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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

UNITED NATIONS ENVIRONMENT PROGRAMME

SCS/80/WP/94 (Revised)

The Present State of Mangrove Ecosystems in Southeast Asia and the Impact of Pollution

REGIONAL

SOUTH CHINA SEA FISHERIES DEVELOPMENT AND COORDINATING PROGRAMME
Manila, March 1980

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The Present State of Mangrove Ecosystems in Southeast Asia and the Impact of Pollution
- Regional -

by

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PREPARATION OF THE REPORT

The FAO/UNEP project on "Impact of Pollution on the Mangrove Ecosystem and its Productivity in Southeast Asia - Preparatory Phase", Project No. 0503-79-04, called for the preparation of country status reports on the impact of pollution on mangrove ecosystem and its productivity in Southeast Asia. Selected specialists from the ASEAN countries were then commissioned to prepare these country reports which were subsequently discussed in an Expert's Consultative Meeting, sponsored by the project, held in Manila on 4-8 February 1980. It was necessary to consolidate the data accumulated from the reports into a regional report for the area. Dr. E. D. Gomez, who also prepared the Philippine report, was designated for this task and this paper is based on his work.

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THE PRESENT STATE OF MANGROVE ECOSYSTEMS IN SOUTHEAST ASIA AND THE IMPACT OF POLLUTION

- A REGIONAL SYNOPSIS -

by

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ABSTRACT

This report reviews and synthesizes country reports from Indonesia, Malaysia, the Philippines, Singapore and Thailand describing the state of knowledge on mangrove forests in this region. It describes the mangrove distribution and associations; including the occurrence of other species, both plants and animals, in mangrove areas. The physical and chemical, estuarine and oceanographic conditions of the environment are given as far as data could be found. Environmental pollution data listed are scanty, but relevant information such as kinds and distribution of industries, agricultural land uses and human population concentrations, as possible sources of pollution are described. The report then gives an overview of the most important pollutants in the region, and reviews the actual knowledge of effects on living aquatic resources. It points out the gaps where more knowledge is needed for the understanding of the effects of anthropogenic pressure on the mangrove ecosystems.

1. INTRODUCTION

Coastal environments in Southeast Asian countries are subjected to a variety of stresses resulting mainly from land-based human activities. One of the unique biotopes occurring in tropical countries is the mangrove swamp, fringing mainly estuaries, but also spreading along the coastline, depending on the presence of the requirements for mangrove development. The whole mangrove ecosystem, the mangal, not only the forest as such, offers a huge variety of uses to humans. Not only is the wood of almost every tree species used for many purposes, but also the aquatic environment serves as a rich food source. Being a biotope on the transition zone from marine to terrestrial environment, or ecotone, this ecosystem is very unique and the interrelationships of its component species are extremely complex. Man is far from understanding the functioning of this very special ecosystem, and from knowing which parts of the nutrient cycles, food chains and webs are the most vulnerable in the system as a whole, and which factors can cause interruption of cycles that are vital for the living healthy mangal. However, nowadays one can observe that mangrove swamps are, in some instances, utilized beyond the needs of local people for food, fuel, and construction material. Exploitation culminates in reclaiming land by clearing out forest areas for settlement and construction of fishponds and salterns. Moreover, changed water qualities of rivers through industrial and domestic waste loads of all kinds exert another stress on the mangrove ecosystem.

The main aim of this report is to draw a picture of the known extent of this environmental stress on mangroves in the Southeast Asian countries, more particularly the area of the ASEAN, to describe the various sources, and to discuss whether the stress, caused by contamination can be regarded as pollution. Pollution, it will be recalled, is described by the IMCO/FAO/UNESCO/WMO/WHO/IAEA/UN Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) as:

> "The introduction by man, directly or indirectly of substances or energy into the marine environment (including estuaries), which results in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities, including fishing, impairment of quality for use of sea water and reduction of amenities."

This definition can undoubtedly be extended to mangrove ecosystems. The report depicts the biological situation of mangroves on one hand, and the abiotic environment on the other, describing the natural marine and estuarine environment as well as anthropogenic impacts or the potential changes through development activities. It is more than trivial to state the mangrove as endangered where they are eradicated, but it is worthwhile to look at activities where they have no obvious immediate impact on the ecosystem. This report is based on five country reports[1/] on the same topic.

1/ Dept. of Zool., Sing., 1980; Gomez, 1980; Piyakarnchana, 1980; Sasekumar, 1980; and Soegiarto, 1980

presented to the FAO/UNEP Expert Consultation Meeting, 4-8 February 1980 in Manila, on the Impact of Pollution on the Mangrove Ecosystem and Its Productivity in Southeast Asia. That meeting terminated a preparatory phase of a project that is anticipated to become part of the Regional Seas Programme for East Asia. On the basis of the five country reports a regional comparison and overview is now given, to serve as technical background documentation for further studies within this anticipated project.

2. ENVIRONMENTAL DESCRIPTION

2.1 Extent and location of mangrove in the ASEAN region

2.1.1 Total area by country

The total mangrove area of all the ASEAN countries is estimated at 4 805 081 hectares.

Through intensive surveys and mappings using satellite imageries as well as aerial photographs, the latest data available on the areal extent of mangrove forests in Indonesia is 3.6 million hectares. Of these, about 60% are forest stands (Soegiarto, 1980). These are found growing in sheltered shores along its long 80 791 kilometers coastline and constitute about 1.9% of its land area.

The Philippines and Thailand likewise indicated data obtained from land satellite imageries. The Philippines, an archipelago of some 7 100 islands with an area of 300 838 km^2 has about 220 242 hectares of mangrove forests bordering its 17 360 km coastline. Of these mangrove stands, 146 000 hectares are with closed canopy representing primary and secondary growth conditions and dominated by true mangrove species. In addition, there are some 74 000 hectares of low density/logged over areas (open canopy) representing the preliminary stage of fishponds/salt bed conversion (Biña et al., 1979 MS). The mangrove forests comprise about 0.7% of the total land area.

For Thailand, the data from satellite surveys include both the mangrove forests and mudflats. Of its 514 000 km^2 land area, about 312 700 hectares are mangrove forests. This is about 0.6% of its total land area (Vibulsresth et al., 1975).

The mangrove swamp forests of Malaysia cover an area estimated at 652 219 hectares (Sasekumar, 1980). The mangrove forests constitute about 2% of its land area which is about 333 652 km^2.

In the island republic of Singapore, only small patches of mangrove swamps are left. Most of the mangrove forests are degraded and disturbed. As of 1979, the total mangrove swamp area remaining is about 18.22 km^2 which is about 2.9% of its total land area of 616 km^2 (Dept. of Zool., Sing., 1980).

Macnae (1968) observed that mangrove forests reach their maximum development and greatest luxuriance in parts of Southeast Asia. The estimated 4.8 million hectares of mangrove forests in the ASEAN region attest to this observation. With an area of about 3.6 million, the mangrove forests of

Indonesia constitute a significant 75% of the total for all ASEAN countries. Of the remaining 25%, Malaysia accounts for about 13.6% while the Philippines and Thailand have about 4.6% and 6.5%, respectively. Singapore contributes a small fraction of one percent.

2.1.2 Geographic distribution within countries

The ASEAN region with its tropical climate and long sheltered coastlines is an area where extensive mangrove swamp forests are found. The map (Fig. 1) shows the approximate geographic location and distribution of mangrove areas in the ASEAN region.

Mangrove areas of large and contiguous extent are found fringing the coasts of the entire Indonesian archipelago. Specifically, the mangrove forests are concentrated mainly on the north and south coasts of Irian Jaya. Extensive growths are also found in Sumatra, Kalimantan, and the Molluccas while patches of mangroves dot the islands of Java, Celebes and Nusa Tenggara (Soegiarto, 1980).

Mangrove areas of significant areal extent border the west coast states of Perak, Selangor and Johore in Peninsular Malaysia; along the coastlines and estuaries of the Sarawak River (1st Division), the Rejang delta (6th Division) and the Trusan River (5th Division) in Sarawak and on the eastern coastal belt of Sabah (Sasekumar, 1980).

Extensive mangrove areas are also found in the Philippines and Thailand. Arroyo (1978 a, b) gave the following account of the areal coverage of mangroves with relatively lush growth in the Philippine archipelago.

"Mangroves of large and contiguous extent are found along the northern coast of Panay Island in Capiz and Aklan; along the coastal areas of San Juanico Strait, Janabas Channel, Maqueda Bay, Carigara Bay, and Biliran Island in Samar and Leyte; between Puerto Princesa to Aborlan coastal area fronting Sulu sea, Bahili vicinity Oyster Inlet, Malampaya Sound and parts of northern and southern Palawan mainland, Culion, Linapacan, Dumaran, Rosa, Balabac and the smaller islands along Green Island Bay of the Palawan Group; Pangil Bay area in Misamis; the coastal area fringing Sibuguey Bay, Margosatubig to Pagadian area fronting Moro Gulf and Illana Bay and the Island of Olutanga and Sacol in Zamboanga del Sur and Basilan Province; the coastal area from Polloc Harbor to Barrio Linek in Cotabato; and in the Sulu Island Group that includes the islands of Tongguil, Balangiungin, Simisa, Bongao southern Tawi-Tawi, southern Jolo, eastern Pata, Cabingaam, Siasi, and Lapac."

While mangroves are found on many islands, better stands are to be found in the south since much of Luzon's mangroves have been reclaimed for other purposes.

In Thailand, the mangrove forests are concentrated in Region 4 on the coast of Andaman Sea (part of the Indian Ocean). Mangrove forests of significant extent are found along the eastern part of the Gulf of Thailand. Small patches of mangroves border the coast on the uppermost part of the Gulf of Thailand (Piyakarnchana, 1980).

In Singapore, most of the mangroves are found on the northern part of the island fringing the southern shore of the Johore straits. There is hardly any mangrove left on the southern coast of the main island and except for a few small patches, the mangroves found on the northwestern shores of the main island are practically all reclaimed or impounded. Of the remaining mangrove swamps, about two quarters occur on the two northeastern islands of Tekong and Ubin. The relatively undisturbed mangroves are located at Pulau Ubin and Pulau Tekong. Also, relatively unaffected swamps border the north-eastern shores along the estuaries of Punggol, Serangoon and Selatar. Patches of mangroves are still found on three southern islands namely Pulau Semakau, Senang and Pawai (Dept. of Zool., Sing., 1980).

The breakdown of mangrove areas by country according to the latest available data is given in Table 1.

2.1.3 Description of mangrove associations

The mangrove forest is such a very complex and diverse ecosystem that different classifications have been given to describe the types of associations existing in it.

One classification given is the classic study of the effect of submergence and salinity on the species composition of the mangrove trees in Cilacap, Indonesia by Haan (1931) as cited by Soegiarto (1980). Haan distinguished six different classes as follows:

Class 1: Range of salinity 10-30 o/oo; the ground is submerged once or twice daily at least 20 days per month; the species of Avicennia or Sonneratia on new soft ground or Rhizophora on hard ground form the outer zone.

Class 2: Range of salinity 10-30 o/oo; the ground is submerged 10-19 days per month; Bruguiera gymnorrhiza grows well; forming the middle zone.

Class 3: Range of salinity 10-30 o/oo; the ground is submerged 9 days or less per month; species of Xylocarpus and Heritiera grow here; forming the third zone.

Class 4: Range of salinity 10-30 o/oo; the ground is submerged a few days in a year only; species of Bruguiera, Scyphiphora and Lumnitzera grow well in this inner zone.

Class 5: Salinity 0 o/oo; the ground is affected very little by tides.

Class 6: Salinity 0 o/oo; the ground is affected by water level only during the wet season.

Classes 5 and 6 represent the trasitional zones to the freshwater swamps behind the mangrove forest. In this zone grow species of Cerbera and Oncosperma.

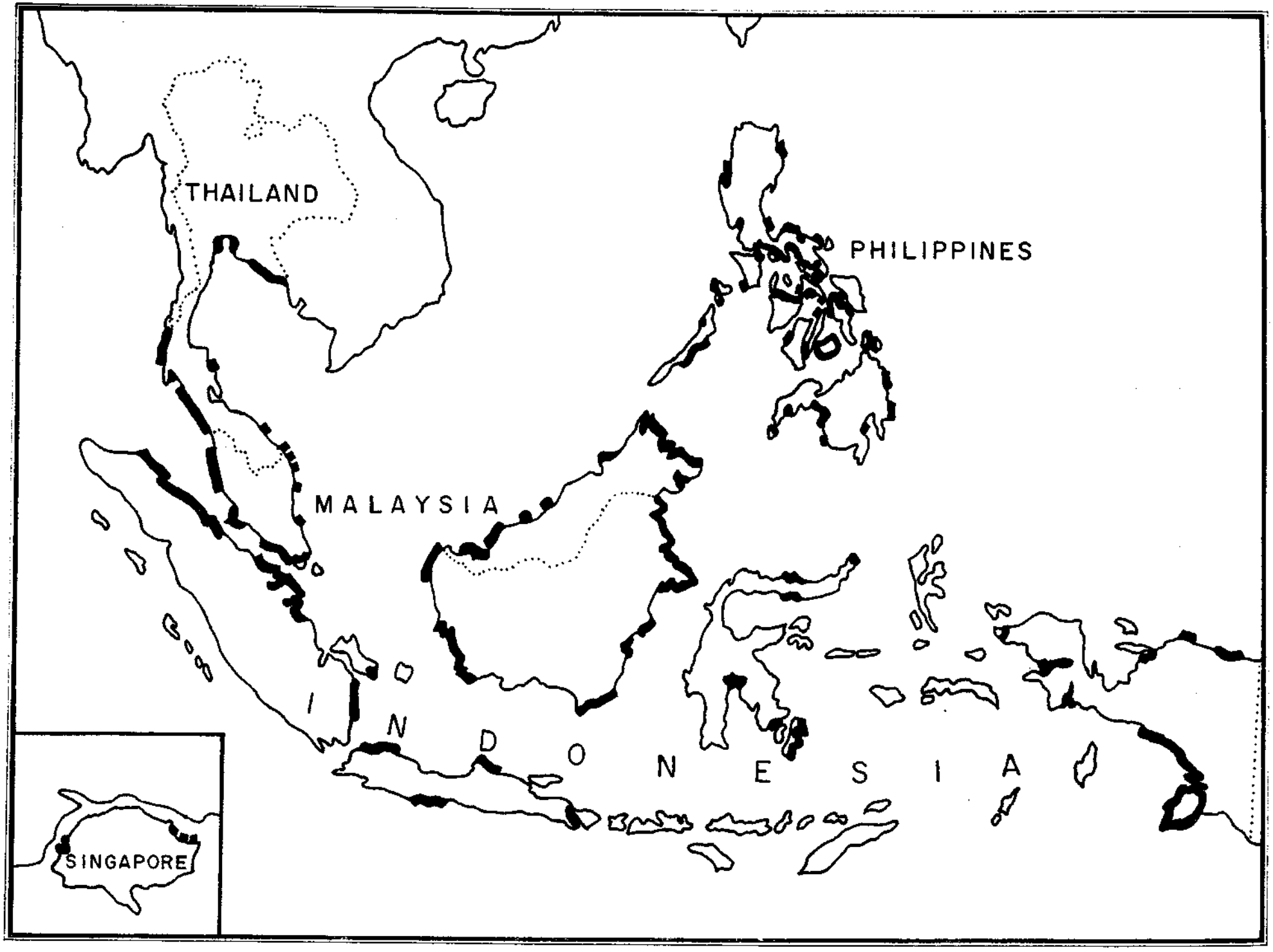


Fig. 1 Mangrove areas in the ASEAN region

Table 1. Areal distribution of mangrove forests in the ASEAN region (in hectares)

1. Indonesia	
Sumatra	397 000
Java	40 400
Kalimantan	90 000*
Celebes	53 000
Molluccas	100 000
Irian Jaya	2 934 000
Nusa Tenggara	3 700
T O T A L	3 618 100
2. Malaysia	
Peninsular Malaysia	113 260
Sarawak	173 614
Sabah	365 345
T O T A L	652 219
3. Philippines**	
Luzon and Palawan (Regions I-V)	61 708
Visayas (Regions VI-VIII)	38 467
Mindanao (Regions IX-XII)	120 066
T O T A L	220 242
4. Singapore***	
Main Island	2 385.51
Offshore Islands	41.12
Pulau Ubin	224.19
Pulau Tekong	558.89
T O T A L	3 209.71
5. Thailand****	
Region 1 (Eastern part of Gulf of Thailand)	47 900
Region 2 (Uppermost part of Gulf of Thailand)	27 300
Region 3 (Western side of Gulf of Thailand)	45 800
Region 4 (Coast of Andaman Sea)	191 700
T O T A L	312 700

* Preliminary data after Wiroatmodjo and Judi, 1979 in Soegiarto, 1980. The latest data is 120 000 hectares.

** This does not include area covered with clouds (Biña et al., 1979 MS) on satellite imagery.

*** Data as of 1978, recently reclaimed areas not included. Estimated total mangrove area as of 1979 is 1 820.0 hectares (Dept. of Zool., Sing., 1980).

**** Data from satellite survey including the mangrove forests and mudflats (Vibulsresth et al., 1975).

Several other classifications of mangrove associations have also been reported (Malaysia - Berry, 1972; Philippines - De la Cruz and Banaag, 1967; Banaag, 1972; Arroyo, 1978; Fortes (in press); Thailand - Piyakarnchana et al., 1978, Aksornkaeo et al., 1979). These were based on the dominant species of plants that grow from the outer edge to the inner zone of the mangrove forest. A typical example is given by Arroyo (1978) from Brown's description of mangrove zonation as follows:

I. Growing along exposed coral reefs

1. Rhizophora group
2. Sonneratia group
3. Avicennia group

II. Along inland edges and higher ground

1. Avicennia group
2. Lumnitzera
3. Aegiceras group
4. Xylocarpus group
5. Heritiera littoralis
6. Acrostichum aureum
7. Acanthus group

III. Along or close to water channels

1. Rhizophora group
2. Nypa fruticans

IV. In open bays

1. Sonneratia group
2. Avicennia group

This pattern of vegetational distribution also exists even in a heavily exploited and depleted mangrove forest as reported from the latest survey made on the Mangrove Experimental Forest in Palsabongan, Pagbilao, Quezon (Gomez, 1980).

No specific classification has been universally adopted by the countries in the region.

2.1.4 Enumeration of mangrove species

The floral composition of the mangrove forests of the five ASEAN countries is given in a comparative list (Table 2) compiled from papers cited in the country reports: Indonesia - Kartawinata et al., 1979); Malaysia - Chia, 1975; Wyatt-Smith, 1964; Liew, 1977 in Sasekumar, 1980; Philippines - Arroyo, 1978; Dept. of Zool. Sing., 1980; and Thailand - Sahavacharin and Boonkerd, 1976; Smitinand, 1976; Sripon and Thamathaworn, 1976.

This table is not meant to be exhaustive. Some gaps in knowledge of floral components are obvious and should not be taken to mean the absence of groups from the mangrove vegetation.

Following the Arulchelvan classification of plant association in the mangrove forest (Arroyo, 1978b), the "True Mangroves" are represented by the families: Rhizophoraceae, Verbenaceae, Sonneratiaceae, Arecaceae, Maliaceae, Combretaceae, Euphorbiaceae, Rubiaceae, and Aegiceratataceae. While the "Mangrove Associates", those which are composed of species associated with the former are represented by the families Sterculiaceae, Meliaceae, Pteridaceae, Acanthaceae, Cesalpiniaceae, Fabaceae and others.

Another group of "Mangrove Associates" found in the mangrove forest are the algae. Lewmanomont (1976) in her study of the algal flora of the mangrove forests in various parts of Thailand divided these algae into two types based on their habitats. The first group were those that attached to the trunk or the roots of mangroves. The second group were those that grew on the mudflat or on sandy-mud areas. Lewmanomont's studies showed that the mangrove roots support the red algae Catenella, Bostrychia, and Murrayella. In the muddy areas, the genera of red algae reported are Laurencia, Gracilaria, Hypnea, Centoceros and Polysiphonia. Also reported to be found in mudflats are the green algae in the genera Enteromorpha, Cladophora, Rhizoclonium, Bryopsis, Ulva, Avrainvillea, Halimeda, and Caulerpa, the brown algae of the genera Ectocarpus, Dictyota and Padina, and two genera of blue green algae: Lyngbya and Symploca. Lewmanomont further reported three genera of submarine flowering plants that are commonly found in the mangrove forests: Halophila, Enhalus, and Cymodocea.

In Malaysia, blue greens and green algae form a large group in the mangrove forest. The bundles of long Microcoleus filamentous colonies were common. Attached algae such as Enteromorpha, Cladophora, and Bulbochaete were also present (Sasekumar, 1980).

Among the algae found in the mangrove forest of Singapore, the green ones form the largest group. They are the genera Capsosiphon, Caulerpa, Cladophora, Lola, Urospora, Derbesia, Pleurococcus, Enteromorpha, and Ulva. Likewise reported are the red algae in the genera Caloglossum, Bostrichium, and Laurencia and at least two genera of brown algae: Ceratium and Peridinium which are microflora (Dept. of Zool., Sing.,1980).

In the Philippines, Fortes (1975) in his study of the algae associated with mangrove trees in Puerto Galera, Oriental Mindoro reported a total of 72 species belonging to 35 genera, 13 orders and four phyla amongst which 22% of the total number are Cyanophyta, 26% Chlorophyta, 6% Phaeophyta, and 46% Rhodophyta. In another study, Cordero (1978) listed 48 mangrove-associated algal species from Aklan province.

Benthic microflora are also abundant in mangrove forest. Sasekumar (1980) lists the centric diatoms Coscinodiscus, Cyclotella, Actinoptychus, Endictya, Biddulphia, and Melosira. A rich assortment of pennate diatoms belonging to numerous genera and species were present. These include Nitzschia, Navicula, Pleurosigma, and Gyrosigma. Colonial forms include Asterionella and Thallasiothrix.

The euchlorophytic phytoplankton found in the mangrove forests of Singapore include a listed total of 29 species belonging to 13 families, the largest of which is the family Coscinodiscaceae (Dept. of Zool., Sing.,1980)

No data are available for Indonesia, Philippines and Thailand.

2.1.5 Zoological communities in mangroves

The zoological communities of the mangrove forest may be described under three zones as affected by the type of substratum and duration of immersion by tidal waters: (i) mudflat faunal community; (2) lower shore faunal community; and (3) high shore faunal community.

Mudflat faunal community

The substratum of mudflats consists mostly of silt and clay, and has a water content of more than 55% by weight. The conspicuous animals here are crabs belonging to the genera Macrophthalmus and Metaplax. Mud-skippers are common. Mudflats in the states of Perak and Selangor, Malaysia are utilized for the semi-culture of the edible cockle Anadara granosa (Sasekumar, 1980).

Piyakarnchana (1976) in his study of the intertidal mudflat community at Ang Sila, Cholburi, Thailand, showed that there are seasonal differences in the composition and abundance of intertidal organisms. The highest values of total biomass were found during the months of December and January. This seasonality may be due to the presence of what Motoh and Solis (1978) termed as seasonal residents, or species which spend the juvenile or sub-adult stages in the mangrove and estuarine areas. In addition to these seasonal residents, Motoh and Solis (1978) in their study of the decapod crustacean fauna in the mangrove and estuarine areas in Panay Island, Philippines further described two other groups that inhabit the area: (1) residents, species which spend their whole life in the mangrove and estuarine areas, (2) casual migrants, species which usually appear in the area. The listing of the species thus classified appears in Table 3.

Lower shore faunal community

This zone which is inundated at all high tides is characterized by the presence of fauna encrusted on the lower stems and roots of trees. Dense populations of barnacles and oysters are found in this zone. Living amongst the assemblage of encrusting animals are many small crabs and polychaetes (such as Perinereis vancaurica). The carnivore gastropod Thais tiaioti preys on the encrusting animals, particularly the oysters (Sasekumar, 1980). Other gastropods are also found in this zone, crawling on the encrusted animals or on the wet soil.

A notable number of corals has been found growing on the roots and stems of mangrove trees in some localities. These include the genera Pocillopora, Millepora, Tubastrea, Barabattoia, Fungia, and Favia (Montecillo and Rosito, 1979). Piyakarnchana et al. (1979) also observed the presence of the horse-shoe crab (Carcinoscorpius rotundicauda) in this zone of the mangrove forest located at the river mouth of the Mae Klong River in Thailand.

High shore faunal community

As one enters the higher shore area, the most striking change noticeable is the disappearance of the encrusting fauna on the lower stems. Instead, the tree dwelling fauna of the high shore area consist of Littorina scabra, Nerita articulata, Cerithidea cingulata, Cerithidea obtusa, Cassidula aurisfelis, Ellobium aurisjudae, Morula fiscella, Cassidula nucleus, Phythia sp.,

and the slug Onchidium. Many of these feed or graze on the soil surface and are deposit feeders. The arboreal gastropods Cerithidea obtusa and Cassidula nucleus and the pulmonates of the family Ellobiidae are capable of efficient aerial respiration (Houlihan, 1979; Reyes, 1979).

On the soil surface live mostly snails and crabs. Apart from the tree living gastropods that occur on the soil, there are the common Assiminea brevicula (a hydroid) and some members of the family Elloddidae.

Burrowing in the soil are many species of crabs belonging to the families Ocypodidae and Grapsidae. The common fiddler crabs are Uca triangularis and U. rosea. More than 10 species of grapsids occur in the higher shore, most of these are deposit feeders. One of the most common species is Chiromanthes onychophorum which plays a significant role in mangrove leaf degradation to detrital - sized particles (Malley, 1978).

The mudlobster Thalassina anomala is conspicuous in landward edge forests where it builds volcano-like mounds up to a meter high. In Malaysia, Thalassina is considered a minor pest since its burrowing activity damages bunds that keep sea water ingress into reclaimed areas (Varuges, 1978).

Polychaetes such as Leiechrides australis and the sipunculid Phascolosoma arcuatum may be abundant. A bivalve Polymosoda (Golvina) occurs in low number, characteristically half buried in mud, and is capable of aerial respiration (Morton, 1976).

Of the fishes, the mudskipper Periopthalmus sp. is found abundant on the swampy forest floor. Others which were caught only within the mangrove areas and therefore considered as mangrove dwellers include Holocentrus spinifer (Holocentridae) and Alutera monoceros (Tetraodontidae) and Dallia sp. (Umbridae) (Rosaroso, 1979).

There is normally a large amount of fallen logs and the tree stumps in the mangrove forest. These are colonized by teredinid bivalves (shipworms) or gribble Limnoria lignorum and a host of small crabs and gastropods (Berry, 1972).

2.1.6 Enumeration of the important fauna

A comparative list of the more common fauna found in the mangrove forests of the five ASEAN countries is given in Tables 4a, 4b, and 4c. The tables were compiled from papers cited in the country reports: Indonesia - Kartawinata et al., 1979 in Soegiarto (1980); Malaysia - Sasekumar, 1980; Philippines - Gonzales, 1977, Ronquillo and Llana, 1979, Reyes, 1979; Singapore - Dept. of Zool., Sing., 1980 and Thailand - Frith et al., 1976. For this report, the only animal groups tabulated are the crustaceans, molluscs and fishes.

The country paper of Singapore (Dept. of Zool., Sing., 1980) presented a comprehensive account of the mangrove fauna belonging to various animal groups.

For the other countries, it was observed that local papers and studies on the mangrove fauna are wanting.

2.2 Agriculture, fishery, industry, population

2.2.1 Agricultural land use

Southeast Asia is basically an agricultural region, although the ASEAN countries are developing towards industrial economics. Singapore is exceptional, being more of a trading and industrial centre.

A considerable part of Southeast Asia is still covered with forest. Fig. 2 is a land use map for the Philippines which may exemplify prevailing conditions in the four larger countries of ASEAN. The arable lands are used for growing rice, corn, coconuts, sugarcane, abaca, tobacco, coffee, and other crops. Thailand is a major exporter of rice in the world. The other countries export coconut products, tobacco, palmoil, hemp, rubber, sugar, etc.

2.2.2 Type and distribution of industrial centres

Singapore is the most industrialized country in the region considering its area of only 616 square miles compared to the other countries. The industries of Singapore include shipbuilding, oil refining, electronics, food processing and other light industries (World Almanac, 1979). The industrial regions of Singapore include Jurong, Sembawang, Kallang, and Chawan-Merlimau Islands (Dept. Zool., Sing., 1980), as shown in Fig. 3.

Thailand and Malaysia are top producers of tin in the world. Thirty-five percent of the world's output comes from Malaysia while Thailand is the fifth largest producer of tin (World Almanac, 1979). Thailand mines tin on the Andaman Sea coast areas off Phuket Island and Phangnga Bay and Ranong.

Of the 65 000 factories of various industrial branches in Thailand, about one-fourth are located in the greater Bangkok region. The rest are scattered in other provinces. The other industries of Malaysia include the production of palmoil, rubber goods, fertilizers, and pottery. The west coast of Peninsular Malaysia is more industrialized than Sabah and Sarawak (East Malaysia), where some industries aggregate at the five major cities along the coast (Fig. 4).

The coastal industrial estates of Indonesia include Pulau Gadung in Jakarta, Gresik, and other parts of Surabaya, Cilacap in the south coast of Central Java, and around the city of Medan in North Sumatra (Soegiarto, 1980).

Factories in the Philippines are highly concentrated in the Metro Manila region. The rest are distributed throughout the islands of the Philippines, but mostly along the coasts.

2.2.3 Fishing area, known spawning grounds

Southeast Asia is composed of countries with extensive coastlines. The Philippines and Indonesia have the longest coastlines owing to their archipelagic nature. In the Philippines, the major fishing grounds are generally located near areas bordered by mangrove swamps.

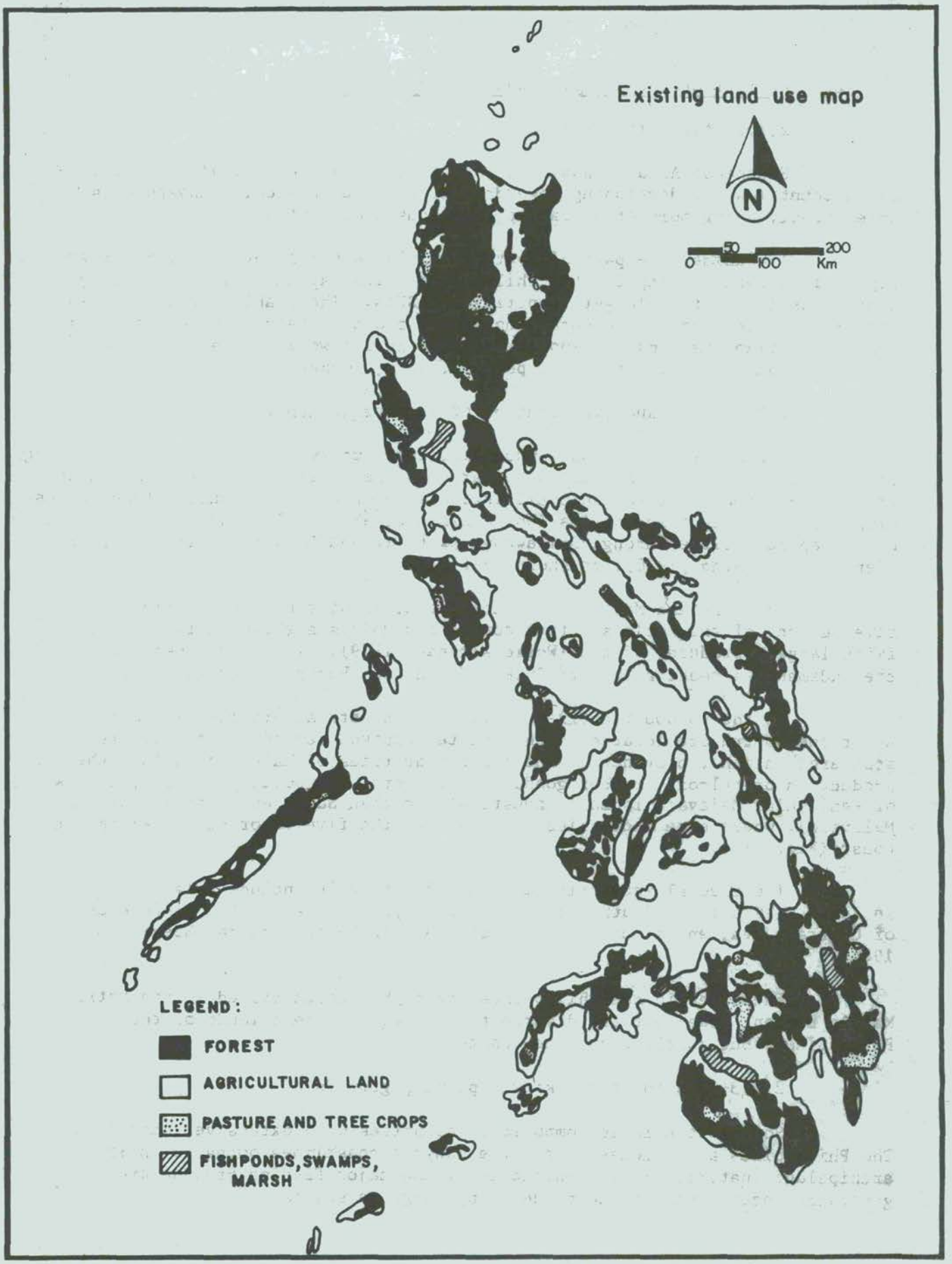


Fig. 2 Existing land use map of the Philippines

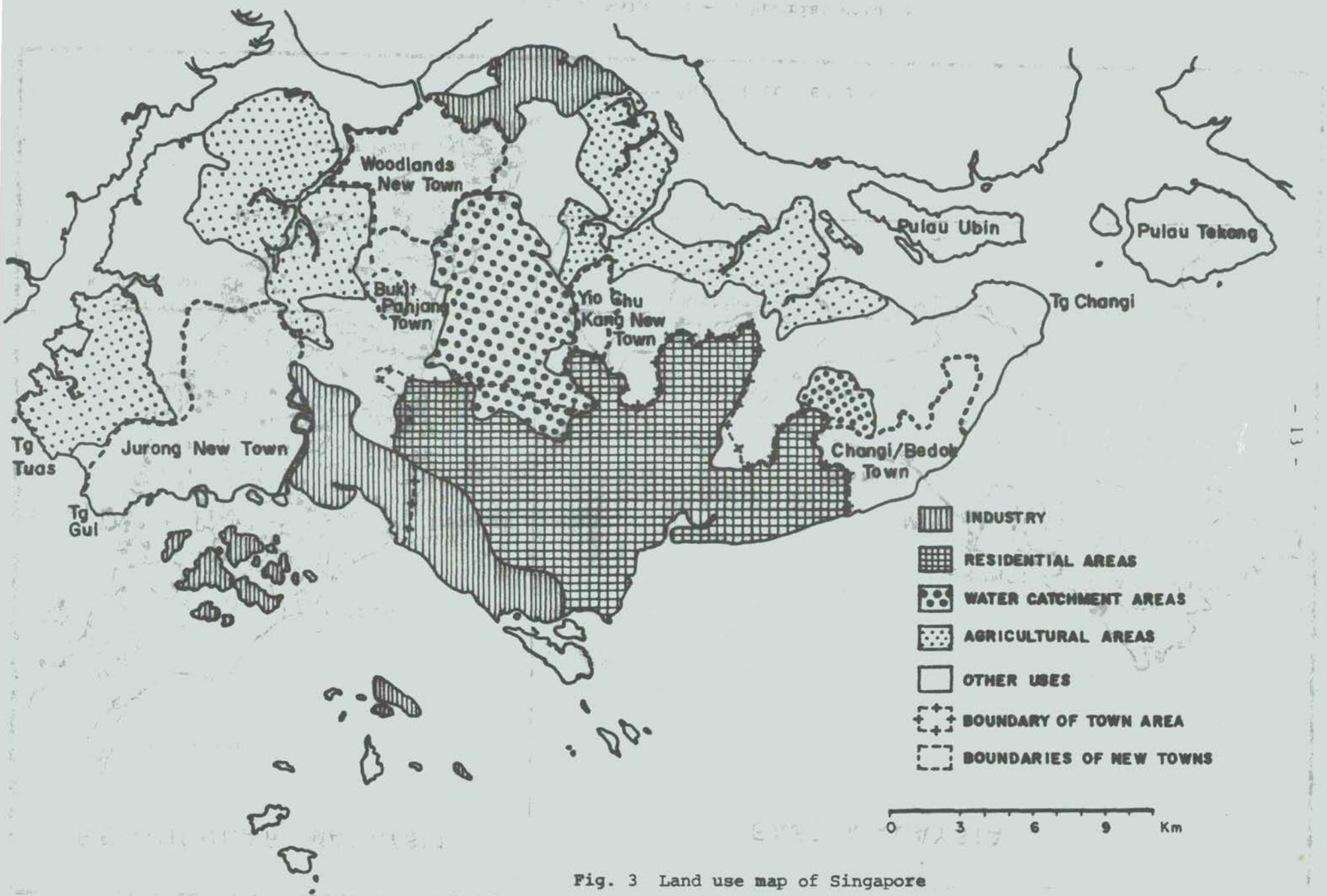


Fig. 3 Land use map of Singapore

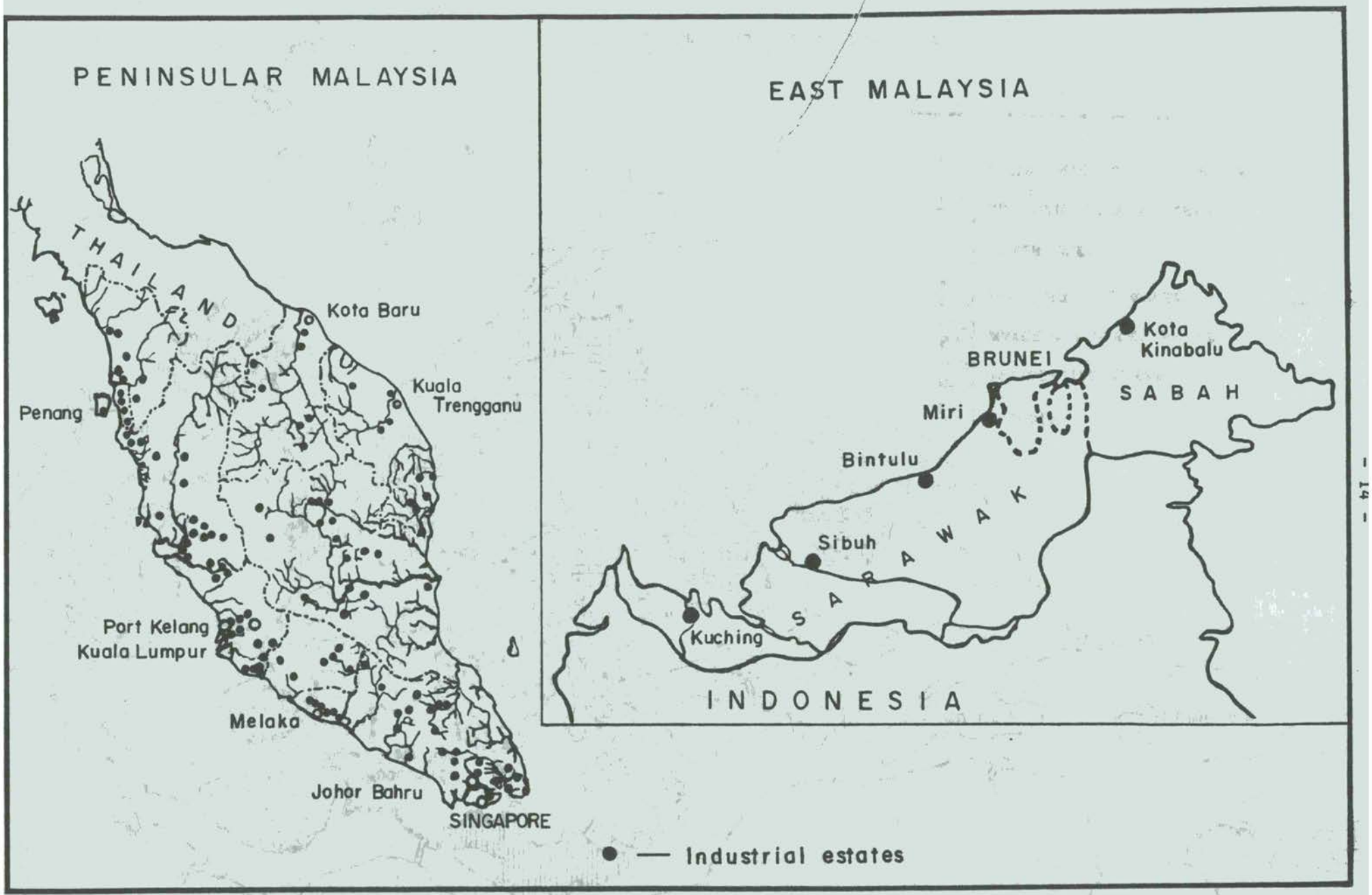


Fig. 4 Malaysia - Industrial estates

It appears that there is no coastal water in Southeast Asia that is not fished. Some of the fishes found in these coastal waters are believed to be dependent on mangroves for at least part of their life cycles. Mangrove swamps are also feeding grounds of many coastal fishes (Christensen and Delmendo, 1978).

The relationship of the mangrove ecosystem to fisheries is indicated in the following references.

Chong (1979) observed that post-larval penaeids migrate into the mangrove inlet (Sg. Semanta Besar) and reside therein for three months.

Phatia (1976), Suntarotok et al. (1976) and Chuensri et al. (1976), noted that the horse-shoecrab (Carcinoscorpius rotundicauda) spawn in the mud-flat area at Cholburi Province, the fry of seabass (Lates calcarifer) and milkfish (Chanos chanos) and larvae of shrimps are abundant in the mangrove forests in the Andaman sea coastal provinces and at Prachuab-Khirikhan Province.

Macnae (1974) reviewed the situation around the Indian Ocean and compared shrimp landings with mangrove areas. He concluded that Penaeus indicus, P. merguiensis and P. monodon depend on mangrove forests for shelter during their juvenile stages, that P. semisulcatus and P. latisulcatus live as juveniles in sea grass beds, that P. japonicum is mangrove intolerant, and finally that most species of Metapenaeus depend on mangrove creeks, back-waters and lagoons.

Inspite of difficulties, a correlation between shrimp landings and mangrove areas has been found in Indonesia (Martosubroto and Naamin, 1977) and between landings of penaeid shrimps and area of intertidal vegetation for 27 locations around the world (Turner, 1977 in Christensen, 1979a).

2.2.4 Areas of reclamation of mangrove forests for other uses (plantation, agriculture, industrial, housing areas)

Singapore is a typical example of a formerly mangrove forested and swampy country that was converted into an urbanized and industrial nation. Ten to twelve percent of the total land area of Singapore used to be mangrove, today, only 3% remains, and reclamation of these remaining areas is still going on (Dept. Zool., Sing. 1980).

The mangrove forests were cleared and swamps filled to locate industries, housing projects, plantations, fishponds, and drainage systems. Their swamps serve as dumping sites of refuse.

Estuaries like Kranji, Tengeh, Pasir Laba, Bajau, Berih and Poyan, Murai and Serimbun were dammed to form freshwater reservoirs for industrial and agricultural use.

Suburban estates modify the mangrove ecosystem for health reasons by spraying oil in the swamps to check infestation of anophelene mosquitoes which bring malaria.

The following short history of mangrove reclamation in Singapore is taken from the Singapore country report.

Kallang Basin was reclaimed for a civil airport from 1931-1937. Swamp Changi was developed for Royal Artillery Batteries in 1928. By 1938 the Sembawang naval base was completed together with Tergah, Selatar and Sembawang aerodromes which were built along the banks of the respective rivers. Sembawang and central parts of Jurong were cleared for industrial developments. The southwest coast from Tuas to Tanjong Gul followed in 1953. Mixed cultivation took place in Tampines and S. Selerang. Jurong was made an industrial estate. P. Samulun and P. Damar Laut were converted to shipyards, S. Pandan to Tanjong Tuas followed in 1967. Most swamps in the islands of Chawan-Merlimau group off Jurong were reclaimed for industrial use. The remaining mangrove areas of Kallang Basin were reclaimed for housing and industrial estates in 1967. A part of Kranji estuary was developed for saw-milling industry. Thus, over the past 150 years the mangrove areas of Singapore were greatly reduced. Chua (1975) noted a staggering rate of reclamation, 5.2 square kilometers per year, in the recent past.

In Malaysia, it appears that the major use of mangrove-reclaimed land is agriculture - mainly for coconut plantations and oilpalm plantations. Extensive areas of mangrove have been reclaimed in the states of Selangor, Penang, and Johor during the last decade. In Selangor state, about 25% of the total area of mangrove forests have been reclaimed in the last ten years. The major part of the remaining major mangrove forests in Selangor is now confined to the few offshore islands. Those on mainland Selangor are being continuously reclaimed. Only 58% of the total average as of 1963 remains. Rice cultivation on reclaimed areas in Merbok estuary was a failure and now has been recommended for conversion in part into fishponds which covers some 400 acres (160 ha). Reclamation for aquaculture will continue in the Merbok estuary region (Sasekumar, 1980).

By 1980, a major power station is expected to be built in the mangrove forests north of Port Kelang Harbour. The station will cover 600 acres (240 ha) (Sasekumar, 1980).

Tin mining appears to be the greatest reclaimer of mangrove forests in Thailand. The Government has granted a mining concession in the mangrove forests amounting to 236 000 rai[1/] (38 000 ha) in Ranong, Phangnga, and Phuket provinces. In addition, 65 957 rai (10 638 ha) have been devoted for salt farms in the mangrove areas and mudflats of six provinces in Thailand. In Satul (close to Malaysian border, west coast), 1 800 rai (290 ha) and 250 rai (40 ha) of the mangrove forest will be used for town expansion and fishing pier construction, respectively. Nakhon Sithammarat (150 km north of Songkhla) needs 100 to 200 rai (16-32 ha) of mangrove areas for fishing pier and fishmeal plants (Piya-karnchana, 1980).

Rabanal et al. (1977) report that there are 4 856 hectares of mud-flats in some four Thai provinces that were probably converted into mangrove swamps for mollusc culture.

1/ 6.2 rai = 1 hectare

In Indonesia, the two five-year development plans of the state revealed the conversion of some 200 000 hectares of tidal forest for agricultural lands in 1969-1974 and an additional 500 000 hectares for ricefield, fishponds, and other production purposes in 1974-1979.

The Cilacap area, an industrial complex on the southern coast of Central Java, has an oil refinery, ferro-sand mining, oil terminals, a fishing port, and an open ocean port. This complex is near 23 000 hectares of mangrove forest which is considered to be largest in Java. Some 85 000 hectares of mangrove forest have been extensively exploited for chipwood since 1974 (Soegiarto, 1980).

The greatest reclaimer of mangrove areas in the Philippine Islands is aquaculture. About 176 230 hectares of mangrove swamps had been converted into fishponds as of 1976 (BFAR, 1976). Forestry data for the period 1967-1975 indicate a rate of denudation of about 3 000 hectares per year (Umali, 1977). Reclamation for agricultural, industrial, and urban settlements have contributed to a lesser degree (Gomez, 1980).

2.2.5 Population distribution

The total population of the five ASEAN nations is in the order of one quarter billion, with Indonesia accounting for more than half and Singapore with about one percent. As given in the World Almanac (1979), the 1977 estimates for the five countries are as follows:

Indonesia	:	143 280 000
Malaysia	:	12 600 000
Philippines	:	45 030 000
Singapore	:	2 310 000
Thailand	:	44 160 000

As one might expect of island nations, most of the population is concentrated in coastal areas in Southeast Asia. This is true even for Thailand (Piyakarnchana, 1980). Fig. 5 shows the population distribution along coastal cities for the region.

2.3 Physical environment

2.3.1 Salinity

Salinity of coastal waters in the Southeast Asian region has been observed to vary with the monsoons (Chua, 1966; Selvarajah, 1961; Gomez, 1980; Castillo and Berenguel, 1976; Soegiarto, 1980).

For Malaysia, the Philippines and Singapore, low salinities have been observed during the months of November to December (coinciding with northeast monsoon) and May to August (coinciding with southwest monsoon).

In Indonesia, the northwest monsoon (December-February) causes heavy rainfall throughout most of the archipelago resulting in the general lowering of salinity near shore (Soegiarto, 1980).

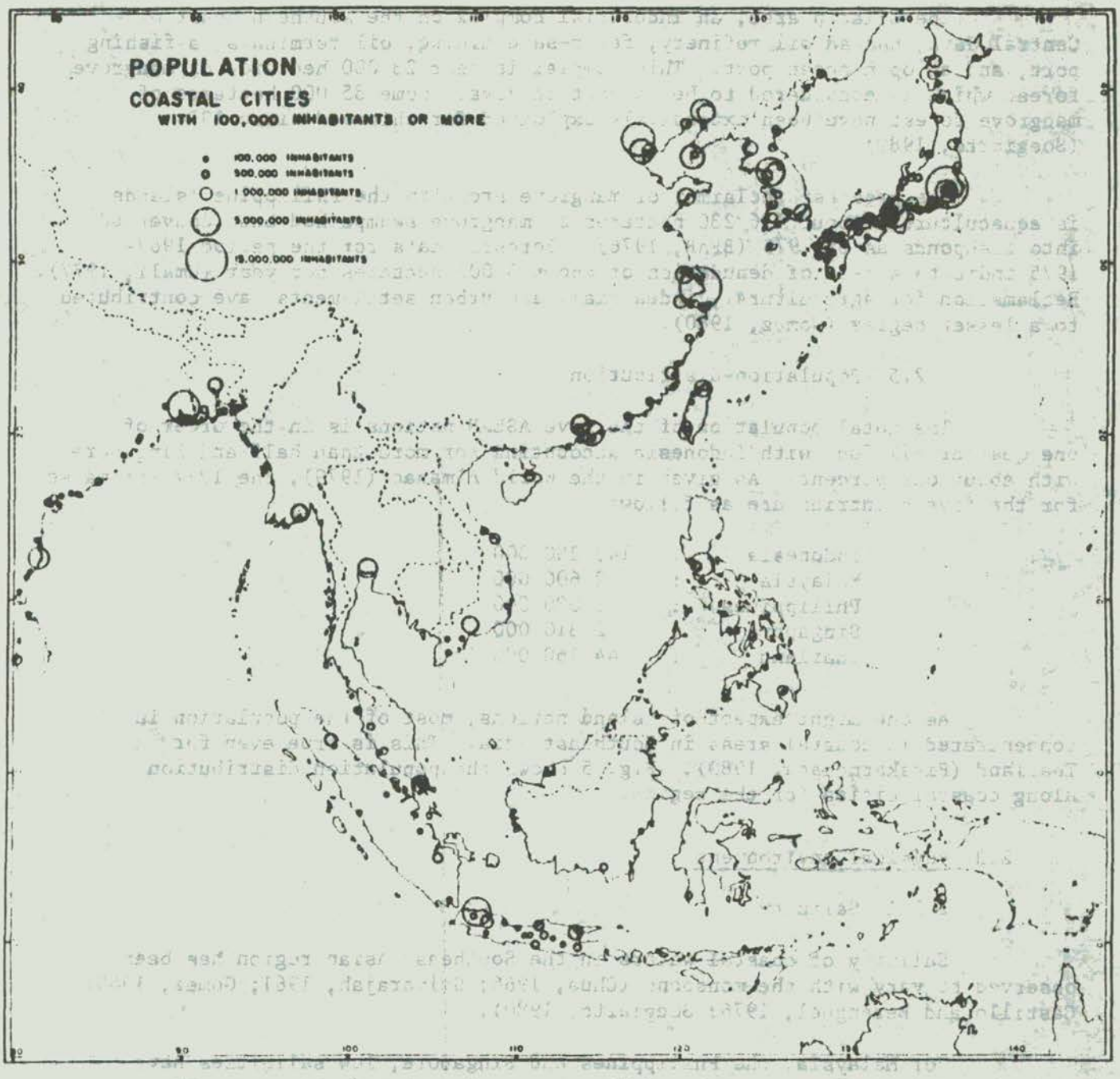


Fig. 5 Population: Coastal cities with 100,000 inhabitants or more

Maximum salinity values have been found in between monsoon periods when a decrease in rainfall is experienced (Gomez, 1980; Sasekumar, 1980; Chua, 1966).

Figs. 6 and 7 show the salinity distribution in surface waters of Southeast Asia for the north monsoon and south monsoon months, respectively (Soegiarto and Birowo, 1975). Salinity values at various areas studied in the region are shown in Table 5.

Salinity has also been found to vary between low and high tides. In a study by Chua (1966) at the Ponggol Estuary (Singapore), higher salinities (23.0 - 28.1 o/oo) at the middle reach were observed during high tides when the estuary was inundated with sea water and lower salinities (12.58-25.45 o/oo) at low tides when freshwater flowed out to sea. The influence of tidal factors on the fluctuation of salinity of the mangrove forest soil water has also been noted by Sasekumar (1974).

In a study of mangrove forests at Chanthaburi, Thailand, Aksornkaoe et al. (1979) found salinity to be higher at the outer edge of the forest and decreasing towards the inner forest (Fig. 8).

2.3.2 Tidal characteristics.

Southeast Asian waters are clearly subdivided so that each basin experiences a different tidal oscillation (Fig. 9). The area close to the Pacific Ocean, like the eastern and southern coasts of the Philippines experience mixed tides with prevailing semi-diurnal type. Other locations in the Philippine archipelago have mixed type tide characteristics showing different degrees of diurnal inequalities, and at some stations like Jolo (Sulu Archipelago) and Manila the tides become predominantly diurnal (Gomez, 1980).

The west and east coasts of Sabah experience mixed tides with prevailing diurnal and prevailing semi-diurnal regimes, respectively. Much of the Sarawak coast experiences mixed tides of the prevailing semi-diurnal type. On the west coast of the Malayan peninsula in the Straits of Malacca, the semi-diurnal tides prevail (Wyrtki, 1961).

Mangrove swamps around Singapore are subjected to semi-diurnal tides (Dept. of Zool., Sing., 1980) while the gulf coast of Thailand experiences mixed tide with prevailing diurnal, with part of the western gulf coast experiencing pronounced diurnal tides.

The Indonesian archipelago has mixed tides with prevailing semi-diurnal on the Indian Ocean side. Varied tidal types, however, characterize the coastal region of Indonesia facing Malaysia and the Philippines as can be seen in Fig. 9.

2.3.3 Rainfall distribution

The climate of the Southeast Asian countries is tropical and influenced by monsoons. The northeast monsoon (November-February) coinciding with the northwest monsoon in Indonesia and the southwest monsoon (May-September) coinciding with the southeast monsoon in Indonesia, bring about precipitation over most of the region.

In Singapore as well as in the Philippines, the southwest monsoon causes more precipitation than the northeast monsoon (Dept. of Zool., Sing., 1980; Obradovich, 1973). During the inter-monsoonal periods, particularly March to May, the monthly rainfall in certain areas in the Philippines vary from zero to 25 mm (Gomez, 1980). This would most likely be true also for the other countries.

However, certain areas in the region have rainfall evenly distributed throughout the year, as in some parts of the Philippines, without pronounced dry or wet months (PCARR, 1977). The Philippines receives an average annual rainfall of 2 360 mm (NEPC, 1979). During the six wet months (May-October), the average number of rainy days per month is 17 (Obradovich, 1973 1973). Except for Mindanao, the islands of the Philippines are exposed to an average of 20 cyclones per year along with rainfall patterns around these systems (PCARR, 1977).

The presence of major topographical features reflect, to some extent, the wet belts in the region (Sasekumar, 1980). In Malaysia, there are two particularly wet belts: (1) one running the full length of the country on the South China Sea side; and the other (2) confined to the northern part of the peninsula on the Malacca Straits side of the mountain ranges.

The entire coastal zone of the west coast of Sabah receives more than 80 inches (2 032 mm) of rain per year while most of the coastal areas of Sarawak receives between 120 to 140 inches (3 048 - 3 556 mm) of rainfall annually (Valencia, 1978 in Sasekumar, 1980).

2.3.4 River flows

With the exception of Singapore, the Southeast Asian countries are characterized by the presence of numerous rivers as exemplified by the Philippines that lists 419 river basins with their estimated annual run-off (Gomez, 1980). The Drainage and Irrigation Department of Malaysia has listed 56 of the rivers of Peninsular Malaysia with the measured monthly and annual discharges during five years (DID, 1978).

Fig. 6 Salinity surface values in Southeast Asia, December - May

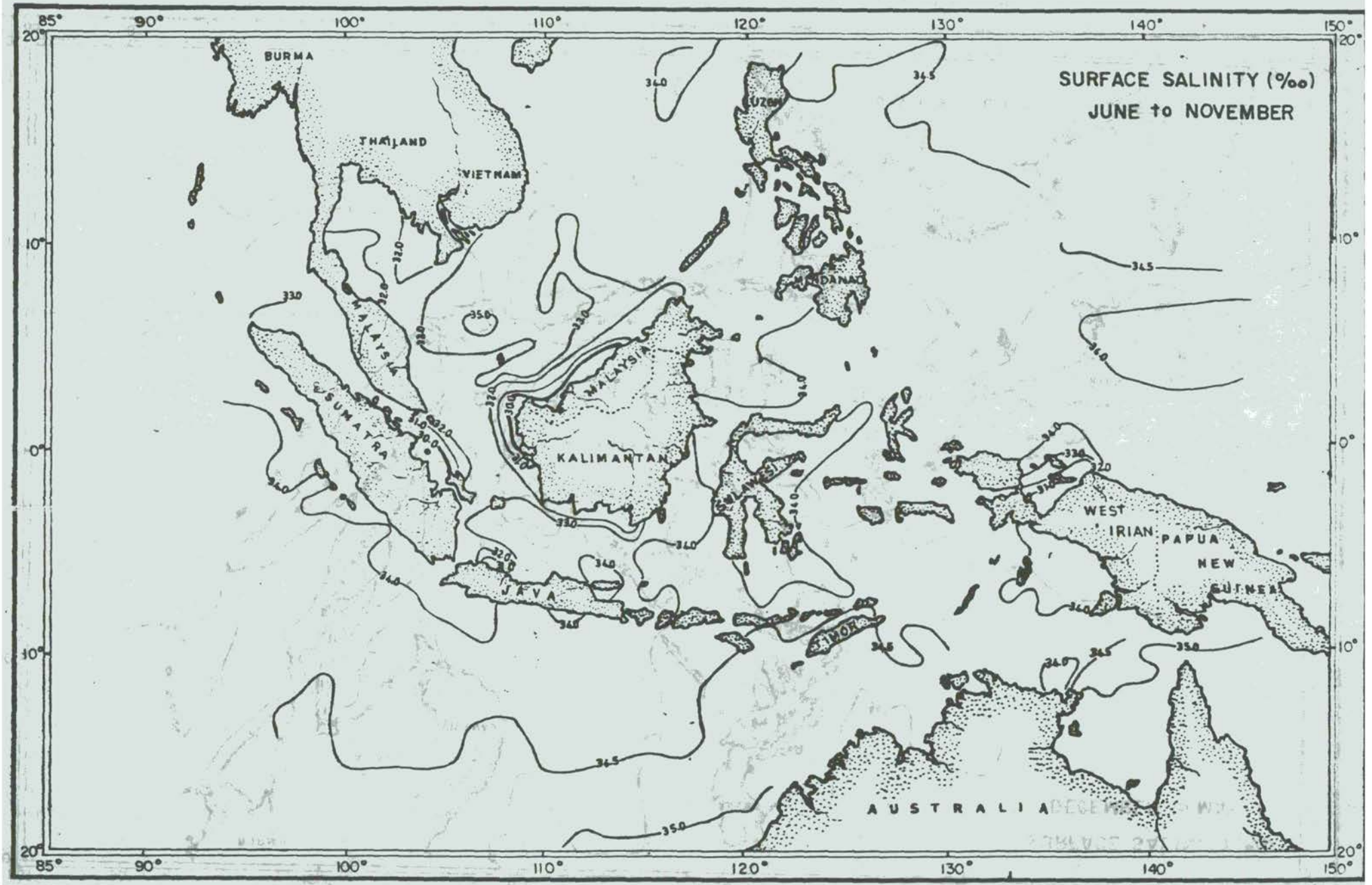
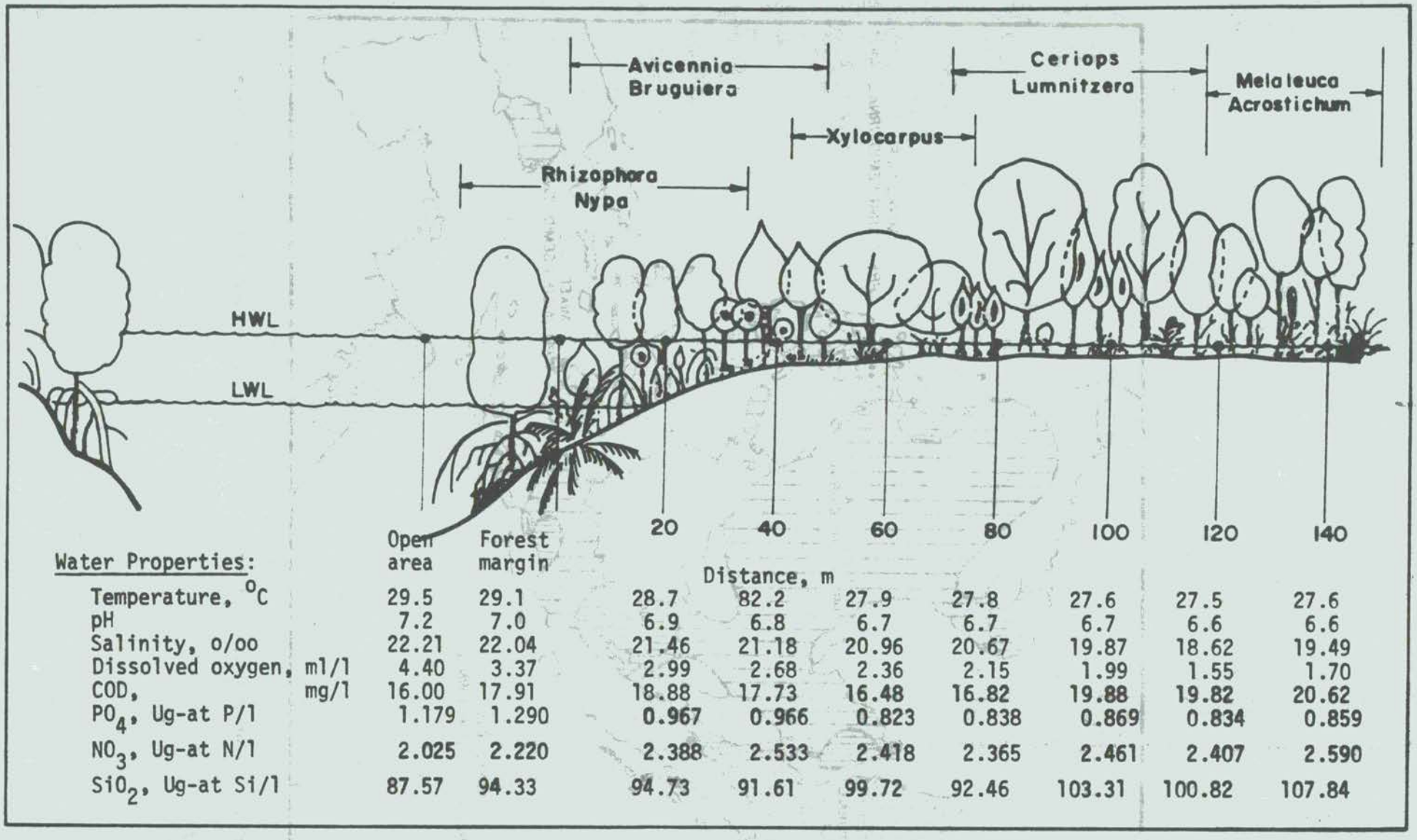


Fig. 7 Salinity surface values in Southeast Asia, June - November



Water Properties:		Open area	Forest margin	Distance, m						
Temperature, ^{o}C		29.5	29.1	28.7	82.2	27.9	27.8	27.6	27.5	27.6
pH		7.2	7.0	6.9	6.8	6.7	6.7	6.7	6.6	6.6
Salinity, o/oo		22.21	22.04	21.46	21.18	20.96	20.67	19.87	18.62	19.49
Dissolved oxygen,	ml/l	4.40	3.37	2.99	2.68	2.36	2.15	1.99	1.55	1.70
COD,	mg/l	16.00	17.91	18.88	17.73	16.48	16.82	19.88	19.82	20.62
PO_4, Ug-at P/l		1.179	1.290	0.967	0.966	0.823	0.838	0.869	0.834	0.859
NO_3, Ug-at N/l		2.025	2.220	2.388	2.533	2.418	2.365	2.461	2.407	2.590
SiO_2, Ug-at Si/l		87.57	94.33	94.73	91.61	99.72	92.46	103.31	100.82	107.84

Fig. 8 Average values of water properties at different locations from forest margin to the land in a mangrove forest

Fig. 9 Geographical distribution of tidal types in Scutheast Asia

Table 5. Ranges of salinity in various areas in Southeast Asia

Location	Salinity ranges (o/oo)
PHILIPPINES	
Visayas Sea (Aprieto, 1978)	32.0 - 33.8
Calatagan Lagoon, Batangas (Castillo & Berenguel, 1976)	29.0 - 33.0
Lingayen Gulf (Sebastian et al., 1959)	28.7 - 33.4
MALAYSIA	
Sungei Sementa Besar (Chong, 1977)	20.3 - 31.0
West Coast, Sabah (Wyrtki, 1961)	31.0 - 32.4
Sungei Sibu (Lai, 1975)	21.0 - 31.5
SINGAPORE	
Ponggol Estuary (Chua, 1966)	18.0 - 28.8
THAILAND	
Ao Nam Bor, Phuket Island (Vuthisathirapinyo, 1976)	24.8 - 30.0
Ao Chalong, Phuket Island (Vuthisathirapinyo, 1976)	15.1 - 30.5

Table 6. Temperature ranges in particular bodies of water in the Southeast Asian region

Location	Temperature ranges (°C)
PHILIPPINES	
Calatagan Lagoon, Batangas (Castillo & Berenguel, 1976)	28.5 - 30.5
MALAYSIA	
Sungei Sementa Besar (Chong, 1979)	27.0 - 29.0
SINGAPORE	
Ponggol Estuary (Chua, 1966)	28.5 - 31.1
THAILAND	
Ao Nam Bor, Phuket Island (Vuthisathirapinyo, 1976)	28.3 - 29.2
Ao Chalong, Phuket Island (Vuthisathirapinyo, 1976)	28.1 - 30.6

2.3.5 Temperature distribution

In tropical waters, the surface water temperature is relatively constant and ranges from 27° to 29°C. Soegiarto and Birowo (1975) showed the distribution of surface temperatures over the Southeast Asian region for the months of December to May and June to November in Figs. 10 and 11, respectively. A general decrease in surface water temperature is experienced during the monsoon months (Dept. Zool., Sing., 1980; Sasekumar, 1980).

Temperature ranges in particular bodies of water studied in various countries in the region are shown in Table 6. The variation of temperature from the mangrove forest margin to the inland forest at Chanthaburi, Thailand was studied by Aksornkaoe, et al. (1979) and is shown in Fig. 8.

2.3.6 Surface currents

Oceanic circulation in the region changes with the monsoons. During the south monsoon, northernly currents are dominant in the middle part of the South China Sea and the Java Sea. The inflow of oceanic water is strong through the Celebes Sea and the Flores Sea from the Pacific. The water of the South China Sea flows through the Strait of Taiwan (Formosa) and Luzon Strait. In contrast, during the north monsoon, a southerly flow of water prevails causing a cyclonic pattern of surface water movement. In this season, the inflow of oceanic water is strong through the Taiwan and Luzon Straits. The outflow from the South China Sea is greatest through the Flores Sea, but a considerable volume flows less strongly from the Celebes Sea to join the water mass from the South China Sea flowing eastward. In both monsoon seasons, a small volume of water enters the South China Sea through the Philippine islands and the Pacific and flows out to the Indian Ocean through the Malacca and the Sunda Straits (FAO/IPFC, 1976).

The profiles of surface currents in Southeast Asia obtained from the Atlas Oseanologi (Soegiarto and Birowo, 1975) for the Northwest and Southeast Monsoons are shown in Figs. 12 and 13, respectively.

2.4 Chemical environment

2.4.1 Types of soil

Most of the studies undertaken on soils in the region have been made for agricultural purposes.

A study by Notohadiprodjo (1979) classified the stability of mangrove soil aggregates based on the percentage of organic carbon as follows:

Aggregates	Range	% organic carbon average
Very unstable	2.86 - 10.96	7.60
Unstable	0.97 - 21.79	4.23
Less stable	2.00 - 11.80	6.53
Little less stable	2.83 - 14.33	8.69
Stable	5.55 - 12.10	9.37

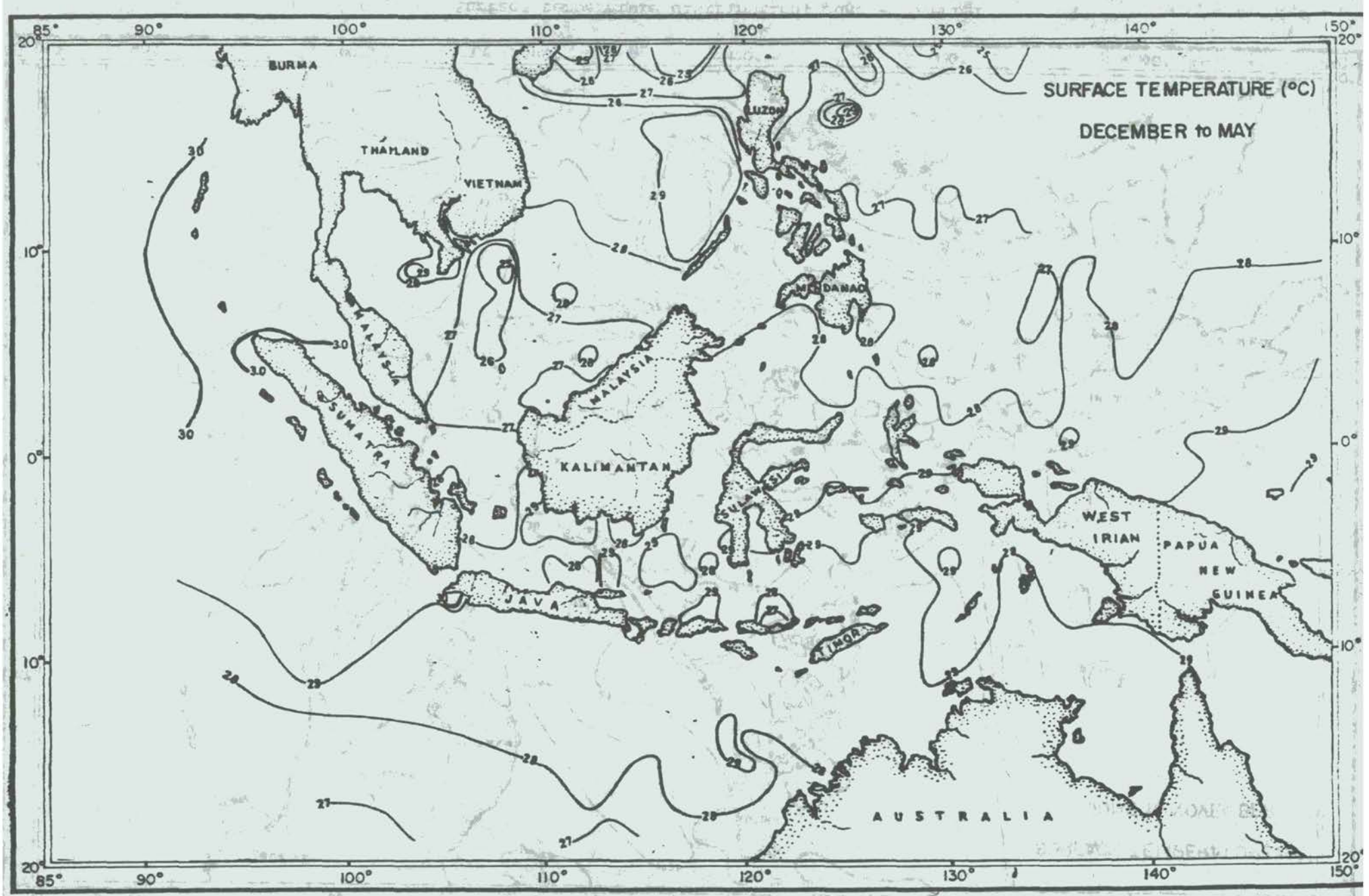


Fig. 10 Surface temperature distribution, December - May
(after Soegiarto & Birowo 1975)

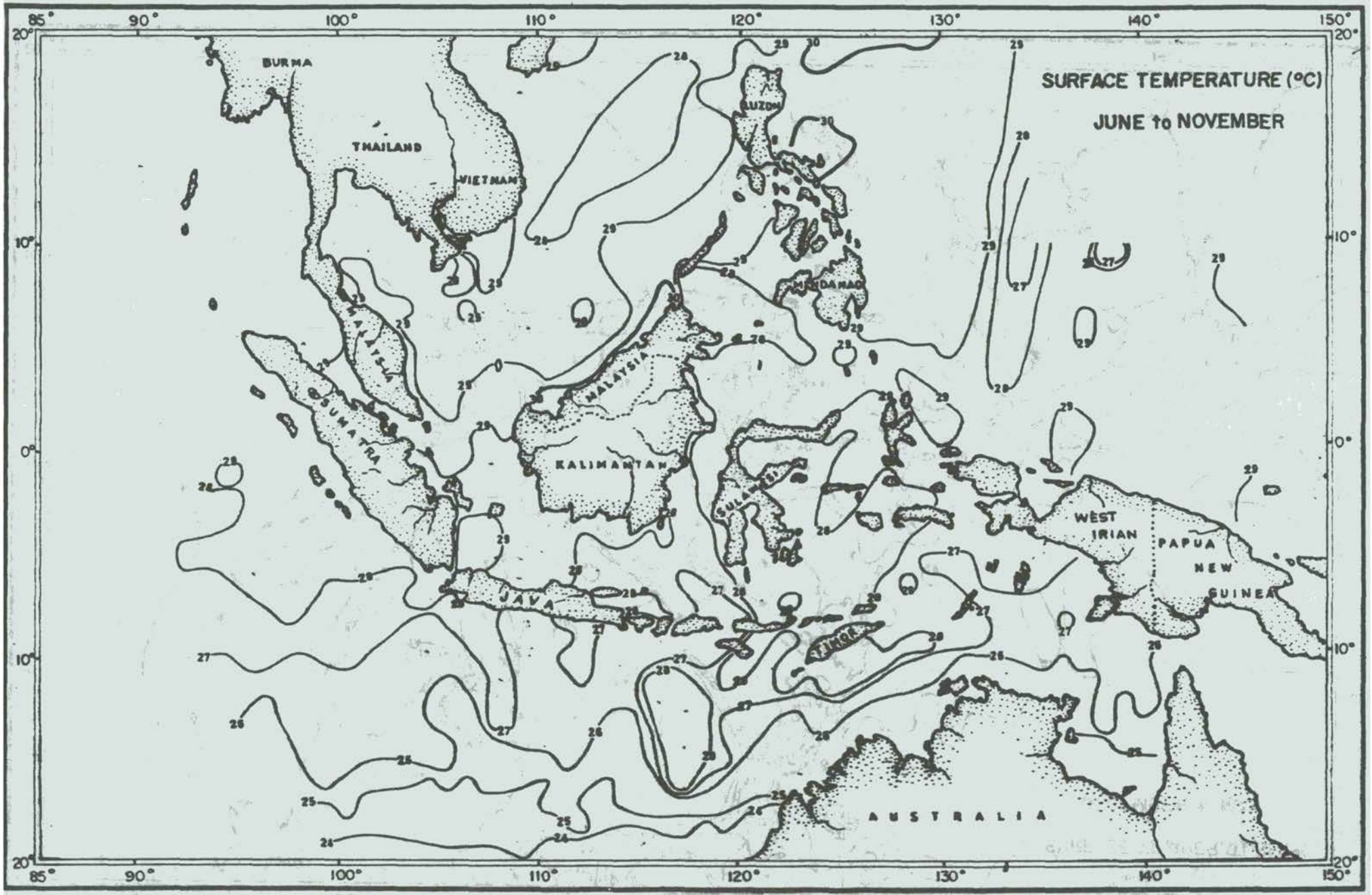


Fig. 11 Surface temperature distribution, June - November
(after Soegiarto & Birowo 1975)

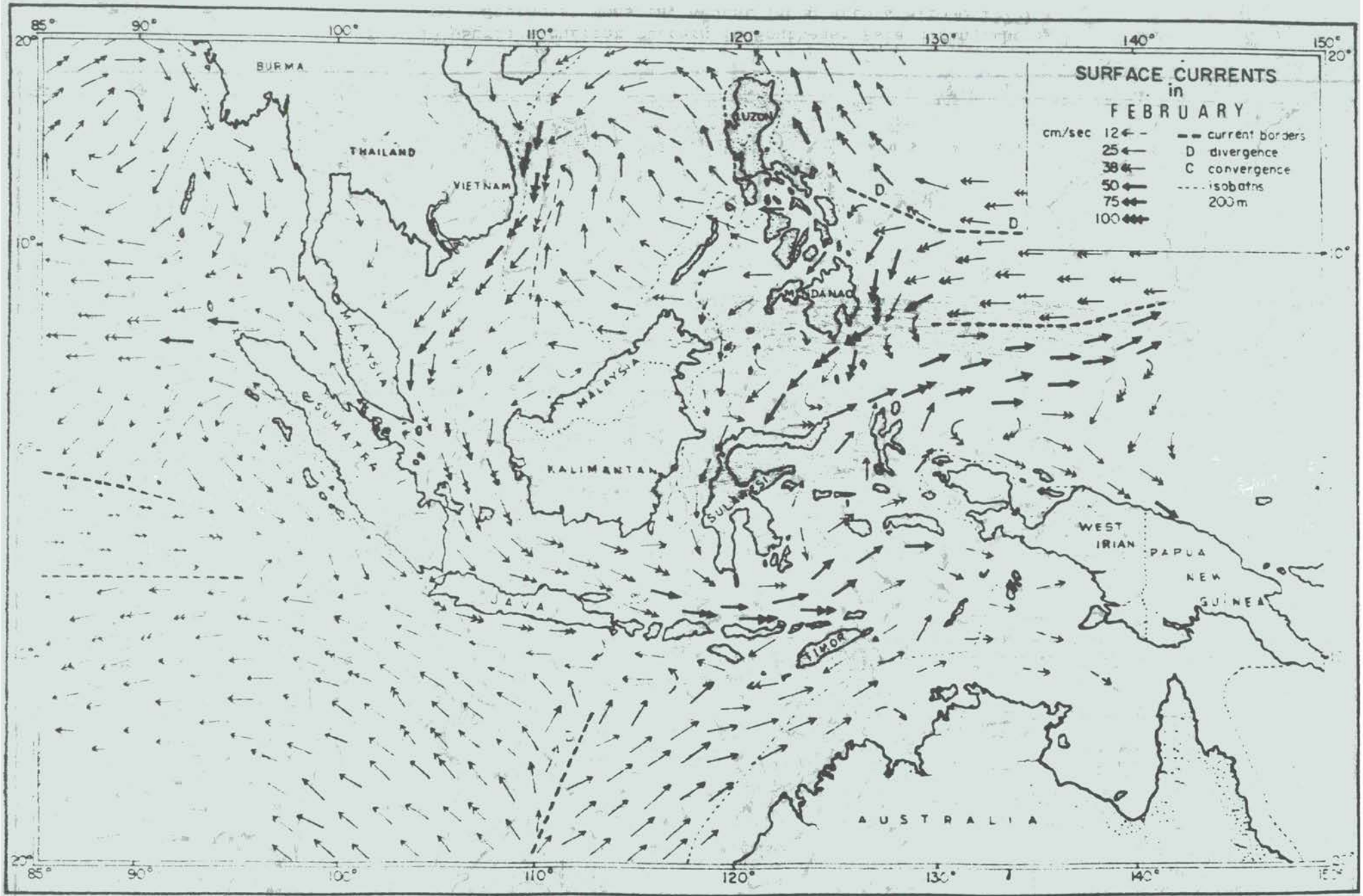


Fig. 12 Surface current pattern in Southeast Asia during the Northwest Monsoon, February (Soegiarto & Birowo 1975)

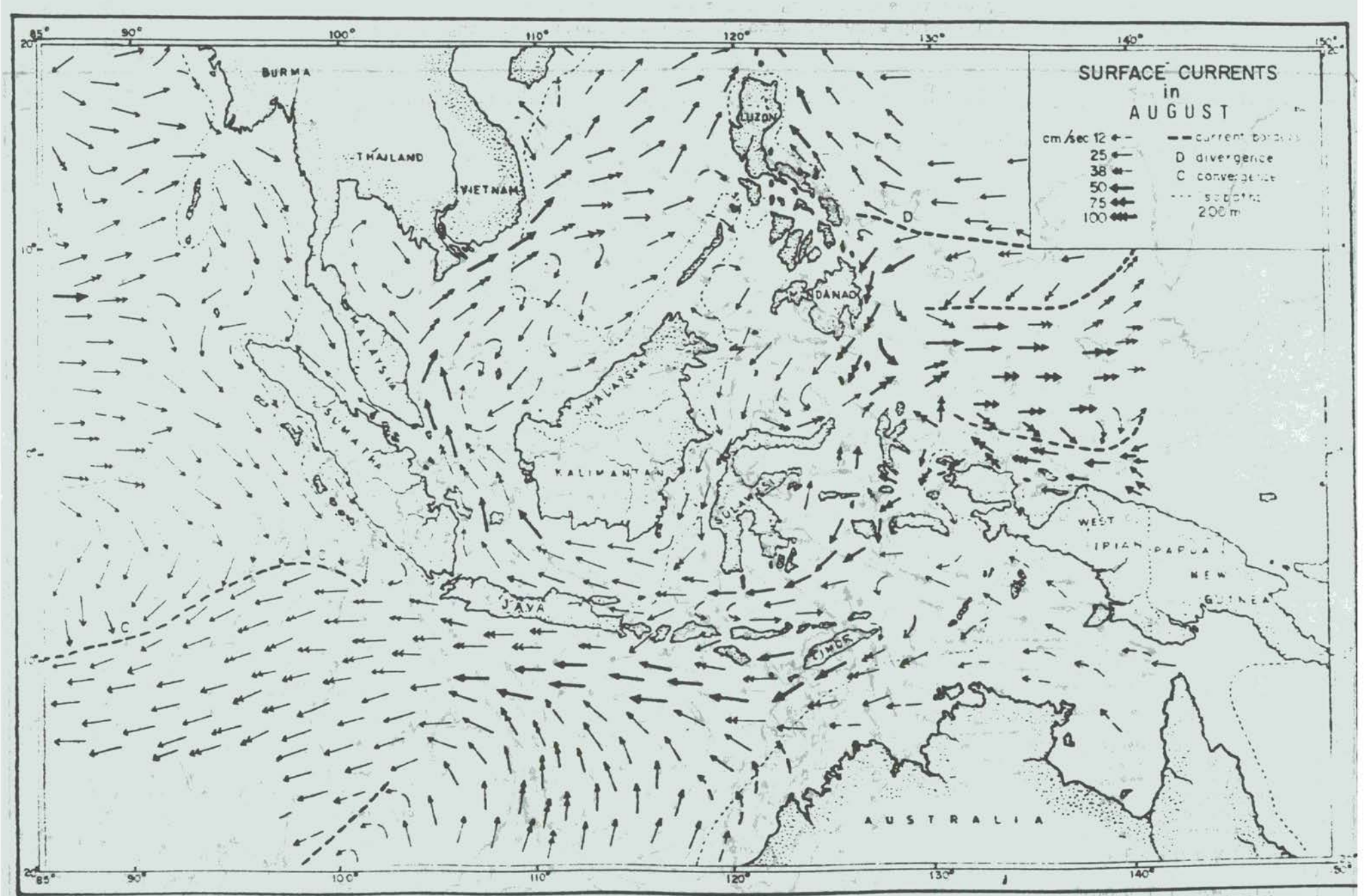


Fig. 13 Surface current pattern in Southeast Asia during the Southeast Monsoon, August (Soegiarto & Birowo 1975)

Kartawinata and Walujo (1977) studied the chemical and physical properties of soil from three mangrove communities in Ranbut Island Nature Reserve, Jakarta Bay. In a community of Scyphiphora and Pemphis with a soil depth of 0 to 10 cm, the texture was as follows: sand - 71.5%; silt - 17.5%; clay - 11.0%. For a Rhizophora mucronata community of soil depth of 0-50 cm, soil texture was as follows: sand - 11.3%; silt - 44.8% and clay - 44.0%.

Some selected river basins have been studied in the Philippines and give a glimpse of soil characteristics of mangrove areas. In the Bicol River Basin, the coastal swamps are of marine origin and consist mainly of soft, unripened clayey sediments. The lower portion of the Partido River Basin, Camarines Sur, consists of brackishwater deposits where the soils are usually poorly drained, gray or gleyed gray, fine loamy and clayey. The upper parts, which are unaffected by tidal flooding have deep soils, 50 to 100 cm, which are somewhat poorly drained, fine loamy and clayey (Bureau of Soils, 1979b).

The Agusan River Basin in Mindanao Island has coastal swamps and marshes with an estimated area of 10% composed of beach ridges and 90% tidal flats. The parent material of the beach ridges are recent marine deposits (beach sand with coral fragments). The soils are shallow to moderately deep, coarse loamy to sandy. The tidal flats are from recent fluviomarine deposits (mud, silt, clay, and organic material). The soils are deep, fine loamy to clayey, soft, muddy and unripe soils mixed with organic matter (Bureau of Soils, 1979a).

The coastal soils in the area between Phaya River and Mae Klong River, Thailand are characterized by water logging conditions and high salinity (Tandatemiya, 1976).

In the mangrove forest at Phangnga province in Thailand, Kongsaenchai (1976) found that the amount of sand increased landward and that other properties such as clay and organic matter content, cation exchange capacity and soil salinity gradually increased seaward.

2.4.2 Nutrients

Nutrient data on the region's rivers, estuaries and coastal waters are scanty. Soegiarto and Birowo (1975) studied the distribution of nutrients in waters around Indonesia which included a large portion of the Southeast Asian region. The average NO_3-N concentration of surface waters in the Philippines was found to be 0.44 ug-at/l while the average PO_4-P concentration was 0.05 ug-at/l (Megia and Lao, 1955).

Nutrient values obtained at various areas in the Philippines, Indonesia and Thailand are shown in Table 7. Seasonal variations in nutrient concentration have been observed in the study of Lingayen Gulf waters in the Philippines (Sebastian et al., 1959) and may be expected to be true in other bodies of water in the Southeast Asian region, as well.

A gradient of decreasing nutrient concentrations moving from the mangrove area seaward has been observed on several mangrove stands in the Philippines (NEPC, 1979; Yap and Tiu, 1979) and at Phuket Island, Thailand (Piyakarnchana, 1980).

Studies of disturbed mangrove areas in Siapar Island, Pangasinan, Philippines showed mean values of 0.20 ug/l for PO_4-P and 0.44 ug/l NO_3-N. These values are very low compared to 167.00 ug/l PO_4-P and 18.0 ug/l NO_3-N in an old growth stand in Ulugan Bay, Palawan (NEPC, 1979).

Table 7. Nutrient levels in various localities in Southeast Asia

Location	NO_3	PO_4
INDONESIA		
River/Streams, Jakarta	2 - 6 ppm	20 - 31 ppm
Estuaries, Jakarta (Bilal et al., 1975)	1.6 - 3.4 ppm	1.0 - 3.2 ppm
PHILIPPINES		
Babatngon Bay, Leyte (NEPC, 1979)	59 ug/l	37 ug/l
Suba Panas, Mactan, Cebu (Yap and Tiu, 1979)	0.36 ug-at/l	-
THAILAND		
Chanthaburi, Thailand (Aksornkaoe et al., 1979)	2.02 - 2.59 ug-at/l	0.82 - 1.29 ug-at/l

2.4.3 Total dissolved oxygen, COD, BOD

The distribution of dissolved oxygen over the Southeast Asian waters is shown in Figs. 14 and 15 (Soegiarto and Birowo, 1975) for the months of December to May and June to November, respectively. Values for dissolved oxygen in particular bodies of water studied in Indonesia, the Philippines and Thailand are shown in Table 8. In his study of mangrove forests in Chanthaburi, Thailand, Aksornkaoe et al. (1979), found that oxygen concentration increased from the dense inner forest seaward with maximum values at the open water edge. Oxygen concentration has also been found to fluctuate with the tides in Philippine mangrove areas studied by Yap and Tiu (1979) with low oxygen content being observed at low tide and high oxygen content during high tide.

Data on BOD and COD remain scanty. The total BOD load from domestic and industrial sewage in Manila was 316 tons BOD per day while Bangkok had 137 tons BOD per day (FAO/IPFC, 1976). Lohwongwatana (1979) estimated the BOD load on the East Coast of Thailand to be 108 tons BOD per day. In the rivers and streams of Jakarta, the BOD was estimated by Bilal et al (1975) to range from 50 to 100 ppm while that in Jakarta's estuarine areas ranged from 14 to 31 ppm.

The only study available on the COD in a mangrove area was obtained by Aksornkaoe et al (1979). The COD values ranged from 16.00 mg/l on the seaward side gradually increasing to a maximum at the inner forest with a value of 20.62 mg/l. The COD reported on Jakarta's rivers and streams by Bilal et al (1975) ranged from 99 to 125 ppm.

Table 8. Dissolved oxygen values in various localities in Southeast Asia

Location	DISSOLVED OXYGEN	
	Figures of authors	Converted to ml/l at 28°C *)
INDONESIA		
River/streams, Jakarta	2 - 4 ppm	1.4 - 2.9
Estuaries, Jakarta (Bilal et al., 1975)	5 - 6 ppm	3.6 - 4.3
PHILIPPINES		
Pagbilao Bay, Quezon (NEPC, 1979)	5.47 ml/l	
Ulugan Bay, Palawan (NEPC, 1979)	4.60 ml/l	
Arangasa Island, Surigao Yap and Tiú, 1979)	4.49 mg/l	3.2
THAILAND		
Chanthaburi (Aksornkaoe et al., 1979)	1.70 - 4.40 ml/l	
Ao Nam Bor, Phuket Island (Vuthisathirapinyo, 1976)	3.67 - 4.65 ml/l	
Ao Chalong, Phuket Island (Vuthisathirapinyo, 1976)	4.37 - 4.71 ml/l	

*) According to Lange's Handbook of Chemistry, 12th ed., 1979

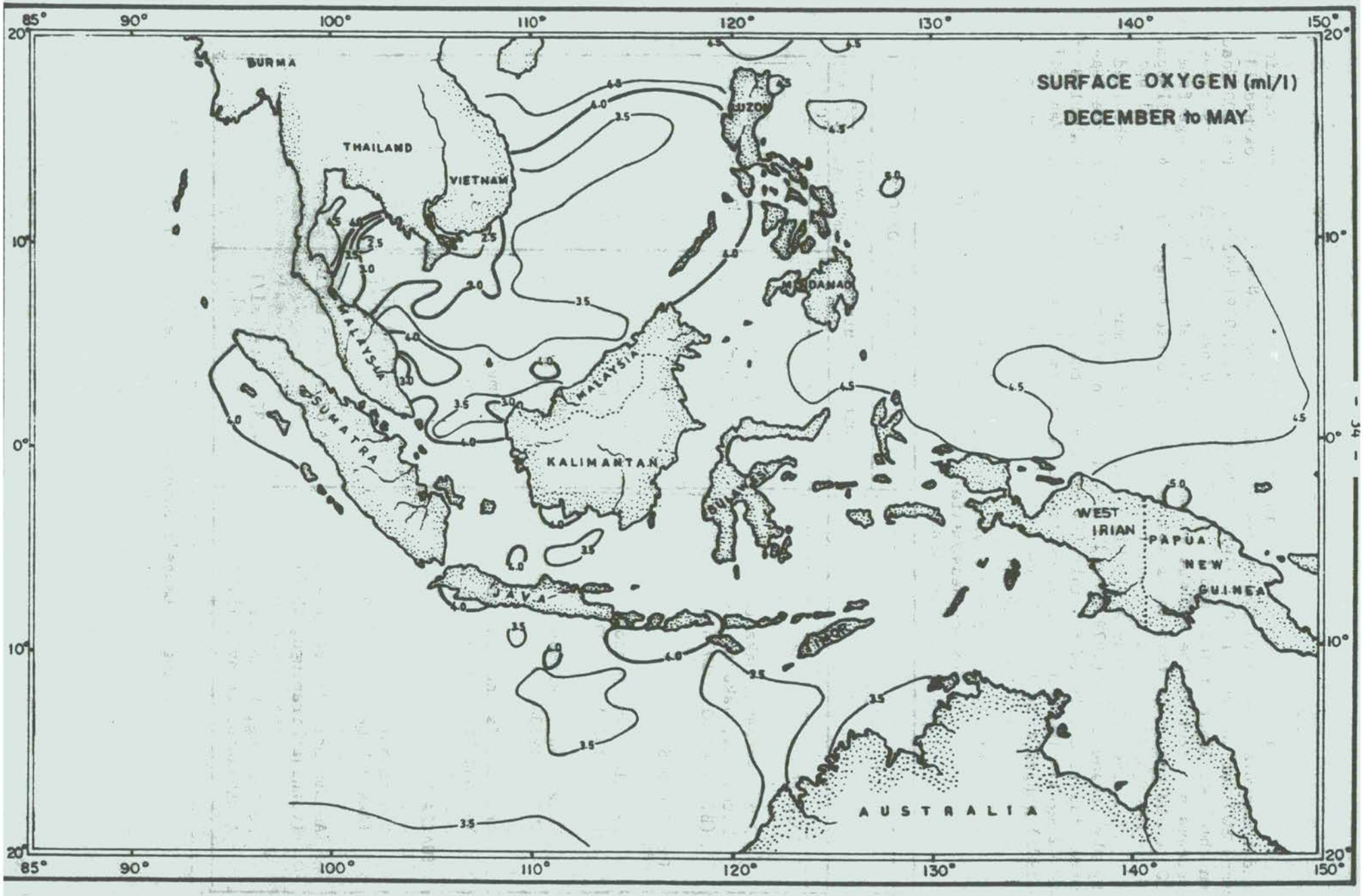


Fig. 14 Oxygen distribution of surface waters, December - May
(after Soegiarto & Birowo 1975)

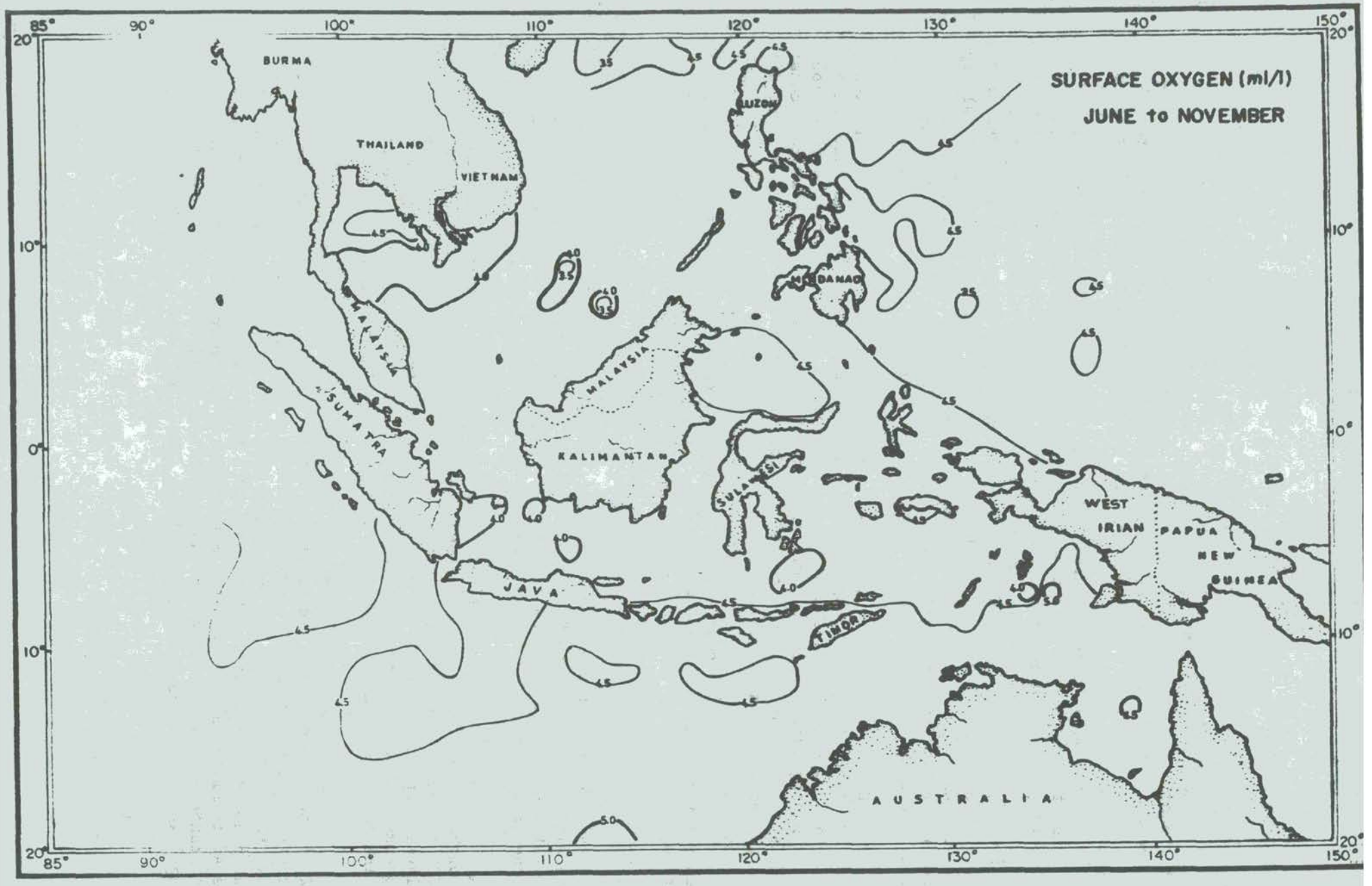


Fig. 15 Oxygen distribution of surface waters, June - November
(after Soegiarto & Birowo 1975)

2.4.4 Suspended solids

Solid wastes from domestic and industrial sources are the major contributors of suspended solids in estuaries and coastal areas in the Southeast Asian region. This is primarily due to the limited use of sewage treatment plants in most of the countries with the possible exception of Singapore.

Emptied into the waters of Manila Bay each day are 350 tons and 114 tons of solid wastes from domestic and industrial sources, respectively. In Jakarta, solid wastes coming from domestic and industrial sources were estimated to be 7 200 m^3/day. Most of the wastes from fishmeal, canning and food processing types of plants as well as sugar mills are dumped into Thailand's rivers. The pork and poultry industry in Singapore produces 14 m^3 of pig slurry and 560 tons of poultry waste daily which poses a disposal problem. Plastic products originating from the heavy traffic in the Straits of Malacca also constitute a serious problem for Malaysia and Singapore (FAO/IPFC, 1976).

Due to orbanization, expansion of agricultural lands, public development, and excessive lumber exploitation, most of the ASEAN countries have also the common problem of siltation on coastal regions. Added to this is siltation due to mining operations - tin mining in southern Thailand, in the western coast of Malaysia and the northeast coast of Indonesia; copper, iron, gold and chromite mining operations in certain areas in the Philippines (FAO/IPFC, 1976).

With continued urbanization and industrialization in the region, an even greater amount of solid wastes and siltation may be expected in the near future.

2.4.5 Pesticides

The use of pesticides for most of the Southeast Asian countries has gone along with increases in agricultural output except for the more limited use, at present, of chlorinated hydrocarbons due to their known persistence in the environment (FAO/IPFC, 1976).

In Indonesia, the amount of pesticides and herbicides distributed throughout the country has increased since 1968 and at present more than 2 000 tons of pesticides are imported annually (Soegiarto, 1980). In 1971, Malaysia imported about 2 827 tons of pesticides (MAPP's Newsletter in Sasekumar, 1980). However, no information on the pesticide concentrations on Indonesian and Malaysian mangrove forests have been obtained.

In the major rivers of the Philippines monitored for pesticides, 76% of the samples contained pesticide concentrations that exceeded the acceptable standard (NPCC, 1979). In the same report by the NPCC, it was shown that the amount of heptachlor and heptachlor epoxide, dieldrin, aldren, endrin and P', P-DDT in the Cagayan de Oro River exceeded the standard. At the Ayala River in Zamboanga del Sur, dieldrin concentration also exceeded the standard. In Manila Bay and adjacent coastal waters, the P', P-DDT range was found to be 0.007 to 0.013 ppb (NPCC, unpublished data).

The P', P-DDT range in the rivers of Thailand was found to be 0.1 to 3.4 ppb (Piyakarnchana, 1980). These rivers eventually find their way to the Upper Gulf of Thailand. Studies by Hungspreugs and Wattayakorn (1979) at the Gulf found no DDT and its derivatives in samples of water about one meter below the surface. However, they did find these pesticides in sediments at the northern part of the upper Gulf with an average of 0.4 to 52.0 ppb dry weight. At the southern part of the Gulf, they found a range of 3.5 to 17.2 ppb dry weight.

Very little information regarding pesticide residues in estuarine and coastal waters are available for the other Southeast Asian countries.

2.4.6 Other organic compounds

Most of the ASEAN nations face no major oil pollution problems at present. Much of the oil pollution in Singapore and Thailand are associated with their refineries. In the Philippines, only the major harbours show occasional moderate levels of oil pollution (National Operations Center for Oil Pollution, Philippine Coast Guard, unpublished data).

However, a different situation exists in Indonesia due to its oil production. Oil exploitation in Indonesia's territorial waters and inland areas, but mainly the heavy oil transportation through Indonesian waters causes frequent oil pollution along many of the country's beaches, coral reefs and mangrove forests (FAO/IPFC, 1976). In the monitoring of hydrocarbon levels in some Indonesian waters in 1973, particularly all the areas contained hydrocarbon concentrations exceeding the mpl for class C and SC waters[1/] of 15 ppm (Wisaksono et al., 1974). At the south coast of Bangka, a hydrocarbon concentration of 200 ppm was recorded. Spot checking on petroleum hydrocarbon levels in Indonesian waters by the Indonesian Institute for Petroleum in 1972/1973 showed levels between 3 to 100 ppm with an average of 35 ppm (FAO/IPFC, 1976)[2/]. Later measurements excluding unwanted organic material showed maximum values of 1.1 ppm hydrocarbons in Java Sea waters.

The transport of oil from the Middle East and Africa through the Straits of Malacca poses a very real problem in the area. Over the treacherous Malacca Straits, many accidents and near accidents have taken place. The more disastrous among them was the spilling of almost 7 000 tons of crude oil by the grounded "Showa Maru" in 1975 into Indonesian, Singapore and Malaysian coastal waters (Soegiarto, 1980). Other areas with high accident risk, concentration of hydrocarbons in water, and tar ball occurrence show the dependence of oil pollution from the tanker routes (Bilal and Kuhnhold, 1980).

1/ Class C : for the propagation and growth of fish and other aquatic resources in fresh surface water.

Class SC: for propagation and growth of fish and other aquatic resources in marine and estuarine water.

2/ These concentrations are not true hydrocarbon values, they represent values for "carbontetrachloride-extractable matter" according to the American Standard Method D 1340.

Continued exploration and exploitation of oil in the region and the continued dependence on crude oil from the Middle East and Africa will undoubtedly place oil pollution as one of the mor major causes of concern for the Southeast Asian countries in the years to come.

2.4.7 Heavy metals

Heavy metal contaminants on the estuarine and coastal areas in the Southeast Asian region come mainly as by-products of industrial production, in the use of pesticides, and from mine tailings in several mining areas.

Rahman et al. (1979) studied ocean bottom sediment samples around Singapore and the concentrations ranged as follows: Pb - 20 to 28 µg/1; Ni - 75 to 98 µg/1; Co - 12 to 21µg/1; and Hg - 0.085 to 0.100 µg/1. In the same study, ocean water samples were examined and the following concentration ranges were found: Pb - 0 to 40 µg/1; Ni - 55 to 100 µg/1; and Co - 0 to 15 µg/1. Another study by Chai and Wong (1976) in the coastal areas of Singapore, the Straits of Singapore, and the Straits of Malacca found concentrations of heavy metals in marine organisms to be generally low. Mercury levels in river waters in Singapore showed a range of 0.020 to 0.036 ppb for four unpolluted rivers and a range of 0.023 to 0.187 ppb in two polluted rivers (Goh, 1973).

In Thailand, a 1975 study of mercury concentration in the marine food chain showed that it increased at higher levels of the food chain and according to animal size (FAO/IPFC, 1976). However, the limits were found to be within normal ranges.

Trace metals studied in fish and plankton in Malaysia showed the following concentrations: fish - 0.5 to 1.5 ppm Cu; plankton - 2.0 to 10.0 ppm Cu; fish - 8.0 to 13.0 ppm Zn; and plankton - 10.0 to 30.0 ppm Zn (FAO/IPFC, 1976).

The concentration of various heavy metals on the east coast of Sumatra was reported by Wasilun (1978) and their concentration ranges are given as follows: Cu - less than 0.1 ppm; Pb - 0.4 to 1.1 ppm; Zn - 0.03 to 0.28 ppm; Hg - nil to 0.5 ppm; Cd - 0.01 to 0.10 ppm; and Co - 0.3 to 0.9 ppm.

A review paper by Gomez (in press) surveyed the presence of heavy metals on the Philippine marine environment. However, there were no specific studies in mangrove areas or of mangrove organisms. The mine tailings and river water on several mining regions in the Philippines were analyzed for metal content by the National Pollution Control Council. The 1978 Annual Report of the NPCC indicated the Amburayan River had a copper concentration from below detectable limit (bdl) to 0.77 mg/1 and a cadmium concentration of bdl to 0.02 mg/1. The Bued River had a copper concentration ranging from 0.02 to 3.36 mg/1 and a lead concentration from below detectable limit to 0.43 mg/1. The Agno River had a copper concentration range of 0.02 to 0.08 mg/1. A survey of mercury in waters, sediments and biological samples in Manila Bay, Palawan, Bislig Bay, and Iligan Bay found mercury levels to be less than 1 ppb in water and less than 0.1 ppm in the biota (FAO/IPFC, 1976).

Recent analysis of brackishwater organisms gave lower results for mercury: shrimps from the Pacific coast of Luzon (Paracale) showed an average of 20 ppb (FW)1/; oyster from Manila Bay (Bacoor) had a mean of 50 ppb (FW). Cadmium levels of these organisms were 400 ppb (FW) for the oysters (FAO, 1979).

1/ (FW) - fresh weight

2.4.8 Thermal waste

Thermal waste in the region is not yet a major problem. However, with the projected increase in power consumption, this particular type of waste may be significant in the near future. In the year 2000 nuclear power plants operating in Indonesia are expected to discharge 657 x 10^6 to 1 095 x 10^6 m^3 of hot water annually into the coastal water environment (Soegiarto, 1980). Plans to set up a 650-megawatt nuclear power plant at Bataan, Philippines will also mean the discharge of water that would be used in cooling (Gomez, 1980). In Thailand, two atomic power plants with a total capacity of 1 200 MW are expected to be established (FAO/IPFC, 1976).

For a thermal power plant, 1 350 kcal of heat is added to water for every kWh produced while a nuclear power plant adds 1 900 kcal to the water for the same amount of power produced (FAO/IPFC, 1976).

At present, thermal pollution is a cause for concern in the Straits of Johor, Singapore (Dept. of Zool., Sing., 1980). The Senoko Power Station on the northern coast of the main island discharges sea water used for cooling the generators. Another power station located at Pasir Panjang has water temperatures of 32°C and 35°C at the condenser outfall for the small and big capacity generators, respectively. Temperature reaching 40°C has been observed (Chin, 1975).

3. ECOLOGICAL ASPECTS

3.1 Relations between faunistic and floristic, and physico-chemical characteristics

Previous sections have indicated species listings and associations in a general sense. Most of studies about the distribution of mangrove biota have been descriptive in nature rather than being elaborations or elucidations of causal relationships.

The distribution of different species of plants and animals in mangrove forests depends upon some physico-chemical parameters such as the type of substratum, grain size, tidal period, salinity, pH, the level of the soil and light.

The effects of physical factors, notably exposure to wave action, and the degree of inundation become apparent in the zonation of mangrove species. Some papers dealing with zonation (Arroyo, 1978a, 1978b; Banaag, 1972) only incidentally refer to the causal relationships, while others (Berry, 1972; Fortes, in press; Kongsaenchai, 1976) explained the presence of certain species in terms of drainage conditions. The work of Haan (1931) relates the combined effect of salinity and the drainage system to the species composition of the mangrove trees in Cilacap, Indonesia.

Fortes (1975) also touches on the relationship of the algal epiphytes with the mangroves although he was more concerned with the distribution of the algae in relation to physical parameters in his thesis.

On the ecological relationships of animal species, Frith et al. (1976) who reported on the zonation of macrofauna on a mangrove shore at Phuket Province in Thailand, concluded that the substratum and the exposure period at low tide were the most important factors limiting the distribution of animals. Some well-known physico-chemical parameters such as temperature, salinity and pH were considered to be of minor importance.

Also related to the ecological relationships of animal species is the study of Johnson (1973) in Singapore where he discussed the distribution of some local species as affected by salinity.

3.2 Effects of mangrove utilization on the aquatic ecosystem

Studies have shown that many species of commercially important marine organisms depend on the mangrove ecosystem for at least a part of their life cycles. Mangroves are also feeding grounds for coastal fishes (Christensen and Delmendo, 1978; Sasekumar, 1980). Furthermore, the mangrove forest, functions as a coast stabilizer, an erosion preventor, and as a pollutant trap (Soegiarto, 1980).

Moreover, the mangrove forest yields energy products such as charcoal and firewood; mangrove species are known to be good building materials for boats and furniture; these species also supply raw material for chipwood, paper and rayon; the bark of some species are sources of tannin dyes; various parts of the mangrove plants are edible while others are used as fodder for animals. Oil is extracted from seeds and the sap of nipa inflorescences can be tapped for sugar, alcohol, or vinegar, while nipa leaves are used in thatching roofs and making cigarette wrappers. Some mangrove species have medicinal values. These are only some of the uses of mangroves (Christensen, 1979b). Becuase of these benefits mangrove forests and swamps support the lives of thousands of families in South-east Asia.

In view of the mangroves' immense importance to mankind, various human activities such as forestry, fishing, and others should be assessed with reference to their impact on the mangrove forest itself, as well as on the adjacent aquatic ecosystem.

3.2.1 Forestry

There is extensive extraction of mangrove forest products in Thailand, Malaysia, Indonesia, and the Philippines. To a certain degree all these countries employ silvicultural management programmes (Christensen, 1979b). Governments generally impose such measures as selective cutting, rotation of area, alternates strip cutting, replanting and shelter-trees saving on operators in mangrove regions. This extraction of mangrove forest products need not cause permanent damage or irreversible imbalance in the mangrove ecosystem as long as it is done within the limits of conservation programmes.

However, the practice of clear-felling can destroy the habitats of some plant and animal species that depend on the aerial roots and trunks of mangrove trees. It may even cause air and soil temperature to rise or cause the soil to erode or harden and in turn inhibit the development of certain larvae (Piyakarnchana, 1980).

It is important to point out that the degree to which forest products are exploited is inversely proportional to the effectivity of the mangrove forest to function as a coast stabilizer, as an erosion preventor, as a pollutant trap or as a breeding area for marine animals.

3.2.2 Fishing activities

Normal fishing activities done in undisturbed mangrove swamps do not appear to have any adverse effects on the ecosystem, unless illegal methods are employed.

Piyakarnchana reports that in the Gulf of Thailand, some fishermen use very fine nets to trap fish at high tide and then collect them at low tide. This method destroys many postlarvae of various organisms in the area.

The use of poison and explosives are among the many destructive means of fishing found in mangrove areas. These destroy not only the young, still non-commercial organisms, but also the specific habitats together with the unrecognized members of the integrated ecosystem. This would disturb the efficient functioning of the ecosystem.

3.2.3 Other activities

Land uses of the mangrove regions may be classified into two groups. The first group includes managed forestry, mangrove agriculture (which is the cultivation and production of species in demand, like Rhizophora and Nypa), and natural fishery. Although these land uses may disrupt the ecosystem, the effects are often negligible, allowing the mangrove ecosystem to maintain its homeostasis.

The second group of land uses includes agriculture (i.e. the conversion of mangrove areas into plantations of rice, corn, etc.; into fishponds and shellfish farms; or into salt farms), mining, industry (i.e. factories, commercial and trade facilities, communication installations and ports), and urban settlements (i.e. the conversion of mangrove areas into residential zones, water drainage systems, water impoundments, waste dumping sites, etc.). These land uses require that the forest be totally cleared, excavated or land-filled. In short, the mangrove ecosystem is destroyed. Furthermore, such changes affect the adjacent regions, like the estuary and coastal waters, in more ways than one.

The invasion of fertilizers and pesticides via agricultural practices has created unrecognized problems for agriculture itself and for the marine ecosystem as well. Pesticides leach out and find their way into streams, rivers, mangrove swamps, estuaries and into the sea. The conversion of mangrove forest into agricultural regions shortens the distance between the source of pesticides and the affected areas.

Some aquaculture practices, like the use of chemicals to kill snails, predators of shrimps, etc., are highly destructive not only to the undesirable species but also to non-target organisms. Not only visible organisms are killed but also the microscopic organisms that are involved in detritus conversion, and biogeochemical cycles.

In the Philippines where mangrove areas are being converted into fishponds at a stagerring rate (Gomez, 1980), there is great fear of not only the subsequent extinction of mangrove forests but also the associated repercussions of such reclamation activities. The conversion of mangrove areas to fishponds could mean the removal of nurseries and feeding grounds of mangrove-dependent fisheries and the consequent decline in the fishery productivity of coastal waters. As shown in fishery statistics of the Philippines, the municipal coastal fisheries contribute most to the total fish production of the country.

In Indonesia, fishery statistics indicate a correlation between shrimp landings and mangrove areas (Martosabroto and Naamin, 1977). A correlation has also been found between landings of penaeid shrimps and areas of intertidal vegetation for 27 locations around the world (Turner, 1977).

Christensen (1979a) compared the different land uses of mangrove areas in Thailand on the basis of annual income per hectare. He noted that the best land use appears to be intensive shrimp farming. The yield of mangrove plantations is also high and charcoal production exceeds both shrimp farming and rice cultivation. The value of mangrove for fisheries, like other land uses, employ many people. Charcoal production ranks low in employment.

Intensification, Christensen concluded, rather than extensification of shrimp farming is called for, and that mangrove forestry could give much higher yields than at present provided the necessary investments are made.

Intensified fish farming appears to be the solution for the problem in the Philippines. Average production rate of fish farms, at present is in the order of 600 kilograms per hectare per year. With intensified methods, the annual production rate can possibly be increased to some 2 tons per hectare. Thus, it may no longer be necessary to release additional mangrove areas for fishpond conversion. Furthermore, the coastal water fishery and other mangrove-dependent species need not be endangered at all.

Salt farming (which requires forest clearing and compacting of the soil to facilitate water collection for evaporation and saturation) causes high levels of salinity and temperature, conditions very disturbing to the stable environment.

Mining activities, in addition to destroying the mangrove ecosystem, result in a great deal of siltation and turbidity, burying other benthic communities wherever the sediment settles. The estuary and coastal waters may also be affected by the sediment overload. This threatens adjacent coral reefs as well.

Singapore exemplifies the condition wherein industry and settlement have reclaimed the mangrove areas, bringing the proportional pollution to adjacent areas. Many mangrove areas have undergone reclamation for all sorts of modern purposes. Some were converted to prawn ponds, and later on turned into housing projects or industrial estates.

Compounding the ecological problems brought about by industries are the waste disposal problems presented by urban settlements. Inhabitants of these settlements utilize mangrove swamps as dumping sites, resulting in enormous organic overload and turbidity. On the other hand, they rid the swamps of malarial carriers through land-filling measures.

Freshwater catchment areas present problems like changes in the soil conditions of adjacent swamps through seepage; withholding freshwater flow from the sea would change the salinity regime of the mangrove swamps located near the water impoundment. The organic component that is normally drained from land into rivers would now fail to contribute to the allochthonous source of energy for the mangrove ecosystem, causing the mangrove community to change (Dept. Zool., Sing., 1980; and Johnson, 1973).

3.3 Effects of pollution

The impact of land and coast/sea-based pollution on the mangrove ecosystem has been little studied.

One of the better documented cases on the effect of land-based pollution is on the Mae Klong River, Thailand. In 1970, effluents from sugar refinery mills on the river's banks damaged cockle farms in the estuarine vicinity. The damage to cockle farms alone at that time was estimated to be 6.4 million baht ($320 000) and considering the damage to other organisms, loss was estimated to be as high as 50 million baht ($2.5 million) (Ratasuk, 1973). On April 9, 1973 the Bangkok Post reported that about 10 tons of shrimp and fish in the Mae Klong River had died (Piyakarnchana, 1980). Razor clam beds were also destroyed along with the cockles as well as one of the tourist attractions in the area. A decrease in cockle production in Samut Songkhram Province from 1971-1974 was also attributed to the river pollution.

Pollution from a canning factory, sugar cane mills, and distillery plants along Pranburi River, Thailand left many organisms dead as reported in 1975. In the Petchburi River, an indication of the extent of damage due to pollutants is that, now, only 10% of the cockle farms produce yields within the normal range (Piyakarnchana, 1980).

Another notable effect of domestic and industrial pollutants emptied into the Chao Phaya River is the increasing appearance of the red water phenomenon in the upper part of the Gulf of Thailand (Piyakarnchana and Tamiyavanich, 1979).

Seow (1976) in a study of a mangrove inlet in Sungei Puloh, Malaysia showed that downstream pollution from agricultural wastes extended over a distance of 2 to 3 kilometers. No pelagic fauna were found at the outfall. But at a distance of 2 kilometers downstream, several species of fish (Liza melinoptera, Dorosoma chacunda, and Haplochilus melastigma) and a penaeid prawn were abundant.

Excessive dumping of wastes into natural waters also cause eutrophication, which at first starts slowly but later accelerates quickly. This eventually leads the waters to die and become useless. A number of natural aquatic environments in Indonesia are apparently approaching this stage, particularly those located in and around population centres (Soegiarto, 1980).

Terrestrial and sea-based mining operations are also believed to be a major cause of damage to natural waters and to the biota. Sediments from these operations, especially those based at sea, disperse over a wide area and in some parts have been found to accumulate to the point of blocking the waterway. Siltation on coral reefs is also known to be a major cause of destruction of these organisms (Piyakarnchana et al., 1979); Soegiarto, 1980).

The effect of heavy metal pollution is felt mainly by the biota but few studies are available in this area. In Singapore, the tolerance of animals to heavy metals in terms of median tolerance limits (TLm) has been assessed by several workers (Dept. of Zool., Sing., 1980).

The resulting deoxygenation from organic pollution could prevent upstream migration of fish and other organisms according to Johnson (1973).

Kapauan (1977) suggests that the mangrove ecosystem will not always act as a sink for pollutants like SO_2, silt, sewage, heavy metals and pesticides. It is possible, he says, that the mangrove mobilizes the pollutants, making them more available and therefore more destructive.

Oil, as pollutant, tends to be trapped within the mangrove forest in the tide-pools which form at the roots of the plants or adhered to the plants themselves. The spilling of 7 000 tons of crude oil by the "Showa Maru" into the Indonesian, Singaporean and Malaysian coastal waters resulted in the destruction of hundreds of hectares of mangrove forests (Soegiarto, 1980). A team sent to the area in August 1977 reported that most of the mangrove forest affected had not yet recovered even after more than two and a half years. However, very few studies in the effects of oil spills and subsequent cleaning-up operations using dispersants have been conducted.

The effects of pollution in rivers, estuaries and inshore waters was reported in the International Workshop on Marine Pollution in East Asian Waters (FAO/IPFC, 1976) and is reproduced, in part, in Table 9.

Table 9. Observed effects of pollution in various countries in Southeast Asia (after FAO/IPFC, 1976)

Particulars	IND			MAL			PHIL			THAI		
	Natural environment											
	a	b	c	a	b	c	a	b	c	a	b	c
Fish kills	x			x	x	x	x	x	x	x	x	x
Changes in relative abundance of different species	x	x		x	x		x	x	x	x	x	x
Increased in harvest and/or commercial value	x	x								x	x	x
Decreased in harvest and/or commercial value	x	x	x	x	x		x	x	x	x	x	x
	Aquaculture											
Direct effects of effluents, e.g. by toxicants contained in them	x						x			x		
Indirect effects of effluents, e.g. plankton blooms	x			x			x			x		
Undesirable accumulation of pollutants	x DDT PCB's									x DDT		

a = in rivers
b = in estuaries
c = inshore waters
x = effects observed

4. IDENTIFICATION OF IMPORTANT POLLUTANTS AND ADVERSE FACTORS, AND PROBLEM AREAS

During the Expert Consultation Meeting on the Impact of Pollution on the Mangrove Ecosystem and Its Productivity in Southeast Asia held in Manila, 4-8 February 1980, a list of critical pollutants damaging mangrove ecosystems in Southeast Asia was produced as shown in Table 10 (FAO/UNEP, 1980). Heavy metals are shown to be the most serious pollutants throughout the region. Pesticides and petroleum hydrocarbons are problems common in almost all the countries while domestic sewage causes serious problems in urban areas. Except for solid wastes, most of these pollutants are not easily removed and will become serious chronic pollution problems in the mangrove forest ecosystem.

In the same workshop, a list of other destructive factors was drawn up and is given in Table 11. The participants indicated the problem areas in their respective countries and these are shown in both tables. It is to be noted that most of these places are industrialized areas.

5. GAPS IN ECOLOGICAL UNDERSTANDING OF MAN-INDUCED STRESS TO MANGROVE ECOSYSTEMS

Arguments for the conservation of mangrove areas in the region have been drawn almost exclusively from secondary sources and cursory field observations.

The major processes maintaining and modifying the mangrove environment and the manner in which the organisms interact with each other and with environmental factors remain largely unknown (Dept. Zool., Sing., 1980). Even more scarce are studies on the direct and indirect effects of various pollutants on the mangrove and its ecosystem. The impact of human activities which contribute to changing the mangrove ecological conditions indirectly, such as the modification of drainage patterns, land reclamation of adjacent areas, input of freshwater nutrients, and watershed development, are still not understood.

Research needs to be done on the feeding habits of fish and other aquatic fauna in mangrove areas to elucidate the possible pathway of pollutants in the foodweb. A comprehensive listing of fish species that actually spend their juvenile years in mangrove environments has yet to be made. Nor is it known to what degree the relationship is obligate or facultative for particular species. Much of the evidence is circumstantial.

Studies on the physico-chemical properties of disturbed and undisturbed mangrove environments remain few as well as data on net primary production. Much has yet to be learned on the energy flow and nutrient cycling in the mangrove ecosystem.

Table 10. List of critical pollutants and problem areas in the ASEAN countries

	Indonesia	Malaysia	Philippines	Singapore	Thailand
BOD					
Agro-industrial wastes	+	+++ West Coast Peninsula	++	+	++ Inner Gulf
Domestic sewage	++	+	+	+	+++ Inner Gulf
Fertilizers	+	+	++	o	+
Toxic substances					
Heavy metals	+++ Jakarta Bay	+++ Juru River, Klang River (Selangor)	+++ Honda Bay Iligan Bay	+	+++ Inner Gulf
Pesticides	++	++	++	o	++
Petroleum hydrocarbons	+++ Dumai, Cilacap	++	++ Luzon	++	++ Inner Gulf
Other organic hydrocarbons	+++ W. Kalimantan	++ PCB	+ PCB	+	++ Inner Gulf PCB, Phenols
Physical pollutants					
Silt	++ Bangka Belitang	+	++ Marinduque	o	+++ West Coast Trat
Thermal energy	+	o	o	+	+
Solid wastes (e.g. plastic bags, etc.)	++ Jakarta Bay	+	++	o	+++ Inner Gulf

Legend: o = none; + = few; ++ = common; +++ = serious

Table 11. List of destructive factors and problem areas in the ASEAN countries

	Indonesia	Malaysia	Philippines	Singapore	Thailand
Land fill	++	++ Selangor	++	+++	++
Fishpond	+	o	+++ Nationwide	+++ P. Ubin P. Tekong	+
Agriculture	++	++	+	o	+
Wood use	+++ Riau Cilacap	+	+++ C-S Luzon Mindanao	o	+++ Andaman coastline
Mining	o	o	o	o	++ Phang Nga Phuket
Salterns	++ N of Java	o	+	o	+

Legend: o = none; + = few; ++ = common; +++ = serious

6. RESEARCH ACTIVITIES

6.1 Description of research activities and capabilities

Studies on the mangrove ecosystem conducted by the Southeast Asian countries have varied in impetus as well as with the country's research capabilities. A summary of research activities and capabilities is shown in Table 12. This table is synthesized from the output of the recent Expert Consultation Meeting on the Impact of Pollution on the Mangrove Ecosystem and Its Productivity in Southeast Asia (FAO/UNEP, 1980) and the International Workshop on Mangrove and Estuarine Area Development for the Indo-Pacific Region (PCARR, 1978).

Hardly any research has been done on the effects of various pollutants on mangrove areas. Much of the work has been on the inventory of mangrove communities in the region although an increasing interest on the ecology and physiology of mangrove communities is indicated by ongoing and proposed research projects.

6.2 Present international cooperation and exchange of information

International cooperation on mangrove research has been going on in the form of information exchange principally through workshops and conferences. Two such meetings were the International Workshop on Mangrove and Estuarine Area Development for the Indo-Pacific Region held in November 14-19, 1977 in Manila and the Symposium on Mangrove and Estuarine Vegetation in Southeast Asia held at the Universiti Pertanian Malaysia in Serdang, Selangor on April 25-28, 1978. There continues to be a lack of research linkages among the Southeast Asian countries, whether they be bilateral or regional.

A discussion of cooperative research and training programmes is expected in a special session of the Regional Symposium on the Mangrove Environment in Asia: Research and Management, to be held in 25-29 August 1980 in Kuala Lumpur under the sponsorship of UNESCO and the University of Malaya. UNESCO has been spearheading the development of mangrove research in the region. Towards this end a project proposal has been prepared for the "Training and Research Pilot Programme on the Mangrove Ecosystem in Asia and Oceania" to be funded by the United Nations Development Programme (UNDP). This project is to be executed by UNESCO and it will involve the training of environmental scientists, mangrove zone managers, and socio-economists for research and management of mangrove ecosystems.

6.3 Need for international support of national research programmes

Although most of the Southeast Asian countries have national research programmes in existence, actual on-going research on mangroves in the region remains rather limited. The reasons for this are multiple. First, there is a dearth of properly qualified mangrove researchers. Secondly, the facilities for research are inadequate both from the standpoint of infrastructure (laboratories or stations) and of equipment. Thirdly, funding for research is minimal.

Table 12. Research activities and capabilities in the Southeast Asian Region

AREA	COMPONENT
1. Inventory of mangrove and estuarine communities	a) Geographic distribution of mangrove estuarine ecosystem b) Survey of flora and fauna and their uses
2. Socio-economic and land uses of mangrove swamps	a) Multiple use of mangrove swamps and estuarine areas b) Relationship of mangrove swamps to fisheries
3. Protection	a) Kinds and sources of pollutants in mangrove ecosystems b) Reforestation studies
4. Geomorphological and hydrological/chemical studies	a) Erosion and sedimentation in mangrove and estuarine areas b) Chemical studies on interstitial waters and sediments
5. Ecological and physiological studies	a) Influence of fresh water discharge on the growth/survival of mangrove tree species b) Nutrient composition, cycling c) Primary productivity d) Food webs e) Mangrove forest regeneration f) Biology of various organisms found in mangrove forests g) Effect of salinity on mangrove seedling germination h) Tolerance studies of various organisms to pollutants
6. Fisheries/Aquaculture	a) Stock assessment of mangrove and estuarine fisheries b) Improvement of catch efficiency (quantity and quality) of existing gears c) Alternative aquaculture systems in mangrove and estuarine areas with minimum alteration of the ecosystem d) Field-testing of aquaculture techniques for increasing production e) Determining the criteria for site selection of mangrove areas for aquaculture development

In order for the various programmes to be substantially implemented, external assistance is badly needed. A manpower training program in the region needs to be developed with international support. Funding for the development of facilities and for the support of research operations is needed also from external sources since the present economic conditions of the developing countries in Southeast Asia cannot adequately support this and other programmes.

6.4 Priority research needs

In the discussion of country reports on the Impact of Pollution on the Mangrove Ecosystem in Southeast Asia, the following research priorities were noted[1/];

1. Effects of palm oil effluents on mangrove aquatic pollution
2. Heavy metal contamination in clams
3. Aquaculture capabilities in mangrove areas
4. Bioassays with commercially important species
5. Pathways of heavy metals and pesticides in mangrove communities
6. Reforestation of areas covered by mine tailings
7. Influence of silviculture treatments on mangrove ecosystems
8. Oceanic transport of oil and its effects on mangroves
9. Field monitoring of fauna and flora
10. Soil quality monitoring in disturbed and undisturbed areas
11. Correlation between fisheries and the state of mangrove forests
12. Effects of oil pollution on the survival of mangrove seedlings
13. Effects of sewage on mangrove ecosystems
14. Effects of hinterland erosion and land accretion on mangroves.

However, it was decided to regroup the above and that greatest priority be given to the following projects:

1. Effects of organic effluents on mangrove aquatic communities
2. Bioassay of pollutants on mangrove biota
3. Effects of destructive factors on mangrove forests and soil quality
4. Impact of mangrove forest utilization on the fisheries in the surrounding waters.

The outlines for these four studies are part of the report of the meeting (FAO/UNEP, 1980), and are reproduced in the Appendix.

7. SUMMARY

An estimated 4.8 million hectares of mangrove areas exist in the Southeast Asian region. This constitutes about 1.6% of the total land area of the five ASEAN countries. Most of the mangrove forests are found in Indonesia (75%) while the remaining 25% are found in Malaysia, the Philippines and Thailand. Singapore contributes a small fraction of one percent to the total mangrove area in the region. Although mangrove swamp forests are found over most of

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1/ Although these are all priority problems, the list is not according to priority.

the region's coastlines, extensive growths are concentrated in particular coastal areas. In Singapore, for instance, most of the mangroves are found on the northern part of the island while hardly any mangrove is left on the southern coast.

Botanical associations in mangrove areas are moderately well identified in the region while zoological communities are lessknown. As yet, no specific classification has been universally adopted by the ASEAN countries. There is still a need to establish causal relationships between the mangrove flora and fauna.

With the exception of Singapore, the ASEAN countries remain basically agricultural with extensive fisheries. However, there is a strong trend towards industrialization. The major crops of the region include rice, corn, coconut, palm oil, sugar cane, abaca, tobacco, coffee and rubber. The industries in the region include shipbuilding, oil refining, electronics, food processing, textile, and other light industries. Tin mining is extensive in Thailand, Malaysia and Indonesia. The Philippines mines iron, copper, gold, chromite and other minor minerals. Singapore typifies a formerly mangrove forested and swampy area that has been reclaimed for urban and industrial projects. In other countries, agriculture, mining and aquaculture are the major purposes for the reclamation of mangrove areas. More than half of the quarter billion people of Southeast Asia is concentrated in Indonesia. The population distribution trend among the region's island nations is coastal.

The physical environment is better characterized on land than in the sea. Rainfall and tidal characteristics are well known but river flows, salinity, sea water temperature and current data are limited. The chemical environment remains inadequately characterized for the region as a whole as evidenced by the dearth of published literature.

Ecological studies in relation to mangroves are few and very little is known on the impact of land, coast and sea-based pollution on the mangrove ecosystem.

Heavy metals have been identified as the most serious pollutants in the region. Pesticides and petroleum hydrocarbons are problems common in almost all the countries while domestic sewage causes serious problems in urban areas. Potential problem areas are to be found near industrial centres by virtue of the concentration of polluting sources.

Much effort is required to determine the major processes maintaining and modifying the mangrove environment. The basic ecological relationships in mangrove areas are still to be understood. Studies on the physico-chemical properties of disturbed and undisturbed mangrove environments are wanting. In addition to this, the impact of human activities on the mangrove ecosystem needs to be studied further.

Most of the researches done in the region have been on the inventory of mangrove communities with a few studies on the ecology and physiology of mangrove communities. International cooperation has been limited to information exchange principally through workshops and conferences. However, cooperative research and training programmes in the region are expected in the near future. The recent Expert Consultation Meeting on the Impact of Pollution on the Mangrove Ecosystem and Its Productivity in Southeast Asia identified the priority research areas in the region and indicated a strong need for international support to substantially implement existing and proposed research programmes.

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9. APPENDICES

9.1 Table 2. List of mangrove and associated species found in the ASEAN countries. (Tabulated from country reports)

	IND	MAL	PHIL	SING	THAI
Division SPERMATOPHYTA					
Subdivision Angiospermae					
Class Dicotyledoneae					
Acanthaceae					
A. ebracteatus Vahl.	*	*	*		*
A. flexicaulis				*	
A. ilicifolius L.	*		*	*	*
A. volubilis Wall.	*				
Pseuderantheum bicolor			*		
Aegiceratáceae					
Aegiceras corniculatum (L)Blanco	*	*	*		*
A. floridum R. and S.	*		*		
Aizoaceae					
Sesuvium portulacastrum L.			*	*	
Annonaceae					
Xylopia sp.				*	
Apocynaceae					
Alstonia macrophylla			*		
Beaumoutia pandacaqui			*		
Cerbera manghas L.	*	*		*	
C. odollam Gaertn.		*		*	
Strophanthus cumiingii			*		
Araliaceae					
Heptapleurum avenae Seem.				*	
Schefflera odorata Blanco, Meer., and Rolfe			*		
Asclepiadaceae					
Cynanchum carnosum Schltr.	*				
Dischidia benghalensis Colebr.	*			*	
D. collyris Wall.				*	
D. nummularia Bl.				*	
D. rafflesiana Wall.				*	*
Dischidia sp.			*		
Finlaysonia obovata Wall.	*		*	*	
Gymnanthera paludosa (Bl.)K.Schum	*				
Hoya augustifolia Elm.			*		
H. coronaria Bl.				*	
H. lacunosa Blume					*
H. merrilii Schltr.			*		

T. 2 (contd.)

	IND	MAL	PHIL	SING	THAI
H. obtusifolia				*	
H. parasitica (Roxb.) Wall. ex. Wight					*
Hoya sp.	*				
Sarcolobus banksii R. and S.	*				
S. globosus Wall.				*	
Asteraceae					
Pluchea indica L.			*		
Bignoniaceae					
Dolichandrone rheedi Seem.				*	
D. spathacea L.F.K. Schum.	*	*	*		
Bombacaceae					
Camptostemon philippinensis (Vid.) Becc.			*		
Boraginaceae					
Cordia mossambica				*	
Caesaphiniaceae					
Bauhinia binata Blanco Fl. Filip.			*		
Caesalpinia crista L.	*				
C. nuga (L.) Ait.		*	*	*	*
C. scadens L.			*		
Cuminga philippinensis Vidal	*				
Cynometra ramiflora L.	*	*	*	*	
Intsia bidurga (Colebr.) O.K.		*			
I. retusa (Kurz.) O.K.			*		
Celastraceae					
Cassine viburnifolia (Juss.) Hou.		*			
Combretaceae					
Lumnitzera littorea (Jack) Voight	*	*	*	*	*
L. lutea Presl.	*				
L. racemosa Willd.	*		*	*	*
Terminalia catappa L.				*	
Convolvulaceae					
Ipomea pes-capre (L.) Roth.			*		
Ericaceae					
Rhododendron brookeamum Low.	*				
Euphorbiaceae					
Breynia reclinata				*	
Excoecaria agallocha L.	*	*	*	*	*
Glochidion littorale Bl.		*	*	*	
G. mindorense			*		
Mallotus papillaris			*		
Sapium indicum Willd.		*		*	

T. 2 (contd.)

	IND	MAL	PHIL	SING	THAI
Fabaceae					
Dalbergia candenatensis Prain.	*		*		
D. menoides Prian.	*				
D. torta Grah.				*	
Derris heptaphylla (L.) Merr.	*		*		
D. heterophylla (Willd.) Backer	*			*	
D. lianoides			*		
D. trifoliata Lour.		*	*	*	*
D. uliginosa Benth.				*	
Desmodium umbellatum L.			*		
Inocarpus fagiferrus (Park.) Fosb.		*		*	
Pongamia pinnata (L.) Merr.				*	
Pterocarpus indicus L.				*	
Flacourtiaceae					
Scolopia macrophylla (W & A) Clos		*			*
Gesneraceae					
Aeschynanthus lobbiana HK				*	
Goodeniaceae					
Scaevola taccada Roxb.				*	
Guttiferae					
Garcinia bankana Miq.				*	
Lauraceae					
Cossytha filiformis L.				*	
Lecythidaceae					
Barringtonia conoidea (Griff.)		*		*	
B. inclyta (Miers.)				*	
B. racemosa Bl.		*			
Loranthaceae					
Amyema gravis Davis	*				
Dendropthoe pentandra (L.)Miq.					*
Viscum orientalis L.	*				
V. ovalifolium D.C.					*
Lythraceae					
Pemphis acidula H.P. and G.Forst			*		
Malphighiaceae					
Tristellateia australasiace L.C. Rich.			*	*	
Malvaceae					
Hibiscus tiliaceus L.		*	*	*	*
Thespesia populnea (L.) Soland, ex. Correa		*	*	*	*

T. 2 (contd.)

	IND	MAL	PHIL	SING	THAI
Melastomaceae					
Medinilla hasseltii BL.				*	
M. sessiliflora Cogn.				*	
Melastoma malabathrium				*	
M. villosa					*
Ochthocharis borneensis Coy.		*		*	
O. javanica Bl.				*	
Pachycentria constricta (Bl.)Bl.	*				
Plethriandra sessiliflora Ridl.	*				
Pogonanthera reflexa Bl.				*	
Meliaceae					
Amoora cucullata Roxb.		*			
Carapa obovata Bl.				*	
Xylocarpus granatum Koenig		*	*	*	
X. gangalicus		*			
X. moluccensis (Lam.) M. Roem		*	*	*	*
X. obovatus					*
Mimosaceae					
Acacia farnesiana			*		
Pthecolobium umbellatum (Vahl) Bth.	*				
Moraceae					
Ficus binnendyckii				*	
F. diversifolia Bl.				*	
Myrsinaceae					
Ardisia elliptica Thumb.		*			
A. humilis Vall.		*			
A. Littoralis				*	
Myrsine sp. (esculenta Buch. Ham)				*	
M. umbellulata (Wall.) Mez.		*			
Rapanea porteriana					*
Myrtaceae					
Elugenia myntifolia Roxb.				*	
Osbornia octodonta F. Muell.	*		*		
Rhamnaceae					
Smythea lanceata (Tul.) Summeril	*				
Rhizophoraceae					
Bruguiera cylindrica (L.) Blume	*	*	*	*	*
B. exasristata Ding Hou	*				
B. gymnorrhiza (L.) Lamk.	*	*	*	*	*
B. hainesii					*
B. parviflora (Roxb.) W & A ex. Griff.		*	*	*	*

T. 2 (contd.)

	IND	MAL	PHIL	SING	THAI
B. sexangula (Lour.) Poir.	*	*	*	*	
(=B. eriopetala)					
Ceriops decandra (Griff.)Ding Hou	*	*	*	*	*
C. tagal (Perr.) C.B. Robinson	*	*	*	*	*
Kandelia candel (L.) Druce	*	*			
Rhizophoraceae					
Pellacalyx sp.				*	
R. mucronata Lamk.	*	*	*	*	*
Rhizophora apiculata Blume	*	*	*	*	*
R. stylosa Griff.	*				
Rubiaceae					
Canthium didymum Roxb.				*	
Hydrophytum sp.			*		
Hydrophytum fornicarum Jack	*				
Ixora timoriensis Eieni	*				
Mermecodia sp.	*		*		
Morinda bracteate			*		
Randia sp.				*	
Scyphiphora hydrophyllacea Gaerth	*	*	*	*	*
S. apiculata Gaerth.		*			
Timonius finlaysoniasus Wall.				*	
Rutaceae					
Melicope angulata (Willd.) Sw.				*	
Paramignya angulata (Willd.) Kurz.	*				
Sapindaceae					
Allophyllus cobbe (L.) Ralusche				*	*
Sapotaceae					
Planchonella obovata (R.Br.)Pierre		*			
Sonneratiaceae					
Sonneratia alba J.E. Smith	*	*	*	*	*
S. caseolaris (L.) Engl.	*	*	*	*	*
S. griffithii					*
S. ovata Backer	*	*		*	*
Sterculiaceae					
Kleinhovia hospita			*		
Heritiera fomes Buch. Ham.				*	
H. globosa Kosterm.		*			
H. littolaris Ait.	*	*	*	*	*
H. tiliaceus L.		*			
Heritiera sp. nov.					*
Ternstroemiacea					
Adinandra miquelii King				*	

T. 2 (contd.)

	IND	MAL	PHIL	SING	THAI
Tiliaceae					
Brownlowia argentata Kurz.	*	*		*	
B. lanceolata Benth - Maragomon (=B. tersa (L.) Kosterm)	*	*	*	*	
Verbenaceae					
Avicennia alba Bl.	*	*	*	*	*
A. lanata L.				*	
A. marina (Forsk.) Vierh	*	*	*	*	*
A. officialis L.	*	*	*	*	*
Clerodendron inerme				*	*
Premna integerrima					*
P. obtusifolia R. Br. Prodr.			*		
Vitaceae					
Columella trifolia			*		
Class Monotyledoneae					
Araceae					
Cryptocoryne ciliata (Roxb.) Schott	*			*	
Aracaceae					
Calamus aquatilis Ridl.		*			*
Corypha elata Roxb.			*		
Cyntostachys lakka Becc.				*	
Nypa fruticans Wurmb.	*	*	*	*	*
Oncosperma filamentosa Bl. (=O. tigillarium Ridl.)	*	*	*	*	*
Phoenix paludosa Roxb.	*				
Cyperaceae					
Cyperus malaccensis Lamk.	*			*	
Diplaehne fusca (L.) Beauv.	*				
Fimbristylis ferrugineus Vahl.	*			*	
Sarpodendron costatum King				*	
Flagellariaceae					
Flagellaria indica L.			*	*	
Liliaceae					
Crinum asiaticum			*		
Orchidaceae					
Adenoncos sumatrana				*	
Aerides odorata Lour.	*				
Anola violacea Schltr.	*				
Appendicula lucida Ridl.				*	
Bulbophyllum apodum Hk. f.				*	
B. avicella Ridl.				*	
B. blumei (Lindl.)				*	
B. botryphora Ridl.				*	

T. 2 (contd.)

	IND	MAL	PHIL	SING	THAI
B. concinnum Hk. f.				*	
B. dixom Roffe					*
B. ovalifolium				*	
B. parpuracens T. & B.					*
B. vermiculare HK. f.				*	
B. xylocarpi J.J.S.	*				
Dendrobium alvifolium (Bl.) RCHB	*				
D. callibotrys Ridl.	*				
D. crumenatum Sw.					*
D. flavidulum Ridl.				*	
D. gemellum Lindl.				*	
D. indivisum (Bl.) Miq.					*
D. luzonense Lindl.			*		
D. pensile Ridl				*	
D. prostratum Ridl.	*				
D. rhizophoreti J.J.S.	*				
D. salaccensis				*	
D. spurium				*	
D. subulatum (Bl.) Lindl.	*				*
Erium albido-tomentosa (Bl.) Lindl.					*
E. floribunda Lindl.				*	
E. obliqua Lindl.				*	
E. ornata Lindl.					*
Eulophia Keithii Ridl.					*
Luisia zollingeri Rehl. f.					*
Microsaccus javanensis Bl.				*	
Obreronia laeta J.J.S.	*				
Paphiopedilum exul (O'Brien) Pfitz					*
Pholidota imbricata (Roxb.) Lindl.					*
Phreatia minutaflora Lindl.				*	
Polystachya flavencens				*	
Pomatocalpa siamensis (Rolfe, ex. Downie Summ)					*
Rhenanthera histrionica Ridl.				*	
Sarcochilus pallidus Bl.			*		
Schoenorchis perpusillus HK. f.				*	
Taeniophyllum obtusum				*	
Thelasis carinata				*	
Trichoglottis misera (Ridl.) Roltt.					*
Pandanaceae					
Pandanus odoratissimus L.				*	
Poaceae					
Aegialitu annulata R. BR.	*				
Chloris sp.			*		
Paspalum distichum Burm.				*	
Subdivision Gymnospermae					
Podocarpaceae					
P. polystachyas				*	

T. 2 (contd.)

	IND	MAL	PHIL	SING	THAI
Division PTERIDOPHYTA					
Aspleniaceae					
Asplenium nidus L.			*	*	
Davalliaceae					
Davallia sp.	*				
Humata heterophylla (Sm.) Desv.				*	
H. parvula Wall.	*			*	
H. repens (L. fils) Diels.				*	
Grammitidaceae					
Ctenopteris moultoni				*	
Hymenophyllaceae					
Hymenophyllum denticulatum Sw.(Misd.)				*	
H. serrulatum (Presl.)				*	
Lindsaeaceae					
Lindsaea borneensis HK.				*	
Lomariopsidaceae					
Elaphaglossum decurrens Desv.				*	
Lycopodiaceae					
Lycopodium taxifolium Sw.				*	
Oleandraceae					
Nephrolepis acutifolia (Desv.) Chr.	*			*	
Polypodiaceae					
Cyelophorus cinnanomeus V.A.V.R.	*				
Drymoglossum pilosettoides (L.) Presl.				*	
Drynaria sparsisera (Desv.) Moore	*				
D. quercifolia J. Sm.			*		
Elaphogloseum decurrens Desv.			*	*	
Lecanopteris sinuosa			*		
Phymatodes scolopendria (Burm.) Ch.	*			*	
P. sinuosa (Wall) J. Sm.	*				
Platycerium coronarium (Koenig) Desv.	*				
Pyrrosia augustata (Sw.)Ching				*	
P. varia (Kaulf.) Far.				*	
Selliguea heterocarpa Bl.				*	
Psilotaceae					
Psilotum complanatum Sw.				*	
P. flaccidum Wall.				*	
Pteridaceae					
Acrostichum aureum L.	*	*	*	*	*
A. speciosum Willd.				*	*

T. 2 (contd.)

	IND	MAL	PHIL	SING	THAI
Schizaeaceae					
Lygodium laxum Pr.	*				
Selaginellaceae					
Selaginella willdenovii (Desv.) Bak				*	
Sinopteridaceae					
Pitynogramma calomelanos (L). Link				*	
Vittariaceae					
Vittaria elongata Sw.				*	
Vittaria sp.	*				
Divison BRYOPHYTA					
Fissidens crassinervis				*	
Frullania sp.	*				
Calymperiopsis sp.				*	
Leucobryum sp.				*	
Microlepidozia sp.				*	
Musci				*	

9.2 Table 3. Faunal list of decapod crustacea in the mangrove and estuarine areas of Batan Bay, Panay Island, Philippines. (from Motoh and Solis 1978).

Class CRUSTACEA Order DECAPODA	Resident	Seasonal resident	Casual migrant	Table value
Section MACRURA				
I. Family Luciferidae				
1. Lucifer sp.	*			
II. Family Sergestidae				
2. Acetes intermedius OMORI	*			*
III. Family Penaeidae				
3. Penaeus monodon FABRICUS		*		*
4. P. semisulcatus De HAAN		*		*
5. P. merguiensis De MAN		*		*
6. P. indicus H.M. EDWARDS			*	(*)
7. P. latisulcatus KISHIVOUYE		*		*
8. P. japonicus BATE				(*)
9. Metapenaeus ensis De HAAN		*		*
10. M. endeavouri SCHMITT			*	*
11. M. burkenroadi KUBO				*
12. Metapeneaopsis palmensis HASWELL			*	(*)
13. Trachypenaeus fulvus DALL	*			(*)
IV. Family Alpheidae				
14. Alpheus lobidens De HAAN	*			(*)
V. Family Palaemonidae				
15. Palaemon debilis DANA	*			
16. Macrobrachium equidens DANA	*			*
Section ANOMURA				
VI. Family Thalassinidae				
17. Thalassina anomala HERBST				
VII. Family Upogebidae				
18. Upogebia sp.	*			
VIII. Family Paguridae				
19. Clibanarius longitarsus De HAAN	*			

T. 3 (contd.)

Class Order CRUSTACEA DECAPODA	Resident	Seasonal resident	Casual migrant	Table value
Section BRACHYURA				
IX. Family Portunidae				
20. Portunus pelagicus LINNAEUS		*		*
21. P. sanguinolentus HERBST			*	(*)
22. Charybdis feriata (LINNAEUS)			*	*
23. Ch. orientalis DANA	*			*
24. Thalamita denae STIMPSON	*			*
25. Scylla serrata FORSKAL		*		*
26. Podopthalmus vigil FABRICIUS			*	*
X. Family Xanthidae				
27. Baptosiuz vinosus H.M. EDWARDS	*			
XI. Family Ocypodidae				
28. Uca coarctata coarctata H.M. EDWARDS	*			
29. U. dussumieri dussumieri H.M. EDWARDS	*			
30. U. vocans vocans LINNAEUS	*			
31. U. chloropthalmus crassipes ADAMS & WHITE				
32. U. triangularis H. MILNE EDWARDS	*			
33. U. lactea lactea De HAAN	*			
34. Macrophthalmus pacificus DANA	*			
35. Macrophthalmus sp.	*			
36. Tmethypocoelis ceratophora KOELBEL	*			
XII. Family Grapsidae				
37. Varuna litterata FABRICIUS		*		*
38. Sesarma impressa H.M. EDWARDS	*			
XIII. Family Gecarcinidae				
39. Cardisoma carnifex HERBST	*			*

NOTE: If values are occasional, the asterisks are shown with parentheses.

9.3 **Table 4 a** Crustaceans found in mangrove forests and adjacent waters in Southeast Asia (compiled from country reports)

	IND	MAL	PHIL	SING	THAI
Class Crustacea					
Subclass Branchiopoda					
Order Diplostraca					
Suborder Cladocera					
Evadne sp.				*	
Subclass Copepoda					
Order Calanoida					
Acrocalanus gibber Gries				*	
Acartia erythraea Gries				*	
A. spinicauda Gries				*	
Calanus spp.				*	
Centropages sp.				*	
Paracalanus crassirostris Dahl				*	
Temora sp.				*	
Tortanus forcipatus (Gries)				*	
Order Cyclopoida					
Corycaeus sp.				*	
Cyclops (lat.) sp.				*	
Oithona sp.				*	
Order Harpacticoida					
Cleta sp.				*	
Nitocra sp.				*	
Onychocamptus bengalensis				*	
Stenhelia sp.				*	
Subclass Cirripedia					
Order Thoracica					
Balanus sp.	*				
Balanus hawaiiensis Broch.				*	*
(=B. amphitrite Darwin ?)		*			*
Chthamalus withersii Pilsbry		*		*	
Subclass Malacostraca					
Order Mysidacea					
Mesopodopsis orientalis Tatt.				*	
Rhopalophthalmus egregius Hansen				*	
Nanomysis insularis Nouvel				*	
Order Isopoda					
Cyathura sp.				*	
Cubaris sp.				*	
Chelura terebrans				*	
Cirolana sp.				*	
Excirolana sp.				*	
E. kumari Bowman		*			
Ligia sp.				*	*
Limnoria lignorum				*	
Olibrinus sp.				*	
Sphaeromia sp.				*	
S. walkeri Stebbing					*

T. 4 a. (contd.)

	IND	MAL	PHIL	SING	THAI
Order Amphipoda					
Amphipod sp. (unidentified)					•
Parhyale sp.				•	
Parorchestia sp.				•	
(Liljeborgiidae? new genus)				•	
Order Decapoda					
Suborder Natantia					
Section Penaeidea					
Acetes sibogae Hansen				•	
A. vulgaris Hansen				•	
A. intermedius Omori			•		
A. erythraeus		•			
Syncarida sp. indet.				•	
Tanaeidacea spp. indet.				•	
Lucifer sp.			•	•	
Metapenaeus brevicornis (Milne-Edw.)		•		•	
M. burkenroadi Kubo			•	•	
M. elegans (de Man)	•			•	
M. ensis (de Haan)			•	•	•
M. intermedius (Kish.)				•	
M. lysianassa (de Man)				•	
M. mastersii (Haswell)				•	
M. mutatus (Lanch.)				•	
M. spinulatus Kubo				•	
M. monoceros			•		
M. affinis			•		
M. endeavouri Schmitt			•		
M. bennettae		•			
Metapeneaopsis palmensis Haswell			•		
Parapeneopsis maxillipedo Alcock		•			
Trachypenaeus fulvus Dall			•	•	
Penaeus pencillatus		•			
P. merguiensis de Man		•	•	•	
P. indicus H. Milne-Edwards		•	•	•	
P. monodon Fabricius			•	•	
P. semisulcatus de Haan			•	•	
P. japonicus Bate			•		
P. latisulcatus Kishivouye			•		•
P. canaliculatus			•		
Section Caridea					
Alpheus bisincisus de Haan	•				
A. crassimanus Heller	•				
A. euphrosyne de Man		•			•
A. lobidens de Haan			•		
A. microrhynchus				•	
A. paludosus				•	
A. rapax Fabricius		•			

T. 4 a. (contd.)

	IND	MAL	PHIL	SING	THAI
Caridina excavatoides Johnson				*	
C. gracilirostris de Man				*	
C. propinqua de Man				*	
C. tonkinensis Bouvier				*	
Leandrites celebensis de Man				*	
L. deschampsi (Nebili)				*	
Leptocarpus potamiscus Kemp				*	
Macrobrachium sp.		*			
Macrobrachium equidens (Dana)			*	*	
M. idae				*	
M. rosenbergi				*	
Palaemon sp.		*			
P. semmelincki				*	
P. debilis Dana			*		
Pontoniinae sp. indet.				*	
Suborder Reptantia					
Section Macrura					
Superfamily Thallassinidea					
Thallassina anomala (Herbst)	*	*	*	*	*
Laomedia astacina (de Haan)		*			
L. astacina (de Haan)		*			
L. healyi Yaldwin and Wear					*
Upogebia n. sp.		*	*	*	*
Callianassa sp.			*		
Section Anomura					
Superfamily Coenobitoidea					
Clibanarius sp.			*		
C. longispinosus				*	
C. padavensis de Man		*			*
Coenobita cavipes Stimpson	*				*
Diogenes sp.	*	*			
D. avarus Heller					*
Clibanarius longitarsus de Haan			*		
Superfamily Galatheidea					
Petrolisthes sp.				*	*
Section Brachyura					
Superfamily Brachyrhyncha					
Family Gecarcinidae					
Cardisoma carnifex (Herbst)	*		*		
Family Grapsidae					
Chiromanthes n. sp.				*	*
C. eumolpe de Man	*	*		*	*
(=Sesarma eumolpe de Man)					
C. fasciatum Lanchester	*	*		*	*
(=Sesarma f. Lanchester)					
C. indiarum de Man				*	*
C. lanchesteri Tweedie				*	
C. onychophorum de Man	*	*		*	
(=Sesarma onchyphora de Man)					
C. semperi Burger				*	*
Clistocoeloma merguiense de Man	*			*	*
Chiromanthes darwinensis					*
C. dussumiere (H. M.-Edw.)					*

T. 4 a. (contd.)

	IND	MAL	PHIL	SING	THAI
Neoepisesarma mederi (H.M.-Edw.)					*
Metaplax crenulata (Genstaecker)		*			*
M. distinctus H. Milne-Edwards					*
M. elegans de Man	*	*		*	*
M. latifrons (White)		*			
Metapograpsus messor			*		
Metaplax sheni Gordon				*	
M. thukuhar			*		
Metapograpsus sp.				*	
Nanosesarma batavicum (Moreira)				*	*
(=Neoepisesarma batavicum (Moreira)					
N. bocourti (Milne-Edw.)				*	
N. brocki (de Man)				*	
N. chentongensis Serene				*	
N. crassimanum (de Man)				*	
N. edamensis (de Man)				*	
N. edwardsi (de Man)				*	
N. gemmiferum (de Man)				*	
N. indicum (de Man)				*	
N. johorensis (Tweedie)				*	
N. kraussi (de Man)				*	
N. kr. borneensis (Tw.)				*	
N. minutum (de Man)				*	
N. palawanensis (Miln.)				*	
N. pontianacensis (de M.)				*	
N. sedilensis (Tweedie)				*	
N. singaporensis (Tw.)		*		*	
(=Sesarma s. Tw.)		*			
N. versicolor (Tweedie)		*		*	*
(=Sesarma versicolor)					
Parasesarma plicatum (Latreille)					*
Sarmatium crassum Dana		*		*	*
S. smithi Milne-Edw.			*	*	
Sesarma sp. juveniles					*
S. batavianum de Man	*			*	
S. bidens de Haan	*				
S. bocourti H. Milne-Edw.	*				
S. longipes (Krauss)	*		*		
S. erythnodactylym Hess	*				
S. guttata			*		
S. impressa H.M.-Edw.			*	*	
S. meinerti de Man	*				
S. melissum de Man		*		*	
		*		*	
S. rousseauxi H. Milne-Edw.	*				
S. rutilimanum Tweedie				*	
S. smithi	*				
S. taeniolata	*				
Varuna litterata			*	*	
Grapsid sp. juveniles (unidentified)					*

T. 4 a. (contd.)

	IND	MAL	PHIL	SING	THAI
Family Leucosiidae					
Ebalia malefactrix Kemp					*
Family Ocypodidae					
Camptandrium sexdentatum Stimpson					*
Dotilla myctiroides (H. Milne-Edw)					*
Ilyoplax sp.				*	
Ilyoplax delsmani (de Man)	*	*			*
I. lingulatus (Rathbun)					*
I. longuarpa Tweedie		*			
I. obliquus Tweedie		*			*
I. orientalis	*	*			
I. punctatus Tweedie		*			*
Leipocten sordidulum Kemp					*
Macrophthalmus sp.			*		
M. bosci Andouin and Savigny					*
M. brevis (Herbst)					*
M. convexus Stimpson	*				
M. definitus Adamsand White	*				*
M. erato de Man		*			
M. latreillei (Desmarest)		*			
M. pacificus Dana			*		
M. orinitus Rathbun		*			
M. telescopicus Owen	*				
M. tomentosus Souleyet		*			
Ocypoda ceratophthalma (Pallas)	*				
O. anenaria de Man	*				
Paracleistostoma sp.					*
Paracleistostoma microcheirum Tweedie					*
Tmethypocoelis ceratophora Koelbel			*		
Tylodiplax tetratylophorus de Man		*			*
Uca sp.					*
U. acuta rhizophorae Tweedie			*	*	
U. annulipes H.M. Edwards	*		*		
U. coarctata coarctata H.M. Edwards			*		
U. chloropthalmus crassipes Adams and White			*		
U. consobrinus de Man	*				
U. dussumiere dussumiere	*	*	*		
U. dussumiere spinata Crane				*	
U. forcipata (Adams and White) (=U. mani Rathbun)		*		*	*
U. lactea annulipes (H. Milne-Edw)					
U. lactea lactea de Haan					*
U. marionis	*		*	*	
U. rosea Tweedie		*		*	
U. signatus (Hess)	*				
U. triangularis (H. Milne-Edw.)	*	*	*	*	*
U. urvillei			*		*
U. vocans vocans (L.)	*		*		
Uca sp. juveniles (unidentified)		*			*

T. 4 a. (contd.)

	IND	MAL	PHIL	SING	THAI
Family Portunidae					
Charybdis feriata (Linnaeus)			*		
C. orientalis Dana			*		
Portunus pelagicus L.			*		
P. sanguinolentus Herbst			*		
Podopthalmus vigil Fabricius			*		
Scylla serrata	*	*	*	*	
Thalamita denae Stimpson			*		
T. crenata (Latreille)					*
Family Stomatopoda					
Chlorida choprai		*			
C. rotundicauda (Miers)					*
Family Xanthidae					
Baptosius vinosus H.M. Edwards			*		
Eurycarcinus sp.					*
Heteropanope glabra Stimpson		*			*
Ozius granulosus (de Man)				*	
O. guttatus Milne-Edw.				*	
Typhlocarcinodes sp.					*

9.4 Table 4b. **Mollusca found in mangrove forests and adjacent waters in Southeast Asia (compiled from country reports)**

	Ind	Mal	Phi	Sing	Thai
Class Gastropoda					
Subclass Streptoneura (Prosobranchia)					
Order Archaeogastropoda					
Family Trochidae					
Monodonta labio Linnaeus	*		*		
Family Neritidae					
Nerita birmanica Philippi		*		*	
N. chamaelon Linnaeus			*		*
N. planospira Anton.	*		*	*	*
N. albicilla Linnaeus	*				
Neritina violacea (Gmelin)	*			*	
N. turrita (Gmelin)	*				
N. lineata (Lamarck)	*				
N. zigzag Lamarck	*				
N. variegata Lesson	*				
N. auriculata Lamarck	*				
Clithon corona Linnaeus	*				
C. oualaniensis (Lesson)					*
Order Mesogastropoda					
Family Littorinidae					
Littorina carinifera Mencke	*			*	*
L. melanostoma Gray	*			*	
L. scabra (L.)	*	*	*	*	*
L. undulata Gray	*	*	*	*	
L. intermedia Philippi	*				
L. brevicula			*		
L. coccinea			*		
L. picta			*		
L. pintado			*		
Nidolitorina pyramidalis			*		
Tectarius vilis			*		
Family Thiaridae					
Melanoides riqueti (Grateloup)	*			*	
M. tuberculata (Muller)	*				
Family Potamididae					
Cerithidia alata Sow.	*			*	
C. cingulata (Gmelin)	*	*	*	*	*
C. djadjariensis (Martin)	*			*	
C. microptera (Kiener)				*	
C. obtusa Lamk.	*	*	*	*	*
C. fluviatilis			*		
C. quadrata Sow.	*			*	
C. weyersi Dautzemberg	*				
Telescopium telescopium (L.)	*	*	*	*	*
T. mauritsi Butol	*	*			
Terebralia sulcata (Born)	*		*	*	
Cerithidia rhizoporarium			*		

T. 4 b. (contd.)

	IND	MAL	PHIL	SING	THAI
Terebralia palustris (L.)	*	*			
Pyzarus ebeninus			*		
Bittium zebrum			*		
Family Cerithiidae					
Clypeomorus bifasciatus			*		
C. chemnitzianus			*		
C. moniliferus			*		
C. traillei			*		
C. zonatum			*		
Cerithium sp.					*
C. pfeifferi Dunker			*		*
C. patulum (Sowerby)			*	*	*
C. morum Lamarck	*				
C. breve Q. and G.					*
C. coralium Sow.					*
Family Stenothyridae					
Stenothyra sp.				*	
S. glabrata (A. Adams)	*				
S. polita Gray		*		*	
Family Planaxidae					
Planaxis sulcatus			*		
P. virgatus			*		
Niso goniostoma			*		
Family Assimineidae					
Assiminea sp.				*	
A. brevicula (Pfeiffer)	*	*		*	*
(=Syncera brevicula (Pfeiffer))				*	
A. nitida	*				
(=S. nitida (Pease))					
S. javana	*				
S. woodmasoniana (Nevill)	*				
Family Fairbankiidae					
Fairbankia bombayana				*	
(=Iravadia reticulata Brandt ?)				*	

T. 4 b. (contd.)

	IND	MAL	PHIL	SING	THAI
Family Capulidae					
Capulus sp.					*
Family Naticidae					
Polinices mamilla (L.)					*
Family Ampullariidae					
Pila scutata				*	
Family Hydrobiidae					
Clenchiella microscopica Nev.				*	
Clenchiella sp.				*	
Sencera sp.				*	
Family Vitrinellidae					
n. gen. nr. Adeorbis				*	
Order Neogastropoda					
Family Muricidae					
Murex capucinus (Lamarck)				*	*
(=Chicoreus capucinus (Lamk.))					
Morula fiscella (Gmelin)			*		
Family Buccinidae					
Cantharus cecillei			*		
Family Nassariidae					
Nassarius sp.		*	*		
N. olivaceus (Brug.)			*	*	*
N. acutidens			*		
N. festivus			*		
N. globosus Quoy and Gaimard					*
N. jacksonianus (Quoy and Gaimard)					*

T. 4b (contd.)

	IND	MAL	PHIL	SING	THAI
Family Melongenidae					
Melongena galeodes Lamarck	*		*		
M. pugilinae			*	*	
Family Turridae					
Iophiotoma polytropa (Hebling)			*		
Family Mitridae					
Imbricaria conularis (Lamarck)			*		
Family Marginellidae					
Marginella corusca Reeve				*	
Subclass Euthyneura					
Order Pulmonata					
Family Ellobiidae					
Auriculastra subula (O. and G.)	*		*	*	
Cassidula aurisfelis (Brug.)	*	*		*	*
C. anguilifera			*		
C. faba (Mencke)			*	*	
C. mustelina (Desh.)	*	*		*	
C. doliolum Petit		*			
C. nucleus (Gmelin)			*		
C. quadrasi Hidalgo				*	
C. triparietalis (Martin)	*				
C. sulculosa (Musson)	*				
Cylindrotis quadrasi (Moell.)				*	
Ellobium aurisjudae (L.)	*	*	*	*	*
E. aurismalchi (Muller)				*	
E. aurismidae (L.)	*			*	
Laemodonta octanfracta (Jones)				*	
L. punctostriatum Adams		*			
L. punctigerum (Adams)		*		*	
L. typica (Adams)				*	
Melampus sp.		*			
M. singaporensis Pfeiff.	*	*		*	
M. castaneus			*		
M. flavus			*		
M. striatus			*		
M. pulchellus (Petit)	*				
Pythia plicata (Ferrussac)	*				
P. trigona (Trosch)	*			*	
P. scarabaeus				*	
Pupa sulcata			*		
P. alveola			*		
Smaragdinella caliculata			*		
S. viridis			*		
Cassidula lutescens Buiot	*				
Family Amphibolidae					
Salinator sp.					*
S. burmana (Blanford)	*	*			
S. fragilis (Lamarck)	*				

T. 4b. (contd.)

	IND	MAL	PHIL	SING	THAI
Family Planorbidae					
Indoplanorbis exustus (Desh)				*	
Family Achatinidae					
Achatina fulica Bowdich				*	
Subulina octona (Brug.)				*	
Order Opisthobranchia					
Family Ochiidiidae					
Onchidium sp.		*			*
O. aberrans Semper				*	
O. ambiguum Semper				*	
O. vaigiense Q. and G.				*	
Peronia grisea (Plate)				*	
P. tumida (Semper)				*	
Peronina alta Plate				*	
Platevindex lutea (Semper)				*	
P. stuxbergi (Waterh.)				*	
Platevindex n. sp				*	
Semperoncis fossor n. gen. n. sp.				*	
Family Haminoeidae					
Haminoea sp.					*

T. 4b (contd.)

	IND	MAL	PHI	SING	THAI
Class Pelecypoda					
Order Pteromorphia					
Family Anomiidae					
Enigmonia aenigmatica (Chemn.)	*			*	*
E. rosea Gray				*	
Family Arcidae					
Anadara auriculata (Lamk.)			*	*	
A. cuneata (Reeve)				*	
A. granosa (L.)				*	
A. antiquata Linnaeus	*		*		
A. nodifera (von Martens)					*
Barbatia sp.			*		
Barbatia fusca (Brug.)				*	
Striarca lacerata (Brug.)				*	
S. pectunculiformis (Dunker)				*	
S. sculptilis (Reeve)				*	
S. tenebrosa (Reeve)				*	
Family Isognomonidae					
Isognomon ephippium (L.)			*	*	*
I. isognomon (L.)				*	
Family Mytilidae					
Brachidontes sp.		*			
Brachidontes rostratus (Dunker)				*	*
Modiolus albicostus Lamk.				*	
M. aratus (Reeve)				*	
M. auriculatus (Krauss)				*	
M. metcalfei (Hanley)				*	
M. philippinarum (Hanley)				*	
M. senhausi (Reeve)				*	
Mytilus viridis (L.)				*	
Septifer sp.				*	
S. bilocularis L.			*		
Family Ostreidae					
Crassostrea spp.				*	
C. echinata (Quoy and Gaimard)			*		
C. tuberculata (Lamarck)			*		
C. lugubrius (Sowerby)			*		
Ostrea amasa			*		
O. echinata			*		
O. imbricata			*		
O. iredalei			*		
O. lugubris			*		
O. malabonensis			*		
O. palmipes			*		
O. cucullata Born	*				
Saccostrea cucullata					*

T. 4b (contd.)

	IND	MAL	PHI	SING	THAI
Order Heteroconchia					
Family Corbiculidae					
Geloina erosa (Sol.)			*	*	*
Polymesoda coaxans Gmelin	*				
P. expansa (Mousson)	*				
Family Glauconomidae					
Glauconome rugosa Hanley				*	
G. straminea Reeve				*	
G. virens (L.)				*	*
Family Laternulidae					
Laternula truncata (Lamk.)				*	*
Family Mesodesmatidae					
Caecella horsfieldi Gray				*	*
Family Pholadidae					
Martesia striata (L.)				*	
Xylophaga? sp.					*
Family Solenidae					
Solen delesserti Chemnitz					*
Sinonovacula constricta (Lamarck)					*
Family Trapeziidae					
Trapezium sublaevigatum (Lamk.)				*	
T. angulatum (Lamk.)					*
Family Tellinidae					
Tellina caproides Lamarck					*
T. opalina Gmelin					*
Family Teredinidae					
Teredo sp.					*
T. edax (Hedley)				*	
T. mannii (Wright)				*	
T. thoracites Gould				*	
Bankia rochi Moll.				*	
Family Ungulinidae					
Diplodonta globosa (Forsskal)					*
D. cumingii (Harrley)				*	
Family Veneridae					
Anomalocardia squamosa (L.)				*	
Dosinia sp.			*		
D. rustica Romer				*	
Gafrarium divaricatum (Gmelin)				*	
G. tumidum Roeding	*		*		*
Meratrix meratrix (L.)				*	
Paphia hiantinus (Lamk.)				*	
P. luzonica (Sowerby)				*	
Katelysia striata (Gmelin)					*
Veneridae gen. indet.				*	

9.5 Table 4c. Fishes found in mangrove forests and adjacent waters in Southeast Asia (compiled from country reports)

	IND	MAL	PHIL	SING	THAI
Class Chondrichthyes					
Order Lamniformes					
Family Sphyrnidae					
Sphyrna zygaena (Linnaeus)			*		
Order Rajiformes					
Family Rhinobatidae					
Rhynchobatus djiddensis (Forsskal)			*		
Family Dasyatidae					
Dasyatis kuhlii (Muller and Henle)			*		
D. uaranak (Forsskal)			*		
Class Osteichthyes					
Order Elopiformes					
Family Elopidae					
Elops machnata (Forsskal)			*		
Family Megalopidae					
Megalops cyprinoides (Brouss.)			*	*	
Family Albulidae					
Albula vulpes (Linnaeus)			*		
Order Clupeiformes					
Family Chirocentridae					
Chirocentrus dorab (Forsskal)			*	*	
Family Engraulidae					
Thrissocles kammalensis (Bleeker)			*		
T. setirostris (Broussonet)			*		
Thryssa mystax (Schneider)		*	*		
(Stolephorus mystax (Bloch and Schneider))					
Scutengraulis hamiltonii (Gray)			*		
Stolephorus commersonii Lacepede		*	*		
S. tri (Bleeker)			*	*	
S. indicus (van Hasselt)			*	*	
Thrissina baelama (Forsskal)			*		
Family Clupeidae					
Anodontostoma chacunda (Hamilton ne Buchanan		*	*		
H. perforata (Cant.)				*	
Nematolosa nasus (Bloch)			*		
Pellona kampeni Wed. and de Beauf.					
Sardinella fimbriata (Valenciennes)				*	
Order Gonorynchiformes					
Family Chanidae					
Chanos chanos (Forsskal)			*		

Table 4c. (contd.)

	IND	MAL	PHI	SING	THAI
Order Siluriformes					
Family Ariidae					
Arius sp.		*			
Arius crossocheilus Bleeker			*		
A. dispar Herre			*		
A. leiotetocephalus Bleeker			*		
A. manillensis Cuvier and Valenciennes			*		
A. venosus Valenciennes			*	*	
A. gagorides (C. and V.)				*	
A. macronotacanthus Blkr.				*	
A. polystaphylodon Blkr.				*	
A. thalassinus (Ruppell)				*	
A. sagor (Hamilton [ne Buchanan])		*			
Osteogeniosus militaris (L.)				*	
Arius maculatus (Thunberg)		*			
Family Plotosidae					
Plotosus anguillaris (Bloch)			*	*	
P. canius (H. Buch.)		*		*	
Order Aulopiformes					
Family Synodontidae					
Saurida tumbil (Bloch)				*	
Order Batrachoidiformes					
Family Batrachoididae					
Batrachus sp.				*	
Order Lophiiformes					
Family Antennariidae					
Antennarius commersoni Cuv.				*	
Order Antheriniformes					
Family Exocoetidae (including Hemirhamphidae)					
Dermogenys pusillus van. Hass.				*	
Hemirhamphodon pogonathus Blkr.				*	
Hemiramphus dussumiere C. and V.			*		
H. far (Forsskal)			*	*	
H. gaimardi C. and V.				*	
H. marginatus (Forsskal)				*	
H. melanurus C. and V.			*		
Zenarchopterus buffoni (C. and V.)				*	
Z. brevirostris (Gunther)			*		
Z. dispar (C. and V.)				*	
Z. ectuntio (H. Buch.)				*	
Z. rasori (Popta)			*		
Family Belonidae					
Tylosurus crocodilus (Les.)				*	
T. strongylurus (van Hass.)		*		*	

T. 4c. (contd.)

	IND	MAL	PHI	SING	THAI
Family Atherinidae					
Atherina forskali (Ruppell)			*		
A. temmincki Bleeker			*		
Pranesus pinguis (juv.)			*		
Family Cyprinodontidae					
Oryzias javanicus (Blkr.)				*	
Panchax panchax (Hamilton and Buchanan)				*	
Family Poeciliidae					
Haplochilus melastigma McClelland		*			
Poecilia sphenops (Val.)		*		*	
Order Syngnathiformes					
Family Syngnathidae					
Bombonia djarong Bleeker (=Sygnathus djarong Bleeker)			*	*	
B. spicifer (Ruppell)			*		
Coelonotus leiaspis (Blkr.)			*		
Costethus (brachyurus) Bleeker			*		
Hippocampus kuda Bleeker			*		
Order Scorpaeniformes					
Family Synanceiidae					
Synanceia horrida (Linnaeus)			*		
Family Platycephalidae					
Platycephala indica (L.)				*	
P. scaber (L.)				*	
Thysanophrys punctatus C. and V.				*	
Order Perciformes					
Family Centropomidae					
Ambassis buruensis Bleeker			*		
A. commersoni Cuvier and Valenciennes			*		
A. interrupta Bleeker (=Chanda interrupta (Blkr.))			*	*	
A. niops Gunther			*		
A. nalua (Hamilton, [ne Buchanan]) (=C. nalua (H. Buch.))			*	*	
A. urotaenia Bleeker (=C. urotaenia Bleeker))		*	*	*	
A. kopsii Bleeker (=C. kopsii (Blkr.))			*	*	
A. gymnocephalus (Lacepede) (=C. gymnocephala (Lac.))		*	*	*	
Chanda commersoni C. and V.				*	
Lates calcarifer (Bloch)				*	

T. 4c. (contd.)

	IND	MAL	PHIL	SING	THAI
Family Serranidae					
Epinephelus tauvina (Forsskal)			*	*	
E. lanceolatus Bleeker			*		
E. undulatus Bleeker			*		
E. salmoides			*		
E. amblycephalus Bleeker		*			
E. salmoides			*		
Anyperodon leucogrammicus (C. and V.)			*		
Family Theraponidae					
Pelates quadrilineatus (Bloch)			*	*	
Therapon puta Cuvier and Valenciennes			*		
T. jarbua (Forsskal)		*	*		
T. theraps Cuvier			*		
Family Apogonidae					
Apogon amboinensis Bleeker			*	*	
A. compressus (Smith and Radcliffe)			*		
A. diversus (Smith and Radcliffe)			*		
A. frenatus Valenciennes			*	*	
A. hyalosoma Bleeker			*	*	
A. lateralis Valenciennes			*		
A. melanopus Weber			*		
A. sangiensis Bleeker				*	
Archamia buruensis (Bleeker)			*		
Family Sillaginidae					
Sillago sihama (Forsskal)		*		*	
Family Carangidae					
Alectis indicus (Rupp.)				*	
Caranx sexfasciatus Quoy and and Gaimard			*		
C. ignobilis (Forsskal)			*		
C. celetus			*		
Carangoides caeruleopinnatus			*		
Caranx deani			*		
Trachinotus blochii (Lacepede)			*		
Scomberoides lysan (Forsskal)			*		
Scomberoides sancti-petri (Cuvier and Valenciennes)			*		
Caranx malabaricus			*		
Family Leiognathidae					
Leiognathus equulus (Forsskal)		*		*	
L. brevirostris (Valenciennes)				*	
L. dussumieri (C. and V.)				*	
L. fasciatus (Lacepede)				*	
L. ruconius (H. Buch.)				*	
Gazza minuta (Bloch)				*	

T. c. (contd.)

	IND	MAL	PHIL	SING	THAI
Family Lutjanidae					
Lutjanus argentimaculatus Forsskal			*		
L. fulviflamma (Forsskal)			*		
L. rivulatus Bleeker			*		
L. fulvus Fowler			*		
L. johni (Bloch)		*			
L. vitta (Q. and G.)				*	
Family Gerreidae					
Gerres filamentosus Cuvier			*		
G. kapas Bleeker			*		
G. lucidus (C. and V.)		*			
G. abbreviatus Bleeker				*	
G. punctatus C. and V.				*	
G. macracanthus Bleeker			*		
G. oyena (Forsskal)			*	*	
G. poieti Cuvier			*		
Pentaprion longimanus (Cantor)			*		
Family Pomadasyidae					
Pomadasys hasta (Bloch)		*	*		
P. opercularis (Playfair)			*		
P. maculatus (Bloch)			*	*	
Family Lethrinidae					
Lethrinus nebulosus (Forsskal)				*	
L. nematacanthus Bleeker			*		
Family Sparidae					
Acanthopargus sp.			*		
Mylio berda (Forsskal)			*		
Family Scianediae					
Johnius belangeri Cuvier			*		
J. dussumieri (Valenciennes)				*	
Kathala axillaris (Cuvier)			*		
Otolithes ruber Schneider			*	*	
Protonobea diacanthus (Lacepede)			*		
Pseudosciaena aneus (Bloch)			*		
P. sina (C. and V.)			*		
Family Mullidae					
Upeneus sulphureus C. and V.				*	
U. (Pennon) tragula Richardson				*	
Family Monodactylidae					
Monodactylus argenteus (Linnaeus)			*		
Family Toxotidae					
Toxotes chatareus (H. Buch.)			*	*	
T. jaculator (Pallas)		*	*	*	

T. 4 c. (contd.)

	IND	MAL	PHIL	SING	THAI
Family Ephippidae (including Platacidae and Drepanidae)					
Drepane punctata (Linneaus)			*	*	
D. longimana (Bloch and Schneider)			*		
Platax orbicularis (Forsskal)			*		
P. batavianus C. and V.				*	
Family Scatophagidae					
Scatophagus argus (Bloch)		*	*	*	
Family Chaetodontidae					
Parachaetodon ocellatus (C. and V.)				*	
Family Cichlidae					
Saurotherodon mossambica (Peters)				*	
Family Pomacentridae					
Abudefduf sp.				*	
A. sordidus (Forsskal)			*		
A. vaigiensis			*		
Family Mugilidae					
Mugil cephalus Linnaeus			*		
M. cunnesius C and V.		*	*	*	
(=Valamugil cunnesius (Valenciennes))					
M. kelaarti Gunther		*	*		
M. sehili Forsskal				*	
(=Valamugil seheli (Forsskal))					
M. subviridis C. and V.		*	*	*	
(=Liza subviridis (Valenciennes)					
M. tade (Forsskal)			*	*	
M. troscheli Bleeker				*	
Liza caeruleo-maculata (Lacepede)			*		
L. ceramensis (Bleeker)			*		
L. macrolepis (Smith)			*		
L. oligolepis (Bleeker)			*		
L. seheli (Forsskal)			*		
L. melinoptera (C. and V.)		*	*		
L. vaigiensis (Q. and G.)			*	*	
Liza dussumieri				*	
Family Sphyraenidae					
Sphyraena barracuda (Walbaum)			*		
S. jello Cuvier		*	*	*	
S. obtusata Cuvier				*	
Family Polynemidae					
Eleutheronema tetradactylum (Shaw)			*		
(=Polynemus tetradactylum ?)		*			

T. 4 c. (contd.)

	IND	MAL	PHIL	SING	THAI
Family Phallostethidae					
Ceratosthetus bicornis Regan				*	
Neostethus lankersteri				*	
Family Labridae					
Halichoeres hyrtli (Blkr.)				*	
Family Gobiidae (including Eleotridae)					
Acentrogobius caninus (C. and V.)				*	
A. caverensis (Blkr.)				*	
A. chlorostigmatoides (Blkr.)				*	
A. cyanomos (Blkr.)				*	
A. globiceps (Harm.) (as "kranjiensis" Herre)				*	
A. janthinopterus (Blkr.)				*	
A. ornatus (Ruppell)				*	
A. puntang (Blkr.)				*	
A. reichei (Blkr.)				*	
A. viridipunctatus (C. and V.)		*		*	
Acentrogobius sp. 1				*	
Acentrogobius sp. 2				*	
Acentrogobius sp. 3				*	
Bathygobius fuscus (Ruppell)				*	
Boleopthalmus boddaerti (Pallas)		*		*	*
Brachygobius kabilensis				*	
B. sua (Smith)				*	
B. xanthomelas Herre				*	
Ctenogobius sp.				*	
Ctenotrypauchen microcephalus (Blkr.)				*	
Glossogobius biocellatus (C. and V.)				*	
G. giurus (H. Buch.)				*	
Gobiopterus chuno (H. Buch.)				*	
G. variegatus (Peters)				*	
Gobius koku Rus.		*		*	
Oligolepis acutipennis (C. and V.)				*	
Oxyurichthys microlepis (Blkr.)				*	
O. papuensis (C. and V.)				*	
Periopthalmodon schlosseri (Pallas)		*		*	
Periopthalmus chrysospilus Bleeker				*	
P. vulgaris Eggert		*			
P. malaccensis Eggert				*	
P. vulgaris ceylonensis Eggert				*	*
Pseudapocryptes lanceolatus (Bloch and Schn.)				*	
Scartalaos viridis (H. Buch.)				*	*
Sicyopterus macrostetholepis (Blkr.)				*	*
Stigmatogobius borneensis (Blkr.)				*	
S. hoevenii (Blkr.)				*	
S. javanicus (Blkr.)				*	
S. poicilostoma (Blkr.)				*	
S. romeri (Weber)				*	
S. sadanundio (H. Buch.)		*		*	
Tamanka ubinensis Herre				*	
Trypauchen vagina (Bloch & Schn.)				*	
"Vaimosa" avicennia Herre				*	

T. 4 c. (contd.)

	IND	MAL	PHIL	SING	THAI
"Vaimosa" jurongensis Herre				*	
Gobiidae indet. (Kranji sp. 7)				*	
Gobiidae indet. (Kranji sp. 8)				*	
Gobiidae indet. (Kranji sp. 13)				*	
Anadameleotris palustris			*		
Belobranchus belobranchus			*		
Bostrichthys sinensis (Lac.)			*	*	
Butis butis (H. Buch.)				*	
B. melanostigma (Blkr.)				*	
Eleotris fusca (Bloch and Schnn.)			*	*	
E. butis Cantor		*			
E. insulinidica (Blkr.)				*	
E. melanosoma Blkr.			*	*	
Hypseleotris modestus (Blkr.)				*	
Odontobutis obscura (Schlegel)			*		
O. aporos (Bleeker)			*		
Ophiocara porocephala (C. and V.)			*	*	
Oxyleotris marmorata (Blkr.)				*	
O. urophthalmus (Blkr.)				*	
Prionobutis koilomatodon (Blkr.)			*	*	
mila mila					
Family Gobioididae					
Taeniodes sp.					*
T. gracilis (Valenciennes)					*
T. caeculus (Shneider)					*
Family Siganidae					
Siganus concatenata Jordan & Seale			*		
S. fuscescens Jordan and Fowler			*		
S. javus Jordan and Seale			*		
(=S. javus (Linnaeus) ?)		*			
S. oramin Jordan and Seale			*		
S. rostrata Seale			*		
S. vermiculatus Evermann and Seale			*		
S. canaliculatus (Park)				*	
Family Trichiuridae					
Trichiurus lepturus Linnaeus			*		
Family Scombridae					
Scomberomorus commersoni Jordan and Seale			*		
Order Pleuronectiformes					
Family Bothidae					
Pseudorhombus arsius (H. Buch.)				*	
Family Psettodidae					
Psettodes erumei (Schneider)				*	

T. 4 c. (contd.)

	IND	MAL	PHIL	SING	THAI
Order Tetrodontiformes					
Family Balistidae					
Monocanthus chinensis (Bloch)				*	
Family Tetrodontidae					
Arothron hispidus			*		
Sphoeroides oblongus (Bloch)				*	
Tetrodon fluviatilis (H. Buch.)		*		*	
Chelonodon sp.		*			

9.6 Outlines of project proposal from the FAO/UNEP (in Collaboration with Unesco and IUCN) Expert Consultation Meeting on Impact of Pollution on the Mangrove Ecosystem and its Productivity in Southeast Asia, Manila, Philippines, 4-8 February 1980

Project I: EFFECTS OF ORGANIC EFFLUENTS ON MANGROVE AQUATIC COMMUNITIES

1. Description of Problem and Project Outline

Organic effluents are one of the major sources of pollution in the coastal waters of Southeast Asia. For example, the major source of pollution in the mangrove ecosystem in Malaysia is the waste from processing agricultural products such as palm oil. Over 2 million metric tons of palm oil were produced in Malaysia in 1979. The processing is done by 135 mills in various parts of the country and in total has an annual effluent production of over 5 million metric tons.

The palm oil effluent is normally discharged untreated or partially treated into the nearest waterway. This leads to deoxygenation of the aquatic system and has deleterious effects on the fishery productivity of the waters. Other organic wastes normally discharged into the Malaysian aquatic environment include rubber effluents, sewage and pineapple waste.

This project would be relevant to pollution problems caused by organic waste and sewage in other Asian countries which have food processing factories, meat processing factories, tapioca factories, sugar mills, saw mills (saw dust) and paper mills.

The above-mentioned effluents are mainly organic and therefore have a high Biological Oxygen Demand (BOD). As the waste is broken down by microbial activity, the oxygen in the water is rapidly consumed. As a result, commercially important prawn and fish species are unable to survive in these waters.

2. Methodology

Various chemical and biological parameters will be studied in order to understand the ecosystem affected by organic pollution. Chemical parameters such as BOD, dissolved oxygen, salinity, nutrients (ammonia, nitrates and phosphates), and H_2S in the forest soil and waterways will be sampled at regular time interval with additional sampling of invertebrates in the forest, and benthos and nekton in the waterways. It is desirable to carry out sampling at the effluent outfall point and at one kilometer intervals along the waterway, right into the sea (approximately 4 sites). The fauna will be identified to species and quantitative data including biomass obtained whenever possible.

Project II: BIOASSAYS OF POLLUTANTS ON MANGROVE BIOTA

1. Description of Problem and Project Outline

Mangrove swamps are increasingly exposed to various types of agricultural, industrial, municipal and other discharges. Except for very severe pollution cases, the mangrove trees themselves do not show signs of pollution stress. However, their seedlings may be more susceptible to polluted environment, and the regeneration of the forest could thus be affected. Equally important in the mangrove ecosystem are the aquatic animal species, and pollution impact might be seen particularly in commercially-important species.

In spite of the synergistic influence of several pollutants and of the complexity of mangrove faunistic communities, but in order to facilitate the initial phase of this project and the exchange and comparison of experimental data and results, the bioassays should initially be conducted with only few species, and only a very restricted number of pollutants: heavy metals: Hg, pesticides: Thiodane, and petroleum for the mangrove seedlings.

Once comparable results are obtained for key species and experimental experience is gained, the bioassays can be expanded to other important species and pollution components.

2. Organisms to be Studied

2.1 Aquatic organisms

The suitability of the test species depends on the commercial importance, the general availability in the whole region, and on the possibility to keep it as test organisms, i.e. its susceptibility to stress in catching, transportation and laboratory handling.

The following species should suit these requirements:

Finfish:	Giant seaperch	*Lates calcarifer*
	Greasy grouper	*Epinephelus tauvina*
Crustacea:	Banana prawn	*Penaeus merguiensis*
	Mud crab	*Scylla serrata*
Bivalves:	Clam	*Anadara granosa*
	Green mussel	*Mytilus viridis*

In addition to the restriction in the number of test species great important must be put on further agreement on the development stage of the individual organisms to be tested.

2.2 Mangrove trees

The suitability of a mangrove tree species also depends on the general occurrence in the region, its importance, and on the seedling characteristics.

It was agreed that *Rhizophora mucronata* and *Avicennia officinalis* would be best suited as test organisms.

3. Substances to be Studied

3.1 Aquatic animals

As mentioned before, it was to initially test the effect of one substance only. Heavy metals and pesticides were given high rank in environmental contamination throughout the region. As jointly agreed upon, organic and inorganic mercury (II) and Thiodane should be tested.

3.2 Mangrove trees

It is recommended that oil pollution be very well studied in relation to regeneration of mangrove trees, but it must still be agreed which type of oil should be used for such an experiment. Many crude, refined and residual oils are commonly discharged and spilt.

4. Methodology

4.1 Aquatic organisms

To achieve good comparability of biological experiments, it is very important, though difficult, to agree upon a standardized method to be used throughout the participating laboratories. In spite of greater reality of a dynamic test, a static one should be adopted and carried out initially because of its higher simplicity which ensures also a higher degree of comparability between laboratories.

The tests would determine the lethal concentration for 50% of the tested specimen in 48 and 96 hours ($48LC_{50}$ and $96LC_{50}$). It is recognized that this is only the most basic test of pollution tolerance and that more detailed testing will be needed at a later stage in order to fully understand the pollution tolerances of the selected organisms.

4.3 Mangrove trees

The effects of the pollutants on the mangrove seedling will best be studied in a field experiment, as the natural implantation and growth of seedling is very difficult to simulate in a laboratory scale. However, it could be tried in a larger-scale experiment under semi-natural laboratory conditions.

Project III: EFFECTS OF DESTRUCTIVE FACTORS ON MANGROVE FORESTS AND SOIL QUALITY

1. Description of the Project

The mangrove flora, physiography and edaphic influences, play a vital role in the maintenance of a well-balanced ecosystem.

As indicated in different country reports, siltation and wood exploitation are some of the factors that cause direct degradation of the mangrove ecosystem, the process may lead to elimination of some species in affected areas. Indonesia, Thailand and the Philippines have indicated serious threats being posed by these factors on the stability of the mangrove ecosystem. Siltation is becoming a major concern in some areas in Thailand as it is also becoming a concern in Indonesia and in the Philippines.

Excessive wood harvesting or exploitation may over-expose the forest floor to inclement atmospheric and physiographic factors that may impoverish it to the point that it may no longer be able to support regeneration either by natural or artificial means. Excessive siltation may, on the other hand, also affect adversely the growth of the mangroves on the landward as well as seaward fringes. Their direct and indirect influences on the mangrove ecosystem is not yet fully and accurately ascertained, but, in the meanwhile, such activities are going on, and before it will be too late to correct or allay their adverse effects, in order to harmonize production with maintenance of an acceptable balanced ecosystem, the conduct of this project becomes an exigent concern.

2. Methodology

A study on mangrove forest management techniques will be conducted within the public mangrove forest inside licensed area. Different silvicultural treatments such as clear-

cutting, selective cutting, shelter-wood, seed-tree method, etc., with a control forest. Regeneration will be monitored under each treatment. Before introducing these treatments, monitoring of flora and fauna will be made, also after cutting.

A study on the effects of mine tailings will be conducted in areas within the mangrove forest which are used as mine tailing dumps. The study sites will be properly delineated and assessed periodically by monitoring their direct and indirect influences on the environment. Physical counts will be made of those trees and regenerations directly affected and survival and growth will be monitored. Samples of different faunal species within and adjacent to areas of the study site will be collected and examined. A relatively homogeneous forest which is not used as mine tailing dump and is also not affected by present dump areas will be used as control area.

For a reforestation study abandoned mine tailing dump areas will be used. Mangrove seedlings of the same species present in the area before the dumping will be planted. Survival and growth of these seedlings will be monitored regularly. Other upland tree species may be used in the trial plantings also.

Land accretion will be studied in areas of rapid accretion due to human developmental activities nearby and those that are accreting naturally. Gauges will be strategically located on the landward, seaward, river banks and mid-mangrove fringes, and accretion will be monitored periodically. Plant composition will be recorded at the start of the study and changes will be monitored within the duration of the study. The immediate effects of rapid accretion of the plant community will also be monitored.

A comparative study on soil structure and composition adjacent to disturbed and undisturbed mangrove forests will be carried out. The disturbed areas will be categorized as follows:

a. adjacent to fishpond areas

b. adjacent to logged-over areas

c. adjacent to salterns

d. adjacent to settlements.

Undisturbed mangrove will be used as control. Soil samples will be taken from the edge of the shore to the coastal flats at given intervals up to at least the area exposed during the lowest tide. Sampling will be carried out four times in the year, that is at the start of the rainy season, during the rainy season, at the start of the dry season and during the dry season.

Project IV: IMPACT OF MANGROVE FOREST UTILIZATION ON THE FISHERIES IN THE SURROUNDING WATERS

1. Description of Problem

Mangrove forests are very important habitats of several commercially-important species of fish, crustaceans and molluscs. They also serve as nursery areas for many of the above species. The mangrove forest area is linked upstream with the land and downstream with the sea so that nutrients are derived from upstream catchment or from tidal flooding, while organic materials are transported into the sea. This organic material forms the base of a complex detrital-based food web and represents a major source of food for a variety of marine and brackishwater organisms.

In recent years, however, increasing areas of mangrove forests have been disturbed by man and subjected to varying degrees of pollution, while certain areas have even been totally cleared and reclaimed for various uses, such as housing, industries, agriculture and transportation needs (roads, harbours and airports). At the same time, there has been a decline of coastal fisheries in recent years in several places. While this decline can largely be attributed to overfishing, it is likely that the increasing disturbance of the mangrove forests by man's activities has contributed significantly to the decline of the coastal fisheries which are dependent on the mangrove forests. However, no studies have been made to assess the impact of varying degrees of disturbance to the mangrove forests through study of social, demographic and economic conditions as well as the existing management practices in order to fill this information gap, so that the management of mangrove forests can be based on sound scientific findings.

2. Plan of the Programme

It is desirable that a number of disturbed areas with varying degrees of destruction should be selected to be used as experimental project sites. However, probably it is better that in the first phase of the project two sites be selected only, i.e. the fisheries around the virgin mangrove forest should be compared with the fisheries adjacent to the worst example of a forest disturbed by cutting. It is also advisable that, during the first phase, the study concentrates on the relationship of shrimp fishery only to mangrove ecosystem. At a later stage of the project, other groups which may be used to describe the productivity of the area being studied can be added to the list, such as other species of crustaceans, molluscs and finfish.

When the study sites have been identified, historical records and review of fisheries conditions surrounding the areas should be made. These types of localities then should be explored experimentally at regular intervals and the data be evaluated. In sampling, a thorough study should be made of the variables involved, and an expert on sampling design should be consulted at the planning stage. As far as it is feasible, these data should be supplemented by catch data from the fishermen in the studied areas.

In the course of the programme, whenever possible, some ecological parameters should also be collected.

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