UNEP

REGIONAL SEAS

E.D. Gomez et al.:

State of the marine environment in the East Asian Seas Region

UNEP Regional Seas Reports and Studies No. 126

Prepared in co-operation with

FAO

IOC

UNEP 1990

PREFACE

The better understanding of the changing problems facing the marine environment is a continuing goal of UNEP's ocean programme, as it provides the necessary scientific background for shaping UNEP's policy towards the protection of the oceans.

The main sources of factual information used in the assessment of the state of the marine environment are data published in open scientific literature, data available in various reports published as "grey literature" and data generated through numerous research and monitoring programmes sponsored by UNEP and other organizations.

Several procedures are used to evaluate critically the large amount of available data and to prepare consolidated site-specific or contaminant-specific reviews.

GESAMP, the IMO/FAO/Unesco/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution, is charged by its sponsoring bodies with preparation of global reviews. Reviews dealing with several contaminants have been already published by GESAMP and others are being prepared for publication. The first global review on the state of the marine environment was also published by GESAMP in 1982, and the second global review was published in 1990 [1/].

In parallel with the preparation of global assessments, the preparation of a series of regional assessments, following the general format of the second global review by GESAMP, was initiated by UNEP in 1986, with co-operation of the Food and Agriculture Organization of the United Nations (FAO) and the Intergovernmental Oceanographic Commission of Unesco (IOC). Fifteen task teams of scientists were set up, involving primarily experts from the relevant regions, to prepare the regional reports under the joint overall co-ordination of UNEP, FAO and IOC, and with the collaboration of a number of other organizations.

The present document is the product of the Task Team for the East Asian Seas Region. The final text of the report was prepared by E.D. Gomez, as Rapporteur of the Task Team for the East Asian Seas Region, with collaboration of E. Deocadiz, M. Hungspreugs, A. A. Jothy, Kuan Kwee Jee, A. Soegiarto, and R.S.S. Wu, whose contributions are gratefully acknowledged.

The report was edited and prepared for publication by Philip Tortell of Environmental Management Limited, New Zealand.

1/ Publications of GESAMP are available from the organizations sponsoring GESAMP.

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1. INTRODUCTION

1.1 Aims of the report

This is a first attempt to provide a perspective of the state of the marine environment in the East Asian Seas region. It is the initial review in a series that will be conducted periodically. Through such an exercise, it is hoped to document the trends in marine contamination in the region as well as general marine ecosystem health. It will be recognized that factors other than pollution may have significant impacts on the well-being or condition of natural habitats. While amelioration of deteriorating trends is welcome and sometimes seen, more often than not it is cost prohibitive.

This report and subsequent ones should therefore be helpful to decision-makers at all levels, national, regional, and international, to provide the database for the management of the marine environment. It is envisaged that the report will also guide potential sponsors from the private sector and the international community to subsidize activities in the region that are apt to contribute to the understanding and betterment of the marine environment.

This report is intended to serve as a reference document to the global review of the state of the marine environment referred to below.

1.2 Geographic coverage of the report

The region covered by this report is Southeast Asia (Fig. 1). It is bounded on the north by the South China Sea and the Philippine Sea; on the west by the Andaman Sea, the Straits of Malacca and the Eastern Indian Ocean; through to the Timor Sea and the Arafura Sea on the south; and the Pacific Ocean on the east. Other significant marine areas include the Gulf of Thailand, the Java Sea, the Sulu Sea, the Sulawesi Sea, the Straits of Macassar, the Flores Sea, and the Banda Sea. The Asian mainland is on the northwest sector while the Australian subcontinent is on the southeast sector. In between these two land masses are the two large archipelagoes of Indonesia and the Philippines with more than 20,000 islands of a wide range of sizes.

1.3 About the report

It is acknowledged that the data used in this report are not comprehensive. While this is partly due to the limitations of the task team members in not being able to access all available data, it is more a reflection of the state of knowledge of the status of the marine environment in the region. As explained in subsequent sections, much data have been discarded due to lack of quality assurance. Even more basic is the fact that the number of studies of any specific contaminant or ecosystem have been few and far between. Hence, the overall picture is far from complete but the image is forming. It is hoped that with each succeeding review, the mosaic will become more complete.

As this report was being completed, two publications of relevance were about to be published but were not available to the task team. The reader is referred to the special issue of Ambio, Journal of the Human Environment, on the East Asian Seas region for recent papers on the marine environment of the area (Vol. 17 No. 3, 1988). And, for a more comprehensive reference on oil pollution in the region, the Proceedings of a Meeting of Experts on the Control of Oil Pollution in the East Asian Seas Region have just been issued as No. 96 of the UNEP Regional Seas Reports and Studies series (Yap et al, 1988).

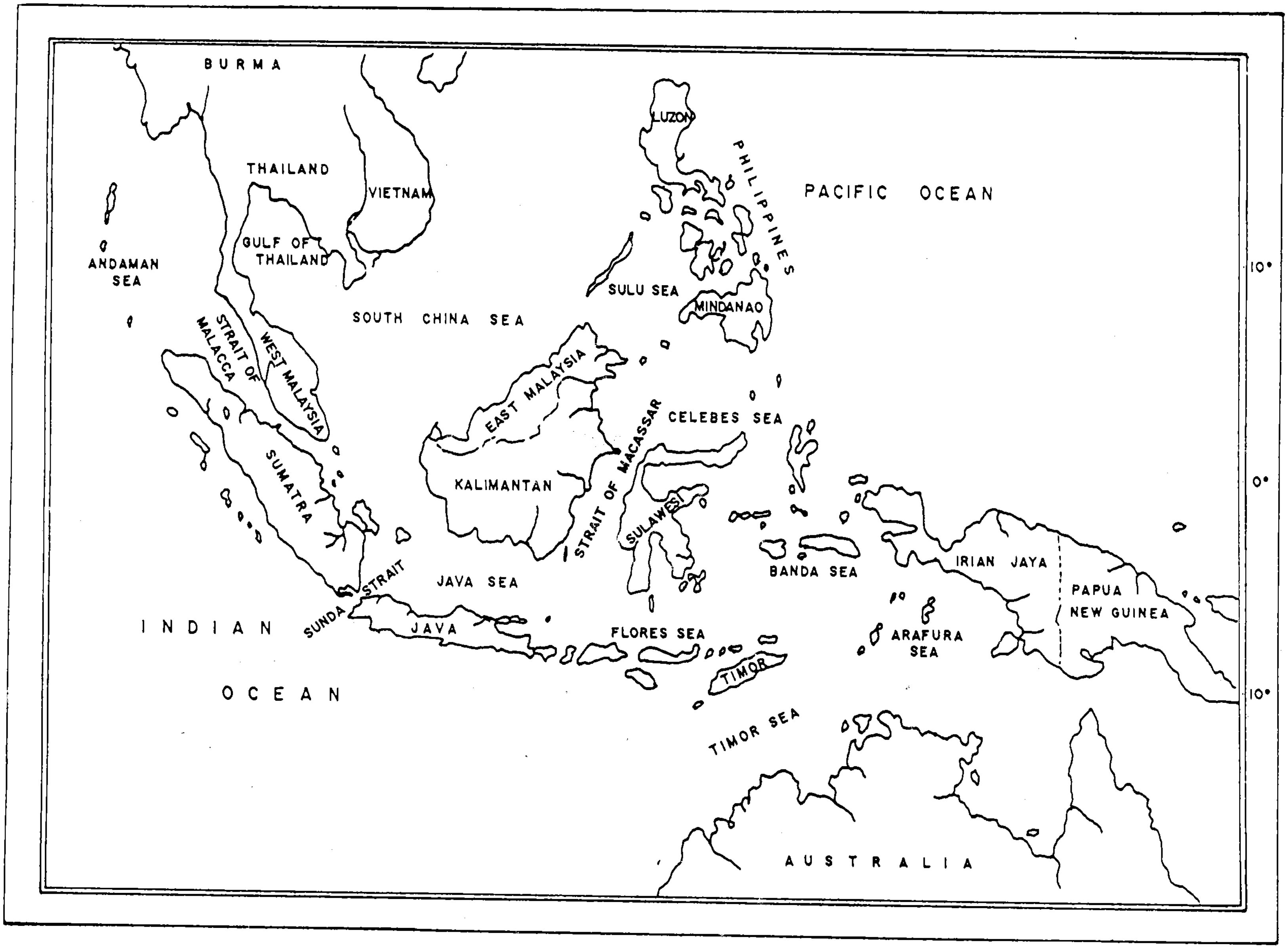


Fig. 1. Map of the Southeast Asian Seas

2. CHARACTERISTICS OF THE REGION

Southeast Asian waters comprise the Andaman Sea, the Straits of Malacca, the Straits of Singapore, the South China Sea, the Java Sea, the Flores Sea, the Banda Sea, the Arafura Sea, the Timor Sea, the Celebes Sea, the Sulu Sea, and the Philippine Sea. The whole body of water covers 8.94 million square kilometers in area, which represents about 2.5 per cent of the world's ocean surface. The southeast Asian marine realm includes shallow continental shelves, deep sea basins, troughs, trenches, continental slopes and volcanic and coral islands. The numerous large and small islands divide the waters into different seas connected by many channels, passages and straits.

Located between the Asian and the Australian continents, the southeast Asian region is strongly influenced by monsoons. The north monsoon in southeast Asia lasts from December to February and the south monsoon from June to August. The rest of the year represents the transition from the north to the south monsoons (March to May) and from the south to the north monsoons (September to November).

The oceanographic characteristics below are drawn from Soegiarto (1985). The water mass of the Southeast Asian region originates from the Pacific Ocean. This is clearly indicated by surface current patterns in the region. The North Equatorial Current flows westwards and upon reaching the Philippine islands, splits into 2 main branches. The northward branch becomes the Kuroshio, and the southward branch, the Mindanao Current. The Kuroshio begins east of northern Luzon as a swift and narrow segment of the western boundary current and flows to the east coast of Taiwan, the East China Sea and the Japan Sea. During the north monsoon, the Kuroshio is deflected into the China Sea. The Mindanao Current flows southeast with a speed of 1 or 2 knots along the coast of Mindanao Island with its main part entering the Celebes Sea through the straits between Mindanao, Sangir and Talaut Islands.

The tides of southeast Asian waters are affected by both the Pacific and the Indian Oceans. Diurnal tides predominate in the South China and Java Seas, whereas mixed tides prevail in the eastern Indonesian archipelago, Philippine waters, the Andaman Sea, Straits of Malacca, and the shelf areas northeast of Australia.

Since the Southeast Asian region straddles the equator, the surface water is characterized by high temperature. This property combined with the influence of low salinity reduces the density of the surface water rather markedly. The large excess of rainfall over evaporation causes an average salinity of less than 34 parts per thousand within a region enclosed by a line running from Sri Lanka, off the islands of Sumatra, Java, Celebes and Philippines to Taiwan.

One of the features of tropical waters is that the surface layer is warm and the annual temperature variation is small. During the north monsoon, generally high surface temperatures of 28-30°C prevail on the west coast of Sumatra and the eastern Indonesian archipelago waters. However, because of the inflow of water masses from higher latitudes, colder water (26-27°C) is found in the South China Sea. Temperatures of 26-27°C also prevail in the Arafura Sea and the south coast of Java. In other waters, temperatures range between 27°C and 29°C.

The average annual range of sea surface temperature in the equatorial region is less than 2°C but is slightly higher, 3°C to 4°C, in the Banda Sea, the Arafura Sea and Timor Sea as well as in the waters south of Java.

The salinity in southeast Asian waters is extremely variable. The effects of high rainfall, run-off of many large rivers, and geographical subdivisions of the seas are responsible for this characteristic. The distribution of discharges from land, presence of large bays and channels with little water exchange contribute to the general lowering of the salinity. The monsoons cause rainy and dry seasons which then also affect the annual variation of salinity.

In general, the surface dissolved oxygen (DO) does not show a strong seasonal variation. DO concentrations for the eastern Indonesian archipelago are 4.0 to 4.5 ml/l at the surface and 2.5 and 3.0 ml/l at depth; for the Sunda Shelf, 3.5 and 4.0 ml/l; for the area of Mindanao current, 4.5 ml/l; for the south coast of Java, 2.5 to 3.0 ml/l at the coastal area and over 4.0 ml/l towards the open sea; and for the South China Sea, 2.5 and 3.0 ml/l.

Several factors influence the water tranparency, e.g., silt content, plankton and other particulate matter in the water. Low water transparency (less than 10 meters deep) is found in the areas of river mouths and in coastal waters around Sumatra, Borneo, and the Gulf of Thailand. In general, the transparency is higher in the deep water (between 10 and 20 meters) and in the open seas (20 to 30 meters).

Turning to the land, the population of the six ASEAN countries and Hong Kong is in the order of a little under one third of a billion people. The region is considered developing and predominantly agricultural, with industries concentrated around a limited number of cities which characteristically have high population densities (2 to 8 million).

Under the circumstances, the marine environment has been influenced more and more by human activities with the degree of contamination being most pronounced near coastal population centres. The concern of individual governments to safeguard the marine environment from further degradation was translated into a regional effort with the development of an action plan initially for the member states of the Association of Southeast Asian Nations (ASEAN). The East Asian Seas Action Plan was adopted in 1981 and since that time, more than half a dozen regional projects have been implemented by national institutions in five countries.

The succeeding chapters present a summary of the available data on marine contamination in the region, specifically from Hong Kong, Indonesia, Malaysia, the Philippines, Singapore and Thailand.

3. MARINE CONTAMINANTS

3.1 <u>Concentrations (levels and distribution) in water, sediments and biota</u>

Data on the concentration of contaminants in sea water and sediment have been very sparsely reported in the EAS region, a region which is still in its infancy in the context of marine pollution monitoring. Laboratories are often faced with the problems of inadequacies in facilities, qualified personnel and funds to carry out this task. Besides, the measurement of heavy metals and chlorinated hydrocarbons in sea water, in particular, requires greater accuracy and sophistication in methodology, owing to their levels being generally a few magnitudes below those in biota.

Concentration in water

Trace metals

This is perhaps the most difficult analysis among the three media considered as the levels of trace metals in sea water are very low compared with the concentration of major elements. Contamination can be easily introduced in all stages - sampling, storage, analysis and concentration measurements.

Hong Kong, Malaysia and the Philippines did not report data of heavy metals in sea water. Singapore reported a trend, decreases in Cd and Pb, but a slight increase in Cu from 1980 to 1985, using atomic absorption spectrophotometry. In 1985, mean Cu concentration varied from 2.0 to 2.9 μg/l.

Thailand reported the following figures for 15 stations in the Upper Gulf of Thailand (Hungspreugs, 1985), in μg/l.

		November 1984 (flood season)	**March 1985** (dry season)
Cd	mean	0.04	0.07
	range	0.01 - 0.09	0.02 - 0.19
Cu	mean	0.97	0.39
	range	0.01 - 3.40	0.01 - 1.30
Pb	mean	0.01	0.02
	range	n.d. - 0.02	0.01 - 0.06
Zn	mean	5.61	4.72
	range	4.29 - 7.59	1.63 - 9.24

N.B. Detection limits are: Cd - 0.005, Cu - 0.01, Pb - 0.005, Zn - 0.5, using the co-precipitation method with $CoCl_2$ - APDC (Huizenga, 1981), then flameless AAS for Cd, Cu and Pb, and flame AAS for Zn. All preparations were performed under laminar flow cabinet or 'clean bench Class 100'.

The concentration of heavy metals in some localized coastal waters of Indonesia has been reported to be very high. Among these are the coastal waters of Jakarta Bay, Surabaya and the Straits of Malacca. Studies by Razak et al. (1984) indicated the severity of heavy metal pollution in Jakarta Bay - Cu, Hg, Pb and Cd levels (0.16, 0.013, 0.31 and 0.19 mg/l, respectively) were found to be higher than the standard set by the Indonesian government: Cu, 0.06 mg/l; Hg, 0.006 mg/l; Pb, 0.075 mg/l; and Cd, 0.01 mg/l.

Petroleum hydrocarbons

Hong Kong reported the levels of dissolved petroleum hydrocarbons in open sea water to be 12-20 μg/l, but near fishing villages, typhoon shelters and marinas, a single measurement showed up to 125 μg/l (Chan & Jie, 1977).

Singapore measured oil and grease in sea water and found the ranges 1-18 (average 4.2) and 0.1-9.2 (average 1.0) μg/l in 1980 and 1985 on the west coast and an average of 2 μg/l in the Straits of Johore (west) in 1980 and 1985.

The Philippines also reported oil and grease in marine water, for example, for Manila South Harbour, at 1.76-5.11 μg/l (National Operation Center for Oil Pollution, 1978 unpublished data) and Cebu 0.66-5.05 μg/l.

For Thailand, Sompongchaiyakul et al. (1986) reported the following levels (as chrysene equivalent, IOC - UVF method) for the Gulf of Thailand.

	April (dry season)	**September** (wet season)
	µg/l	
Near river mouths	2.94 ± 1.84	0.65 ± 0.70
Mid-Gulf	0.30 ± 0.25	1.72 ± 2.14
East Coast, Upper Gulf	0.38 ± 0.34	0.52 ± 0.38

Dissolved and dispersed petroleum hydrocarbon (DDPH) measurements in water samples from the Upper Gulf resulted in a mean concentration of 2.3 µg/l crude oil equivalents, with the range from 0.65-8.3 µg/l. In the Lower Gulf the range of hydrocarbons found was 0.07-6.6 µg/l and the mean was 1.3 µg/l. There is no significant difference in the amounts of DDPH observed between the samples collected during the dry (April) and wet (August) seasons nor between the Upper and the Lower Gulf. However, a significant correlation was found between DDPH concentrations and tidal stage, especially for river mouth stations (Wattayakorn, 1987a).

Indonesia being an oil producing nation and a major route for transporting petroleum and petroleum products, hydrocarbon pollution in its waters, especially in Jakarta Bay, was critical. Wisaksono (1974) recorded that samples taken around the harbour have concentrations of 60 to 100 µg/l, whereas samples collected away from the harbour registered a concentration range of 0.5 to 4.00 µg/l (Martin et al, 1983). Widespread occurrence of tarballs was also noted on the beaches of Pari Island Group, Jakarta Bay. Toro & Djamali (1982) reported seasonal variation ranging from 0.28 to 2101.37 g/sq. m.

For Malaysia, Law & Yusof (1986) reported in the Matahari Expedition Report that the South China Sea off Terengganu coast showed very high overall mean dissolved hydrocarbon levels in the range 960-990 µg/l at 1 m, 10 m and 20 m depth for two-thirds of the stations and the rest was between 160-170 µg/l. The high values were probably the result of offshore oil and gas exploration and exploitation activities in the area. One year after, Law & Mahmood (1987) investigated the area further south, off the coast of Kuantan and Pulau Tioman and found lower levels at around 38 µg/l from 1-50 m depth.

<u>Chlorinated hydrocarbons</u>

For the Philippines, from 1976 to 1982, marine waters in 9 areas were analyzed for alpha-, beta- and gamma-HCH, aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide and p-p-DDT.

	range (µg/l)
aldrin	trace - 0.180
alpha-HCH	trace - 0.063
beta-HCH	0.008 - 0.063
gamma-HCH	trace - 0.299
dieldrin	trace - 0.088
endrin	trace - 0.024
heptachlor	trace - 0.059
heptachlor epoxide	trace - 0.022
p-p-DDT	0.012 - 0.112

(Ref. Philippines, 1980).

For Thailand, Thoophom et al. (1984) analyzed water samples from mussel and oyster growing areas of the Upper Gulf of Thailand for DDT, PCB, heptachlor, aldrin, chlordane, endosulfan and found only DDT in 9% of the samples from 8 sampling surveys throughout the year 1983. The maximum concentration was 0.011 µg/l.

Concentrations in sediments

Trace metals

The levels of Cu and Zn in Victoria Harbour, Hong Kong, sediments at 111 and 247 µg/g dry weight respectively, were some 5 and 2.5 times higher than those in other Hong Kong areas (mean: 22 and 96 µg/g respectively), although the Fe level (as reference metal) at 31,560 µg/g was about the same as the mean of 33,120 µg/g for other areas. This can be related to urban and industrial discharges in Victoria Harbour. Contamination of sediments by Cu, Zn and Pb, was less marked in Deep Bay (Yim & Fung, 1981; Phillips & Yim, 1981).

(Methodology of metal analysis : a sample of the <170 µm fraction was digested in a 4:1 v/v nitric : perchloric acid mixture, and metal concentration determined by flame atomic absorption spectrophotometry).

For peninsular Malaysia, metal concentrations in sediments from 14 stations in the South China Sea ranged from 0.41-2.39 µg/l for cadmium, 1.94-9.21 µg/l for copper, 12.45-49.88 µg/g for zinc, 6.09-22.30 µg/g for nickel and 1.94-12.76 µg/g for lead. These metal levels indicate that the study area is unpolluted (Noor Ahzar et al, 1987).

For the Upper Gulf of Thailand, monitoring of 18 stations in 1982 showed the following results for "strong HNO_3 leaching" of Al, Fe, Mn, Cu, and Ni in sediments.

Al g/kg)	**Fe** (g/kg)	**Mn** (mg/kg)	**Cu** (mg/kg)	**Ni** (mg/kg)
27 ± 14	20 ± 6	700 ± 140	8.1 ± 6.5	21.0 ± 8.6

From this work, it was found that conc. HNO_3 leached out 39-68% of Al, 68-92% of Fe, 72-100% of Mn, 36-85% of Cu and 100% of Ni as compared to the total digestion method (Windom et al, 1984).

The following are trace metal concentrations in HNO_3 -acid digested sediment samples from the south western portion of the South China Sea (Noor Azhar et al, 1987):

Cd	0.41 - 2.39 µg/g
Cu	1.94 - 9.21 µg/g
Pb	1.94 - 12.76 µg/g
Ni	6.09 - 22.30 µg/g
Zn	12.45 - 49.88 µg/g

The low metal concentrations are indicative of a non-polluted marine environment. This is to be expected because the sampling sites are located offshore.

Another indication of heavy metal pollution in Jakarta Bay, Indonesia is the high levels of Hg, Cu, Mn, Zn, Fe, Cd, Ni, Co and Cr in sediments (Martin et al, 1983).

	Conc. Range (mg/kg) except for Fe in %
Hg	0.05 - 4000
Cu	10 - 780
Mn	900 - 1900
Zn	60 - 7140
Fe	3 - 7%
Cd	5 - >400
Ni	4 - 16
Co	10 - 25
Cr	4 - 33

Petroleum hydrocarbons

From the two 1982 surveys in the Upper Gulf and the Eastern Seaboard of Thailand, the following results were obtained (chrysene standard, IOC Manuals and Guides) in µg/g dry weight.

	April	**September**
Near river mouths	0.711 ± 0.876	0.186 ± 0.084
Upper Gulf (West)	0.138 ± 0.038	0.088 ± 0.043
Mid Gulf	0.069 ± 0.088	0.092 ± 0.032

There did not appear to be significant differences in the concentrations for the dry and wet seasons except for the river mouth stations, probably due to the dilution effect of fresh water at the flood season (September) (Sompongchaiyakul et al, 1986).

Using crude oil as standard, Wattayakorn (1987b) reported the range of hydrocarbons at 0.70-62 µg/g in the Upper Gulf and 0.03-8.3 µg/g in the Lower Gulf. The highest concentrations of hydrocarbons were found in areas of high anthropogenic activities. The results show the sediments of the Lower Gulf to be relatively uncontaminated by hydrocarbons of petroleum or other fossil fuel origin, and that the Upper Gulf area is generally only lightly contaminated (Wattayakorn, 1987b).

This study has shown that concentrations of hydrocarbons were higher in samples from river mouth and coastal stations due to land-based and boating activities, run-off from land and introduction via seawage outfalls. Concentrations of hydrocarbons are generally three to four orders of magnitude higher in sediments than in the water column for the same study area which were previously reported by Wattayakorn (1987).

Indonesia reported hydrocarbon concentration in sediments from Jakarta Bay to range from 9.0 to 331 µg/g. The highest concentration was found from samples just outside the Sunda Kelapa and in the Tanjung Priok harbours.

Law & Mahmood (1987) reported the oil concentration in the offshore Terengganu at 6.43-1332 µg/g while the surface sediment off Kuantan coast showed an average of 42.92 µg/g. Obviously the higher value areas were very polluted.

Chlorinated hydrocarbons

No data are available for most countries. For Thailand the average value of DDT for 5 stations on the Andaman Sea coast was 0.002 µg/g dry weight while the average for the Upper Gulf of Thailand was 0.008 µg/g (Hungspreugs & Wattayakorn, 1978).

In Indonesia, Martin et al. (1983) reported DDT concentration to range from 1.0 to 13.0 µg/g and PCB levels from 4 to 9 µg/g in Jakarta Bay.

Concentrations in biota

Heavy metals

The contamination of marine biota by heavy metals and chlorinated hydrocarbons (Tables 1 and 2), is also inadequately reported in the EAS region. By nature, the levels of heavy metals in oysters (Crassostrea) are of a different order of magnitude than those of mussels and clams (Forstner & Wittmann, 1981). Levels for heavy metals in biota in Thailand are provided by Huschenbeth & Harms (1975) for fish and by Hungspreugs & Yuangthong (1984) for oysters and mussels.

Petroleum hydrocarbons

Very little information is available on petroleum hydrocarbon contamination in marine biota in the EAS region, except for a single set of records from biota in the Gulf of Thailand taken in 1986 (fish: 0.12-0.60 mg/kg; shellfish: 0.06-2.38 mg/kg), which suggest conditions similar to a relatively unpolluted area (Sompongchaiyakul et al, 1986).

Chlorinated hydrocarbons

From the meagre information available on chlorinated hydrocarbons in marine biota (Table 3.2), it is not possible to assess the extent of contamination in fish and bivalves in the EAS region. In Hong Kong, only 73 km^2 of land is arable so the use of pesticides is low (only about 150 tonnes active ingredients per year) and there is no local production. There is no data on chlorinated hydrocarbons in water, only in mussels and human milk samples (Ip, 1983) which showed twice the DDT and HCH level as in the average human milk. Minor quantities of HCB and PCB were found. In another study, out of the 15 stations sampled, only mussels, Perna viridis, from 2 stations show very high levels of DDT and PCB, up to 2.043 mg/kg and 1.904 mg/kg respectively(Phillips, 1985). In Thailand, the trend is very clear that during 1973 to 1983, the uses of more toxic organochlorine group of pesticides was fast decreasing resulting in much lower levels of such compounds in the marine organisms (Vongbuddhapitak et al, 1985). The investigations on 80 species of fish, shrimp, squid and bivalves show a range of <0.01-0.03 mg/kg wet weight.

Radioactive contamination

Information on radioactive contamination in marine biota is lacking in the EAS region, except for a single record from Thailand taken in 1984 (fish: 1.5-2.1 pc/g; shellfish: 0.2-1.6 pc/g), which may be considered to be comparable to that of ambient levels (Polphong et al, 1984).

Table 1. Concentration (mg/kg) of heavy metals in marine biota

Locality		Cd	Cu	Hg	Pb	Zn	Remarks
Straits of Malacca:1/							
Fish	(1983)	Trace2/	0.05	0.01	Trace	1.7	Ambient
		0.10	0.75	0.58	1.20	10.8	
Shellfish	(1983)	0.21	0.37	0.01	0.25	9.2	Ambient
		7.70	0.77	0.07	0.74	25.2	
Singapore waters:1/							
Fish				No data			
Shellfish	(1974)	0.10	2.10	-	1.30	-	Ambient
		0.13	2.70	-	1.60	-	
Indonesian Waters:1/							
Fish	(1979)	0.02	0.33	0.02	0.09	0.30	Polluted
		0.03	0.68	0.20	0.68	9.96	
Shellfish	(1979)	0.02	0.08	0.05	0.68	11.31	Polluted
		0.25	3.18	0.50		19.85	
South China Sea:				No data			
Gulf of Thailand:							
Fish	(1975)1/	0.01	0.50	0.01	0.01	6.2	Ambient
		0.06	1.25	0.10	0.09	11.8	
<u>Perna viridis</u>		0.13	2.97	0.001	0.54	78	Ambient
	(1984)3/	1.05	11.48	0.025	2.05	201	
<u>Crassostrea commercialis</u>		0.76	70.9	0.002	1.51	424	Ambient
	(1984)3/	5.02	185.7	0.030	5.19	1347	
Philippine Waters:1/							
Fish	(1974-1985)	Trace	Trace	0.01	0.01	0.2	Polluted
		0.36	4.43	1.10	0.08	58.4	
Shellfish	(1975-1982)	0.02	2.36	0.02	0.04	10.4	Polluted
		3.84	51.90	0.84	2.20	201.0	
Hong Kong Waters:1/,2/,5/							
Fish	(1976-1979)	Trace	Trace	Trace	Trace	2.3	Ambient
		-	0.3	0.1	-	6.6	
		Trace	Trace	Trace	Trace	0.8	Polluted
		-	1.1	0.4	0.3	25.4	
Shellfish 4/		Trace	1.1	Trace	Trace	10.1	Ambient
	(1976-1979)	-	35.2	0.1	3.0	105.0	
		Trace	6.3	Trace	Trace	13.5	Polluted
		5.4	309.0	1.3	0.4	662.0	

1/ values expressed in terms of wet weight.
2/ minimum and maximum values.
3/ values expressed in terms of dry weight.
4/ including molluscs and crustaceans
5/ The above levels are compiled based on all the existing published data on metal levels in fin fish, oysters, crustaceans and other molluscs.

Table 2. Concentration (mg/kg) of chlorinated hydrocarbons in marine biota

Locality	DDT	-HCH	-HCH	Dieldrin	Aldrin	Heptachlor	Heptachlcr	PCB's	Remarks
Straits of Malacca:1/									
Fish (1983)	3.0 2/ 16.0	-	1.0 12.0	Trace 4.0	-	-	-	20.0 40.0	Ambient
Shellfish (1983)	26.0 50.0	-	2.0 8.0	1.0 5.0	-	-	-	27.0 44.0	Ambient
Singapore Waters					No data				
Indonesian Waters					No data				
South China Sea					No data				
Upper Gulf of Thailand:1/									
Fish (1985)	<0.01	nd 4/	-	nd 5/ 0.01	nd 0.01	nd	nd	nd	
Bivalves (1985)	0.01	<0.01 4/	-	<0.01	<0.01	nd	nd	nd	
Philippine Waters:1/									
Fish (1976-1985)	-	Trace 0.80	Trace 0.50	Trace 0.10	Trace 0.10	Trace 0.20	Trace -	- -	Ambient
Shellfish (1982)	-	0.30 0.09	Trace 0.03	0.01 0.03	0.01 -	0.01 -	-	-	Ambient
Hong Kong Waters:3/									
Fish					No data				
Shellfish (1985)	Trace 2.04	Trace -	- 0.21	- -	- -	- -	- -	Trace 1.90	Polluted

1/ values expressed in terms of wet weight
2/ maximum and minimum values
3/ values expressed in terms of dry weight
4/ values for BHC
5/ nd - non detectable

3.2 Transport and fluxes across boundaries

The transport of sediment by rivers into the sea has been recognized as a growing problem in Indonesia. Watersheds or catchment basins dominated by sedimentary formations are more susceptible to erosion than those of volcanic geology (Meijerink, 1977). The increasing rate of erosion is exemplified by a study of Soemarwoto (1974) who showed that the sediment load of the Citarum River rose six-fold in a two-year period.

For Malaysia, the amount of surface soil transport from peninsular Malaysia into the Straits of Malacca was 26 million tonnes/year. From peninsular Malaysia to the South China Sea, it was 22 million tonnes/year (Jaafar, 1986).

Soil erosion in the Philippines has been estimated at 500 million tonnes per year because of the extensive loss in vegetation cover (de Vera, 1978).

For Thailand, it has been estimated that during 1981-1983 the suspended solid load into the Gulf of Thailand was 3.95 million tonnes/year, BOD 75.7 million kg/year, nitrogen 57.9 million kg/year, and phosphorus 9.4 million kg/year (Thailand, 1984).

3.3 Quality assurance, data validation and management

Although it is accepted in principle that data quality is of utmost importance, in practice intercomparison exercises of contaminant analysis are still very limited in this region. Only a small number of laboratories participate in such activities. The activities are limited to chemical analysis of prepared samples, but none on sampling methods and storage, especially of water for trace metal analysis, in which a lot of errors are still made. The acid reagents used in sample preservation and in the analytical methods themselves are very often the major source of errors in trace metal analysis. As a result of more concern and care on this problem, the reported levels of trace metals in natural waters of Thailand seem to be decreasing greatly and probably data generated before 1981 are no longer acceptable. Recently, a very useful US NOAA publication became available - "Reference Materials for Marine Science" which helps marine chemists to locate the desired reference and standard materials in this field.

In Hong Kong, all samples for conservative pollutant analysis are collected by various government agencies but the analysis is performed at the central laboratory which maintains very high standards and observes strict quality control.

The Malaysian laboratory (Fisheries Research Institute) responsible for carrying out the measurements of organochlorine and heavy metals in marine biota has been following the ICES method and has participated in the IOC/GEMSI intercalibration exercise but the results were not yet available to participants at the time of writing.

In the Philippines, two laboratories participated in an intercalibration exercise on metals and their results are acceptable for Cu, Cd and Hg. The results for other metals must be interpreted with caution. They also took part in an organochlorine intercalibration exercise of IOC/UNEP but the results are not yet available.

In Singapore, analysis of samples is done by well-trained technicians in well-equipped laboratories with the use of procedures in the "Standard Methods for Water and Wastewater Analysis".

In Thailand, some laboratories have taken part in the FAO/IOC-organized intercalibration exercises but the results varied from metal to metal. One laboratory obtained acceptable results with their samples from the IAEA, using the neutron activation method. Another laboratory analyzed reference samples side by side with the unknown samples to check the results. For water sample analyses, calibration was made with reference to sea water, river water and estuarine water from the National Research Council of Canada.

4. HUMAN ACTIVITIES AFFECTING THE SEA

4.1 Disposal of urban and industrial waste water

Sewage (human and domestic waste) is the major source of organic pollution in various populous coastal areas in the region. As a result of population growth, there is a steady increase in sewage discharge. While varying degrees of treatment are employed in some localities, disposal of untreated sewage directly or indirectly (e.g. via rivers and waterways) is the general practice. For instance, in Thailand, pollutants discharged from the Chao Phraya River are the major contribution to coastal water pollution. An estimated net BOD reaching the Gulf of Thailand via this river alone is 114,670 kg/day. The estimate for all the rivers emptying into the Gulf is 305,212 kg/day (Thailand, 1984).

Law (1986) investigated the extent of domestic sewage pollution in Kelang coastal waters in Malaysia. Faecal coliform count was used as an index. Very high counts of faecal coliform bacteria were found at the river mouth where the mean value was 3.0 x 10^4 MPN/100 ml. The heavy load of faecal coliform bacteria in the sediment from the river mouth, 360 MPN/g dry sediment, also reflected strong sewage pollution in this area. Low counts were detected in the water about 10 km from the river mouth, mean values being 31 - 54 MPN/100 ml while for the sediment, the values were 3.8 - 3.9 MPN/g dry sediment. These levels were below the safety limit recommended for recreational waters (100 MPN/100 ml). The result of this study suggested that the extent of sewage pollution in Kelang coastal waters was confined within 10 km from the Kelang River mouth.

The success of Singapore in reducing water pollution significantly over the past years is a noteworthy exception in the region. Today, modern sanitation facilities are available to 97% of the population, compared with 55% in 1972 (Singapore, 1986). In addition, the Sewerage Department operates an industrial water works to recycle waste water for industrial use in the Jurong industrial area. In 1985, an average of 12,924 m^3 of industrial water was sold each day. Also commendable is the massive clean-up of the Singapore River which involved resiting street hawkers in markets and food centres with proper sewerage and refuse removal facilities, dredging of dumped garbage (amounting to about 30 tonnes) and removal of flotsam. After 8 years, about 90% of pollution was eliminated. The river has been transformed into a major tourist/recreation area from a "murky, smelly backwater crowded with lighters and littered with rubbish" (Anonymous, 1984). A hydrological survey of the previously lifeless waters revealed 39 species of organisms consisting mainly of bivalves, crustaceans, polychaetes and fish.

The decrease in the faecal coliform levels in the coastal waters of Singapore attests to the remarkable reduction of water pollution in this country. Average faecal counts decreased from 43 MPN/100 ml and 126 MPN/100 ml in 1980 to 18 MPN/100 ml and 32 MPN/100 ml in 1985 for the western and eastern coasts, respectively. Even more dramatic is the decrease in the Strait of Johore where average faecal coliform counts went down to 64 and 137 MPN/100 ml in 1985 from 320 and 521 MPN/100 ml in 1980 for the western and eastern sections of the strait, respectively (Kuan, 1987). The overall improvement on the state of the Strait of Johore waters in recent years, with respect to organic pollution was attributed to a great extent to the improved quality of discharges from Singapore.

For most developing countries in the region, however, it appears unlikely that the quality of sewage effluents will be improved significantly in the near future considering the escalating quantities and phenomenal costs in central treatment facilities at the secondary and tertiary levels.

In addition, livestock wastes (i.e. piggeries, poultries) are also discharged in the raw form. However, in Malaysia, more stringent environmental regulations requiring livestock wastes to be subjected to primary treatment in oxidation ponds prior to disposal, are expected to improve the quality of these effluents in the future.

Organic inputs from various industries (e.g. pulp and paper mills, sugar mills, soft drink plants, etc.) in more industrialized areas are also considerable. More industries, however, are treating their wastes with the advent of stricter enforcement of environmental regulations and remarkable advances in treatment technology. Notable in this respect is the significant reduction of the net organic load of palm oil and rubber effluents in Malaysia by 97% and 80%, respectively, over a period of five years (1980-1985).

Anoxic conditions in bottom waters due to high organic load have been reported in various localities (e.g. portions of the Straits of Malacca, Manila Bay, Victoria and Tolo Harbours in Hong Kong). In enclosed/semi-enclosed areas in Victoria Harbour, anoxia occurs transiently or permanently. In this particular area, the average oxygen saturation steadily declined from 83.4% in 1973 to 61.5% in 1983 (Fig. 2). Recent hydraulic and pollution modelling studies in this harbour have shown that any additional pollution loading could cause unacceptable levels of oxygen (<50% saturation). A similar decline in the oxygen levels in Tolo Harbour, has been noted (Fig. 2). Decrease in oxygen levels was reported to be further aggravated by the development of the summer thermocline/halocline. Unfortunately, no drastic improvement in water quality has been found since the commissioning of two sewage treatment plants in 1982.

Morgan & Valencia (1983) have shown the distribution of population concentration, sewage pollution and organic pollution in terms of biochemical oxygen demand (BOD) in selected localities in Southeast Asia (Fig. 3). Of these localities, the highest BOD from industrial sources was reported from Manila while that from domestic waste was reported from the coastal waters of the Upper Gulf of Thailand.

In Thailand, fishery factories located at the Ta Chin River mouth, discharged wastewaters containing high phosphate (over 70 mg/l), nitrate (180-275 mg/l), ammonia (30-35 mg/l) and organic matter (6,500-28,000 mg/l), but the volume released into the water was small in comparison with the municipal waste or industrial waste from distilleries. Of the nutrients in the Chao Phraya River mouth, the organic fraction of nitrogen was about 95% while that of reactive phosphorus was 50% (Silpipat & Champongsang, 1981).

At present industrial wastes in Indonesia are still rather limited and localized as compared to other sources of pollutants. However, it can be expected to be very important sources in the future, particularly with the current government drive for industrialization in many sectors of the economy.

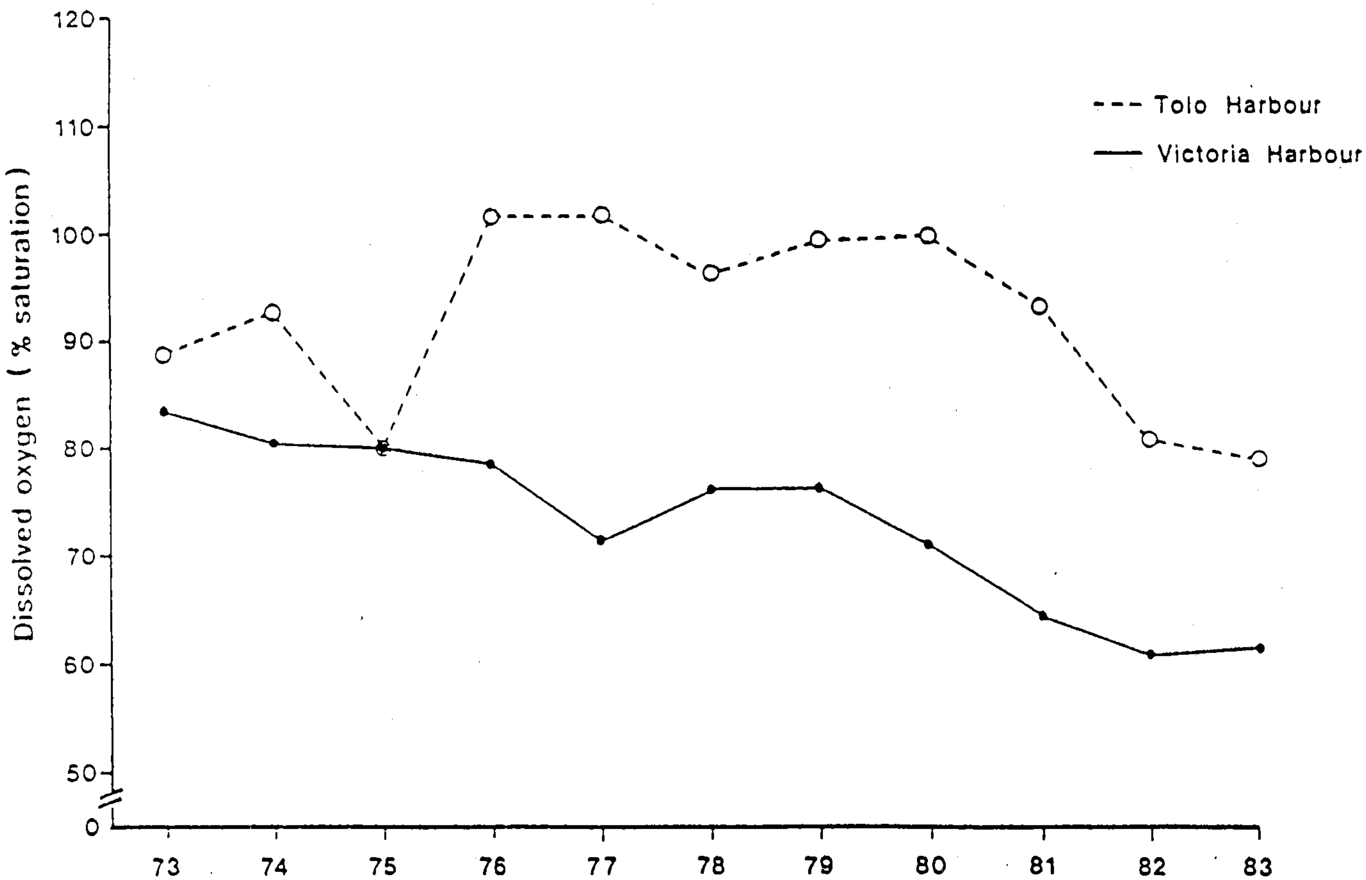


Fig. 2. Dissolved oxygen levels (% saturation) in Victoria and Tolo Harbours from 1973-1983

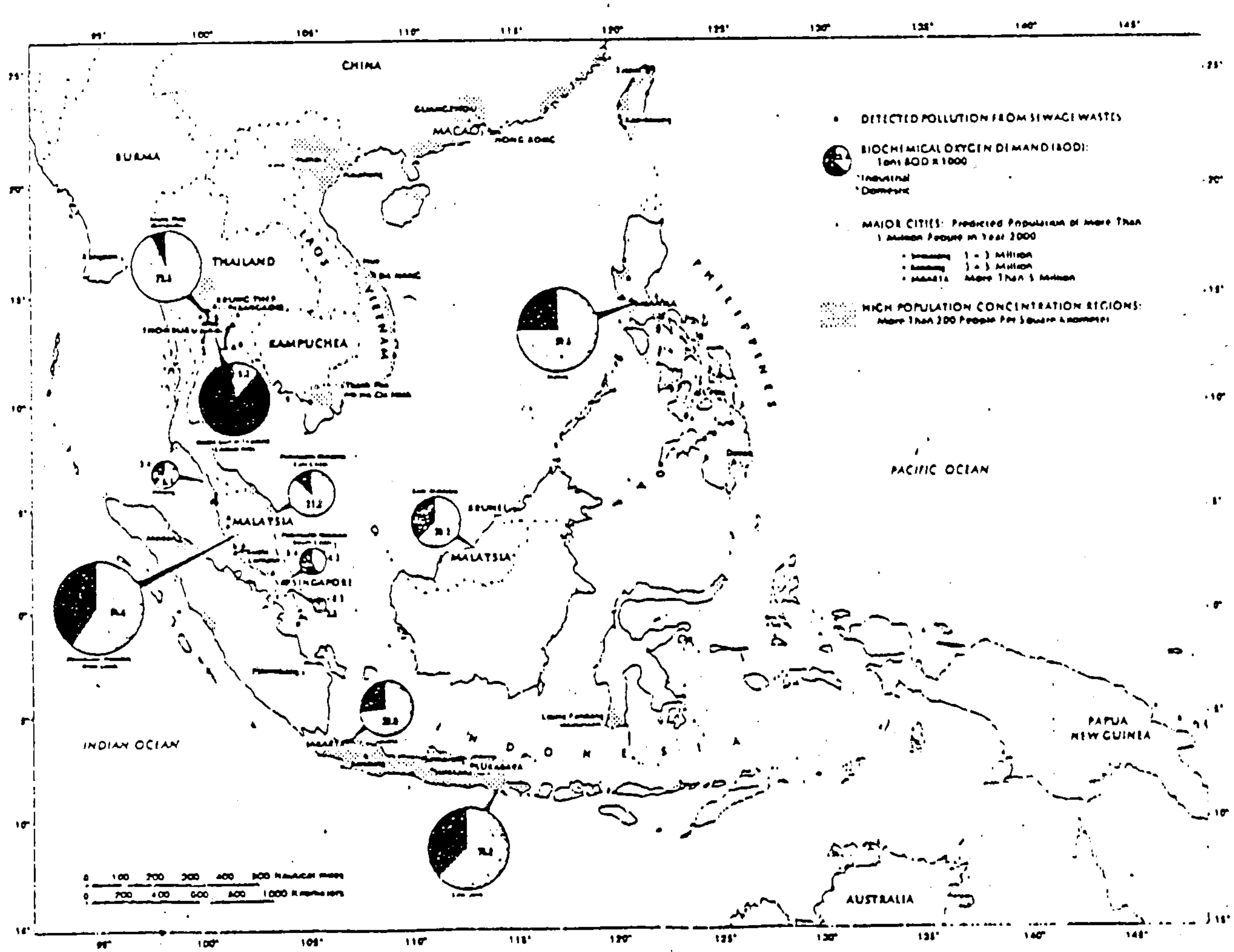


Fig. 3. Sewage and biological oxygen demand

On the whole, there is little or no evidence of toxic contaminants being released in high concentrations through industrial waste waters in the region.

The discharge of cooling waters in coastal seas from industries like power generating plants cannot be totally disregarded. Besides the oily residues of the effluent, more important is the heat that is dissipated into the coastal waters. Unfortunately, there is also little information on this although it is most likely that impacts from cooling waters are very localized and not as widespread as in temperate areas.

As an example, only a few steam-power electric generators are operating now in Indonesia with a total capacity of only about 750MW. Therefore, the volume of thermal waste from these plants is still relatively small. However, this condition will change rather drastically when the Indonesian Government starts to implement a plan to multiply electric power generation in Indonesia.

4.2 Development of coastal areas

Rapid population growth and the drive for economic development have brought about continued development of coastal areas in the region. One of the major modifications in the coastal areas is land reclamation. As far back as the early 1970s, the natural coastal area fringing Hong Kong Island and Kowloon had almost been totally reclaimed (Fig. 4). Some 3,600 ha of land have been reclaimed around Victoria Harbour. The area reclaimed in recent years (1982-1985) is shown in Table 3. In most other countries in the region, reclamation of mangrove areas for industrial sites, housing projects, drainage systems, agricultural and aquaculture developments is prevalent. In Singapore, 10-12% of the total land used to be mangrove areas; today, only 3% remains and reclamation is still going on. In addition, some coral reefs have been adversely affected by the reclamation activities.

Table 3. Total coastal area reclaimed in Hong Kong (in ha.) from 1981 to 1985 (Wu, 1987).

YEAR	**Total area reclaimed (ha.)**
1981	9.6
1982	40.6
1983	25.5
1984	62.5
1985	600.6

Of the 2.5 million ha of mangrove area in Indonesia, 200,000 ha were converted for agriculture between 1969-1974 and an additional 500,000 ha for rice fields and fish ponds, among other uses, during the period 1974-1979 (Soegiarto & Polunin, 1981). Between 1979-1999 another half million hectares of coastal land are projected to be converted to agricultural land. There is a national plan to develop additional 100,000 ha of shrimp ponds. The main objective of this plan is to promote the culture of penaeid shrimps for export. Since mangrove areas are most suitable to be developed for shrimp ponds, large areas of mangrove have been converted into shrimp ponds without any consideration for the potential long term environmental consequences.

Likewise, in Malaysia, about 20,000 ha of the 570,000 ha of mangrove coastlines have been reclaimed. As much as 114,000 ha more are expected to be converted for similar developments in the years to come (Jothy, 1984a).

Available data from the Philippines indicate that by 1952, 88,681 ha had been converted to fishponds. By 1982, the area had increased to 195,831 ha. Many limited areas have been converted from mangrove swamps to agricultural land and other uses. Thus, of an original mangrove area exceeding 400,000 ha, only about half remains. Moreover, of the remaining area, another half has been exploited to a greater or lesser degree so that only 106,133 ha are presently covered by mangrove vegetation.

Inevitably accompanying coastal development is the problem of domestic and industrial discharges discussed in the first section. Subsequent impacts on the marine environment occur in varying degrees. Reclamation considerably decreased water circulation in some portions of Manila Bay and is thought to contribute to increased coliform counts in these areas. Similarly, the reduction of Victoria Harbour due to reclamation up to 1985 has reduced tidal flushing and augmented pollution due to sewage discharges. Reclamation of the airport runway has also seriously reduced water flow near Kowloon Bay making the waters permanently anoxic and devoid of benthic communities.

Comparative studies on the structure of littoral communities on 12 reclaimed shores of different ages in Hong Kong suggest that it would take 8-10 years to reach a climax community. Moreover, since reclamation may have changed the shore type, substratum and surrounding hydrography, recolonizaton by a different type of community may occur.

Posing more serious impact on the marine environment in many countries in the region is the increase in sediment load resulting from various activites such as reclamation, dredging and harbour construction in addition to improper land use (e.g. denudation of forests and mangroves, bad agricultural practices). Malaysian fishermen in the Straits of Malacca claim that offshore dumping of inert dredge spoils has driven fish from their fishing grounds. These activities also contribute significantly to degradation of coral reefs in localized areas throughout the region (Yap & Gomez, 1985).

Harbour construction is taking place with greater emphasis along the less developed Malaysian coasts bordering the South China Sea. This is expected to bring about a significant increase in sediment load in the neighboring waters. A related development is that of tourist resorts along both east and west coasts of peninsular Malaysia, which will result in increased sewage discharge. Of greater concern is the establishment of industrial estates in various parts of the country. Effluent from these will have a greater impact on coastal waters.

Enhanced sedimentation through serious soil erosion due to poorly planned agriculture and forest exploitation was thought to be the worst human impact on Indonesian estuaries. Apart from these, some reefs along the north coast of Java have been buried due to similar activities and reclamation (Soegiarto & Polunin, 1981). It was also reported that inorganic pollution in Malaysia particularly due to soil erosion and river siltation is more serious than organic pollution (Jaafar,

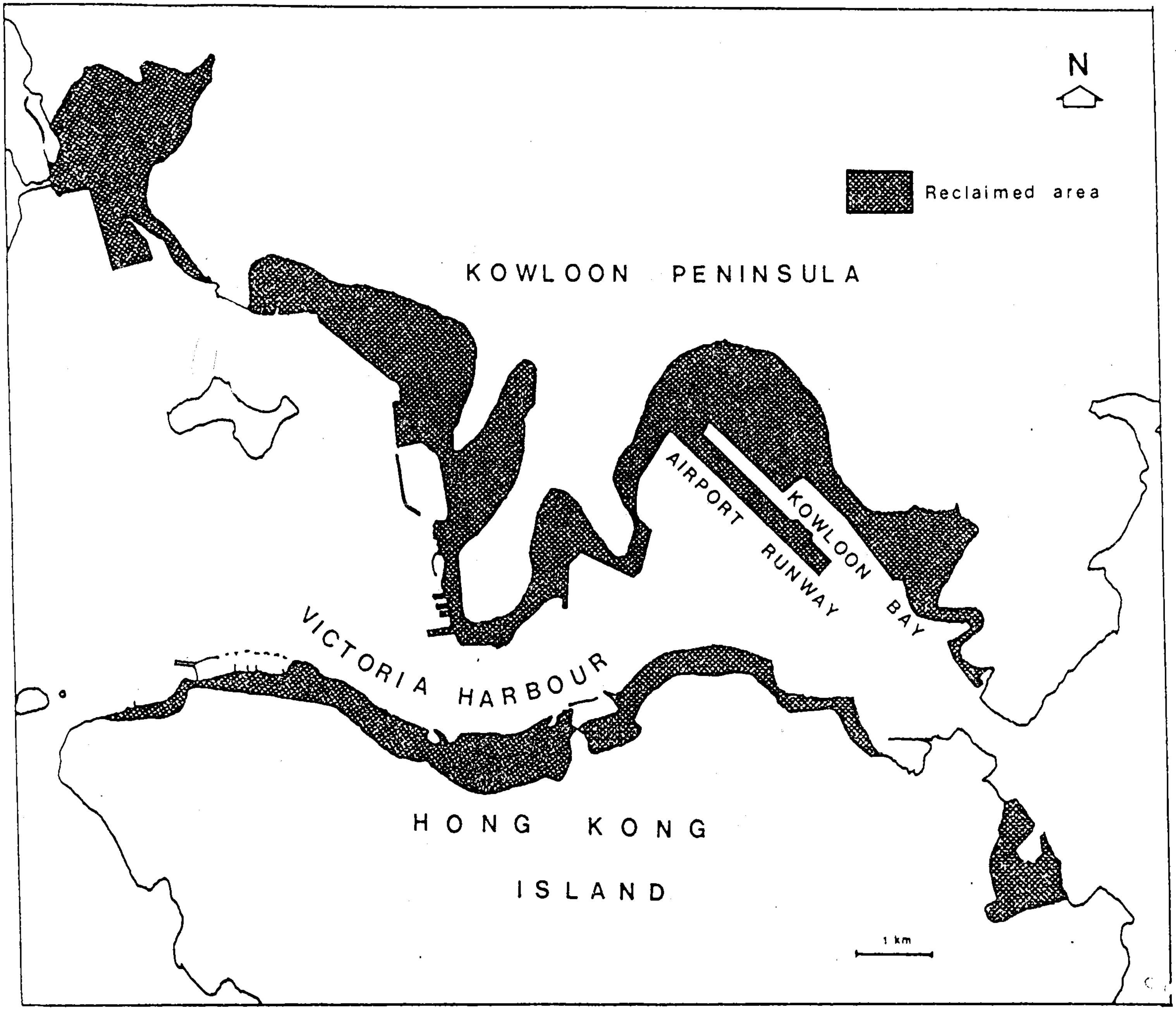


Fig. 4. Map of Victoria Harbour showing reclaimed areas

1986). On the other hand, it is notable that in 1985, the Strait of Johore was found to be free from the presence of high levels of suspended sediments. This was a marked improvement over the earlier years when the strait was very turbid (Malaysia, 1986a).

As an archipelago, Indonesia has to develop rather intensive sea transport and harbour infrastructure, be it for national or for international trade. Coinciding with this scheme, and for easier accessibility, more and more industrial estates have been 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. These industries create a good number of job opportunities and revenue to the Government. Unfortunately, they also generate a great volume of industrial waste, which if mismanaged could exert environmental pressures on the coastal region.

4.3 Manipulation of hydrological cycles

Limited data on manipulation of hydrological cycles are available for the region. All major rivers draining the Central Plain of Thailand have dams built in the upper reaches for hydroelectric power generation as well as irrigation purposes. As a result of these, rice can now be grown twice a year instead of the normal once a year. On the other hand, salinity intrusion in soils has damaged orchards on both sides of two rivers, the Chao Phraya and Mae Klong. Damage ranged from reduction of productivity in most cases, to complete destruction of even the exceptionally tolerant coconut trees. Aside from this, some parts of the river banks in Bangkok draw up slightly salty artesian well waters. This, however, is not surprising in view of the fact that Bangkok is only slightly above sea level. The Mae Klong residents seem to suffer from the intrusion effect much more than the Chao Phraya residents. It was suggested that this may be attributed to the greater discharge of the latter river.

Similarly, there are eight major dams across the upper reaches of rivers in Malaysia, and more are planned. Besides these dams, there are tidal control gates built at the lower stretches of the rivers. The sharp decline in the salinity of immediate coastal waters when the gates are raised during periods of heavy rains, has been reported to bring about mortality in coastal shellfish beds and marine fish cultured in suspended cages.

4.4 Other land use practices

Deforestation is a widespread problem in the region, whether one is referring to a small territory like Hong Kong or a large country like Thailand where only about 25% of its original forests remain. Large scale denudation of the land has resulted in erosion and sedimentation of coastal areas.

4.5 Disposal of contaminated sediments, mine tailings and solid industrial wastes

There is very limited information on disposal of industrial wastes. The industrial sector of Hong Kong is reported to produce some 600 tonnes of industrial sludge per year. This, together with sewage, septic tank, agricultural waste and alum sludges (0.3 million m^3 in 1983 and expected to increase to 0.5 million m^3 in 1990) is dewatered and dumped in the open sea. Effects of sludge dumping on the marine environment have not been studied. Likewise, no assessment has been made on the impact of toxic, hazardous, difficult (THD) wastes which amounted to 29,838 tonnes in 1984. These include alkali and acid waste, oil and oil-water emulsions, solvents, metal oxides, tannery and cyanide waste among others. Over 95% of these wastes are diluted before being discharged into the sea through the sewer system of Victoria Harbour. Altogether, about 100 million m^3 of materials and marine spoils generated from various development projects were dumped into the coastal waters of Hong Kong for the period 1981-1986. In 1980, four major open water dumping grounds for all marine spoils were selected to replace the 20 scattered marine dumping sites all over Hong Kong. The results of a single survey at one of these four major dumping sites showed normal benthic and fish communities at about a kilometer away from the site.

With the exception of Hong Kong, mining is one of the major industries which contributes to the socio-economic development of many countries in the region. Consequently, considerable terrestrial mine tailings have been transported into the coastal zone. In the Philippines for instance, about 300,000 tonnes of mine tailings are generated daily from metallic mining firms alone. Of these, about 145,000 tonnes are dumped directly into the sea via pipe-line systems. Conceivably, the eventual settling of the sediment onto the seabed has in many places smothered pockets of coral reef. Studies on the effects of sedimentation in general on coral reefs (Yap & Gomez, 1985), provide useful baseline data on the more apparent effect of sediments and recovery of damaged reefs. The effects of the accompanying toxic ions in these tailings are less known.

4.6 Disposal of solid matter (litter)

Solid waste, chiefly garbage, is commonly disposed of either by the sanitary land fill method or by incineration in many urban areas. However, as mentioned in the earlier sections, direct dumping of garbage in many rural as well as urban areas is widespread. While coastal land fills also release sediment and organic materials into the neighbouring waters, direct dumping of domestic refuse poses a greater impact. Littered coral reef areas near coastal settlements are a common sight in many places in the region (e.g. Ambon Bay, portions of the Straits of Malacca, various coastal areas in the Philippines). The increased use of plastic in recent years has consequently increased the load of non-degradable litter in the sea. This, more than any other refuse material, presents a potential detrimental impact. It is very likely that sensitive benthic communities (e.g. coral and seagrass beds) may be smothered and the community structure disrupted. However, no such obvious impact attributed to smothering by refuse in particular, has been reported.

In general, the large scale disposal of litter in the sea is not a common practice. Garbage dumping by ships, however, is not uncommon. The wastes often find their way to shores near shipping lanes.

Singapore has very strict laws against littering and illegal dumping of waste. The country has an efficient system of solid waste disposal, 70% through incineration and 30% via sanitary landfill.

The volume of floating refuse in Hong Kong is exceptionally high. Floating refuse scavenged from the sea increased from 3,279 tonnes in 1970 to 8,200 tonnes in 1983. In addition, a considerable amount (e.g. 1,026 tonnes in 1982) is collected from urban beaches. In terms of number of items and area covered, plastic materials form the main bulk (> 50%). Apart from being a nuisance which spoils the aesthetic value of the environment, floating refuse also reduces the amenity of swimming beaches and causes marine navigational hazards (particularly for hydrofoils which are abundant in Hong Kong).

4.7 <u>Marine transport of oil and other hazardous substances</u>

Crude oil amounting to about 3 million barrels is shipped through Southeast Asian waters daily via the Straits of Malacca, in addition to about 3.8 million barrels per day which leave this region through the South China Sea to Japan (Fig. 5) (Bilal, 1985). The Malacca Straits are dangerously shallow in certain stretches and deepwater channels are narrow. This in addition to its heavy traffic (Table 4) has resulted in several major accidents involving oil spills. Some of these are listed in Table 5.

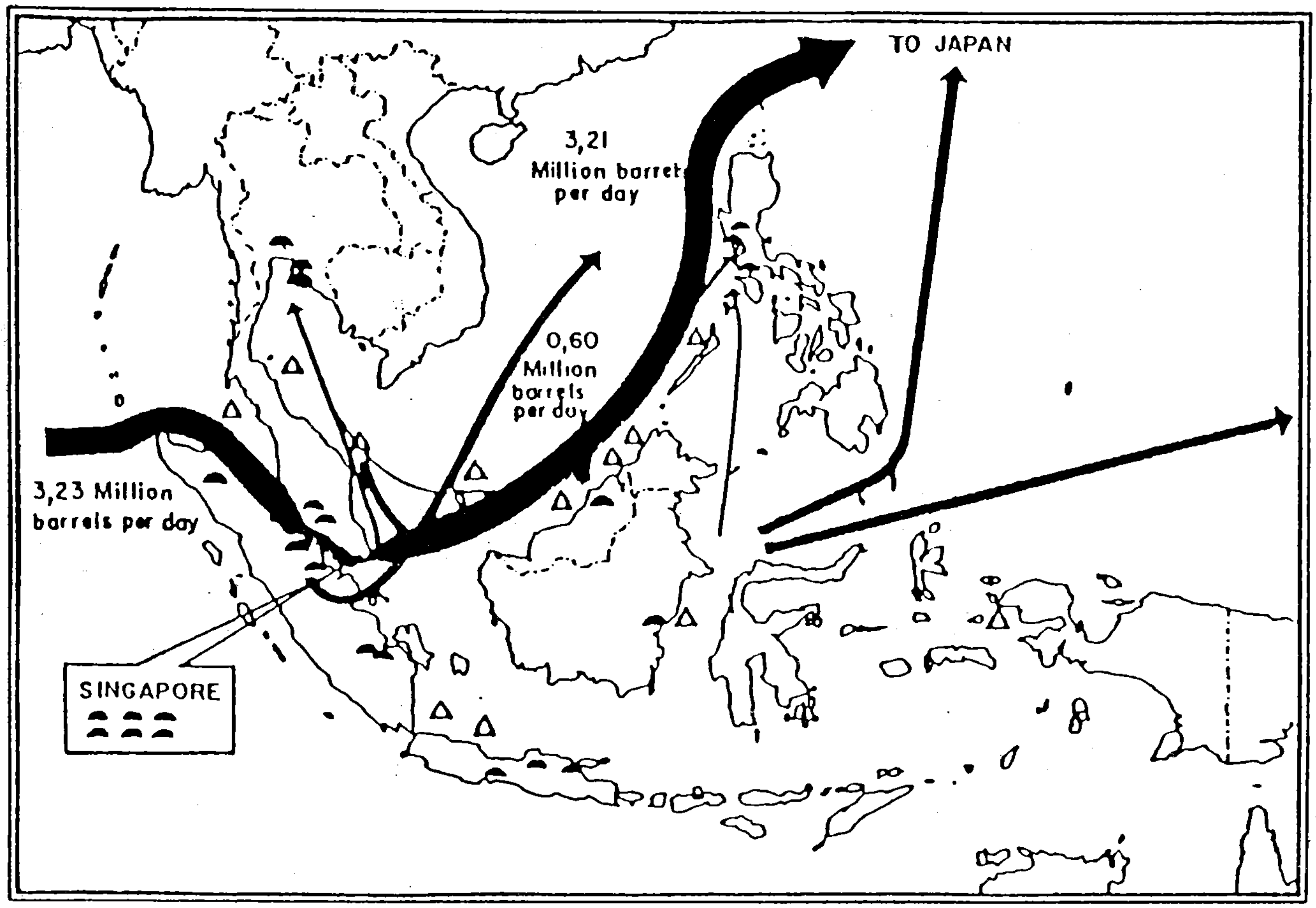
There is little information available on the effects of these oil spills on the marine environment. In Hong Kong, marine fish farming was seriously affected. In the incidents involving the Ap Lei Chau in 1973, the Oriental Financier in 1976 and the Adrian Maersk in 1977, cultured fish were killed or tainted resulting in the loss of over 273 tonnes and 540,000 fry. In the 1982 and 1985 spills, several swimming beaches on the south of Hong Kong Island were seriously contaminated and top layers of the beach sand had to be scooped off for disposal.

Table 4. Frequencies of tanker movements in Southeast Asia (Valencia, 1981).

Destination (Route)	**Hypothetical Vessel Size**	**Frequency**
South Korea and Japan	200,000 DWT	984/yr (1/0.4 days)
Japan (Lombok-Makassar-Sulawesi Sea-east or west of the Philippines)	VLCCs	140/yr (1/2.6 days)
Sulawesi Sea	VLCCs + Tankers	25-30/yr (1/13.5 days)
Port Dickson, Malaysia	90,000 DWT	40/yr (1/9 days)
Singapore	VLCCs	91/yr (1/4 days)
(Singapore-Straits)	Various	15,356/yr (1/.024 days or 1/34 min.)

The grounding of the Japanese super tanker Showa Maru in January 1975 in Singapore Strait, which is considered to be the largest oil spill incident in the region, caused extensive defoliation and death of mangroves. Three years later, no sign of regeneration was reported (Soegiarto & Polunin, 1981). Similarly, the spill from the Diego Silang in the Malacca Straits in 1976 resulted in defoliation of mangrove trees mainly due to the smothering of the pneumatophores.

Aside from these incidents, a greater volume of oil discharge comes from normal shipping operations like tank-cleaning, drydocking, bunkering and cargo loading and unloading. Oil released during deballasting operations is in the form of tar lumps and weathering produces tarry residues and tar balls. Bilal et al,



— < 0.1 million barrels per day (7 barrels = 1 metric ton)
— 0.1-0.2 million barrels per day
▬ 0.2-1.0 million barrels per day
█ > 3 million barrels per day
Δ Offshore production site
Refinery

Fig. 5. Transport of crude oil in Southeast Asia (1975)
(after Finn et al, 1979 in Bilal, 1985)

Table 5. Oil spill incidents in Southest Asia*

Country	Location	Date	Name of Ship	Cause	Quantity (tons)	Type
Hong Kong	-	- 1968	Columbia Trader	Grounding	190	heavy marine diesel
	-	- 1973	Ap Lei Chau	-	4,000	heavy marine diesel
	-	- 1973	Eastergate & Circae	Collision	200	aviation fuel
	-	- 1974	Korea Hope	Grounding	160	aviation fuel
	Junk Bay	- 1976	Oriental Finance	Grounding	-	-
	-	- 1977	Adrian Maersk	Grounding	1,100	bunker oil
	Repulse Bay	- 1982	(burst pipe)	Discharge	2,000	fuel oil
	Repulse Bay	- 1985	Frota Durban	Grounding	60	bunker oil
Indonesia	Labon Besar	Jul. 1987	Elhani	Grounding	2,000	oil
	Batu Berhanti	Jul. 1987	Stolt Avance	Grounding	73	oil
Malaysia	Singapore Straits	Jan. 1975	Showa Maru	Grounding	7,700	-
	Singapore Straits	Apr. 1975	Mysella	Grounding	2,000	-
	Malacca Straits	Jul. 1976	Diego Silang	Collision	6,000	-
	Singapore Straits	Oct. 1976	Citti di Savona	Collision	1,000	crude oil
Philippines	Pasig River	Aug. 1975	L-1909 Lusteveco	Barge sinking	5.2	fuel oil
	Manila Bay Vic. Cavite	Aug. 1975	L-235 Lusteveco	Grounding	9.2	fuel oil
	Off Escalante Pt. Negros Occ.	Oct. 1975	M/S Shotoku Maru	Collision, Sinking	-	fuel oil
	Rosario, Cavite	Apr. 1976	Filoil Refinery	Accident	1.6	sludge oil
	Sasa, Davao	Aug. 1976	Mobile Depot	Leakage due to broken pipeline	1.6	fuel oil
	San Fernando, La Union	Oct. 1976	LSCC Petrochem	Grounding	1.4	fuel oil
	BRC Batangas	Nov. 1976	M/T Raja Sulayman	Leakage	4.2	crude oil
	Vic. Cape San Agustin	Dec. 1976	M/S San Diamond	Sinking	-	fuel oil
	Manila Bay	Dec. 1976	M/V Gen Santos	Sinking	8.4	fuel. diesel oil

* Culled from country reports. For additional information, please consult Yap et al. 1988. Oil pollution and its control in the East Asian Seas region.

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	Junk Bay	- 1976	Oriental Finance	Grounding	-	-
	-	- 1977	Adrian Maersk	Grounding	1,100	bunker oil
	Repulse Bay	- 1982	(burst pipe)	Discharge	2,000	fuel oil
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	Batu Berhanti	Jul. 1987	Stolt Avance	Grounding	73	oil
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	San Fernando, La Union	Oct. 1976	LSCO Petrochem	Grounding	1.4	fuel oil
	BRC Batangas	Nov. 1976	M/T Raja Sulayman	Leakage	4.2	crude oil
	Vic. Cape San Agustin	Dec. 1976	M/S San Diamond	Sinking	-	fuel oil
	Manila Bay	Dec. 1976	M/V Gen Santos	Sinking	8.4	fuel. diesel oil

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Table 5 (Cont'd)

Country	Location	Date	Name of Ship	Cause	Quantity (tons)	Type
Singapore	-	Apr. 1975	Tosa Maru & Cactus Queen	Collision	-	-
	-	Jun. 1975	Kowei Baru & Monte Cristo	Collision	-	-
	Malacca Straits	Jun. 1975	Liengku & Neissei Maru	Collision	-	crude oil
	South of St. John's Island	Oct. 1975	Seatiger	Collision, Grounding	- -	- -
	Eastern Anchorage	Dec. 1975	Sachem, Gen. Madalineki	Collision	-	-
	Eastern Anchorage	May 1976	Margo & George Hanake	Collision	-	-
	Eastern Anchorage	Jul. 1976	Forresbank & Mareva A.S.	Collision	-	-
	Off St. John's Island	Sep. 1976	Soyakaze & Marrita E.	Collision	-	-
	East Coast	May 1986	SB228B	Sinking	40	bunker oil
	East Coast	Aug. 1987	World Bermuda	Pipeline leak	50	oil

(1982) reported some areas in the region that had quite significant contamination by tarballs. Concentration of tarballs in Northern Luzon, Philippines was 0.630 kg/km^2 and was as much as 1.6 kg/km^2 northeast of this area in 1973. As for Indonesia, there were reports of stranded tarballs in two beaches, (i.e. Pulau Putri, 1970; and Pulau Tidung, 1972) in Kepulauan Seribu. Density of stranded tarballs could reach about 2,000 g/m^2. Stranded tarballs were also found on the south coast of Java and a few beach areas in Malaysia. Fig. 6 shows the distribution of oil lumps and transport of oil and surface currents in Southeast Asia.

Oostdam (1984) in a comparative survey of the degree of tar pollution in 265 beaches of the Indian Ocean, the South China Sea and the South Pacific Ocean reported tar concentrations found in the beaches of four countries in Southeast Asia. The mean values that he reported were: Indonesia: Sumatra, 0.7 $\pm$ 1.0 g/m and Java, 11.4 $\pm$ 18.7 g/m; Malaysia, 125.1 $\pm$ 129.4 g/m; Singapore, 10.0 $\pm$ 1.2 g/m; and Thailand, 17.8 $\pm$ 26.6 g/m.

Contamination from the discharge of oily bilge waters and spillage of gasoline from large vessels and small craft used by fishermen is evident on an increasing scale in various coastal waters.

Since 1984, concerted efforts were taken by the Malaysian and Singapore Governments to control pollution from vessels in the Strait of Johore. These have resulted in a decrease in the level of oil and grease in the narrow strait.

Accidents involving transport of toxic substances are uncommon. The only available information was reported from the Philippines. In December 1977, 350 tonnes of sulfuric acid were reported to have been lost at sea. In June 1978, 500 tonnes of caustic soda were spilled due to a sinking barge and in September of the same year, 20,000 bags of fertilizer were spilled from a vessel due to a typhoon.

4.8 Exploitation of non-living marine resources

Oil and gas

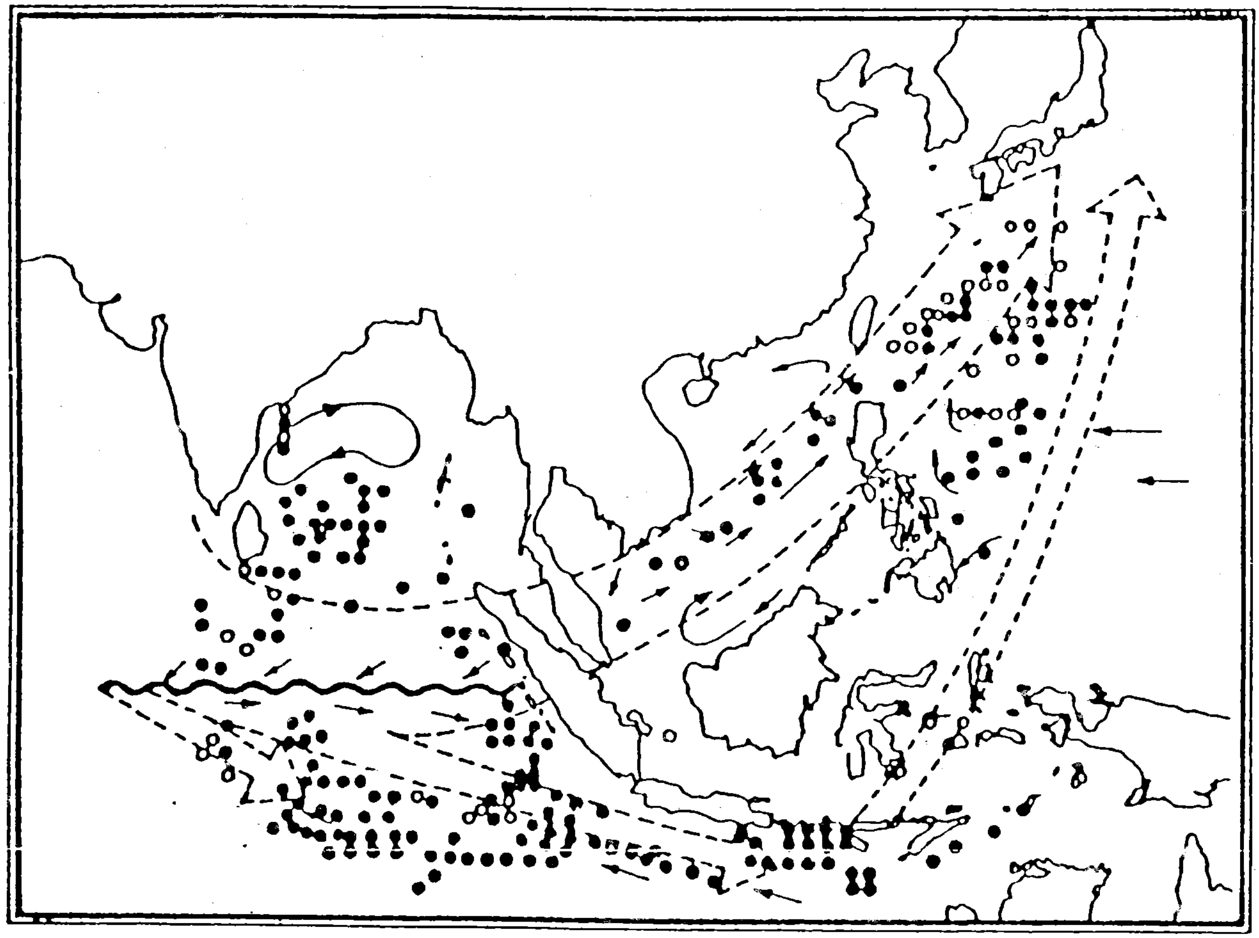
The South China Sea and the Indonesian waters can be said to be the center of activity for oil and gas exploration and exploitation in the EAS region. From the offshore wells the oil and gas are conveyed to shore-based terminals chiefly by seabed pipelines. Other areas where exploitation is in progress on a smaller scale include the Gulf of Thailand, for gas, and the Palawan and Sulu Archipelago areas of the Philippine waters, for oil.

According to Ahmad (1988), oil and gas production in 1986 totaled 2 million bbls/d. and 5 billion ft^3/d respectively with 45% of these currently produced offshore.

Adequate precautions have been taken by the oil industry to prevent accidents such as blow-outs at the oil wells and leakages from the seabed pipelines.

Tin

Mining for tin is in progress in the sandy seabed of the Andaman Sea off Phuket Island, in the northern portion of the Straits of Malacca. Mining is carried out in the shallow coastal area by the use of dredges. Further south in the Straits of Malacca are potential areas with tin deposits, which may be



- ● Few oil lumps
- o Many oil lumps
- Transport of oil (width indicates amount)
- Average surface currents
- Border between currents

Fig. 6. Oil lumps, transport of oil and surface currents in South and East Asia (after Nasu et al, 1975)

exploited if environmental considerations are disregarded; the seabed here is chiefly soft mud, and any agitation may give rise to a considerable increase in the turbidity of the water.

Sand

In Philippine coastal areas, magnetite sand mining was carried out in the 1970s but the activity is now discontinued by law, in order to conserve recreational shorelines. However, mining for silica sand is still in progress in the Palawan area, but on a limited scale.

In Hong Kong waters, seabed mining for sand was also actively pursued in the 1970s, to cater for the building industry. The annual extraction of sand from the seabed was then in the region of 1,560,000 tonnes. This quantity has now declined to about 240,000 tonnes owing to the importation of sand from China.

Coral

Mining of coral reefs used to be carried out in the 1970s, in the South China Sea off the east coast of peninsular Malaysia and in the Sulu Sea near Sabah. The calcareous skeletons of coral were used in the building industry. The activity, however, has been reduced due to the establishment of conservation programmes including marine reserves. There is no legislation yet outlawing coral mining in Malaysian waters outside of marine parks.

4.9 Exploitation of living marine resources

Traditional fishing

There is a general decline in fishery resources in the EAS region as a whole, mainly due to over- exploitation. This can be related to increasing populations in the area and human demands for food. The bulk of the fishery comes from the inshore coastal waters, within 50 km from shore. In the Malaysian sector of the Straits of Malacca the annual catch recorded in 1985 was about 327,000 tonnes compared to the potential yield of this area which is estimated to be only about 250,000 tonnes. On the contrary, in the South China Sea waters bordering Malaysia, about 246,000 tonnes of fish were caught in the same year, as against a potential yield of 690,000 tonnes, thereby indicating the greater potential for exploitation in this area. The major species exploited include the Indian mackerel (Rastrelliger kanagurta), the cockle (Anadara granosa), the anchovy (Stolephorus sp.) and a variety of penaeid prawns. The main gear used in fishery exploitation in Malaysian waters are the otter trawl, the purse seine and the drift gill net. The otter trawl, though acclaimed to be an efficient fishing gear, is also known to have damaging effects on the seabed marine ecosystem.

In the Lower Gulf of Thailand natural stocks of the short-necked clam (Paphia undulata) were exploited quite intensively. In recent years their stocks have shown a sharp decline believed to be due to the disturbance of the seabed by the destructive beam trawl. The annual fishery production in Thailand is about 2 million tonnes, but a significant amount of this comes from distant waters. This is owing to the virtual collapse of the fishery in the Thai waters as a result of over-fishing, particularly by trawlers.

Indonesian waters have also been over-exploited, due to the tremendous demands for food by the large population of the country. Trawl fishing has been banned in Indonesian waters in recent years in an effort to bring about recovery of the resources.

The annual catch of fish in Philippine waters was about 1.8 million tonnes in 1985. Here again the resources have been exploited to bring about significant declines. A major portion of the fish consumed in Hong Kong comes from the South China and East China Seas. The catch per unit effort as well as the demersal fish stocks in the northern shelf of the South China Sea have declined since 1975, due to over-fishing. Within Hong Kong waters fishery production has declined in the Tolo Harbour and Tolo Channel, probably due more to pollution.

Abusive fishing

Apart from the traditional methods of fishing, abusive fishing by the use of underwater explosives and poisons is carried out in many parts of the EAS region, particularly in the waters of Indonesia, Malaysia, the Philippines and Thailand. Such practices are illegal and are under constant surveillance by enforcement officials. Underwater explosives are commonly used in coral beds, which have fairly heavy concentrations of fish and which cannot be exploited by nets.

Exploitation of aquarium fish

Marine aquarium fish are being exploited in several countries, particularly the Philippines, chiefly for export. In 1984 a catch of 0.4 tonnes of marine aquarium fish was recorded. The fish used to be collected in greater quantities in earlier years, by the use of sodium cyanide. This practice has now been discouraged, in view of poor export demands and the requirement by overseas importers that the fish be caught by non-harmful means.

Exploitation of marine shells

Marine shells are being exploited in the Philippine waters, but due to depletion of stocks, there has been a steady decline in their exploitation. In 1983 about 2 tonnes of shells and byproducts were exported. The ban on the collection of certain species has not prevented unscrupulous elements from exploiting them. The shellcraft industry has also been developing in other countries in the region, and production is on the increase.

Coastal mariculture

The decline in fish resources generally experienced in the EAS region has triggered the development and expansion of coastal mariculture.

Cockles (Anadara granosa) are being farmed in about 5,000 ha of the coastal mudflats in the Straits of Malacca, bordering the west coast of peninsular Malaysia. The annual production of cockles from these mudflats, as recorded in 1985, was about 44,800 tonnes (Malaysia, 1986b). There are moves to expand this activity further to other coastal mudflats in the region. This bivalve is known to thrive well in waters carrying high organic loads.

Coastal mariculture is also growing in importance in the Straits of Malacca. The major species cultured are the sea bass (Lates calcarifer), the grouper (Epinephelus tauvina and the tiger prawn (Penaeus monodon) in ponds and cages; and the green mussel (Perna viridis) on rafts. The annual production of fish and crustaceans from coastal mariculture, as recorded in 1985, was about 600 tonnes (Malaysia, 1986b).

Similarly, mariculture is rapidly expanding in the waters of Indonesia, Thailand, the Philippines and Hong Kong, partly to off-set the decline in the natural stocks. In Thailand, the 1981 mariculture production for several bivalves was as follows: blood clams (Anadara) - 77,735 tonnes, green mussels (Perna) - 129,633 tonnes, and oysters (Crassostrea spp.) - 60,105 tonnes (Hungspreugs, pers.comm.).

5. BIOLOGICAL EFFECTS

The most pronounced biological effects in the region are those resulting from organic pollution and eutrophication. Biological effects resulting from other types of pollution are much less obvious.

5.1 Eutrophication and associated phenomena

Eutrophication in various coastal waters receiving high organic inputs from sewage is common in the region. Substantial information on the biological effects of organic enrichment is available from a series of studies in Hong Kong. It has been shown that organic loading has caused an increase in the standing crop of phytoplankton in Victoria Harbour (Thompson & Ho, 1981). In Tolo Harbour additional changes in species composition of the phytoplankton community, with diatoms being gradually replaced by dinoflagellates, are also noted.

Malaysia reported nutrient enrichment in some parts of the Straits of Malacca (around Penang Island and in Johore) and off the coast of Sabah that has given rise to eutrophication of waters and high BOD (Jothy, 1984a). However, in other offshore areas of the South China Sea the phosphate levels were low, e.g. Trengganu surface average 2.17 mg/m^3 (Law & Rashid, 1986), off Kuantan 5.58 mg/m^3 (Law & Shaik, 1987). Organic load from sewage in the northern part of the Straits is believed to have given rise to considerable levels of microbial contamination in shellfish.

Both toxic and non-toxic red tides have been reported in the Philippines (Pyrodinium bahamense var. compressa), Thailand (Trichodesmium erythream, Noctiluca miliaris, Ceratium furca and Gonyaulax spp.), Indonesia (Noctiluca miliaris), Malaysia (Noctiluca miliaris, Pyrodinium bahamense var. compressa) and Hong Kong (a total of 18 species, including Gymnodinium nagasakiense, Noctiluca miliaris, Ceratium furca, and Prorocentrum micans). Several other red tide phenomena have been reported from Kau Bay, Halmahera, Ambon Bay, and Jakarta Bay. Except for Jakarta Bay, the cause of red tide blooms are not yet scientifically substantiated. Noctiluca miliaris blooms occur in Jakarta Bay periodically due to eutrophication of the coastal waters (Adnan, 1984a; Praseno & Adnan, 1978). The bloom normally occurs in September or October, coinciding with the first period of the season's heavy rain. It is also noted that the occurrences of red tide are more frequent in Malaysia, the Philippines, Thailand and Hong Kong in recent years.

Fish kills caused by red tides have also been recorded in the region. Farmed fish which are confined in cages as well as juvenile fish, are most seriously affected (Suvapeepun et al, 1984). For example, from 1980 to 1984 a total of 11 fish kills in mariculture areas in Hong Kong were caused by red tides with a total loss of 56 tonnes of cultured fish. It has also been alleged that the Noctiluca bloom in 1982 prevented settling of green mussels on poles in the upper Gulf of Thailand. Red tide toxins accumulated by shellfish are also well documented in the region, (the resulting public health hazard is discussed in section 5.2). The unusually frequent red tide blooms in Thailand in 1983, however, were not associated with any increase in nitrogen and phosphorus for that particular year in the general area. Although there is no direct evidence to attribute the occurrences of red tides to eutrophication in the region, there appears to be a correlation between the progressive increase in the frequency of red tide occurrences in Hong Kong since 1977 (Table 6) and an increase

Table 6. Number of red tides and fish kills due to red tides, algal blooms and oxygen depletions in Tolo Harbour, Hong Kong (Wu, 1987).

Year	No. of red tides	No. of fish kill due to red tides, algal blooms and oxygen depletions
1977	2	1
1978	1	-
1979	1	-
1980	4	2
1981	3	-
1982	3	-
1983	11	1
1984	16	2
1985	16	2
1986	26	4
1987	19	3

in the level of eutrophication. The frequency of occurrence is also higher in eutrophic waters compared with that in open clean waters, and the causative species of red tides have become more diversified in recent years (Wong & Wu, 1986).

The most pronounced biological effects of eutrophication are probably those on benthic communities. Detailed studies conducted in 1978-1980 in Hong Kong clearly showed spatial changes in the epi-benthic community structure along the organic pollution gradient. The decrease in community diversity as well as abundance and dominance of predatory gastropods along the gradient also reflect changes in trophic structure brought about by organic pollution. In contrast to the situation in Manila Bay, however, no significant change in the percentage of deposit feeders was found. Likewise, the species composition and trophic structure of the fish community changed in relation to the pollution gradient. In the harbour where organic pollution is severe, summer mortality of fish and benthos due to oxygen depletion followed by winter recovery becomes a regular phenomenon, and it was postulated that such a phenomenon may be characteristic in subtropical benthic systems subject to high levels of organic pollution. It was also noted that the time required for recovery after complete defaunation was much shorter when compared with that in temperate regions (Wu, 1982).

Other studies in 1976 and 1979 on the benthic community in Victoria Harbour indicated no significant evidence of pollution, despite the heavy pollution load. It was concluded that the pollution impact was fairly localized due mainly to good flushing rates in the harbour (Shin & Thompson, 1982; Thompson & Shin, 1983).

5.2 Public health effects

5.2.1 Paralytic shellfish poisoning (PSP)

The occurrences of toxic red tide blooms in the region, described in section 5.1 above, have led to several documented PSP cases in the region.

A few isolated cases of red tide have also been reported from Indonesia (Adnan, 1984a and 1984b). An incident of red tide poisoning through the ingestion of clupied fish, Sardinella spp. and Selaroides leptolepis, was reported in two fishing villages in East Flores, East Nusa Tenggara province in November 1983. In that incident four people died, and some 240 were taken ill after consuming their daily catch.

The first recorded PSP outbreak in Thailand occurred in May 1983, in which 63 people were affected (with one fatal case) after consuming green mussels (Perna viridis) contaminated by dinoflagellates (Gonyaulax sp.). In this incident, PSP toxin was detected in mussels and oysters. The highest level recorded was 12,057 µg/100g in one mussel sample (Saitanu & Tamiyavanish, 1984).

Toxic red tides caused by Pyrodinium bahamense var. compressa have occurred several times in the inshore waters of the west coast of Sabah and Brunei Bay since 1976 in which PSP and fatal cases were reported (Jothy,1984b). A bloom of this species occurred and extended for some 3 months during the second half of 1983 in the Philippines (Estudillo & Gonzales, 1984). In this incident, some 24 people died and many more suffered from PSP symptoms after consuming seafood exposed to this toxic red tide.

Although there has been no documented case of PSP in Hong Kong, toxic species (e.g. Gymnodinium nagasakiense) have been found in these areas. The potential risk of PSP resulting from the ingestion of shellfish, therefore, should not be overlooked.

5.2.2 Pathogens in water and shellfish

Concentrations of coliform in a number of locations in the region exceed national standards, indicating the potential risk of exposure to human pathogens and consequent disease transmission. However, records of human disease associated with swimming in polluted waters are lacking for the region.

A drastic increase in coliform count was noted in Manila Bay from 1983 to 1985 (Table 7). Coliform counts in all beach resorts exceeded the maximum allowable total of 1000 MPN/100 ml for recreational waters. Coliform counts in other areas of the bay also exceeded the maximum of 5000 MPN/100 ml for waters for aquaculture.

In Hong Kong, recent surveys found that five swimming beaches exceeded the standard for recreational waters (Wu, 1987). Coliform levels as high as 26,000 MPN/100 ml were obtained in some samples. In the early 1980s, 2 of the 41 gazetted swimming beaches were already closed to the public because the bacterial counts exceeded the local standard (i.e. running median of five consecutive samples not exceeding 1000 E. coli/100 ml) and in 1987, a total of 4 beaches were closed for swimming because the contamination exceeded the above standard. Likewise, an increase in faecal pollution was evident in Tolo Harbour and Victoria Harbour, as reflected by a progressive increase in the levels of total coliforms and faecal coliforms from 1973 to 1983 (Table 8). A wide area with levels of faecal coliform exceeding 1000 MPN/100 ml was identified in Victoria Harbour. Faecal coliform levels reached 10^5 - 10^6 in areas with poor water circulation in the harbour.

Table 7. Coliform counts in selected coastal areas in the Philippines (MPN/100 ml)

Location	1977	1978	1979	1980	1981	1982	1983	1984	1985
I. Manila Bay									
1. Punta Grande	-	760	764	340	560	373	512	1324	3332
2. Villa Susana	-	1200	362	870	3600	1400	650	7070	12960
3. Star Fish	-	900	716	963	2000	616	648	3448	19892
4. San Agustin	-	1000	766	1212	780	1468	1175	3730	10679
5. San Isidro	-	1400	928	1296	8500	1212	1372	3826	12955
6. Villamar	-	760	667	520	1100	257	365	1646	3128
7. Lido	-	800	670	397	700	272	526	903	3431
8. Mabuhay	-	660	770	364	1334	355	428	1623	3369
9. Future Seaside of MCCRRP	-	-	-	-	-	58026	34489	55050	62254
10. Baclaran	-	-	-	-	-	986084	251911		
11. Seaside of MCCRRP (CDCP)	-	-	-	-	-	16782	3124	7816	22504
12. Northwest of CCP	-	-	-	-	-	18952	5322	7403	17361
13. South Breakwater	-	-	-	-	-	-	47477	72880	-
14. Holiday	-	-	-	-	-	299	430	2225	3522
15. Garden Coast	-	-	-	-	-	255	440	1397	3408
16. Pasig River Outlet	-	-	-	-	-	86442	41474	27146	79339
17. Luneta Grandstand	-	-	-	-	-	-	-	77926	297641
18. Vitas Navotas	-	-	-	-	-	-	-	-	512120
II. 19. Davao City	-	-	-	-	-	-	-	-	2002
III. 20. Cebu Harbour	18139	-	-	-	-	-	-	-	-

Table 8. A comparison of yearly median values of total coliforms and faecal coliforms in Victoria Harbour and Tolo Harbour stations over the period 1973-1983, no./100 ml (Wu, 1987).

	Total coliforms		Faecal coliforms	
	Victoria Harbour	Tolo Harbour	Victoria Harbour	Tolo Harbour
1973-74	1,600	3	560	1
1974-75	1,100	41	690	12
1975-76	2,900	2	1,300	2
1976-77	4,900	2	3,000	2
1977-78	2,500	2	1,300	2
1978-79	2,800	26	1,900	2
1979-80	7,600	280	3,300	7
1980-81	14,000	160	9,600	68
1981-82	17,000	650	3,700	61
1982-83	3,200	150	2,500	42

In coastal waters around Jakarta, pathogens have been reported in edible shellfish and fish. Similarly, high numbers of faecal coliform were found in shellfish beds contaminated by sewage pollution in the Straits of Malacca.

Elevated coliform levels in oysters and mussels in the Gulf of Thailand were reported particularly during the high flow season resulting in low salinity of coastal waters. Bacteria examined were Vibrio parahaemolyticus, V. cholerae and Salmonella sp. Studies conducted on the Pacific oyster Crassostrea gigas in Deep Bay, Hong Kong, in 1973 showed that the level of contamination increased markedly with the onset of the summer rains in June to levels of 4.7-12 E. coli/mg tissuewhich is higher than the shellfish standard of 2 E. coli/mg. (Leung et al, 1975). This indicates that the potential risk of human pathogen transmission by consumption of local oysters is high. In addition, studies in 1972 revealed a range of pathogenic bacteria (e.g. Salmonella spp., Shigella boydii and S. flexneri) that were found in clams (Katelysia sp. and Venerupis sp.) collected from Tolo Harbour (Kueh & Trott, 1972). More recent studies in 1985 showed that the levels of total coliform and faecal coliform in clams (Tapes variegatus) and mussels (Perna viridis) collected from Tolo Harbour were generally high, reaching up to 11,000 total coliform/g and 370 faecal coliform/g (Ni & Huang, 1985). An epidemic outbreak of hepatitis associated with the consumption of shellfish occurred in Hong Kong in early 1988. Within the first three months of the year, 1396 cases of hepatitis had been reported, in which 591 cases were confirmed to be hepatitis A and 76 cases hepatitis B. More than half of the victims consumed local shellfish shortly before the infection, indicating that local shellfish are grossly polluted and served as the main carrier of the hepatitis virus in this epidemic outbreak.

A survey of pathogenic bacteria in shellfish in Jakarta Bay indicated contamination of *Anadara* (cockle) and *Crassostrea* (oyster) by *Salmonella*, *Shigella*, *E. coli* and *Staphylococcus* (Thayib et al, 1977).

5.2.3 Others

High concentrations of Cd and PCB have been identified in oysters, mussels and seafood samples in Hong Kong (for levels, Phillips, 1982, 1985; Phillips et al, 1982), suggesting a possible risk of exposure to organochlorines and Cd for the Hong Kong population.

5.3 Damaged habitats and resources and their potential for recovery and rehabilitation

During the drought and the low flow in the rivers of Thailand in 1972, sugar factories along a river bank discharged untreated sugar waste directly into the river, causing extensive damage to the tube shell beds and cockle farms near the river mouth. Recovery was noted 2 years later and now the cockles and the tube shells are growing again, though recovery is still not quite complete for the cockles.

In Hong Kong, it has been shown that the recovery of the epi-benthic community, after pollution-induced defaunation, takes a much shorter time when compared with that in temperate regions. Complete recovery of inter-tidal communities on reclaimed shoreline, however, takes some 8 years.

The transformation of the once heavily polluted Singapore river into a recreation/tourist centre (discussed in the previous chapter) is perhaps the most remarkable example of recovery of a damaged habitat in the region. Other encouraging signs are the effectivness of pollution control measures evidenced for instance by the decrease of oil pollution in Johore Strait, coupled with advances in treatment technology for palm oil and rubber effluents in Malaysia. These developments contribute to reduction of the pollution load in coastal waters.

Rehabilitation of mangrove areas has been taking place in the region in recent years (e.g. central Philippines).

Damaged coral reefs are generally known to recover slowly, especially where the stress is caused by human activities such as dynamite fishing (Alcala & Gomez, 1979). Recent studies on the recovery of natural damage as caused by a storm indicate that the recovery time may be considerably shorter (Alcala et al, 1986).

Some efforts have been taken to rehabilitate and preserve coral reefs in the region through the establishment of marine reserves in Indonesia, Malaysia, Thailand and the Philippines (Gomez et al, 1984) (Table 9). Significant increases in the standing stock of fish have been noted where protection has been effective (e.g. Sumilon, Philippines). There are also plans for establishing similar reserves in Singapore. In addition some studies on coral transplantation and recolonization of damaged reefs have been initiated in the Philippines.

The development of artificial reefs in Malaysian coastal waters to increase fish production is being undertaken extensively both in the Malacca Straits and in the South China Sea. Similar developments are also taking place in various localities in the Philippines. On the whole, results have been very

Table 9. Marine parks and sites of special scientific interest

Country/Existing park	Projects/Recommended areas
A. ASEAN Countries*	
INDONESIA	
- Komodo Island Game Reserve - Ujung Kulon National Park - Pulau Pombo Marine Park - Pulau Kasa Marine Park - Banda (1972) - Seribu Islands - South of Moyo Island - Karimun, Java Island - Bunaken Manado Tua - Maumere Bay	- Bali Barat - Teluk Sarera marine area
MALAYSIA	
- Tunku Abdul Rahman National Park, Sabah (1974) - Turtle Islands National Park, Sabah (1977) - Pulau Tiga National Park, Sabah (1978) - Klias Peninsula National Park	- Semporna Marine National Park, Sabah - Pulau Redang (South China Sea off Trengganu) - The Paya Group of islands (Straits of Malacca off Kedah) - The Tioman Group of islands (South China Sea off Johore) - The Rawa Group of islands (South China Sea off Johore) - The Tinggi Group of islands (South China Sea off Johore) - The Perhentian Group of islands (South China Sea off Trengganu) - Pulau Kapas (South China Sea off Trengganu) - Pulau Tenggol (South China Sea off Trengganu)
PHILIPPINES	
- Hundred Islands National Park, Luzon (1940) - Manila Bay Beach Resort National Park, Luzon (1945) - Agoo-Damortis Shore and Territorial Waters, Luzon (1962) - Cagayan Island Marine Sanctuary (1970)	- Apo Reef Marine Park, Mindoro - Sombrero Island, Batangas - Guindulman, Bohol - Balicasag, Bohol - Honda Bay, Palawan

* Gomez et al, 1984. In the case of Indonesia, additional marine conservation areas were provided by the Ministry of State for Population and the Environment (1988) while for Malaysia, Mr. Jothy provided additional recommended areas.

Table 9. (Cont'd)

Country/Existing park	**Projects/Recommended areas**
PHILIPPINES (cont'd)	
- Camiguin Island Marine Sanctuary (1970)	
- Guiuan Peninsula Marine Sanctuary, Samar (1970)	
- Malampaya Sound Marine Sanctuary Palawan (1970)	
- Nasugbu Marine Sanctuary, Batangas (1970)	
- Panguil Bay Marine Sanctuary, Mindanao (1970)	
- Polillo Islands Marine Sanctuary (1970)	
- Turtle Islands Marine Sanctuary, Sulu (1970)	
- Southern Luzon Marine Biological Station	
- Macajalar Bay Marine Biological Station	
- Puerto Galera Marine Biological Station and Reserve, Mindoro	
- Matabungkay Bay, Luzon	
- Sumilon Island, Eastern Cebu (1974)	
SINGAPORE	
- none	- none
THAILAND	
- Koh Tarutao National Park off Satun (1974)	- Phi Phi Islands
- Similan Island Marine Park, Andaman Sea	
- Surin Island Marine Park, Andaman Sea	
- Nai Yang National Park	
B. HONG KONG	
- Tsim Bei Tsui	- Mai Po Marshes
- Pak Nai	
- Lung Kwu Chau, Tree Island & Sha Chau	
- Tai Tam Harbour (Inner Bay)	
- Tai Long Bay	
- Lai Chi Wo Beach	
- A Chau	

promising and widespread reef development in the region is anticipated. While some of these artificial structures are not permanent, continuous efforts by coastal inhabitants to maintain or replace them may have long term benefits.

5.4 Accidents and episodic events

Information on natural catastrophies in the region is available almost exclusively for the Philippines, and to a much lesser extent, for Thailand.

In the Philippines, the natural events that have caused some impact on coastal areas are volcanic eruptions, storm surges and tsunami. Major eruptions of Mount Mayon in 1984 resulted in mudflows into the sea on the southeastern coast of Luzon. A total volume of 1,389,740 m^3 of mud was reported to have reached the sea, the impact of which was not measured. The only available information indicates that leachates of mud contained mean concentrations of 59.1 ppm chloride, 281.3 ppm sulfate and 93.6 ppm sulphur.

Several tsunami have been recorded in the past century, with the most destructive one occurring in 1976. A violent earthquake (approx. magnitude 8) originating beneath the Moro Gulf south of Mindanao spawned a tsunami that affected 700 km of coastline. On shore, wave heights ranged from 3 m to a maximum of 9 m and water reached up to 2 km inland. About 8,000 persons died or were missing after the catastrophe with another 10,000 injured and about 90,000 rendered homeless. The most dramatic effect was on human settlements. Much beach and mangrove vegetation as well as marine life along the coast was also adversely affected. No assessment was made of the impact on marine communities.

Storm surges are somewhat more common than tsunamis, even though they are often mistaken for the latter. Although the effect may be similar, they are of entirely different origin. The piling up of water is brought about by storms or wind forcing up shallow bays. In the Philippines, typhoons in 1897, 1908, 1912, 1970 and 1975, among others, have been known to cause storm surges. In the last occurrence, water levels reached a height of 2.4 m on shore and more than 100 houses were washed out and other buildings damaged.

In Thailand, a series of strong depressions occurred in close succession in October 1983 which resulted in the flooding of the low-lying areas in many parts of the country for more than a month. Fortunately, there was no subsequent epidemic outbreak.

In Hong Kong an accidental oil spill in 1973 caused severe mortalities of bivalves, gastropods, sipunculids and crabs, but no great reduction of natural populations was found for most of the species except for the gastropods Monodonta labio and Nerita albicilla. A total kill of the meiofauna on the affected sandy beach was also found (Wormold, 1976; Stirling, 1977; Spooner, 1977).

Results of investigations after another accidental spill in Hong Kong in 1985 also showed that the effects of the oil spill were minimal (Shin, 1986). The total hydrocarbon content of water and sediment in the most affected areas decreased rapidly from 2.5 to 0.5 mg/l and 50 to 25 mg/kg respectively 20 days after the spill, and returned to background levels at the end of the 150 days study period. No reduction in species, number of individuals and species diversity was found on rocky shore, soft bottom and in plankton communities in the affected area, except for severe mortality of the rocky shore gastropod, Monodonta australis, immediately after the spill.

6. PREVENTION AND CONTROL STRATEGIES

The commercialization and industrialization of coastal areas usually go hand in hand with the growth of slums. Unless tackled in time, the slum dwellings degenerate and become major sources of pollution and public health hazards because solid and liquid waste reception facilities cannot cope with the demands of the new society.

Slum formation is inevitable in any country undergoing rapid urbanization. It calls for much effort to establish a network of sewers, drains, etc., and proper waste collection and treatment facilities. Provision of these facilities is essential as pollution control laws cannot be enforced without them. Thus prevention and control of marine pollution must be carried out within an integrated approach.

At the national level, marine pollution control strategies through land use regulations are currently practised in the region at various degrees of effectiveness.

Most countries in the region use environmental impact assessment (EIA) as a tool in their planning process. These include Indonesia, Malaysia, the Philippines, Thailand and Hong Kong. In Singapore, although EIA is not required by law, it is still done for large projects, like petrochemical plants. Otherwise, the control on environmental pollution is done through a thorough vetting process where all relevant authorities must endorse the project before it can proceed.

Zoning or segregation of incompatible development is necessary to try and balance the need for development and protection of the environment. In the Philippines, there are regulations to prevent the location of industries in highly urbanized areas, e.g., industries to be located outside the 50 km radius of Manila City Hall. In Singapore, there is a buffer zone of 100 m between the residential estates and light industries. Heavy and more polluting ones must be sited in specialized industrial parks. Industries are not allowed to discharge effluents into watercourses without specific approval from the Environment Authority. Indonesia's transmigration policy has succeeded in relieving over-congested coastal areas and provided homes for the poor, by moving excess population to less populated and resource-rich areas.

The agency responsible for coordinating environmental matters in Indonesia is the Office of the State Minister for Population and the Environment (KLH). The national themes of "The Environmental Principles of National Development" and "Development Without Destruction" are well adopted by decision makers, planners and environmentalists in Indonesia. Priority areas of concern have been identified, e.g.,

- problems related to forest utilization
- problems related to human settlement
- problems related to marine pollution

The KLH function now is much broader in scope. It coordinates national efforts on environmental matters, including drafting of laws and regulations and establishing environmental standards. In order to be effective, the KLH has to be supported by many government agencies, research institutions, universities and many national committees dealing with the environment. One such committee is the National Committee on Marine and Coastal Environments. One of the functions of this committee is to prepare rules and regulations on the development andmanagement of marine and coastal areas, monitor pollution and give advice to the KLH to take the necessary action on marine environmental protection.

The conservation and protection of natural resources and the environment is coordinated by the Directorate-General of Forest Protection and Nature Conservation of the Department of Forestry. Its responsibilities also include the coastal environment (coral reefs, mangroves) set aside as conservation areas and the development of the marine parks system.

The Centre of Oceanological Research and Development (CORD) of the Indonesian Institute of Sciences is the lead institution for research and monitoring of marine pollution. This centre plans to establish 22 monitoring stations located in key sites in Indonesian waters.

Many marine areas have been identified as national parks (Table 9) for the protection and conservation of critical marine ecosystems in the Asean region. Of these, Koh Tarutao National Park is also designated as an Asean Heritage Park. In Hong Kong, certain habitats like mangrove areas are classified as "Site of Special Scientific Interest" for a higher degree of protection. In the Philippines, the status of many parks is unknown. However, there is a growing awareness of the importance of marine parks and reserves, particularly for recreation and as replenishment areas for fisheries. In Malaysia, a total of 23 coastal marine locations have been gazetted as parks or fisheries prohibited areas (Malaysia, 1974, 1985).

In order to ensure that natural ecosystems will be conserved, a number of coastal nature reserves have been established in Indonesia. Currently, the Indonesian Government is exploring the possibility of increasing nature conservation areas, from the present 8 million to 10 million hectares by 1990, including a marine parks and reserves system.

Pollution control at source is effected through setting of standards, rules and regulations and strict enforcement. Water quality standards have been set up in most EAS countries. Thailand's water quality standards will be ready for implementation soon. Polluters are required to install effective pollution control facilities. Effluent discharge has to comply with Trade Effluent Standards. In Singapore, where industries discharge effluents exceeding the limits for discharge into public sewers, a levy is charged based on the concentration of the pollutants in the effluent. For direct discharge into watercourses, strict compliance with effluent standards is required. In the Philippines, a permit system has been instituted with corresponding penal provisions. In Malaysia, standards of effluent discharge are governed by the following regulations: Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979; Environmental Quality (Clean Air) Regulations, 1978; Environmental Quality (Prescribed Premises) (Crude Palm-Oil) Regulations, 1977; Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations, 1978; and Environmental Quality (Control of Lead Concentration in Motor Gasoline) Regulations, 1985.

Effective pollution control strategies need strict compliance with environmental laws. This needs a strong political will to implement as the tendency is to favour development rather than environment. Environmental infrastructures like sewage treatment works are costly, and it is easier to spend the money on creating jobs than protecting the environment. In some cases there may be a need to take unpopular decisions like resettlement and removal of the sources of pollution, e.g., re-site polluting industries away from the coastal areas or resettle squatter colonies into proper premises. This has been done in Singapore and is planned for implementation in Hong Kong and Malaysia.

Besides the above measures, Indonesia, Malaysia, Singapore, the Philippines and Hong Kong have oil spill contingency plans. Thailand is drawing up its national oil spill contingency plan although the oil companies in Thailand already have a shared oil spill contingency plan.

To sustain long term prevention and control, effectiveness depends on the environmental awareness of the people in the region. Environmental education is therefore essential in maintaining a healthy marine environment. Environmental education and awareness have been accorded top priority in the EAS region and are actively being pursued by Indonesia, Malaysia, the Philippines, Singapore, Thailand and Hong Kong.

As pollution of the marine environment is not constrained by national boundaries, regional co-operation to sustain the health of the marine environment is very important. Regional co-operation in prevention of accidents and marine pollution has been successfully implemented in the EAS region. Examples of this include

1. Traffic Separation Scheme in the Straits of Malacca and Singapore.
2. Tripartite Agreement to Combat Oil Spills in the Straits of Malacca and Singapore.
3. Tiered Area Oil Spill Response Capability Plan.
4. ASEAN Oil Spill Contingency Draft Plan.
5. ASCOPE Plan for the Control and Mitigation of Oil Pollution.
6. Regional Plan to Combat Oil in the Straits of Lombok/Makasar and the Celebes (Sulawesi) Sea.

Since the Traffic Separation Scheme was implemented there has been no major accident in the Straits of Malacca, the last being the Diego Silang incident in 1976.

The regional exchange of information is now being increasingly encouraged in an effort to prevent environmental disasters.

In addition to the above, EAS countries are signatories to a number of international conventions related to the marine environment as shown in Table 10.

7. TRENDS AND FORECASTS

By the end of the Twentieth Century, 15 of the world's 25 most populous cities will be found in Asia. Of these 15 cities in Asia, 13 will be situated in coastal areas, each with a population of more than 10 million people. The waste from such human settlements and the associated economic activity is enormous and in many of the cities, the waste enters raw into the coastal waters. It can also be anticipated that increasing ship traffic will result in further contamination of coastal waters, whether from oil, hazardous chemicals, or litter.

The countries in the EAS region are mainly coastal states. Indonesia and the Philippines comprise mainly of islands and it can be assumed that virtually the entire population in these countries has an impact on the marine environment in the region. The trend for an increasing population is still forecast by the World Bank. A comparison of the population in 1985 and the projections for the year 2000 showed the following:

Table 10. International Conventions

1	UN Convention on Law of the Sea	Brunei, Indonesia, Malaysia Philippines, Singapore
2	International Convention relating to Limitation of Liability of Owners of Sea-going Ships	Singapore
3	Convention on the International Maritime Organization (IMO)	Indonesia, Malaysia, Philippines Singapore, Thailand
4	Convention on Facilitation of International Maritime Traffic	Singapore
5	International Convention for the Safety of Life at Sea	Philippines, Singapore
6	International Convention on Loads Lines	Philippines, Singapore
7	Agreement on the International Association of Lighthouse Authorities (IALA)	Singapore
8	Convention on the International Hydrographic Organization	Malaysia, Singapore
9	Protocol of Agreement to the International Convention of 1924 for the Unification of certain Rules of Law relating to Bills of Lading	Singapore
10	Agreement for the Facilitation of Search for Ships in Distress and Rescue of Survivors of Ship Accidents	Singapore
11	Convention on the International Regulations for Prevention of Collisions at Sea	Malaysia, Singapore
12	Convention on International Maritime Satellite Organization	Singapore
13	International Convention on Civil Liability for Oil Pollution Damage	Indonesia, Hong Kong, Singapore
14	Protocol to the International Convention on Civil Liability for Oil Pollution Damage	Singapore
15	Convention on the Continental Shelf	Malaysia, Thailand
16	Convention on the High Seas	Indonesia, Malaysia, Thailand
17	Convention on International Trade in Endangered Species of Wild Fauna and Flora	Indonesia, Malaysia, Philippines Singapore, Thailand, Hong Kong

	1985	2000 (million)
Indonesia	165	204
Malaysia	16	21
Philippines	55	75
Singapore	2.6	3
Thailand	52	66
TOTAL	290.6	369

(From World Resources Institute and International Institute for Environment and Development, 1986)

In the ASEAN countries alone, the population is expected to increase by 27% over a 15-year period. This would certainly increase pollution stress and pressures from exploitation of resources of the marine environment.

Marine water quality in Hong Kong (1985 population: 5.5 million) has been deteriorating over the past 10-15 years . Even with the construction of sewage treatment plants, there was no significant improvement. The emphasis on environmental improvement is expected to lead to some amelioration. There are plans to move polluting farms and industries away from coastal areas which should lead to a general improvement in the marine environment.

Malaysia's success in controlling palm oil effluent discharges has reduced the BOD entering the marine environment from 202,000 tonnes in 1980 to 148,000 tonnes in 1985. Deforestation and earthworks in the country have increased soil erosion causing 26 million tonnes of surface soil to enter the Straits of Malacca annually. However, with commitment from the highest government levels to improve the environment, it is expected that the degradation of the marine environment will be checked. An example of a positive development is the establishment of artificial reefs in Malaysian coastal waters which is expected to generate increased biological productivity in the years to come (Jothy, 1986).

Utilization of resources is still proceeding at a rate beyond natural replenishment in the Philippines. Over a period of 70 years, mangrove cover decreased by 75%. There was also a decline in the demersal fisheries standing stock by 3% a year and a decline in the quality and quantity of coral reefs and seashell resources. Concentration of trace metals in Manila Bay and areas affected by mine tailings has been increasing.

Singapore's marine water quality has been improving over the past 10 years. Most areas are expected to maintain their present level of cleanliness except for the Serangoon River mouth where a significant improvement in water quality isnot expected until late 1989 when pig farms will be removed.

In Thailand, it has been reported that natural resources, like forest cover and fish, have decreased in quantity. However, it was also noted that artificially introduced contaminants have also decreased. The quality of fresh water has improved but this cannot be said of coastal areas where tourist development is taking place. Much of the pollution in these areas is caused by back-yard tourism and migrant workers flocking to these new development areas in search of a livelihood.

Whilst there appears to be an increasing awareness of the urgent need to control marine pollution, the cost to effectively implement such a programme is very high. On the other hand, the economics of not doing so could be worse. This needs a strong commitment from political leaders. A concrete step in this direction is the Jakarta Declaration of 1987 where the Environmental Ministers of ASEAN adopted a resolution on sustainable development. A start has already been made in all EAS countries but more effort is needed to push forward the task of protecting the health of the marine environment.

Climatic change effects

There is limited information available on the effects of climatic change in the region. Available data are presented below.

Annual mean air temperature readings in Hong Kong for the period 1884-1986 exhibit an increasing trend (Fig. 7) which is more pronounced during the period 1950-1960. No obvious trend is observed in mean sea temperature readings at Waglan Island, Hong Kong for the period 1958-1986 (Fig. 8) and in annual mean sea level at North Point, Hong Kong for the period 1977-1985 (Fig. 9).

Mean maximum air temperatures measured at a meteorological station (Bayan Lepas) in peninsular Malaysia indicate an increase of 0.5°C maximum air temperature, over a 50 year period (1935-1985) (Malaysian Meteorological Service, pers. comm.).

An analysis of 80-year mean sea level (MSL) data at three tide stations in the Philippines showed no discernible trend in Cebu (Fig. 10) and increasing trends in Manila (Fig. 11) and Davao (Fig. 12). The MSL increase in Davao is noted at approximately 15 cm for a 30-year period while in Manila, an increase of about 2 cm per year is noted for the period 1965-1985. The variation was attributed to development activities such as reclamation, fishpond construction, and coastal subsidence due to over-abstraction of groundwater. Siltation of the waterways is also a possible contributing factor to MSL variation.

Mean air temperature readings in Baguio, Philippines show an increasing trend (Fig. 13). Temperature readings in Manila (Manila International Airport), however, while exhibiting a progressive increase for the period 1950-1980, show a decline commencing on the year 1981 (Fig. 14). On a national perspective, loss of vegetative cover is one factor identified as influencing temperature variation.

Mean sea level data generated over a 41-year period from 29 stations in the Gulf of Thailand exhibit numerous fluctuations but no trend is readily recognized (Siripong, 1985). Three stations near Bangkok, however, show a slight rise in MSL. Bangkok which is about 2 m above MSL is believed to be "sinking" as a result of heavy groundwater abstraction in several of the city's suburbs.

The impact of climatic change in the region cannot be assessed at this time. A separate study will address this question.

8. ECONOMICS

An in-depth discussion on the economic implications of environmental impact in the EAS region is not possible at this juncture. Environmental issues that may be expected to have an economic bearing on countries in the region are raised below:

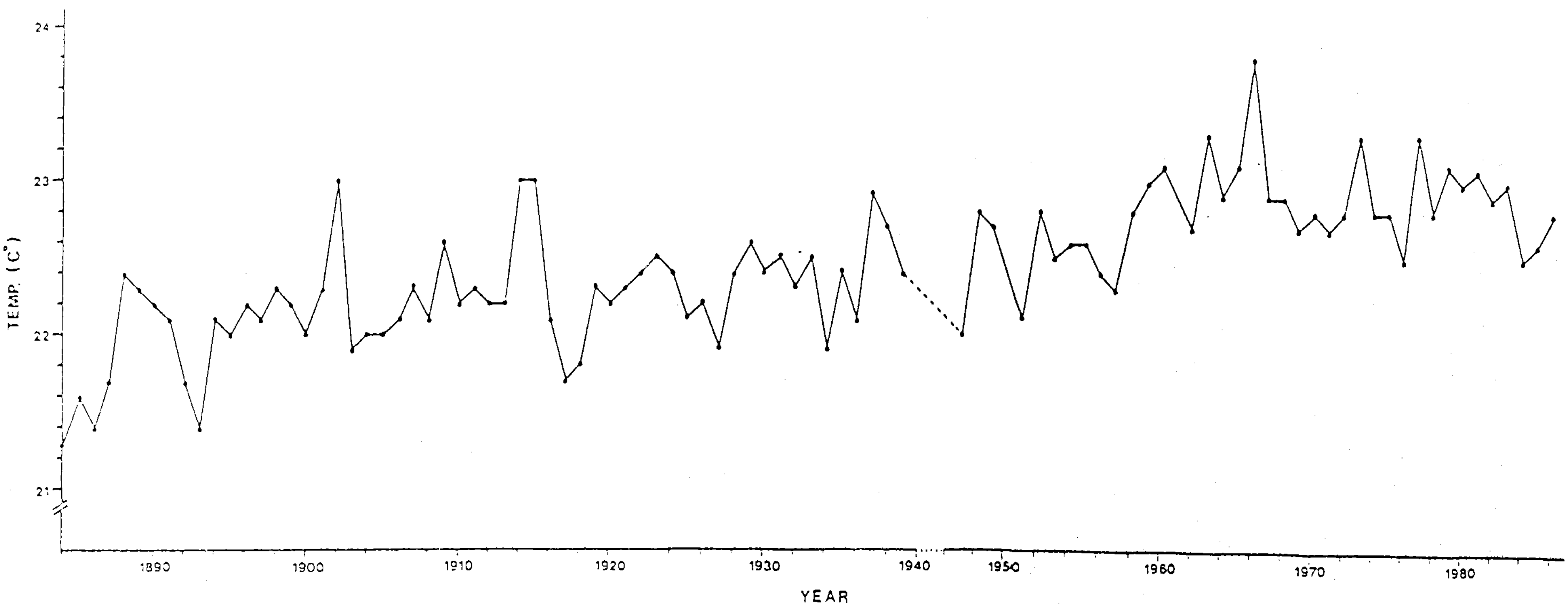


Fig. 7. Annual mean air temperature in Hong Kong (Wu, 1987)

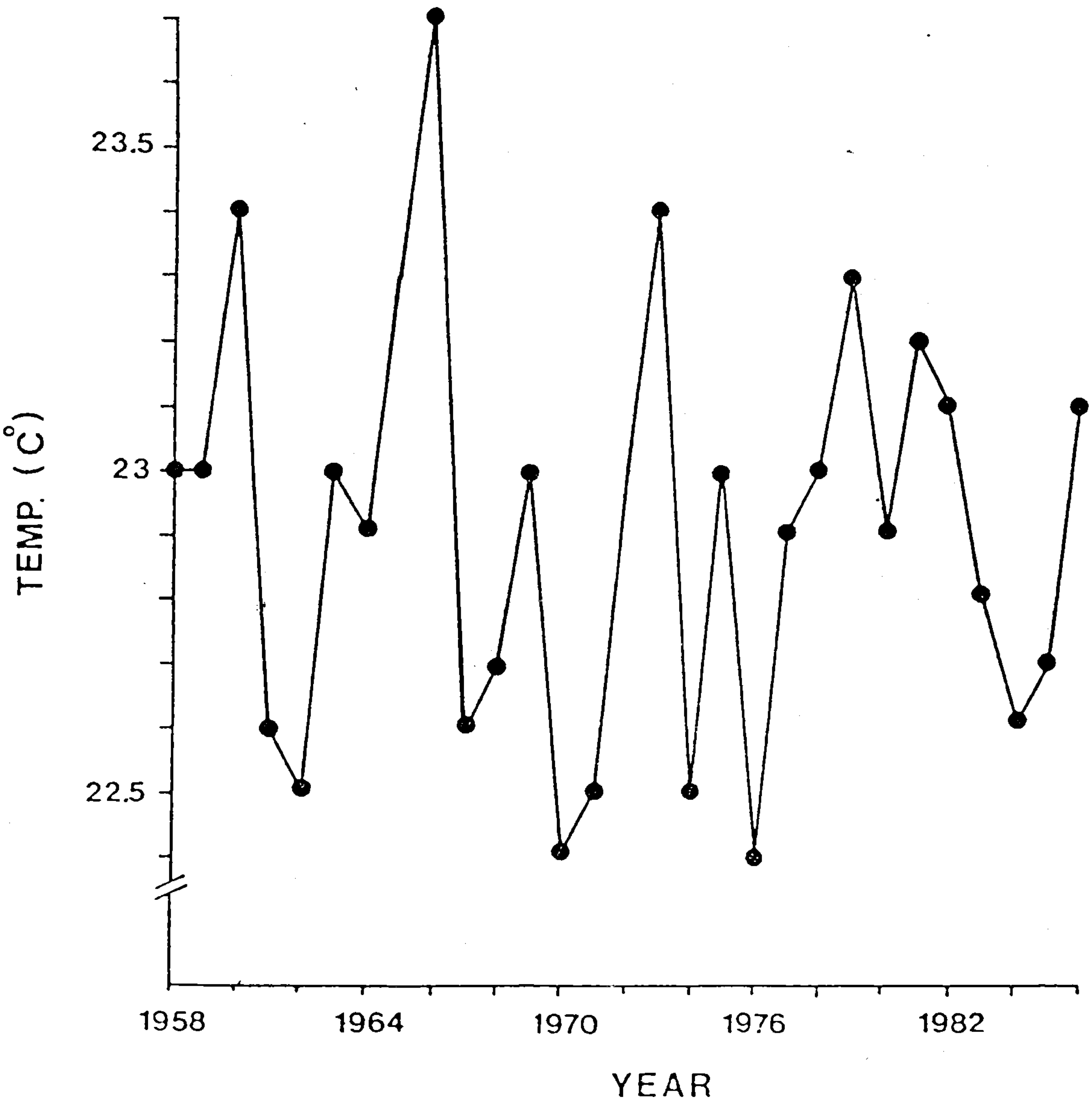


Fig. 8. Sea surface temperatures (°C) - annual mean (Waglan Island, Hong Kong) (Wu, 1987)

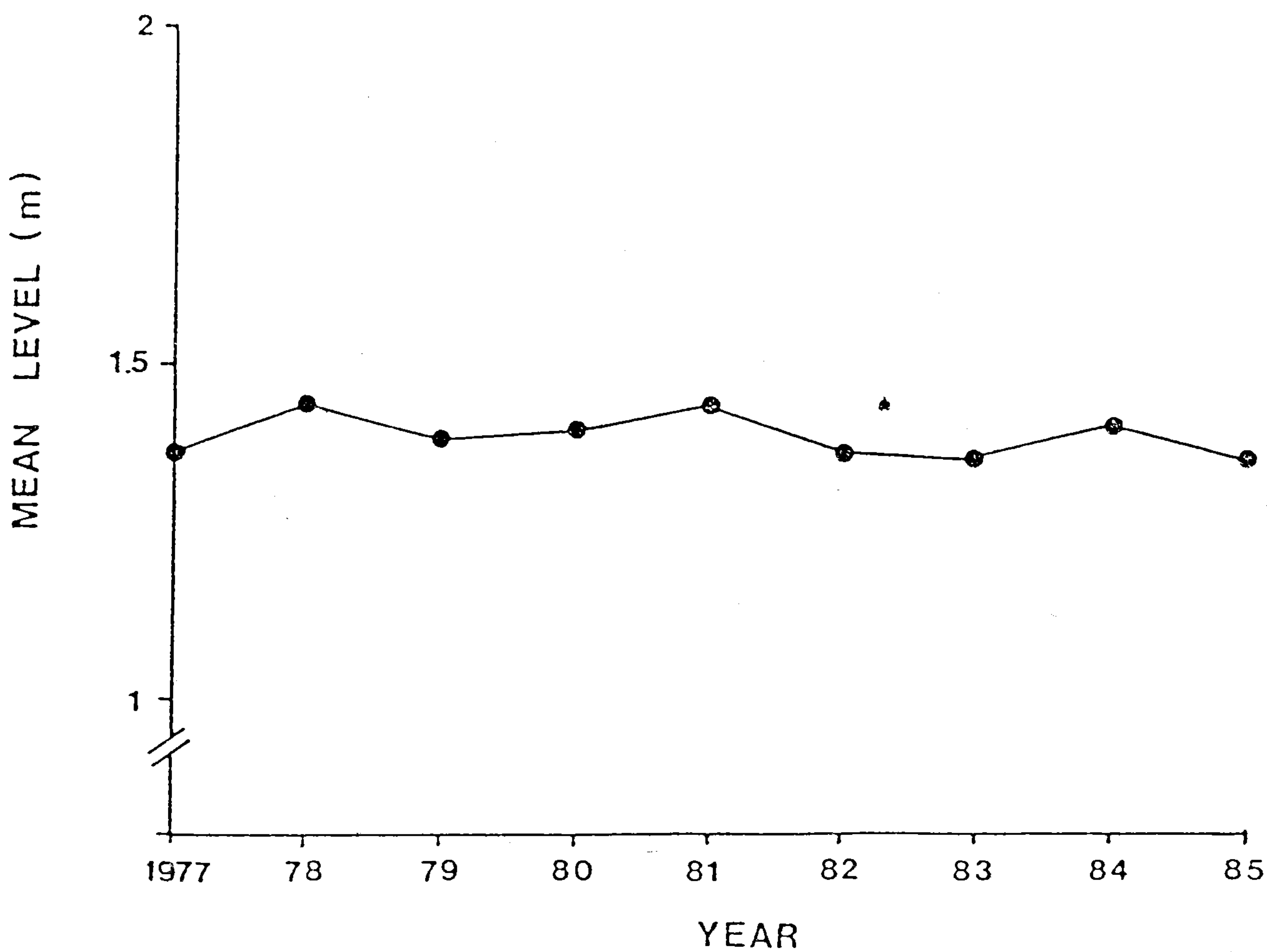


Fig. 9. Annual mean sea level about chart datum at North Point, Hong Kong (Wu, 1987)

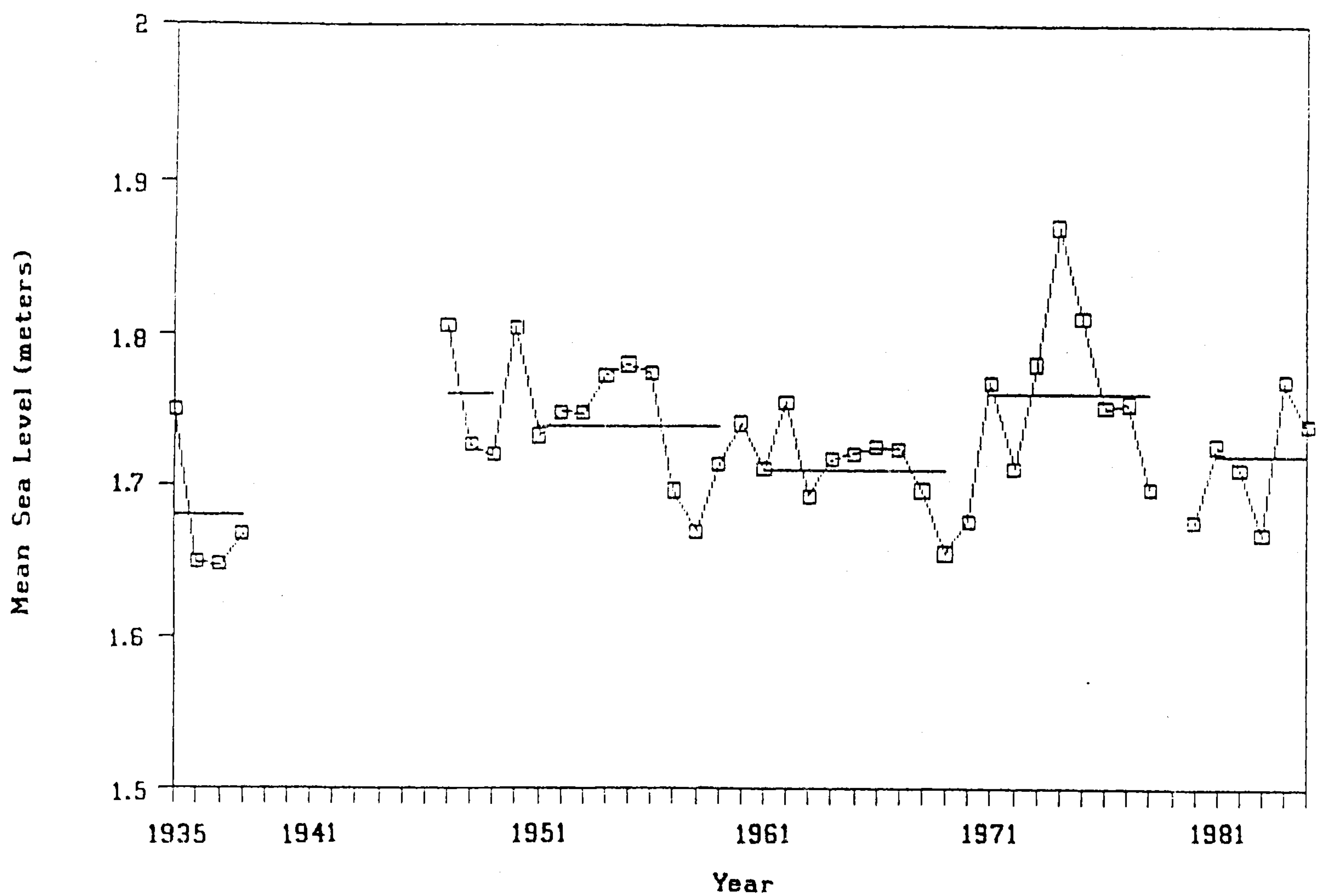


Fig. 10. Annual mean sea level in Cebu, Philippines, 1935-1985
(Gomez & Deocadiz, 1987)

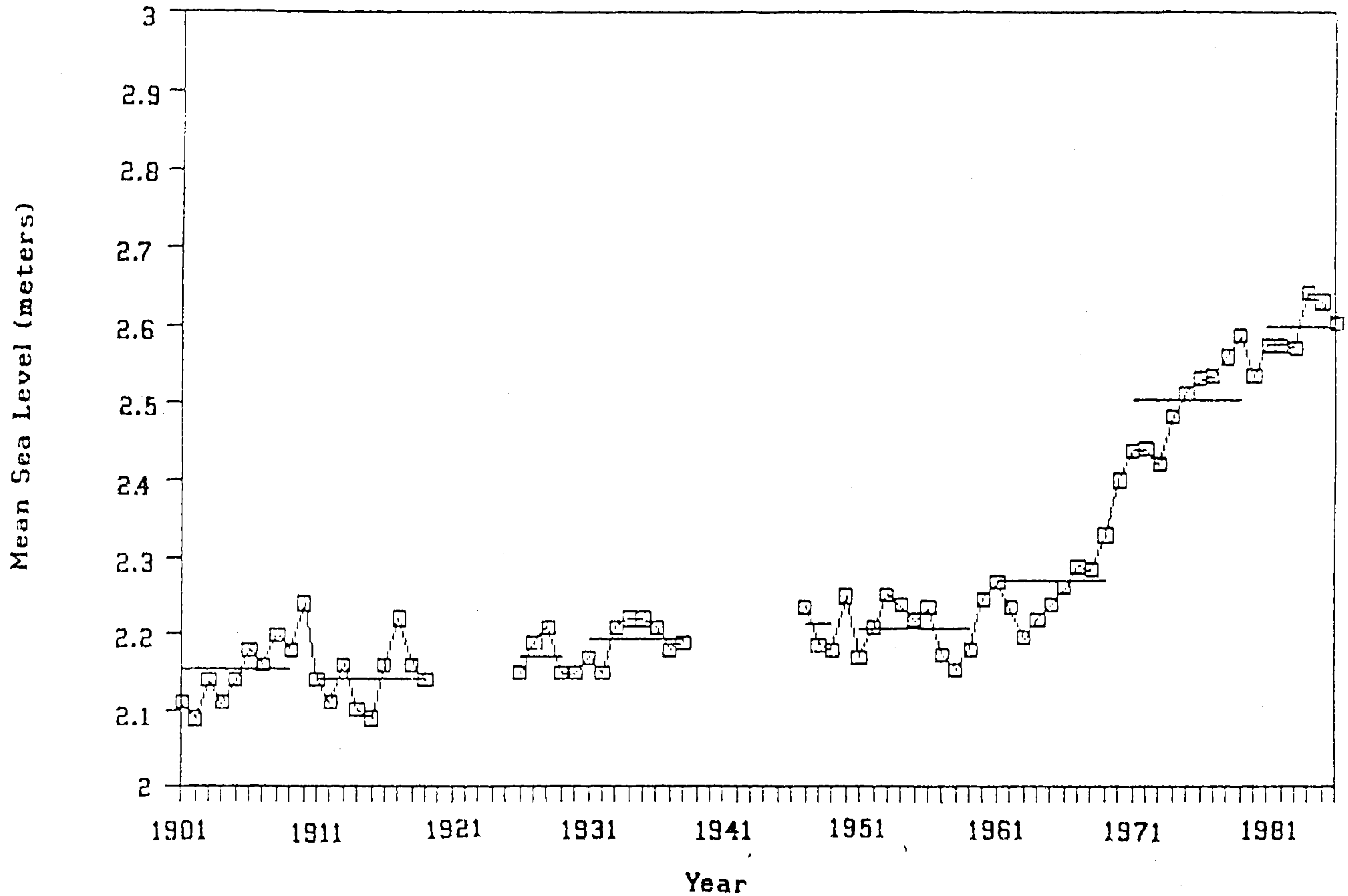


Fig. 11. Annual mean sea level in Manila 1901-1986
(Gomez & Deocadiz, 1987)

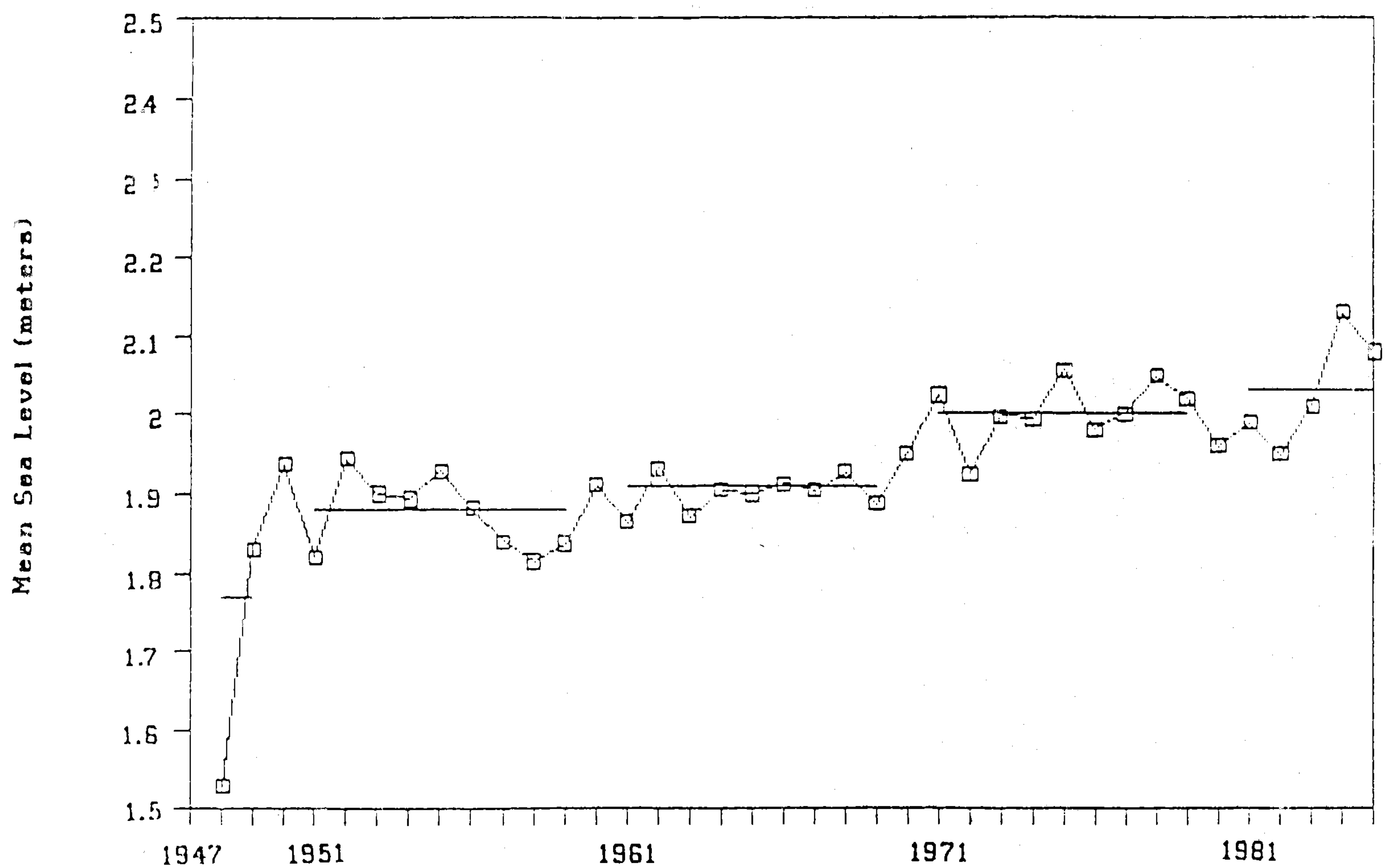


Fig. 12. Annual mean sea level in Davao, Philippines 1947-1985
(Gomez & Deocadiz, 1987)

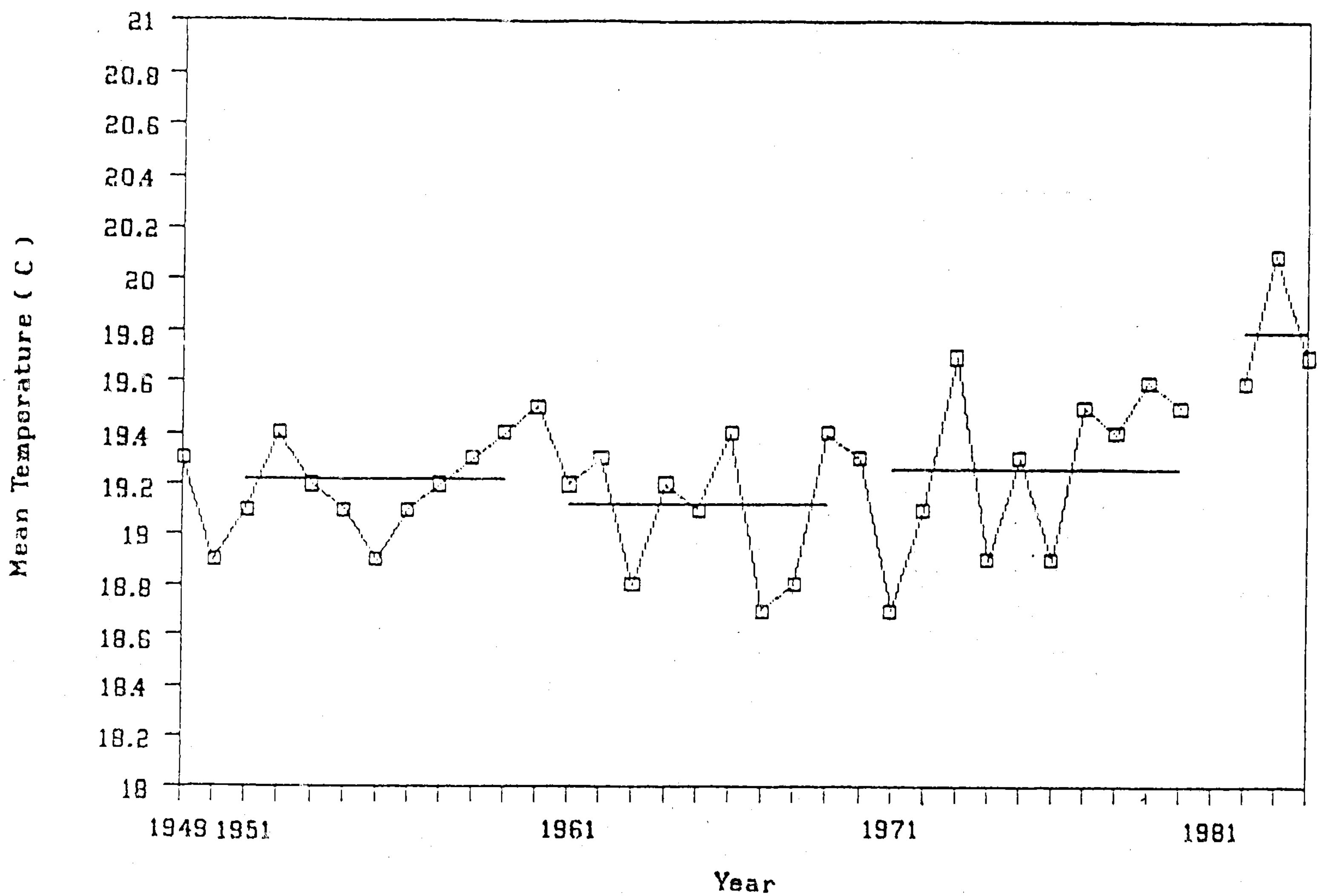


Fig. 13. Annual mean temperature in Baguio, Philippines 1949-1984 (Gomez & Deocadiz, 1987)

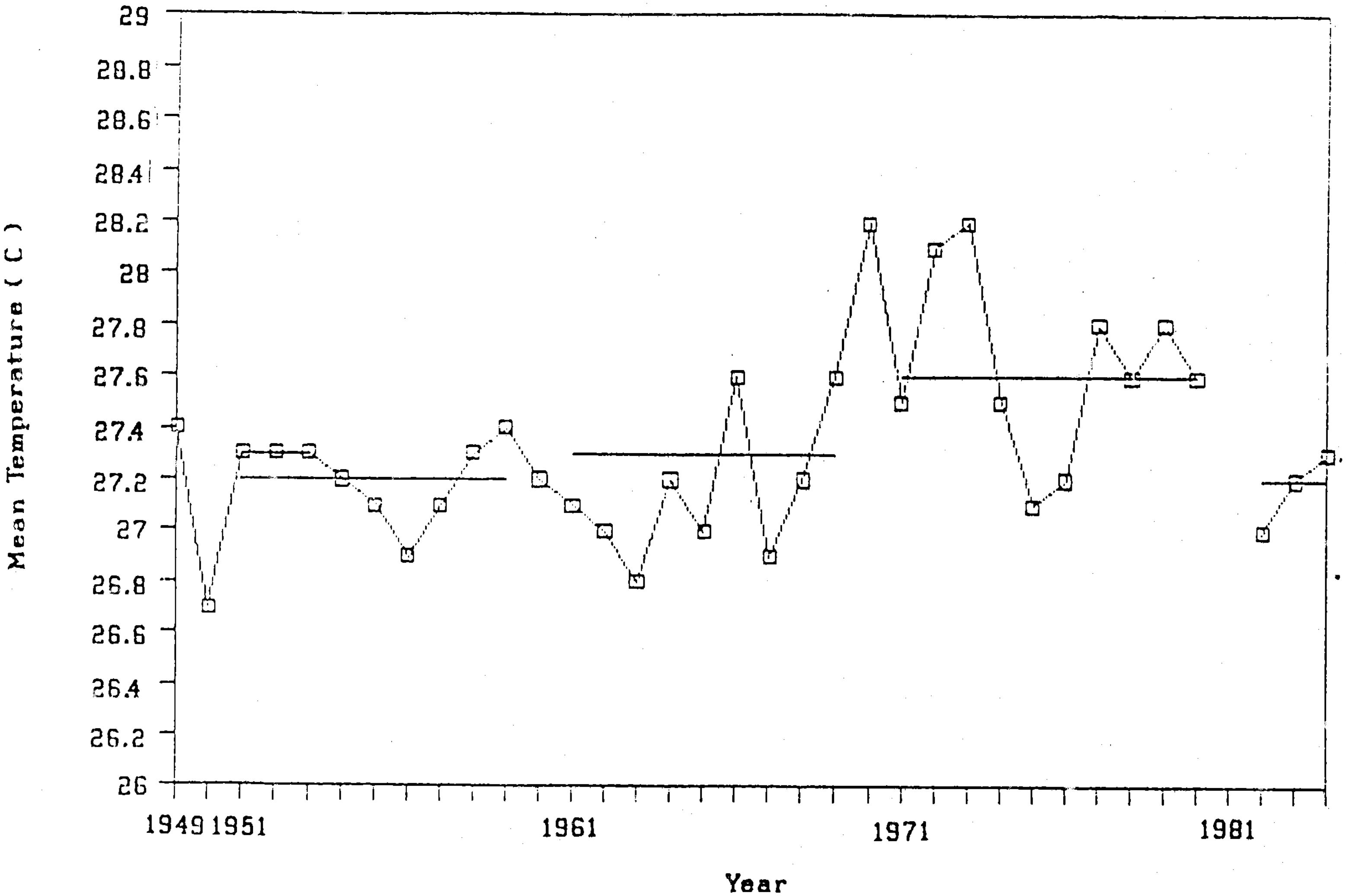


Fig. 14. Annual mean temperature at Manila International Airport 1949-1984
(Gomez & Deocadiz, 1987)

(a) Pollution caused considerable losses to the mariculture industry in Hong Kong. Detailed losses during 1976 - 1986 are tabulated as follows:

Cause	Total no. of incidents	Total loss (tonnes)	Total loss (in HK$)
Red tides, algal blooms & oxygen depletions	38	124	6,437,000
Coastal development (e.g. reclamation, silting etc.)	7	12	1,072,000
Oil spillages	5	132	4,038,000
Toxic discharges (from industries or accidents)	4	2	101,000
TOTAL	54	270	11,648,000

(b) The clean up cost for the "Frota Durban" accident in 1985 paid by the Hong Kong Government (including dispersants, staff and equipment cost, transport and administrative cost) was estimated at HK$1.2 million (HK$7.80 = US$1.00). The cost was recovered from the ship owner.

The operational resources involved in clearing the oil spill from the "Evergrand" was 300 men, 20 craft and 10,000 gallons of dispersant, working continuously for 180 hours. The amount of oil spilled was 400 tons.

The cost to clean up a recent oil spill of 50 tons off the east coast of Singapore was about S$400,000 (S$2.05 = US1.00).

(c) The cost of restoring marine life to the Singapore River and Kallang Basin was about S$300 million.

In order to improve water quality in Tolo Harbour, the Hong Kong Government has agreed to spend HK$ 4 billion for : (a) dredging the river bed in the catchment area, (b) control of animal wastes and (c) improving the sewage treatment facilities.

(d) The cost of clean-up of oil spills in the Straits of Malacca, by Malaysia, amounted to M$260,756 for the 1975 SHOWA MARU Oil Spill and M$2,661,639 for the 1976 DIEGO SILANG Oil Spill.

Penalties and fines levied on industries in Malaysia, for effluents discharged against the established standards, amounted to M$680,787 for the period 1979-1985.

The dredging of harbours and estuaries in Malaysia, as a result of heavy siltation, was carried out at a cost of M$297 million for the period 1979 - 1983; the volume of dredge spoils amounted to 90.9 million m^3 for the same period. A further expenditure of M$107.8 million is expected to be required for the continuation of the activity for the period 1985 - 1988, when about 27 million m^3 of silt are expected to be dredged.

Finally, we note below the potential economic consequences of various impacts on the coastal and marine environment:

(a) Oil spills - Cost of clean-up; environmental damage in terms of loss of living aquatic resources, including the sensitive eggs and larval stages which will form the future stocks of the fishery; damage to fishing gear; loss of livelihood by fishermen; loss of revenue from tourism as a result of damage to recreational beaches; compensation; etc.

(b) Industrial effluents - Environmental damage in terms of loss of marine and aquaculture resources; cost of restoration of the marine environment; fines and compensation.

(c) Dredge spoils - Offshore dumping of dredge spoils from harbours and estuaries, in the absence of coastal hydrographic considerations, have frequently led to the rapid return of the dredge spoils to their original location; environmental damage caused by the dumping, especially in ecologically sensitive areas, leading to losses of valuable aquatic resources; loss of livelihood for fishermen; etc.

(d) Coastal reclamation - Resultant changes in coastal hydrography leading to erosion of other shorelines, particularly recreational beaches; loss of revenue from tourism; loss of valuable shellfish beds; compensation.

(e) Sewage effluent - Leading to microbial contamination of shellfish beds and the resultant loss of export earnings from shellfish; increased cost to consumers of clean or depurated shellfish; loss of livelihood by shellfish farmers; human health problems resulting from the consumption of contaminated shellfish; etc.

(f) Eutrophication - A phenomenon that is often implicated in red tides and paralytic shellfish poisoning (PSP), which could invariably lead to loss of export earnings from fish and shellfish, human health problems, and loss of livelihood for fishermen and shellfish farmers.

9. SUMMARY

This report is a first attempt to provide a perspective of the state of the marine environment in the East Asian Seas region, that is, the marginal seas surrounding the ASEAN countries including Hong Kong (Fig. 1).

The tropical seas covered by the report lie between the Asian mainland and the Australian continent, interspersed with some 20,000 islands. These islands plus the sections of the Asian mainland that include Thailand and part of Malaysia and Hong Kong, harbour a population of about 300 million people, the majority of whom are coastal dwellers.

Marine contaminants have been analyzed sporadically in water, sediments and biota. Results to date indicate generally low levels but with some noteworthy exceptions in some of the heavily used bays. Because of limited capability in the region, a more comprehensive picture of concentration levels and trends of many contaminants remains to be developed. Some efforts are being taken to improve quality of data and manpower capability in the region through intercalibration and training.

The major source of organic pollution in the region is sewage, much of which is discharged raw into coastal waters whether directly or through rivers and waterways. Elevated faecal coliform levels are detectable near population centres with the notable exception of Singapore which has waged a concerted effort to curb pollution at source. Organic inputs from industries are considerable near industrialized areas, although there is no evidence that toxic contaminants are being released in high concentrations.

Significant portions of coastal areas have been developed for residential, agricultural and industrial land uses. Virtually no natural coastlines remain in Hong Kong and Singapore because of their high population densities. In the larger countries, coastal alteration is most pronounced at population centres.

Where industries have developed, there is some evidence of industrial waste disposal at sea including mine tailings. However, this is not widespread as the region is not heavily industrialized. Litter is more evident, particularly near ports and harbours. Both ports and shipping lanes are exposed to some oil contamination because of the large volume of petroleum products that transit the area (approx. 3 million bbls/day). A few major oil spills have occurred in the region.

While much of the transported oil comes from other regions, oil and gas production within Southeast Asia is significant, amounting to about 2 million bbls/day and 5 billion ft^3/d respectively, nearly half of which is offshore. Some tin mining is carried out on the seabed, principally in Thailand.

Southeast Asian nations are reliant on fisheries for a significant proportion of their protein intake. Thailand and the Philippines each produce about two million tonnes annually. However, due to over-exploitation and destructive fishing methods, some stocks have manifested a declining trend. Some efforts are now being taken to increase mariculture production as an alternative.

The sewage discharge mentioned above has led to eutrophication of some coastal waters. In recent years, more red tides have been reported in the region, although the link to eutrophication or sewage discharge has yet to be established. There is more direct evidence that eutrophication adversely affects benthic communities.

Red tides are both toxic and non-toxic. A number of incidents involving paralytic shellfish poisoning have been recorded in virtually all the countries in the region. In several cases, the causal organism is the dinoflagellate Pyrodinium bahamense var. compressa.

Elevated coliform counts in some coastal waters have been taken as an indication of the presence of pathogens in the water. Some pathogenic bacteria have been reported occasionally, resulting in the closure of swimming beaches. Chronic public health problems arise and an outbreak of hepatitis in 1985 in Hong Kong (and China) has been associated with the consumption of shellfish.

More and more concern has been expressed at the destruction of productive ecosystems like mangrove swamps and coral reefs. Since these are known to support fisheries, their continued degradation will have great repercussions. Efforts are now being made to conserve these habitats and in some instances, steps are being taken to rehabilitate them. It is hoped that the natural recovery process which normally takes decades may be shortened considerably.

There have been a few major oil spills. Natural catastrophes have also been reported in the region. The annual cyclones have occasionally caused storm surges that have destroyed natural communities and human settlements.

All countries in the region are now taking measures to protect the marine environment, spearheaded by their respective environmental departments. Measures include pollution control at source, environmental impact studies, national and regional legislation to prevent and respond to oil spills, and adherance to internatonal conventions on the protection of the marine environment. The establishment of marine protected areas is also now more common.

With a rapidly expanding population, the stresses on the marine environment are likely to continue. However, more and more resources are being committed to environmental protection, so that the rate of degradation is being reduced. Indeed, in some cases a reversal of the trend has been achieved. More and more countries are realizing the high costs of pollution and it makes more economic sense to shift towards prevention rather than damage control.

10. REFERENCES

Adnan, Q. (1984a), Blooming and distribution of some dinoflagellates along the northern coast of Java. Paper presented at the Red Tide Workshop, Cronulla, New South Wales, Australia, 11-20 June 1984.

Adnan, Q. (1984b). Distribution of dinoflagellates at Jakarta Bay, Taman Java, Banten and Benoa Bay, Bali: a report of an incident of fish poisoning at Eastern Nusa Tenggara. In Proceedings of the Consultative Meeting on Toxic Red Tides and Shellfish Toxicity in Southeast Asia, Singapore, 11-14 September 1984, edited by A.W. White, M. Anraku and K.K. Hooi. SEAFDEC and IDRC, pp. 25-27.

Ahmad, I. (1988), Petroleum industry and the environment in ASEAN. UNEP Reg.Seas Rep.Stud., (96).

Alcala, A.C. and E.D. Gomez (1979), Recolonization and growth of hermatypic corals in dynamite-blasted coral reefs in the Central Visayas, Philippines. N.Z.Dept.Sci.Ind.Res.Inf.Ser., 137(2):645-61.

Alcala, A.C., E.D. Gomez, L.C. Alcala and T.F. Luchavez (1986), Notes on the recovery of coral reef at Pescador Island, off Moalboal, Cebu, Philippines, from typhoon damage. Silliman J., 33(1-4):24-30.

Anon. (1984), The Singapore River - A flow of history. The Mirror, Singapore, 15 November 1984.

Bilal, J. (1985), The state of hydrocarbon pollution in the East Asian Seas based on studies in the Southeast Asian Seas region. UNEP Reg.Seas Rep.Stud. (69):217-34.

Bilal, J., et al (1982), Occurrence of tar pollution along shores in Indonesia. In French-Indonesian Research Cooperation in Oceanography. Jakarta, LEMIGAS and CNEXO.

Chan, D.K.O. and M.S.F.L.K. Jie (1977), The extent of oil pollution in the beaches and inshore waters of Hong Kong. In Biological Research in Southeast Asia, edited by B. Lofts and S.T.H. Chan. Dept.Zool.Univ. Hong Kong Occas.Pub., (3):160-6. 160-166.

De Vera, M. R. (1978), Factors affecting soil erosion in the Philippines. In Proceedings of the Seminar-Workshop on the Integration of Soil Conservation Concepts in the School Curriculum, Los Baños, Philippines, 24-26 October 1978. Quezon City, National Environmental Protection Council, pp 37-56.

Estudillo, R.A. and C.L. Gonzales (1984), Red tides and paralytic shellfish poisoning in the Philippines. In White A.W. et al (eds). Proceedings of the Consultative Meeting on Toxic Red Tides and Shellfish Toxicity in Southeast Asia, Singapore, 11-14 September 1984. Singapore, SEAFDEC and IDRC, pp 52-9.

Finn, D.P., Y. Harayama, M.J. Meimandi-Nejab, T. Piyakarnchana and J.N. Reeves (1979), Oil pollution from tankers in the Straits of Malacca: a policy and legal analysis. Honolulu, Hawaii, East-West Center, Open Grants Papers, (6):153p.

Forstner, U. and G.T.W. Wittmann (1981), Metal Pollution in the Aquatic Environment. Berlin, Springer Verlag, 2nd ed., 486 p.

Gomez, E.D., R.T. Bina and C.A. Rodriquez (1984), Marine parks in ASEAN countries. In Proceedings of the first ASEAN Forestry Congress, Manila, 10-15 October 1983, edited by Bureau of Forest Development, Quezon City, Ministry of Natural Resources, Book 3, (6):811-20.

Huizenga, D.L. (1981), The cobalt-APDC coprecipitation technique for the preconcentration of trace metal samples. Graduate School of Oceanography, University of Rhode Island, Technical Report (81-3):93 p.

Hungspreugs, M. (1985), Marine pollution by heavy metals in the East Asian Seas Region. UNEP Reg.Seas Rep.Stud., (69):239-48.

Hungspreugs, M. and G. Wattayakorn (1978). Comparative studies of DDT residues in sea water, sediments and marine organisms in the Gulf of Thailand and the Andaman Sea. Bangkok, Chulalongkorn Universtiy, Report on Scientific Research, Faculty of Science, (3):96-104.

Hungspreugs, M. and C. Yuangthong (1984). The present levels of heavy metals in some molluscs of the Upper Gulf of Thailand. J.Water Air Soil Pollut., 22(4):395-402.

Hungspreugs, M., S. Silpipat, C. Tonapong, R.F. Lee, H.L. Windom and K.R. Tenore (1984). Heavy metals and polycyclic aromatic hydrocarbon compounds in benthic organisms of the Upper Gulf of Thailand. Mar.Poll.Bull., 15(6):213-8.

Huschenbeth, E. and N. Harms (1975). On the accumulation of organochlorine pesticides, PCB and certain heavy metals in fish and shellfish from Thai coastal and inland waters. Arch.Fisch.Wiss., 26:109-22.

Indonesia, Ministry of State for Population and the Environment (1988). Oil pollution control measures and arrangements in Indonesia. UNEP Reg.Seas Rep.Stud., (96).

Ip, H.M.H. (1983). Breast milk contaminants in Hong Kong. Bull.Hong Kong Med.Assoc., 35:1-16.

Jaafar, A.B. (1986). Quality and control of river discharges into Malaysian coastal waters. Ensearch Malaysia, 2(1):5-13.

Jothy, A.A. (1984a). Capture fisheries and the mangrove ecosystem. In Ong, J.E. and W.K. Gong (eds). Productivity of the Mangrove Ecosystem: Management Implications. Penang, Universiti Sains, pp 129-41.

Jothy, A.A. (1984b). Status of shellfish toxicity and related problems in Malaysia. In White, A.W., M. Auraku, and K.K. Hooi (eds.). Proceedings of the Consultative Meeting on Toxic Red Tides and Shellfish Toxicity in Southeast Asia, Singapore, 11-14 September 1984. Singapore, SEAFDEC and IDRC, pp. 33-4.

Jothy, A.A. (1986). Artificial reef development in Malaysia. In Wong, T.M., J.E. Ong, and K.S. Ong (eds.). Towards greater productivity of our coastal waters. Penang, Malaysian Society of Marine Sciences, pp. 5-16.

Kueh, C.S.W. and L.B. Trott (1972). A preliminary bacteriological examination of water and shellfish in Shatin Hoi, Hong Kong. Chung Chi J., 12:79-84.

Law, A.T. (1986). Monitoring of sewage pollution in the estuarine and coastal waters off Port Kelang, Malaysia. In Proceedings of the International Conference on Tropical Living Aquatic Resources, Serdang, Malaysia, 2-5 August 1983, edited by H.H. Chan et al, Serdang, Universiti Pertanian Malaysia, pp. 236-41.

Law, A.T. and Z.B. Mahmood (1987). Distribution of petroleum hydrocarbons in the south-western portion of the South China Sea. Fac.Fish.Mar.Sci., Univ.Pert. Malaysia, Occas.Publ., (4):53-60.

Law, A.T. and M.K.A. Rashid (1986). Inorganic nitrogen and phosphate distribution in the South China Sea.

Law, A.T. and A.R. Shaik (1987). Phosphate distribution in the southwestern portion of the South China Sea.

Law, A.T. and R.B. Yusof (1986). Hydrocarbon distribution in the South China Sea.

Leung, C., K.F. Shortridge, B. Morton and P.S. Wong (1975). The seasonal incidence of faecal bacteria in the tissue of the commercial oyster Crassostrea gigas Thunberg 1793, correlated with the hydrology of Deep Bay, Hong Kong. In: Morton, B. (ed.). Proceedings of the Pacific Science Association Special Symposium on Marine Science. Hong Kong, The Government Printers, pp. 114-27.

Malaysia, State of Sabah (1974). The National Parks ordinance, 1962. Second supplement to the Government Gazette, No. S23.

Malaysia (1985). Fisheries Act, 1963. His Majesty's Government Gazette, P.U. (A) 140.

Malaysia, Department of Environment (1986a). Comparative analysis of marine pollution in the Strait of Johore 1985. Kuala Lumpur, Department of Environment, 14 p.

Malaysia, Department of Fisheries (1986b). Annual fisheries statistics, 1985. Kuala Lumpur, Department of Fisheries, Ministry of Agriculture, 117 p.

Martin, S.L., M. Marchand, A.M. Le Gueblec and J.P. Caprais (1983). Determination de la pollution chimique des baies de Jakarta, Banten, Cilacap (Indonesia), hidrocarbures, organochlores, methane. Paris, CNEXO-COB-ELGEM, Doc. EL/Chimie/ YLM-MM/233/83:57 p.

Meijerink, A.M.J. (1977). A hydrological reconaissance survey of the Serayu River basin, Central Java. I.T.C. Journ.,Enschede, 1977:646-7.

Morgan, J.R. and M.J. Valencia (eds.) (1983). Atlas for Marine Policy in Southeast Asian Seas. Berkeley, University of California Press, 126 p.

Nasu, N., T. Kamiyanagi and K. Kitani (1975). Petroleum pollution in the high seas. Oceanographic Survey Notes (2).

Ni, C.Z. and Z.G. Huang (1985). Faecal coliform contamination of intertidal bivalves from Hong Kong. In Morton, B. and D. Dudgeon (eds.). Proceedings of the Second International Workshop on Malacofauna of Hong Kong and Southern China. Hong Kong, Hong Kong University Press, pp. 473-8.

Noor Azhar M.S., A. R. Mohamed, S.Arima and S. Higashikawa (1986). Trace metals in sediments and benthic organisms from the south-western portion of the South China Sea. Fac.Fish.Mar.Sci., Univ.Pert.Malaysia, Occas.Publ., (4):77-84.

Oostdam, B.L. (1984). Tar pollution of beaches in the Indian Ocean, the South China Sea and the South Pacific Ocean. Mar.Pollut.Bull., 15(7):267-70.

Philippines, National Pollution Control Commission (1980). Annual Report, Manila, National Pollution Control Commission.

Phillips, D.J.H. (1982). Trace elements in the Pacific oyster in Hong Kong. Arch.Environ.Contam.Toxicol., 11:533-537.

Phillips, D.J.H. (1985). Organochlorines and trace metals in green lipped mussels Perna viridis from Hong Kong waters: a test of indicator ability. Mar.Ecol.Progr. Ser, (21):251-8.

Phillips, D.J.H. and W.W.S. Yim (1981). A comparative evaluation of oysters, mussels and sediments as indicators of trace metals in Hong Kong waters. Mar. Ecol.Progr.Ser., (6):285-93.

Phillips, D.J.H., G.B. Thompson, K.M. Gabuji and C.T. Ho (1982). Trace metals of toxicological significance to man in Hong Kong seafood. Environ.Pollut.(B), 3:27-45.

Polphong, P., S. Mahapanyawong, and N. Rativanich (1984). Radioactivity in sea water during 1981-1983. In Proceedings of the Third Seminar on Water Quality and the Quality of Living Resources in Thai Waters, 26-28 March 1984. Bangkok, National Research Council, pp. 214-21.

Praseno, D.P. and Q. Adnan (1978). Noctiluca miliaris Suriray perairan Teluk Jakarta. Oseanol.Indonesia, 11:1-25.

Razak, H., H. Hutagalung and S. Surtipanti (1984). Pengamatan Kebutuhan Kimiawi (KOK) oksigin biologi (KOB) dan logam berat di perairan Selat Malaka. In: Moosa, M.K., D.P. Praseno and W. Kastoro (eds.): Evaluasi kondisi perairan Selat Malaka 1978-1980. Jakarta, LON-LIPI, pp. 67-73.

Saitanu, K. and S. Tamiyavanish (1984). Paralytic shellfish poisoning in Prachuap Khirikhan Province and West Coast of the Upper Gulf of Thailand. In Proceedings of the Third Seminar on Water Quality and Quality of Living Resources in Thai Waters, 26-28 March 1984. Bangkok, National Research Council, pp. 39-44.

Shin, P.K.S. (1986). Effects of a spill of Bunker oil on the marine biological communities in Hong Kong. Paper presented at the International Symposium on Environmental Pollution and Toxicology, Hong Kong Baptist College, September, 1986, Hong Kong.

Shin, P.K.S. and G.B. Thompson (1982). Spatial distribution of the infaunal benthos of Hong Kong. Mar.Ecol.Progr.Ser., (10):37-47.

Silpipat, S. and A. Chanpongsang (1981). Seasonal variation in the source, quantity and impact of nutrients in the Upper Gulf of Thailand. In Proceedings of the Second Seminar on Water Quality and Quality of Living Resources in Thai Waters, 26-28 May 1981. Bangkok, National Research Council, pp. 215-26.

Singapore (1986). Parks, environment and utilities. Ministry of Environment.

Siripong. A. (1985). The characteristics of the tides in the Gulf of Thailand. Paper presented at the Fifth National Seminar on Mangrove Ecosystem, July 1984, Phuket, Thailand. Bangkok, National Research Council (in Thai).

Soegiarto, A. (1985). Oceanographic assessment of the East Asian Seas. UNEP Reg.Seas Rep.Stud. (69):173-84.

Soegiarto, A. and N. Polunin (1981). The marine environment of Indonesia. A report prepared for the Government of the Republic of Indonesia. Gland, Switzerland, IUCN/WWF, 257 p.

Soemarwoto, O. (1974). An ecosystem approach to the problem of dams. Paper presented in the Environment Week, Jakarta, 21-26 January 1974, 11 p. (in Indonesian).

Sompongchaiyakul, P., M. Hungspreugs and S. Lim (1986). Baseline values of petroleum hydrocarbons in the Upper Gulf of Thailand and the Eastern Seaboard. Paper presented at the Third Symposium on Marine Science, 6-8 August 1986, Bangkok, Thailand. Bangkok, National Research Council.

Spooner, M.F. (1977). Oil spill in Hong Kong. Mar.Pollut.Bull., 8:62-5.

Stirling, H.P. (1977). Effects of a spill of marine diesel oil on the rocky shore fauna of Lamma Island, Hong Kong. Environ.Pollut, 12(2):93-117.

Suvapeepun, S., S. Chernbamrung and W. Wangcharoenporn (1984). Effect of water discolouration on coastal fisheries. Report of the Marine Fisheries Division. Bangkok, Fisheries Department, 15 p.

Thailand, Department of Health (1984). Survey of the water quality in the estuary. In Proceedings of the Third Seminar on Water Quality and the Quality of Living Resources in Thai Waters. Bangkok, 26-28 March 1984. Bangkok, National Research Council, pp. 62-78.

Thayib, S.S., W. Martoyudo and F. Suhadi (1977). Beberapa macam bakteri penyebab penyaki perut manusia pada kerang Anadara dan Crassostrea. Oseanol.Indonesia, 7:49-55.

Thompson, G.B. and P.K.S. Shin (1983). Sewage pollution and the infaunal benthos of Victoria Harbour, Hong Kong. J.Exp.Mar.Biol.Ecol., 67:279-99.

Thoophom, K., K. Atisook, Y. Lertruengdei and A. Vongbuddhapitak (1984). Pesticides and PCB residues in molluscs and sea water. In Proceedings of the Third Seminar on Water Quality and Quality of Living Resources in Thai Waters, Bangkok, 26-28 March 1984. Bangkok, National Research Council, pp. 205-13.

Toro, V. and A. Djamali (1982). Fluctuation of tarball in P. Pari, Kepulauan Seribu. Jakarta, LON-LIPI, 9 p. (mimeo, in Indonesian).

Valencia, M.J. (1981a). Shipping, energy and environment: South-East Asian perspective for the 1980s. Workshop Report, East-West Environment and Policy Institute. Honolulu, East-West Center.

Vongbuddhapitak, A. K. Atisook, G. Thoophom, B. Sungvaranond and Y. Lertreungdej (1985). Organochlorine residues in marine faunas from Thai waters, 1973-1983. J.Dept.Med.Sci., 27(3):271-88.

Wattayakorn, G. (1987a). Dissolved/dispersed hydrocarbons in the Gulf of Thailand. Paper presented at the Fourth Seminar on Water Quality and the Quality of Living Resources in Thai Waters, Surat Thani, Thailand, 7-9 July 1987. Bangkok, National Research Council.

Wattayakorn, G. (1987b). Distribution of petroleum residues in surficial sediments from the Gulf of Thailand. Paper presented at Specialised Conference on Coastal and Estuarine Pollution, Fukuoka, Japan, 18-21 October 1987. Tokyo, Japan Meteorological Agency.

Windom, H.L., S. Silpipat, A. Chanpongsang, R.G. Smith Jr. and M. Hungspreugs (1984). Trace metal composition of and accumulation rates of sediments in the Upper Gulf of Thailand. Estuar.Coast.Shelf Sci., 19:133-42.

Wisaksono, W. (1974). Beberapa aspek pencemaran minyak di perairan Indonesia. Paper presented in the Environment Week, Jakarta, 21-26 January 1974, 25 p.

Wong, P.S. and R.S.S. Wu (1986). Red tides in Hong Kong: Problems and management strategy with special reference to the mariculture industry. J.Shorel.Manage., 3:1-21.

World Resources Institute and International Institute for Environment and Development (1986). World Resources, 1986. New York, Basic Books, 353 p.

Wormold, A.P. (1976). Effects of a spill of diesel oil on the meiofauna of a sandy beach at Picnic Bay, Hong Kong. Environ.Pollut., 11:117-30.

Wu, R.S.S. (1982). Periodic defaunation and recovery in a subtropical epibenthic community, in relation to organic pollution. J.Expt.Mar.Biol.Ecol., 64:253-69.

Yap, H.T. and E.D. Gomez (1985). Coral reef degradation and pollution in the East Asian Seas region. UNEP Reg.Seas Rep.Stud. (69):185-207.

Yap, H.T., R.M. De La Paz and L.T. McManus (eds.) (1988). Oil pollution and its control in the East Asian Seas region. UNEP Reg.Seas Rep.Stud. (96):290 p.

Yim, W.W.S.and K.W. Fung (1981). A geochemical reconnaissance survey of marine sediments in Hong Kong. Hong Kong Eng., 9:33-9.

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