An oyster hatchery in a mangrove-lined creek in Malaysia.

The West Coast of Peninsular Malaysia

by

Choo, P.S.,
Ismail l.

and

Rosly, H.

Fisheries Research Institute,
Ministry of Agriculture, Malaysia.

9. *INTRODUCTION*

With increasing industrialization and urbanization since the 1980s, pollution problems have featured more prominently in Malaysia and public awareness has increased. Hazards to the coastal environment in Malaysia include domestic discharge, sewage (including animal wastes), industrial and agricultural effluents, as well as pollution caused by major engineering and development projects.

Furthermore, the accelerated development of improperly planned coastal aquaculture has also had negative environmental impacts. Extensive conversion of mangrove swamps into ponds, changes in hydrologic regimes in enclosed waters due to proliferation of aquaculture structures and the discharge of high levels of organic matter into coastal waters (Chua *et* a!., 1989) are among these negative impacts.

Sheppard (1992) analyzed fish catch data by plotting resource use against demand and showed that there was a steep decline in fish catch per unit population from 1970 to 1990. This is indeed alarming, as it indicates that fish resources are being exploited beyond maximum sustainable yield (MSY) levels despite the numerous management programmes already being implemented. The effect of mainly land-based pollution and destruction of natural habitats, such as mangrove swamps, coral reefs and seagrasses, could be major factors responsible for this situation (Lulofa, 1977, Sasekumar, 1980, Phang, 1990).

This report describes the state of the coastal environment of western Peninsular Malaysia.

10. *MARINE HABITATS*

10.1 *Mangroves*

The total acreage of mangrove forests in Peninsular Malaysia has been estimated around 103,000 ha, the bulk of these fringing the west coast (Tang *et a!.,* 1990). Of this total, the Larut Matang mangrove swamp in the state of Perak is not only the largest (40,000 ha), but is also stated to be the best managed mangrove forest in the world (Gong *et a!.,* 1980). Other major areas of mangroves include Merbok, Kedah (9,037 ha), Kelang mangrove swamps, Selangor (22,500 ha) and the Johor mangrove swamps, Johor *(25,618* ha). Figure 6 alongside shows the extent of the mangrove forests on the west coast.

The threat to Malaysia mangroves lies in land conversion or deforestation for agriculture, industry and, to a lesser extent, for aquaculture. Aquaculture sites are shown in Figure 6. It has been estimated

Fig. 6 Map of Peninsular Malaysia showing marine habitats of the west coast and major aquaculture activities

that 27,000 ha of mangrove swamps are suitable for aquaculture (Cedney et *al.,* 1982). Malaysia, however, has a national committee of experts to oversee its mangrove forest management (NATMANCOM, 1986).

10.2 *Coral reefs*

There are only two significant coral reef sites on the west coast:

- The Payar group of islands in the north of Kedah, and
- The Sembilan group of islands off Perak (see Figure 6).

A smaller site is at Cape Rachado, near Port Dickson, Negri Sembilan . The reefs are of the shallow water, fringing type, which are found around many offshore islands (De Silva, 1982). There is a comprehensive paper on the status of the coral reefs on the west coast of Peninsular Malaysia (Jothy, 1973).

The biggest threats to the coral have been due to exploitation for commercial and educational purposes, coupled with siltation and sedimentation caused by development projects (Liew and Hoare, 1982). The Department of Fisheries has taken steps to conserve and rehabilitate the country's coral reefs by gazetting as marine parks many of the islands where corals are found. The Payar group of islands is the best-known beneficiary of this conservation policy.

10.3 Seagrass beds

A recent review of seagrass distribution by Kushairi (1992) indicated five areas of seagrass off the west coast of Peninsular Malaysia (see Figure 6). Five species were found in shallow waters, ranging in depth between 0.2 and 1.8 m. The species mentioned are *Halophila ovalis, H. uninervis, H. pinifolis, H. minor* and *Enhalus acoroides.* Phang (1990) for the occurrence of *Cymodocea rotunda* in Port Dickson, for the occurrence of *C. serralata* in Johor. It would seem that these two species have disappeared completely, probably due to environmental pressures. Sasekumar, quoted by Phang (1990), described the occurrence of *Syringodium* sp. from the Pulai estuary in Johor. The seagrass beds are endangered by erosion, faecal contamination and heavy metal pollution (Phang, 1990 and Kushairi, 1992).

11. *MARINE POLLUTION*

Malaysian coastal waters are mainly contaminated with oil and grease, faecal coliform bacteria and suspended solids. Land development, agriculture and high population density are among the main causes of water pollution (Environmental Quality Report — EQR — 1990). Major river basins and industrial zones are shown in Figure 7 (see facing page).

11.1 *Sewage*

The coastal waters of Malaysia show substantially high levels of faecal coliform bacteria. In 1990, for instance, 90 per cent of the 114 coastal water samples in Pinang, exceeded the proposed interim standard of 100 MPN/100 ml of faecal coliform meant for recreational purposes (Environmental Quality Report, 1990). Out of 38 coastal water samples in Perak and 138 in Johor, examination revealed that about 50 per cent exceeded the proposed standard. In Kedah/Perlis, about 45 per cent of the 75 samples analyzed were higher than the proposed standard. Seriously affected beaches in Pinang in 1990, included Batu Maung, Telok Tempoyak, Batu Ferringhi and Pantai Bersih.

Fig. 7 Map of major river basins and industrial zones in Peninsular Malaysia.

Based on the 1990 statistics provided by the Veterinary Services Department, Malaysia, the standing pig population (SPP) of the coastal states of Peninsular Malaysia was approximately 2.3 m and averaged approximately 717 SPP/farm. By the year 2000, the SPP is projected at around 3 million. The table alongside shows the number of farms and the pig population of the west coast states in Peninsular Malaysia

Number of farms and pig population in the west coast states of Peninsular Malaysia (1990-91)

State	*No. of farms*	*Pig population*
Melaka	62	92,290
Kedah	9	5,116
Perak	559	407,688
N. Sembilan	654	618,326
Selangor	481	487,011
Pinang	1,187	390,179
Johor	164	302,470
Total	3,226	2,313,080

Pig farms generate large quantities of waste and some of these farms discharge effluents directly into estuaries and tidal rivers without any pretreatment. A report by the Veterinary Services Department, Malaysia, in 1982, indicated that most states have serious pollution problems that can be attributed to pig farms. It has been found that 45 per cent of the farms in Selangor and 82 per cent in Negri Sembilan pollute the environment. Due to economic constraints, waste abatement is practised only in the large farms. Piggery wastes not only contaminate the water with bacteria and parasites, but also exert high demand for oxygen (ROD) and cause eutrophication. Characteristics of raw wastewater from pig-pens are given in the table alongside.

Characteristics of raw waste water from pig-pens

Parameter	*Range*
BOD (mg /l)	900 – 21,690
COD (mg/l)	4800 – 39,000
Total solids (mg/l)	3690 – 22,300
Suspended solids mg/l)	636 – 15,900
Ammoniacal nitrogen (mg I)	75 – 950
Total nitrogen mg /l)	370 – 2080
Organic nitrogen (mg/l)	140 – 1370
Phosphate mgi)	60 – 1600

Source: Ho, Y. C.. *et al.,* 1984.

11.2 *Heavy metals*

The Department of Environment reported higher concentrations of heavy metals in the waters off the west coast of Peninsular Malaysia compared to other areas because of the greater extensive land use and industrialization. In 1990, among the rivers that recorded samples exceeding the standard values of 0.02 mg/litre lead were Sg. Perak, Sg. Selangor, Sg. Kelang, Sg. Linggi and Sg. Melaka. Rivers with zinc levels exceeding 0.4 mg/litre included Sg. Sepang, Sg. Langat and Sg. Kelang. Sg. Bernam, in the west coast of Peninsular Malaysia, recorded copper values higher than the proposed value of 0.012 mg/litre. Rivers that recorded values exceeding the proposed value of 0.004 mg mercury/litre included Sg. Muar, Sg. Duyong, Sg. Kurau, Sg. Bernam, Sg. Selangor and Sg. Kelang. Cadmium and arsenic concentrations were negligible in most of the rivers monitored.

Almost all the samples collected from the coastal waters of Malaysia contained values of lead, copper and cadmium above the proposed standards of 0.05 mg/litre lead, 0.01 mg/litre copper and 0.005 mg/litre cadmium. The coastal waters of Perak and Penang recorded high levels of cadmium, copper, lead, mercury and nickel. In 1990, around 50 per cent of the 41 samples collected from Perak had values exceeding the proposed standard of 0.005mg mercury/litre. In 1989, more than 80 per cent of the 42 samples collected from the coastal waters of Perak had values above the proposed standard of 0.01 mg nickel/litre. And in Pinang, all the samples analyzed for nickel exceeded this value.

Shellfish and fish analyzed by the Fisheries Research Institute (FRI) indicated that it was safe to eat fish and shellfish from Malaysian coastal waters (Jothy and Ibrahim 1987; Shahuntala. 1986 and 1989).

11.3 *Agro-based industries*

Pollution from the palm oil and rubber processing mills is the most severe in agro-based industries (Mohd. Ismail Yaziz, 1983). This is because the wastes from these effluents contain very high concentrations of organic material, suspended solids, nitrogen and phosphorous. The discharge of the concentrated waste water into surface waters leads to rapid depletion of dissolved oxygen.

PALM INDUSTRY

Close to about two million hectares are under oil palm in Peninsular Malaysia. Malaysia is currently the world's major producer of crude palm oil (CPO), producing five million tonnes in 1988. The coastal states of Peninsular Malaysia produced 3.6 million t of CPO in 1991 from 153 operating mills (see table below). The average annual production was 136,420 t CPO/mill, with each mill operating at an average of 371 hrs/mth. From the 3.6 million t CPO, about 9-11 million t (CPO x 2.5-3) of palm oil mill waste (POME) were produced (Mohd. Tayeb et al., 1987).

Crude palm oil (CPO) production in Malaysia in 1991

State	*CPO prodn. (t)*	*No. of mills*	*Avg. capacity (CPO/ T/Y)*	*Avg. operating hrs (Hr/Mill/MO)*
Johor	1,682,262	66	175,058	369.88
Kedah	91,271	4	108,000	397.06
Melaka	42,020	2	108,000	417,15
N. Sembilan	341,323	13	174,308	374.91
Pinang	61,338	4	123,600	307.86
Perak	793,174	35	138.775	397.00
Selangor	589,348	29	127,200	331.53
Total	3.600.736	153		

Methods for treating POME (anaerobic and aerobic/facultative, oxidation ponds etc.) are well established (Wong, 1980; Ma, 1988). The average characteristics of POME are listed in the table below. The effluent standards necessary for POME before discharge into a water body are shown in the table below right.

The average characteristics of untreated palm oil mill effluent (POME)

Parameter	*Range*	*Mean*
pH	3.4-5.2	4.2
BOD (mg/l)	10,250-43,750	22, 260
COD (mg/l)	15,550-100,380	50,710
Total solids (mg/ l)	11,460-78,710	40,370
Suspended solids (mg l)	4400-53,640	17.620
Volatile solids (mg/l)	8770-71,610	33,820
Oil and grease (mp/l)	130-17,970	6110
Ammoniacal nitrogen (mg/l)	4-77	35
Total mtrogen (mg/l)	180-1360	750

Source Chew. T. Y. and Yeoh. B G., 198'

Maximum standards for effluent discharge into watercourses for the oil palm industry

Parameter (mg/l)	*Concentration (mg/l) 1984 and after*
BOD	100
COD	1000
Total solids	1500
Oil & *grease*	50
Ammoniacal nitrogen	150
Total mtrogen	200

Source : Environmental Protection Act, 1986

Aside from the high organic load, the final effluent can also contribute to eutrophication due to the nitrogen and phosphorous load in the **POME.** Treated effluents are also known to contain certain bacterial populations. In the digested POME, for example, 1-42 x 10^6/100 ml total coliform and 1-518 x 10^6/100 ml faecal coliform have been recorded (Mohd. Tayeb et ***al.,*** 1987).

Aspects of waste utilization have been widely researched. Some of the uses for POME are in land application, as animal feeds, and for biogas production.

RUBBER INDUSTRY

About 1.9 million ha of land in Malaysia were under rubber cultivation in 1989. The production of 1.42 million t of natural rubber placed Malaysia as the world's top producer that year. However, the rubber industry in Malaysia is slowly declining, with planters switching to more lucrative crops like oil palm and cocoa.

Factories manufacturing latex concentrates and standard Malaysian rubber (SMR) produce waste which could pollute the environment. The Rubber Research Institute, Malaysia (RRIM) states that 48 factories produce latex concentrate and 96 factories produce SMR. About 4.5 litres of effluents are produced for every litre of latex processed (Ahmad Ibrahim et ***al.,*** 1980) and 22 litres of effluents are generated per kg of dry rubber produced (Mohd. Tayeb et ***al.,*** 1980). Besides, 6.23 x 10^6/100 ml total coliform, 0.75 x10^6/100 ml faecal coliform and 0.13 ***x*** 10^6/100 ml ***streptococcus*** have been recorded from the raw effluent (Mohd. Tayeb et ***al.,*** 1980). Properties of effluents from raw rubber processing are given in the table below.

Characteristics of raw rubber effluent

Parameter	*Block*	*Sheer*	*Crepe*	*Latex concentrate*
pH				5.4
BOD (mg/l)	1769	1322	305	3524
COD (mg/l)	2899	2471	846	4849
Total solids (mg/l)	1961	1976	546	3860
Suspended solids (mg/l)	322		7	818
Ammoniacal nitrogen (mg/l)	68	73	6.4	466
Total nitrogen (mg/l)	141	143	75	602

Source : Wong. K.K. 1980

Methods of treating rubber effluents have been established and the effluent standards set by the Department of Environment, DOE, are given in the table alongside.

Maximum standards for effluent discharge into watercourse for the rubber industry

Parameter	*Concenrrarron (mg/l) 1984 and after*
BOD	100
COD	400
Total solids	1,000
Suspended solids	150
Ammoniacal nitrogen	300
Total mtrogen	300

Source : Environmental Protection Act, 1986

11 .4 Pesticides

Synthetic organic pesticides were first introduced in the 1940s and were not only very effective in the control of agricultural pests but also in curtailing disease vectors, such as mosquitoes. Estimates in Malaysia put the value of pesticides used at MS $3 15 million* in 1990, with an annual increase of about 8 per cent/year over the last five years (Tan et ***al.,*** 1992). The widespread, and often indiscriminate, use of pesticides, however, has created environmental deterioration and has had detrimental effects on nontarget organisms. Today, pesticide usage in Malaysia is controlled by the Pesticide Board of the Department of Agriculture.

* US $ I = MS $ 2.5 appx. (1990)

Little is known about the distribution of pesticides in the aquatic environment. Organochlorines, which generally cause more serious and widespread contamination than other pesticides, are still widely used, and only guidelines – not legislation – are available on their use.

Studies have shown that organochlorines have contaminated some of Malaysia's river systems and aquatic life. A survey in the Kelang River basin by Tan ***et al.*** (1990) reported that the river was contaminated with 0.005-0.061 ng aldrin/l, 0.009-0.256 ng endosulfan/l and 0.039-1.742 ng heptachlor/l. The study also reported that DDE, DDT and heptachlor were found to be present in all the rivers sampled on the west coast of Peninsular Malaysia. However, the levels were still below the critical values established for Malaysian aquatic life. This indicates that organochlorine pesticide pollution is less of a problem than other organic or inorganic pollutants. A survey carried out by Jothy ***et al.*** from 1975-1978 found that the cockle, ***Anadaragranosa,*** contained PCB values ranging from 0.028-0.038 ppm-HCH ranging from 0.003-0.008 ppm, dieldrin 0.001-0.005 ppm, DDT 0.004-0.009 ppm, DDE 0.016-0.042 ppm and DDT 0.027-0.050 ppm. These values were far below the limits of acceptability for human consumption. Rohani et ***al.,*** (1992) reported that the levels of organochlorines and PCBs in the cockle, ***Anadara granosa,*** the oyster, ***Crassostrea belcherei,*** and the green mussel, ***Perna viridis,*** were generally low, and within the acceptable limits prescribed by the Swedish National Food Administration.

In its efforts to minimize pesticide contamination of the environment, the Pesticide Board, in collaboration with the manufacturers and end-users (mainly oil palm and rubber estates), have introduced new, improved application techniques and strategies. Since 1980, new control strategies, such as the Integrated Pest Management (IPM) programmes, have been introduced.

11.5 Soil erosion and sedimentation

Suspended solids, which act as an indicator of soil erosion and river siltation, have caused a major environmental problem in Malaysian waters during recent years (Environmental Quality Report, 1990). The high levels of suspended solids in the river systems are associated with the continuous and intensive land clearing, uncontrolled development, mining and logging activities in the catchment areas. In Peninsular Malaysia, out of 53 rivers monitored between 1986-1990, 27 rivers (51 per cent) were classified as very polluted, six (11 per cent) were considered slightly polluted and twenty (38 per cent) were considered clean. The worst affected rivers in terms of suspended solids on the west coast of Peninsular Malaysia were Sg. Pontian Besar and Sg. Benut in Johor, and Sg. Tengi and Sg. Buloh in Selangor.

The coastal waters of Peninsular Malaysia are nowadays polluted with suspended solids, (Environmental Quality Report, 1990). River estuaries on the west coast with substantially high levels of suspended solids include Kuala Sungai Kedah in Kedah, Kuala Sungai Juru in Pinang, Kuala Sungai Kurau and Kuala Sungai Sepetang in Perak, Kuala Sungai Melaka in Melaka and Kuala Sungai Lurus in Johor.

11.6 Petroleum

The Malacca Strait is one of the world's busiest oil transport routes and, accidental and deliberate oil spills affect the marine environment. In 1990, very high oil and grease contents were found on the Perak coast. All 141 water samples collected by the Department of Environment exceeded the proposed interim oil standards set for marine aquatic conservation resources (Environmental Quality Report, 1990). Of the 70 samples collected from the coastal areas of Negri Sembilan, 90 per cent exceeded the proposed standard. In Melaka and Selangor, 75 per cent of the 24 and 23 samples collected respectively contained oil and grease levels exceeding the proposed standard. All

75 samples collected from Penang and the 61 samples from Kedah/Perlis, however, had levels below the proposed standard.

Beach tar sarnpling is carried out by the DOE on selected beaches, especially those designated for recreational purposes. Johor beaches have oeen found to be seriously affected with tar balls (188.7-512.9 g/m strip). Beaches in Melaka, Negri Sembilan, Perak and Selangor have relatively low levels of tar balls (0.2-10.0 g/m strip) (Environmentai Quality Report, 1990).

11.7 *Power plants*

Relatively little information is available on the effects of power generating plants on the marine environment. Anton (1990) made a study on the impact of a 3000 MW electricity-generating power station in Kapar, Selangor. Water was heated l-7ºC above ambient (29º C). Her studies indicated that the total number of cells and species diversity were high at stations which recorded higher seawater temperatures and could be advantageous to shellfish culture in the vicinity. However, studies on seagrass showed the deleterious effect of temperature elevation of just 3ºC; the sea-grasses were killed and replaced by algal mats.

11.8 *Aquacuiture*

High priority is given by the Malaysian Government to the development of aquaculture in the country. It is estimated that by the year 2000 more than 200,000 t of seafood would be produced from farming (Tengku Ubaidillah, 1985). Aquatic organisms successfully cultured in the coastal areas of Peninsular Malaysia include the blood cockle, Anadara granosa, the mussel, *Perna viridis,* the oyster, *Crassostrea belcherei* and *C. iredulei,* the penaeid prawn, mainly *Penueus monodon,* and finfish, including *Lutes culcurifer, Epinephelus* sp. and *Lutianus* sp.

Aquaculture that is badly planned or managed can cause coastal erosion and the pollution of riverine and coastal waters. However, properly planned and managed aquaculture systems should have only a minimum impact on the riverine and coastal waters and should not be a threat to the environment.

Most of the brackishwater ponds in Malaysia are utilized for penaeid prawn culture and these ponds are normally sited in mangrove areas. Guidelines have been formulated by a National Working Group of Mangroves (NATMANCOM, 1986) on the use of mangroves for this purpose.

So far, no complaints about adverse effects on the environment have been received for mollusc culture. However, Chua et al. (1989) reported that the effects of oyster and mussel culture on water quality are indirect: excessive sedimentation occurring in Sapain Bay and Himamaylan Island, Central Philippines, has been attributed to extensive mollusc farming (Young and Serna, 1982; Maragos et al., 1983). The high sedimentation resulted in increased water turbidity, although no marked reduction in primary productivity has been reported.

Cage culture for the rearing of grouper *(Epinephelus* sp., seabass *(Lutes* culcurifer) and snapper (Lutianus sp.) was introduced in Peninsular Malaysia in the mid-Seventies. Pollution associated with cage farming is caused by waste (faeces and uneaten food) and nutrient discharges which reduce dissolved oxygen in the water and cause high Biological Oxygen Demand. However, adverse effects on water quality due to cage farming have generally not been reported, but complaints of polluted water affecting fish farmed in cages are frequently received. To overcome the problem of culturing fish in coastal waters which may be polluted, the Department of Fisheries is conducting research on the cage culture of fish in the open seas, which are normally less polluted.

12. MARINE FISHERIES

In Peninsular Malaysia, landings of marine finfish and shrimp showed an increasing trend between 1970 and 1980, but, then onwards, declined untii 1986. From 1986 onwards, there has been an increase in the recorded landings, partly due to the landings from the deep sea areas of the Malaysian Exclusive Economic Zone (EEZ) (Annual Fisheries Statistics, Malaysia 1970-1990).

The fisheries resource within the inshore water appears to have reached its maximum level of exploitation, but the declaration of the EEZ has enabled the Malaysian Government to actively encourage the development of the offshore fishery (Lui, 1992).

The fisheries on the west coast of Peninsular Malaysia contribute around 70 per cent of the total marine resources of Peninsular Malaysia (Annual Fisheries Statistics, Malaysia). These resources are made up of two major groups – ihe demersal and the pelagic resources.

12. 1 Demersal resources

The demersal fish resources include species from the following families – Mullidae, Nemipteridae, Sciaenidae, Lutjanidae, Tachysuridae and Synodontidae (Mohammed Shaari *eta!.,* 1974., Lui and Ahmad Adnan, 1988). While landings of the dominant fish groups have remained quite consistent over the years, the relative abundance of certain fish groups observed some dramatic changes. The landings of cephalopods in Peninsular Malaysia have shown an increase from 3462 t in 1970 to 27,939 tin 1988. The landings of *I.actarius lactarius,* which was abundant in the early Sixties, has disappeared in the Seventies, and the landings of ray also declined over the years (Annual Fisheries Statistics, Malaysia). The shrimp resource contributed substantially to the demersal landings on the west coast of Peninsular Malaysia. The economically important species include *Metapenaeus, Parapeneopsis* and *Penaeus,* which are widely distributed in the shallow waters by the west coast (Lee, 1972).

12.2 *Pelagic resources*

The major groups of pelagic fish that contribute significantly to the commercial fisheries are the scombrids, carangids, engraulids, the clupeids and neritic tunas. The pelagic fish resources appear to exhibit a seasonal inshore-offshore migration pattern in relation to the Northeast Monsoon. During the off-monsoon season, there seems to be an inshore movement of the pelagics, and during the monsoon season, offshore migration and dispersion occur (Anon, 1989).

13. ALGAL BLOOMS AND FISHKILLS

Fish kills from natural or culture fisheries are occasionally reported. Causes of mortality include pollution, eutrophication or algal blooms. Cases of shellfish poisoning from algae blooms, such as *Pyrodinium,* have been reported only in Sabah, East Malaysia.

In Malaysia, the red tide blooms that cause Paralytic Shellfish Poisoning (PSP) have so far been reported only in the waters off Sabah. In Peninsular Malaysia, red tide bloom varieties that do not cause PSP have frequently been reported. *Noctiluca scintillans* has been reported in Johor, causing fish and shrimp mortality. The red tide occurrences in Malaysia are listed in the table alongside. The dinoflagellate, *Pyrodinium bahamensa* var. *compressa* has **been reported to cause human** fatalities as well as mortality of **aquatic life. Blooms caused by** *Noctiluca scintillans* and *Hornellia marina* have been **reported to cause only fish and** shellfish mortality.

Record of red tide occurrences in Malaysia

Date	*Site*	*Organism*	*Impact*
Feb-May '76	K. Kinabalu. Sabah	Pvrodinium	202 affected, dead, aquatic life mortality
Aug. '78	T. Kumbar, Pinang	*Noctiluca*	Fish kills.
Nov. '78	P.BetongK.Sg. Pinang, Pinang	*Noctiluca*	Fish asphyxiation
Oct. '79	T. Kumbar, Pinang	*Noctiluca*	Fish asphyxiation
May '80	Brunei Bay, Sahah	*Pvrodinium*	30 affected, 1 dead
Jan. '83	Gava Island, Sabah	*Pvrodinium*	31 affected, 3 dead
Man., May-Jul., Sep-Nov. '83	Johor St.	*Hornellia*	Fish, shrimp, crab mortality
Jan. - Mar. '84	Gava Island, Sabah	*Pvrodinium*	9 affected, 7 dead
Jan. Feb. '85	Johor St.	*Hornellia*	Shrimp mortality
Sep. '85	Kimanis Bay. Sahah	*Pvrodinium*	Toxin in *Crassostrea belcherei*
Dec. '87 . Jan '88	Sabah waters	*Pvrodinium*	31 affected, 3 dead, cats died.
Jun. '90	S8. Dindings, Perak	unidentified	Sores in fish, mussel mortality

Source.' Choo, 992.

Fish kills in the coastal and estuarine waters of several rivers in western Peninsular Malaysia have been on the increase over the years. The table alongside shows the outbreak of fish kills and diseases. Highest mortality was probably due to either factory effluents or high organic load in the water.

In the state of Johor, a review of 1987-1991 revealed 21 written reports made to the Department of Fisheries. Of these 21 cases, six (28.6 per cent) were associated with palm oil mill effluents, five (23.8 per cent) with industrial wastes and five others (23.8 per cent) with spills and direct or indirect pollution caused by sand dredging and mining.

Fish kills in coastal waters of west coast of Peninsular Malaysia

Date	*Location*	*Outcome*	*Reported cause*
June '75	B. Feringghi, Pinang	Fish mortality	Severe organic pollution; piggery waste.
Oct. '77	Juru estuary, Pinang	Mass cockle mortality	Effluent pollution; heavy ram with salinity drop.
Nov. '19	Tebrau Bay, Johor	Mass mortality of fish fingerlings	Piggery wastes.
Nov. '80	Prai estuary, Pinang	Fish mortality	Factory effluents.
Jan. '81	Pulau Aman, Pinang	Cage-cultured fish mortality	Oil spill.
Mar. '84	Batu Maung, Pinang	Mass *cockle* mortality	Piggery wastes and soil erosion.
Apr. '85	Muar estuary, Johor	Oyster mortality	Factory effluent.
Sep. '85	Tebrau Bay, Johor	Mussel mortality	Low oxygen.
Jun. '89	Kuala Kurau, Perak	Fish kills	High sediment.
Apr. '90	Sg. Sepetang and estuary, Perak	Fish kills	Factory effluents.

Source : Department of Fisheries.

14. ONGOING RESEARCH PROJECTS

14.1 Department of Environment

The DOE implements the following programmes to reduce environmental pollution (Environmental Quality Report, 1990):

- Pollution control and prevention;
- Integrated project planning;
- Environmental inputs to resource and regional development planning;
- General environmental programmes; and
- Pro-active response to international environmental issues.

14.2 Fisheries Research Institute (FRI)

The research projects carried out by the FRI include :

Water quality monitoring and fish kills;
Heavy metals in water, sediments and fish/shrimp/mollusc tissues;
Pesticide residue studies in tissues of fish/shrimp/molluscs;
Antibiotic residue studies in fish/shrimp/molluscs;
Toxicological studies, especially of oil-dispersants and pesticides;
Impact of sediments on the coral reef ecosystem;
Conservation studies in mangrove, coral reef and seagrass habitats; and
Development of artificial reefs for fisheries conservation, rehabilitation and management.

The FRI also participates in the International Atomic Agency (IAA) Project on Marine Sediment Contaminant Survey implemented in 1990, and also in the project on Marine Sediment Pollution.

Other participants in these two projects include Universiti Pertanian Malaysia, Universiti Kebangsaan Malaysia, the Nuclear Energy Unit and the DOE.

14.3 Universities

Some on-going projects carried out in the Universiti Sains Malaysia include studies on the impact sediments have on coral reef ecosystems, toxicity studies of effluents discharged from crude oil terminals, the effect of tributyltin on the aquatic environment, and heavy metals and organic wastes treatment studies.

In the Universiti Pertanian Malaysia, research projects on marine pollution include studies on hydrocarbon pollution, the impact of sediments on the coral reef ecosystem, a study of the impact of industrial plants on the marine environment, as well as work on the Environmental Sensitivity Index (ESI) mapping.

Other current Universiti Malaya research projects include multidisciplinary studies on coastal and marine ecosystems and pollution studies related to toxicity testing for pesticides, organic chemicals and heavy metals in fish and other aquatic life.

15. CONCLUSIONS

Coastal marine environment pollution does pose a major threat to the well-being of the fisheries industry in Malaysia. However, the Government of Malaysia is well aware of the problems, and specific action plans are being mobilized to alleviate and control environmental degradation. Malaysia has been actively involved in the recently concluded UNCED Earth Summit held in Rio, in Brazil, July 1992 and is also a cosignee of the Declaration on Biodiversity. Malaysia is firmly committed to the 1982 Law of the Seas Convention. These policies are being translated into action: Thirtytwo islands have been gazetted as protected marine parks, and environmental impact assessments have been made mandatory for major development projects.

16. REFERENCES

AHMAD IBRAHIM, S. SETHU. MOHD. ZIN KARIM and ZAID, ISA. 1980. Anaerobic/facultative ponding system for treatment of latex. *Proc. Rub. Res. Inst. Malaysia* PIns. *Conf.,* **pp 419-435.**

ANNUAL FLSHERIES STATISTICS, **1970-1990. Dep. of Fisheries, Min. of Agriculture, Kuala Lumpur, Malaysia**

ANONYMOUS. *1989. Deep-sea fisheries resources within the Malaysian Exclusive Economic Zone — survey report of demersal and pelagic* **resources. Paper presented at the Seminar Sumber Perikanan Laut Dalam di Zon Eksklusif Ekonomi (ZEE). Malaysia, Kuala Lumpur.**

ANTON, A. 1990. Effects of thermal discharge on marine phytoplankton. *Proc. 12th An. Sem. of the Mal. Soc. of Mar.* **Sc.. Kuala Lumpur.**

CHOO. P. S. 1992. *A review of red tide occurrences* **in** *Malaysia.* **(In preparation).**

CHEW, T. Y. and YEOH.B. G. 1987. Palm oil mill effluent as a source of bioenergy. *Proc. Natl. Symp. Oil Palm By-Prod. for Agro-based Ind.,* **pp. 155-168.**

CHUA, T.E.. JAMES, N.P. and FLORDELIZY, Y.G. 1989. The environmental impact of aquaculture and the effects of pollution on coastal aquaculture development in Southeast Asia. *Marine Pollution Bulletin.* **Vol. 20, No. 7: 335-343.**

DE SILVA. M. W. R. N. 1982. The status and conservation of coral reefs in Peninsular Malaysia. *Proc. of the 4th Ann. Sem. of the Mal. Soc. of Mar. Sci.*

DEPARTMENT OF ENVIRONMENT. *1990. Environmental Qualify Reports.* **Min. of Sc., Tech. and Env., Malaysia, Annual report.**

GEDNEY, R. H ., KAPETSKY, J .M. and KUHNHOLD. *1982. Training on assessment of coastal aquaculture in Malaysia.* **Manila Sourh China Sea Fisheries Development and Coordinating Programme. SCS/GEN/82/35.**

GONG, W.K., ONG, J.E., WONG, C.H. and DHANARAJAH, C. 1980. *Productivity of mangrove trees and its significance in a managed* mangrove ecosystem in Malaysia Asian Symp. *on* Mangrove Env. Res. and Mgmnt., University of Malaya and UNESCO, August 25-29. 1980.

HO, Y.C., CHEE, Y.S.. CHONG. C.N., CHOY, C.K., YEOH, B.C. and YEW, K.K. 1984. Environmental, social and economic considerations in the management of swine wastes in Malaysia. *Proc. Reg. Sem. Tech. Utilization and Mgmnt. o f Agri. Wastes.*

JOTHY, A.A. 1983. ***The need for standardization of techniques and intercalibration of results in pollution assessment and monitoring in Asian seas.*** Paper at Symp. on Reg. Co-op. on the Protection of the Env., 15th Pac. Sci. Cong., Dunedin, New Zealand, February 1-11 1983.

_____ ***1973. Coral reefs in the coastat wafers of West Malaysia, their utilization and conservation.*** Departmental paper, Fisheries Research Institute, Penang.

JOTHY, A.A. and IBRAHIM, R. 1987. ***Toxicity screening of oil dispersants in Southeast Asia.*** Paper presented at the UNEP Symp. on Reg. Coop. in Env. Prot. of the Mar. and Coast. Areas of the Pacific, XVI Pacific Science Congress, Seoul, Korea, August 25-26, 1987.

KUSHAIRI, R. 1992. ***The areas and species distribution of seagrasses in Peninsular Malaysia.*** To be presented in the 1st National Natural Res. Symp., FSSA, Universiti Kebangsaan Malaysia, Kota Kinabalu, Sabah, July 23-26, 1992.

LEE, C.K. 1972. Commercial species of penaeid prawns in West Malaysia. Mal. ***Agric. J., 48(3) : 264-277***

LIEW, H. C. and HOARE, R. 1982. The effects of sediment accumulation and water turbidity upon the distribution of *Scleractinian* corals at Cape Rachado, Malacca Strait. ***IN: Proc. of the Conf. on Trends in App. Biol. in Southeost Asia.*** October 11-14, 1979, Pinang, Malaysia. SBS, USM.

LUI ***Y*** .P. ***1992. Multispecies fish resources and multispecies fisheries in the coastal waters of Peninsular Malaysia, with special reference*** to ***the West*** Coast. Paper presented at the Sixth Sess. of the Standing Committee on Res., Research and Dev Colombo, Sri Lanka. May 18-21, 1990. FAO Fisheries Report ***No.*** 463 Suppl. Rome, FAO, 215pp.

LUI Y.P. and AHMAD ADNAN, 1988. Demersal fish resources in Malaysian waters (15). Fifth trawl survey off the west coast of Peninsular Malaysia (Nov-Dec., 1980). ***Fisheries Bull.*** No. 56, Department of Fisheries, Ministry of Agriculture, Malaysia.

LULOFA, R.B. 1977. Conservation of the marine environment-coral reefs. *Proc. First Sem. of the Mat. Soc. of Mar. Sci.. 1977.*

MA, A.N. 1988. Status of treatment technologies for palm oil industrial effluents. *Proc. SLDB/PORIM workshop on Palm* Oil Milling ***Technology.*** pp. 96-109 IPMKS 1988.

MARAGOS, J.E., SOEGIRTO, A., GOMEZ, E.D. and DOW, M.A. 1983. Development planning for tropical coastal ecosystem. ***IN: Natural Systems for Development. What Planners Need*** To ***Know.*** Ed. R.A. Carpenter. pp. 229-298, MacMillan Publishing Company, New York.

MOHAMAD ISMAIL YAZIZ. 1983. Control and management of water quality in Malaysia. *Pertanika, 6: 69-87*

MOHD. TAYEB DOLMAT, MOHD. ZIN KARIM, ZAID ISA. and PILLAI, K. R. 1980. Land-disposal of rubber factory effluent: Its effects on soil properties and performance of rubber and oil palm. *Proc. Rub. Res. Inst. Malaysia Plns. Conf.,* pp. 436-455.

MOHD. TAYEB DOLMAT., LIM, K.H., ZIN ZAWAWI ZAKARIA and ABD. HALIM HASSAN. 1987. Recent studies on the effect of land application of palm oil mill effluents on oil palm and the environment. *Proc. of 1987 Intl. O.P./P. O . Conf. Agric.*

MOHAMMED SHAARI, S.A.L., G. RAUCK, K.S. ONG, and S.P. TAN. 1974. Demersal fish resources in Malaysian waters, 2. Trawl survey of the coastal waters off the West Coast of Peninsular Malaysia (Dec. 12, 1970 · Jan. 22, 1971). ***Fish.*** Bull. No. 3, Min. of Agri. and Rur. Dev., Malaysia.

NATMANCOM, 1986. *Guidelines in rhe use of rhe mangrove ecosystem for brackishwafer aquaculture in Malaysia.* Report of the working group of Mal. Nati. Mangrove Corn.

PHANG, S. M. 1990. Seagrass A neglected natural resource in Malaysia. ***Proc. 12th Ann. Sem. of the Mol. Soc. of Mar. Sci.,*** Kuala Lumpur.

ROHANI IBRAHIM, CHAN, S. M. and ISMAIL ISHAK. ***1992.*** *Organochlorine pesticides* ***and PCB residues in some Malaysian shell fish.*** Paper presented in the Sem. on Pesticides in the Mal. Env.: Impact on Agri. and Ecosystems, February 27, 1992, Selangor.

SASEKUMAR, A. 1980. *The present state of mangroveecosystems in Southeast Asia and the impact of pollution: Malaysia.* **South China Sea Fisheries Development and Coordinating Programme, Manila.**

SHAHUNTALA, D. V. 1986. Heavy metal levels in Malaysian fish. *Fisheries Bulletin* **58, Ministry of Agriculture, Malaysia.**

_____ (1989). *Heavy metals in Malaysian shellfish.* **Paper presented in Sem. Penyelidikan Perikanan, Melaka, June 25-29. 1989.**

SHEPPARD, *C.* **R.** *C.* **1992.** *Marine parks in Malaysia: Research. development and display.* **Rep. on Proj. No. ADB 862-MAL., Kuala Lumpur, Malaysia.**

TAN, G. H.. YEOH, H. F., ZAIN KARIM and MOKHTAR YUSOF. 1992. *Pesticide use and control in Malaysia.* **Paper presented in Seminar on Pesticides in the Mal. Env.: Impact on Agri. and Ecosystem, Dept. of Agri., Malaysia, Kuala Lumpur, 1992.**

TAN, G.H., GOH. S. H., VIJAYALETCHUMY, LOONG. C.P. and ANG. K.L. 1990. Monitoring of water-borneorganic chemical pollution in the Kelang River Basin. Bull *Sing N.I. Chem., 18: 67-77.*

TAN<;, H. T.. HARON Hj. ABU HASSAN. and CHEAH, E. K. 1990. *Mangrove forests of Peninsular Malaysia — A review of management and research objectives and priorities.*

TENGKU DATO UBAIDILLAH BIN ABDUL KADIR. 1985. Aquaculture development strategy and programme. IN: *Report on Aquaculture Conference.* **Fisheries Dept. (Min. of Agri.) in collaboration with International Convention Secretariat (Prime Minister's Dept.).**

WONG, K. K. 1980 Application of ponding systems in the treatment of palm oil mill and rubber mill effluents. *Pertanika, 3 :* **133-141.**

YOUNG, A. and SERNA, E. 1982. Country report. Philippines. IN: *Proc. of the Wkshp. on Bivalve Cult. in Asia and Pacif.* **(B.F. Davy & M. Graham Eds.), IDRC · 200c. Intl. Dev. Res. Cent. of Canada, Ottawa: 16-19.**

APPENDIX VII

Institutions engaged in environmental research, monitoring and enforcement

GOVERNMENT

Department of Environment, Malaysia

The Department of Environment (DOE) is structured in three functional divisions, namely Planning and Development, Operation and Administration. The Operation Division has two main sections, Enforcement and Monitoring. The DOE does not carry out research directly, but commissions the universities and other research agencies IO undertake particular research projects.

The DOE is staffed by officers from various disciplines. In 1990, there were, at the professional level, 46.5 per cent engineers and 51.7 per cent scientists. Oneofficer was an economist. At the intermediate level, 64.8 per cent had received engineering training and 35.2 per cent held science qualifications.

Fisheries Research Institute, Malaysia

The Fisheries Research Institute (FRI), Department of Fisheries, was founded in 1957. It has a research section, the Aquatic Ecology Section, which carries out studies on water quality monitoring in areas which are important to coastal fisheries and aquaculture. Pollution research on bacteriology, heavy metals, pesticides, antibiotics and toxicology are also given priority. Conservation studies involving seagrass communities, mangrove and marine, park coral reef ecosystems, as well as artificial reef research, are also carried out.

UNIVERSITIES

Universiti Sains Malaysia (School of Biological Sciences, School of Physics and School of Chemical Sciences), Universiti Pertanian Malaysia, (Faculty of Fisheries and Marine Sciences, and Faculty of Science and Environmental Studies), Universiti Malaya (institute of Advanced Studies, Department of Zoology and Department of Chemistry), Universiti Kebangsaan Malaysia and Universiti Teknologi Malaysia are all involved with pollution research. Subjects ranging from oil and grease, hydrocarbon, metal, pesticide and organic waste pollution are investigated. The universities also study the seagrass, mangrove and coral reef ecosystems.

NONGOVERNMENTAL AGENCIES

Nongovernmental agencies involved with environmental and pollution research include :

Environmental Management & Research Association of Malaysia
36B, 2nd Floor, Jalan 20/16A, Paramount Garden, 46300 P. Jaya.

Malayan Nature Society
P. O. Box 10750, 50724 Kuala Lumpur.

Environmental Protection Society, Malaysia
17, Jalan. SS2/53, 47300 Petaling Jaya.

Malaysian Fisheries Society
C/o Faculty of Fisheries & Marine Sciences, Universiti Pertanian Malaysia, 43400 Serdang

Malaysian Society of Marine Sciences
C/o School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang.

WHO Western Pacific Regional Centre for the Promotion of Environmental Planning and Applied Studies
P. 0. Box 12550, 50782 Kuala Lumpur.

World Wide Fund For Nature, Malaysia
P. 0. Box 10709, 50724 Kuala Lumpur.

Sahabat Alam Malaysia
37, Lorong Birch Penang.

Consumer Association of Penang
87, Jalan Cantonment 10250 Penang

APPENDIX VIII

Legislation against threats to the marine environment

Malaysia is relatively well served with legislation that regulates potential environmental threats. The departments involved in this, as well as the enforcement agencies, are listed in the table below and on the facing page.

Existing regulations are, for the most part, adequate in maintaining reasonable environmental quality in the country. Malaysia, however, is currently in the process of reviewing national environmental laws to block loopholes in some regulations, upgrade others and draft new directives in some cases.

The DOE is responsible for matters pertaining to the environment. In the case of a fish kill, toxic waste dumping or oil spill, for instance, the DOE would be contacted. Contingency teams involving other agencies, such as the Marine Department, the Department of Transport, the Navy, the Department of Fisheries and the petroleum companies would also be mobilized to fight the disaster.

Environmental laws relating to the marine environment

Activity	*Relevant Act or provision*	*Department involved*	*Enforcement agency*
Transportation (a) Shipping	Merchant Shipping Ordinance 1952 Merchant Shipping Ordinance 1960 (Sabah) Merchant Shipping Ordinance 1960 (Sarawak)	Ministry of Transport Marine Dept. Peninsular Malaysia Marine Dept. Sabah Marine Dept. Sarawak	Ministry of Transport Marine Dept. Peninsular Malaysia Marine Dept. Sabah Marine Dept. Sarawak
hi Transportation of petroleum by ships	Petroleum (Safety Measures) Act 1984 Petroleum (Safety Measures) Transportation of Petroleum by Water) Regulations 1985	Prime Minister's Dept.	Prime Minister's Dept.
(c) Transportation of petroleum by pipelines	Petroleum (Safety Measures) Act 1984 Petroleum (Safety Measures) (Transportation of Petroleum by Pipelines) Regulations 985	Factory & Machinery Dept.	Factory & Machinery Dept.
(d) Pollution from ships	Merchant Shipping Ordinance 1952 (Part VA) Environmental Quality Act 1974 (Section 26, 27 & 29) Exclusive Economic Zone Act 1984	Ministry of Transport	Marine Dept.
(e) Pollution from dumping	Merchant Shipping Ordinance 1952 Exclusive Economic Zone Act 1984	Marine Dept.	Marine Dept.
(f) Reception facilities	Merchant Shipping Ordinance 1952 Merchant Shipping Act 1991	Ministry of Transport Marine Dept.	Marine Dept.
Dredging	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Sand-mining	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Draining of wetland	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Coastal reclamation	Environmental Quality (Prescribed Activities) Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Fisheries **Development** (a) Construction of fishing harbour	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
(b) Harbour expansion	Environmental Quality (Prevcribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
(c) Land-based aquaculture projects accompanied by clearing of mangrove forests	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment

Activity	*Relevant Act or provision*	*Department involved*	*Enforcement agency*
Fishing **and fish conservation** (a) Fishing	Fisheries Act 1985	Dept, of Fisheries	Dept. of Fisheries Marine Depi. Navy Marine Police
(b) Licensing of fishing vessels and fishing appliances and imposition of conditions on licences	Fisheries Act 1985 (Section 8 and 11) Fisheries (Maritime) Regulation 1967	Dept. of Fisheries	Dept. of Fisheries
(c) Prohibition of certain fishing methods	Fisheries (Prohibition of Meihod ol Fishing) Regulations 1983	Dept. of Fisheries	Dept. of Fisheries
(d) Prohibition of fishing in certain areas	Fisheries (Prohibition Areas) (Amendment) **Regulations 983**	Dept. of Fisheries	Dept. of Fisheries
(e) Establishment of turtle sanctuary	Rantau Abang Prohibited Fishing Areas **Order** 1991	Dept. of Fisheries	Dept. oF Fisheries
(f) Establishment of marine park, its control and protection	Fisheries Act 1985 (Section 41, 42. 43, 44 and 45)	Dept. of Fisheries	Dept. of Fisheries Marine Dept. Navy Marine Police
(g) Setting up fisheries marine culture systems	Fisheries (Marine Culture System) Regulations 990	Dept. of Fisheries	Dept. of Fisheries Marine Dept. Navy Marine Police
Forestry (a) logging or conversion of forest land to other land use in areas adjacent to state and national parks and national marine parks	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environnient	Dept, ol Environment
(b) Conversion of mangrove swamps for industrial, housing or agriculture use	Environmental Quality (Prescribed Activitiesl (Environmental Impact Assessment) Order 987	Dept. of Envirotiment	Dept. of Environment
Development of ports (a) Construction of ports	**Environmental Quality (Prescribed Activities)** (Environmental Impact Assessment) Order 1987	**Dept.** of Environment	Dept. of Environment
(b) Port expansion	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Exploration and exploitation (a) Oil and gas fields development	**Continental Shelf Act** 1966 Petroleum Mining Act 1972 Petroleum Development Act 1974 Exclusive Economic Zone Act 1984 Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
)b(Construction of offshore and onshore pipelines	Environmental Quality (Prescribed Activities) (Environmental Assessment) Order 1987	Dept. of Environment	Dept. of Environment
(c) Construction of offshore structures	Continental Shelf Act 1966 Petroleum Mining Act 1972 **Euclusive Economic Zone Act 1984**	Petroleum Authority	Petroleum Authority
(d) Registration of offshore industry mobile units and offshore industry	Merchant Shipping Ordinance 1952	Ministry of Transport	Ministry of Transport
Resort **and recreation development** (a) Construction of coastal resort facilities or hotels	**Environmental Quality (Presctibed Activities)** (Environmental Impact Assessment) Order 1987	**Dept.** Of Environment	Dept. of Environment
(b) Development of tourist or recreational facilities on islands in surrounding waters which are gazetted as national marine parks	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Sewage and industrial effluents discharge	Environmental Quality Act 974 Environmental Quality (Sewage and Industrial Effluents) Regulations 1979	Dept. of Environment	Dept. of Environment

APPENDIX IX

Other publications on the marine environment

ABDULLAH ALl, ABANG. 1985. Management and utilization of industrial wastes *Mal. Agri. Digest,* 4:20-21.

ABU BAKAR JAAFAR, LAW, A. T. and NOOR AZHAR SHAZILI. 1985. *A review of marine pollution monitoring and research programme in Malaysia.* Paper presented at the IOC Westpac Meeting of Pot. Res. and Monitoring Task Team, April 17 - 19, 1985, Townsville, Australia.

AHMAD MUSTAPFFA Hi. BABJEE, YAP, T. C., ChEE, Y. S., CANDIAH, P., LIM, E. S. and CHEONG, Y. L. 1983. *Proposalfor the abatement ofpollution from piggery waste in Peninsular Malaysia.* Vet. Div., Min. of Agri., Malaysia.

ANG, T. T . LI M, P. E. and SENG, C. E. 1987. *Environmental baseline studies on the Penang Development Corporation proposed land reclamation in the Proj Industrial Estate.* Rep. to PDC for the preparation of environmental impact assessment (EIA), Mar., 1987.

_____ 1986. *Physicochemical baseline study ofproposed land reclamation off the Proj Industrial Estate.* Rep. to PDC for the preparation of environmental impact assessment (EtA), Jul., 1986.

_____ 1987. Heavy metal concentrations in coastal seawater and sediments off Prai Industrial Estate, Penang, Malaysia. *Mar. Pol. Bul.,* 18, 611-612.

BAKRY SHAH JOHAN, TENGKU. 1985. Control of soil erosion and river siltation. *Ilmu Alam,* 14 & 15:73-89.

BILAL, J. and KUHNHOLD, W.W. 1980. *Marine oil pollution in Southeast Asia.* FAO South China Sea Fish. Dcv. and Coordinating Prog., SCS/80/WP.92, Manila, 85p.

CHAN, E. H. and LIEW, H. C. 1988. *A review on the effects of oil based activities and oil pollution on sea turtles.* Paper at 11th Ann. Sem. of the Mal. Soc. of Mar. Sci. March 26, 1988, Universiti Malaya, Kuala Lumpur, Malaysia.

CHONG, S. F. 1985. Sediment problems and their management in Peninsular Malaysia. *Berita Ensearch,* 2:2-3.

CHOO, P. S. 1992. A study of the water quality at a coastal cage-culture site in Penang, Malaysia. *Fish. Bull.* Min. of Agri. Malaysia.

_____ 1987. The effect of ethylene diamine tetraacetic acid disodium salt on the spawning and hatching of penaeid prawn eggs. Fish. Bull. No. 49 Min. of Agri., Malaysia.

CHUA, T. E. and MATHIAS, J. A. (Eds). 1978. *Coastal resources of West Sabah: A preliminary study in relation to a potential oil spill.* Rev. ed. Universiti Sains Malaysia Press, Penang, Malaysia.

CHUA, T.E. and MATHIAS, J. A. PAW, J. N. and GUARIN, F. Y. 1989. The environmental impact of aquaculture and the effects of pollution on coastal aquaculture development in Southeast Asia. *Mar. Poll. Bull.,* Vol. 20, No. 7, pp. 335-343.

CHUA, T.E. and MATHIAS, J. A. and CHARLES, J. K. (Eds.). 1984. *Coastal resources of East Coast of Peninsular Malaysia.* An assessment in relation to potential oil spills. Universiti Sains Malaysia Press, Penang, Malaysia.

COLEMAN, J. M., GAGLIANO, S. M. and SMITH, G. S. 1970. Sedimentation in a Malaysian high tide tropical delta. IN: *Modern and ancient society of economic palaeontologists and mineralogists* (Eds: Morgan, **J.** M. *&* Tulsa, O. K.), pp. 185-197.

DIN, **Z.** B. and BROOKS, J. M. 1986. Use of adenylate energy charge as a physiological indicator in toxicity experiments. *Bull. Env. Contam. Toxicol.,* 36: 1-8.

DIN, Z. B., FAY, R. M. and BROOKS, J. M. 1984. The role of volatiles in the toxicity of ocean dumped industrial wastes to marine phytoplankton. *Proc. of the 5th Intl. Ocean Disposal Sym.* Corvalis, Oregon, U.S.A.

DIN, Z.B., FAY, R.M. and BROOKS, J.M. 1983. Sublethal effects for a chemical industrial waste on the growth and reproductivity for a marine phytoplankton in a flow-through laboratory culture system. *Proc. Intl. Dev. Mgmnt. Trop. Liv. Aq. Res.;* Serdang, Malaysia.

GONG, W. K. and ONG, J.E. 1985. The different uses of mangrove and their possible impacts on mangrove and adjacent coastal fisheries. IN: *Proc. MAB/COMAR Reg. Sem. on Man's Impact on Coastal and Estuarine Ecosystems.* (Eds. Saeki,T. *et al.)* pp. 21-26.

GONG, W. K. and ONG, i.E. and WONG, C. H. 1983. *Pollutants and the mangrove ecosystem.* Paper at Jt. Oc. Assembly. Halifax, Nova Scotia, Canada. August 2-13, 1983.

HO, Y. C. 1985. Control and management of pollution of inland waters in Malaysia. *Berita Ensearch* (Malaysia), 2:2-4.

ICHIKAWA T., LAW, A. T., MOHAMAD RAFFEE JUSOH and AZHAR OTHMAN. 1987. Nitrogen distribution in the coastal waters of the South China Sea. *IN: Matahari Expedition '86* (Eds. Mohsin, A. K. M., Mohd. Ibrahim, Ambak, M. A. & Abd. Ridzwan). Fac. of Fish. and Mar. Sci., University Pertanian Malaysia, Occ. pub. No. 4.

ISMAIL ISHAK. 1988. *Cockle depuration in Malaysia.* Paper at the ASEAN Consultative Wkshp. on Mollusc Depuration, Penang, Malaysia. October 4-7, 1988.

JANGI, M. S. and ZAMZABAR A. R. 1989. Prevalence of *Vibriofluvialis* in water, sediment and cockles from a river estuary in Malaysia. *Mal. Appl. Biol.* 9: 17-25.

JANGI, M. S. and ZAMZABAR A. R. ESPARAN, M. and HAMID, M. Y. 1980. An ecological study of bacteria associated with Malaysian cockies, *Anadara granosa L. Ma!. App!. Biol.,* 9: *17-25.*

JOTHY, A. A. 1982. The fate of fisheries and aquaculture in the wake of a deteriorating aquatic environment in Malaysia. *Proc. Symp. on the Mal. Env. in Crisis.* Consumers Assn. of Penang, Penang.

_____ 1982. Malaysia: Valuable and vulnerable marine resources in the shipping, energy and environment. IN: *Southeast Asian Perspectives for the Eighties* (Eds. Valencia *et a!.),* Dalhousie Oc. Studies Prog., Canada.

_____ 1987. *Detection and determination of organochlorine residues in Malaysian fish.* The intl. Conf. on Pesticides in Trop. Agri., Kuala Lumpur, September 23-25, 1987.

_____ 1984. Status of shellfish toxicity and related problems in Malaysia. IN: *Toxic red tides and shellfish toxicity in Southeast Asia* (Eds. A. W. White, M.Anraku and K. K. Hooi, pp., 33-34.Southeast Asian Fisheries Development Centre, Singapore, and International Development Research Centre, Ottawa.

JOTHY, A.A. ROHANI IBRAHIM and VELU MURUGAN. 1985. *Toxicity screening of oil dispersants.* Country Report-Malaysia. Review Meeting of UNEP/EAS Project 2.2; Coop. Res. on Oil and Oil Dispersants and Toxicity Testing, Sydney, Australia, November 18-22, 1985.

JOTHY, A.A. and ROHANI IBRAHIM 1990. Toxicity screening of oil dispersants in Malaysia. *Proc. Sem. Penyelidikan Perikanan,* IPP Pulau Pinang, Jab. Perikanan, Kementerian Pertanian Malaysia.

JOTHY, A.A. 1976. *Report on marine pollution problems in Malaysia.* Paper presented at the Intl. Wkshp on Mar. Poll. in East Asian Waters. Universiti Sains Malaysia, Penang, April 7-13, 1976.

_____ 1986. *Biological effects of marine pollution strategies and methodologies for their measurements and monitoring in Southeast Asian waters.* Paper at IOC Symp. on Status and Trends in the Dev. of the GIPME Prog., including the Mar. Poll. Monitoring (MARPOLMON) Sys., Paris, September 22-24, 1986.

KHOO, K. H., ZUBIR DIN, LEONG T. S. and CHONG, **C.** S. 1991. *Toxicity study of effluent dischargedfrom Bintulu, Labuaand Miri crude oil terminals, and from Lutong refinery.* Rep. prep. for Petroliam Nasional Berhad, 110 p.

KOH, H. L., LIM, P. E., SIEH, K. C. and ZAMALI MIDUN. *Environmental impact due to pollutant discharge in Selat Johor.* ASEAN-USAID Coastl. Reso. Mgmnt. Study.

KOH, H. L., CHONG, C. S. and LIM, P. E. 1988. Impact assessment of sewage disposal in Penang Southern Channel of Malaysia. IN: *Pollution in the Urban Environment-POLMET88. Vol. 2* (Eds. Hills, P., Keen, R., Lam, K. C., Leung, C. T., Oswell, M. A., Stokes, M. & Turner, E.), pp 171-176. Vincent Blue Copy Co. Ltd., Hong Kong.

LAI, H. C. and FENG, M. C. 1984. A review of oil spills with special references to mangrove environment. IN: *Fate and effects of oil in the mangrove environment.* 4 (Eds. Lai, **H. C.** & Feng, M. C.), Universiti Sains Malaysia, pp. *5-19.*

_____ 1985. Effects of oil in mangrove environment. *Berita Ensearch,* Malaysia *2:4-5.*

_____ 1984. Simulation of oil spills in mangrove swamp. IN: *Fate and effects of oil in the mangrove environment.* (Eds. Lal, H. C. & Feng, M. C.), Universiti Sains Malaysia, pp. 139-147.

_____ 1984. The use of dispersants in oil spills control and its guidelines. IN: *Fate and effects of oil in the mangrove environment.* (Eds. Lai, H. C. & Feng, **M.** C.), Universiti Sains Malaysia, pp. 227-246.

LAI, H. C. FENG, M. C. LIM, C. P. and LEE, K. T. 1984. Effects of naturally and chemically-dispersed oil on invertebrates in mangrove swamps. IN : *Fate and effects of oil in the mangrove environment.* (Eds. Lal, H. C. *&* Feng, M. C.), Universiti Sains Malaysia, Penang, pp. 123-136.

LAI, H. C. FENG, M. C. and LIM, K. H. 1984. Effects of oil on mangroves in field conditions. IN: *Fate and effects of oil in the mangrove environment.* (Eds. Lai, H. C. & Feng, M. C.), Universiti Sains Malaysia, Penang, pp. 67-98.

LAI, H. C. FENG, M. C. and FANG, M. C. 1984. Recommendations of follow-up research on oil pollution. IN: *Fate and effects of oil in the mangrove environment.* (Eds. Lai, H. C. & Feng, M. C.), University Sains Malaysia, pp. 247-252.

_____ 1984. Field and laboratory studies on the toxicities of oils to mangroves. IN: *Fate and effects of oil in the mangrove environment.* (Eds. Lai, H. C. & Feng, M. C.), Universiti Sains Malaysia, pp. 539-546.

LAW, A. T. and SINGH, A. 1987. Heavy metals in fish at the Kelang estuary, Malaysia. *Mal. Nat. J.,* 41: 505-513.

LAW, A.T. and ABD. RAHMAN SHAIK. 1987. Phosphate distribution in the South China Sea: Coastal waters off Kuantan to Pulau Tioman. IN: *Matahari Expedition '86* (Eds. Mohsin, A. K. M., Mohd. Ibrahim, Ambak, M. A. & Abd. Ridzwan) Fac. of Fish. and Mar. Sci., Universiti Pertanian Malaysia. Occ. Pub. No. 4.

LAW, A.T. 1983. *Oil degrading microorganisms in Malaysian coastal waters.* Petronas Oil Spill Sem., October 18-20, 1983, Kuala Lumpur, Malaysia.

_____ 1978. *Essential and toxic metals in Malaysian finfish and shellfish.* Ph.D. thesis, Universiti Malaya. 112 p.

_____ 1983. *Monitoring of sewage pollution in the estuarine and coastal water of Port Kelang, Malaysia.* Preprint Intl. Conf. on Dev. and Mgmnt. of Trop. Liv. Aq. Res., August 2-5, 1983, Universiti Pertanian Malaysia.

_____ 1983. *Biodegradation for volatile hydrocarbons in continuous culture.* Petronas Oil Spill Scm., October 18-20, 1983, Kuala Lumpur, Malaysia.

_____ 1980. Sewage pollution in Kelang River and its estuary. *Pertanika 3(1):* 13-19.

LAW, A.T. and ZULKIFLI B. MAHMOOD. 1988. Distribution of petroleum hydrocarbon in the South China Sea: Coastal waters off Kuantan to Pulau Tioman. IN: *Matahari Expedition* '86(Eds. Mohsin, A. K. M., Mohd. Ibrahim, Ambak, M. A. & Abd. Ridzwan) Fac. of Fish. and Mar. Sci., Universiti Pertanian Malaysia. Occ. publ. No. 4.

LAW, A.T. 1985. *Effect of dispersant Corexit 9527 on the biodegradation of ESSO Tapis A crude oil in Port Dickson coastal water.* Fin. rep. to ESSO Malaysia Production. Inc. 17 p.

_____ 1984. Population and activity of hydrocarbon-degrading microorganisms in the coastal waters of Peninsular Malaysia. *Pertanika* 7(1) 19-26.

LAW, A.T. and A. SINGH. 1987. Distribution of mercury in Kelang estuary. *Pertanika* 10: 175-181.

_____ 1987. Distribution of manganese, iron, copper, lead and zinc in water and sediment of Kelang Estuary. *Pertanika,* 9: 209-217.

LAW, A.T. and AZAHAR OTHMAN. 1985. Faecal coliform bacteria distribution in the coastal waters of Peninsular Malaysia. *Pertanika* 8(1) 131-134.

LAW, A.T. and MOHD. KAMIL ABD. RASHID. 1986. Inorganic nitrogen and phosphate distribution in the South China Sea. IN: *Matahari Expedition '86* (Eds. Mohsin, A. K. M., Mohd. Ibrahim, H. M. & Ambak, M. A.). Fac. of Fish and Mar. Sci., Universiti Pertanian Malaysia. Occ. pub. No. 3, pp. 93-100.

LAW, A. T. and RAHIMI BIN YUSUF. 1986. Hydrocarbon distribution in the South China Sea. IN: *Malahari Expedition '85* (Eds. Mohsin, A. K. M., Mohd. Ibrahim & Ambak, M. A.,) Fac. of Fish. and Mar. Sci., Universiti Pertanian Malaysia. Occ. publ. No. 3, 233 p.

LEE, C. K. and LOW, S. K. 1980. Short communication (II). A study of wastewater discharge from electroplating factories. *Pertanika,* 3: 159-161.

LIM, C.K., KOH, H.L. and LIM, P.E. 1987. Perspectives of sewage treatment and disposal in Penang Island, Malaysia 2000. IN: *Proc. Intl. Conf on Water Mgmnt. in 2000 for the Dev. Countries.* Singapore. pp. 23-30.

LIONG, P. C. 1983. *Heavy metals in shellfish from the northern part of Malacca Straits.* Paper at Intl. Conf. on Dev. and Mgmnt. of Trop. Liv. Aq. Res., Universiti Pertanian Malaysia, Serdang. August *2-5,* 1983.

LIONG, P.C. and K. RAJENDRAN. 1986. On the toxicity of ammonia to cockle. *Fish. Bull.* No. 46. Min. of Agri., Malaysia.

MA, A.N., CHEAH, S.C. and ONG, A.S.H. 1988. Towards zero discharge from palm oil mill. *Proc. 1987 Intl. Oil Palm/Palm Oil Conf. – Prog. and Prospects,* pp. 429-433. IPMKS 1988.

MA, A.N. 1988. A novel process for the treatment of palm oil refinery wastewater. *Palm Oil Development* (Malaysia), *8:5-7.*

MACLEAN, J.L. 1989. Indo-Pacific red tides, 1985-1988. ***Mar.*** *Poll. Bull.* Vol. 20, No. 7, pp. 304-309.

MAHESWARAN, A. 1982. *Industrial wastewater control – Malaysian policy and legislation.* Paper at Sem. on Industrial and Hazardous Waste Control. Kuala Lumpur, October 4-8, 1982.

_____ 1978. *Marine pollution and its control.* Paper at 1st Mar. Sci. Conf. 'Our Seas in Perspective'. 1978.

MAHMUD, A.A. 1988. *Protection of Malaysia's marine environment: challenges and opportunities for the petroleum industry.* Paper at Sem. on the Mar. Env.: Challenges and opportunities. March 31 - April 2, 1988. Inst. of Strategic and Intl. Studies, Kuala Lumpur, Malaysia.

MOHAMMED SHAARI BIN SAM ABDUL LATIFF. 1971. The effect of the oil slick dispersant, Esso Corexit 7664, and the joint effect with crude oil on the survival of marine glass fish, *Ambassis* sp. and Palaemonid shrimps. *Mal. Agri. J.* 48(l): 13-19.

NORHAYATI MUSTAPHA. 1980. General introduction to solid waste management. *Sekitar* (Malaysia), 4:14-21.

ONG, H.K. 1985. Treatment of piggery wastes. *Berita Ensearch,* Malaysia, 2:6.

ONG, J.E. and GONG, W.K. 1985. The environmental impact of the use of mangroves for aquaculture. iN: *Development Forum* 15,36-44. Paper at 6th Ann. Scm. of the Mal. Soc. of Mar. Sci. on Mar; Poll. in Mal. Waters, Universiti Sains Malaysia, Pulau Pinang, Mar. 1983.

ONG, J.E., GONG, W.K. and THOMAS, C. 1984. Effect of heavy metals, zinc and lead on *Rhizophora macranata* Lam, and *A vicennia a/ba* B!. seedlings. iN: *Proc. of the Asian Symp. on Mangrove Env: Res. and Mgmnt.* (Eds. Soepadmo, E., Rao, A. N. & Macintosh, D. J.,), pp. 568-574.

OWENS, J. D. 1978. *Co/ijorm* and *Escherichia co/i* bacteria in seawater around Penang island, Malaysia. *Water Research* pp. 365-370.

PATIMAH, I. and SAMIN, K. 1989. Heavy metal content in fish in Sarawak Waters. IN: *Expedisi Matahari '87.* Occ. Pub. No. 8, Fac. of Fish. and Mar. Sci., Universiti Pertanian Malaysia.

PHANG, S.M. 1988. The potential of integrating fish culture with an algae pond system treating palm oil mill effluents. *Proc. 1987 Intl. Oil Palm/Palm Oil Conf. – Prog. and Prospects,* pp. 422-428. IPMKS 1988.

RAKMI A. R., KALM, M. and WAN NOOR W. M. 1984. Reduction of palm oil heavy metal content in the refining process. *PORIM Bulletin* (Malaysia), 9:16-21.

A. RAN! ABDULLAH and LATIFAH MAHMUD 1992. *Pesticides in the Malaysian aquatic environment.* Paper at Scm. on Pesticides in the Mal. Env.: Impact on agri. and ecosystem, February 27, 1992, Selangor, Malaysia.

ROSLY HASSAN and CHUAH, T. T. 1991. *Feeding, total N and total P loadings in a shrimp pond – some observations.* Paper at 3rd Fish. Res. inst., Penang, Malaysia, 29.9.91-2.10.91 in Penang.

SCHOLZ, N. and SHAHUNTALA D. V. 1982. Heavy metals in Malaysian fish – a preliminary study. *Mal. Agri. J.* 53(3): 169-184.

SEOW, R. C. W. and BROOM, M. J. 1980. *The effect of organic pollutants on the distribution, community structure and abundance of the pelagic ichthyofauna in a Malaysian mangrove inlet.* Asian Symp. on Mangrove Environment: Res. and Dcv., Kuala Lumpur, August 25-29, University of Malaya and UNESCO.

SHAMSUDIN, L. 1988. Water pollution and the water quality requirement of coastal carbon areas. IN: *Proc. Wkshp. Tropical Urban Ecosystem Studies,* UKM. UNESCO/ROTSEA. January 18-21, 1988.

SHAZILI, N.A.M. and CHE, A.R. MOHAMAD. 1989. *Determination of heavy metal contents in sea water from the Malacca Straits by differential pulse anodic stripping voltammetry.* Preprint: Advances in Fish. and Mar. Sci. The JICA/FPSS experience. March 10-11, 1989, Melaka, Malaysia.

SHAZILI, N.A.M., CHE, A.R. MOHAMAD, HUSAIN, M. L. and YAAKOB, R. 1986. Heavy metal content of sediments in the South China Sea. IN: *Ekspedisi Matahari '86* (Eds. Mohsin, A. K. M., Ibrahim, M.H.M. and Ambak, A.) Fac. of Fish. and Mar. Sci. Universiti Pertanian Malaysia, 0cc. pub. No. 3, pp. 113-116.

SINGAM, G. 1982. *Strategies and enforcement of industrial waslewater control in Malaysia* (A case study). Paper at Scm. on Ind. and Hazardous Waste Control. Kuala Lumpur, October 4-8, 1982.

SIVALINGAM, P.M., KHAIRUL, ANUAR and SIDHU, H.S. 1982. PCBs and persistent pesticide pollutants in Malaysian waters and some economically important marine organisms. IN: ***Proc.*** *Univ. Perlanian Mal!.* UNESCO and FIESEOP Reg. Scm. on Water Tech. towards Rur. Dev. University Pertanian Kuala Lumpur. Malaysia, p. 10.

1983. *Marine pollution by municipal waste treatment in Penang.* Paper at Scm. of Mar. Poll. in Mal. Waters. Universiti Sains Malaysia, Penang, 1983.

1985. Impact of domestic and industrial waste on the coastal zone environment of the Straits of Malacca. IN: *Coastal zone managemant in the Straits of Malacca* (Eds. Burbridge, R., Koesobiono, Dirsch, H. & Patton, B..) pp. 179-214. Proc. of Symp. on Env. Res. and Coast. Zone mgmt. in the Straits of Malacca. November 11-13, 1985, Medan, Indonesia.

1987. *INAA in the evaluation of heavy metal pollution in marine algae.* Paper at Asean Tech. '87 Intl. Conf. (Asia-Chem. Session), Kuala Lumpur 1987.