CHAPTER I

INTRODUCTION

Ship-breaking industry is an activity which steels are recovered from scraping of old vessels. This activity has been carried out to meet the steel demand due to significant construction bloom in Thailand. A ship-breaking activity, however, can cause an environmental quality deterioration to the near-by areas. A contamination of oil leaked from the vessel frequently occurs during a breaking process. This oil contamination potentially causes environmental impacts on various activities such as fishing, aquaculture and tourism (Petpiroon, Yoo-sook-swat and Sanguansin, 1986).

Thailand is pursuing numerous development programs to become a newly-industrialized country (NIC) within the year 2000. The development of fundamental industries on the Eastern Seaboard and an establishment of the Map Ta Phut Industrial Estate and its Deep Sea Port are examples of those programs. In the illumination of an increasing industrialization, the amount of petroleum hydrocarbons utilized along the coasts, as sources of energy, has also been increased.

As mentioned previously, the Eastern Seaboard, especially at the Map ta Phut area is developed to suit the industrial development purposes. Activities carried out within the area may lead to an

increase in oil pollution. Ship-breaking industry is considered as one of this oil pollution source. In order to prevent and protect our marine resources from this activity, oil pollution must be controlled. Therefore, the dispersion of petroleum hydrocarbons in seawater and its accumulative nature in sediments, some bivalves and accumulation of tar on beaches were studied. This project has set by and incooperated with the Fisheries Environmental Section of the Eastern Marine Fisheries Development Center, Department of Fisheries of the Royal Thai Government at Rayong Province. It is urgently needed that information be provided on levels of hydrocarbons generally present in the Map Ta Phut area in order to be applied to minimize the damage that may occur.

Objectives

The main objectives of the study can be formulated as the followings:

1. To determine the dispersion characteristics of petroleum hydrocarbons in seawater around the ship-breaking industry area at Ban Nong Faeb, Map Ta Phut Sub-District, Mueng District, Rayong Province.

2. To estimate the concentrations of petroleum hydrocarbons accumulated in the sediments and bivalve, Donax sp., found in this area.

3. To investigate the distribution of beach tar around the ship-breaking area.

Expected Results

Under the objectives mentioned above, the expected results are as follows:-

1. Quantities of petroleum hydrocarbons accumulated in the seawater, sediment, and some bivalves.

2. Baseline information on toxic petroleum hydrocarbons in bivalve Donax sp. found in this area.

4. Baseline information on the distribution patterns of petroleum hydrocarbons to be used to develop a management plan.

5. Description of the dispersion patterns of petroleum hydrocarbons from the ship-breaking industries with tidal current measured at the same times of water sample collections.

LITERATURE REVIEW

Oil pollution in the sea is widely recognized as a problem, and usually brings a negative impact to the marine environment, marine living resources as well as activities utilizing marine resources such as fishing, aquaculture, recreation activities, etc. Recent researches on the matter have been widely studied. These include petroleum hydrocarbons in seawater (both in subsurface and surface microlayer (SMIC)), in sediment and bivalve tissues, bioassay of petroleum hydrocarbons on living organism, and global pelagic and beach tars which were altered from oil via emulsification and bacteria degradation.

Petroleum Hydrocarbons in the World Wide Marine Environment

Enrichment of hydrocarbons in top 150 μm to bulk water 20 cm below the surface were determined from Narragansett Bay in 1971 (Duce, et al.,1972). The area was free of industrial and municipal effluents and major ship traffic. Enrichment value was 1.4 ± 0.4 where as of fatty acid was 1.5 ± 0.4 in the same sample.

In April 1974 Bordon, Keizer and Dale (1974) estimated concentration of petroleum hydrocarbons in seawater from the region between Nova Scotia and Bermuda using fluorescence spectrophotometry. Concentration in surface water (0-3 mm), 1 m and 5 m depth expressed in unit of Venezuelan crude oil equivalent are as follows:

Depth	n	Mean(µg/l)	SD(µg/l)
0-3 mm	43	20.4	60.7
1m	24	0.8	1.3
5m	24	0.4	0.5

There was considerable variability in the concentrations suggesting that the distribution of oil in seawater is quite patchy especially in surface waters.

The comparative survey of petroleum hydrocarbon in three lake sediment core samples were established (Wakeham, 1976). Concentration of petroleum hydrocarbon in µg/g were summarized as follows:-

Quinault Lake	10-25 µg/g (bulk sediment)
Washington Lake	1500 µg/g (surfacial sediment) and
	30 µg/g (30cm)
Sammamish Lake	500 µg/g (surfacial sediment) and
	100 µg/g (deeper sediment)

Law (1981) collected samples of subsurface (1m) water and surface sediment from sites in the North Sea, English Channal, Irish Sea and a number of estuarine area in order to provide information on the levels of hydrocarbon generally present in the UK marine water. Total hydrocarbon concentrations (THCs) of water samples (analyzed by UVF technique) ranged from 1.1-74 µg/l Ekofisk crude oil equivalents. In offshore areas the THCs were low and increasing with proximity to the shore. Higher THCs were found in water samples from areas of domestic, industrial and shipping activity. THCs of sediment samples ranged from 0.27-340 µg/g dry wt Ekofish crude oil equivalents. Concentration were higher in samples containing finer sediment types,

and in samples from inshore areas, particularly industrial estuaries and bay. High total hydrocarbon concentrations in both water and sediment were found close to the gas production area off the Norfolk coast.

GC and GC/MS were used to examine the aliphatic hydrocarbon fraction of specimens of the mussel, Mytilus edulis, collected from the legs of North Sea oil production platform (Rowland and Volkman, 1982). The aliphatic hydrocarbon fraction showed the distribution of fossil fuel hydrocarbons typical of that found in mussels exposed to low levels of petroleum. The presence of n-alkane ($n\text{-}C_{14}$ -$n\text{-}C_{27}$), pristane and phytane peaks above the Unresolved Complex Mixture (UCM) points to either a recent small spill or to continuous exposure to low levels of petroleum which was the source of these pollutant hydrocarbons. In addition to a UCM of fossil pollutant hydrocarbons (46-77 g/g dry weight),the fraction was dominated by large amounts of C_{31} and C_{33} n-alkanes biosynthesized by Emiliania huxleyi (marine algal).

High concentrations of n-alkane were observed in South Baltic Sea in 1983 (Grzybowski, et al., 1987) at location of industrial activity, being 1744.0/40.0, 216.0/188.0, 143.5/148.5 and 47.1/219.2 µg/l at 0 and 5 metre, respectively. PAHs such as Phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(ghi)perylene were also determined. Concentration of a carcinogenic benzo(a)pyrene in sea water corresponding with places of high

industrial activity, being 2.9/3.1, 1.4/1.6 and 0.8/1.1 for 0 m/5 m.

Law and Andrulewiez(1983) analyzed samples of water collected at 5-m depth and surface sediment from the southern Baltic Sea for total hydrocarbons by UVF and GC. The sediment and mussel samples were also analyzed for specific aliphatic and aromatic hydrocarbons by GC/MS. The total hydrocarbon concentrations (THCs) of water samples ranged from 2.0 µg/l for offshore area to 130 µg/l Ekofisk crude oil equivalents for station within inshore area. THCs of sediment ranged from 4.0 to 140 µg/g, which was highest in all samples occurred either inshore or in deep offshore basins where fine sediment accumulated.

The surface microlayer (SMIC), upper 30-60 micrometer, were determined compared with one bulk-water sample from Chesapeake Bay (Hardy, et al.,1983) using GC/MS technique. Compared with typical bulk-water alkane levels, high concentrations of particulate alkanes occurred in SMIC at all stations. The mean concentration of particulate alkanes for all SMIC samples was 102 µg/l (±80) where that of PAHs was 1.60 µg/l. The PAHs concentration 376 times greater than the bulk water was found. The authors suggested that aquatic surface contamination in Chesapeake Bay was widespread. It originated from a variety of sources and existed in concentrations potentially toxic to floating fish eggs and other surface organisms. Suspected sources of surface contamination included gasoline and diesel fuel combustion, coal combustion, and petroleum product releases.

Water samples from Eastern Mediterranean were obtained at 1 m-depth from 1977 to 1979 to assess the level of dissolved and

dispersed petroleum hydrocarbons using UVF technic (Ravid, et al., 1985). These data pointed that all investigated areas of the Eastern Mediterranean were polluted by aromatic hydrocarbon ranging from 0.3-40.0 µg/l chrysene equivalent. Waste oil released from harbors, the shipyard and the oil refinery plant caused oil contamination. High values of dissolved hydrocarbons were found in an oil drilling area and the ship-lane areas.

Concentrations of n-alkane between C_{15}-C_{32} and PAHs were determined at zero and 5 m depth of seawater from Southern Baltic Sea in 1983 (Grzybowski, et al., 1987). The report showed the highest concentration of n-alkane and PAHs was observed at location of high industrial activities.

N-alkane (0/5m depth) (µg/l)	Carcinogenic Benzo(a)pyrene (0/5m depth) (µg/l)
1744.0/40.0	2.9/3.1
216.0/188.0	1.4/1.6
143.5/148.5	0.8/1.1
47.1/219.2	

The PAHs found in this area were phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(k)fluoranthene, benzo(a)pyrene and benzo(ghi)perylene.

Levels of petroleum hydrocarbon accumulated by mussels collected from Ebro Delta on the Catalonian coast of Iberian Peninsula were generally high, in the order of 100-800 g/g dry weight

(Risebrough et al.,1983). Petroleum appears to derive from multi-point sources of contamination along the area of the Catalonian coast.Those are local municipalities,industries,offshore submarine and nuclear power plant.

According to Rowland and Volkman (1982), concentrations of UCM hydrocarbons in μg/g were compared with values obtained by other workers as follows:

46-77	North Sea oil-production platform
600-1200	Oil refinery outfall
3-298	Various US Mussel Watch stations
17.6	Pristane area in north-east Gulf of Alaska
88	Oil seep,Goleta Point,South California
20-40	Areas near high urban populations, San Francisco Bay.
27-199	Cape Code Canal,Mass.following Spill of No.2 fuel oil.

Petroleum Hydrocarbons in ASEAN Waters.

Hydrocarbon concentrations in ASEAN waters have been compared by Gomez (1986) and DOE (1986). In water of Indonesia, concentration ranging from 0.3 to 1.1 ppm were found north of Jakarta, in the vicinity of Cinta and Arjuna oil terminals. Hydrocarbon levels of 0.4-1.2 ppm were measured in Pangkalan Susu, and concentrations of 1.2-1.5 ppm off Dumai. In the Philippines, hydrocarbon pollution is most evident in Manila Bay.

In Peninsular Malaysia, concentrations are on the order of 0.1 to 0.2 ppm for the eastern coast waters, while at Penang (west coast), the measured level is 0.12 ppm. During the period 1980-1983, the

degree of pollution (mainly from oil and grease) on the Malaysian side of the Jahore Strait was more serious compared to the Singaporean side, although it was found to be increasing on an alarming trend for both sides. The high level of pollution particularly on the east side of the strait was associated with the relative high intensity of shipping activities in the port of Jahore. In 1984, due to concerted efforts to control oil pollution from vessels, the quality of waters in the strait improved considerably 1000 times.

Oil contamination in east and west coast of Singapore, according to Gomez (1986), was contributed by discharges from land-based industries. The mean oil and grease concentration from the east side of the strait decreased significantly from 5.1 mg/l in 1980 to 2.0 mg/l in 1985. On the western side of the strait, the mean concentration remained at 2 mg/l for the same period.

Petroleum Hydrocarbons in Thai waters.

Studies on petroleum hydrocarbons in Thai waters have been performed as follows:-

Intrarapanich (1979) monitored seawater and sediment samples in the Gulf of Thailand in 1979. The concentrations of petroleum hydrocarbons were found at levels of 0.4-0.5 µg/l and 0-0.3 µg/g dry wt. for seawater and sediment, respectively.

Petroleum-derived n-paraffins in seawater and sediments were studied in the Gulf of Thailand during May and November 1977 using GC

technic (Hungspreugs and Switachart, 1980). No significant seasonal differences were noted. During May and June, the range of concentration of C_{10} to C_{30} n-paraffins was 20.5-329 µg/l (mean 110.9 µg/l) while in September to November, the range was between 23.4 and 428 µg/l (mean 151.4 µg/l). A higher mean concentration (233 µg/l) was recorded near a major oil refinery in Chonburi Province. Sediments from the Upper Gulf of Thailand contained higher mean concentrations of n-parafins in the dry season (3.7 µg/g wet wt) than in the wet season (2.9 µg/g). The annual mean concentration of n-paraffins in sediments of the Lower Gulf was 1.2 µg/g, while at the Chonburi area more n-paraffins were contaminated with mean concentration of 7.9 µg/g wet wt.

Samples of subsurface seawater (1m) were collected in the Gulf of Thailand between April 1985 and September 1986 (Wattayakorn, 1987(a)). These were analyzed for dissolved/dispersed petroleum hydrocarbons by fluorescence spectroscopy (UVF). A mean concentration of 2.3 µg/l crude oil equivalents, with the range from 0.65-8.3 µg/l were found from the Upper Gulf. In the Lower Gulf the range of hydrocarbon found was 0.07-6.60 µg/l and the mean was 1.3 µg/l.

Dissolved petroleum hydrocarbon in the seawater at 1 m-depth and in surfacial sediments were analyzed using UVF method using chrysene as a standard (Sompongchaiyakul, Hungspreugsd and Lim ,1986). The results are shown as follows:-

seawater	(Upper Gulf)	
	April-May	0.380-5.646 µg/l
	mean	1.305±1.724 µg/l
	September-November	0.059-6.095 µg/l
	mean	0.782±1.148 µg/l
		*
sediment	April-May	0.064-2.164 µg/g
		**
		0.047-1.820 µg/g
		*
	September-November	0.059-6.095 µg/g
	mean	0.096±0.55 µg/g

* = wet sediment extraction, ** = dry sediment extraction.

Petroleum hydrocarbons in bivalves and fishes were also analyzed. The results are shown as follows:-

		Conc.(µg/g dry wt)
Fish	Polynemus sp.	0.117
	Cynoglossus sp.	0.598
	Parastramateus niger	0.415
Bivalves	Papia undulata	0.462
	Perna viridis	0.059
	Anadara granosa	2.376

Concentrations of dissolved petroleum hydrocarbon in the Chao Phraya river, Bang Prakong river, Tha-Chin river and the Upper Gulf of Thailand during the rainy season (September to December) and the summer season (March to April) in 1983-1984 have been reported (Chatkittikunwong ,1986). Using Gas Chromatography (GC), Gas Chromatography/Mass Spectrometry (GC/MS) and Spectrofluorometry (UVF) technics, the concentrations for each season are summarized as follows:-

- The Chao Phraya river	:	0.190-0.431 µg/l in rainy season.
		0.514-0.799 µg/l in dry season.
- The Bang Prakong river	:	0.056-0.406 µg/l in rainy season.
		0.318-0.678 µg/l in dry season.
- The Tha-Chin river	:	0.260-0.550 µg/l in rainy season.
		0.337-0.435 µg/l in dry season.
- The Upper Gulf of Thailand	:	0.172-0.886 µg/l in rainy season.

Data from GC and GC/MS showed the presence of hydrocarbon compounds in water collected from those areas. The compounds were mainly straight chain alipphatic hydrocarbons of C_{15}-C_{32}.

Hunspreugs, et al.,(1984) measured, polycyclic aromatic hydrocarbons (PAHs) in bivalve tissues collected in the Upper Gulf of Thailand in 1984. Employing methodology similar to that of the U.S. Mussel Watch (cited in Goldberg et al., 1978). PAHs were monitored in the bivalves Ostrea pliculata, Perna viridis and Amusium pleuronectes. The concentrations found in these species indicated the presence of low levels of PAH in water of the Upper Gulf. PAH detected included acenaphthene, acenaphthylene, benzo(a)pyrene, fluoronthene, phenanthrene, methylphenanthrene, and triphenylene. A high concentration of fluoranthene (470 ng/g) was found in oyster collected from Ko Si-chang. Benzo(a)pyrene was presented in all species at concentration varying from 1.0 to 8.1 ng/g. Acenaphthene, Acenaphthylene, Methylphenanthrene and Triphenylene were found at maximum concentrations of 16.3, 18.0, 3.5 and 0.003 ng/g, respectively. High degradation rates were observed when radio-labled chlorobenzene, phenanthrene and chrysene were added to water and

sediment of the Chao Phraya River. However, degradation rates were found to be lower in the water and sediment of the Gulf of Thailand. Calculated half-lifes of chlorobenzene in the Chao Phraya river and the gulf were about 68 and 130 days where as of chrysene in sediment sample were 189 and 153 days, respectively.

Petroleum hydrocarbon concentrations around the ship-breaking site were studied by Petpiroon and Yoosuksawat (1987). They reported that ship-breaking activities at Ban Nong Faeb, Tambon Map Ta Phut, Rayong Province polluted the seawater and beaches through occasional discharges and spills of oil. This is due to the fact that demolishing processes involved in these activities usually cause oil pollution. This oil contamination is the potential environmental impacts to activities such as fishing, aquaculture and tourism.

Samples of surfacial sediments were collected between April 1985 and May 1986 from 35 stations in the Gulf of Thailand (Wattayakorn, 1987(b)). The aromatic hydrocarbons from the column chromatography were determined by UVF. Total aromatics averaged 11 and 1.1 µg/g dry weight of sediment for the Upper and Lower Gulf respectively. The range of hydrocarbons were 0.70-62 µg/g in the Upper Gulf and 0.03-8.3 µg/g in the lower Gulf.

Dissolved petroleum hydrocarbons in seawater samples (1m depth) collected from the coastal areas of Pattaya to Trat in November-December 1987 and April 1988 were determined by fluorescence

spectroscopy (Petpiroon, 1988). Forty sampling stations were selected along the coastline to reprersent beneficial uses of the coastal resources such as recreation beaches, aquaculture and fishing ports. These were compared with 21 sampling stations both nearshore (5-20 km) and offshore (25-90 km). The results indicated that onshore waters were more polluted by dissolved petroleum hydrocarbon than nearshore and offshore waters. Concentration of dissolved petroleum hydrocarbons in onshore waters ranged 0.018-5.286 μg/l with the mean of 0.650 μg/l where as that in nearshore and offshore range being 0.009-0.707 with the mean of 0.320 μg/l. The maximum value was found at Ban Nang Faeb, Tambon Map Ta Phut. The highest mean found at Rayong Province was 0.908 μg/l, for Cholburi, Trad and Chantaburi were 0.658, 0.468 and 0.397 μg/l respectively.

Concentration of petroleum hydrocarbon in samples collected within 1 square kilometer of the ship-scrapping activities at Ban Nongfab, Rayong Province ranged from 6.19-14.57 μg/l crude oil equivalents for seawater, and 0.38-1.65 μg/g wet weight for sediments (Petpiroon, et al.,1986). Fisheries resources affected by oil contamination were anchovies, mysid shrimps, Donax spp. and Atrina spp.. No oil spills were observed but tar balls were found scattering on beaches near the site during the survey period (November 5-10, 1986)

Wattayakorn (1989) reports the concentrations of petroleum hydrocarbon in water and sediment from two mangrove forests which have

been affected by different types of human activities. One is Laem Fa-pa mangrove forest, which is in the Chao Phraya river where the largest city of Thailand named Bangkok located. The other is Takua Pa mangrove forest in Pang-nga Province which is more remote and less populated. Petroleum hydrocarbon in seawater and sediment were measured using UVF technique. Petroleum hydrocarbon concentration in water and sediment showed the same trend, being higher at Laem Fa-pa than at Takua Pa mangrove forest. The mean concentration in water in each station being 2.22, 3.70,6.19 and 1.96 μg/l crude oil equivalent for Takua Pa and being 10.17 and 7.67 for Laem Fa-pa mangrove forest. The concentrations in Laem Fa-pa mangrove water samples are also in the same magnitude as that previously reported for the Inter-calibration Exercise organized by IOC/Chulalongkorn University in 1986 (mean concentration of 8.2 μg/l) and these values seem to be the background levels of hydrocarbons in water for the Chao Phraya estuary. High concentrations, however, can also be found around the point source area, i.e. Bangkok Harbor.

High concentrations of hydrocarbons in water were observed at low tide for both mangrove areas, indicating that run-off from land is important source of petroleum in an estuarine environment.

The mean concentration in sediment for Takua Pa mangrove forest was 9.47, 6.88, 4.96 and 5.97 μg/g at each station and was 236.02 and 42.29 μg/g for Laem Fa-pa. The highest concentration of hydrocarbons at Laem Fa-pa was found during a small spill from a tanker upstream in the Bangkok Harbor area, being 464.20 μg/g are fast

disappeared five months after the spill (129.59 μg/g) The author suggested that it could be attributed to biological, chemical and physical breakdown processes which could take place at the same time. Therefore, more detailed study on the degradation rate of petroleum and petroleum products in the tropical climate environment like Thailand should be pursued.

Accumulation of petroleum hydrocarbons in sediment core samples collected from Bangkok Harbor and the Chao Phraya River mouth have been studied (Wiroonphol, 1989). Both areas are parts of the Chao Phraya estuary. N-alkanes from C_{15} -C_{25} were found, with concentrations range from 1.2-8.2 and 0.4-45.0 μg/g for Bangkok Harbor and the Chao Phraya River mouth sediments. At the same areas PAHs concentrations detected were 3.1-40.4 and 0.6-10.7 μg/g, respectively.

Petroleum hydrocarbons in bivalves Perna viridis and Green mussel collected from Ang Sila, Srichang Island and Sriracha were studied using GC technic (Siravajanakul, 1989). Total aromatic hydrocarbons in both species varied from 34.97-74.08 μg/g dry weight.

Analysis of petroleum hydrocarbons in water samples (at 1 m depth), sediments collected from the lower Tha Chin River in March and August 1989, and Green mussel (Perna viridis) collected from the muout of the Tha Chin River in August 1989 were performed by fluorescence spectroscopy (UVF) and gas chromatography (GC) (Sunwanich, 1990). The results of water sample analysis, by the UVF method, showed average petroleum hydrocarbons were 2.53±0.95 μg/l chrysene equivalents in

March and 1.61±0.41 µg/l in August 1989. Comparison of the concentrations in March and August showed to be statistically different within the significant level of 0.01. The result of sediment sample analyses using GC technic showed n-alkane ranging C_{15}-C_{32}. Total aliphatics averaged 20.99±7.85 and 15.39±3.15 µg/g dry weight for March and August, respectively. The sediment samples contained polycyclic aromatic hydrocarbon (PAH) ranging 2-6 rings. Concentrations of total PAH averaged 2.71±0.52 µg/g in March and 2.03±0.46 µg/g in August. Mussel samples contained total n-alkane (C_{15}-C_{26}) ranging 1.28-1.87 µg/g PAH found included Naphthalene, Biphenyl, 2,6-Dimethylnaphthalene, Dibenzofuran, Fluoranthene, Pyrene and Chrysene, with individual PAH concentrations ranging 12.5-81.0 ng/g dry weight.

Observation of Tar Balls in various Regions

Most tar balls are originally derived from discharged of oily wastes and the remainder turns into tar balls and deposited on the sea bottom or carried ashore by waves and currents. The observation of beach tars washed ashore have been reported as follows:

Burns et al.(1982) reported on tar balls at Omani coastal waters which includes the narrow strait of Humuz on the north coast of Oman. More than half of all oil transported in the world passes through this Strait. The quantity of beach tar ranged from 5 to 2,325 g/m with an average of 224 g/m. These values are among the highest reported for any world area by UNEP (1981). A trend of increasing

levels of oil residues close to the Strait of Hormuz was also reported. Locally high levels were seen near offshore tanker loading facilities. Data supported that tanker deballasting is a major source of oil pollution on the Omani coast.

Robertson and Knap (1985) observed stranded pelagic tar balls from Whalebone Bay and Surf Bay on the Burmuda Island in Sargasso Sea in 1982. This study area are representative of north-western Atlantic Ocean. The average deposition of tar at Whalebone Bay and Surf Bay are 248 and 139 g/m, respectively. A significant decline in the amount of pelagic tar stranding between 1978-1979 and 1982-1983 were also observed. The conclusion was that decreases in the number of accidents (tanker spills and platform blow-outs) during 1982 and improved oil pollution control measures on tanker operation, i.e. and implementation of MARPOL 73/78, may have reduced the inputs of tar ball forming hydrocarbons to that area.

Coles and Gunay (1989) monthly observed the abundance of beach tars on Saudi Arabian Gulf beaches from May 1985 to October 1986. The abundances were exceedingly high. The highest value reported was 2.32 kg/m (2,320 g/m) of beach in Kuwait, while Bahrain, Burmuda and Oman were the only other areas to have exceeded 0.5 kg/m (500 g/m). The highest values obtained were more related to recent oil spills than to seasonal changes in prevailing oceanographic conditions. The reported oil spills data were provided by the Saudi Arabian Meteorological and Environmental Protection Administration.

A study on the deposition of tar balls on the sandy beaches of the eastern coast of the Gulf of Thailand (Lam Chabang, Sattahip and Bang Phra beaches), Songkhla beach which located on the western coast of the Gulf and the Andaman sea coast (Lam Phanwa and Karon beaches) was carried out during December 1976 to December 1977 (Piyakarnchana, et.al., 1978). Tar balls could be detected on almost all of the beaches and the season of the year. For eastern coast of the Gulf, Lam Chabang showed the highest amount of tar balls and quite a wide range. The high value from the samples collected in April 1977 was 109.1 g/m. On Sattahip beach, located south of Lam Chabang, two peak of tar balls concentration were recorded in January (17.4 g/m) and May (35.6 g/m). Very small amounts of tarballs were observed at Bang Phra beach throughout the sampling period. The amount of tar balls on Songkhla beach was surprisingly high, ranging from 0.19-715 g/m. The average amounts in April, July 1977 and in February 1978 were comparatively higher than those on the east coast. Amount of beach tar deposited on Lam Phanwa ranges from 0.1 to 63.8 g/m^2 and the highest value (63.8 g/m^2) was observed in December 1977. on Karon beach, located on the less protected coast, the results indicated that amounts of tar balls were higher than that at Lam Phanwa beach. The highest peak of 180.4 g/m^2 was observed in November 1977.

The amount of beach tar monitored along beaches in the Gulf of Thailand in 1979 (Intrarapanich,1979), were 0.00-148.46 g/m^2

The amounts of the tarballs on Songkla Beach were found to range from 0.0 to 2.31 g/m^2, with the mean of 0.25 g/m^2 (Sakarin and Saknimit, 1979). The collections were made from October to December 1976 at high and mid-tide marks. No tar ball was found at the low tide mark.

The distribution of tar balls on beaches along the Andaman Sea coast of Thailand were studied by Limpasaichol (1984). Heavy deposition of tar balls (up to 1980 g/m. was seen on Kalim beach in the south-west monsoon. The deposition of beach tar on Patong beach (2-9 g/m in 1980-1981), Karon beach (67-297 g/m in 1980-1981), Lam Pan Wa beach (7-53 g/m in 1980-1981), Ao Makarm beach (0-2 g/m in 1980-1981) were also observed. Heavy deposition was recorded during the south-west monsoon period between June and July, 1979 on Kuek Kuk and Kao Luk beaches of Phung-nga Province, Karon beach of Phuket Province and Pak Meang beach of Trang Province to be 791, 244, 734, and 384 g/m, respectively. Whereas during April 1980 in the north-east monsoon period, a very amount small amount of tar was recorded as less than 5 g/m maximum of which sand coated and aged tar predominated along the coast.

Petpiroon et al. (1986) reported that tar balls were found to scatter after an oil contamination at about 200 meter along the shoreline near the ship-breaking industry area after the scraping. This factory is located in Ban Nong Faeb, Tambon Map Ta Phut, Amphoe Meung, Changwat Rayong.

Effects of Petroleum Hydrocarbons on Organisms (Bioassay)

Acute toxicity of crude oil on marine organisms was studied in terms of 96-hr.median lethal concentration on several crustaceans;0.86-4.9 mg/l for spiny lobster Homarus americanus larvae and 0.8 mg/l for Pendulus danae (Vanderhorst et al.,1976), 3.2 mg/l for Lucifer foxoni (Lee et al.,1978) and 0.08-0.7 mg/l for juveniles Penaeus merguiensis depending on temperature (Phettongkam,1979).

Differences in growth and growth rate between control fish (white sea bass (Lates calcarifer Bloch.)) and fish exposed to Water Soluble Fraction (WSF) of light Arabian crude oil were observed (Showpreesha, 1986). The acute toxicity showed that 96-hour median lethal concentration (96-hr LC50) is 1.00 mg/l.Lack of normal orientation and schooling behavior were also recorded.

Smith and Hargreaves (1984) found that mysid shrimps exposed to 1.1 mg/l naphthalene increased respiration rate. However,when mysid shrimps were exposed to 0.088 mg/l naphthalene, a decrease in respiration rate was recorded.They also found that both exposures caused an aberrations in daily activity cycle.

Table 1-1 Related researches on petroleum hydrocarbons in the marine environment in various regions of the world.

Sample	Study areas	Petroleum Hydrocarbon concentrations	References
Seawater	Nova Scotia and Bermuda (North west of Atlantic Ocean)	20.4 µg/l (0-3mm) 0.8 µg/l (1m) 0.4 µg/l (5m)	Gordon,et al., 1974.
Seawater	Gulf of Mexico (Spilled area)	1-200 µg/l	McAuliff,1975.
Seawater	Rhine River	0.05-0.5 µg/l	Helman and Humer,1980.
Seawater	North Western Arabian Gulf Kuwait Saudi-Arabia Karta Bahrain	1.2-546 µg/l 2.95 µg/l 4.14 µg/l 3.29 µg/l 0.4-5.7 µg/l	Samra,Emara, and Shunbo, 1986.
Seawater	Andaman Sea	51.0 µg/l (surface) 55.0 µg/l (10m)	Topgi,Noronha and Fondekar, 1981.
Seawater Sediment	Tausar Estuary	<0.001-0.05 µg/l 0.03-1.5 µg/l	Readman,Preston and Mantours,1982.
Seawater	Chesapeake Bay	102 µg/l (alkanes) 1.6 µg/l (PAH)	Hardy,et al., 1983.
Seawater	Eastern Mediterranean	0.3-40.0 µg/l	Ravid,et al., 1975.
Seawater	Aden Gulf Indian Ocean (tanker route) Pacific Ocean (tanker route)	13 µg/l 5 µg/l 0-4 µg/l	
Seawater	Southern Baltic Sea	47.1-1744.0 µg/l (surface) 40.0-219.2 µg/l (5m)	Grzybowski, et.al.,1987.

(cont.)

Sample	Study areas	Petroleum Hydrocarbon concentrations	References
Suspended sediment in seawater	Northwest of the Gulf of Mexico - 10 kms offshore - 20 kms offshore - 90 kms offshore	 1.91 µg/l 1.46 µg/l 1.02 µg/l	Macko,1987.
Estuarine water	Rhone River Marseilles city (Domestic waste) Lions Gulf (recepter for Rhone water) West coast of Mediteranian Sea	18-23 µg/l 104 µg/l 1.5-5.5 µg/l 0.5-11 µg/l	Marchand, 1988.
Seawater	Open Adriatic Sea North Adriatic Turkist (near shore) Mediterranean sea	0.14-4.8 µg/l 0.16 µg/l 0.5-3.5 µg/l 0.02-0.04 µg/l	Hamiton,1989.
Sediment core samples	Quinault Lake Washington Lake Sanmamish Lake	10-25 µg/g (bulk sediment) 1500 µg/g (surface sed.) 30 µg/g (30m.) 500 µg/g (surface sed.) 100 µg/g (deeper sed.)	Wakeham, 1976.
Sediment	3 Creeks in Verginia State -White House Cove -Sarah -Carter	 96 µg/g 119 µg/g 30 µg/g	Voudrias and Smith, 1986.
Sediment	Coatzavoalcos River in Mexico	0.93-7.4 µg/g (n-alkane) 22-3.20 µg/g (aromatic HC.)	Farran, et al.,1987.
Seawater	Gulf of Thailand near oil refinery	20.5-329 µg/l (wet season) 23.4-428 µg/l (dry season) 233 µg/l	Hungspreugs and Switachart, 1980.
Sediment	Gulf of Thailand	2.9 µg/g wet wt. 3.7 µg/g wet wt.	

(cont.)

Sample	Study areas	Petroleum Hydrocarbon concentrations	References
Estuarine water	The Chao Phraya River	0.19-0.43 µg/l (rainy season) 0.514-0.799 µg/l (dry season)	Chatkittikunwong, 1986.
	The Bang Prakong River	0.056-0.406 µg/l (rainy season) 0.318-0.678 µg/l (dry season)	
	The Tha-Chin River	0.26-0.55 µg/l (rainy season) 0.337-0.435 µg/l (dry season)	
Seawater	The Upper Gulf of Thailand	0.172-0.886 µg/l (rainy season)	
Seawater	Gulf of Thailand	0.380-5.664 µg/l (April-May) 0.059-6.095 µg/l (Sep.-Nov.)	Sompongchaiyakul, Hungspreugs and Lim, 1986.
Sediment		0.064-2.164 µg/g wet wt. (April-May) 0.047-1.820 µg/g dry wt. (April-May) 0.059-6.095 µg/g wet wt. (Sep.-Nov.)	
Seawater Sediment	1 km ^{2} of ship-breaking factories at Ban Nong Faeb	6.19-14.57 µg/l 0.38-1.65 µg/g wet wt.	Petpiroon Yoo-sook-swat, Sanguansin, 1986.
Seawater	East coast of the Gulf	0.02-5.29 µg/l (on shore) 0.009-0.707 µg/l (near shore and offshore)	Petpiroon, 1988.
	Ban Nong Faeb	0.302 µg/l	
	Cholburi	0.658 µg/l (mean)	
	Trad	0.468 µg/l (mean)	
	Chantaburi	0.397 µg/l (mean)	
Seawater	The Upper Gulf of Thailand	0.65-8.30 µg/l	Wattayakorn, 1987 (a).
	The Lower Gulf	0.07-6.60 µg/l	
Sediment	The Upper Gulf	0.70-62.00 µg/g 0.03-8.30 µg/g	Wattayakorn, 1987 (b).
Estuarine water	Lam Fa-Pa	7.67, 10.17 µg/l	Wattayakorn, 1989.
	Takua Pa	1.96, 2.22, 3.70, 6.19 µg/l	

(cont.)

Sample	Study areas	Petroleum Hydrocarbon concentrations	References
Estuarine Water and Sediment	The Lower Tha-Chin	0.93-4.25 µg/l (March) 0.95-2.47 µg/l(August) 20.99±7.85 µg/g (Ali.,March) 15.39±3.05 µg/g (Ali.,August) 2.71±0.52 µg/g (PAH,March) 2.03±0.46 µg/g (PAH,August)	Sunwanich and Wattayakorn, 1990.
Sediment core sample	Bangkok Harbour	1.2-8.2 µg/g (n-alkane) 3.1-40.4 µg/g (PAH)	Wiroonphol, 1989.
	The Chao Phraya River mouth	0.4-45.0 µg/g (n-alkane) 0.6-10.7 µg/g (PAH)	

Table 1-2 Studies of petroleum hydrocarbons in various kinds of bivalves in the world.

Samples	Sources	Hydrocarbon conc.(ug/g)	Methodology	References
Mytilus edulis	Southern Baltic Sea	230 (Ekofisk crude oil)	UVF	Law and Andrulewicz, 1983.
Mytilus californianos	Coastal California	7-180 (Total aliphatic) 3-290 (Total polycyclic aromatic)	GC	Risebrough, et al.,1983.
Perna viridis	Gulf of Thailand	39.6 (Polycyclic aromatic hydrocarbons)	GC	Hungspreug, 1984.
Mytilus edulis	Valdez Port Alaska	11-936 (Total Hydrocarbons)		Shaw, et al., 1986.
Mytilus edulis	Cape peninsula, South Africa	53-1147 (Total aliphatic) 1-50 (Total polycyclic aromatic)	GC UVF	Mason, 1987.
Mytilus edulis	Boston Harbor Massachusetts, USA	12.2	UVF	Farrington, et al.,1988.
Mytilus edulis	Venice North-east of Italy	0.2-19.6 (Chrysene eqv.)	UVF	Nasci, et al., 1989.
Mytilus edulis	Gulf of Nepal	295	GC	Wade, et al., 1989.

Table 1-3 Related researches of beach tar observation in various regions.

Study areas	Duration	Amount of beach tar	References
Eastern coast of the Gulf of Thailand	Dec 76-Dec 77		Piyakarnchana, et al.,1978.
-Lam Chabang		highest as 109.1 g/m (Apr.1977)	
-Sattahip		max.as 17.4 g/m (Jan.1977) and 35.5 (May1977)	
-Bang Phra		2.9 g/m (Jan.1977)	
Songkhla Beach		0.18-715 g/m	
Andaman Sea Coast			
-Lam Phanwa		0.1-63.8 g/m^2	
-Karon Beach		0.1-180.4 g/m^2	
Sonkhla Beach	Oct-Dec 1978	0.0-2.3116 g/m^2	Sakarin and Sakninit, 1979.
Gulf of Thailand	1981	0.00-148.46 g/m^2	Intrarapanich, 1981.
Rayong Province (near the ship-breaking site)	Nov 1986	scattering on beaches	Petpiroon,et al., 1986.
Burmuda			
- Surf Bay		decrease from 338 g/m in 1978-1979 to 139 g/m in 1985.	Smith and Knap, 1985.
- Whale bon Bay		decrease from 1108 g/m in 1978-1979 to 248 g/m in 1985.	
Saudi Arabia	May85 - Oct86	greater than 10 kg/m	Coles and Nizmigunay, 1989.