these activities. Matrix 2 (Table 2) relates wastes to effects on the marine environment.

Matrix 3 (Table 3) relates effects to alternative uses and completes the cause-effect sequence. This matrix permits one to identify rapidly the sensitivity of "other uses" to effects commonly associated with residuals. The other uses selected cover a wide range of developments, but the list is not comprehensive. It does not include, for example, military activities, chemical manufacturing plants, wildlife conservation, coal mining or metal ore extraction and processing. The characteristics of particular uses and their scale may differ substantially from place to place and each example must be considered individually.

In order to provide a convenient summary of the relationships represented by the matrices, a matrix overview has been prepared (Table 4). It presents the three matrices in a combined format which allows the relationships to be followed more easily. For example, mining for construction materials may produce industrial waste water, dredge spoil and affect water circulation, among other results. These wastes and changes in physical conditions have a number of effects upon the marine environment including the six listed. These effects will have potential impacts upon other uses of the coastal area such as the six selected. It is possible to select any group of activities and examine their impacts concurrently to determine potential use conflicts and environmental consequences.

The evaluations of impacts of mining of construction materials and of oil terminals are illustrations of the application of the matrices.[2]

Example: Mining of Construction Materials

Construction materials from marine sources include sands and gravel for concrete buildings and structures, shell sands for the production of Portland cement, and sand for beach replenishment or land fill. The selection of a site for mining is usually based on local need, that is, some development is being considered which will require construction materials. Exploration for a source of materials[3] may result in the discovery of a number of minable deposits from which a selection may be made. Assuming the presence of adequate reserves, the selection would be influenced very strongly by the distance of the deposit from shore, the depth of water and characteristics of the bottom. Transportation costs for bulk materials usually represent a major portion of the product cost whether the material is transported by pipeline or in the hopper of the dredge, and the cost of the delivered product is very sensitive to changes in transport needs. Most standard dredges are limited in digging to a combined water depth and deposit thickness of about 33 m. Greater depths require commensurately greater capital expenditures or lease costs for the dredge.

Bottom characteristics assume prime importance in the consideration of the deposit itself as well as in the consideration of the pollution implications of its removal. In all cases, but particularly where the sources of materials are limited or there are compelling political or other reasons influencing site selection, it is important to examine the potential environmental conflicts and determine the options applicable to the operation.

In discussing the implications, it has been found convenient to use the following illustrative example. A sand and gravel deposit is being developed some 3.33 km off the coast to supply the construction of a large port development in a West African state. The sand and gravel is delivered by hopper dredge to the construction site in a sheltered estuarine natural harbor. The material is pumped ashore to the plant where it is washed with fresh water, screened, and graded, before being

stockpiled for delivery to nearby sites by road. The development of the port is necessary for the outward shipment of ore from an extensive deposit in the hinterland. No previous development has been carried out in the area which is tropical with a low rainfall and situated at the mouth of a major river.

Preliminary Environmental Impact Assessment

As indicated in Matrix 1, industrial waste waters, sludges and mud, and dredge spoils may result from the plume of fine sediment created by the overflow of the dredge hopper during the pick-up operation. In the open sea, 3.33 km from shore, the dispersion of the fines would be such that redeposition would be unlikely to result in a significant local buildup. This could, however, be measured if it were close to nearby fish spawning or shellfish grounds, for example, by simple bottom sampling techniques. On shore, the washing plant would result in accumulation of mud and organic debris. The dried stockpiles would generate dust whereas the plant itself would be a source of noise.

Significant changes in the physical environment may also result as the operation at sea will alter the bottom characteristics by lowering the seabed several meters over an area of a few square miles. There is some likelihood of affecting wave conditions sufficiently to cause alteration in the equilibrium of adjacent beaches (shoreline) or nearshore bars (shore profile). Removal of the gravel substrate will alter the bottom characteristics of the mined area and locally change the habitat for benthic fauna. Because no sand is removed from or placed directly on the beach, the littoral sand budget may not be directly affected unless sand is moved shoreward on a seasonal or intermittent basis. Changes in circulation due to altered bottom characteristics could affect beach conditions indirectly as could changes in wave refraction. On shore, the construction of the unloading dock and plant will have changed the shoreline by the construction of bulkheads and the placement of fill. This will have a local effect on the circulation and possibly tidal zone life but, in order to determine this, preconstruction surveys and projections should be made based on simple biological examinations.

Example: An Oil Terminal

Because of increased prices for oil, there is a worldwide search for new reserves. The shallow seas and continental shelves are being examined everywhere and thoughts have even turned to the Antarctic. Consequently, the provision of additional oil terminals may become necessary in many countries. Such coastal development commands top priority so the importance of being aware of its possible pollution implications does not need to be stressed. Pollution may arise from three main groups of causes:

1. Conveyance of oil to or from the terminal by tanker or pipeline or both,

2. Construction of offshore moorings, jetties, quays, tank farms and other installations, and

3. Development of refineries and ancillary industries, e.g., for the production and/or utilization of petrochemicals.

Because oil is such a convenient energy source, its presence may lead ultimately to the development of a multitude of industries and this possibility should be kept in mind at the planning level. By itself, an oil terminal does not employ many people--the processes of landing, storage and onward transportation can be largely automated--so that extensive housing development for operating a terminal alone is not usual. The location of an oil terminal will generally be determined by its proximity to the oil fields. The particular requirements of a site are identical to those for a port and harbor with additional attention to waste disposal.

Preliminary Environmental Impact Assessment

The developments (1) and (2) above are associated with two main kinds of pollution arising from the spillage of oil and interference with coastal current and sediment transport regimes through erection of massive structures on and near the shore. The effects of such structures will not differ from those

associated with ports and harbors described in Matrix 1.

Bringing oil ashore by pipeline is to be preferred wherever practical, although the pipeline may constitute a substantial interference with fishing. Even if buried initially (a common requirement if the seabed traversed is suitable), such pipelines may emerge above the sea bottom due to erosion of sediment by current and wave action. For this reason alone, the banning of all trawling across the pipeline and in a defined band alongside it is highly desirable. Dredging of any kind and anchoring of any ship in this band should also be prohibited. For these reasons, the siting of a pipeline and terminal needs to be planned so as to minimize interference with existing shipping and fishing activities or any such activities considered likely to develop on the basis of knowledge of unexploited resources, such as shellfish beds or mineral deposits.

In theory, spillages may occur at any point along a pipeline but, in practice, facilities are usually incorporated for isolation of particular sections which thus restrict considerably the amount of oil that can be released. Regions of greatest vulnerability offshore are related to the character of the sea bottom and the degree of exposure to wave action during storms, and to accidents arising from ships unaware of the pipeline's position. Spillages from pipelines occur only rarely but are most frequent at the ends, i.e., the connections with the production platform or its ancillary structures and with the shore terminal. Spillages at sea, generally speaking, present fewer hazards and are more readily dispersed than spillages in the coastal zone. Heavy oils are an exception to this. Contingency plans must be made in advance for dealing with offshore spills, and the operators should be required to have available both equipment (including ships) and trained personnel for this purpose as a condition of a lease. Spillage of oil in the coastal zone may be very damaging locally for both living resources and amenities.

Matrix 2 gives an indication of how such damage may arise. Contingency plans should be prepared by the local authority for minimizing the effects of such spills. Even with the best will in the world, mechanical and electrical faults do occur, occasionally resulting in oil spillages. It must also be admitted that human error of one kind or another is a frequent cause of oil release, even in the best managed installations. The inevitability of spillages must be kept in mind during initial planning and site selection. The potential for damage differs considerably according to the type of crude oil being brought ashore, particularly according to its content of aromatic substances.[4]

If oil is brought ashore or distributed from the terminal by tankers, then the additional risks of pollution normally associated with such ships, e.g., tank cleaning, discharge of waste oil, and sewage and garbage disposal, need to be considered. Suitable reception facilities for ships' wastes need to be provided ashore. As indicated in Matrix 3, oil terminals and refineries may produce environmental effects which have considerable impact on other uses of the coastal area but no other activity appreciably interferes with terminal and refinery operation.

Of possible industrial developments near an oil terminal, a refinery and the production of petrochemicals are the most likely. Refineries may entail substantial leveling and infilling of coastal areas and will certainly produce effluents that are actually or potentially damaging and add significantly to the risks of spillage of oil and oil products. In most cases, road, rail or ship access will need to be developed for the distribution of products. Additional urban development with increased sewage discharge will be inevitable. Well-run refineries release only small quantities of oil and refined oil products but many of the latter are toxic to marine life and liable to cause tainting of fish, shellfish, and other seafood. The coastal area immediately adjacent to either a refinery or a petrochemical plant must in practice be regarded as sterilized so far as fishing is concerned.

No general guidance can be given as to the extent of marine pollution risks from petrochemical plants since, in theory at least, the list of possible products is extremely lengthy and contains many potentially harmful organic substances. Judgments as to the likely hazards can only be reached on the basis of knowledge

of chemical substances to be produced or utilized and which may be discharged, local water movements, and distribution of harvestable resources. Each major group of chemical substances requires specialized production equipment and usually a new plant will be constructed if new products are to be made and marketed. For this reason, unheralded changes of any magnitude in the character of effluents or the appearance of new substances in the effluents are unlikely.[5]

A Brief Note on Data Requirements

A comprehensive program of coastal area development and management requires general and detailed information on the coastal environment as well as social, economic and demographic data on coastal activities including human settlement and industry. The objective of the data collection is to provide information on the potential effects of coastal development activities, and limitations should be placed on the amount and kinds of data required. Assessments must be based, however, upon adequate information regarding conditions in the marine environment and a multidisciplinary approach to baseline studies is essential.

As noted recently,[6] "too much emphasis has been placed on the data gathering functions" in existing literature. Data collection can never be considered finished or complete, but the major obstacle to better management in developing countries is not lack of data or information but "the ability to analyze and process the data so that it yields the insight required to make the decision."

A first step in all cases is the collection and evaluation of pertinent existing information from both published and local records. The basic data required for a preliminary evaluation of the implications of coastal area development are also related to assessing the potential of an area for development. Categories of basic data include:

1. Physical oceanography and meteorology,
2. Biological and chemical conditions,
3. Seabed conditions (bathymetry, sediment transport and bottom deposits),
4. Living resources (particularly those already exploited),
5. Existing discharges of sewage and industrial effluents,
6. Physical characteristics of the coast, including freshwater discharges.

Giving special attention to likely situations in developing countries, it is possible to work at different levels of sophistication with respect to available methods and instrumentation. A basic program of observations[7] requiring a minimum of trained manpower and technical facilities such as ships, instruments, and data-processing devices can produce the required basic information for allowing a preliminary assessment of the suitability of a site for a given type of development as well as its possible impact on the coastal and marine environment. These relatively simple observations may still be used profitably when more sophisticated technology becomes available and can form the basis for some decision making.

Conclusions

The matrix method was applied to specific examples in the workshop and this provided an opportunity to work through the sequence. This exercise assisted in demonstrating the importance of information in reaching sound decisions as well as the complexity of the process. Although no data are required for the general case, actual evaluation of the degree of interaction and the nature and extent of the environmental effects does call for careful study of local conditions. Indeed, matrices for a general case must be regarded as illustrative only and they should not be taken as more than a guide for the preparation of matrices for actual projects.

Furthermore, the evaluation of individual effects may be weighted to indicate the magnitude of the effect and its significance. The total effect of an

activity on the environment and on other uses is the sum of individual effects. The severity of the impact will be subject to different perceptions and evaluations and, consequently, the matrix method must be considered as a tool, the use of which may lead to decisions based on specific conditions, requirements, and goals.

SUMMARY OF DISCUSSION ON METHODOLOGIES FOR COASTAL AREA MANAGEMENT: MATRIX APPROACHES

Matrix Methods

It was emphasized that the use of impact matrices (Tables 1 to 4) and overlay mapping as tools for the evaluation of offshore petroleum development had to be viewed in the context of the whole evaluation process. The impact matrix serves as a screening device to ensure completeness in the checking of types of impact. It also provides an indication of the questions that need to be answered at the beginning of an evaluation. Its usefulness depends on the degree to which the activity is differentiated.

As an example, it was felt that a first order disaggregation of offshore petroleum development would be a division into field development, production, transport, and processing activities. These activities could be further disaggregated into, e.g.:

Extraction--geological survey, exploratory drilling.

Field development--drilling to determine field site, construction and erection of platforms.

Production--pumping, repair and service, storage.

Transport--pipeline (laying, operation); tanks (loading, voyages, unloading).

Processing--terminals, refining.

It was recognized that the result of using the matrix approach for these activities would be an indication of the type of impacts. The next step would be to obtain information regarding the detailed characteristics and magnitudes of the impacts.

It was considered that the example of oily wastes as an impact of offshore development could be taken as an exercise. Accidental and operational discharges could be differentiated for the various sources--platforms, tankers, pipelines, and terminals--and the quantity of expected discharges estimated as base information for the evaluation.

It was recognized that the matrices in the Neuman paper were developed by persons with experience in the substantive areas concerned, but with experience mainly restricted geographically to temperate zones. However, it was considered that for Southeast Asia most of the categories were relevant but may vary in their significance. Whereas it was understood that no one person could be familiar with all the processes identified in the Table, areas suspected of receiving impact could be identified, however, and this suspicion could be checked with specialists in other agencies. It was also suggested that the matrix could be organized differently to show primary and secondary impacts.

The use of matrices for identifying waste management aspects of coastal resource development was the subject of a wide ranging discussion. However, it was emphasized that matrices are tools for revealing the consequences of releasing wastes and that they do not prescribe decisions. Other factors that may influence development decisions include the displacement of workers, facilities and industries, and the social impacts of offshore development on onshore communities.

A discussion of alternative ways of measuring social impact ensued. It was proposed that impacts of waste management be rated or ranked on matrices to provide better guides for decision making, but the usefulness of this tool was questioned and other guidelines for the use of matrices were proposed. These included the need for clear definition of matrix categories, specification of impacts at particular sites rather than in general, and the importance of identifying types of technology affecting waste generation and management.

NOTES

1. IMCO/FAO/UNESCO/WMO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP). Marine pollution implications of coastal area development, *Rep. Stud. GESAMP* (11), 1980, pp. 109-112.

2. The following discussion is excerpted from GESAMP, supra n. 1.

3. Exploration for a source of materials is described in GESAMP. Scientific aspects of pollution arising from the exploration and exploitation of the sea-bed, *Rep. Stud. GESAMP* (7), 1977, 37 pp.

4. For further information on this subject, see GESAMP. Impact of oil on the marine environment, *Rep. Stud. GESAMP* (6), 1977, 250 pp.

5. An initial appreciation of the potential for harm of particular substances in the marine environment can be obtained from GESAMP. Review of harmful substances, *Rep. Stud. GESAMP* (2), 1976, 80 pp.

6. E. Chacko. Environmental assessment techniques: Their applicability to coastal management. Paper presented at the Workshop on Coastal Area Development and Management in the Caribbean Region held in Mexico City, Mexico, from 24 September to 5 October 1979.

7. GESAMP, supra n. 1.

TABLE 1. Matrix no. 1: wastes and direct changes in physical conditions resulting from coastal area developments

Wastes and Direct Changes in Physical Conditions / Coastal Activity	Sewage	Urban Runoff	Garbage	Industrial Waste Waters	Cooling Waters	Organic Solid Wastes	Inorganic Solid Wastes	Sludges	Dredge Spoils	Dusts	Floating Solid Wastes	Scums	Oil & Oily Wastes	Pesticides	Atmospheric Contaminants	Odors	Noise	Water Circulation	Shoreline Profile	Wave Conditions	Beach Conditions	Seabottom Conditions	Sediment Transport
Urban development	X	X	X				X		(X)		X	X	X	(X)	X	(X)	X		X		X		(X)
Tourism & recreation	X		X				X		(X)		X		X	(X)			X		X		X		(X)
Ports & harbors	X		X				X		X		X		X				X	X	X	X	X	X	X
Oil terminal with refinery	(X)		X	X	X		X	X	X			X	X		X	X	X		X		X	(X)	(X)
Paper & pulp mill				X		X	X					X		(X)	X	X	(X)	X			X	X	
Metallurgical plant				X			X	X		X		X			X	X	X				X	(X)	
Fish processing				X		X					(X)	(X)				X	(X)				(X)		
Mining for construction materials				X					X	X								(X)	X[b]		X	X	X
Power stations					X		X[c]			(X)					X			X			(X)	(X)	(X)
Mariculture																(X)					(X)	(X)	
Intensive agriculture[a]						X		X				X											
Construction phase			X				X		X				X		X		X	X	X		X	(X)	(X)

[a] In immediate coastal zone, e.g., rice, sugarcane, halophytes, or stock farming or horticulture.
[b] If carried out on the beach or in shallow coastal water.
[c] If using solid fuel, e.g., coal.

NOTES

1. The residuals (wastes) identified are those associated with current practice in carrying out the activity.
2. The symbol "X" placed at an intersection denotes a relationship with a pronounced effect. Minor effects are noted by the symbol "(X)". Such relationships may be either direct or secondary--or through the action of other items identified by "X" in other columns for the same activity.
3. The matrix identifies the presence of interactions but not their relative importance. The development of tourism and recreational activities, for example, gives rise to sewage and dredge spoil but no attempt is made to determine whether the effect of sewage is worse than that of spoil. The precise significance of each effect must be evaluated specifically for each site.

TABLE 2. Matrix no. 2: effects of wastes and physical changes on the marine environment

Wastes and Physical Changes \ Effects	Salinity	Turbidity	Color	Temperature	pH	Dissolved Oxygen	BOD	Nutrients	Metals	Other Dissolved Substances	Microorganisms	Fauna & Flora	Primary Productivity	Erosion	Deposition & Accretion	Aesthetic Value
Sewage	X	X	X	(X)	(X)[a]	X	X	X	X	X	X	X	X		X	X
Urban runoff	X	X	X	(X)		(X)	(X)	(X)	X	X			(X)		X	
Garbage		X				X	X	(X)		(X)		(X)			X	X
Industrial waste waters	X	X	X	(X)	(X)[a]	X	X	X	X	X		X	X		X	X
Cooling waters	X[b]			X		(X)			(X)	(X)[c]						
Organic solid wastes		X				X	X	X		X	X	X	X		X	X
Inorganic solid wastes		X							X			X			X	X
Sludges		X	X			X	X	(X)	X	(X)	X	X	(X)		X	(X)
Dredge spoils		X	X			X	X	X	X	X		X	(X)		X	(X)
Dusts		(X)	(X)						X			(X)	(X)		(X)	X
Floating solid wastes										(X)		(X)				X
Scums			X						(X)	(X)		(X)	(X)			X
Oil & oily wastes		(X)	X			(X)	X		(X)	X	(X)	X				X
Pesticides										(X)		X				
Atmospheric contaminants									X	X		(X)				X
Odors										(X)						X
Noise												(X)				X
Water circulation	X	X		X		X		X				X	X	X	X	
Shoreline profile		(X)		(X)[d]								X		X	X	X
Wave conditions		X				X						X		X	X	X
Beach conditions		X		(X)[d]								X		X	X	X
Seabottom conditions		X				(X)		(X)	(X)			X	(X)	X	X	X
Sediment transport		X				(X)		(X)	X			X			X	X

[a]In estuaries and other water bodies with restricted circulation.
[b]If fresh water is used for cooling.
[c]Substances introduced to combat fouling and corrosion, etc.
[d]Close inshore.

NOTES

1. As with the first matrix, significant relationships are identified by "X" at the appropriate intersections; minor relationships have "(X)" placed at the intersection.
2. In virtually every situation, the ecological equilibrium of an area may be affected by one or more residuals in the form of a change in the character of the habitat or some aspect of the food web due to alterations in primary productivity, fauna, or flora.
3. As with the previous matrix, the fact that an effect is identified in a qualitative assessment does not imply that its relative importance is high.

TABLE 3. Matrix no. 3: the potential impact of marine environmental effects on selected uses of a coastal area

Marine Environmental Effects \ Uses of Coastal Area	Urban development	Tourism and recreation	Ports and harbors	Oil terminal & refinery	Paper and pulp mill	Metallurgical plant	Fish processing	Mining for construction materials	Power stations	Intensive agriculture	Commercial fishing	Mariculture	Navigation	Desalination	Sea-salt production (solar)
Salinity			X						X	(X)[a]	X	X		X	X
Turbidity		X							X		X	X		X	X
Color		X													(X)
Temperature		X							X		X	X		X	
pH										(X)[a]		(X)			
Dissolved oxygen											X	X			
BOD		X									X	X		X	X
Nutrients		X								X[a]	X	X		X	(X)
Metals		(X)					X			X[a]	X	X		X	X
Other dissolved substances							X			X[a]	(X)	X		X	X
Microorganisms	X[b]	X[b]					X			X[a]	X	X		X	X
Fauna and flora	(X)	X	X						X		X	X	X	X	X
Primary productivity		X									X	X		X	X
Erosion	X	X	X					X			X	X	X		
Deposition accretion		X	X					X			X	X	X		
Aesthetic value	X	X													

[a]Growth of halophytes.
[b]If sewage organisms are present in significant quantities.

TABLE 4. Matrix overview[a]

Coastal Activity	Wastes And Physical Changes: Water circulation	Oil & oily wastes	Dredge spoils	Inorganic solid wastes	Industrial waste waters	Sewage
Urban development		X	(X)	X		X
Tourism & recreation		X	(X)	X		X
Ports & harbors	X	X	X	X		X
Oil terminal & refinery		X	X	X	X	(X)
Mining for construction materials	(X)		X		X	
Power station	X			X[b]		

Effects	Desalination	Horticulture	Commercial fisheries	Power stations	Ports and harbors	Tourism & recreation
Turbidity	X	X	X	X		X
Temperature	X	X	X	X		X
Metals	X	X	X			(X)
Fauna & flora	X	X	X	X	X	X
Erosion		X	X		X	X
Aesthetic value						X

[a]The "other uses" shown are selected as examples.
[b]If using solid fuel.

SENSITIVITY RANKING OF ENERGY PORT SHORELINES*

—Miles O. Hayes,
Erich R. Gundlach, and
Charles D. Getter†

INTRODUCTION

According to U.S. Coast Guard statistics, more than 50 percent of the oil spills that occur in U.S. waters take place in ports and harbors.[1] In some cases, these spills cause extensive environmental and property damage. Therefore, it is evident that sound energy port management requires a contingency plan to deal with oil spills. A well-conceived contingency plan usually includes: (1) identification of possible spill sources and subsequent dispersal patterns; (2) selection and acquisition of containment equipment; (3) selection of recovery and disposal sites; (4) determination of appropriate spill cleanup and control methods; and (5) a coordinated and well-organized system of rapid response to the spill. An effective plan should also include a mapping program that clearly defines the sensitivity of the coastal environments of the area to spilled oil so that the most sensitive environments may be protected. The purpose of this paper is to outline efforts made by our group over the past four years to provide shoreline sensitivity maps for a number of agencies concerned with contingency planning for oil spills.

ENVIRONMENTAL SENSITIVITY INDEX

Introduction

The environmental sensitivity index (for oil spills) that we presently use has evolved considerably over the past four years. The concept is based on field investigations of four massive oil spills (*Metula*, *Urquiola*, *Amoco Cadiz* and IXTOC 1) and several smaller incidents (including spills under tropical and ice conditions), plus an extensive literature survey. A list of the studies of major oil spills that have provided the most information on this subject is presented in Table 1.

Our first application of the concept of a sensitivity index was during the mapping of the geological sensitivity of the coastline of Lower Cook Inlet, Alaska.[2,3] That study defined an oil spill susceptibility index, which was based primarily "on the physical longevity of

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TABLE 1. Oil spill studies containing details of oil impact on shoreline environments

Study	Spill	Date	Type and Amount
B. Campbell, E. Kern, and D. Horn[a]	WWII tankers U.S. East Coast	Jan. to June 1942	Various; 533,740 tons
J.E. Smith[b]	*Torrey Canyon* Scilly Isles, U.K.	Mar. 1967	Arabian Gulf crude; 117,000 tons total; 18,000 on shore
M. Foster, A.C. Charters, and N. Neushul[c]	Santa Barbara Blowout	Jan. 1969	California crude; 11,290 to 112,900 tons total; 4,509 tons on shore
E.H. Owens[d]	*Arrow*, Chedabucto Bay, Nova Scotia	Feb. 1970	Bunker C; 18,220 tons total
R.W. Hann[e]; A. Blount[f]	*Metula*, Strait of Magellan, Chile	Aug. 1974	Saudi Arabian crude; 53,000 tons total; 40,000 tons on shore
E.R. Gundlach and M.O. Hayes[g]; E.R. Gundlach, C.H. Ruby, and A.E. Blount[h]	*Urquiola*, La Coruña, Spain	May 1976	Persian Gulf crude; 110,000 tons total; 25,000 to 30,000 on shore
E.R. Gundlach and M.O. Hayes[i]; M.O. Hayes, E.R. Gundlach, and L. O'Ozouville[j]	*Amoco Cadiz* Brittany, France	Mar. 1978	Arabian Gulf crude; 223,000 tons total; 60,000 on shore
Robinson, J.[k]	*Peck Slip* Eastern Puerto Rico	Dec. 1978	1,500 tons, No. 6 oil
--[l]	IXTOC 1 Gulf of Mexico	June 1979 to present	Several hundred thousand tons; crude oil

[a] B. Campbell, E. Kern, and D. Horn. Impact of oil spillage from World War II tanker sinkings, *Massachusetts Institute of Technology Sea Grant Report No. MITSG 77-4* (1977), 85 pp.
[b] J.E. Smith. *Torrey Canyon, Pollution and Marine Life* (Cambridge, England: University Printing House), 196 pp.
[c] M. Foster, A.C. Charters, and N. Neushul. The Santa Barbara oil spill, part I, initial quantities and distribution of pollutant crude oil, *Environmental Pollution*, v. 2, 1971, pp. 97-113.
[d] E.H. Owens. *The Restoration of Beaches Contaminated by Oil in Chedabucto Bay, Nova Scotia,* Marine Science Branch, Manuscript Report Series, No. 19, Ottawa, Canada, 1971, 77 pp.
[e] R.W. Hann. *Oil Pollution from the Tanker Metula,* Texas A&M University, Civil Engineering Department, Report to the U.S. Coast Guard, 1974, 61 pp.
[f] A. Blount. Two years after the *Metula* oil spill, Strait of Magellan, Chile--oil interaction with coastal environments, *Technical Report No. 1d-CRD, Coastal Research Division* (Columbia, South Carolina: Department of Geology, University of South Carolina, 1978), 214 pp.
[g] E.R. Gundlach and M.O. Hayes. The *Urquiola* oil spill, La Coruña, Spain: case history and discussion of methods of control and cleanup, *Marine Pollution Bulletin,* v. 8(6), 1977, pp. 132-136.
[h] E.R. Gundlach, C.H. Ruby, and A.E. Blount. *Urquiola* oil spill, La Coruña, Spain: initial impact and reaction on beaches and rocky coasts, *Environmental Geology,* v. 2, no. 3, 1978, pp. 131-143.
[i] E.R. Gundlach and M.O. Hayes. Chapter 4, investigation of beach processes, in W.N. Hess, ed., *The Amoco Cadiz Oil Spill, a Preliminary Scientific Report.* NOAA-EPA Special Report, Chapter 4 (Boulder, Colorado: Environmental Research Laboratory, 1978).
[j] M.O. Hayes, E.R. Gundlach, and L. D'Ozouville. Role of dynamic coastal processes in the impact and dispersal of the *Amoco Cadiz* oil spill (March 1978), Brittany, France, *Proceedings of the Oil Spill Conference* (Los Angeles, California, 1979), pp. 193-198.
[k] Robinson, J. Ed., *Impact of IXTOC 1 Oil on the South Texas Coast,* in press.
[l] Several reports in preparation.

oil in each environment in the absence of cleanup efforts."[4] This same principle was used by Nummedal and Ruby[5] to map the Alaskan coast of the Beaufort Sea. Gundlach and Hayes[6] expanded the concept to include some biological considerations. This expanded index, called the Oil Spill Vulnerability Index, was used to map several additional areas in Alaska.[7]

At present, our major goal is to integrate biological features into the index. The purpose of this effort is to add living resource information to the index and yet retain its relative simplicity. This has been difficult in some cases, notably with migratory marine mammals and birds. A workable solution has been to indicate (on the maps) the areas critical to these species for feeding and reproduction. Also delineated are the seasons in which these species use certain areas. This method has proven suitable for the mapping of protected habitats and commercial species as well. The result is a color-coded symbol which indicates on the maps the presence of protected, commercial, and ecologically important species and their habitats.

In the process of integrating biological and geological concepts, certain problems became apparent. For example, the large grain size of gravel beaches allows deep penetration and long-term persistence of oil (relatively high geological sensitivity), whereas infaunal organisms find it difficult to colonize gravel (relatively low biological sensitivity). This contradiction has been handled by assigning an intermediate ranking (ESI-6) to gravel beaches. Also, some portions of exposed rocky headlands, which have low geological sensitivity, have relatively large standing stock biomass. In such cases, a special symbol is used to indicate the presence of an especially productive biological community.

Methods of Study and Application

The ultimate goal of this work is to produce maps of coastal environmental sensitivity with respect to oil spill impact. These maps are meant to provide information that the On-Scene Coordinator (OSC) will ultimately use in directing response to oil spills. The areas under consideration are usually large and diverse and funding levels relatively low. Therefore, a technique is required that can assess large sections of shoreline rapidly and reduce the findings to usable maps of a suitable scale (on the order of 1:40,000). The method we employ is called the integrated zonal method, which has been adapted from the zonal method developed by Hayes and others[8] to classify large sections of the Alaskan coast for the Office of Naval Research. The addition of a biological component to these field studies, which were primarily geologically oriented at first, presents an integrated approach to determining environmental protection priorities. The method is briefly summarized as follows.

Before fieldwork, available literature, aerial photographs, maps, charts, biological keys, and tidal data are collected and analyzed. Fieldwork begins with an aerial reconnaissance of the study site flown at low tide. Observations are recorded verbally on tape and photographically with a 35 mm camera. Ground stations are selected at regular intervals on the basis of geomorphic and biological variability, and the desired detail of coverage of the study area. Areas of particular economic or biological importance are selected for further study. Each sampling station includes a topographic profile of the beach, three equally spaced sediment samples, a hand-drawn sketch (to force inspection of all aspects of the area), and photographs from various angles. Primary producers, dominant consumers, and standing stock biomass are assessed. Typically, this includes a census of intertidal organisms with emphasis on ecologically or economically important species. If available, field data are compared and analyzed with respect to other data (e.g., data of the Fish and Wildlife Service) from the study site.

During and after fieldwork, the data are compiled and analyzed. Sediment samples are sieved and calculated for grain size and related statistical parameters.[9] Biological data are analyzed by application of standard statistical techniques.

The last stage is the construction of detailed maps which indicate the determined index values for the entire coastal area mapped. Such features as areas of particular biological importance, major recreational centers, access roads for cleanup equipment, and mooring points for booms also are indicated. The map base

should be one that is familiar to the user, such as a NOAA coastal chart or a U.S. Geological Survey topographic map.

An Example

In order to demonstrate some of the details of the system, an example of one of the indexes we have used will be discussed. It is important to realize that a ranking system for any given locality may not be applied indiscriminantly to another locality, primarily for two reasons:

1. The coastal morphology may be different; therefore, basic habitats and substrate conditions may be different in the two areas under comparison; and

2. Biological communities may be different, depending upon differences in temperature, light, substrate, available nutrients, and so forth.

Therefore, it is usually necessary to conduct a thorough literature search and preliminary fieldwork before devising a sensitivity index for a new area.

A ranking system for cold temperate coastal areas. Much of our mapping work to date has been in cold temperate regions such as southeastern Alaska. The system that we have worked out for part of the Alaskan coast provides an example that can be used to demonstrate the system.

A ranking and discussion of the ten environments most commonly encountered in cold temperate regions is listed below. The environments are ranked so that the environment least sensitive to long-term oil spill damage is a "1," and the one most sensitive is a "10."

1. Exposed, Steeply Dipping or Cliffed Rocky Headlands

   Observations during the *Urquiola* and *Amoco Cadiz* oil spills showed that oil was generally kept 5 to 10 m offshore by waves reflecting off steep rocky cliffs. Damage was minimal, and oil that did strike the cliffs was removed rapidly by wave activity. Biomass is usually low on exposed shores of this type. Where organisms are present, they are usually kelp and their associated subtidal communities which are relatively unaffected by floating oil.

2. Eroding Wave-Cut Platforms

   Deposited oil is removed relatively rapidly from this environment because of its wave-swept condition. This was observed to take less than a few weeks at the *Metula* site. If the platform is exceptionally wide and supports a high biomass, such sites are indicated by a special notation on the maps because of potential biological impact. Residence time of oil would be very brief, however. Bird rookeries and mammal pupping areas are common on rocky headlands and cliffs associated with wave-cut platforms. Seasonal utilization is noted with a special symbol.

3. Flat, Fine-Grained Sand Beaches

   Compact, fine-sand beaches inhibit oil penetration and, as they generally accrete very slowly between storms, the depth of oil burial is minimal. Cleanup is simplified by the presence of a hard substrate. Amphipod populations are likely to be destroyed, although, as we observed at the *Urquiola* and *Amoco Cadiz* spills, recovery may occur after a few months.

4. Steeper, Medium- to Coarse-Grained Beaches

   As observed at the *Urquiola* spill site, oil burial and penetration may be great on depositional, medium- to coarse-sand beaches. Cleanup tends to grind oil into the beach because of the loose packing of the sediment. After a major spill, oil from the beach face is eliminated by natural wave activity, usually within months.

5. Mixed Sand and Gravel Beaches

   On mixed sand and gravel beaches in Spain, oil from the *Urquiola* rapidly penetrated to depths of 30 cm in the sediment. Cleanup of such beaches is difficult without

removing so much sediment that beach erosion may result.

6. Gravel Beaches

Investigation of the *Urquiola* site revealed that oil penetrated most deeply (60 cm) into well-sorted gravel beaches. Follow-up study of a gravel beach at the *Amoco Cadiz* site revealed that oil persisted as fresh mousse eight months after the spill. Biomass is usually very low in this environment. This is due to the low water content of the substrate and its inability to support an infaunal community. However, the observation that it retains oil for months to years with concomitant pollution of neighboring environments and the water column leads us to rank it relatively high on the integrated scale.

7. Exposed, Compacted Tidal Flats

As observed at the *Metula* and *Urquiola* spill sites, oil does not readily adhere to, or penetrate into, the compact surface of these sand or mud flats. However, biological damage can be very extensive. At the *Amoco Cadiz* spill site, millions of heart urchins and clams that inhabited the lower intertidal and shallow subtidal zone of this environment were killed. This environment was formerly ranked as a "5" on the geological index because of the short residence time of the oil, but it has been moved to a "7" on the integrated index because of high potential biological impact. Areas with especially high productivity are noted with special symbols.

8. Sheltered Rocky Coasts

Spilled oil tends to coat the rough surface of rocks within sheltered environments. Because wave energy is low, oil may persist several months to years. The resident biological community may be abundant and diverse and likely to be damaged or destroyed due to long-term exposure to oil.

9. Sheltered Estuarine Tidal Flats

Several sheltered tidal flats at the site of the *Amoco Cadiz* oil spill in France remained severely contaminated until at least 18 months after the spill. Even in places where mechanical cleanup operations succeeded in removing surface oil, the interstitial water was still oiled. A high biomass of deposit and filter feeders creates the potential for severe biological damage. Long-term biological changes may include failure of some species to recolonize oiled substrate.

10. Sheltered Salt Marshes

Salt marshes are one of the most productive portions of the coastal zone. It has been shown that large amounts of oil in the marsh environment can be devastating, as at the *Metula* and *Amoco Cadiz* spill sites. At West Falmouth, Massachusetts, the effects of the 650-ton *Florida* spill (no. 2 oil) were detectable for at least seven years after the spill.[10] With lesser quantities, the marsh may be able to recover (e.g., *Urquiola* site), although repeated spill incidents are usually damaging.[11]

A Hypothetical Case

In order to demonstrate how the index would be applied to an energy port, a simplified hypothetical example is shown in Figure 1. This map shows the location of the different coastal environments of the port area, plus recommended boom locations, swimming beaches, bird rookeries, and urban areas. The index used is the one developed for cold temperate areas.

A hypothetical wreck site is indicated just outside the harbor entrance. In this case, the first line of defense would be the narrow harbor entrance because the most sensitive areas are located inside the harbor. Therefore, we have indicated the location of booms at the entrance (B1). In order to effectively position the booms, details about tidal level fluctuations, wave action, and tidal currents would have to be known. Where available, this type of information is included in

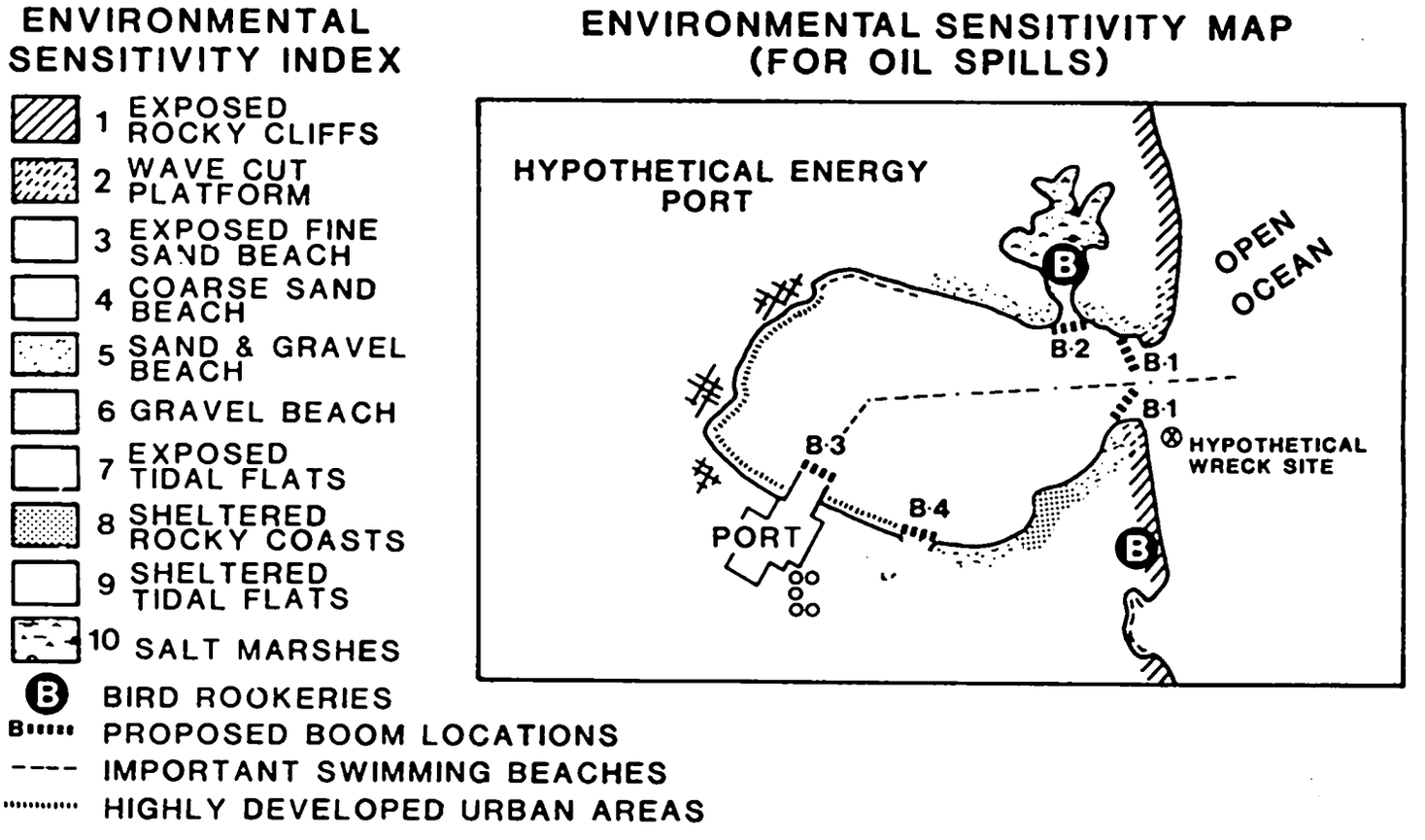

FIGURE 1. Hypothetical energy port with superimposed environmental sensitivity index (for oil spills)

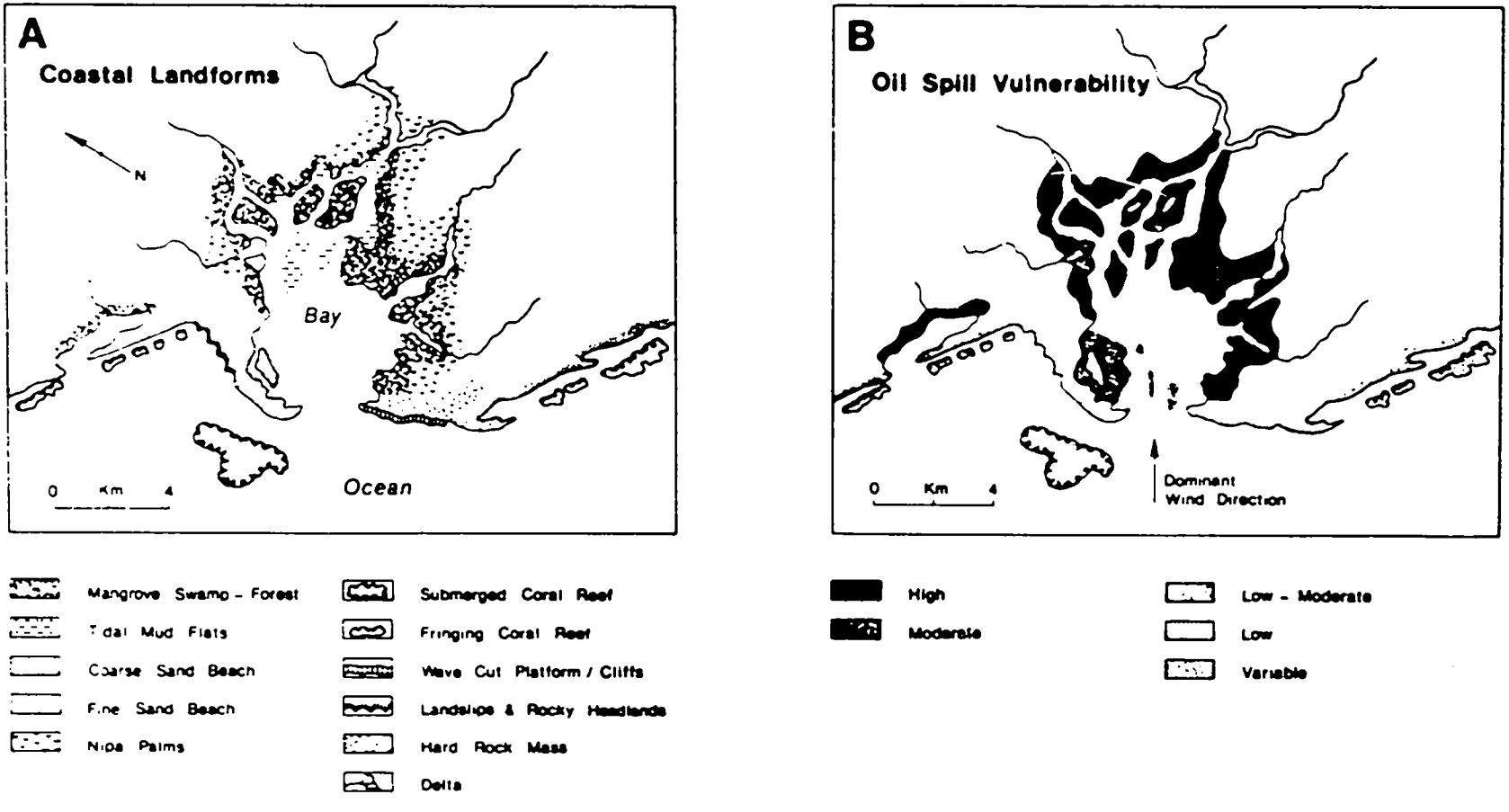

FIGURE 2. Construction of an environmental sensitivity index for a hypothetical section of a tropical coast

our sensitivity index atlases. The swimming beach south of the wreck site would also receive priority attention.

If oil reached the inner harbor, secondary lines of defense would have to be established. The first area to be protected would be the extensive marsh area on the north side of the harbor (boom position B2). Other areas that would receive early attention would be the marsh area on the south side of the harbor and, perhaps, the port area itself (boom locations B3 and B4). The swimming beach north of the city would also be protected and/or cleaned as soon as possible after the spill.

The presence of two bird rookeries is also shown on the map. These rookeries may harbor species which are legally mandated for protection during an oil spill.

The Texas Experience

When it became apparent that IXTOC 1 oil would impact the Texas coast during the summer of 1979, the authors and several colleagues were contracted by NOAA to construct environmental sensitivity maps for the southern one-third of the Texas coast (Rio Grande to Aransas Pass). Eventually, the entire Texas coastline was mapped. The sensitivity index applied to the Texas coast was an integrated index that consisted of the following classes:

1. Erosional scarps in clay
2. Not present
3. Exposed fine-grained sand beaches
4. Sheltered fine-grained sand beaches
5. Exposed tidal flats
6. Mixed sand and shell beaches
7. Exposed tidal flats (moderate biomass)
8. Not present
9. Sheltered tidal flats (high biomass)
10. Salt marshes and mangroves

Because of the semiarid climate of the region, this scale is considerably different from the one used in Alaska. Some of the exposed tidal flats of southern Laguna Madre, for example, contain high salt and other evaporite concentrations.

The presence of a limited number of mangroves (10) was another climate-related addition to the index. There is evidence that heavy oiling of mangroves can be severely damaging. The most notable case occurred in southwest Puerto Rico where the *Zoe Colocotronis* spill caused the defoliation and death of 1 ha of red and black mangroves.[12] In another case (Florida Keys oil spill), Chan[13] reported that mangroves were killed where the sediment or pneumatophores were oiled. Recently, the defoliation of 0.2 ha (0.5 acres) has been documented by our research group at the site of the *Peck Slip* oil spill in eastern Puerto Rico. Defoliation and probable death seemed to occur where both sediment and prop roots were heavily oiled. Recovery of a mangrove ecosystem may take an estimated 20 years.[14]

As the mapping units were completed, the maps were presented to the Scientific Support Coordinator who passed them on to the OSC and the U.S. Coast Guard Strike Team. The sensitivity maps became an integral part of the overall plan to protect the Texas coast.

With this and other background data, the lines of defense were set. Basically, the plan evolved into allowing the oil to impact the outer beaches, which were mostly "3s" on the index, and to concentrate on keeping oil from passing through the tidal inlets. Most of the sensitive coastal areas along the Texas coast are located inside the bays and lagoons, landward of the barrier islands. Second lines of defense, aimed at protecting the marsh and mangrove areas ("10s"), were established inside the inlets. Fortunately, very little oil passed through the inlets during the 1979 onslaught of the oil.

The following quote[15] attests to the usefulness of the environmental sensitivity maps provided by our team in dealing with the IXTOC I oil in Texas:

> By identifying sensitive bays and inlets, and less sensitive barrier beaches, the study essentially directed Coast Guard efforts in establishing booms across inlets

to protect the most fragile areas. This is the first time that available information could be so effectively gathered and utilized in combatting an oil spill.

SUMMARY OF DISCUSSION ON SENSITIVITY RANKING OF ENERGY PORT SHORELINES

The presentation on environmental sensitivity indexes in relation to oil spill stimulated many specific and general questions. Considerable interest was shown in techniques used to measure the impact of oil spill on organisms in sediment. In the case of the IXTOC 1 spill on the Texas coast, volumetric measurement of the organisms in the sediment were made before and after the spill impacted the coast, and thus a reduction of biomass, particularly amphipods, could be demonstrated as being related to oil pollution. It was noted that the length of time oil remains buried in beach sediments depends on the duration of the beach cycle, which involves the erosion and redeposition of sand on the beach. In some places, the beach cycle lasts only a few days, whereas in others, it lasts for months. A beach cycle would have an average duration of four to eight months. If the oil remains buried for several years, the result may be long-term contamination of the interstitial waters in the beach which can cause long-term impact on the biota. It was noted that this long-term effect had been documented at the site of the spill of the tanker *Arrow* in Nova Scotia.

As regards the effect of chemical dispersants as it relates to sensitivity indexes, it was noted that in most spills studied, dispersants were used mostly in offshore waters and there were no apparent onshore biological effects of dispersants. In connection with the concern with the effect of oil on mangroves, a common coastal vegetative type in the region, the meeting was informed that oil penetration of mangrove area bottom sediments was generally very slight due to their fine-grained character. However, the horizontal penetration into the mangrove forest was on the order of 200 to 300 m. A secondary effect of oil spills is the blooming of the green alga *Enteromorpha* which occupies niches vacated by die-offs of organisms vulnerable to oil.

The use of the index was demonstrated on a map (Figure 1) prepared for the Workshop. It was noted that one defensive method that could be applied to protect sensitive ecosystems along the inner coast of the bay from spilled oil was to trap the oil in a pool with booms, and use skimmers and sorbent pods to remove the oil from the water surface. As regards the designation on the map of coral reef areas as of variable sensitivity, it was explained that contrary to expectation, coral reefs do not appear to be highly sensitive to oil spill as the oil seems to pass over the reef and on to the shore. This experience agreed with observations in Indonesia. However, it was noted that if the oil sinks onto the reef, there would be a greater possiblity of impact.

In the case of the IXTOC 1 spill, the investigating team had ten days to make the baseline survey. In cases where there is no lead time, it was recognized that sensitivity judgments would have to be made on the basis of the maps and data at hand, and advice would be rendered to the cleanup force on a day-to-day basis. In this connection, it was considered that particular sites such as coasts bordering major tanker routes and those adjacent to areas of offshore production were more susceptible to impact by spilled oil. Such areas could be delineated and a strategy of environmental sensitivity index studies developed. It was noted that the indexes were usually modified to a minor extent for new sites to include environments not present in areas previously studied. The relative indexes would not be affected by the type of oil spilled; however, the actual amount of damage for each index type would certainly depend on the toxicity and half-life of the oil type.

In regard to the manpower requirements and cost of environmental sensitivity index mapping, it was noted that in the south Texas coast study, two persons working in a helicopter and three on the ground completed the study in ten days. Normally, a crew of two geologists and two biologists can map a 500 km segment of coastline in approximately three weeks. The cost for such surveys to be undertaken by consultants varies with the degree of sophistication of the biological input. The meeting was informed that a study being planned for Alaska would cost approximately US $100/km of coastline, including helicopter support for the aerial

mapping. It was stressed that in any such study, it was important to use local maps and charts familiar to the authorities responsible for protection and cleanup.

Acknowledgments

Dave Maiero of SAI and Geoffrey Scott of RPI contributed significantly to the integration of biological concepts into the environmental sensitivity index. Funding for development and application of the index has been provided by NOAA, Office of Marine Pollution Assessment (John Robinson, Program Manager); NOAA, Marine Ecosystems Analysis Program (Howard Harris, Program Manager); Alaska Department of Fish and Game; and NOAA, Outer Continental Shelf Assessment Program (Herb Bruce, Program Director). Funds for field investigations of the *Metula*, *Urquiola*, *Amoco Cadiz*, *Peck Slip* and IXTOC 1 oil spills were provided by National Science Foundation; NOAA, Environmental Research Laboratories; the jointly Franco-American administered AMOCO fund; and NOAA, Office of Marine Pollution Assessment.

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A BASIC TOOL FOR LAND USE PLANNING: GEOSCIENTIFIC MAPS OF THE NATURAL ENVIRONMENT'S POTENTIAL

—C. H. v. Daniels*

Coastal area development and management is first of all a matter of planning. It requires at the very beginning a detailed knowledge of the natural environment of the planning area. How to use natural resources and how to cope with natural hazards are questions answered by information available only from specialists. However, planners and decision makers are often overburdened with a flood of different information which is difficult for them to digest and transpose into that necessary for their planning project. That is why the specialist scientist whenever involved in planning activities should translate his special knowledge into a language which the planner is able to understand. In this way, the planner may achieve a new status of consciousness concerning, e.g., environmental problems in his region which he otherwise would not take into account.

For several years, geoscientists of several countries have tried to introduce a new type of geoscientific map which has been given different names but which is always based on the same principle: to reduce complicated geoscientific knowledge into smaller, more easily understandable portions. Of course this process increases the number of maps produced because the content of each single map is limited to a special type of information which the planner should be able to process. The planner can use this specific map much more easily than a geologic map produced in the traditional manner. The latter is difficult to read and misinterpretation may result if used by nonexperts. This new type of map was introduced in Germany by LÜTTIG as "Geoscientific Map of the Natural Environment's Potential (GMNEP)." The need for the GMNEP in addition to the conventional map system developed when geologists became increasingly involved in planning concerning questions of raw material resources, ground and surface waters, soils, foundation sites, etc. In such planning, a decision on priorities may require direct input from geoscientists If the planner does not know the properties and economic values of the geologic factors he will not be able to determine these priorities.

Thus the GMNEP was designed to show from a geoscientific perspective what nature has provided in certain geographic areas for utilization by man. It must, however, be stressed that the GMNEP is not designed to replace decision making. It only displays proposals for utilization and there may exist other nongeologic factors of higher importance for planning purposes.

The GMNEP was developed in different scales (1:500,000; 1:200,000; 1:25,000)

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according to the different size of the planning areas (state, region, or community). The procedure for constructing the GMNEP is as follows: the basic maps are the conventional geologic map and the conventional soil map. The "second generation" maps are derived partly from these maps. These new maps generally contain only one type of information. There are two types of essentially different information with regard to the natural environment's potential. The first is that generally dealing with natural resources and leads to so-called "claim maps" displaying, e.g., important raw material deposits, high groundwater potential, soils of high potential agricultural yield, and unique geoscientific sites for research and instruction. The second type of information concerns natural risks or hazards, e.g., areas with unsuitable foundation properties, salt water intrusion, seismic activity, erosion danger, and flood risk. The type of special information displayed on the maps depends on the geologic environment and the importance of single geologic features. Each country will have its own geologic environment and problems.

For the Lower Saxony state area, there is now in production a GMNEP set of 11 maps representing the special geologic conditions of the country and meeting the geoscientific information requirements of planners. A general legend is used on all sheets covering both flat coastal and river plains and also mountainous areas. The first sheets were designed by using conventional map production techniques, whereas the latter will be produced by using a modern system of electronic data processing which was especially developed for geoscientific purposes by the Federal Geological Survey.

The Lower Saxony GMNEP set consists of the following maps:

- Agricultural yield potential: five quality stages of natural yield (without artificial influence) for arable land and grassland;
- Drought hazard: five quality stages (very high to very low) of the danger of desiccation of soils depending on climate, soil type, and groundwater in the region;
- Foundation soil strength: numerous cohesive and noncohesive soils differentiated with regard to the bearing capacity of the subsurface;
- Groundwater potential: the amount and quality of the groundwater, danger of contamination, drainage areas, salt-water intrusion lines, groundwater level lines, and groundwater flow direction lines;
- Groundwater protection areas: already existing (legally fixed) protection areas and areas of groundwater extraction priority (for future utilization);
- Near-surface raw material deposits: sand and gravel, clay, limestone, sandstone, lignite, oil shale, etc.;
- Raw material protection areas: the same areas as the foregoing map but divided into three categories of protection status;
- Oil and gas: hydrocarbon deposits with rates of production and reserves for each oil and gas field;
- Salt deposits: all kinds of economically mineable salt deposit types, existing and abandoned mines, and possibilities of waste and bulk storage;
- Ore deposits, coal and industrial minerals: all other underground mining areas except hydrocarbons and salt; and
- Unique geological features and sites: famous outcrops, cliffs, caves, springs, dunes, etc., the protection of which is desirable for research and instruction of students.

The next step in GMNEP production should be the extraction of the most important information from all the different claim and risk maps, and its summarization in one final utilization map (GMNEPU) which can serve as a basis for planning. By this procedure, the GMNEPU produced from the

whole GMNEP set can indicate proposed specific land uses or even coexisting land uses in one area.

Six man-years are required to produce a GMNEP set of 22 maps. To avoid misunderstanding, it is worth repeating that the GMNEPU is not designed to replace decision making but only to provide alternative land utilization options from a geoscientific point of view. Of course an attempt should be made to invite other persons to produce similar thematic maps suitable for land use planning. The MNEP, the map of the natural environment's potential, could be the result of this attempt.

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OVERLAY MAPPING

—James K. Mitchell*

A SUMMARY OF THE EXERCISES

(Figures 1 to 11 in Pocket)

Overlay mapping is a tool that can be used to determine the compatibility of possible coastal and marine uses with each other and with the natural characteristics of the environment. The degree of detail of the maps determines to what extent the degree of impact and the degree of compatibility between the proposed project and other uses can be estimated. After using overlay mapping, a next step is to collect and evaluate information about the characteristics of the impact, its size, and regional effects.

For Workshop exercises, 11 overlay maps were prepared by James K. Mitchell, a Professor in the Department of Environmental Resources, Cook College, Rutgers University, New Brunswick, New Jersey. These transparent maps, which represented a hypothetical coastal area in the region, consisted of Topography and Drainage (Figure 1), Water Depths (Figure 2), Surface Currents and Winds, Month A (Figure 3), Surface Currents and Winds, Month B (Figure 4), Wave Action and Sediment Movement (Figure 5), Landforms and Vegetation (Figure 6), Flood Prone Areas (Figure 7), Geological Hazards (Figure 8), Settlement and Transportation (Figure 9), Mineral Resources (Figure 10), and a blank sheet for plotting alternatives (Figure 11).

The exercises consisted of three parts. The first (Table 1) was designed to inform the participants of the major classes of available data for evaluation of environmental constraints on offshore mineral development. The second was designed to illustrate a technique for manipulating these data to identify sites for resource development. The third was designed to practice the use of this technique in the siting of a hypothetical oil tanker terminal to serve the development of an oil field (Table 2).

In the latter exercise, seven separate sites for the terminal were chosen by fifteen working groups. Eleven of these groups identified grid squares B-4, C-4, or G-2 as preferred port development sites although no ideal tanker terminal location was found to be possible for the given physical conditions. The main criteria for selection were absence of major natural hazards and the presence of existing infrastructure.

Upon request, the participants were supplied with information about the size of the offshore oil field, its production capacity, the socioeconomic character of adjacent areas, and the economic costs of basic oil field development facilities. Most groups attempted to include these variables in cost-benefit calculations, or traded them off against other unknown factors. The provision of additional data

*James K. Mitchell is a Professor in the Department of Environmental Resources, Cook College, Rutgers University, New Brunswick, New Jersey.

on environmental, social, and economic characteristics was shown to increase specification of data needs and their linkages to development decisions were demonstrated. It was suggested that environmental science variables provided more universally understood guides to resource development than social and economic planning variables.

The discussion then focused on the purpose and applicability of the maps. Although it was recognized that the maps had been kept simple for instructional purposes, it was considered that more detail on inland uses that have an impact on the coastal area, such as land clearing or mining, might be included on such maps intended for actual use in coastal area planning. It was noted that the overlay mapping technique presented here could be used initially to produce a general land

TABLE 1. Scenario for sand mining

1. Approximately 40-80,000 m^3/year of sand is required for urban development.
2. Sand deposits exist in grid squares 4-B and 3-F (Figure 10 in pocket).
3. The cost of imported sand is apparently prohibitive now and may increase.
4. The Government has passed a law to stop any more mining of the beaches.
5. The local fishermen object strongly to the mining of offshore sand because they claim it will negatively affect their operations.

Alternatives

1. Employ a small dredge committed fully to the production on an as-needed basis.
2. Employ a large dredge to remove a three-year supply and stockpile it on a beach.

Questions

1. What serious conflicts exist?
2. What data are needed to help resolve these conflicts?
3. Will the cost of gathering and processing the data and resolving the conflicts approach the cost of importing the sand?

TABLE 2. Data for the offshore oil field exercise

The Deposit and Existing Infrastructure

1. The oil deposit to be developed is situated in grid squares 5-A and 5-B (Figure 10 in pocket).
2. The deposit is light, sweet crude with a production capacity of 100,000 barrels/day maximum pumping capacity over a 15 year production cycle.
3. Existing pipelines and storage capacity are fully utilized, and the existing refinery is capable of processing only heavy, sour crude.

Financial Arrangements

1. Joint-venture between country and private multi-national oil company; unlimited capital for investment at favorable terms.
2. ADB and World Bank funds available to the country for the project.

Economic Data

1. (a) Platform cost is US $35 million each.
   (b) Pipeline cost is US $1 million per mile.
   (c) Storage terminal cost is US $20 million.

Environmental Data

1. Fisheries produce 150,000 tons/year.
2. Tourism (recreational beach) receives 200 tourists per day.
3. Rare species of turtle.
4. Mangroves.
5. The climate is not a major constraint to operation of production platforms, but may affect tanker operations.

Socioeconomic Data

1. Present population is 3,000 persons.
2. Subsistence fishing of unknown yield (and human dependence).
3. Tourist hotel with 5,000 visitors/year.

use suitability map. If combined with a criteria list for development projects and updated to incorporate changes in technology and scientific and socioeconomic information, no new suitability map for a specific site would be required. Whereas it was recognized that such regional maps for a whole country would be useful for general development planning if prepared prior to specific development project proposals, it was also recognized that the costs of preparing such regional maps must be balanced against the likelihood of certain areas coming under development stress. It was noted that in the developed world, development stress had come before planning but that if such maps had been available first, they would have been very useful in development planning.

It was also noted that parameters depicted on the maps could be weighed by constructing a table or matrix of criteria, weighing these criteria, and then transferring these weights or combinations thereof to the maps using shades of colors for different weighting of parameters. In this way the suitability of specific geographic regions for particular uses could be delineated. It was noted that in employing this technique, it would be important to keep in mind the difference in types of values being employed, such as economic, socio-political, and natural environmental parameters.

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FIELD TRIP TO THE PROJECT SITE FOR "COASTAL RESOURCES AND ENVIRONMENT SURVEY USING LANDSAT MULTI-SPECTRAL (MSS) SCANNER DATA" (DECEMBER 8 TO 9, 1979)

—Prescillano M. Zamora*

Delegates to the International Workshop on Coastal Management and Development participated in a two-day trip to the coastal areas of Pangasinan and La Union Provinces, Luzon, Philippines. The visit was organized by the Natural Resources Management Center (NRMC), the country's foremost arm for remote sensing, which at present is undertaking a coastal resources and environment survey using LANDSAT MSS data. The area for the center's study extends from the Lingayen Gulf of Pangasinan along the coastal areas of La Union and Ilocos Sur Provinces.

The purpose of the visit was to provide the delegates with an opportunity to view firsthand the Philippine coastal zone and its uses. The trip also provided an opportunity for the NRMC to present some of the projects and programs being implemented by agencies of the Philippine government for the protection, development, and assessment of the country's coastal zone.

One particularly relevant project is the Identification and Assessment of Coastal Zone Utilization and Environmental Problems in the Philippines undertaken by Dr. Prescillano Zamora, a botanist from the University of the Philippines at Quezon City and a member of the Coastal Zone Management Committee of the National Environmental Protection Council (NEPC).

Areas actually visited by the delegates included the Lingayen Beach, the town of Sual, and the Hundred Islands in Lucap, all located in Pangasinan Province, and the Baguio Mineral District in Mountain Province (Figure 1). The participants also traveled along the coast from Dagupan, Pangasinan to Bauang, La Union on their way to Baguio to provide them with a glimpse of the land use patterns along the coastal zone.

Prior to departure, the delegates were given printed materials on the various activities being conducted by the NRMC relating to the coastal zone. The group left Manila on December 8 for Dagupan City and traveled through the provinces of Bulacan, Pampanga, and Tarlac, while listening to a brief lecture on the geomorphological characteristics and land use of certain portions of the provinces. The NRMC staff traveling with the delegates included Dr. Prescillano Zamora, Mr. Ricardo Biña (a marine biologist and head of the Remote Sensing Technology Applica-

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*Prescillano M. Zamora is a Professor at the University of the Philippines and a Consultant to the National Environmental Protection Council, MIS, and Natural Resources Management Center, MNR, Quezon City, Philippines.

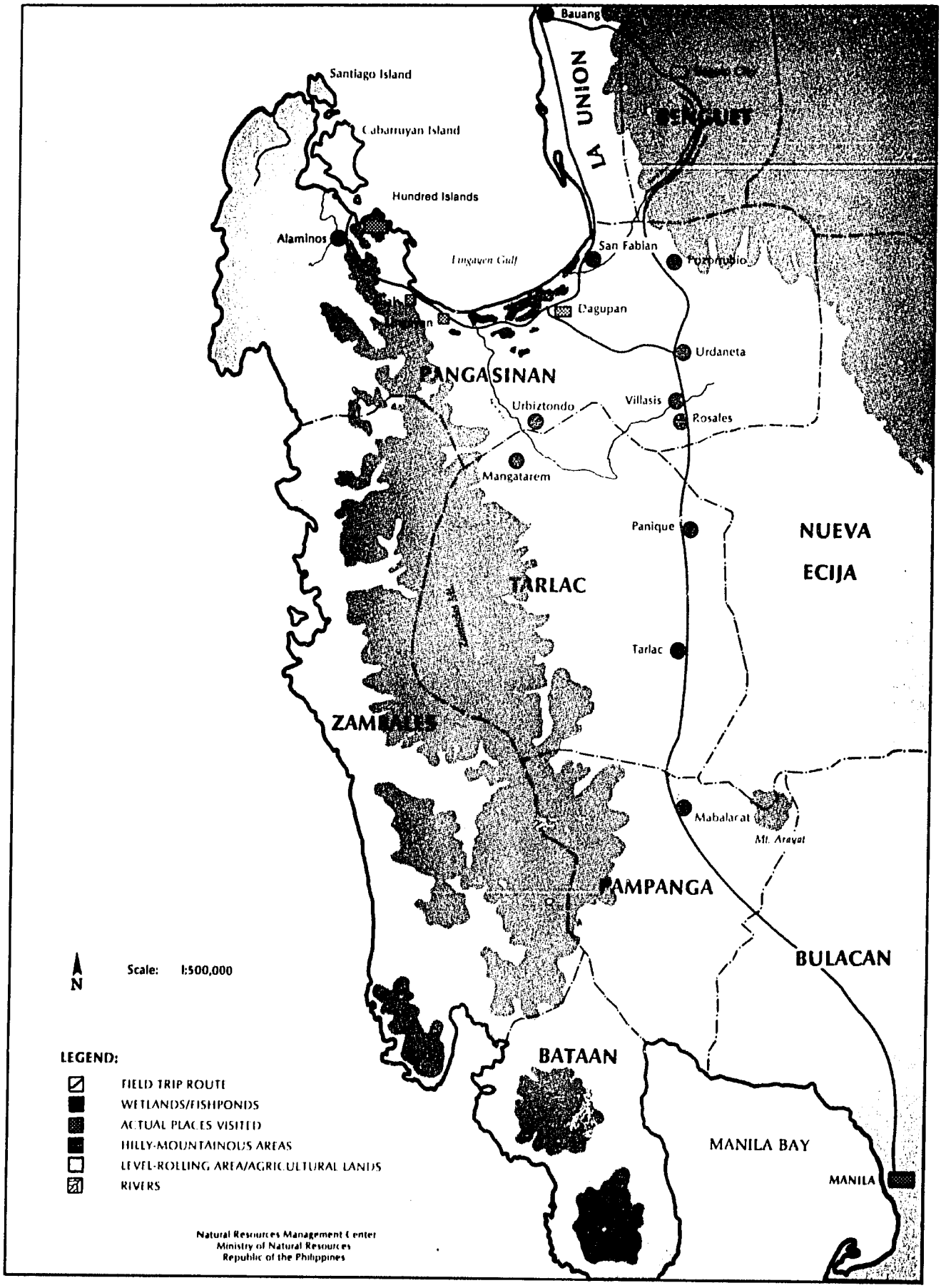

FIGURE 1. Route of the field trip

tions Division of the NRMC), two geologists, a zoologist, a biologist, and a geodetic engineer.

Arriving in Dagupan City before noon, the delegates checked in at the McAdore International Palace Hotel. In the afternoon, the coastal areas of Pangasinan were visited. First on the itinerary was the Blue Beach in Lingayen Gulf, west of Dagupan City. While enroute to Blue Beach, the delegates were shown the extensive fishponds along the coastal areas of Dagupan and Lingayen. These fishponds were formerly mangrove and nipa palm stands which were indiscriminately logged to give way to salt beds and milkfish raising.

The beach proper is located near the provincial capital, Lingayen, and is about 4 km from one of the mouths of the Agno River. Here the delegates were shown different coastal uses such as recreation, fishponds, and rice lands. Being very near Agno River, the area is affected by siltation, and the beach processes, such as receding shorelines and formation of sand spits and lagoons, were viewed and explained.

The group proceeded westward, passing through extensive areas of fishponds and nipa palm growth to Port Sual and Lucap. These towns were visited for a demonstration of various conflicts in the utilization of coastal areas in Pangasinan. The government, for instance, had planned to convert Port Sual into an international port to reduce the volume of ships docking at the Manila Bay piers. The plan was met by opposition from fishermen, and by salt-bed and fishpond owners whose means of livelihood would be displaced with the construction of the port.

The town of Lucap is a tourist and recreation spot famous for the Hundred Islands. The Hundred Islands is a group of numerous islets largely composed of reef limestone formerly connected to the mainland. Wave and water action resulted in the isolation of this land formation from the mainland and its disaggregation into numerous isles. The area is the focal point of a classical conflict in the utilization of coastal areas. The government had planned to construct a hotel on one of the biggest islands in the chain and to pipe fresh water from the mainland to this island. This proposal was opposed by marine conservationists because they feared destruction of sea life and disturbance of the marine ecosystem. Fishermen also opposed the idea because they feared the loss of their main source of income. These conflicts in coastal land use underscored the necessity of developing government policies and laws regarding utilization of coastal zone features.

In the evening, the delegates attended a reception hosted by the NRMC, accompanied by a slide presentation on the latest results of the NRMC project being conducted by the Center. Among the items illustrated were land use maps of Dagupan and Alaminos, maps of flood prone areas, and localities with cases of erosion such as the Urbiztondo and Mangataran Bridge, all in Pangasinan. These maps were the result of computer analysis of digital LANDSAT data carried out using the General Electric Multi-spectral Image Analyzer System installed at NRMC. Also presented to the delegates were aerial photos of Pangasinan and La Union coastline showing various land uses such as fishponds, rice and coconut plantations, and areas of former beach mining for magnetite sand in Agoo, La Union, now banned by the government.

The following day, December 9, the delegates proceeded north towards Baguio passing through the Naguillan Road. This particular route was selected since it proceeds along the coast for approximately 60 km. Traveling along the coast, the delegates had a fleeting view of the different land uses and cover such as nipa palm stands, grass and brushlands, rice fields, and coconut plantations. They also witnessed changes in the topography of the land. The Lingayen, Dagupan, and San Fabian areas, for example, are part of a vast plain of alluvial deposits from the Agno and Bued Rivers which drain the level land.

Farther north the level land becomes narrower and is flanked to the east by hills of sedimentary rocks. This narrow zone extends from Damortis, La Union to Bauang, La Union. Rain-fed rice in these areas is cultivated up to the coastline. Land nearer the hills is covered by brush and grasses and occasionally planted with rice irrigated by river water.

Baguio was included in the itinerary to afford the delegates the opportunity

to witness activities carried out about 45 km north-northeast of Lingayen Gulf which directly affect the condition of this coastal area. The mountains of Baguio contain rich deposits of porphyry copper and gold which are being mined by private corporations near the Kennon zigzag road. Tailings from the mining operations are dumped in the headwaters of the Bued River which drains into the Lingayen Gulf. The tailings carried by the Bued River into the Gulf directly affect the quality of water in the Gulf and indirectly the marine life. Actually witnessing this phenomenon leads to a better appreciation of the necessity of having a clear definition of the extent of the coastal zone in terms of space or activities affecting coastal areas so that policies and laws for the protection and development of these areas can be rationally formulated.

The group left Baguio for Manila in the afternoon and traveled along the Kennon road, which parallels the Bued River. Here they could view the mining centers and the effects of the mine tailings.

VI. RECOMMENDATIONS AND LIST OF PARTICIPANTS

WORKSHOP RECOMMENDATIONS

The workshop after due consideration strongly recommended that:

1. Coastal Area Development and Management (CAD&M) be included as an agenda item in all future meetings of relevant regional, intergovernmental organizations including ASEAN, CCOP, CCOP/SOPAC, ESCAP, SEAFDEC, SPC, SPEC, UNEP, OETB, IOC/WESTPAC, and other relevant UN bodies.

2. The agenda items on current and projected activities of CAD&M include consideration of the following:

   a. Major projects

   b. Data requirements and collection

   c. Research

   d. Legislation

   e. Policy and regulations

   f. Training

   g. Workshops

   h. Public education

3. One of the existing regional bodies be responsible for the collection, documentation, and dissemination of information pertinent to CAD&M.

4. To facilitate communications, one individual be designated in each national government and regional organization to be responsible for all matters dealing with CAD&M.

5. In order to optimize the development of their coastal areas, close communication, cooperation, and coordination be established among all organizations within each country involved directly or indirectly with CAD&M.

6. A team of experts be made available to visit each member country upon request to identify the CAD&M problems and to organize inter-organizational seminars, workshops, and research and to develop and/or review in-country and regional programs as appropriate.

7. Based on the specific coastal area development and management problems in member countries, further regional workshops be organized to apply the concepts of coastal area development and management to topics such as, but not limited to:

   a. Ports and harbors

   b. Water resources

   c. Mineral resources

   d. Coral and mangrove ecology

   e. Fisheries

   f. Animal husbandry

   g. Agriculture

   h. Mariculture and aquaculture

   i. Recreation and tourism

   j. Marine transport

k. Ocean energy activities

l. Standardization of data

m. Mapping

n. Environmental control

o. Coastal area protection

8. A directory of specialists, agencies, and institutions listing their areas of competence in CAD&M be compiled by OETB and the information disseminated to the countries.

and further recommended that:

9. Present national legislation of the member countries pertinent to CAD&M be reviewed to insure that it incorporates principles of good resources management and, where legislation is found to be deficient, immediate steps be taken to formulate adequate rules and regulations, appropriate institutional arrangements and a review process of CAD&M activities.

10. An intergovernmental personnel exchange program be established or continued among member countries to improve CAD&M methods and the transfer of appropriate technology.

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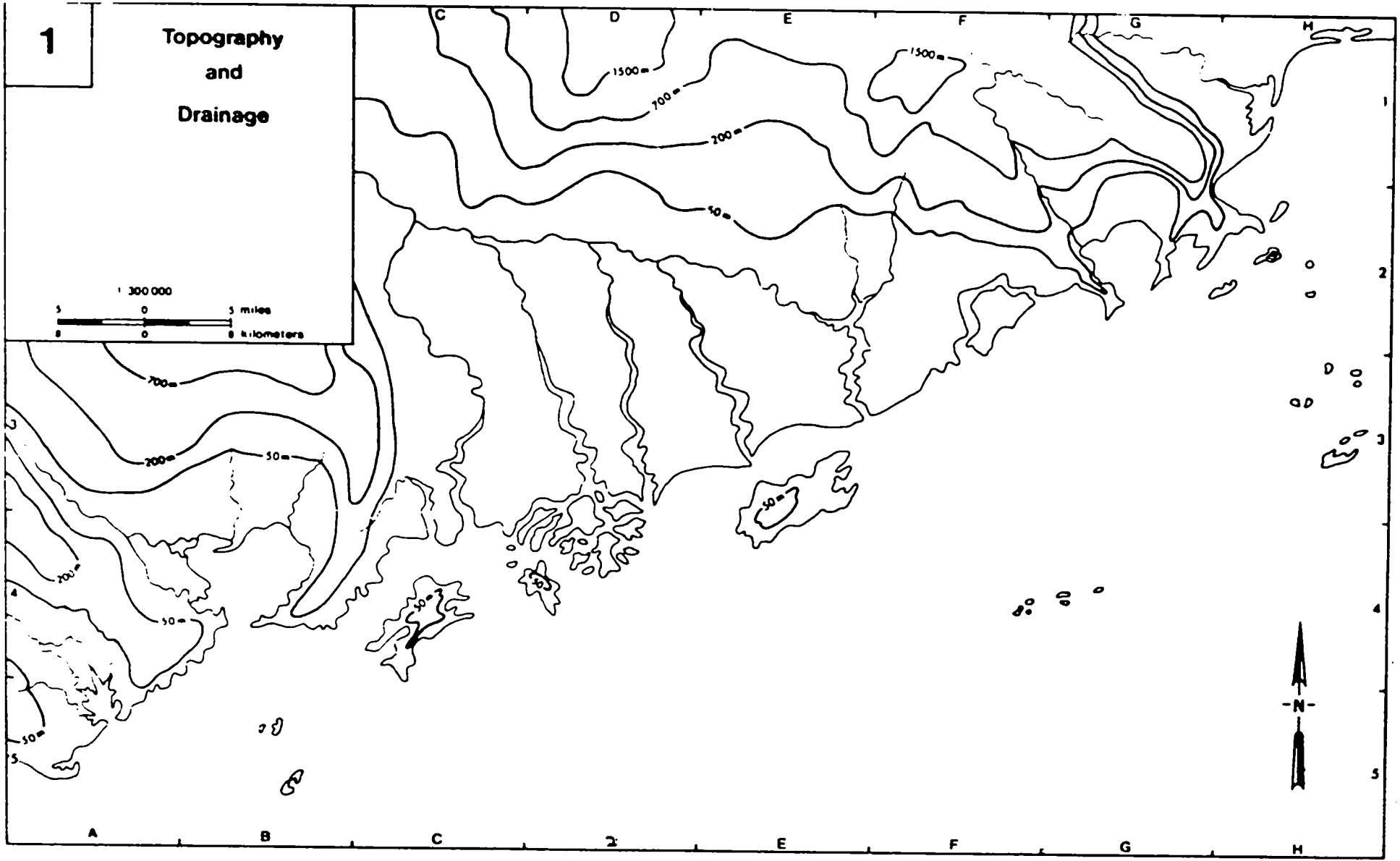
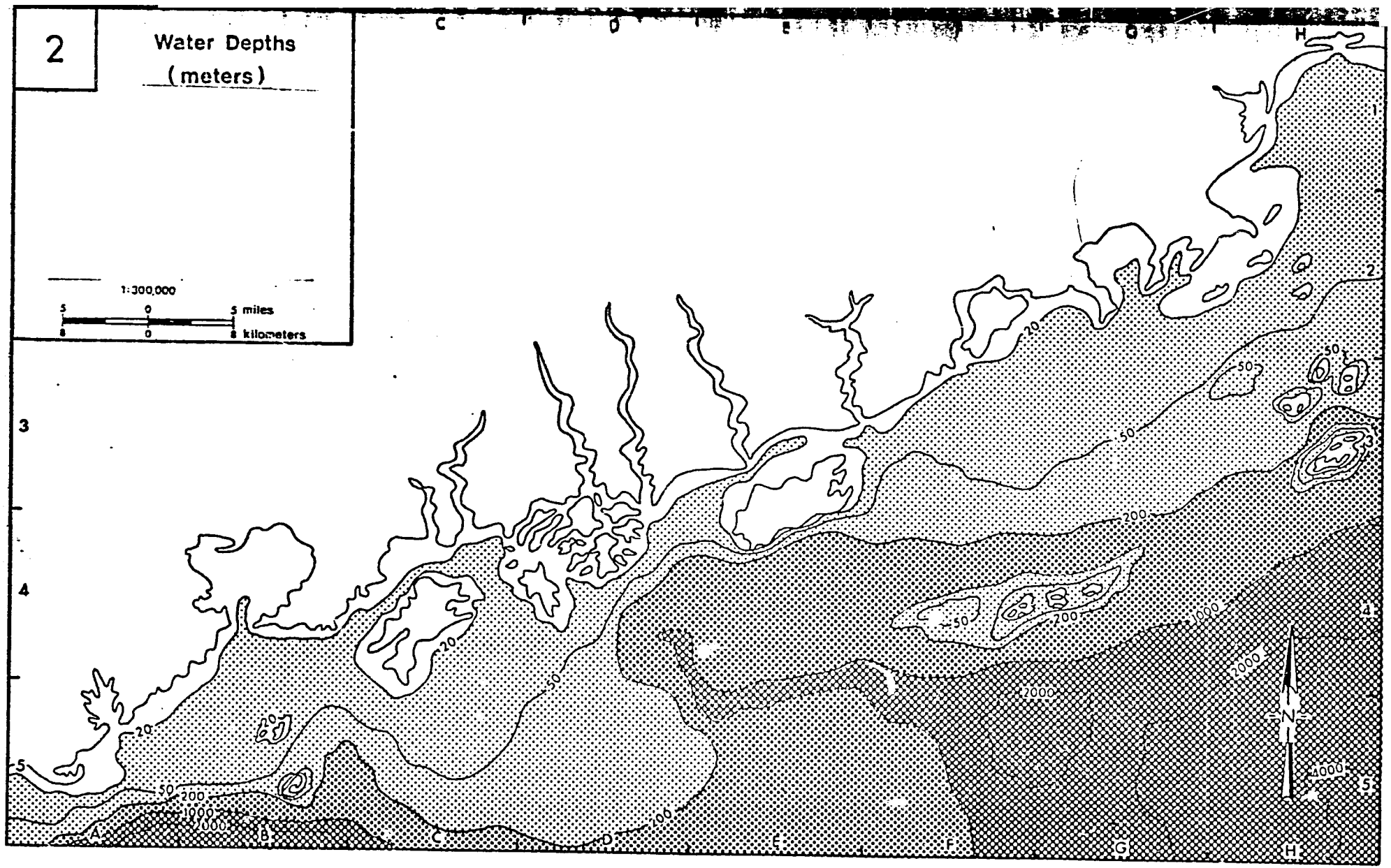
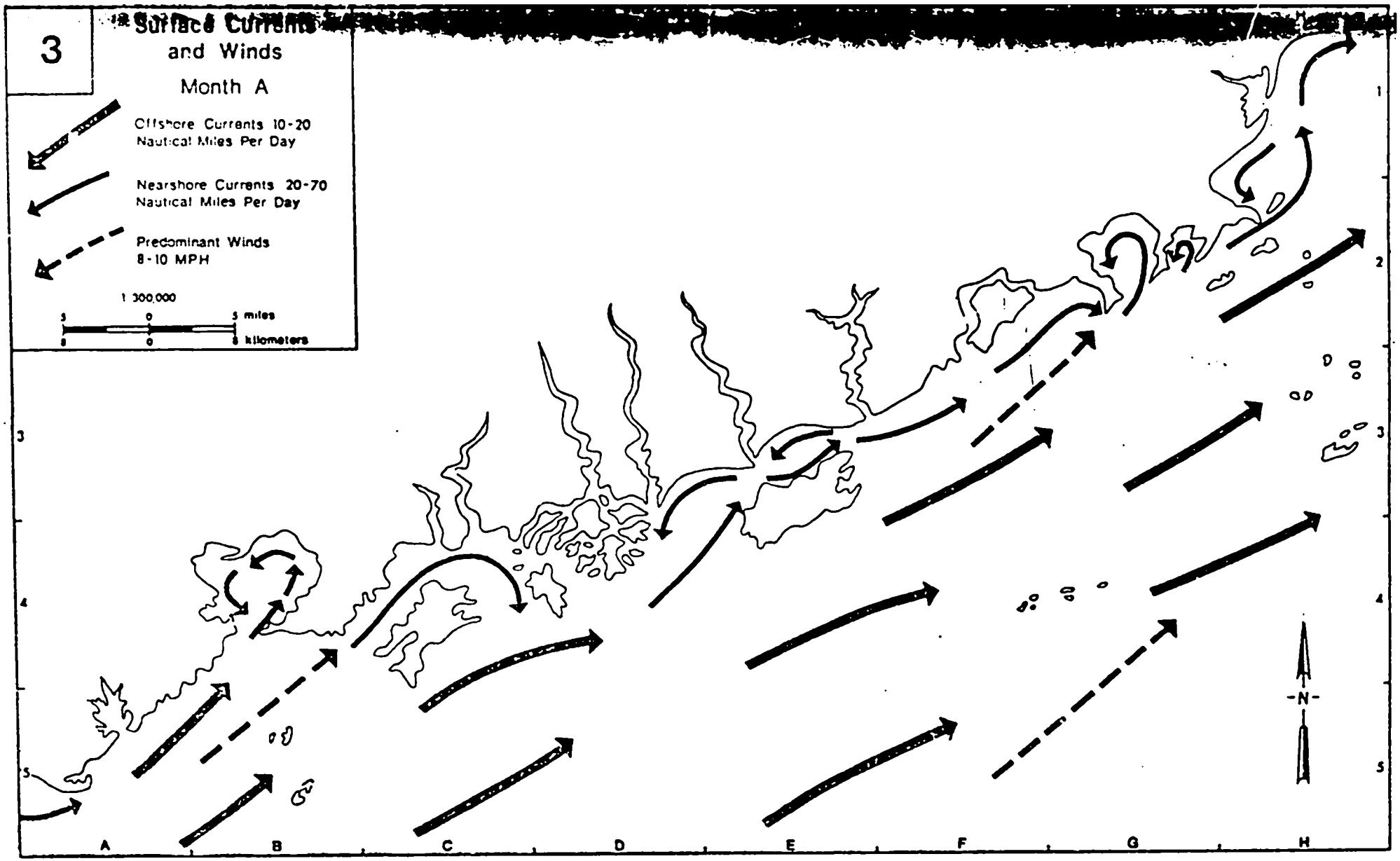
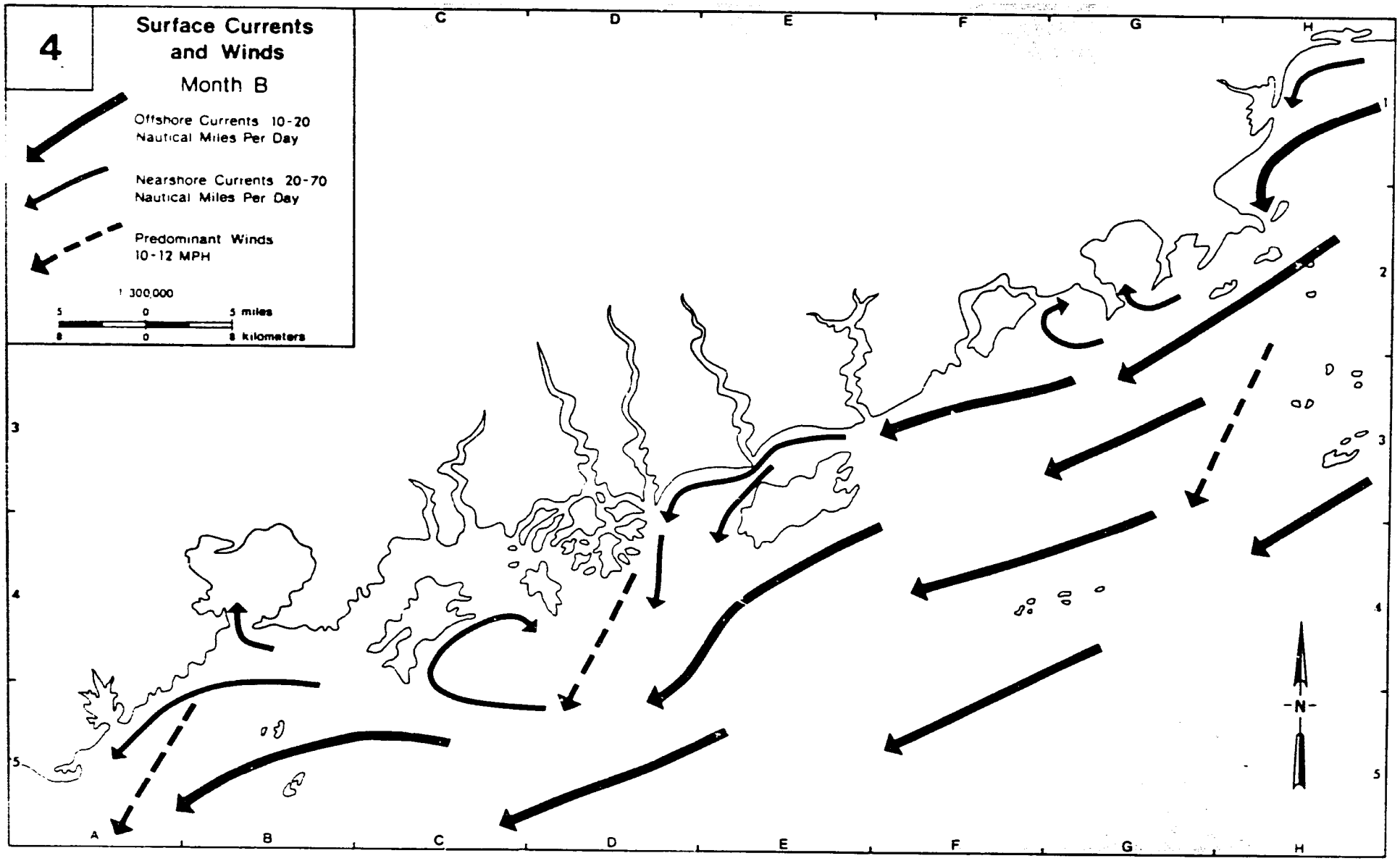

1
Topography
and
Drainage
1 300 000
5 0 5 miles
8 0 8 kilometers
1500m
700m
200m
50m
N
A
B
C
D
E
F
G
H
1
2
3
4
5


2
Water Depths
(meters)
1:300,000
5 0 5 miles
8 0 8 kilometers
A
B
C
D
E
F
G
H
1
2
3
4
5
20
50
200
1000
2000
4000
N


3
Surface Currents
and Winds
Month A
Offshore Currents 10-20
Nautical Miles Per Day
Nearshore Currents 20-70
Nautical Miles Per Day
Predominant Winds
8-10 MPH
1:300,000
5 0 5 miles
8 0 8 kilometers
N
A
B
C
D
E
F
G
H
1
2
3
4
5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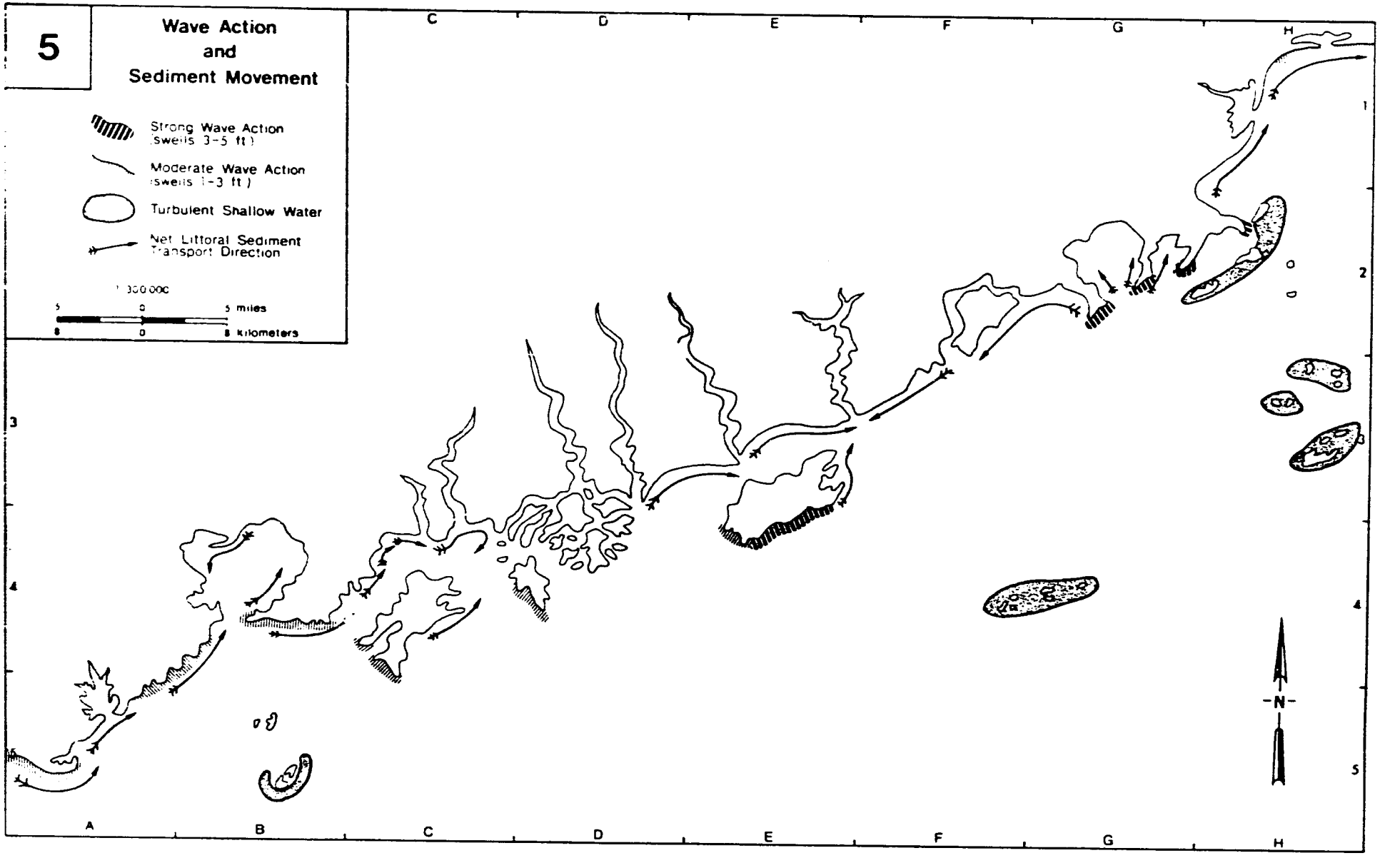
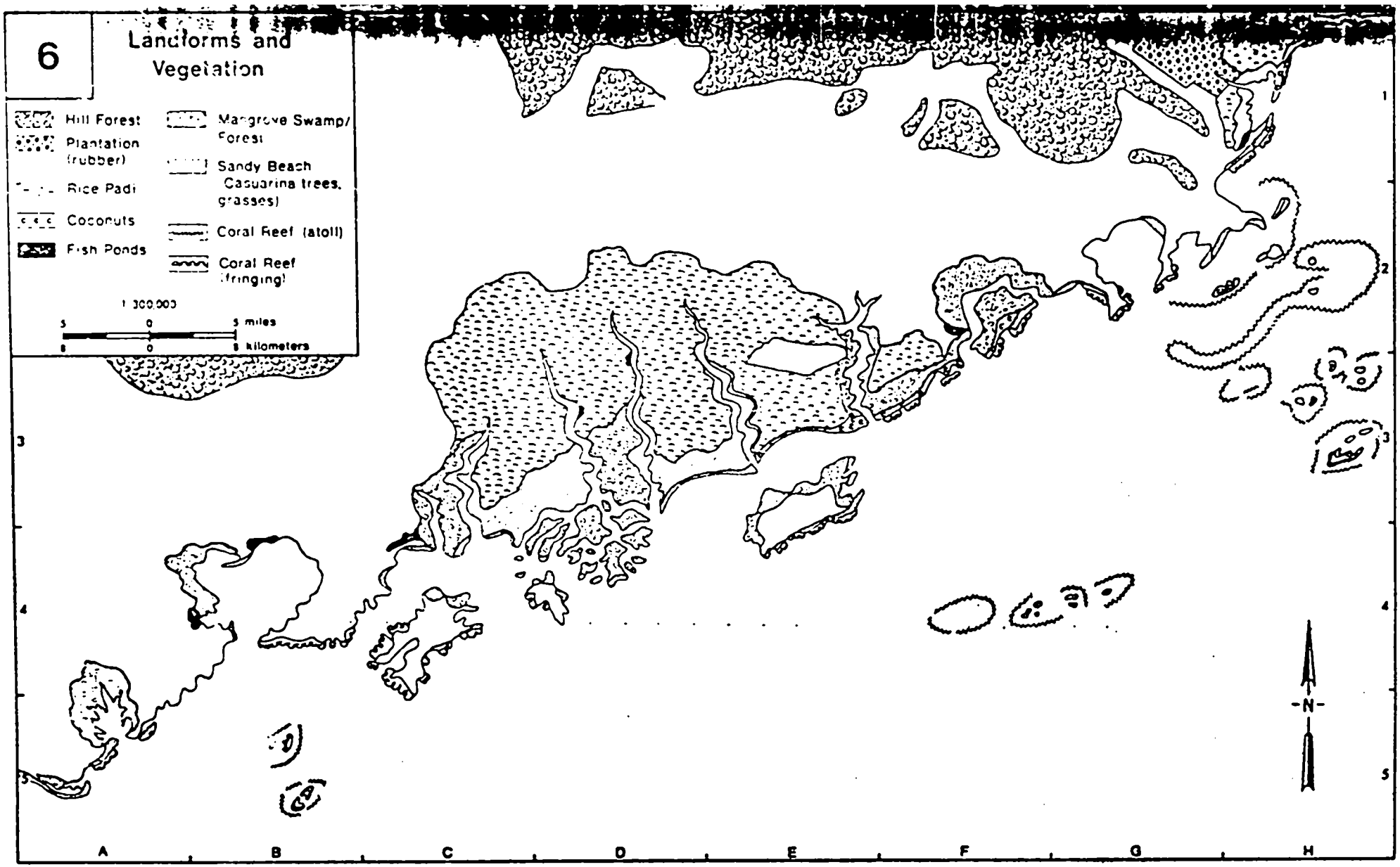
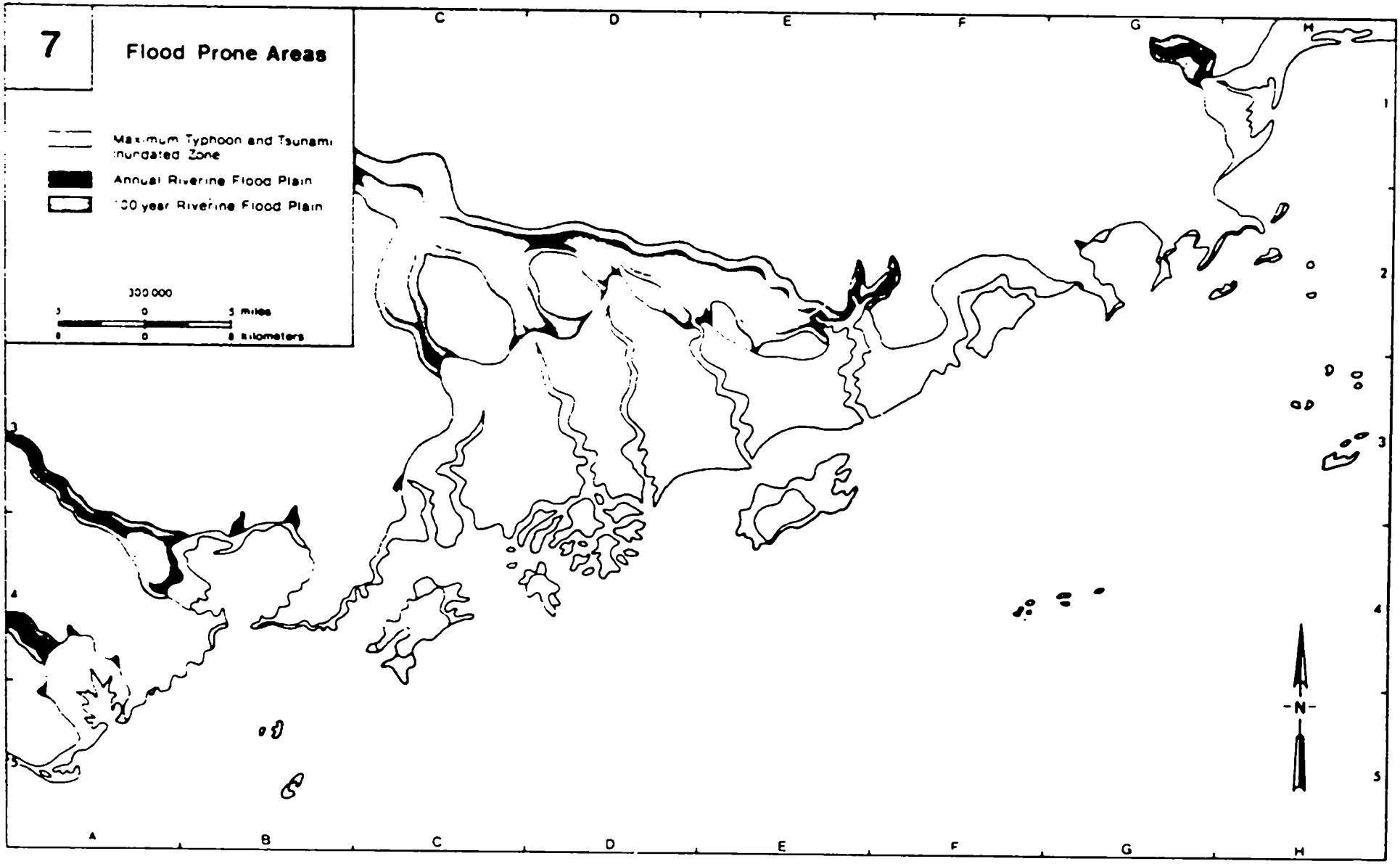
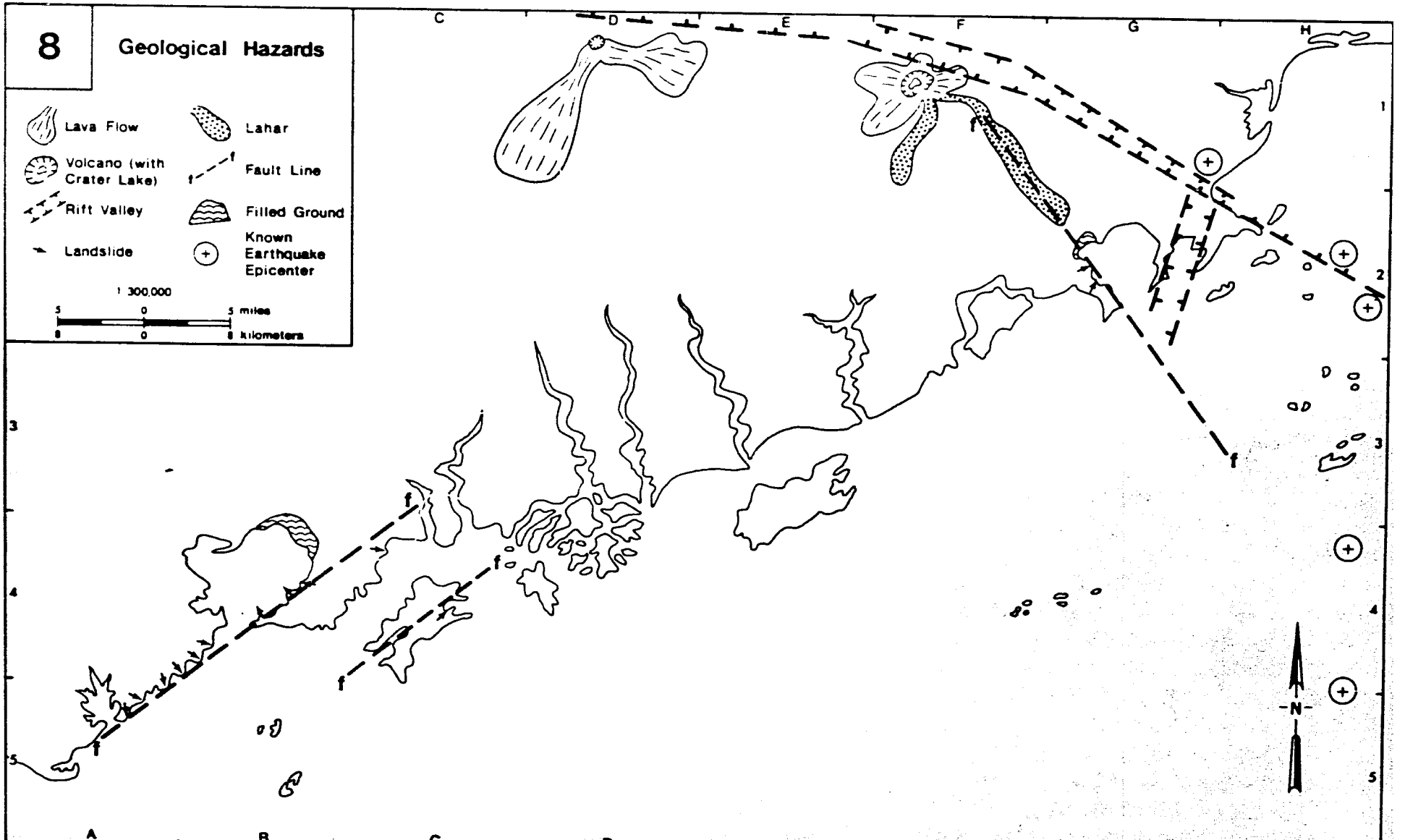
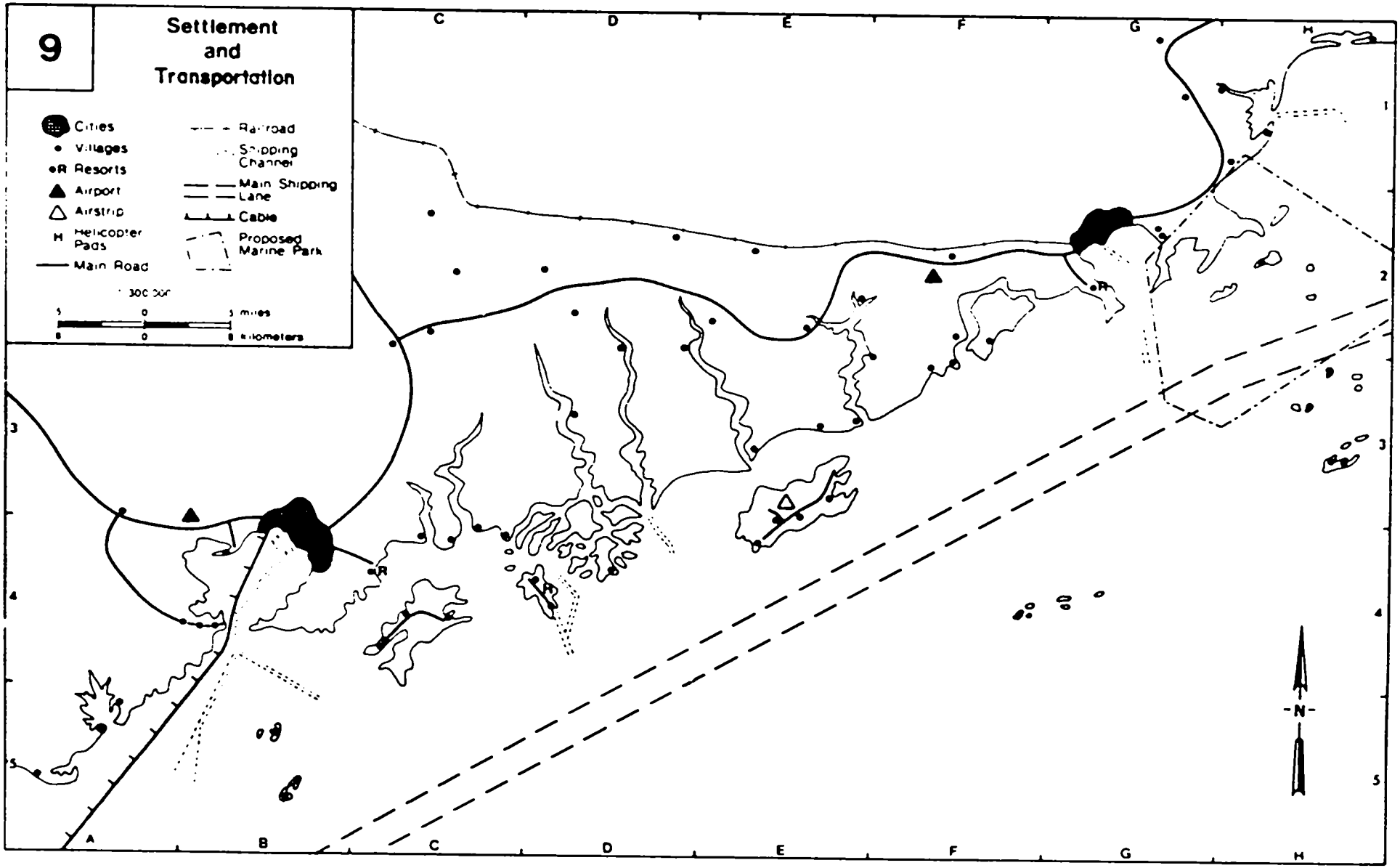
Surface Currents and Winds
Month B
Offshore Currents 10-20 Nautical Miles Per Day
Nearshore Currents 20-70 Nautical Miles Per Day
Predominant Winds 10-12 MPH
1:300,000
5 0 5 miles
8 0 8 kilometers
N
A
B
C
D
E
F
G
H
1
2
3
4
5

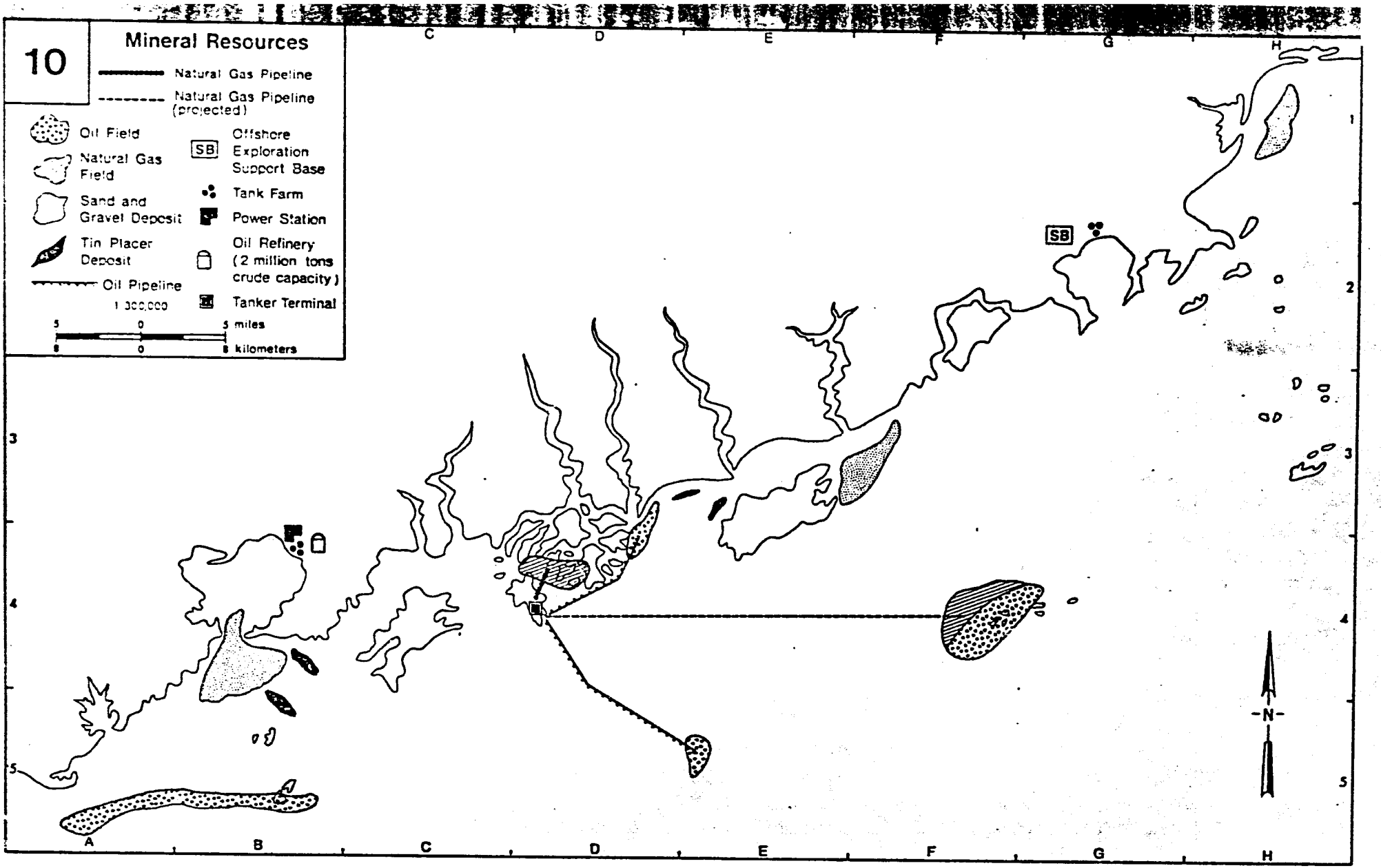

5
Wave Action
and
Sediment Movement
Strong Wave Action
(swells 3-5 ft)
Moderate Wave Action
(swells 1-3 ft)
Turbulent Shallow Water
Net Littoral Sediment
Transport Direction
1:300,000
5 0 5 miles
8 0 8 kilometers
N
A
B
C
D
E
F
G
H
1
2
3
4
5

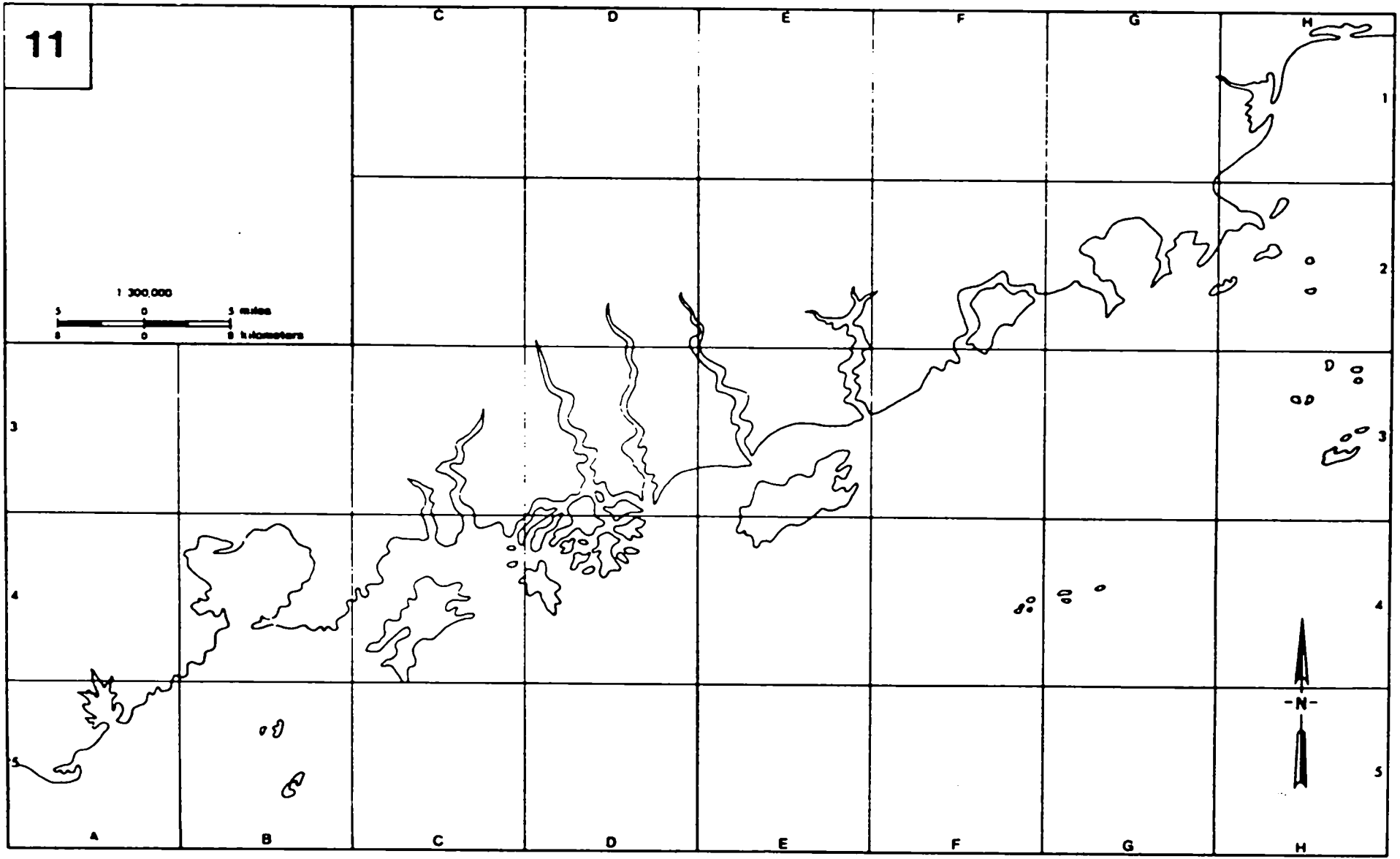

6
Landforms and Vegetation
Hill Forest
Plantation (rubber)
Rice Padi
Coconuts
Fish Ponds
Mangrove Swamp/ Forest
Sandy Beach (Casuarina trees, grasses)
Coral Reef (atoll)
Coral Reef (fringing)
1:300,000
5 0 5 miles
5 0 5 kilometers
N
A
B
C
D
E
F
G
H
1
2
3
4
5


7
Flood Prone Areas
Maximum Typhoon and Tsunami Inundated Zone
Annual Riverine Flood Plain
100 year Riverine Flood Plain
300 000
5 miles
8 kilometers
N
A
B
C
D
E
F
G
H
1
2
3
4
5


8
Geological Hazards
Lava Flow
Lahar
Volcano (with Crater Lake)
Fault Line
Rift Valley
Filled Ground
Landslide
Known Earthquake Epicenter
1 300,000
5 0 5 miles
8 0 8 kilometers
N
A
B
C
D
E
F
G
H
1
2
3
4
5


9
Settlement and Transportation
Cities
Villages
Resorts
Airport
Airstrip
Helicopter Pads
Main Road
Railroad
Shipping Channel
Main Shipping Lane
Cable
Proposed Marine Park
miles
kilometers
N
A
B
C
D
E
F
G
H
1
2
3
4
5


10
Mineral Resources
Natural Gas Pipeline
Natural Gas Pipeline (projected)
Oil Field
Natural Gas Field
Sand and Gravel Deposit
Tin Placer Deposit
Oil Pipeline
1:300,000
Offshore Exploration Support Base
Tank Farm
Power Station
Oil Refinery (2 million tons crude capacity)
Tanker Terminal
5 0 5 miles
8 0 8 kilometers
SB
SB
N
A
B
C
D
E
F
G
H
1
2
3
4
5


11
1 300,000
5 0 5 miles
8 0 8 kilometers
N
A
B
C
D
E
F
G
H
1
2
3
4
5