CHAPTER I

INTRODUCTION

Background.

Thailand is one of the developing countries in the Southeast Asia. In recent years, economic and social development plans have been implemented by the Royal Thai Government. The recent one, the Fifth National Economic and Social Development Plan (NP) (1982-1986), has three major objectives. The first objective is to change the nation's industrial structure by introducing more heavy industries with gas and minerals as raw materials in addition to encouraging manufacturing of export products at port sites. Secondly, the plan has an objective to decentralize the population and industrials growths away from the capital city. The last objective is to initiate markets for products of rural regions by providing alternative routes of exporting and encouraging cargo industries.

As a result of the implementation of the Fifth NP, many coastal areas along the Gulf of Thailand such as the Eastern Seaboard (ESB) Zone have been developed as industrial estates. The coastal area of the ESB zone extends from Sattahip, Chonburi to Trat Province and the industrial estate locates at Mab Ta Phud, Amphur Muang, Rayong Province.

As a result of the industrial development of the country, the steel demand has been increased and more demand is expected in

the future. At the present time, in Thailand a few electric furnace steelmaker plants are available and therefore most of the raw materials such as steel scraps and rods must be imported. The cost of imported steel scraps always is very high and therefore in order to suit the steel demand growth, alternations of steel scrap supply are essential. Therefore, the ship-breaking industry in country is promoted in order to supply cheaper raw materials to steelmaker plants.

1. Ship-breaking Industry.

The ship-breaking industry is established with an objective to recover steel as well as accessory parts from scrapping of old vessels. Recovered products are fragments of steel which will be reused as raw materials for steel manufacturing such as steel smelting and steel mill to produced new steel products. The part of better quality steel fragments will be reformed into rod or steel wire to be supplied to construction industries. The lower quality steel will be supplied to smelting plants for resmelting.

Ship-breaking industries have been operated in many Asian countries such as in Taiwan, Hong Kong, South Korea, India, Bangladesh, the Philippines and Thailand. Since 1983, five ship-breaking industry plants have been established along the coast of the Gulf of Thailand. One plant locates at Vonnapa Beach, Chonburi, two at Mab Ta Phud, Rayong and the other two at Prachuap Khiri Khan.

In recent years, the ship-breaking industries in Thailand have been viewed as one of causes of environmental

degradation. Pollutants originated from the ship-breaking activity such as oils, petroleum hydrocarbons and steel fragments may contaminate the environment. Resolution of the Eastern Seaboard Committee on prohibiting such activity in the Inner Gulf of Thailand and a recommendation to relocate the ship-breaking site is an example of an attempt to solve the environmental problems caused by ship-breaking activity. As a consequence of the resolution, in 1984 the Royal Thai Government promulgated an Act of Parliament to specify areas for such activity to be outside of the Inner Gulf of Thailand. Oil pollution is a major problem associated with this activity. Oil spill or oil leak and tar ball from ship-breaking activity are considered as pollutants which have impacts on marine fishery resources and fishing activities (Petpiroon, Yoo-Sook-Swat & Sangunsin, 1986). Among many pollutants which are directly distributed to the environment and together distributed with oils into environment, are some heavy metals because metals are constituents of ship materials.

2. Ship-breaking Processes.

Before the breaking process takes place old unoperated vessels are purchased from world trade centers in England, Germany, or Taiwan. Dangerous gas within these vessels is eliminated at Singapore prior to transport to ship-breaking plants in Thailand.

Steps involved in the ship-breaking process are explained in details as the followings.

2.1 At the earliest step, parts and accessory equipments are removed. Then upper part of the vessel is cut down

to almost reach its' engine room in order to lessen the weight of the vessel such that it can be trawled to anchor at the pier of the plant.

2.2 Oil in the fuel tank and engine room is transferred to a storage tank for sale.

2.3 Remaining oil which cannot be removed is eliminated by burning.

2.4 Remaining parts of the vessel are cut down to small pieces of steel.

2.5 While the process takes place near shore, booms are launched in order to prevent oil spill.

2.6 In case where the oil escapes from boom, chemical reagents are immediately used to remove it.

3. Sources of Heavy Metals from Ship-breaking Industry.

During a ship-breaking process, heavy metals can be released to the nearby marine environment through the following pathways.

3.1 Heavy metals are converted to vapor or gas or released as dust when parts of the ship are electrically cut down with high temperature. Heavy metals such as zinc, copper, lead, and cadmium are found to adsorbed on the surface of particles released during this step (Van Craen, Denoyer, Natusch & Adams, 1983). These particles distribute into the atmosphere and eventually deposit into seawater near the activity area. Heavy metals may be

leached from these particles in appreciable amount to the marine environment.

3.2 Most of the petroleum hydrocarbons or oils used in the ship contain some heavy metals. For example, lead is used to mix with fuel to prevent engine knockdown etc. Therefore, when oil spill occurs during ship-breaking process, heavy metals are also distributed to the environment.

3.3 The steel fragments are eroded by water and weathering.

3.4 Pieces of steel directly falls into the sea and some heavy metals are released into the seawater.

The quantity and the distribution characteristics of some heavy metals in the marine environment caused by the ship-breaking activity depend on the number of ships broke, oceanographic condition, wind velocity and direction, current velocity and direction, etc.

4. Need of the Study.

As a result of the ship-breaking activity, heavy metals contaminate the marine environment and consequently cause impacts to marine life. Major heavy metal contaminations are found to be lead, copper, zinc and iron.

The aim of this study is to understand the distribution nature of lead, copper, zinc and iron in the marine environment in the vicinity of the ship-breaking area. Three periods observed

during this study are

1) a period before the activity starts.

2) a period during the ship-breaking activity is under way, and

3) a period after the ship-breaking activity is finished.

The result from this study can be used as baseline information for an establishment of prevention and control measures for heavy metal pollution originated from ship-breaking industry.

5. Concept of the Study.

This study is carried out in order to determine the contamination of heavy metals by the ship-breaking activity. The contamination can be determined by an analysis of heavy metal concentrations in the seawater near the ship-breaking plants vicinity. The determination of particulate and dissolved concentrations will indicate the forms of heavy metals prevail in the seawater. The analysis of dissolved organic carbon will result in an understanding of a binding effect of contaminated heavy metals and a possibility of particulate heavy metals formation.

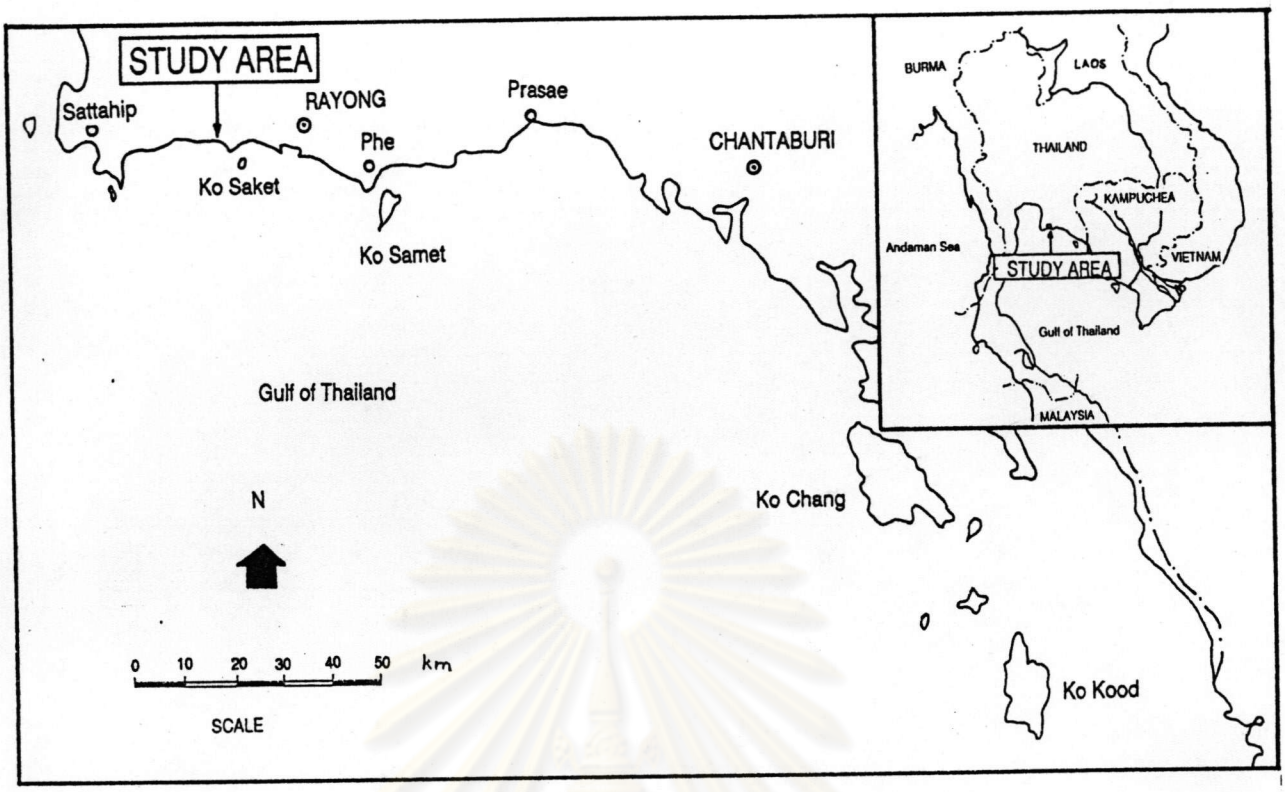
The concentrations of heavy metals can be varied with different factors therefore current speed and direction and a 24 hours concentrations variation are observed. In addition a leaching experiment will confirms the contamination of heavy metals due to ship-breaking activity.

In order to study the impact of heavy metals contamination on living organisms, pen shell (Atrina vexillum) is selected as an indicator because of their high abundance in this area. The heavy metal contents of this bivalves will indicate an accumulative concentration and the extent of heavy metal contamination.

6. Study Area.

The study area is at Tambon Mab Ta Phud, Amphur Muang, Rayong Province, which covers the coastal area extends from Ban Pla to Rayong River mouth. This area is approximately 220 km from Bangkok. Within this study area there are seven water channels and the Rayong River which discharge fresh water into the sea. This area is under the influence of the southwest monsoon therefore the rainy season prevails during May to October. The northeast monsoon prevails during November to February.

The coastline of the study area is a narrow sand beach which lies in the east-west direction as shown in Figure 1-1. The shoreline topography shows a relatively steep slope of about 1/250 in the near shore region and then propagates to a gentler slope of 1/1,000 offshore. The bathymetry of the sea bottom in this area is shown in Figure 1-2. There are fisherman communities along the coastline at Ban Pla , Ban Kong Pet , Ban Pra Doo , and Ban Ta Kuan. Two ship-breaking plants, Thai International Steels Co.,Ltd. and Thai Hua Lee Co.,Ltd., are located at Ban Nong Faeb, Mab Ta Phud while the petrochemical industry, Thai Petrochemical Industry Co.,Ltd., is located near the Rayong River mouth.



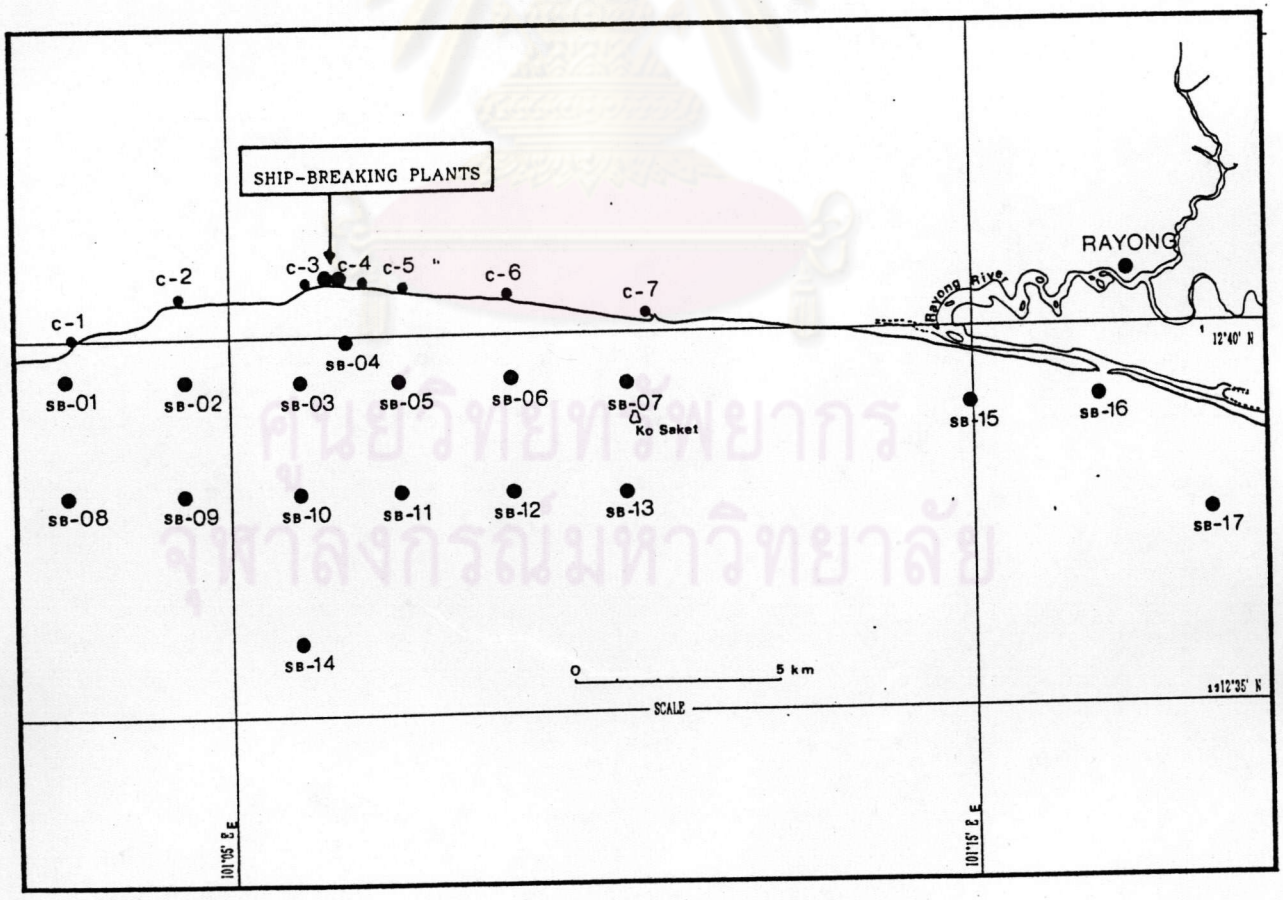


Figure 1-1 Location map of the study area, Ban Nong Faeb, Mab Ta Phud, Amphur Muang, Rayong Province.

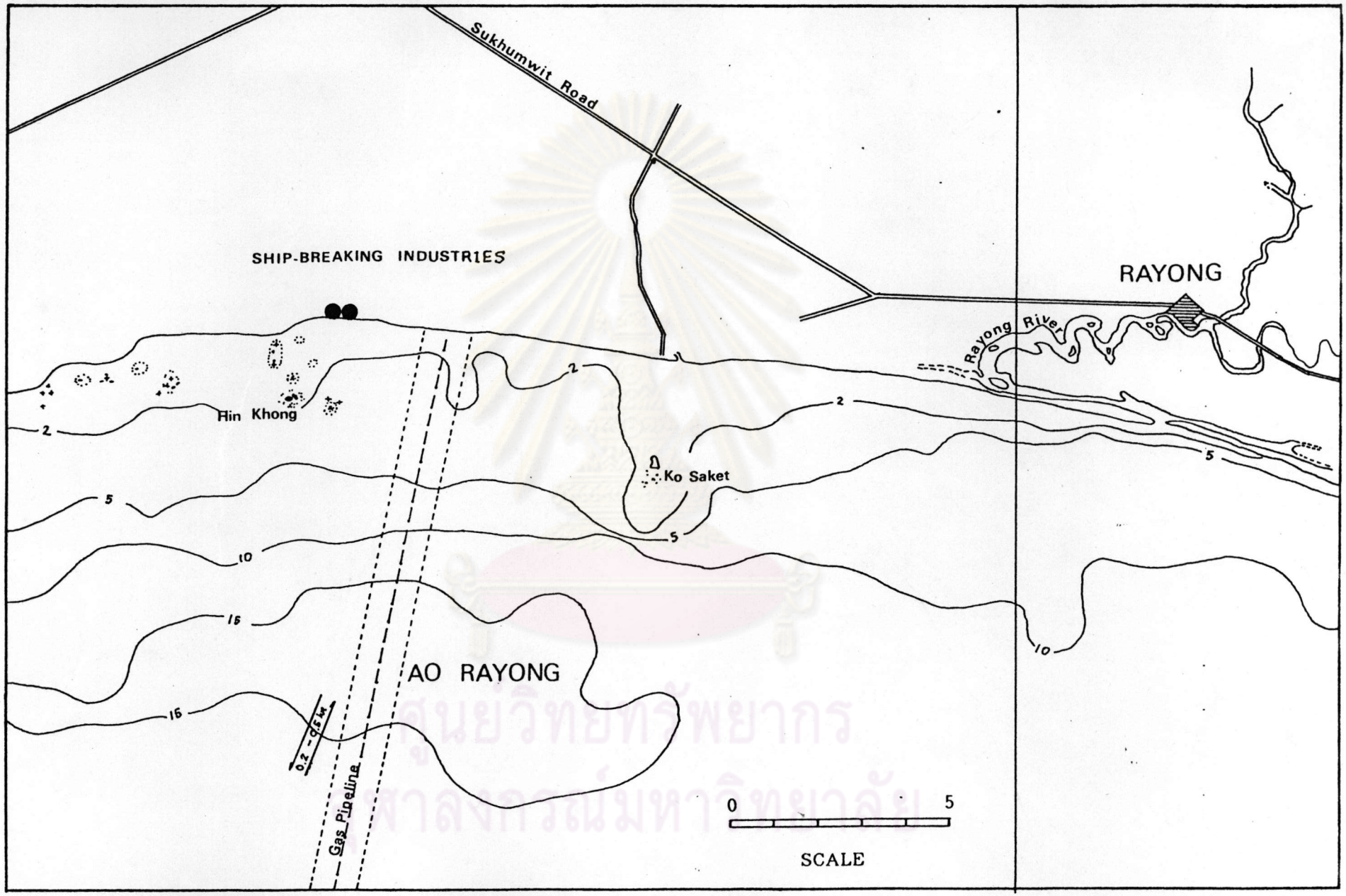


Figure 1-2 Bathymetry of the sea bottom within the study area.

For the two ship-breaking plants, the Thai Hua Lee Co., Ltd., has been in operation since 1983. This company employs fifty workers and breaks up ships of the size of 500-2,000 ton. The Thai International Steels Co.,Ltd., was in operation at 1985. It employs two hundred and eighty workers and breaks ships size larger than 1,000 ton. The total weight of ships broke during 1985 to 1989 for the Thai International Steels Co., Ltd. were 363,720.29 ton.

The time required for the breaking of each ship is about 29-115 days depending upon the ship size and the oceanographic conditions.

Literature Review.

1. Sources of Heavy Metals in the Environments.

Major natural sources of heavy metals are rock weathering, degassing, and they can be released from terrestrial and submarine volcanoes and dissolution from marine sediments (UNEP,1982). Natural rocks contain small amounts of heavy metals. For example, typical lead in many igneous and metamorphic rocks concentrations range from 10 to 20 µg g^{-1} , 10 to 70 µg g^{-1} in carbonaceous shales, and about 100 µg g^{-1} or more in phosphate rocks (UNEP,1985).

Heavy metals found in seawater and sea bed is a result of natural processes and human activities. Some heavy metals such as lead, copper, zinc, iron, cadmium, etc., are utilized as raw materials in many industries. In addition, heavy metals are

discharged together with other wastes such as sewage, detergents and other inorganics (Albert, Leyden & Patterson, 1976 ; Idthikasem, Bamrungrajhiran, Kaewpakdee & Chingchit, 1981). An investigation of the coastal seawater near the industrial and populated areas at the eastern part of the Gulf of Thailand indicated high concentrations of lead and mercury (Vashrangsi *et al.*, 1981).

2. Distribution of Heavy Metals in the Marine Environments.

When heavy metals are introduced into the sea, some of them do not remain in the water column. They may concentrate in the surface film or adsorb to suspended matters and settle to the bottom. Heavy metal may reenter the seawater column through various physical, chemical and biological processes. The geological distribution of individual heavy metals and consequently the regional inputs to the environment are not uniform (UNEP,1982).

Various chemical forms of heavy metals exist in the aqueous environment. Those heavy metals can dissolve, suspend with suspended matters, and deposit in the sediment and interstitial water. Both suspended matter and deposited sediment are included in adsorbed organic matter, iron and manganese oxide lattice positions. A large part of the heavy metals exist in the aqueous environment is associated with suspended particles (Kremling, 1985).

The organic matter can influence heavy metal concentration in seawater and atmosphere above sea surface. Both suspended matter and deposited sediment contain some organic matters. At the surface of the seawater, the organic matters are

formed as a microlayer film where heavy metals are adsorbed. Reactions occur at the seawater surface, particularly waves and mixing process, cause heavy metals to transport into the seawater column and to distribute in the vertical direction (Wallace, Hoffman & Duce, 1977; Wallace & Duce, 1978). Sedimentation of those heavy metals also takes place especially in estuaries and harbor areas. However, very fine gained particles and colloidal material with very low setting velocity always stay in suspension for long period of time and are able to be transported over a long distance.

3. Heavy Metals in the Marine Environment at Mab Ta Phud Area.

For the year 1981, Idthikasem reported the concentrations of silver, cadmium, cobalt, mercury, lead and zinc in seawater at the upper part of the Gulf of Thailand to be higher than the oceanic world average. However, it is natural that estuarine water always contain higher trace metals than the oceanic world average. A significant increase of most heavy metals concentrations was reported by Idthikasem *et al.*(1981) during the year 1977 to 1981. This increase of heavy metal values was possibly a result of human and industrial waste. Vashrangsi *et al.*, 1981 investigated the coastal seawater at the eastern part of the Gulf of Thailand and found high concentrations of lead and mercury at the industrial and populated areas. However, the heavy metal levels in the Gulf of Thailand as reported by Hungspreugs (1982) were much lower than those of Idthikasem *et al.* (1981).

When river water mixes with seawater, the salinity and pH of river water increases, causing the removal of some heavy

metals from the dissolved form into particulate. Hungspreugs, Dharmvanij and Wattayakorn (1985) found the removal of several metals cadmium, copper, lead, zinc, manganese and iron from dissolved form into particulate form in the region 0 - 10 ppb in the Bang Pakong estuarine zone.

In 1987, Petpiroon investigated the distributions of lead, zinc and copper in seawater from the coastal areas of Rayong, Chantaburi and Trat and found that the average concentrations of the three metals studied were normal for seawater and sediments , and within acceptable standards for the coastal marine environment. The mean concentrations of copper, zinc and lead in four mollusc species collected from Rayong Bay in January and July 1987 were found to be within acceptable levels for consumption, with the highest level in pen shell (Atrina vexillum) (Petpiroon, 1989).

As indicated by Utoomprurkporn, Hungspreugs, Dharmvanij & Yuangthong (1987), when contamination of heavy metals during laboratory analysis can be prevented, the concentrations of heavy metal observed are much lower than those reported earlier. Therefore, this should be noted when the aforementioned concentrations reported by many researchers are reviewed.

4. Impact of Heavy Metals on the Marine Environment.

Although, the heavy metal contents in the ship materials are not high but they may become harmful pollutants. Concentrations of heavy metals in seawater are always low principally due to their low solubility and high reactivity in the seawater. A direct or an indirect action of heavy metals on the marine organisms is

always found. The toxicity on marine organisms may range from an immediate, such as sudden death, to more prolonged ones, such as defective development or defective reproduction. The levels of toxicity depend on factors such as the concentration and chemical forms of heavy metals.