FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

UNITED NATIONS ENVIRONMENT PROGRAMME

SCS/80/WP/94a (Rev.)

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

INDONESIA

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
- Indonesia -

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 Consultation Meeting, sponsored by the project and held in Manila on 4 to 8 February 1980. It was necessary to consolidate the data accumulated from the reports into a regional synopsis for the area.

The synoptical report (SCS/80/WP/94) is supplemented by five country reports for Indonesia, Malaysia, the Philippines, Singapore, and Thailand (SCS/80/WP/94a to SCS/80/WP/94e), which were presented at the above meeting. The presented paper is based on the work of Dr. A. Soegiarto, the editorial reviewing was done by Dr. W. W. Kuhnhold of the SCSP.

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

by

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ABSTRACT

This report is a brief overview over the problems around the utilization and conservation of mangrove forests and the mangrove ecosystems in Indonesia. It describes the extent of the mangrove forests, its floral and faunal composition, and modes of utilization. Major factors and processes influencing the coastal zone are described, and some available data on pollutant analyses are given. The problems of various land uses and future waste problems are touched. Finally, suggestions for most urgent needs and programmes in the field of mangrove ecosystem research are made.

The Annex contains a bibliography of mangrove literature for Indonesia beyond the references of this report.

1. INTRODUCTION

The rich and diversified life of the seas has been an important source of food for the Indonesian people for centuries. Fishes, crustaceans, molluscs, and seaweeds are a few examples of these resources. In addition, the minerals and hydrocarbon resources currently have been tapped from the shallower parts of our waters.

Aside from the renewable and non-renewable resources, the seas have many other roles, such as inter-island, regional and international trade, communications, recreation and tourism. Unfortunately, as a result of the strong efforts in economic development in almost all sectors, the marine environment has been subjected to severe pressures, either directly or indirectly, such as the increasing number of incidents of pollution and the general environment degradation of certain coastal areas, including the mangrove ecosystem.

2. THE PHYSICAL ENVIRONMENT

The Indonesian physical environment is unique. Geographically, the Indonesian archipelago is situated between the Asian and the Australian continents and between the Pacific and the Indian Oceans. It is located between 94°E and 141°E and 6°N and 11°S (Fig. 1, Table 1). The archipelago consists of more than 13 000 islands with more than 81 000 km of coastline (Table 1), one of the longest of a single country. The Indonesian waters cover two-thirds of the Indonesian territory.

Generally speaking, the Indonesian territorial seas are divided into four parts. The shallow Sunda Shelf in the west, the Sahul shelf in the east, the deep ocean in the south and the deep seas, straits and channels in the middle. Because of its geographic location, the Indonesian archipelago is strongly governed by monsoon-type climate. Generally, the northwest monsoon lasts from about December to February and the southeast monsoon from June to August. The rest of the year represents the transition periods from the northwest to the southeast monsoon (March-May) and back from the southeast to the northwest monsoon (September-November). During the northwest monsoon the wind blows eastward and causes heavy rainfalls throughout most parts of the Indonesian archipelago. Rainfalls combined with the heavy runoffs of many rivers from the greater Sunda Islands (Sumatra, Java and Kalimantan) result in a lowering of salinity of coastal waters. Sometimes the 30 o/oo isohaline is pushed far toward the open sea. At the same time the surface current from the South China Sea brings the low salinity water into the western part of the Java sea, which is surrounded by those three islands and pushes the higher salinity eastward. With the onset of the southeast monsoon, these low salinity waters are transported back westward and into the Java sea and the south China sea, i.e. they are replaced by waters of the higher salinity from the Macassar Strait and the Flores Sea. The maximal westward penetration of the high salinity water masses generally occurs in or around September. Further review of the oceanographic features of the Indonesian waters is given in other publications (Soegiarto, in press; and Soegiarto and Birowo, 1975). Figures 2 to 9 describe four abiotic oceanographic features of the Indonesian and the adjacent seas during the northwest and southeast monsoons.

Table 1. Physical data on the Indonesian environment (excluding data for Province of East Timor)

A. Geographical extension	94°15'E - 141°00'E
	06°08'N - 11°15'S
B. Number of islands	13 667
C. Territorial waters (12-mile limit)	3 166 162 km^2
Land area	2 027 083 km^2
D. Coastal area	
Length of coastline	80 791 km
Tidal/swampy forests	10×10^6 ha
Mangrove forests	3.6×10^6 ha

The bottom of the almost 81 000 km of coastline basically consist of three different types: rock, sand, and mud. Their distribution is partly governed by the strength of water energy (current patterns and wave actions). Along the coastline, one can find various biotopes, such as coral reefs, mangrove, sago, nipa and other swamp forests.

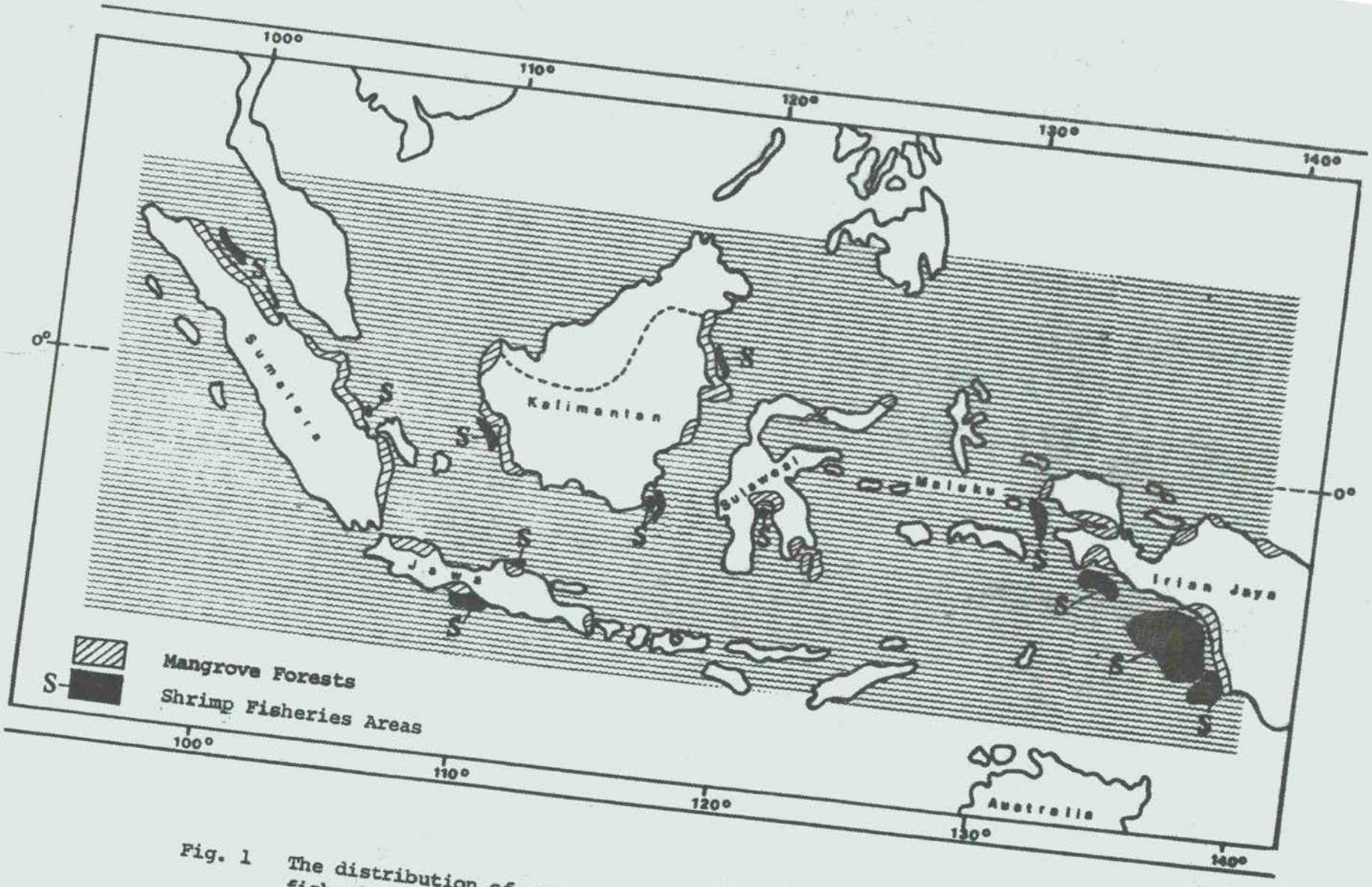


Fig. 1 The distribution of major mangrove forests areas and shrimp fisheries in Indonesian waters (after Martosubroto, 1979)

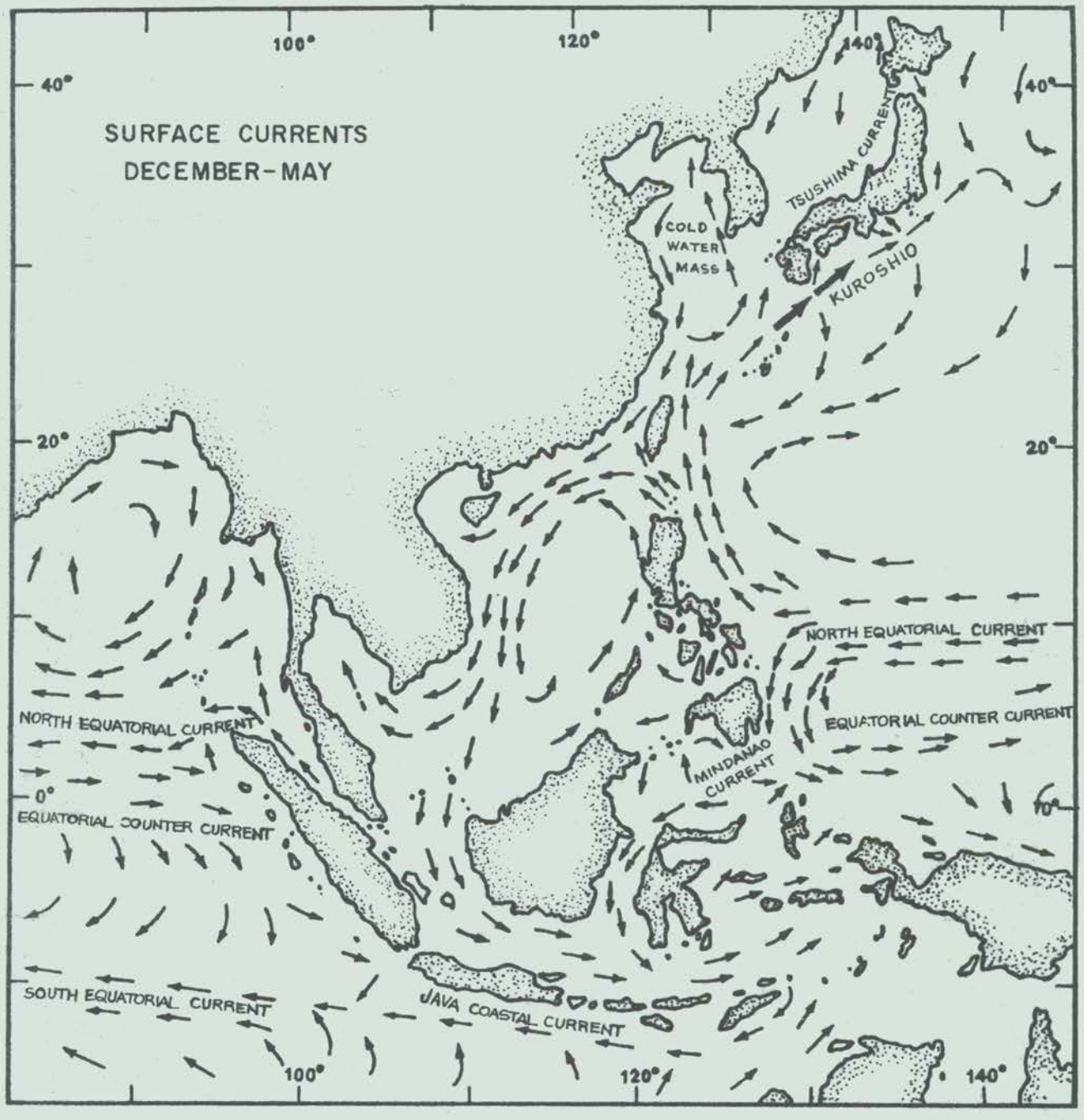


Fig. 2 Surface current pattern of the Indonesian and adjacent waters during the northwest monsoon, December-May (after Soegiarto, in press)

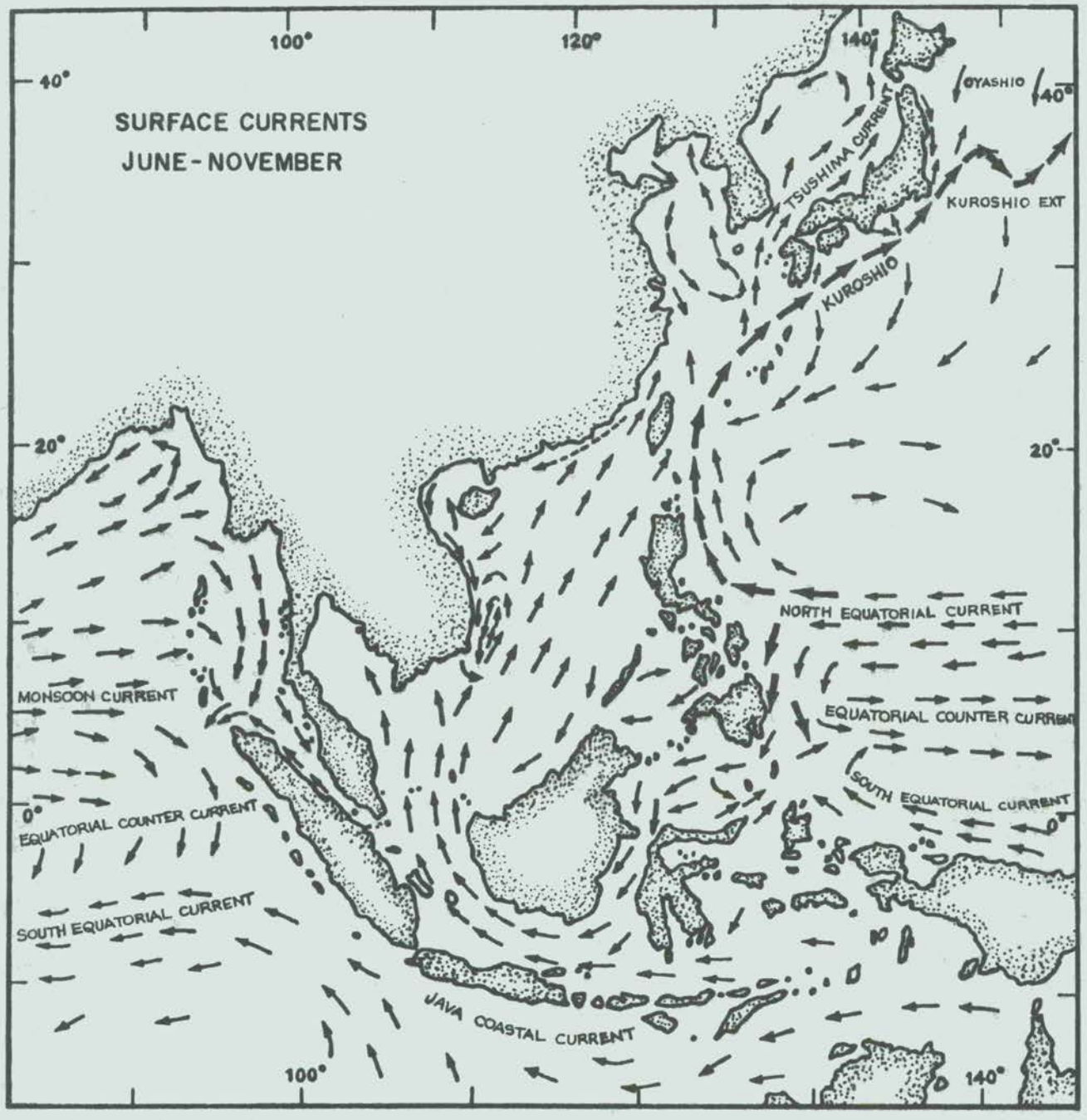


Fig. 3 Surface current pattern of the Indonesian and adjacent waters during the southeast monsoon, June-November (after Soegiarto, in press)

Fig. 4 Surface salinity distribution of the Indonesian and adjacent waters in northwest monsoon, December-May (after Soegiarto and Birowo, 1975)

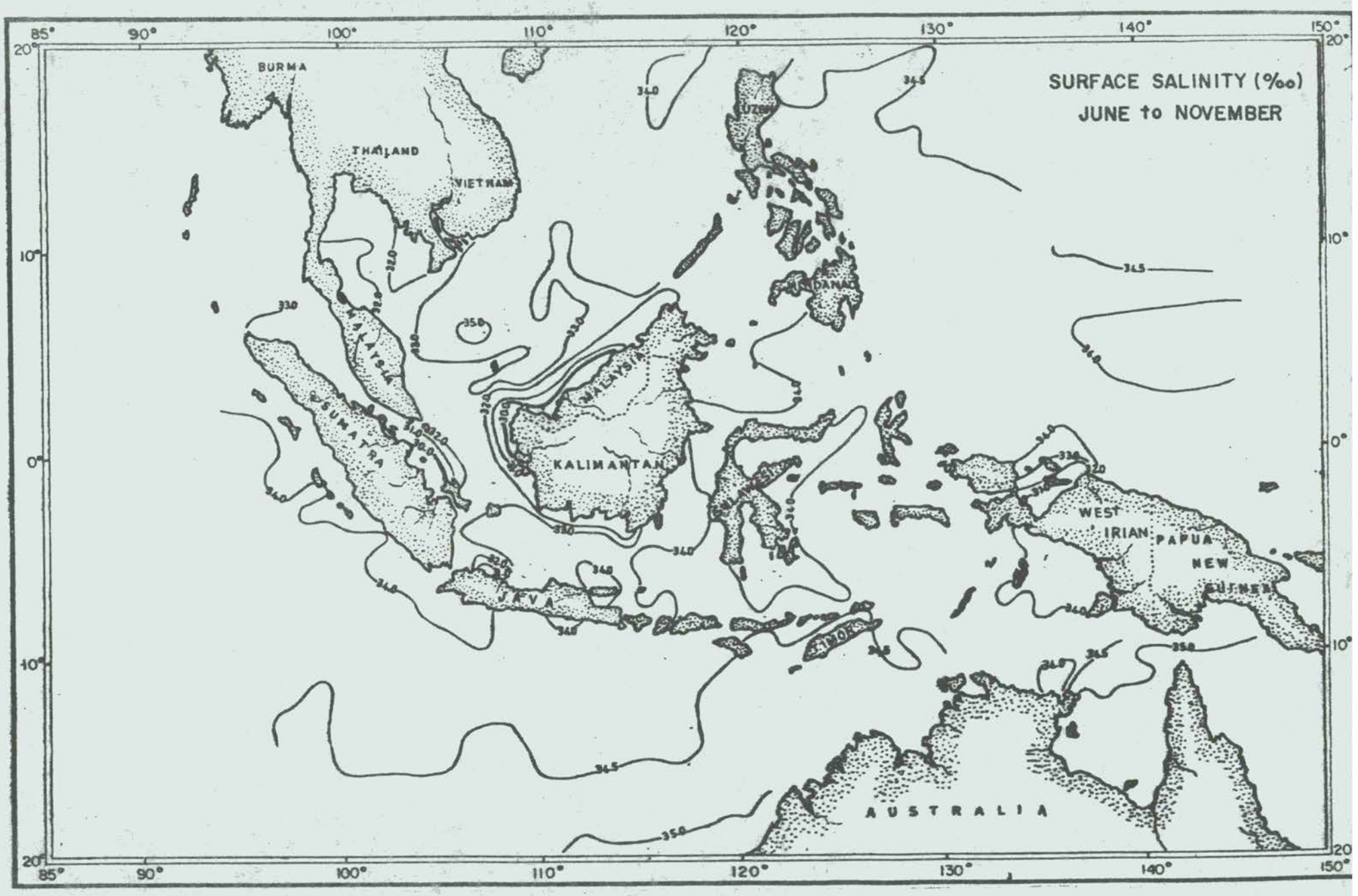


Fig. 5 Surface salinity distribution of the Indonesian and adjacent waters in the southeast monsoon, June-November (after Soegiarto and Birowo, 1975)

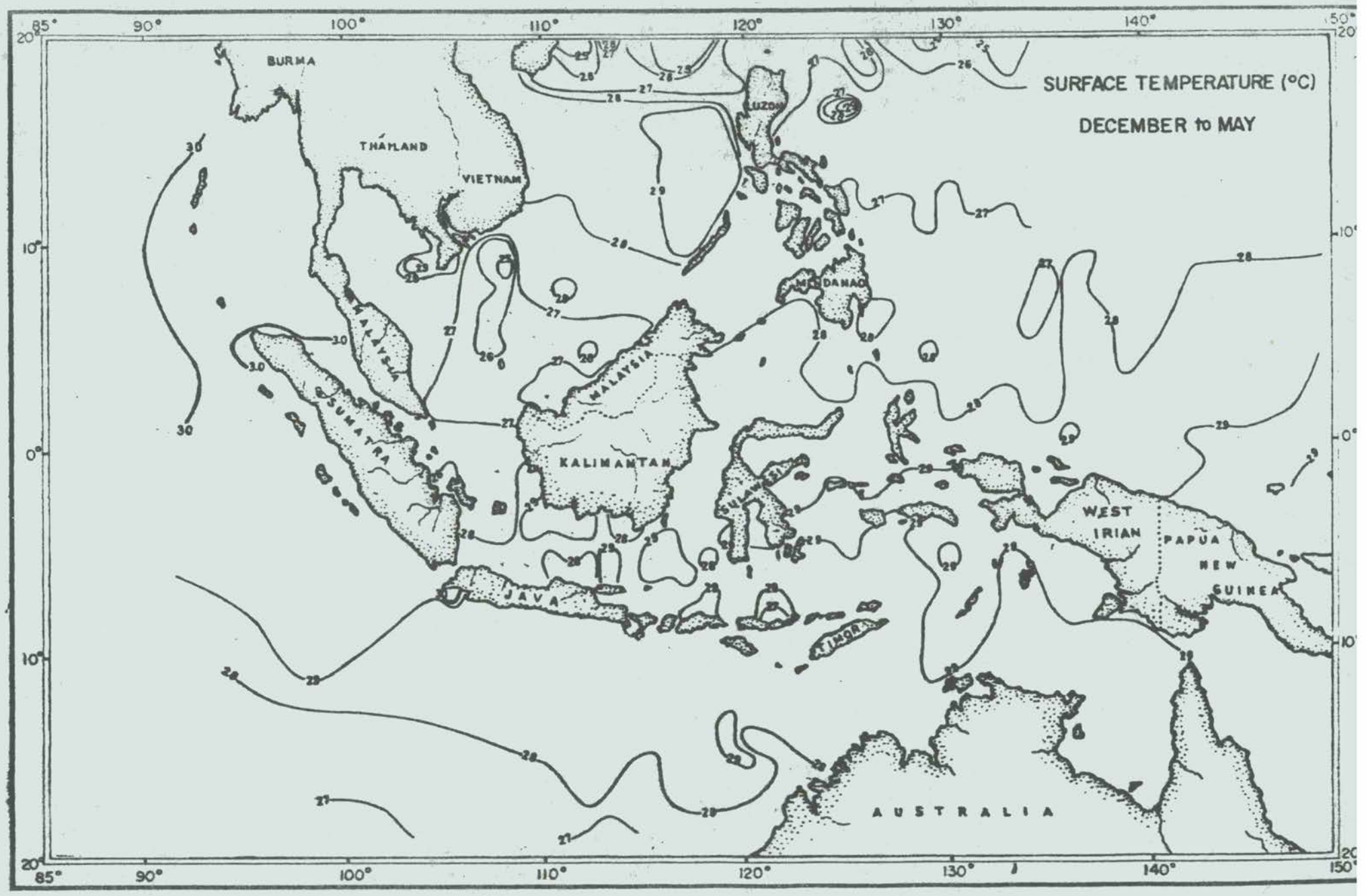


Fig. 6 Surface temperature distribution of the Indonesian and adjacent waters in northwest monsoon, December-May (after Soegiarto and Birowo, 1975)

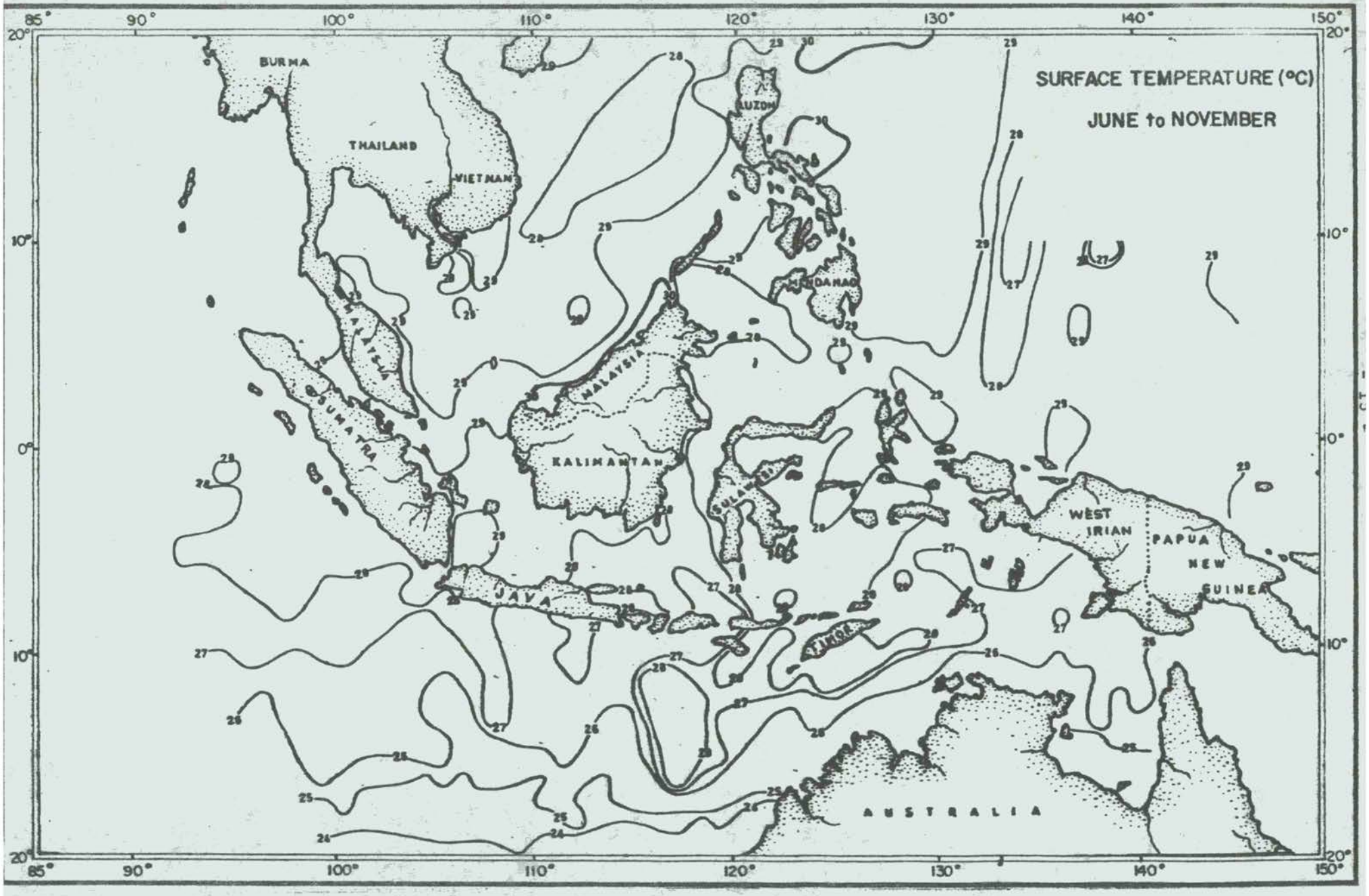


Fig. 7 Surface temperature distribution of the Indonesian and adjacent waters in Southeast monsoon, June-November (after Soegiarto and Birowo, 1975)

Fig. 8 Surface distribution of dissolved oxygen in the Indonesian and adjacent waters in northwest monsoon, December-May (after Soegiarto and Birowo, 1975)

Fig. 9 Surface distribution of dissolved oxygen in the Indonesian and adjacent waters in southeast monsoon, June-November (after Soegiarto and Birowo, 1975)

3. THE LIVING RESOURCES

Gradually, the utilization of the marine resources in Indonesia is growing and expanding in order to meet the increasing demands for food, energy, raw materials for industries, job opportunities and foreign exchange. Currently, the annual fish production in Indonesia is about 1.6 million metric tons which consists of about 1.2 million tons production from the marine sector and 400 000 tons from the freshwater and aquaculture sectors. The annual rate of increase during the Second PELITA (Five-Year Development Plan, 1974-1979) is estimated between 3 to 5 percents. However, the increase is confined to the marine sector, which for itself increased by approximately 6 percent annually in this period (Table 2). The production from inland waters irregularly declines in certain years due in part, to urbanization, absorption of labour force to other sectors of the economy (e.g. logging industries), siltation and hyper-eutrophication in many lakes, swamps, and rivers; and reduction in mix-culture practices due to the increasing use of pesticides and herbicides in agriculture.

The Indonesian seas can produce a restricted maximum sustainable yield of 4 million tons annually. Therefore, the current production of 1.2 million tons represents only about 30 percent of the potential yield. On the other hand, the estimated potential yield of freshwater capture and culture (including brackishwater) is 2.3 million tons. Thus, the current production is only about 17.4 percent of the potential A strong upward trend has also become apparent in the volume and value of exports of living aquatic resources from Indonesia. The export activities are mainly dominated by the export of shrimps and prawns. Export of fresh shrimps was negligible before 1966. In 1967, the export value was a low US$25 000 - and rose quickly to US$877 000 - in 1969, to US$3 630 000 - in 1970, and to US$13 742 000 - in 1972. The value of exports of living aquatic resources in 1976 was over US$130 million

The distribution of the traditional fishing grounds on which the above figures are based are shown in Fig. 10. A comparison with Fig. 1 for the shrimps ground will reveal some differences, but most of the areas watched obvious differences can be noted for the west coast of Sumatra and south coast of Borneo. In Irian Jaya the shrimp fishery seem to have more extended towards the open sea.

Slowly, the marine fisheries in Indonesia are growing and expanding, not only to meet the increasing demand of inexpensive animal protein for the people, but also to contribute to the urgently needed foreign exchange. It is realized, however, that in order to expand the fishery industries more rapidly, many constraints have to be overcome: the widespread need to develop technical skills, to modernize equipment and fishing methods, to expand the existing fishing grounds while looking for new ones, to study the life cycle, migration and population dynamics of the more economically important species, to seek for new exploitable species and to try to abate the effect of increasing pollution on the production of living resources.

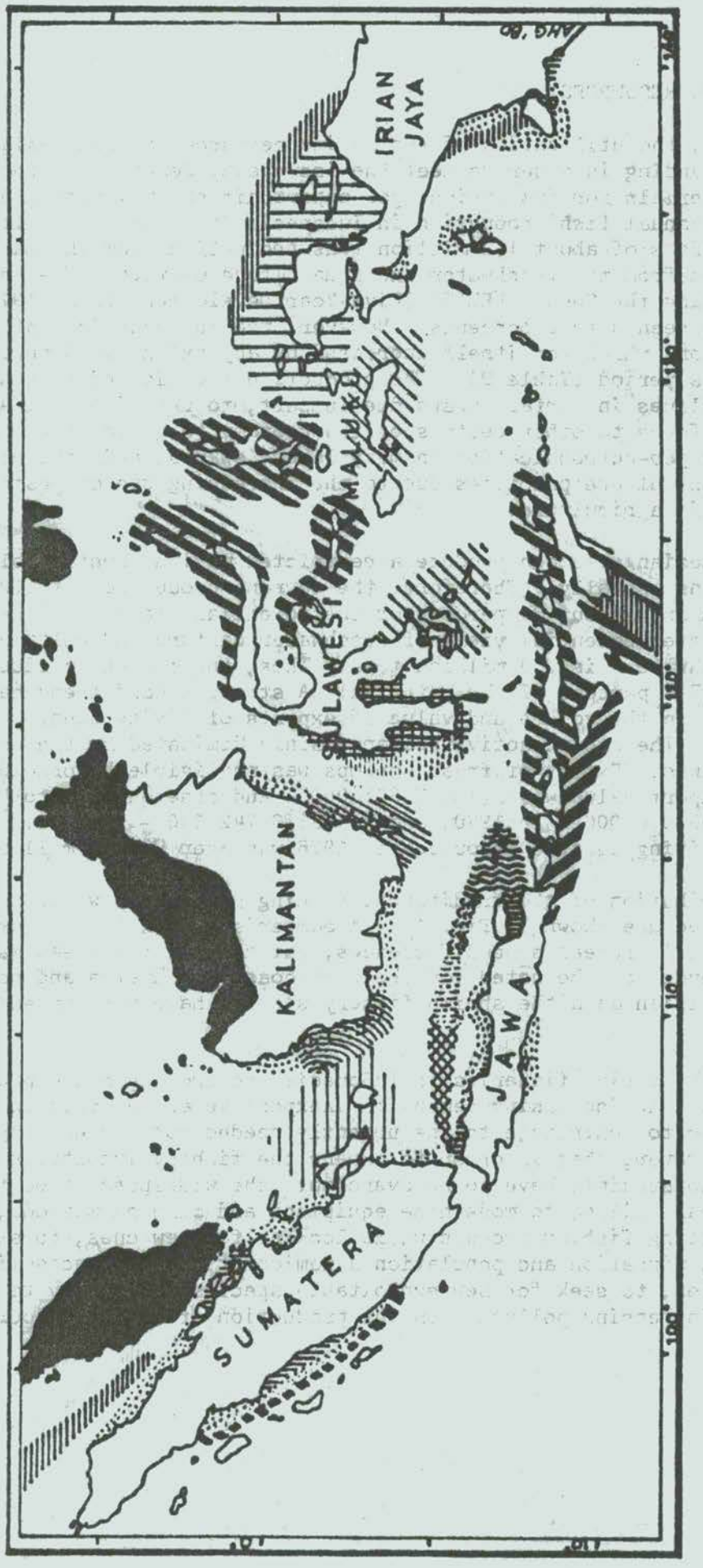
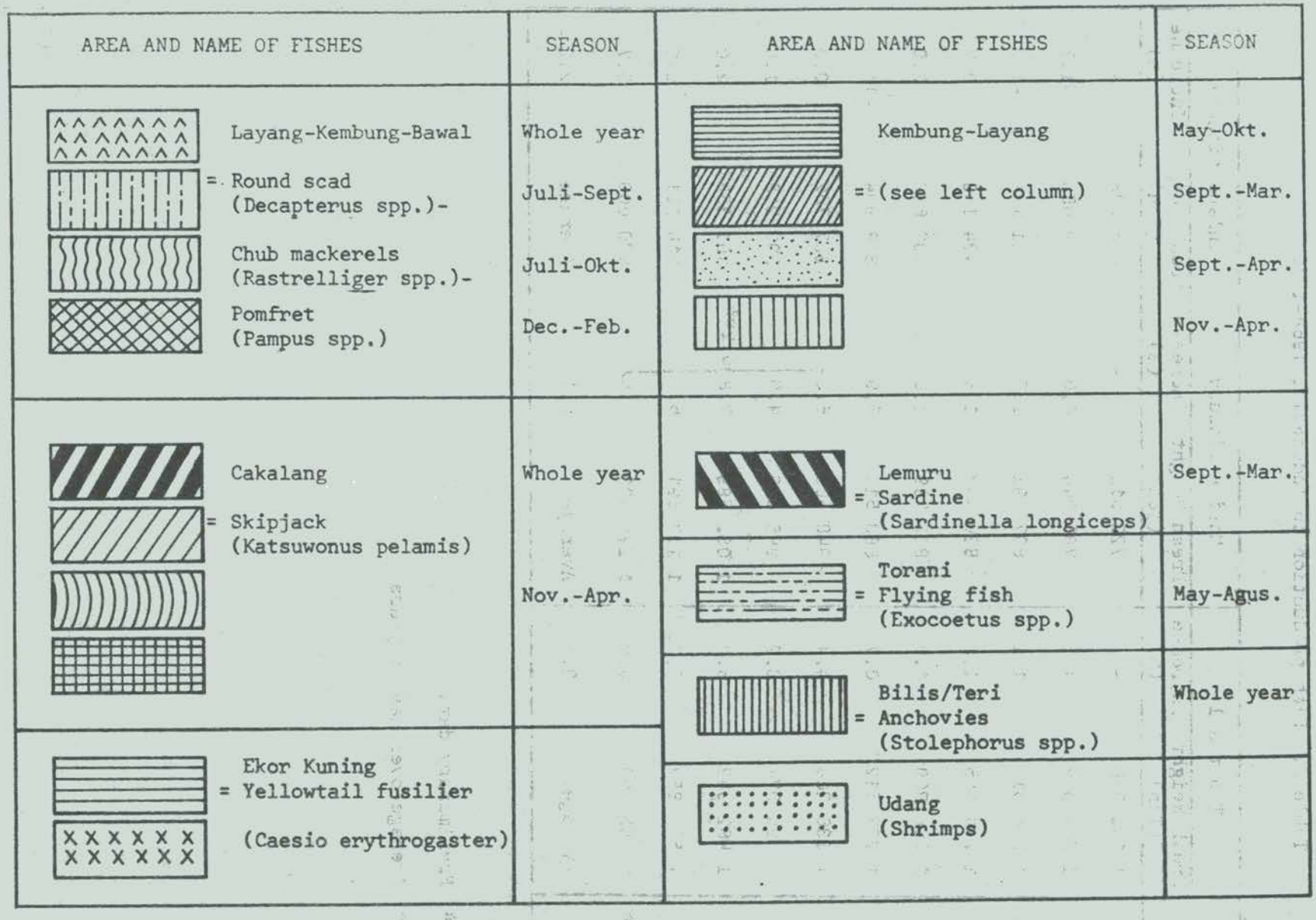


Fig. 10 Seasonal important fishing areas (after Unar, 1972)



Legend to Fig. 10

Table 2. Fish production in Indonesia, 1968-1978

Year	T o t a l		Marine fishery		Inland fishery	
	Fresh Weight (Ton)	Increase (%)	Fresh Weight (Ton)	Increase (%)	Fresh Weight (Ton)	Increase (%)
1968	1 159 040	-	722 512	-	436 528	-
1969	1 214 399	4.6	785 344	8.0	429 055	-1.7
1970	1 228 512	1.1	807 391	2.7	421 121	-1.9
1971	1 244 555	1.3	820 447	1.6	424 108	0.7
1972	1 268 909	1.9	836 289	1.9	432 620	2.0
1973	1 277 512	0.7	888 518	5.9	388 994	-11.2
1974	1 336 268	4.4	948 566	6.3	387 702	-0.3
1975	1 390 074	3.9	996 856	4.9	393 218	1.4
1976	1 482 942	6.3	1 081 589	7.8	401 353	2.0
1977	1 571 852	5.7	1 157 691	6.6	414 161	3.1
1978*	1 655 000	5.0	1 225 000	5.5	430 000	3.7
	Average	3.5	Average	5.1	Average	-2.2

6.2**

* Preliminary data

** Average over last 5 years

4. THE MANGROVE ECOSYSTEM

4.1 General aspects

Mangrove forest grows in humid tropical coastal areas; one of the centres of distribution is the Southeast Asian region. The mangrove forest normally develops along the protected coastal areas with muddy to sandy bottoms. But in some cases, it can also grow in wave swept rocky coast. In Indonesia it develops well along the inward coastlines of most of the large islands.

Ecologically, the mangrove forest form a rather shart transitional gradient between the marine and the freshwater environments. Therefore, only flora and fauna that have strong tolerance to this kind of environment can survive. This factor predetermines more or less the number of species existing in a mangrove ecosystem. Each biota or group of biota occupies a niche and even forms an aggregate and spatial zonation of their own. Van Steenis (1958) mentioned the combination of factors that may cause the species ecological preference, such as:

- soil types: hard or soft texture, ratio between the sand and mud contents
- salinity and tide: daily variation, annual average, the length of time, frequency and depth of enundation
- species tolerance to current and wave actions
- general tolerance of their young stages (seedlings, larvae) to the above-named factors

4.2 Areal coverage

Based on earlier sources of literatures, the areal coverage of the mangrove forest in Indonesia was ranging from one to two million hectares. However, through intensive surveys using satellite imageries as well as areal photographies, the latest record is 3.6 million hectares of mangrove forest with about 60 percent (2.1 million hectares) as forest stands (Wiroatmodjo and Judi, 1979). These forest areas are distributed over various islands of the Indonesian archipelago (Table 3, Fig. 1).

4.3 Flora and fauna

Since the 19th century the mangrove forest had become the centre of interests of many biologists. In part, this interest was due to the unique forms of aerial roots of a mangrove tree. However, most of the studies carried out in a mangrove forest normally was only to enumerate the tree species. Table 4 is taken from Kartawinata, et al. (1979), who in turn have improved the listing of flora species by Backer (1911), Steenis (1935, 1958) and Soemodihardjo, et al. (1977). It is understandable that the species composition varies from one forest to another and from one island to another.

Table 3. Areal distributions of mangrove forests in Indonesia (Preliminary data after Wiroatmodjo and Judi 1978, thousand hectares)

I. Sumatra	Aceh	50.0	
	North Sumatra	60.0	
	Riau	75.0	
	South Sumatra	195.0	
	Lampung	17.0	
	Total Sumatra		397.0
II. Java	West Java	20.4	
	Central Java	14.0	
	East Java	6.0	
	Total Java		40.4
III. Kalimantan	East Kalimantan	20.0*	
	South Kalimantan	20.0	
	Central Kalimantan	10.0	
	West Kalimantan	40.0	
	Total Kalimantan		90.0
IV. Celebes	South Celebes	24.0	
	Southeast Celebes	29.0	
	Total Celebes		53.0
V. Molluccas	(North and Central Halmahera, Aru, Buru, Taliabu)		100.0
VI. Irian Jaya	(South coasts and north coasts)		2 934.0
VII. Nusa Tenggara	(Sumbawa and Timor)		3.7
	Total for Indonesia		3 627.1

* The latest datum is 120 000 ha.

Table 4. List of plants found in Indonesian mangrove forest (after Kartawinata, et al., 1979)

TREES

Apocynaceae
Cerbera manghas L.

Bignoniaceae
Dolichandrone spathacea (L.f.) K. SCHUM.

Combretaceae
Lumnitzera littorea (JACK) VOIGT
L. lutea PRESL.
L. racemosa WILLD.

Euphorbiaceae
Excoecaria agallocha L.

Leguminosae
Cumingia philippinensis VIDAL
Cynometra ramiflora L.
Pithecellobium umbellatum (VAHL.) BTH

Meliaceae
Aegiceras corniculatum (L.) BLANCO
A. floridum R. & S.

Myrtaceae
Osbornea octodonta F.v.M.

Palmae
Nypa fruticans WURMB.
Oncosperma tigillaria (JACK) RIDL.
Phoenix paludosa ROXB.

Rhizophoraceae
Bruguiera cylindrica (L.) LMK
B. exaristata DING HOU
B. gymnorrhiza (L.) LMK
B. sexangula (LOUR.) POIR.
Ceriops decandra (GRIFF.) DING HOU
C. tagal (Perr.) C.B. ROBINS.
Kandelia candel (L.) DRUCE
Rhizophora apiculata BL.
R. mucronata LMK.
R. stylosa GRIFF.

Rubiaceae
Scyphiphora hydrophyllacea GAERTN.

Rutaceae
Paramignya angulata (WILLD.) KURZ

Sonneratiaceae
Sonneratia alba J.E. SMITH
S. caseolaris (L.) ENGL.
S. ovata BACK

Sterculiaceae
Heritiera littoralis DRYND. ex W. AIT.

Verbenaceae
Avicennia alba BL.
A. marina (Forsk.) VIERH.
A. officinalis L.

SHRUBS

Leguminosae
Caesalpinia crista L.

Rubiaceae
Ixora timoriensis DECNE

Tiliaceae
Bronlowia argentea KURZ
B. lanceolata BTH.

Verbenaceae
Clerodendrum inerme (L.) GAERTN

Table 4 (continuation)

FERNS

Acanthaceae
Acanthus ebracteatus VAHL.
A. illicifolius L.
A. volubilis WALL.

Araceae
Cryptocoryne ciliata (ROXB.) SCHOTT.

Cyperaceae
Cyperus malaccensis LAMK.
Diplachne fusca (L.) BEAUV.
Fimbrystylis ferruginea (L.) VAHL.

Daenstaedtiaceae
Acrostichum aureum L.

Gramineae
Aegialitis annulata R. BR.

LIANA

Asclepiadaceae
Cynanchum carnosum SCHLTR.
Finlaysonia obovata WALL.
Sarcolobus banksii R. & S.
Gymnanthera paludosa (BL.) K. SCHUM.

Leguminosae
Dalbergia caudenatensis (DENNST.) PRAINS
D. menoeides PRAIN;
Derris heptaphylla (L.) MERR.
D. heterophylla (WILLD.) BACKER

Rhamnaceae
Smythea lanceata (TUL.) SUMMERH.

EPIPHYTES

Adianthaceae
Vittaria sp.

Asclepiadaceae
Dischidia benghalensis COLEBR.
Hoya sp.

Daenstaedtiaceae
Davallia sp.

Ericaceae
Rhododendron brookeanum LOW.

Jungermanniceae
Frullania sp.

Melastomataceae
Pachycentria constricta (BL.) BI.
Plethiandra sessilifolia RIDL.

Orchidaceae
Aerides odorata LOUR.
Anota violacea SCHLTR.
Bulbophyllum xylocarpi J.J.S.
Dendrobium alvifolium (Bl.) RCHB.f.
D. callibotrys RIDL.
D. prostratum RIDL.
D. rhizophoreti J.J.S.
D. subulatum (Bl). LINDL.
Oberonia laeta J.J.S.
O. rhizophoreti J.J.S.

Polypodiaceae
Cyclophorus cinnamomeus V.A.V.R.
Drynaria sparsisora (DESV.) MOORE
Drymoglossum heterophyllum C. Chr.
Humata parvula (WALL.) METT.
Nephrolepis acutifolia (DESV.) VHR.
Platycerium coronarium (KOENIG) DESV.
Phymatodes scolopendria (BURM.) CHING
P. simeosa (WALL.) J. SM.

Rubiaceae
Hydnophytum formicarum JACK
Myrmecodia sp.

Schyzaeaceae
Lygodium laxum PR.

PARASITES

Loranthaceae
Amyema gravis DAVIS.
Viscum orientalis L.

The first and relatively complete record of fauna in a mangrove forest in Indonesia is probably that of Verwey (1929) from the Jakarta Bay area. He listed various groups of animals, including mammals, reptiles, birds, amphibians, and insects. In addition Verwey (1930) made a special study on the distribution of crabs. Based on the result of this study, he could distinguish various zonation based on the dominant species of crab, e.g. Sesarma taeniolata zone, Uca consobrinus zone, Uca signatus zone, Metaplex elegans zone and Scylla serrata zone. Other studies normally concentrate only on a certain group of animals.

The mangrove fauna actually consists of the territorial component and the marine component. Some representatives of the territorial component are for example: bat (Pteropus vampyrus), various (Varanus salvator), wild pig (Sus sp.), monkey (Maccacairus sp., Nassalis larvatus), various birds, and insects. The marine components fauna is generally more prevalent, and is in particular dominated by the gastropods and the brachyurans (Table 5).

In addition to the sedentary fauna, there is a number of species utilizing the mangrove ecosystem only as temporary habitat, be it as spawning area, as nursery, or only as temporary shelter. For example, some economic species of shrimps are known to be mangrove dependent (MacNae, 1974; Unar, 1972). Therefore, the shrimp fisheries normally are strongly correlated with the distribution of mangrove forest (Fig. 1, Martosubroto and Naamin, 1977; Martosubroto, 1979).

4.4 Zonation

In addition to species composition one can differentiate various zonations. These zonations normally are governed by the interaction of several factors, such as the frequency and length of time of submergence, salinity, and the drainage system. Generally, each zone is called by the dominating woody tree species, for example, it could be distinguished (from outer edge to the inner zone): Zonneratia zone, Avicennia zone, Rhizophora zone, Bruguiera zone, Ceriops zone, and Nypa fruticans association.

In his classic study on the effect of submergence and salinity on the species composition of the mangrove trees in Cilacap (South Java), Haan (1935) could distinguish six different classes as follows:

Class 1: range of salinity 10-30 o/oo. The ground is sugmerged 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; to form the outer zone.

Class 2: range of salinity 10-30 o/oo. The ground is submerged 10-19 days per month; Bruguiera gymnorhiza grow 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.

Table 5. List of fauna found in a mangrove forest (after Kartawinata, et al, 1979)

GASTROPDA

Potamididae
- *Terebralia palustris* (LINNAEUS)
- *T. sulcata* (BORN)
- *Telescopium telescopium* LINNAEUS
- *T. mauritsi* BUTOT
- *Cerithidea djadjarensis* (MARTIN)
- *C. alata* (PHILIPPI)
- *C. obtusa* (LAMARCK)
- *C. quadrata* SOWERBY
- *C. weyersi* DAUTZEMBERG
- *C. cingulata* (GMELIN)

Ellobiidae
- *Cassidula aurisfelis* BRUGUIERE
- *C. Lutescens* BUTOT
- *C. mustelina* DESHAYES
- *C. triparietalis* (MARTENS)
- *C. sulculosa* (MUSSON)
- *Auriculastra subula* (QUOY & GAIMARD)
- *Ellobium aurisjudae* LINNAEUS
- *E. aurismidae* (LINNAEUS)
- *E. tornatelliforme* (PETIT)
- *Pythia plicata* (FERUSSAC)
- *P. trigona* (TROSCHEL)
- *Melampus singaporensis* (PFEIFFER)
- *M. pulchellus* PETIT
- *M. semisulcatus* MOUSSON

Littorinidae
- *Littorina scabra* (LINNAEUS)
- *L. carinifera* (MENKE)
- *L. intermedia* PHILIPPI
- *L. melanostoma* GRAY
- *L. undata* GRAY

Neritidae
- *Nerita 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* (LINNEUS)

Thiaridae
- *Melanoides riqueti* (GRATELOUP)
- *M. tuberculata* (MÜLLER)

Amphibolidae
- *Salinator burmana* (BLANFORD)
- *S. fragilis* (LAMARCK)

Cerithidae
- *Cerithium morum* LAMARCK

Melongenidae
- *Melongena galeodes* LAMARCK

Trochidae
- *Monodonta labio* (LINNAEUS)

Assimineidae
- *Syncera brevicula* (PFEIFFER)
- *S. javana* (THIELE)
- *S. nitida* (PEASE)
- *S. woodmasoniana* (NEVILL)

Stenothyridae
- *Stenothyra glabrata* (A. ADAMS)

BIVALVIA

Carbiculidae
- *Polymesoda coaxans* GMELIN
- *P. expansa* (MOUSSON)

Veneridae
- *Gafrarium tumidum* RODING

Anomiidae
- *Enigmonia aenigmatica* (CHEMNITZ)

Ostreidae
- *Ostrea cucullata* BORN

Arcidae
- *Anadara antiquata* LINNAEUS

Table 5 continuation

CRUSTACEA

Grapsidae
- *Sesarma taeniolata* WHITE
- *S. meinerti* DE MAN
- *S. bataviana* DE MAN
- *S. cumolpe* DE MAN
- *S. smithi* H. MILNE - EDWARDS
- *S. bocourti* A. MILNE - EDWARDS
- *S. fasciata* LANCHESTER
- *S. bidens* DE HAAN
- *S. onychophora* DE MAN
- *S. rousseauxi* H. MILNE - EDWARDS
- *S. erythrodactylum* HESS
- *S. longipes* (KRAUSS)
- *Metopograpsus latifrons* (WHITE)

Ocypodidae
- *Uca vocans* LINNEUS
- *U. lactea* (DE HAAN)
- *U. signatus* (HESS)
- *U. consobrinus* (DE MAN)
- *U. annulipes* (H. MILNE - EDWARDS)
- *U. dussumieri* (H.MILNE - EDWARDS)
- *U. triangularis* A. MILNE - EDWARDS
- *Macrophthalmus convexus* STIMPSON
- *M. telescopicus* OWEN
- *M. definitus* ADAM & WHITE
- *Ocypoda ceratophthalma* (PALLAS)
- *O. arenaria* DE MAN
- *Ilyoplax delsmani* DE MAN
- *I. orientalis* (DE MAN)

Portunidae
- *Scylla serrata* (FORSKAL)

Gegarcinidae
- *Cardisoma carnifex* (HERBST)

Thalassinidae
- *Thalassina anomala* HERBST

Alpheidae
- *Alpheus crassimanus* HELLER
- *A. bisincisus* DE HAAN

Paguridae
- *Coenobita cavipes* STIMPSON

Balanidae
- *Balanus* sp.

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 effected very little by tides.

Class 6: salinity 0 o/oo. The ground is effected by water level only during the wet season.

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

Verwey (1930) on the other hand proposed another type of zonation based on the dominating species of crabs inhibiting the area, as mentioned in Section 4.3

4.5 Physical and chemical properties

Studies on the physical and chemical properties in mangrove biotopes in Indonesia are very scarce indeed. Most of the studies were carried out in the attempts to determine the suitability of a mangrove forest to be converted into rice fields (e.g. IPB, 1969 and 1975; Van Wijk, 1951). Notohadiprodjo (1979) classifies the stability of mangrove soil aggregates based on the percentages of organic carbon contents as follows:

Aggregates	Organic Carbon	
	Range	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

From the soil samples taken in the mangrove forest in Cilacap, he found out that:

- 91% of the soil contain 40% or more clay
- 65% of the soil contain 60% or more clay
- 95% of the soil contain higher percentage of colloidal clay (less than 0.5 micron in diameter)
- 53% of the soil contain higher percentage of medium silt than other fractions

Kartawinata and Waluyo (1977) made some studies on the physical and chemical properties of the soil in three different mangrove communities in the Rambut Island nature reserve, Jakarta Bay (Table 6).

Table 6. Chemical and physical properties of the soil from three mangrove communities in the Rambut Island Nature Reserve, Jakarta Bay (after Kartawinata and Walujo, 1977)

Soil properties	*Scyphiphora-Pemphis* community	*R. mucronata* community	*R. mucronata R. stylosa* community
Soil depth (cm)	0 - 10	0 - 50	0 - 10
Texture (%)			
Sand	71.5	11.3	90.0
Silt	17.5	44.7	6.0
Clay	11.0	44.0	4.0
pH	7.6	6.7	7.6
Organic matter (%)	7.8	62.1	2.0
Nutrients (%)			
N	0.28	1.26	0.10
P_2O_5	0.282	0.075	0.054
K_2O	0.082	0.283	0.040
CaO	47.962	11.357	49.723
MgO	0.776	1.704	0.874
Exchangeable cations (m.e.)			
Ca	33.9	68.8	27.1
Mg	14.2	69.5	7.5
K	1.3	6.4	0.8
Na	29.5	149.3	21.4
Total	79.1	292.4	56.8
Absorption capacity	23.5	84.4	5.6

4.6 Utilization

For centuries the Indonesian people traditionally has utilized mangroves, mostly for the production of firewood, charcoal, tannin dyes, timber, and even boats.

The following genera are frequently used for these purposes: Rhizophora, Bruguiera, Ceriops, Avicennia, Nypa and Oncosperma. The nypa leaves are used for various purposes such as tatchroof, basket, cigaret wrappers. The stalk of the flower can be cut and the sap is tapped for making brown sugar or arrack (some kind of spirituous liquor).

The Riau archipelago has been known as centre for mangrove charcoal production for quite some time. The products have mostly been and are still exported to Singapore and Hong Kong. The Forestry Service of the Riau archipelago has reported that in Riau there are about 666 charcoal producers with an average production of 150 ton charcoal per year. Usually each producer can burn charcoal six times in one year. The following table gives some idea as to the volume of charcoal production and other products in the Riau archipelago.

Year	Charcoal (in ton)	Firewood (in m^3)	Pulpwood (in m^3)
1973	20 079	21 714	22 038
1974	22 322	52 851	39 412
1975	23 384	52 261	63 347
1976	27 251	12 062	63 347

In recent years mangrove wood has also been used as raw material for a paper mill in Gowa, south Celebes. The Gowa paper mill used bamboo as the basic raw material and mangrove wood as an additive. They found out that by processing with a ratio of 80% bamboo and 20% mangrove they could obtain a very good quality paper (Rachmat, 1975). In 1974, the Chipdeco company started to produce chipwood from mangrove in East Kalimantan, exploiting about 85 000 ha of mangrove forest.

5. SOME ENVIRONMENTAL PROBLEMS

5.1 Logging

The mangrove ecosystem has many functions. As has been outlined above the mangrove forest can be exploited for the firewood, charcoal, timber, and for raw materials for paper and chipboard. In addition, it functions also as coast stabilizer, erosion preventor, as spawning and nursery ground, food producer for many animal groups, and even as pollutants trap. Most of the environmental problems in a mangrove ecosystem are usually related to its various ecological functions.

For example, Versteegh (1952) mentioned that the exploitation of mangrove forest in Indonesia is generally not based on a conservation

principle. He pointed out the widespread cutting of mangrove trees for tens of years in the Riau archipelago without any conservation measures. For a charcoal production he designed a 30-year exploitation cycle as follows: the mangrove forest is divided into many sub-blocks of 120 ha each. Only 4 ha of forest should be cut from each sub-block. Thus the exploitation cycle is 120:4 = 30 years.

In order to ensure a long term exploitation, at present many forest companies follow Versteegh management scheme. The exploitation cycle may vary from 20 to 40 years, depending on the density of the stand and area of the forest to be exploited.

In order to preserve the ecological functioning of mangrove forest the Indonesian government, through the Department of Agriculture and the Directorate General of Forestry, has regulated the felling of mangrove forests. A 50-200 metre green belt of mangroves should be retained along the coast. This belt not only aims to preserve the ecological function of mangrove forest in the coastal zone, but in addition also to ensure the natural regeneration process in the region.

5.2 Pollution

There is only one study on the impact of pollution specifically carried out in a mangrove ecosystem, i.e. the study in the Cilacap mangrove swamp by Hardjosuwarno et al. (1975). The Cilacap area has been designated an industrial complex for the southern coast of central Java: a ferro-sand mine, an oil terminal, a fishing port as well as open ocean port, and, since 1977, an oil refinery has been operated here. This complex is situated adjacent to 23 000 ha mangrove forest, the most extended mangrove forest in Java. In the study the following physical and chemical parameters were monitored: temperature, pH, DO, CO_2, carbonate, alkalinity, and hydrocarbons. Although, the hydrocarbon contents of both the mud and seedlings were relatively very high, on the average 769.9 ppm and 6 150.7 mg/seedlings, respectively, the authors still could not see any effect of this pollutant to the mangrove ecosystem nor to the productivity of the water around it.

Due to the lack of environmental data in mangrove ecosystem, it is rather difficult to determine pollution. Fortunately, however, rather substantial studies on pollution have been carried out in coastal waters adjacent to many of the mangrove areas. The following factors, processes, and chemical substances have been identified as major sources of pollution in the aquatic environment of Indonesia (Soegiarto, 1975 and 1976).

5.2.1 Sedimentation

Erosion is a natural process without which there would be no soil. On the other hand, accelerated erosion of this soil due to poor land management will not only rob the land of its fertility, but it also destroy the freshwater and marine communities on which the sediment settles. Excessive siltation associated with poor land management probably is the single worst form of pollution in tropical aquatic environment. Indonesia appears to be no exception. Dredging and mining also contribute to this problem.

In Java excessively rapid runoffs and erosion are recognized to be a serious problem leading to flooding of lowland fields, damage to irrigation networks, and loss of topsoil. In Java, notwithstanding the extensive terraces on sloping lands, erosion occurs on higher slopes which are too steep to terrace. Delta-build-up along the north coast is accelerating, and is likely to be adversely affecting subtidal marine communities that require clear water.

Soemarwoto (1974), for example, has monitored the silt contents of the Citarum river, where the Jatiluhur dam is located. He found out that the silt content is increasing six fold in a two-year period. He reported that on the average the silt content was 3.5 o/oo in 1970, 9.3 o/oo in 1971 and has increased to the average of 20.9 o/oo by 1972. Preliminary measurements of other major rivers in Java told a similar story.

In Sumatra and Kalimantan (the Indonesian part of Borneo), where the population pressure on agricultural and forestry land is still lower than in Java, major erosion problems are probably of more recent occurrence. They are largely due to the rapidly expanding logging, and lumber industries. It can be anticipated that fisheries in the vicinities of the mouths of the effected rivers will decline, if they have not already begun to do so.

5.2.2 Chlorinated hydrocarbons

The amount of pesticides and herbicides distributed in Indonesia is increasing since 1968, when Indonesia launched the agricultural intensification and extensification programmes. A few high yielding rice varieties, such as IRI-8, are used in these programmes. Due to their greater vulnerability to pests these strains have received an intensive treatment with pesticides. Although it seems that the volume of pesticides imported slightly declined in 1970 and 1971, it started to increase again in 1972. Currently, more than 2 000 tons of pesticides are imported to Indonesia annually.

5.2.3 Petroleum hydrocarbon

As of last year (1979) the total petroleum production in Indonesia was about 0.6 million barrels per day. Although most of the crude oil still derives from the on-land oil fields, an increasing portion is coming from the offshore fields. At present about 35% of the oil are already gained from the offshore wells.

Concurrent with the increase of oil production, petrochemical industries are also mushrooming. Generally they are still discharging the effluents into the nearby rivers, lakes, or estuaries. Some of the effluents, as it was found out later, contain hazardous materials such as sulphuric acid and arsenic. As an illustration it can be mentioned that soon after the Gresik (Surabaya) petrochemical plant started to operate, complaints from local fishermen were received due to the fouling of their brackish water ponds, and tainting of the fishery products around the effluent outfalls. The plant operator was asked to stop discharging the effluents into the estuaries, and to dump the hazardous materials into deep waters.

Over 90% of the crude oil from the Middle East and Africa for Japan are transported through the relatively shallow and treacherous Straits of Malacca and Straits of Singapore. Many accidents and near accidents have taken place in these straits. The biggest one was the grounding of the super tanker (238 000 dwt) SHOWA MARU on 6th January 1975, in the Singapore strait, just inside the Indonesian territorial waters. SHOWA MARU spilled almost 7 000 tons of Middle East crude into the Indonesian, Singaporian and Malaysian coastal waters. As a result, hundreds of hectares of mangrove forests died. In August 1977, a team was sent to the area and they reported that even more than two and half years after the accident most of the mangrove forest effected had not yet recovered.

Due to the potential increase of pollution by petroleum hydrocarbons in the Indonesian waters, serious efforts have been made to develop monitoring programmes. The first attempt was made by the LEMIGAS (the Indonesian Petroleum Institute) in 1972/1973. Table 7 shows the results of the first spot check measurements by the team. Later measurements in 1975 and 1976 with an improved method discriminating non-hydrocarbon compounds showed concentrations of below 1 ppm in the Java Sea, north of Jakarta (Bilal, et al., 1979; Muchtisar and Muluk, 1977). Further measurements in the Straits of Malacca were carried out by the Marine Fisheries Research Institute in 1976 and 1978 (Wasilun, 1978). Table 8 shows a range of concentrations of <0.1 - 7.2 ppm for the surface waters (median 1.3 ppm) and <0.1 - 6.3 ppm for subsurface waters.

5.2.4 Domestic and industrial wastes

At present there is no single sewage system in Indonesia. All wastes are literally dumped into the natural environment, including the coastal waters.

Rivers and streams traditionally are used as waste baskets delivering a great portion of the waste into the sea. When the community is still small, these waters are able to degrade the waste materials. However, with the community growing in size these natural water environments are unable to assimilate what is dumped there. Excessive eutrophication is quickly observed. If necessary steps are not taken, these waters will die and become unusable. Many natural water environments in Indonesia are approaching that stage, particularly those that are located in or around population centers or industrial estates. For example, Bilal et al. (1975) have made a preliminary investigation on the quality of surface waters in the city of Jakarta. Their findings showed that almost all surface waters of Jakarta are severely polluted (Table 9).

5.3 Future waste problems

In addition to previous factors the following gives a list of some potential pollutants that will be of importance in the near future in Indonesia.

Table 7. Preliminary inventory on the hydrocarbon* level in some Indonesian waters in 1972 and 1973 (Wisaksono, 1974)

Location	Hydrocarbon concentrations* (ppm)	Date of collection
West coast of Kalimantan	20 - 48	May 1972
Bangka Strait	20 - 40	May 1972
South coast of Bangka	30 - 200	May 1972
Around Jakarta Bay	3 - 25	1972
North coast of Java (Cirebon, Semarang and Surabaya)	35 - 60	February 1973
South coast of Bali	40 - 50	November 1972
South coast of Bali	14 - 18	November 1973
North coast of Bali	40 - 70	November 1973
Eastern Indonesian waters	40 - 60	January 1973
Jakarta Bay		
- Off Tanjung Priok Harbour	60 - 100	1972
- Around Nirwana Island	19.6	September 1972
- Around Ayer Besar Island	14.1	September 1972
- Around Kelor Island	20.6	September 1972
- Around Sakit Island	17.1	September 1972
- Around Pari Island	4 - 10	August 1973
Cilacap Oil Terminal	34	October 1972
Bali Oil Terminal	30	October 1972
Merak Oil Terminal	6 - 20	April 1973
Musi River	23 - 54	April 1972
Around Wonokromo refinery	17 - 33	October 1973
Around Plaju and Sungai Gerong refineries	9 - 15	May 1973
Around Balikpapan refinery	8	June 1973

* The expression "hydrocarbon" is misleading as the analytical method used (ASTM D1340) actually refers to - "oil and grease", but can comprise other substances as well, and not only (petroleum) hydrocarbons, which is meant here (note of ed.).

Table 8. Results of hydrocarbon (HC) monitoring along the East Coast of Sumatra in November 1976 and July-August 1978 (after Wasilun, 1978) (for locations of stations see Fig. 11. Numbering of stations in 1978 has been adapted to survey 1976).

Station No.	1976		1978	
	Sampling depth (m)	HC (ppm)	Sampling depth (m)	HC (ppm)
1	0	nil	0	1.4
	10	nil	10	1.2
	20	trace	25	2.3
2	0	trace	0	0.9
	10	trace	10	2.3
	18	trace	15	0.9
3	0	trace	0	2.1
	10	trace	10	3.1
	19	nil	15	3.8
4	0	nil	0	0.7
	5	nil	7	0.7
5	0	trace		
	15	trace		
	28	trace		
6	0	trace		
	5	trace		
	10	nil		
5X			0	<0.1
			10	<0.1
6X			0	<0.1
			10	<0.1
			25	<0.1
7	0	nil		
	5	nil		
	10	trace		
8	0	trace		
	7	nil		
9	0	trace	0	3.4
	5	trace	10	3.0
	10	trace	19	2.2

Table 8. Continuation

Station No.	1976		1978	
	Sampling depth (m)	HC (ppm)	Sampling depth (m)	HC (ppm)
10	0	trace	0	2.0
	10	trace	10	<0.1
	25	trace	20	<0.1
11	0	trace	0	1.4
	10	trace	15	2.8
	28	trace	30	2.4
12	0	trace	0	1.1
	15	trace	12	<0.1
	30	0.80	25	0.2
13	0	1.28	0	0.9
	15	trace	10	1.4
	30	trace	25	0.2
14	0	nil		
	15	nil		
	28	trace		
15	0	trace	0	<0.1
	5	trace	7.5	<0.1
			15	<0.1
16	0	nil		
	15	nil	0	<0.1
	30	nil	10	<0.1
16X			0	0.9
			10	1.6
			20	3.1
17	0	nil	0	<0.1
	10	nil	7.5	0.3
	20	nil	15	1.4
18	0	nil	0	2.3
	5	nil	10	2.3
	10	nil		
19	0	trace	0	4.7
	10	trace	7.5	3.1
	19	trace	15	-
20	0	trace	0	0.6
	10	trace	10	0.3
	20	trace	20	0.7

Table 8. Continuation

Station No.	1976		1978	
	Sampling depth (m)	HC (ppm)	Sampling depth (m)	HC (ppm)
21	0	trace	0	1.4
	15	0.29	10	0.9
	30	0.48	20	2.8
22	0	trace	0	3.5
	15	trace	15	4.3
	30	trace	30	1.3
23	0	nil	0	0.5
	10	trace	13	0.9
	18	trace	26	0.4
24	0	trace	0	1.9
	10	trace	8	1.9
	15	trace	16	1.0
25	0	trace	0	0.5
	10	trace	7.5	0.9
	20	trace	15	2.8
26	0	trace	0	0.9
	10	trace	12.5	0.3
	20	trace	25	1.4
27	0	nil	0	2.5
	5	0.91	10	5.3
	10	trace		
28	0	nil	0	2.4
	5	trace	15	1.1
			30	0.6
29	0	nil	0	0.9
	15	nil	15	2.7
	30	nil	30	5.7
30	0	trace	0	7.2
	5	trace	10	3.1
	10	nil	20	6.3
31	0	trace	0	3.6
	5	trace	10	4.9
	10	trace		

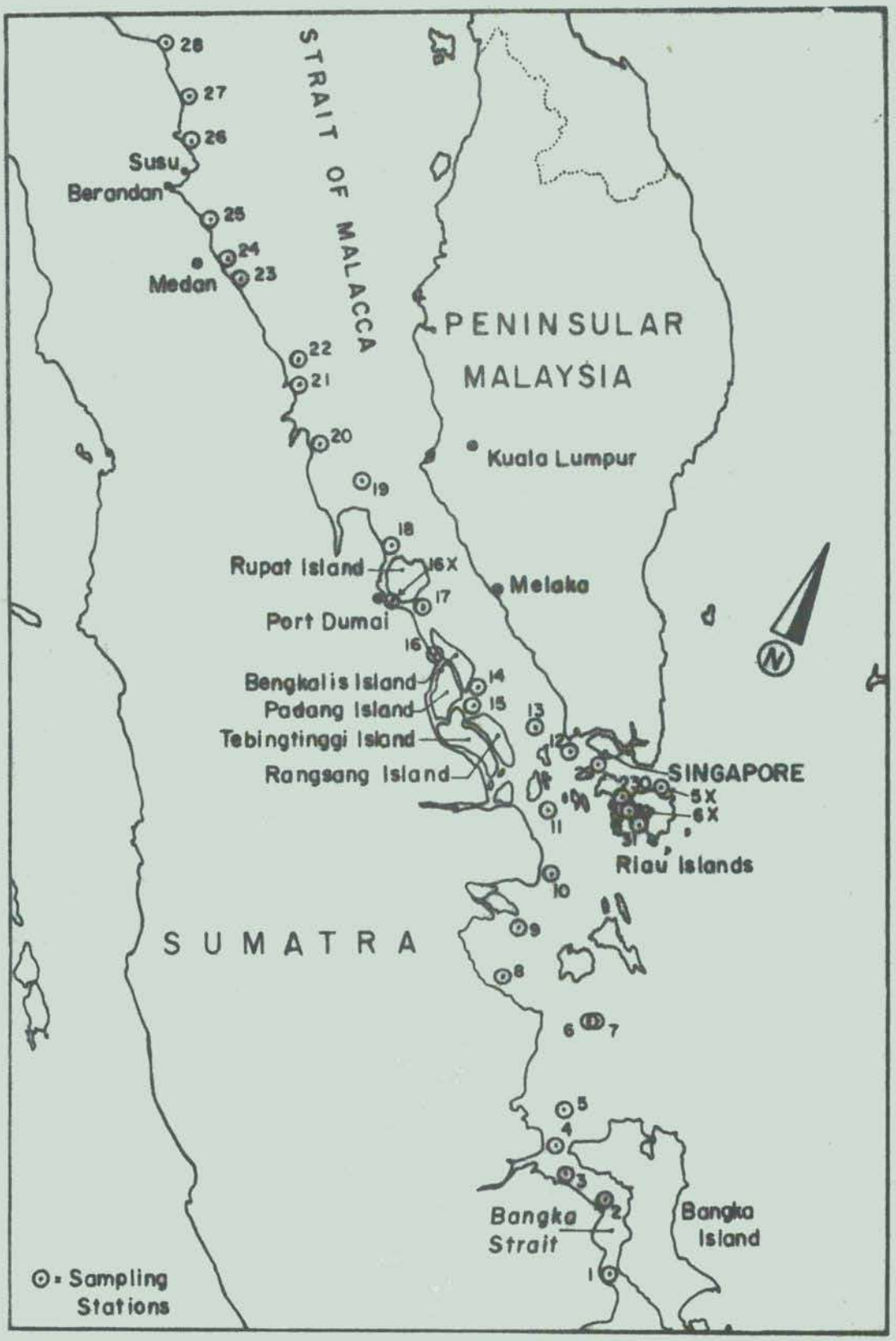


Fig. 11 Sampling stations for water analyses in 1976 and 1978

Table 9. Preliminary data on the surface water quality of Jakarta (after Bilal, et al., 1975)

Parameters	Rivers and streams in the city (ppm)	Estuary (ppm)
Dissolved Oxygen (DO)	2 - 4	4.8 - 6.3
Biochemical Oxygen Demand (BOD)	50 - 100	13.9 - 30.7
Chemical Oxygen Demand (COD)	99 - 125	-
NH_4 - N	8.2 - 16.5	0.6 - 0.9
NO_3 - N	0.5 - 1.7	0.4 - 0.85
PO_4 - P	10 - 15	0.5 - 0.8
Hydrocarbons (HC)	10 - 18	0.0 - 0.39
pH	6 - 7	6.5 - 7.3
Hg	0.004	0.004
Cu	0.01	0.01
Cd	0.01 - 0.03	0.05 - 0.07

5.3.1 Industrial wastes

At present industrial wastes in Indonesia are still very minor as compared to other sources of pollutants. However, it can be expected that they will be very important sources in the future, particularly with the current government's drive for industrialization in many sectors of the economy.

5.3.2 Thermal wastes

Only a few steam power electric generators are now operating in Indonesia with a total capacity of about 200 MW. Therefore, the volume of thermal waste from these plants is still negligible. However, this condition will change rather drastically when the Indonesian government starts to implement its plan to multiply the electric power production in Indonesia.

In 1974 the Indonesian government through the National Seminar on Energy made a projection that by the year 2 000 the electric power production in this country will be increased from currently about 5 000 MW to 64 000 MW. Out of this amount 23 to 39% or 15 000 to 25 000 MW are expected to come from nuclear power plants. The first nuclear power plant is expected to operate by 1985. It means that by the year 2 000 the annual volume of hot water being discharged from these nuclear power plants alone will be about 650×10^6 to $1\ 000 \times 10^6$ m^3. Almost all of this hot water is expected to be discharged into the coastal waters. In addition, economists also predict a tremendous increase in the volume of hot water being discharged from the electrical steam power plants as well as from other industries.

5.3.3 Radioactive wastes

Concurrent with the expected increase in the thermal pollution from the nuclear power plants, it is only logical to expect an increase in the amounts and kinds of radioactive wastes to be disposed of. Hopefully, by that time the level of technology has reached such a stage that no radioactivity is released into the environment from any nuclear power plant or waste deposit.

5.4 The problems of land use

5.4.1 Human settlement

Most of the major cities and population centres are located on coastal area. Seventy-five percent of medium size cities (population over 100 000) in Indonesia are located in the coastal areas (see Regional Synopsis, E.D. Gomez). This increases the pressure on the coastal resources and coastal environment.

5.4.2 Harbour and other infrastructures for sea transports

Since Indonesia is an archipelago, she has to develop rather intensive sea transport and harbour infrastructure, be it for national or be it for international trade.

5.4.3 Industrial sites

For reason of easier accessibility, more and more industrial estates are developed in the coastal area. A few examples can be mentioned here: Pulau Gadung in Jakarta, Gresik and other parts of Surabaya (East Java), Cilacap at the south coast of Central Java, and around the city of Medan in North Sumatra.

5.4.4 Agricultural development

In order to meet the increasing demands for staple food, the Indonesian government has launched a comprehensive extensification agricultural programme. For example, in the First Five-Year Development Plan (1969-1974) almost 200 000 ha of tidal forests have been converted into agricultural lands. In the Second Five-Year Development Plan (1974-1979) an additional half million hectares have been converted into rice fields, fishponds and other production purposes. At this stage, however, we know very little about the long-term impacts of such large scale conversion to the ecology of the remaining tidal forests, and the surrounding areas, in particular to the linked marine ecosystem.

5.4.5 Recreation and tourisms

Development of recreational areas would help to improve the national economy. As an island nation, the coastal region and beach resorts are the logical and attractive possibilities. The number of foreign and domestic tourists has been increasing steadily, and this will lead to further development of touristic and recreation facilities.

5.4.6 Nature reserves

To ensure that natural ecosystems will still exist in the future, a number of nature reserves have been established in Indonesia. Many of these reserves are located in the coastal areas. Currently, the Indonesian government is exploring the possibility of increasing the nature conservation area, from presently 3.5 million to 10 million hectares by 1984. Taking advantage of this programme and owing to the increasing pressures subjected to the marine and coastal environments, a marine parks and reserves system will be established. Many potential sites have been identified. Surveys and studies on these sites will be carried out jointly by the Indonesian National Institute of Oceanology, the Directorate of Nature Protection and Conservation and the World Wildlife Fund.

6. SUGGESTED RESEARCH PROGRAMMES

This status report makes it clear that there are many gaps of knowledge linked to the anthropogenic pressures on coastal environment, especially the mangrove forests. It is hoped that national and regional programmes supported by international and UN organizations can help filling these gaps. Some of the suggested research needs and research programmes,

which are considered most urgent to give answers to the problems above and help making decision for beneficial development are identified and listed in the following:

I. Basic ecological and environment factors

a. Inventory and detail areal coverage of mangrove forests

b. Species composition and species diversity for both the flora and fauna in mangrove forests, and the zonation based on this species diversity

c. Food chains, biological aggregations, and the energy flow in various communities or trophic levels

d. Physical and chemical properties of the soil and the water in the mangrove ecosystem

e. Biology of reproduction of mangroves, including the methods of pollination and dispersion

II. Effects of changes in the environment

a. Silviculture practices in order to obtain the maximum sustainable yield

b. Relation between a mangrove ecosystem and fisheries in the surrounding waters

c. Impact of some external pressures, e.g. pollution, overharvesting, conversion to other uses, etc., on the survival and productivity of mangrove ecosystem

For the effectiveness of such a programme, it is suggested that an integrated research activity should be confined to one representative mangrove area in one country, and if budget, manpower, and other facilities are available it could be extended to other countries in Southeast Asia for comparison and better understanding of the variability. Since Southeast Asia is strongly influenced by the monsoon, it is further suggested that the research activities should cover at least the period of the northwest and the southeast monsoons.

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* Note of editor:

NOTE: In addition to these references, the author has also compiled a bibliography on mangrove forest in Indonesia (see Appendix).

ANNEX

BIBLIOGRAPHY ON MANGROVE ECOSYSTEM IN INDONESIA

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