Erosion in a coastal village in Thailand.

The Andaman Sea Coast, Thailand

by

Prawin Limpsaichol
Phuket Marine Biological Centre,
Phuket, Thailand.

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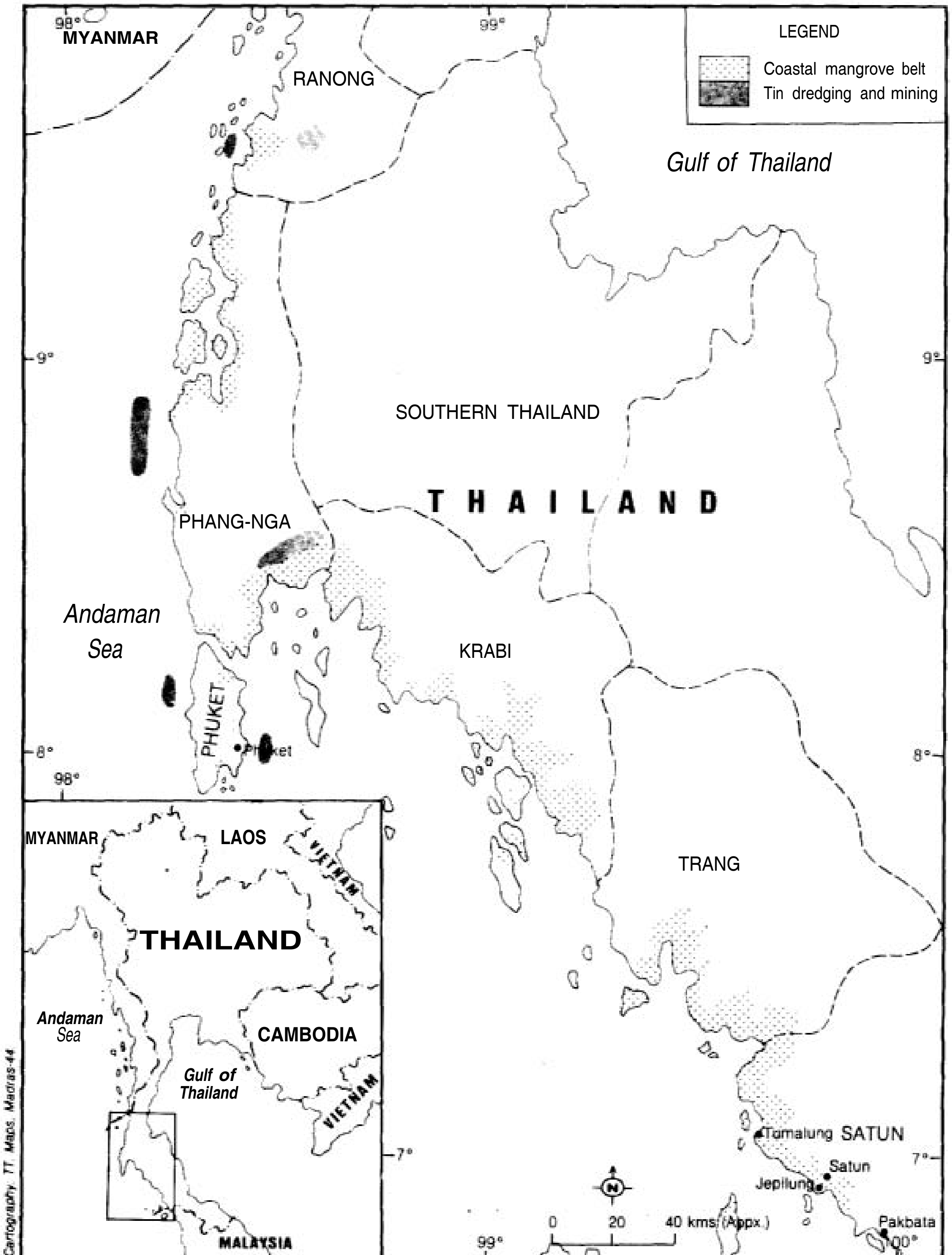
17. *INTRODUCTION*

The provinces of Ranong, Pharig-nga, Phuket, Krabi, Trang and Satun face the Andaman Sea and have a total coastline of about 700 km (Figure 8). Approximately 100,000 m^2 constitutes the narrow sea shelf, which is about 108 km wide in the north (Ranong Province), narrows down to 27 km in the middle (Phuket Province) and widens again to about 130 km in the south (Satun Province).

Fig. 8. The Andaman Sea coast of Thailand with the location of fishery harbours/ landing places, the coastal mangrove belt, tin dredging and mining areas.



Source. Financial Bureau, 1991

The sea off the Phang-nga, Phuket, Krabi and Trang Provinces is influenced by semi-diurnal tides of approximately 3 m in spring and 1 m in neap tide. The water circulation is tidally dominated by a major flow in a northeasterly direction. During the Northeast Monsoon, the surface and subsurface flow in the nearshore areas appears to move northwards at a speed of 2-4 cm/sec , while during the Southwest Monsoon, the surface flows southwards at a speed of 5-8 cm/sec., gliding over a counter subsurface flow northwards of 2-5 cm/sec. (Limpsaichol et al., 1987).

The water characteristics have been summarized by Limpsaichol et *al.,* 1987. The northern stretch, from Ranong to Phuket Province, is influenced by deepsea upwelling resulting in high salinity (32.9-33.4 ppt), while the southern stretch (Phuket to Satun Province) is influenced mainly by surface run-off resulting in a lower salinity (32.6-32.8 ppt). The dissolved oxygen, pH and temperature values are 5.5-6.4 mg/l, 8.06-8.15 and 27.6°C- 29.3°C respectively and are fairly uniform along the coast.

The southern waters are relatively well-mixed, with total suspended solid values being 9.9-14.8 mg/l. Somewhat lower values are recorded in the northern waters. The nutrient concentrations of nitrate (NO_3) and phosphate (PO_4) ranged between 0.12-3.40 and 0.08 - 0.87 ug/l, respectively. The surface water in the south is fertilized mainly by mangrove run-off (Limpsaichol et *al.,* 1987) resulting in a primary production of 180-880 gC/m^2/year (Janekaran and Hylleberg, 1987), while surface water in the north is fertilized by upwelling bottom water (Limpsaichol *et al.,* 1987) resulting in a high primary production of around 700 gC/m^2/year (Wium-Andersen., 1977).

Along the western coast of Thailand, there are vast areas of turbid water. This is caused by silt from the rivers, especially after heavy rains. Part of it is of natural origin, but during the last decade the silt outflow has increased exponentially due to bad land management and mining. The decreased light penetration causes a loss of primary production, which has a considerable negative impact on fisheries.

18. *MARINE HABITATS*

18.1 *Mangroves*

Large areas of the Andaman Sea coast are covered by mangrove forests (see Figure 8). In the north, the mangrove area is estimated to be 21,800 - 36,700 ha, while in the south it is 26,500 - 31,500 ha, with the total area being about 50,000 ha. The largest mangrove areas are found on the Phang-nga coast (Suppapipat, 1988).

Rapid economic growth has made land prices soar and competition for land along the coasts is intense. Vast areas of mangroves are encroached upon and fish production is decreasing. Each hectare of mangrove forest is estimated to yield 24 t of marine fish and crustaceans. The fish value of one ha is US$ 2,777 (Kapetsky, 1987).

Outside mangrove forests, measurements show that dissolved oxygen, pH and temperature are 5.5-6.4 mg/l, 8.05-8.27 and 27.6-29.3° C respectively. Total suspended solids of 10.1-28.5 mg/l generally occur near the shore. Higher values, however, are frequently found. Extreme values of about 600 mg/l have been recorded during the Southwest Monsoon, particularly in the inner estuaries of Phang-nga, Krabi and Trang Provinces.

In the provinces of Phuket, Phang-nga, Krabi and Trang about 50 per cent of the mangrove forests have been denuded in the last three decades. The damage has been worst in Krabi. About 93,700 ha of mangrove forests remain unscathed (Suppapipat, 1988; Aksornkaew, 1988).

Ongoing degradation of mangrove forests also adds to coastal water sedimentation. Legislation has, fortunately, resulted in stepped-up measures to protect the mangroves.

18.2 *Coral reefs*

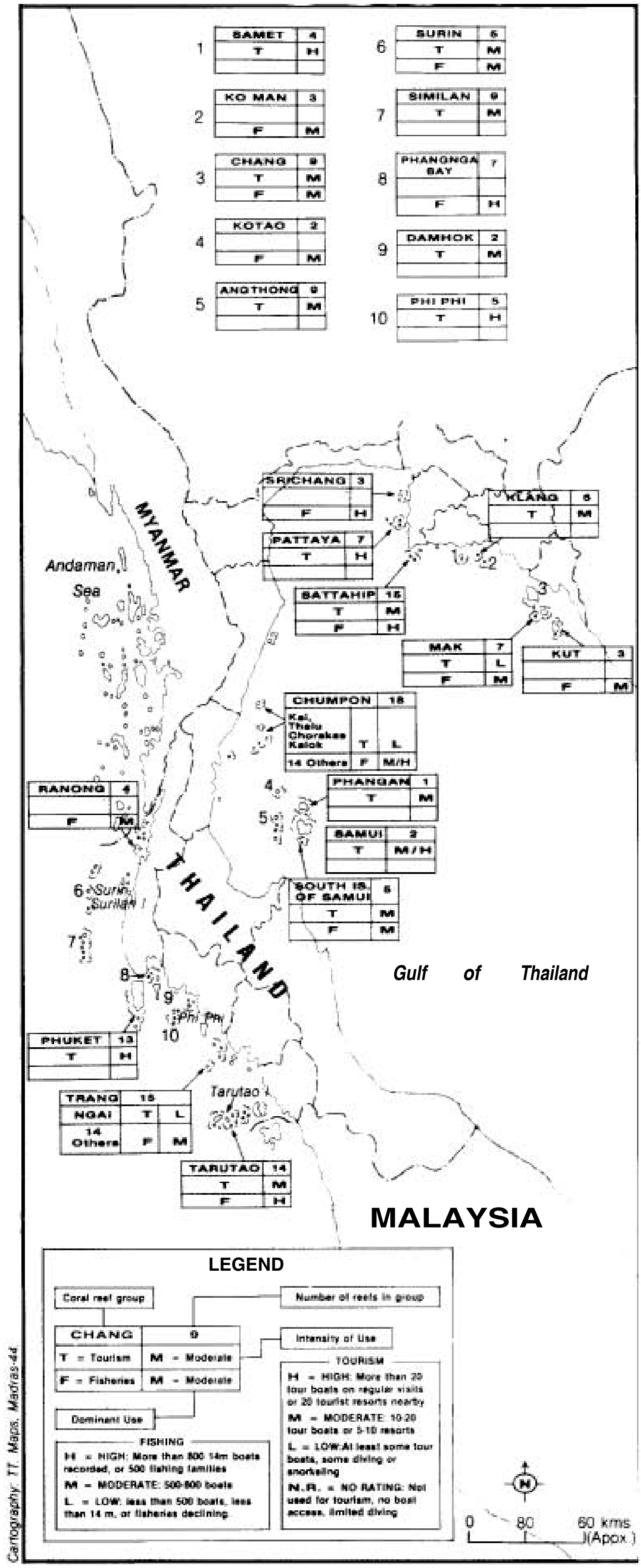
The Andaman Coast also possesses a considerable extent of coral reefs. Although large parts of the reefs have been damaged by natural and anthropogenic activities, most are still in good condition. The distribution and state of the coral reefs are presented in Figure 9. In this habitat, more than one hundred species of reef fish, including economically important ones, have been recorded. The healthiest reefs are found around the islands of Phang-nga, Krabi and Trang Provinces.

In the offshore island belt from the Rok Islands, in Trang Province, to Phi and Hong Islands, in Krabi and Phang-nga Provinces respectively, more than half the reef corals were found to be alive and in good condition during this study. The genus *Porites* appears to be dominant, both in number and percentage coverage, and is followed by *Acropora.* (Chansaeng, *et* a!., 1988). Reef degradation is mainly caused by Starfish *(Acanthaster planci),* invasions, storm damage, dynamite blasting, boat anchoring for tourism activities and sedimentation smothering. (Chansaeng, *et a!.,* 1988). In order to preserve coral reefs, marine parks have been established in the best preserved reef areas along the Andaman Sea coast, *e.g.* Surin-Similan Island, Lanta Island, Phi Phi Island and Tarutao Island.

18.3 Seagrass beds

Seagrass beds are distributed in the shallow water areas, often at the fringes of the mangrove areas and in estuaries, at depths

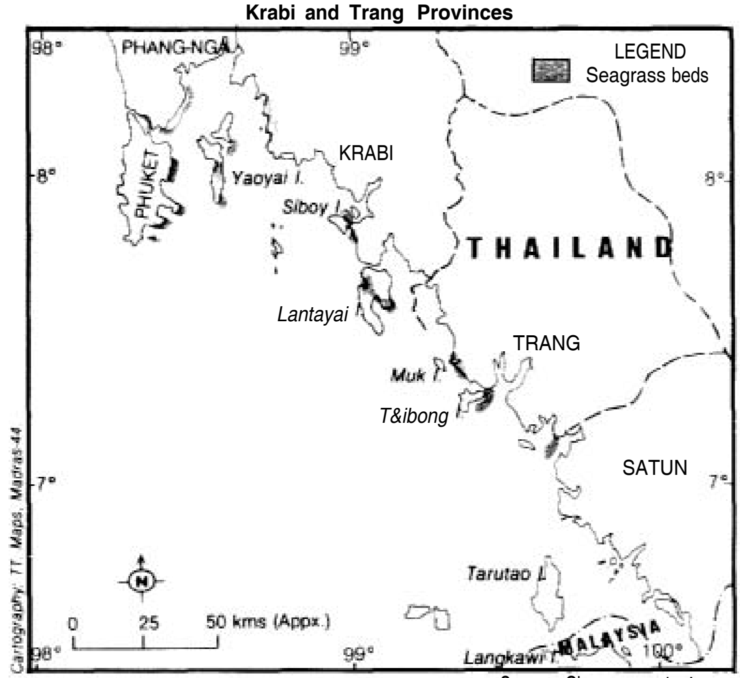
Fig. 9. The coral reefs of Thailand



of approximately five metres (Figure 10). Many economically valuable fish species, such as groupers, molluscs and shrimps use these areas as nursing grounds. Mammals, like Seacows *(Dugong dugong),* also depend on seagrass beds. Seagrass, however, is sensitive to turbidity and damages have been recorded in turbid zones.

An area of seagrass beds, of about 17 km^2, is found along the coastal stretch of the Andarnan Sea. The largest seagrass beds are located from Haad-chaomai to Muk Island as well as on Talibong Island in Trang Province. Other extensive seagrass beds are found in Phang-nga Bay and in Lanta Bay in Krabi province (Chansaeng *eta!.,* 1988).

Fig. 10. Seagrass beds in the nearshore areas of Phuket, Phang-Nga, Krabi and Trang Provinces



Source: Chansaeng *et at.* 1988

19. *MARINE FAUNA*

The density of macrobenthic fauna on the coastal seabed of the Andarnan Sea ranges from 200 to 1000 animals/m^2. The majority are molluscs, *Echinodermata* and *Chordata.* (Chatananthawej and Bussarawit, 1987).

Of the 49 fish families in the Andaman Sea, 25 set larvae along the Thai coasts. Of these, 64 per cent belong to economically important species. Zooplankton occur with an average density of 682 ind/m^3 corresponding to a biomass of approximately 20 mg/rn3. Clupeoids are the most abundant planktonic crustacean, comprising 30 per cent of the biomass, while *Brachyura* larvae, shrimps and bivalves comprise 1.2-10.7, 0.9-2.6, and *0.2-5.5* per cent of the biornass respectively (Boonruang, 1985). The sea around Phi Phi Island, south of Lanta Yai Island and east of Yao Yai Island, is, in fact, a spawning ground for Chub Mackerel. Fish larvae abound in March and April (Sutthakorn and Saranakomkul, 1986).

The benthic fauna has been studied along the coasts of Phuket. In Phang-nga, Krabi and Trang an average biomass of 26.5 g/m^2 was found. Polychaetes dominated in numbers and an average density of 256 ind/m^2 was noted. Crustaceans and molluscs also made up a considerable part of the bottom fauna, recording densities of 224 and 138 md/rn2 respectively. Only a few echinoderms occurred. Fish and other animals were found at a density of 23.7 and 48 ind/m2 each and with a biornass of around *l* g/m^2. The bottoms mainly consisted of the silt-clay fraction (40 per cent) (Chansaeng *et al.,* 1988).

The annual maximum sustainable yield of commercial pelagic fish in the Andaman Sea is estimated to be 50,000 t. For demersal fish it is estimated to be 200,000 t. The catches of commercial fish are still under the sustainable yield. During some years, however, fisheries in the Andaman Sea are close to the annual production (Phasuk, 1987). The total catch of fish and other species, such as shrimp, crab, squid and bivalves, was 300 000 t in 1985, about 85 per cent of it fish (Sudchai, 1987). This is about 15 per cent of the total catch in the country. Marine demersal fish catches in 1985 in the Andaman Sea amounted to roughly 100 000 t, valued at 450 million baht* (Department of Fisheries, 1987). Bivalve production from natural beds was 630 t valued at about 5 million baht (Department of Fisheries, 1986). Shrimp catches were about 1,660 t valued at about 80 million baht (Department of Fisheries, 1987). And the pelagic fish catches of 38,500 t were valued at about 238 million baht. The most important species found in the catch were Chub Mackerel, Spotted Tuna, Bonito, scad, Hairtail Scad. Bigeye Scad and trevallies (Department of Fisheries, 1987).

20. MARINE POLLUTION

20.1 Mining/dredging

Tin is exploited by dredging the sea bottom and by landbased mining. The dredging operations are concentrated in the coastal areas of Ranong and Phuket Province. Earlier, the tailing effluents from inland mining operations were simply discharged directly into canals and rivers transporting large amounts of silt to the coasts, causing very turbid water over vast areas. Now, the Department of Mineral Resources has tried to limit the direct discharge of suspended solids. To achieve this, a pond or sand basin is required, allowing suspended solids to settle before the water is discharged. Very turbid water from inland mining in Ranong Province is, however, still being discharged into rivers and drained into the sea.

The tailings from offshore dredging (see Figure 8, p. 57) are still discharged into the sea, leading to very turbid waters despite a piping discharge technique having been developed (AIT, 1986). An efficient technique for minimizing the suspended solids still remains to be developed. Highly turbid waters caused by tin mining have been found in the mangrove forests of upper Phang-nga. A great decline in the cockle population has, in fact, been observed in adjacent sites. When tin prices dropped and dredging operations were temporarily stopped for about a year, the cockle population recovered significantly.

Low water transparencies (1.0 - 1.8 m) occur as a result of the high content of suspended solids (Limpsaichol et *al.* 1987). It is reported that inland tin mining operations use 420,000 m^3/year of water and produce suspended solids of approximately 50,000 t/year, which are discharged into the rivers and streams (Kositrut, 1988). Kositrut also reports that inland lignite mining in Krabi Province discharges suspended solids into the waterways. Suspended solids are mainly composed of silt and clay fractions, which are deposited and resuspended in estuaries and other sheltered coastal areas (Limpsaichol and Bussarawit, 1988).

A study has shown that the turbid water from one tin mining vessel caused reduced primary production (10-50 per cent of the values in the unaffected sea) in an area of about 5 km^2 (Limpsaichol et *al.,* 1984).

The available information on toxin bioaccumulation shows that macrobenthos, including bivalves, have been affected in the vicinity of offshore dredging operations. During the post-dredging phase, the recolonization is extremely slow. The substrates of dredged areas contain more heavy metals than undredged areas (Khokiattiwong and Rojanovipart, 1986). The slow restoration of macrobenthos may be due to the high level of trace metals in the substrate. High concentrations of trace metals are also recorded in the municipal sewage discharged into the bay of Phuket City (PMBC's unpublished data).

The concentrations of heavy metals in seawater are very low around Phuket and the average values of copper, zinc and iron are 1.3 ± 0.8, 1.5±0.6 and 2.6 ± 0.5 ug/I respectively (Brown and Holley, 1982).

* US$1 = 25bahtappx.

20.2 *Industries*

The Andaman Coast is not very industrialized compared to the Gulf of Thailand coast. The table on the facing page lists the industries in the eastern provinces and Figure 11 shows where the industrial zones are/will be located.

20.3 *Oil*

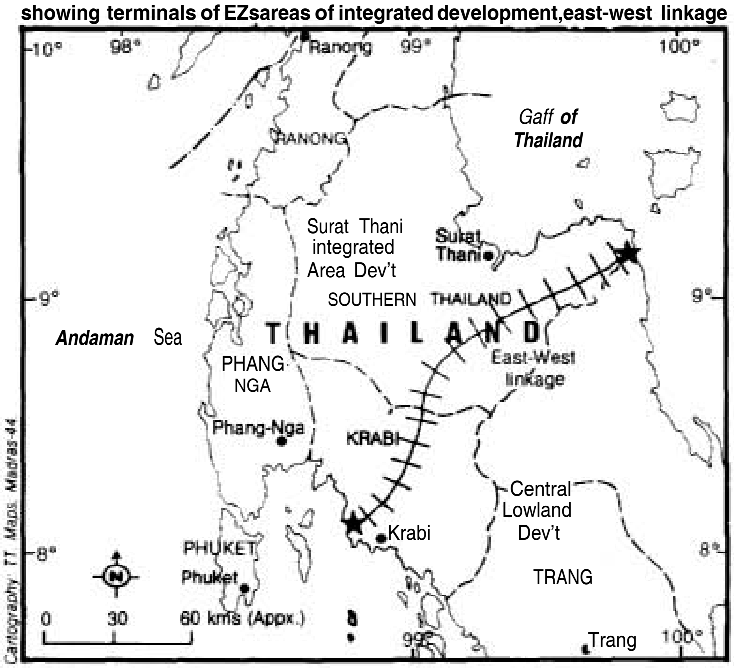
Andaman Sea water contains on average 0.69±0.17 microgram/litre of dissolved hydrocarbon, ranging from 0.04 microgram/litre to 1.21 microgram/litre (Limpsaichol *et* a!., 1987). Heavy deposition of fresh tar lumps was also recorded during the Southwest Monsoon in 1979 on beaches in the Phang-nga, Phuket and Trang Provinces. Limpsaichol 1984 registered 791, 734 and *354* g/m respectively, per beach transect. Lower amounts, were registered in 1981.

20.4 *Infrastructural development*

The proposed connection between Phuket and Surat Thani could cause great damage to the coastal environment, unless it is well planned and managed. Roads, railways and pipelines are to connect the deep sea ports of Krabi on the west coast and Khanom on the east coast (see Figure 12). This will shorten by 800-2800 km the distance for transporting crude oil and containerized cargoes. It is also hoped that the project will create competitive industrial locations and alleviate the too-intensive industrial growth in the coastal areas around Bangkok and the northern parts of the Gulf of Thailand. The project is to be financed by the Japan International Cooperation Agency, (JICA) and the World Bank.

Fig. 11. Sites for industrial estates/zones in the **upper south of Thailand**

Fig. 12. Proposed sites for industrial estates/zones in the upper south. showing terminals of EZsareas of integrated development,east-west linkage



Cartography: TT. Maps. Madras-44.

The coastal waters around Phuket and Chong Samui are very sensitive. Additions of suspended matter, nutrients etc., as a result of this development project, could have devastating effects for both fisheries and tourism.

Major industries along the Andaman Sea coast

Area	*Industry*	Number	Input material ton/year	Output product ton/year
Ranong Provinces	– Fishmili	8	148,200	23,000
	– Seafood (frozen/dried)	2	3680	1400
	– iron processing	2	60	60
	– Cold storage	2		
	– Wood processing	14		
	– Agriculture product processing	19		
	– Shipyard/slipway	7		
	– Miscellaneous	73		
	Total	**127**		
Phuket Province	– Marine product processing (canned, dried, frozen)	3	**924**	468
	Para rubber processing	9	89,500	59,200
	– Fishmili	3	24,860	6,240
	– Metal processing	**2**	78	67
	– Tin smelting		20,000	5,000 (pure tin) 1,765 (other metal + tin)
	– Metal plating	1	220 (chemicals)	48,000 pcs.
	– Shipyard	3	wood + iron + etc.	Repaired 1,050 **built** 5
	– Cold storage processing	2	3327 (Fish, shrimp, squid, etc.)	3270
	– Miscellaneous	262		
	Total	286		
Trang Province	– Marine product processing (dried, frozen)	3	720	36
	– Para rubber processing	13	178,000	138,700
	– Cold storage	3	17,240	17,000
	– Fishmill	2	24,738,200	5,802,000
	– Marine product canning		638	3,500,000 cans
	– Oil (extracts of plant and animal)	4	365,420	34,595
	– Miscellaneous	211		
	Total	237		
Satun Province	– Marine product canning and processing		3680	6,252,600 cans
	– Para rubber processing		8000	6000
	– Palm oil processing	2	92,000	22,700
	– Fishmill	**4**	148,800	3040
	– Cold storage	2	1500	1500
	– Shipyard	3	wood, iron etc.	**4-5** vessels/mth
	– Iron processing	3	iron + etc.	1700 pcs/month
	– Miscellaneous	121		
	Total	**137**		

Source. Provincial Industry Report, 1989. Office of Provincial Industry.

20.5 Agriculture

About one million hectares of agricultural land along the Andarnan coastline drain towards the sea. Rubber, coconut and oil palm, together with the staple, rice, are mainly grown in this area. The agricultural activities are important to the economy of southern Thailand and large amounts of pesticides, including herbicides and insecticides, like tosaphene etc, are used. It is estimated that the amount of pesticides used in 1987 along the Andaman Sea Coast was about 2,500 t/yr in 1987 (personal communication, with Provincial Agriculture Officer and unpublished). Fortunately, DDT application has been banned.

It is suspected that the coastai waters of the Andaman Sea may be contaminated with synthetic organic compounds from agricultural applications. No information, however, is available.

There are many palm oil factories in tile Krabi and Trang Prrovinces producing mainly organic wastes that are then drained into the rivers and the sea.

20.6 Fishery harbours

Fishery harbours are located along the Andaman Sea coastline, often close to mangrove forests and estuaries. They produce organic wastes, derived from fish cleaning, degutting and garbage, besides oily bilgewater The principal harbours arc the Kanong, Phuket and Satun fishery harbours (see Figure 8, p. 57). Each of these harbours provides berthing and fish handling facilities for approximately 200-400 fishing vessels. There arc also a number of smaller fishery harbours along the coast.

About 10,000 people, connected in some way with fishing activities, arc active in each main harbour. The amounts of organic waste generated by these people are difficult to estimate, but very high levels of' bacterial content have been recorded in the harbour waters Faecal coliform counts exceed the water quality standard of 1000 MPN/100 ml for general purposes (ONEB 1989).

Waters around fishery harbours are also utilized for many human activities They also often support rich marine life. Organic wastes provide an important nutrient input in estuaries, supporting primary production and improving fish growth. Phytoplankton blooms occur regularly in Patong Bay, which continuously receives treated and untreated organic wastes from hotels and other sources. It is necessary to ensure that the organic wastes are within acceptable limits otherwise there is a risk of outbreaks of PSP and DSP, as in the upper Gulf of Thailand (Piyakarnchana et al., 1987).

Fishing vessels also discharge bilgewaters and other oily wastes into the surrounding waters. Each vessel is bound to renew about thirty litres of used lubricant every month. The minimurn number of vessels, 200, will produce 6000 litres, or about six tonnes of cily bilge wastes, every month at each fishery harbour. Fortunately, dumping does not occur at the same time. All harbour5 should have facilities for collecting and cleaning this waste, since it has a commercial value and can be reused instead of being discarded.

20.7 Aquaculture

There arc three types of aquaculture practised on the Andaman coast :

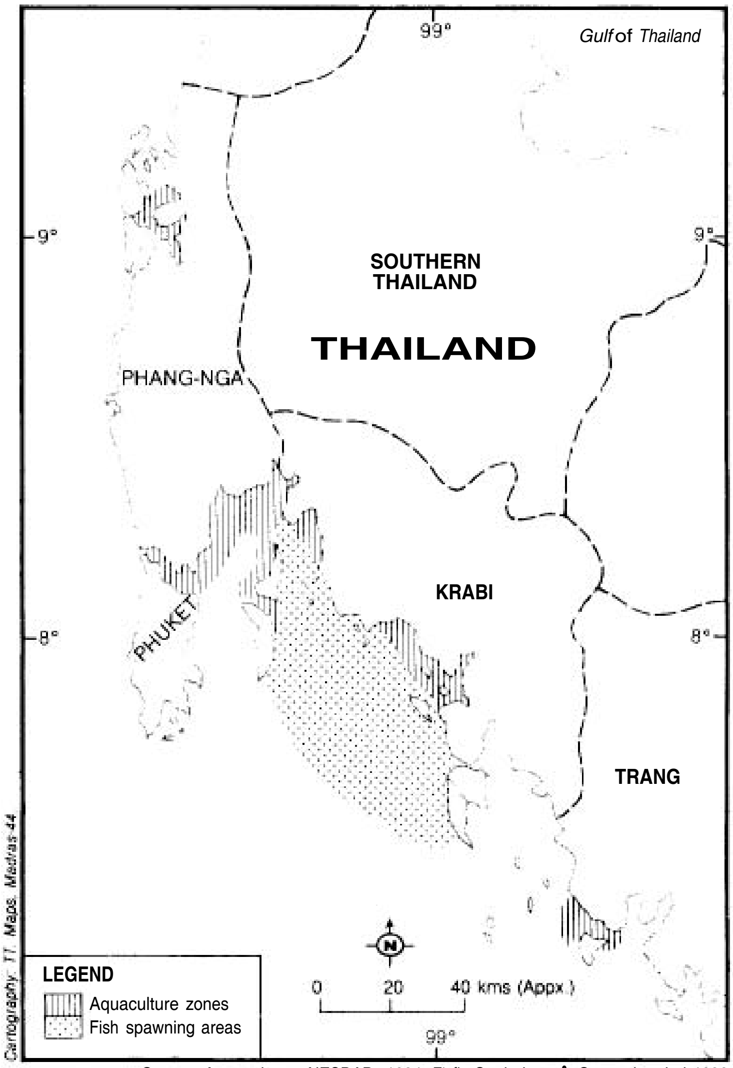
- Culture of molluses.
- Cage culture of finfish (mariculture)
- Land-based shrimp culture.

The areas of aquaculture activities are presented in Figure 13 on the facing page. 1 he most intensely developed areas are found in Phang-nga Province, where about 85 per cent of the coast is used for farming Shrimp production here in 1986 touched about 15,800 t valued at 1,340 million baht. Cockle production yielded 4,320 t valued at 23 million baht. Farmed fish also contributed significantly; 176 t worth 15 million baht (Department of Fisheries, 1987). In addition, there was a small production of a few tonnes oysters and other bivalves in 1987, valued at about 37,000 baht (Department of Fisheries)

1988); A coastal area of 350 ha has been developed for aquaculture in the region, as shown in Figure 13. The Financial Bureau Department (1991) reported that 111,600 ha of mangrove area were being utilized for aquaculture in Thailand, a figure obtained by remote sensing. This represents 63 .4 per cent of the total damaged mangrove area in the country.

Mollusc mariculture has also been intensively promoted in the coastal region. In 1984, the total mollusc mariculture beds in the Andaman Sea covered 1030 ha. The mollusc production was 1100 **t**, including both cultured and naturally harvested mussels. The species included Bloody Cockle *(Anadara granosa, A. nodifera),* Green Mussel *(Perna viridis),* oyster *(Crassostrea belchen, C. lugubris, Saccostrea cucullata),* Horse Mussel *(Odiolus senhaysenii)* pearl shell *(Pinctada maxima, P. margaritierae* and Shortnecked Clam *(Paphia undulata)* (Department of Fisheries, 1986). It is anticipated that aquaculture and mollusc culture will be more intensively promoted in the future as part of the country's development plans.

Fig. 13. Aquaculture zones and fish (Chub Mackerel and scad) spawning areas



Source. Aquaculture NESDAB, 1984, Fisfl Sutthakorn & Saranakomkul 1986

The enormous growth of shrimp culture along the coasts has caused the pollution of adjacent waters in the northern parts of the Gulf of Thailand. In addition to conventional pollution from nutrients and organic wastes, different types of chemotherapeutants are discharged from the shrimp farms. The environmental impacts of these in tropical habitats are still unknown, but they constitute a potential threat. Many shrimp farmers from the north and east have been forced to move to the southern and western parts of the country. Unless strong action is taken to manage the shrimp farms environmentally, the same pollution problems will appear along the west coast.

The decree of July 1, 1991, states that all shrimp farms will have to register with the Ministry of Agriculture Cooperatives. Also, farms over ten hectares are required to seek official permission from the Ministry before being established. This obligatory registration is clearly an important step in the right direction. The rationale behind these recent moves can be traced back, in part, to the excessive pesticide and antibiotic residues found in cultivated Thai shrimp, which has forced Japanese authorities to reject, in many cases, shipments bound for that country.

21. *THE ENVIRONMENTAL STA TUS IN THE ANDA MA N SEA A ND THE GULF OF THAILAND: A COMPARISON*

The Gulf of Thailand is more environmentally degraded than the Andaman Sea due to a greater concentration of industries and other polluting activities around it. Great care should, therefore, be taken to avoid similar development on the Andaman Sea coast.

The **table** alongside compares the water quality in the two regions. Further information may be found in Appendix XIII.

22. *COASTAL RESOURCE MANA GEMENT*

The Office of the National Environmental Board (ONEB, 1989) has established coastal water quality standards in order to guide the planning of coastal resource mangement and to prevent the degradation of coastal water quality both of the Gulf and the Andaman Sea waters. Coastal waters in Thailand, are divided into five classes:

- Preservation areas.
- Natural conservation
- Propagation of marine life
- Recreation.
- Industry and navigation

Comparison of coastal water qualify in West and East Thailand

Parameter	*Andaman Sea (west coast of Phuketj*	*Gulf of Thailand (east coast Chon buri Provincel*
Temp. °C	24.0-31.0	27.0-32.0
pH	7.7-8.7	7.6-8.7
Salinity ppt	27.0-35 0	21.1 -35.0
Dissolved oxygen ppm	5.0-7.0	2.0-8. 5
Total suspended solids ppm	1.3-21.9	3.0-97.0
Water transparency m	6.5-18.0	0.5-5.5
Total coliform bacteria MPN/100 ml	120-35,000	20-240,000

Source. Trididech et *al,* 1987

The classification of coastal waters is shown in the table below and coastal water qualities are shown in the table on the facing page.

Coastal water quality classification and objectives

Classification beneficial	*Conditions for principal uses/Objectives*
Class **AA** (Preservation area)	To ensure preservation of natural (Preservation Area) areas, the following uses are allowed – Scientific research and education, such as demonstration, observation arid,- or monitoring. – Aesthetic enjoyment – Inactive management/preservation activities
Class A	
A1 (Conservation of coral community)	A1) Conservation of coral community
A2 (Conservation of natural areas)	A2) Conservation of natural areas, such as mangrove habitats and marine spawning, nursing and feeding grounds.
Class **B**	
B1 (Propagation of marine life/aquaculture)	B1) Aqaaculture
B2 (Propagation of mar/ne life/shellfish)	B2) Shellfish
Class C	
C1 (Recreation/water-contact sport)	C1) Water-contact sport
C2 (Recreation/water-proximity sport)	C2) Water-proximity sport
Class D	
Industrial area	For protection of natural water resources used usa receiving waterbody for industrial waste discharges.

Coastal water quality guidelines

Parameter	Natural conservation Preservation			Propagation of marine life		Recreation		Industry
	Preservation	Conservation of coral community	Conservation of coral area	Aquaculture	Shellfish	Water contact sport	Water contact sport	
CLASS	AA	A_1	A_2	B_1	B_2	C_1	C_2	D
Floatable solids	n	NOB	NOB	NOB	NOB	NOB	NOB	NOB
Floatable oil/grease	n	NV	NV	NV	NV	NV	NV	NOB
Color/Odour	n	–	–	NOB	NOB	NOB	NOB	NOB
Temp **(°C)**	n	≯32.0	≯32.0	≯32.0	≯32.0			x ≯ 3*
pH	n	7.5-8.9	7.0-8.5	7.0-8.5	7.0-8.5			--
Salinity (ppt)	n	29-35	x ≯ 10%	x ≯ 10%	x ≯ 10%			--
Transparency (m)	n	x ≯ 10%	x ≯ 10%	x ≯ 10%	x ≯ 10%	x ≯ 10%		--
DO (mg/l)	n	≮4	≮4	≮4	≮4	–		
Total coliform (MPN/100 ml)	–	–	–	1000	n	1000		
Faecal coliform (MPN/100 ml)			–		ne			
NO_2-N (mg/l)	n	n	n					--
PO_4-P (mg/l)	n	n	n					--
Hg (mg/l)				≯0.0001				≯0.0001
Cd (mg/l)				≯0.005				≯0.005
Cr (mg/l)				≯0.1				--
Cr hex (mg/l)				≯0.05				≯ 0.1
Pb (mg/l)				≯0.05				
Cu (mg/l)				≯0.05				
Mn (mg/l)				≯0.01				
Zn (mg/l)				≯0.01				
Fe (mg/l)				≯0.03				
F(mg/l)				≯ 1.5				
Residue Cl_2. (mg/l)				≯ 0.01				
Phenols (mg/l)				≯ 0.03				
NH_3-N **(mg/l)**				≯0.4				
Sulfide (mg/l)				≯ 0.01				
CN (mg/l)				≯ 0.01				
PCB (mg/l)				n				
Total **chlorinated** pesticides (g/l)				≯0.05				
Radioactivity								
- x - **Gross** (BecquereVl)				≯0.1				
- ß - Gross (Becquerel/I)				≯0.1				

Source: **National Environment Board, B.E 2532 (1989).**

NOTES: NOB = Not objectionable; NV = Not visible; n = Natural condition

x = Change from natural condition

*** = Does not include natural floatable solids,**

-- = **May be established as** necessary

nc = Natural condition until enough information

* = **Not more than**

= **Not less than**

23. REFERENCES

AKSORNKAEW, S. 1988. Mangrove habitatsdegradation and removal in Phang-Nga and Ban Don Bays. Thailand. ICLARM *News Letter on Tropic01 Coastal Area* Monogemenr. Manila, April 1988:3 (I): 16.

ASLAN INSTITUTE OF TECHNOLOGY (AIT). 1986. *Field investigation. Project: Control oj waste disposal from offshore* tin mining *phase* I. Report No. 191. Department of Mineral Resources, Bangkok.

BOONRUANG, P.L. 1985. The community structure, abundance and distribution of zooplankton at the east coast of Phukct Island, Southern Thailand, Andaman Sea. *Phuket Mar. Biol. Cen. Res. Bull.* 39:1-13.

BROWN, B.E. and HOLLEY, MO. 1982. Metal levels associated with tin dredging and sampling and their effect upon intertidal reef flats at Ko Phuket, Thailand. Coral reefs, 1:131-137.

BUTLER, P.A., CHILDRESS. R. and WILSON A.J. 1973. The association of DDT residues with losses in marine productivity. Ed. M Ruivo. *Marine pollution and* sealife, Fishing News Ltd., Surrey. England 262-265.

CHATANANTHAWEJ, B. and BUSSARAWIT, S. 1987. Quantitative survey of the macrobenthic fauna along the west coast of Thailand in the Andaman Sea. *Phuker Mar. Biol. Res. Bull 47: I-23.*

CHANSAENG, H. BOONYANATE. P., POOVACHIRANON. S., PHONGSUWAN, N. and BUSSARAWIT. S. 1988. Project 2: Living resources in coastal areas with emphasis on mangroves and coral reef ecosystem: Subproject on inventory and monitoring of coral reefs, seagrass and soft bottom communities in the Andaman Sea. Asean-Australia *Cooperative Program* on Marine *Science.* Phukct Marine Biological Centre. Phuket Province, Thailand. 244 p.

U.S. ENVIRONMENTAL PROTECTION AGENCY, (EPA), U.S. 1976. Quality *criteria for* water.. U.S. Environmental Protection Agency, Washington D.C.:139-157.

FINANCIAL BUREAU. 1991. *A report on the present status of mangrove forest* urea of *Thailand.* Planning and Project Division, Bangkok, Thailand. 47 p.

HUNGSPREUGS, DHARMVANIJ, M.S. and UTOOMPRURKPORN. W. 1987 The marine environment of Ban Don Bay. *Proceedings ofthe 4th Seminar on the Water Qualify and Quality of Living Resources in Thai waters: 297-307.* July 7 - 9, 1987, by NRCT, Surat Province, Thailand.

JANEKARAN, V. and HYLLEBERG, J. 1987. The primary production along the Andaman Sea Coast *of* Thailand. *Phuket Mar. Biol. Cent. Res. Bull.*

JARACH. W. 1987. Heavy metal contents in sea water of the upper Gulf of Thailand. *Proceedings of the 4th Seminar on rhe Water Quality and Quality of Living Resource.7 in Thai Waters: 122-129.* July 7-9, 1987, by NRCT. Surat Thani Province, Thailand.

KAPETSKY. J.M. 1987. Conversion of mangroves for pond aquaculture: Some short-term and long-term remedies. FAO *Fisheries Rep. No. 370. Suppl. 1987, p. 129-141.*

KHOKIATTIWONG, S. and ROJANOVIPART, P. 1986. *Heavy metal distributions in marine sediments on the west coast of Phuket Island.* Paper presented at the Science Seminar. University of Kasetrart, January 1986.

KOSITRUT, N. 1988. *Water pollution* Paper presented in the Workshop on the Coastal Issue and Management of the Upper South Area. April II 12, 1988, Phang-nga Province, Thailand. 8 p.

LIMPSAICHOL, P. 1984. The distribution and variation of tar on beaches along the Andaman Sea coast of Thailand. *Phuker Mar. Biol. Res. Bull.* 34:1-12.

LIMPSAICHOL, P.H., KOKIATTIWONG, S and BUSSARAWIT, N. 1987. Assessing coastal water quality of the Andaman Sea of Thailand. *Proceedings of the 4th Seminar on the Water Qualify and the Quality of Living Resource.? in Thai* Waters: 309-320, July 7 - 9, 1987, Surat Thani Province by NRCT, Surat Thani Province, Thailand.

LIMPSAICHOL, P.. KOKIATTIWONG, S. and PHONGSUWAN, N. IY87. Subsurface current pattern, of the Southern Andaman Sea, Trang to Satun Provinces of Thailand. *Proceedings of the Seminar* on *Fisheries.* Department of Fisheries, Bangkok.

LIMPSAICHOL, P. and POOPETCH, T. 1984. Theeffect of dumping suspended solids at sea on chlorophyll aconcentrations and primary production values. *Phuket Mar. Biol. Cent. Res. Bull. 33.*

LIMOPSAICHOL, P. and BUSSARAWIT, *N.* 1988. *Technical report on the coastal environment of Phang-nga Boy.* Asean/US Cooperative Programme on integrated coastal resource development and management planning of the upper south Coastal Zone. *Phuket Mar* Biol. Cent.. Phuket Province, Thailand.

LERTRUENGDEJ, VONGBUDDHAPITAK, T. A. and ATIUSOOK, K. 1987. Insecticide and PCB residues in marine fauna from Thai waters. *Proceedings of the 4th Seminar on the waler Quality of Living Resources in Thani walers:* pp. 264-269, July 7-9, 1987, by NRCT, Surat Thani Province, Thailand.

MACLEAN, J. L. 1984. Indo-Pacific red tide occurrences 1972-1984. TOXIC Red Tides and Shellfish Toxicity in Southeast Asia. *Proceedings, Consultative Meefing.* Singapore, September 1 I-14, 1984:92-102.

MAHAPANYAWONG, W., POLPONG, P., WANABONGSE, P. and RATIVANICH. N. 1987. Radio activity and radioactive elements in seawater, sediments and living resources in the Gulf of Thailand during 1973-1986. Proceedings *of the 4th Seminar on the Warer Quality of Living Resources in Thai Waters. pp.* 137-148. July 7 - 9, 1987 by NRCT, Surat Thani Province, Thailand.

ONEB. 1989. *Laws and standards on pollution control in Thailand* (2nd ed) No. NEB 05-02031. EQSD, ONEB, Thailand. 113 p.

PHASUK, B. *1987.* The marine fisheries in Thai waters. *Proceedings of fhe Seminar on rhe Future of Thai Fisheries* pp. 53-137. June 4-6. 1987, Pattaya, Thailand, SEAFDEC.

PIYAKARNCHANA. T., FUKUYO. and WISESSONG, S. 1987. Distribution along the coastline of the causative shellfish poisoning phytoplankton dinoflagellates in Thai waters. *Proceedings of the 4th Seminar on the Water Quality and* Qualify *of* Living *Resources* in *Thai* Waters. p. 201. July 7-9, 1987 by NRCT, Surat Thani Province, Thailand.

PIYAKARNCHANA, T.. BUNPAPONG, bl. and PHOLPUNTHI, P. 1990. Tidal influence on the distribution and population density of toxic dinotlagellate: *Alexandrium cohorticula* Balech, in the upper part of the Gulf of Thailand. Asian *Fisheries Forum,* pp. 890-902. Asian Fisheries Society, Manila.

ROJANAPANTIP, BORIBOON L.B. and BOONYASHOTIMONGKUL, T. 1987. Mercury content in marine fauna. *Proceedings of the 4th Semrnar on the Wafer Quality and Quality of Living Resources in Thai Waters: pp. 233-244,* July 7 - 9, 1987 by NCRT, Surat Thani Province, Thailand.

STRICKLAND, J. D.H. and PARSONS, T.R. 1975. *A practical handbook* of sea *water analysis,* Fish Res. Board. Can., Ottawa. 311 p.

SAITANU, K., LUANGTONGKUM S. and POONSUK. K. 1987. Microbiological quality of the east coast of upper Gulf of Thailand. *Proceedings of rhe 4rh Seminar on rhe Water Quality and Quality of Living Resources in Thailand Wafers;* pp. 149-164. July 7 - 9, by NRCT, Surat Thani Province, Thailand.

SUWAPEEPAN, S., 1984. The impact of red tide on coastal fisheries. *Proceedings of the 22nd Seminar* on Fisheries, Kasetsart University, pp. 203-312.

SUPPAPIPAT, S. 1988. Mangrove: Good policy but poor enforcement Agro-Industry *Magazine. 36:27-35.* June 1988

SUDCHAI. K. 198'. Product of marine fisheries in Gulf of Thailand and Andaman Sea. *Thai Fisheries Gazette. 40(2):* 169-175

SUTTHAKORN, P. and SARANAKOMKUL, L. 1986. *Biological aspects of Chub Mackerels. Rastrelliger* spp. *and Round Scuds* Decapterus *spp. in the* west coast of *Thailand.* Technical report. Andaman Sea Fisheries Development Centre. *97 p.*

TEMIYAVANICH, S., ROJNAVIPART 1984. Physicochemical status of eastern Gulf waters. *Proceedings of the 3rd Semrnar on rhe Water Quality and the Quality of Living Resources* in *Thai* Waters. pp. 183-198. March 26 28 at Marine Science Center, Bangsaen, Thailand.

THOOPHOM, G., ATISOOK., LERTREUNGDEJ, Y. 1987. Insecticide and PCB residues in molluscs and rea water. *Proceedings of the 4th Seminar on the Water Quality and Quality of Living Resources in Thai Waters:* pp, 256-263, July 7 - 9, 1987, by NRCT. Surat Thani Province, Thailand.

TRIDIDECH, T., UNKULVASAPAUL, M. and SIMACHAYA, W. 1987. Coastal water quality and establishment of water quality for Thailand. *Proceedings of the 4th Seminar on the Water Quality and Quality of Living Resources* in *Thai* Waters pp. 394-404. July 7 9, 1987. by NRCT. Surat Thani Province, Thailand.

WATTAYAKORN, G. 1987 Dissolved/dispersed hydrocarbons in the Gulf of Thailand. *Proceedings of the 4th Seminar on the Warer Quality and Quality of Living Resources in Thai Waters* : pp. 105-13. July 7 - 9, 1987, NRCT. Surat Thani Province. Thailand.

WIUM-ANDERSEN, S. 1977. Primary production in waters around Surin Islands off the west coast of Thailand *Phuket Mar. Biol. Cent. Res. Bull.* 16:1-4.

APPENDIX X

Institutions engaged in environmental research, monitoring and enforcement

On the Andaman Sea coast of Thailand, rhe Phuket Marine Biological CenCentre (PMBC) is the only laboratory that deals with marine environmental research and reconnaissance studies monitoring. There is a similar research laboratory located on the coast of the Gulf of Thailand: the Eastern Marine Fishery Development Centre, Ranong Province. The National Institute of Coastal Aquaculture is located in the lower Gulf. These three laboratories are operated by different divisions. but they all belong to the Department of Fisheries.

PMBC is not concerned with legislation or enforcement of environmental laws. However its recommendations are recognized and credited. The Department of Fisheries promulgates laws and regulations on fisheries that indirectly concern environmental conditions. The Office of Environmental Board (ONEB), under the Ministry of Science and Technology, deals with Environment Impact Assessments (EIA). Non-government Organizations (NGO) and environmental legislation. ONEB, however. has no powers of enforcement and has to depend upon other authorities, such as the provincial authorities. to deal with specific issues.

The chemical analysis methods employed by PMBC are rhose recommended by APHA. AWWA and WPCF (Strickland 1975) and are tabulated below:

Parameters	Sampling pre-analysis	Final	Methods	Sensitivity
Heavy metals				
Hg,	-	-		-
Cd, Pb	PMBC	Bangkok	Atomic absorption, Flameless emission, Perkin Elmer	3-20%
Zn,Fe,Cu	PMBC	Bangkok	Atomic absorption. Flame emission, Perkin Elmer.	3-20%
Pesticides	-	-	-	
Petroleum				
Hydrocarbon	PMBC	PMBC	Hexane extraction, Spectrofluoromety.	20%
Nutrients				
P&N	PMBC	PMBC	Spectrophotometers	0.05ugat/
Bacteria				
Coliform	PMBC	PMBC	Multiple tube	-
Faecal coliform	PYBC	PMBC	Multiple tube	
Others	PMBC	PMBC	Plare count	-
Radioactive isotope	-			
Dioxinn	-			

There are both government and private laboratories working on environmental analyses. Many private laboratories arc engaged in water, waste water and air pollution analyses. It is very difficult to include them all, so only the important ones are listed.

GOVERNMENT

1. Chemical Agricultural Division, Technical Agricultural Department, Bangkok.
   Laboratory for soil, water, waste from industry and agriculture, and pesticide analysis
2. Medical Science Department, Bangkok.
   Analysis of pesticide residues, heavy metals, microbiology of food and water quality, as well as waste water from industries.
3. Scientific Research Instrument Centre, Chulalongkorn University, Pathumwan, Bangkok.
   Both biological and chemical analyses. Atomic absorption spectrophotometer (AA) technique, either with or without flame for heavy metals detection. For pesticides (organochlorine and organophosphate), the gas chromatography (GC) technique is used.
4. Faculty of Public Health, Mahidol University, Rajvitee Road, Bangkok.
   This is an environmental, toxicology and occupational health laboratory. Coliform bacteria analyses, using multiple tube technique, are undertaken. Pesticide and heavy metal analyses of water and waste water are carried out using the same technique as Chulalongkorn University (see above).

PRIVATE

1. Sahafarm. Bangkok.
   Studies pesticide residues in meat, fat, shrimp, water, soil, raw material and feed, using the GC technique.
2. International Quality Assurance Laboratory (IQA) 2096/5-8 Ramkhumhaeng Rd., Hua Mark, Bangkok 10240.
   Specializes in waste water analyses, especially for heavy metals, using the AA technique.

APPENDIX XI

Legislation against threats to the marine environment

There are, at present, no laws and regulations on water pollution control. Many existing laws and regulations, relating to public health and safety, as well as the environment, have, however, been indirectly applied. They include:

Public Health Act (1941, 1984)

Enacted by the Ministry of Public Health (MOPH). these laws aim to protect public health. The Act authorizes local governments to issue ordinances to ensure proper collection and disposal of human and other solid wastes and to prevent adverse effects on public health. This Act, however, does not enforce adequate treatment of sewage and waste water generated by communities. Also, considering that the Act was passed almost 50 years ago, the penalties and service fees specified are insufficient to act as effective deterrents or to provide adequate services. The limited budgets and manpower that local government\ have, as well as the lack of clear guidelines on enforcement, weaken the Act's effectiveness. The MOPH is currently revising it to improve water pollution control as well as control in other specific areas.

National Environmental Quality Act (1975)

This Act aims to protect and conserve the quality of the nation's environment. It has established ONEB, EIA requirements for specific projects and standard5 of water pollution control, as well as financial and legal instruments to ensure enforcement. The limitations of the latter, however, detract from achieving the main objectives of the Act and implementation of the national policy for water pollution control, which is to preserve and enhance the quality of the nation's waters.

Factory Act (1969)

Enacted by the Ministry of Industry (MOI), this Ac! aims to control the waste discharges from industrial activities. Enforcement, however, is ineffective because small and household industries in many urban areas are not monitored. Also, the Act does not control the discharge from gas stations which are, in fact, major contributors to water pollution in urban areas.

Building Code (1936, 1979)

Enacted by the Ministry of Interior (MOInt), this Code controls building construction in urban areas. It requires the installation of a proper collection and treatment system for human waste, i.e. a leaching pit with soakway for house, and a septic tank with a cesspool for large buildings. The lack of monitoring to ensure proper construction of the treatment system reduces the effectiveness of the Code. The MOInt is currently revising the Code to effectively control waste water discharges from buildings.

Navigation in Thai Waters Act (1913)

This law aimr to control construction along public watercourses and pollution that affects living resources, besides preventing sedimentation that obstructs navigation. It prohibits the dumping of rocks, gravel, silt, mud, detritus, solid waste, sewage, oil and chemicals into public waters such as rivers, canals, swamps, reservoirs and lakes. Constraints include lack of enforcement due to limited personnel and budget. Also, the low priority given by the Harbour Department, to the Act's aims, and other social and political complications hamper the Act's effectiveness.

Provincial Authority Acts

Municipal Government Act
Sanitary District Act
City of Pattaya Act
Bangkok Metropolitan Act

Under these acts, local governments are assigned compulsory functions (such as providing water supply and drainage), as well as optional functions (such as providing public utilities) These Acts, however, lack specific authority or control over sewage and waste water collection or treatment.

All this legislation is ineffective due to budget and staff limitations as well as to a lack of enforcement will

The Division of Environmental Industry, Industrial Control Department, Ministry of Industry. has the authority 10 check waste discharge and is also responsible for appropnate action in case of serious accidents with hazardous industrial wastes. The Fishery Department is contacted first when a fish kill is reported.

APPENDIX XII

Other publications on the marine environment

AKSORNKOAE, S 1989. Mangroves Ecology *und Management,* 1SBN 974-552-881-1, (In Thai)

PHA. AWWA. and WPCF. 1975 *Standard* methods for the examination of water *and* waste water, 14th Edition. 4PH.4. Washington, 1193 p.

CHONCHUENCHOP P. and COLLEAGUE. 1987. Diseases of Cage-Culture Seabass in Satun, Trang and Krabi Province. Thor Fisheries Gazette, 40(3):315-326.

DFPARTMENT OF MINERAI RESOURCES. 1987 *Tin mining concession in Phang-nga Bay* Division of Mapping, DMR Bangkok, Thailand.

INTEGRATED UTILITY OF NATURAL RES and EN\'. DIV , NATI ENV. BOARD (NEB) 1992. Provincial State *of the Coast: Runong.* NEB (In Thai).

________ *Provincial State of the Coast Phang-ga NEB (In* That).

________ *Provincial State of rhe Coast.* Trang, NEB (In Thai).

________ *Provincial State ofthe Coast.* Phuket, NEB. (In Thai).

________ *Prov incial State of the Coast:* Krabi. NEB (In That)

________ *Prov incial State of the Coast.* Satun. NEB (In Thai).

KHOKIATTIWONG, S. 1991. Coastal hydrography of the southern Andaman Sea of Thailand, Trang to Satun Province, *Proceedings of the First Workshop of [he Tropical Marine Mollusc Programme. 67-93* August 12 - 16, 1991, Phuket Marine Biological Centre, Phuket Province, Thailand.

LIMPSAICHOL P. and BUSSARAWIT, N. 1991. An assessment of the coastal environment of Phang-nga Bay, Thailand, pp 3-11. IN ; Chou L.M., Chua T.E., Khoo H.W., Lim P.E., Paw J.M.. Silvestre G.T , Valencia M.J., White A.T. and Wang P.K. (eds). *Towards an integrated management* of tropical *coastal* resources, ICLARM Conference Proceedings 22, 455 p. National University of Singapore, Singapore; National Science and Technology Board, Singapore; and International Centre for Living Aquatic Resources Management. Philippines.

NEB 1992, Master Plan for Coral Reef Management of Thailand. (In Thai)

1991 A National Coral Reef Strategy for Thailand. Vol. I: Statement of Need

PIDO, M.D. and HODGSON, G. 1991. The Integrated Management Plan for Ban Don Bay and Phang-nga Bay Thailand, *Tropical Coastal Area Management* Vol. I, No. 3, Metro Manila, Philippines.

PROMAMON, P. 1987. Status of mariculture in Thailand and guideline for future development. *Proceedingsof rhe Seminar on the Future of Thai Fisheries.* pp. 139-307. June 4-6, 1987, Pattaya, Thailand. SEAFDEC.

PHROMLERT, C. 1992. Local government initiatives in waste management. pp. 185-188. IN : Chua T.E. and Garces L..R. (eds). *Waste management in the coastal areas of the ASEAN region. Roles of governments, banking institutions, donor agencies, private sectors and communities.* ICLARM Conference Proceedings 33. 218 p. Ministry of the Environment and Canada-ASEAN Centre, Singapore, Asian Development Bank, and International Centre for Living Aquatic Resources Management, Philippines.

RUANGPAN, *S. 1992. Results of fishing experiment with vertical bottom longline in Andaman Sea.* Technical Paper No. 1/ 1992, Exploratory Fishing Division, Department of Fisheries, Ministry of Agriculture and Cooperatives. (In Thai).

SUNDSTROM, B.. JANEKARN. V., HYLLEBERG, J. and BOONRUANG. P. 1987. Annual pelagic primary production with notes on physical and chemical variables at Phuket, the Andaman Sea, Thailand. *Phuket Mar. Biol. Cent.* Res. Bull. 47 : l-2 1

SUDARA, S. 1992. *Coral Reefs.* Wildlife Fund Thailand: Under the Royal Patronage of H.M. The Queen. ISBN 974-88782-2-8. (In Thai).

1991. *Mangrove Forest.* Wildlife Fund Thailand: Under the Royal Patronage of H.M. The Queen. ISBN 974-88684-9-4 (In Thai).

1991. *Seagrass Beds.* Wildlife Fund Thailand: Under the Royal Patronage of H.M. The Queen. ISBN 974-88720-0-9. (In Thai).

SOCIETY OF ECONOMICS OF THAILAND. 1981 *Development plan ofsourhern resource of Thailand.* 11 p

APPENDIX XIII

Environmental Conditions in the Gulf of Thailand

The upper Gulf Haters contain an average of dissolved dispersed petroleum hydrocarbons (DDPH) of 2.3 micro g/l (crude oil equivalents 0.65-8.30 micro g/l) T he average value of only 1 .3 micro g/l is recorded in the lower Gulf waters (crude oil equivalents 0.07-6.6 micro g/l). DDPH derives from river discharges of diesel oil and petroleum (Wattayakorn 1987). Values from the Andaman Sea coasts are only 0.04-1.21 micro g/l, i.e significantly lower.

Rojanapantip et al. (1987) reported that mercury investigations were conducted on the contaminations found in the Andaman Gulf in 1973-1986. A total of 1680 specimens were analyzed from 94 species of fish, squid, shrimp etc. The average results ranged from 0.02-0.058, 0.019-0.043 and 0.039-0.075 mg/kg of mercury from samples from the upper Gulf, loner Gulf and Andaman Sea (Phuket to Satun Province) respectively. The recorded levels are well below the highest permissible value recommended by the World Health Organisation (WH0) 0.5 mg mercury/L This limit is, however, exceeded in occasional sharks.

Jarach (1987) reported that the dissolved heavy metals found in seawater during the part four years uere copper 3.8-30.0. iron 480-1080, mercury 0.1-13.7 and zinc 3.1-190.0 micro g /l. Extreme values of 2,150 micro g Fe l and 88.7 micro g hg/l were recorded. Generally, however the levels were well below the threshold limit. Despite this, mercury showed an increasing upward trend, which could be regarded as a warning signal for potential hazards affecting marine fauna.

During 1973-1986. a radioactive survey was undertaken in the Gulf of Thailand. Gross beta activity measurements of seawater and fresh sediments resulted in 1.58± 0.1 l · l 1 .38 ± 0.76 Bq/l and 0.03 ±0.01 · 0.53 ± 0.17 Bq/l respectively, while the activity of living resources (fish and oyster) was 0.01 ± 0.0001-0.09± 0.003 Bq/l (Mahapanyawong, et al. 1987). In Sweden. sea food exceeding 150 Bq/kg is not allowed to be sold.

Microbiological quality of the seawater of the east coast of Gulf of Thailand has been analyzed Coliform, faecal coliform, faecal streptococcus and Clostridium perfringens were found in most samples. The highest values recorded were in bivalves. whilst relatively low values were found in sediment and seaw ater. However, since only Vibrio prahaemolyticus was recorded in most specimens and Salmonella spp and Vibrio cholera were absent, it was concluded that the shellfish uere acceptable and safe for human consumption (Saitanu er al. 1987)

Piyakarnchana et al. (1987, 1990) reported that four species of dinoflagellates causing shellfish poisoning were found along the gulf coastline. These caused Paralytic Shellfish Poisoning (PSP) and Diarrhoetic Shellfish Poisoning (DSP) and were identified as *Alexandrium leei, Dinophysis caudata, Protogonyaulax tamarensis and P. cohoriticula*. These species, however, have not yet been observed in the Andaman Sea samples from Phuket and nearby areas.

Suwapeepan (1984) reported that the occurrence of red tide in the Gulf was causing damage to the extent of US$ l .2 million to coastal aquaculture Maclean (1984), revealed that red tide occurrence and shellfish toxicity in Southeast Asia were caused by *Protogonyaulax bahamaensis* var *compressa, P. tamarensis, P. cohoriticula, A lexandrium leei and Dinophysis caudata.* The red tide occurred in the upper Gulf, particularly during periods of heavy rainfall. Rainwater washing out large amounts of nutrients into the upper Gulf causes increased growth of dinoflagellates. The dinoflagellate species responsible for red tides may, however, vary from year to year. Before 1983, the red tides Here dominated by Nocticula *scintillans,* but in 1983 they were dominated by *Ceratium furca* Algal blooms in the Gulf. however, generally comprise three species, namely *Noctiluca scintillans* causing green water colour. Ceratium furca causing red water colour and *Oscillatoria erythrace* causing blue-green water colouring, Temiyavanich and Rojnavipart (1984) found that *Dinophysis caudata* was causing red water colour and had poisonous decomposition products.

Thoophom et al, (1987) revealed that the insecticides Dichloro Diphenyl Trichloroethane (DDT), Dieldrin, BHC, Endrin and Lindane were detected in three mollusc samples of green mussel *(Perna viridis L).* oyster *(crassostrea commercialis)* and cockle *(Anadara graanosa)* The results showed levels lower than 0 01 mg/ kg. DDT values, however, ranged from 0.002 to 1.404 micro g/l and Lindane ranged from 0.002 to 0.1 l micro g/l. Extremely high levels uere detected only in a few samples. Samples of marine fish, shrimp and squid from the Andaman Sea (Krabi, Phuket and Trang Provinces) showed in levels lower than 0.01 mg/l. This level is well below the standard threshold limit of 0.07 mg/kg (L'S EPA, 1976, Butler et. al., 1973). Lertruengedj et al., 1987, however, found that high levels of DDT were recorded in 1973, but they decreased in the following years. This was probably due to the banning of DDT application It uas also found that PCB's were virtually absent in the Gulf water. Some values of water quality analyses are shown in the tables alongside.

Water quality of upper south regions of the Gulf (Ban Don Bay, Surat Thani Province) and the Andaman Sea (Phang-nga Bay, Phuket Province

	*Gulf**	*Andaman Sea"*
Salinity (ppt)	32 3 32.4	31 4 32 0
Mater temperature (C)	29 30	28.2 · 29
pH	8.16. 8.23	8.23 -8.35
Dissolved oxygen (ppm)	1 . 3 4.8	6.0 7.0
Chlorophyll a (mg/ m^3)	1 2 3.4	287 · 956
Hydrocarbon (micro g/l)	0.79 2 37	0.25 - 0.74
P (umol 1)	0-10	0.1-0.5
N (umol 1)	0 12	0 l ! l 60
SiO, (umol l)	5.8 33 l	–
Organic Carbon (mg l)	1 -25 - 40	-

Sources * Hungspreugs et al 1987 ** Limpsaichol et al,. 1988

Hungspreugs (1987) reported that the major phytoplankton genera in the Ban Don Bay water were *Bacteriastrum* spp., *Pleurosigma spp., Thalassiotrix* rpp., *Cerataulina spp., Thalassionema* rpp. and *Rhizosolena* spp. These had densities ranging from 1788-24,389 ind/l. The most abundant zooplankton types were calanoid copepods and decapod larvae which ranged from 7737 to 38.514 ind/m^3. The benthic organisms reported from the area were polychaets, bivalves, gastropod5 and crustaceans and others, with an average density of 141 ind/m^2.