CHAPTER 7 ENVIRONMENTAL CONDITION OF CAI LAN PORT

7.1 The Socio-economic Characteristics of Quang Ninh Port, Bai Chay Bay and Cai Lan Areas

7.1.1 Introduction

Cai Lan Port is located on the edge of Bai Chay Bay in Quang Ninh Province. Key contributions to the economy in this area are coal production, fisheries and tourism. The location of Cai Lan Port close to the coal shipping centre of Hon Gai, the coastal fisheries of outer Ha Long Bay and the tourism centre of Bai Chay and the Ha Long Bay islands mean that these are important factors to consider with regard to the port's construction. This section describes the socio-economic framework of Quang Ninh Province then focuses on Bai Chay Peninsula and the areas surrounding Cai Lan Port.

Data for this section are sourced from a report by the Ministry of Commerce, Urban and Rural Planning Institute; from the Data Collection on Social and Natural Environment of Quang Ninh Province collected by the Institute of Ecological Economy (data set referred to hereafter as DSQNP); from interviews conducted by the Environmental Specialists in Quang Ninh Province and in Hanoi; and from field data and observations collected by the Environmental Specialists.

The area around Cai Lan Port is sparsely populated The closest settlement to Cai Lan Port is Cai Lan Village with a population of approximately 80 people. Cai Lan Village is 2 - 3 km from the larger towns of Bai Chay and Gieng Day. Gieng Day is a busy town with a shipyard and brickworks the main industrial facilities. Bai Chay is the focus of a successful tourist industry. Hon Gai and Quang Ninh Port, across Cua Luc Strait from Bai Chay, are the shipping ports for the nearby coalfields. Fishing is an important activity in the area generally.

Cai Lan and the Bai Chay Peninsula is connected to Hanoi (to the west) and Cam Pha and the China border (to the east) via Route 18 which is the main coastal road in this part of Northern Vietnam. Much of this road is in poor condition, being narrow and in parts unpaved. Other services in the area such as solid waste disposal and sewage treatment are at present lacking.

The area is on the verge of a rapid upswing in economic activity, one key part of which is the development of Cai Lan Port. Details about the existing population, natural resources, infrastructure, cultural features and amenity conditions are provided in the following sections.

7.1.2 Quang Ninh Province

7.1.2.1 Location and Population

Quang Ninh is located in the north east of Vietnam between latitude 20^0 and 21^0 14' north and 106^0 and 108^0 east. It borders China in the east, the East China Sea in the south, Hai Hung Province and Hai Phong City in the west and Ha Bac and Lang son provinces in the north. Hon Gai, the provincial capital, is 180 km east of Hanoi and 62 km from Hai Phong.

According to 1992 statistics the population of Quang Ninh is approximately 874,000, with an annual increase of 3.09%. Quang Ninh is urbanising rapidly and the urban population in 1992 accounted for 43.1% of the total population (data from Ministry of Commerce).

7.1.2.2 Natural Resources

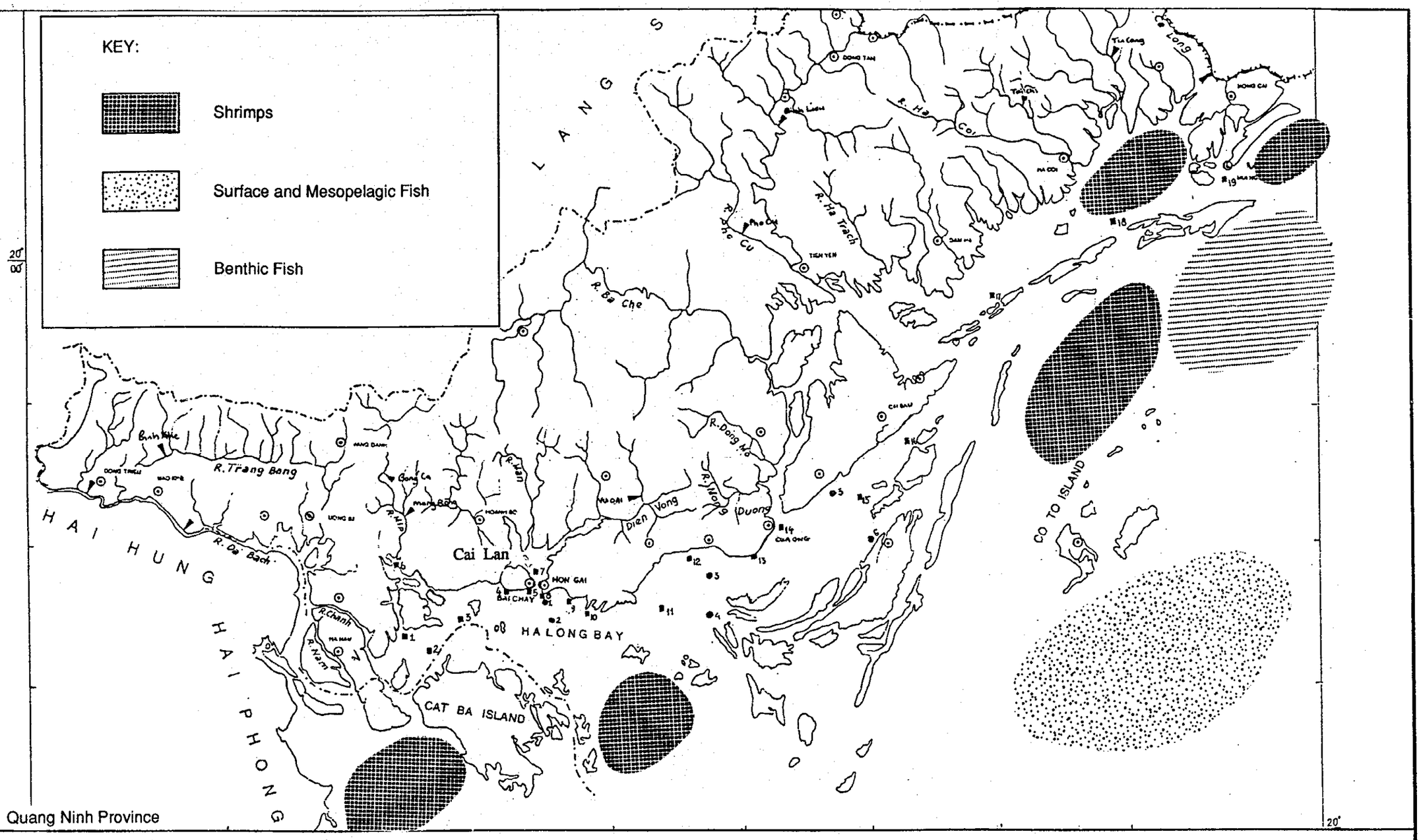
The area available for agriculture in Quang Ninh Province is 72,000 ha, of which approximately 43,00 ha is for rice. Other food crops include maize, sweet potatoes, cassava and vegetables. Industrial crops produced include ground-nuts, soya beans, sugar cane, sesame and rushes.

Forestry lands cover approximately 388,000 ha, of which 196,000 ha is classified as natural forest area. Forest types include bamboo forest, mangrove forest, mixed forest and timber forest. Timber production capacity is approximately 3.2 million cubic metres. Medicinal plants, commercial trees and plants such as pine and cinnamon are also constituents of the forests. Commercial forestry is still developing in the province.

Quang Ninh's seashore is approximately 250 km long with an intertidal seashore area of 100 square kilometres. The province's sea area includes several State-owned fishing grounds with various sea resources which include shrimp, lobster, squid and crabs, as well as fin fish. The main fisheries for the region generally are outside the Ha Long Bay islands, as shown in Fig. 7-1-1. Total fisheries exploitation for Quang Ninh Province is estimated at more than 30,000 tons per year (data from DCQNP), which equates to around 1% of the national catch. The same source indicates that 10,000 people in the province are involved in the fishing industry.

Mineral resources in Quang Ninh Province are plentiful. The province is the largest coal production area in Vietnam. Coal mines are located across a 430 km long belt of land which lies between Cam Pha and Dong Trieu. The capacity of the area is 3.6 billion tons of which 18 - 20

million tons is mined annually at present. Clay resources are found locally at Gieng Day, Kich Tho and Lang Bang (the latter in Hoanh Bo district). The clay is used to produce bricks and tile and the resource is estimated at hundreds of millions of cubic metres.



Source: Quang Ninh Province

LOCATION OF FISHING GROUNDS

FIG. 7-1-1

FEASIBILITY STUDY FOR CAI LAN PORT CONSTRUCTION PROJECT

Limestone is present in large quantities from Dong Trieu to Hoanh Bo and Ha Long Bay. Sands and grits are also present in many localities. Van Hai sand-field in Cam Pha district, with a capacity of 5.6 million cubic metres, is now being used for glass making.

Kaolin is present in Dong Trieu and Hai Ninh. The Tan Mai kaolin mine in Quang Ha district, with a capacity of 56 million cubic metres, is being exploited for ceramics, cement and heat-resistant brick production.

Mineral water is produced in Quang Ninh Province at several localities. This includes hot or thermal mineral water as well as water for drinking, which is now being exploited.

7.1.2.3 Industrial Production

Industrial production accounts for 78% of Quang Ninh's general industrial and agricultural production, and is thus an important part of the province's economy (data from DSQNP). Key products for the year 1991 and their production figures are as follows:

- Coal	3.9 million tons
- Bricks	57 million pieces
- Tiles	6.4 million pieces
- Mineral water	1.8 million litres
- Sea products	8,000 tons (1,100 tons exported).

Agricultural products generally play a smaller part in the economy. Production figures supplied in DCQNP are as follows:

- Buffalo	43,860 head
- Cows	7,657 head
- Pigs	179,898 head
- Horses	18 head
- Goats	1,304 head
- Beehives	2,904 head

The key exports are coal, frozen sea products, cinnamon, and handicraft items. Imported goods included petroleum, steel, asphalt, fertiliser and insecticides.

7.1.3 Bai Chay Bay

7.1.3.1 Population Distribution around Bai Chay Bay

The main centres of population around Bai Chay Bay are focussed on the newly created Ha Long City. This includes the town of Hon Gai, which lies on the eastern side of Cua Luc Strait. On the western side of Cua Luc Strait and making up the western part of Ha Long City are Bai Chay Precinct and the Gieng Day, Ha Khau and Hung Thang Precincts. Hung Thang commune, Tuan Chau commune and Thanh Cong commune are also within western Ha Long City.

The town of Hon Gai, on the eastern edge of Cua Luc strait, extends north along the Bai Chay Bay shoreline and east along the Ha Long Bay coast. This town is the centre of government for Quang Ninh Province. Hon Gai is a busy coastal port, dedicated to the shipping of coal under the direction of the Ministry of Energy. Large coal mines are located in the hill country east of Hon Gai, in the vicinity of Cam Pha and elsewhere along the coastal range of hills. Other economic activities here include fishing and tourism. The total population of eastern Ha Long City is approximately 100,907 people, of whom 99,027 are urban dwellers and only 1,880 are rural.

The population of western Ha Long City is a total of 28,484 people. Of these, 84% are urban dwellers and 16% are rural. Table 7-1-1 shows the population distribution on the western side of Cua Luc Strait.

Bai Chay Precinct, on the western side of Cua Luc Strait, is a coastal settlement. It is one of the main population centres of the Bai Chay "peninsula" which stretches along the southern edge of Bai Chay Bay, separating the estuarine waters of the Bay from the coastal waters of Ha Long Bay. The residential area of Bai Chay extends westward around the

Table 7-1-1 Population of Bai Chay Peninsula.

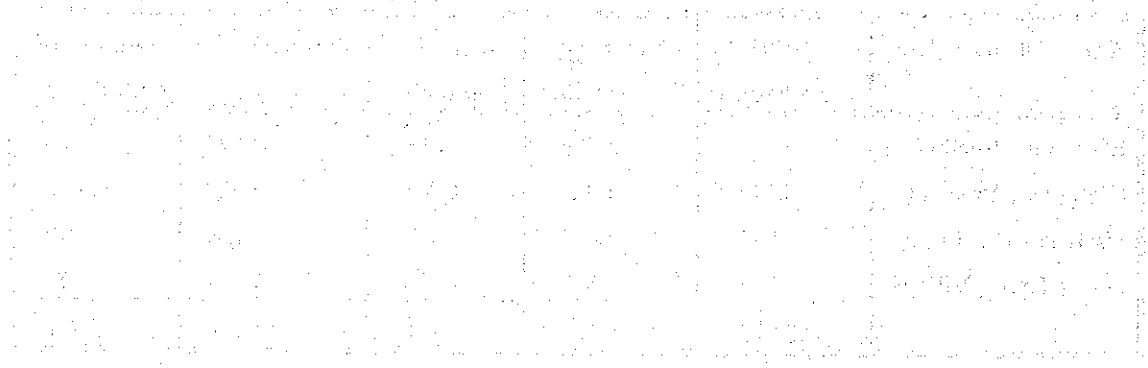
Administrative Unit	Total Population	Number of Households	Female Population	Population at Working Age	Number of Students
Bai Chay Precinct	9,218	2,088	4,664	4,876	2,206
Gieng Day Precinct	8,347	1,822	4,006	4,229	1,808
Ha Khau Precinct	7,581	1,683	3,871	4,254	1,912
Hung Thang Village	3,132	529	1,593	1,472	233
	28,278	6,077	14,134	17,531	6,216

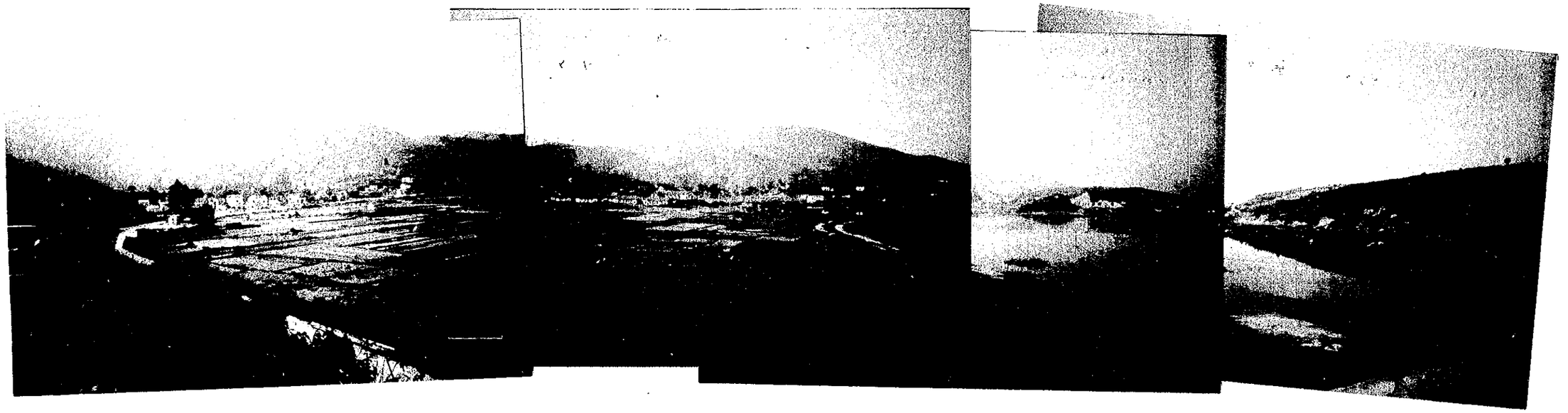
Source: Data Collection on Social and Natural Environment of Quang Ninh Province. Census date 1989.

7.1.3.2 Population of Cai Lan and Other Nearby Centres

The small settlement of Cai Lan is within the boundaries of Bai Chay Precinct but is physically distinct from it, lying approximately 2 km to the west. The settlement itself is about 1 km from Cai Lan Port. Plate 7-1-1 shows Cai Lan as viewed from Route 18. The port area lie just out of sight to the right of the photograph. Approximately 80 people live in Cai Lan, mostly along Route 18 which leads to the Port. Residences are also present along Route 18 between Cai Lan and Gieng Day. In the Port area itself, there are no permanent dwellings and the few occupants are Port workers. Some house-boats moor along the shoreline near the Port. A small number of village people (2 or 3 families) live close to the small estuary at Cai Lan. The people of Cai Lan will be most directly affected economically and socially by the port development.

Some of the people who reside near Cai Lan are involved in agriculture, growing mixed crops on an area of reclaimed estuary near to Cai Lan Port.





CAI LAN SETTLEMENT AS VIEWED FROM ROUTE 18

PLATE 7-1-1

DATE: DECEMBER 1993

FEASIBILITY STUDY FOR CAI LAN PORT CONSTRUCTION

Others are likely to be employed by the Government and in the tourist industry, as described later in this section.

Other centres of population on and near the Bai Chay peninsula are Gieng Day (population 8,347) and Ha Khau (populations 7,581), both approximately 5km west of Cua Luc Strait. Hung Thang, on the Ha Long Bay coast, has a population of 3,132. Further west still is the settlement of Dong Dang, 11km west of Cua Luc Strait and in the western-most corner of Bai Chay Bay. Four km north of Dong Dang on the Troi River is Hoanh Bo which is also near the edge of Bai Chay Bay.

From Hoanh Bo around the northern edge of Bai Chay Bay the population is scattered in small hamlets or single dwellings. Most of this rural population is located on the low-lying agricultural land close to the coast, and on the lower slopes of the surrounding hill-sides. This scattered population structure remains similar around the northern and eastern shores of Bai Chay Bay. Table 7-1-2 shows the population structure of this area.

Table 7-1-2 Population of northern Bai Chay Bay area.

Administrative Unit	Total Population	Number of Households	Females	Population at working age	Women at Working Age	Number of Students	
						1o	2o
Hoa Binh	1,212	171	581	371	181	188	
Vu Dai	983	156	510	368	162	170	
Le Loi	4,169	768	2,092	1,046	569	554	166
Thong Nhat	6,645	1,259	3,331	2,151	1,036	1,136	250
Viet Hung	8,325	1,780	4,191	2,681	1,231	1,002	631
Troi	6,911	1,349	3,325	2,985	1,315	1,090	546

Source: DCQNP.

7.1.3.2 Economic Activities of Ha Long City

Most people in western Ha Long City (the Bai Chay peninsula) are employees of the government and thus their main income is from salary (information from interview with Quang Ninh Planning Committee). A smaller number of people are employed in the tourist industry, while a very few are employed in the fisheries and agricultural sectors.

Considering the limited area of agricultural land in the area (estimated at approximately 200 hectares by Quang Ninh Province) this is not surprising.

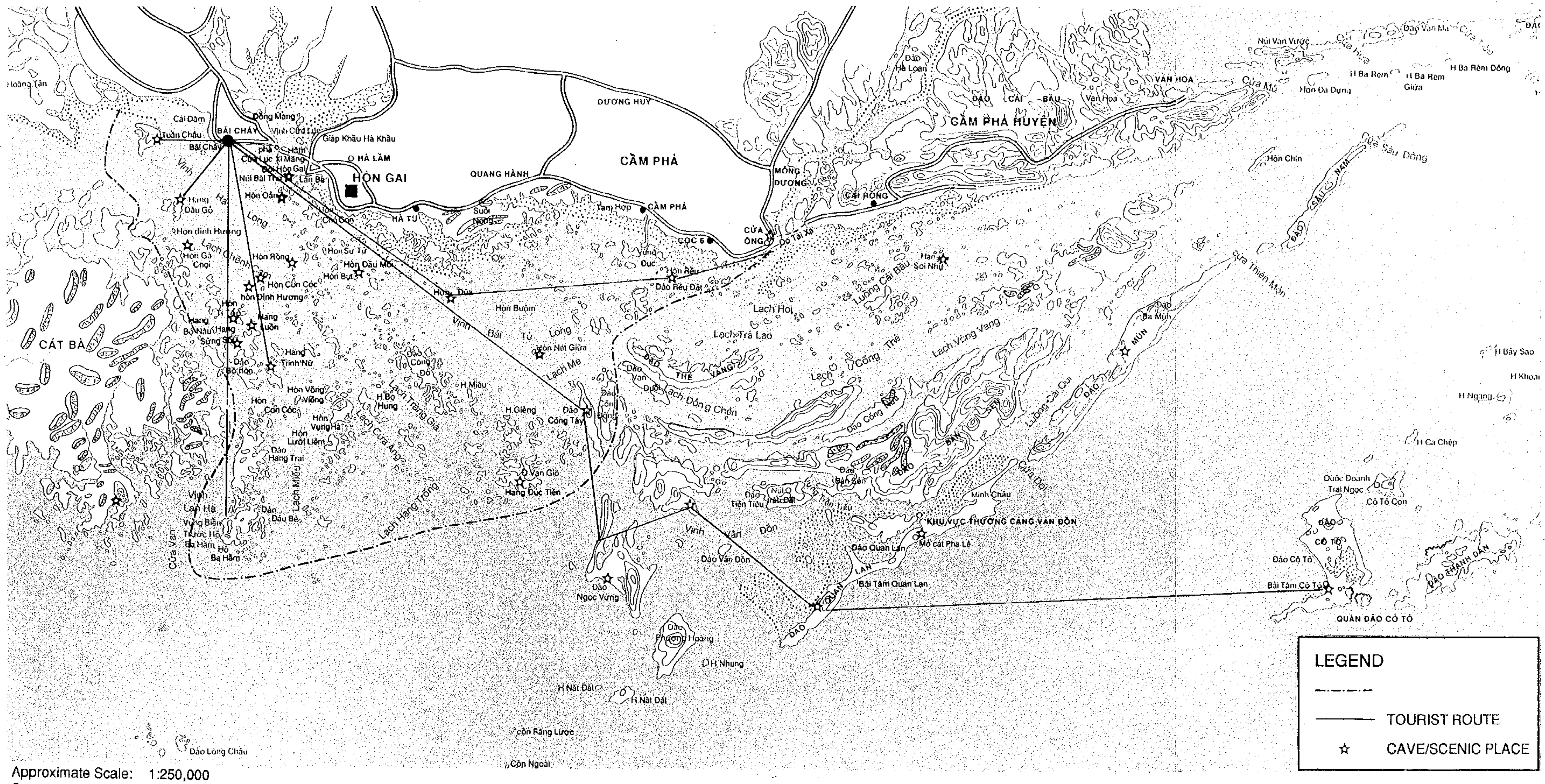
The main economic activities in the area (excluding government service) are described briefly below.

(1) Tourist Development

Bai Chay is increasingly dominated by tourism as many people, both foreigners and Vietnamese, are attracted by the beautiful scenery of the limestone coastline and offshore islands. Numerous hotels are present in the area, with many more under construction. Quang Ninh Planning Committee estimates of the number of beds now present in Bai Chay at 3,000 of which around 500 are of "international" standard. The annual tourist traffic is estimated by Quang Ninh Province at 150,000 to 200,000 people, of whom 30% are foreign visitors. An increase of tourists to 700,000 per year is expected by the year 2000.

The State Planning Committee of Quang Ninh Province estimates the total number of people employed in the tourist industry at 737 people, most of whom are working in Bai Chay.

Numerous tourist boats work from a small jetty located on the Ha Long Bay shoreline. The main tourist destinations are the islands offshore and their beautiful caves and historic places as shown in Fig. 7-1-2. There are no regular tourist routes into the inland waters of Bai Chay Bay.



Approximate Scale: 1:250,000
Source: Local Tourist Map

LOCATION OF TOURIST ROUTES AND SHIPPING ROUTES IN HA LONG BAY

FIG. 7-1-2

FEASIBILITY STUDY FOR CAI LAN PORT CONSTRUCTION PROJECT

The main tourist routes on land are the following:

Bai Chay - Yen Lap Lake - Yen Tu - Bai Chay
Bai Chay - Cam Pha - Mong Cai.

During field trips to the area the Environmental Specialists did not observe any tourists in Bai Chay Bay, on the section of Route 18 which leads past Cai Lan Port, or on Route 18 B around northern Bai Chay Bay. This does not seem to be a tourist destination at present (this was confirmed during interviews with joint venture Vietnamese-French tourist operators operating from a village near the island of Hon Deu, Bai Chay). The limited opportunities for viewpoints from the road around Bai Chay Bay, and the poor road condition, suggest that this route is not likely to be favoured by tourists in the immediate future.

(2) Fishing

In the Hon Gai - Bai Chay area, around 12,000 to 14,000 tons of finfish are caught annually, and around 2,000 to 3,000 tons of shrimp (data from Department of Science, Technology and Environment, Quang Ninh Province). Much of this is for export to other Asian countries. The trade with Japan is estimated to have a value of around US$3,000 per annum.

Most of the offshore fishing fleet is based in Hong Gai and along the coast north of Hong Gai. The exception is the coastal settlement of Hung Thang, west of Bai Chay, where almost the whole population of around 3,100 people is supported by offshore fishing.

The season for finfish runs from September to April, while squid are mainly harvested in spring. Processing is carried out at two factories in Hon Gai and Hai Phong.

Fish for local consumption in the Hon Gai - Bai Chay area are sourced mainly from Ha Long Bay, with a small contribution from Bai Chay Bay. The annual local catch is estimated at 1,000 tons. Boats from both Hon Gai and Bai Chay exploit the fisheries of these coastal and inshore waters. Local fishermen who live around the inner shores of Bai Chay Bay also fish in the estuary. The abundance of fresh seafood is a feature of the many restaurants of Bai Chay.

(3) Forestry

The hilly ridges along the centre of Bai Chay peninsula have had their natural forest cover removed. Much of this area has been used in the past by the local people to collect firewood and other traditional materials. This is no longer permitted as the Ministry of Forestry is engaged in a re-afforestation program aimed particularly at the protection of soil and water resources. Commercial forests are estimated by Quang Ninh Province to cover around 150 ha of the total peninsula area of 4,500 ha. Species planted recently as part of the re-afforestation are generally *Pinus* species (*P. mekuisi* and *P. masoniana*). *Eucalyptus* species are considered by Ministry of Forestry personnel to be less suited to the soils of this area. However, there are many small plantations of *Eucalyptus* species (mainly *E. canaldulensis*) which have been planted by the local residents.

(4) Ports

Hon Gai coal port and the floating Quang Ninh port are the largest ports in the vicinity of Cai Lan and Bai Chay Bay. On the western side of Cua Luc Strait there are several other ports. These include the Bai Chay ferry terminal at Cua Luc Strait, the already constructed berth at Cai Lan and the "Polish" shipyard, Ha Long shipyard, approximately 3 km west of Cai Lan at Gieng Day. This shipyard can handle vessels of up to 5,000 DWT. Another small shipyard is located at Cai Dam (also known as Ha Long shipyard).

The B-12 oil port is located inside Bai Chay Bay only a few hundred metres from the ferry terminal. This is accessible to 30,000 DWT vessels. Fuel is unloaded at an offshore buoy and pumped via a fixed line to the onshore fuel storage tanks. These have a capacity of 23,000 m^3. A pipeline links this storage area to a larger facility at Ha Khau, approximately 8 km to the west. There are some plans to relocate Bai Chay fuel handling facilities to a small island in Ha Long Bay. This matter is still under discussion.

(5) Industry

Five brick and tile factories are located in the Bai Chay peninsula area, producing 100 million pieces per year. One is located directly beside Bai Chay Bay, at Gieng Day. Two others are located in this vicinity. The two other factories are at Ha

Khau and Ha Long. Several small garages, engineering workshops and pharmaceutical plants are also in operation in the general area.

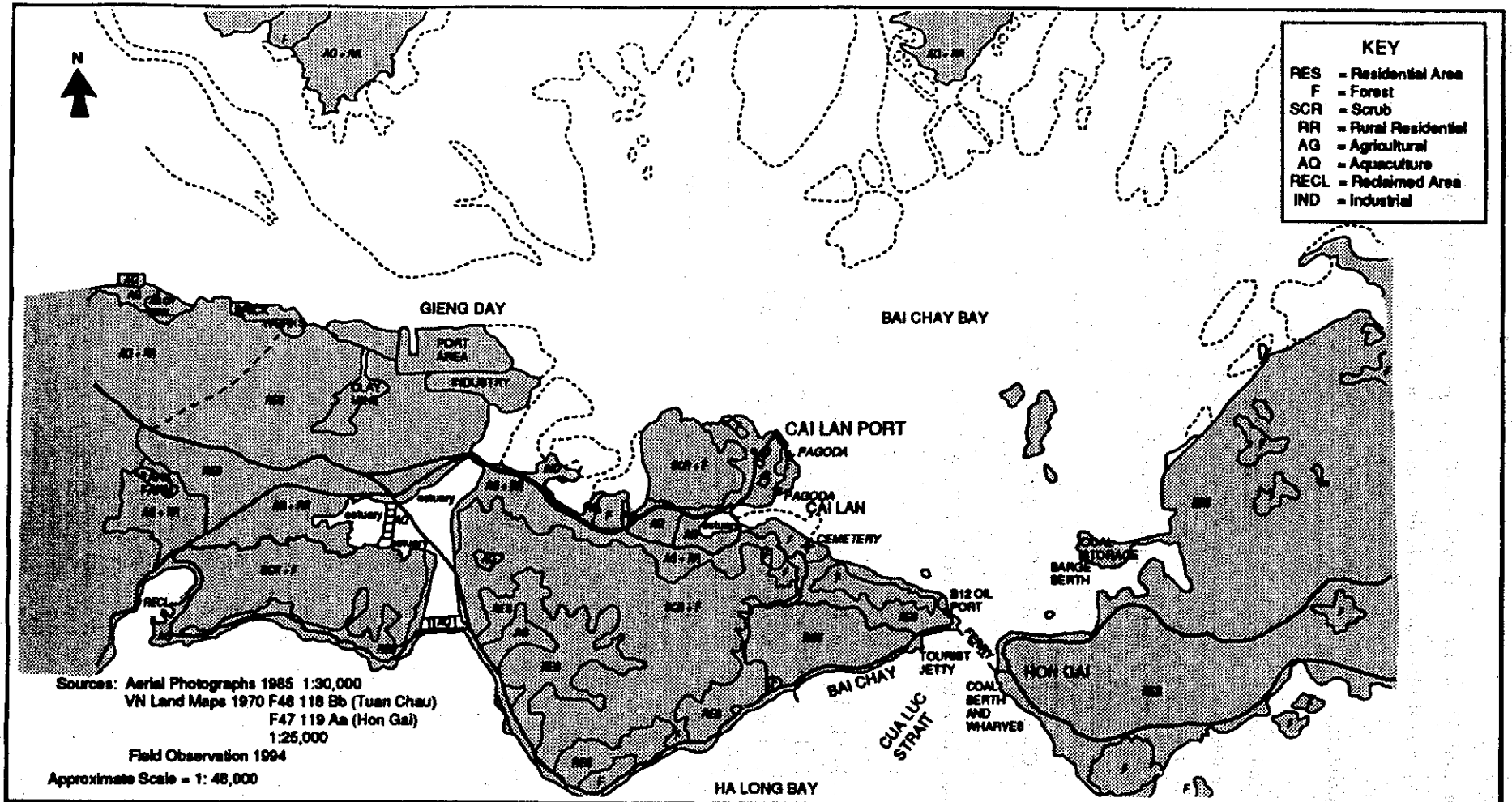
(6) Agriculture

The rural population on the Bai Chay peninsula is focussed on small areas of low-lying arable land in the hinterland of Cai Lan and near the south western shoreline (Cai Dam). Quang Ninh Province estimates the total agricultural area on the peninsula as 200 ha, mainly producing foodstuffs for direct consumption in the local area.

7.1.3.3 Land Use Characteristics of Bai Chay Peninsula and Environs

The land use characteristics of the Bai Chay peninsula are shown in Fig. 7-1-3 and summarised below.

Bai Chay peninsula has a central range of hills which rise to peaks a maximum of 185 m above sea level. Much of this hilly area is scrub-covered or supports plantation forests of *Pinus* or *Eucalyptus* species. A large part of the coastal area is residential, particularly on the southern side facing Ha Long Bay. In Bai Chay there is a combination of residential and commercial use, with much of the land closest to the shoreline devoted to tourist hotels and restaurants.



LAND USE OF BAI CHAY PENINSULA AND ENVIRONS

FIG. 7-1-3

FEASIBILITY STUDY FOR CAI LAN PORT CONSTRUCTION PROJECT

Around the northern edge of the peninsula the steeper hillsides between Bai Chay and Cai Lan are forested or planted with plantation species. The flat land around the small estuary at Cai Lan is used for agriculture. The hills between the Cai Lan agricultural land and the port area are mainly very low scrub with some large areas of plantation, particularly *Eucalyptus*.

Further to the west, Gieng Day has a large residential area and also some areas devoted to industry. A brick works, ship yard and clay mine are present in this area. In the estuary between the Bai Chay peninsula and the mainland some aquaculture ponds have been established.

All of the Bai Chay peninsula environment has been modified, and there is little or none of the original vegetation remaining. Information from the Biogeography Division, Institute of Geography, Hanoi, indicates that the original forest vegetation would have been a dense evergreen forest with up to five vegetation layers. The information available does not indicate when the last remnants of this forest would have been removed.

7.1.3.4 Economic Activities of Bai Chay Bay's Northern Shoreline

Although the northern shoreline of Bai Chay Bay is separated from the Cai Lan area by several kilometres of estuary, the potential effects of the port development on water quality and hence on the mangrove ecosystem make this an area of importance to this study. The mangrove ecosystem plays an important part in the lifestyle and economy of the people who live around the northern shoreline. Economic activities in this area revolve mainly around agriculture and the harvesting of sea food of various types (refer Chapter 6). Large areas of mangrove are present around the northern estuary and these are heavily exploited for firewood. Shell fish are collected from the mud flats (up to 2 kg per person per hour) in some places. Mangrove worms are also harvested from the area. Although much of this natural produce is utilised directly by the local population, some is marketed as well.

Large areas of mangrove have been developed for aquaculture, particularly shrimp. A recent study by Anh (1992) found that approximately 180 ha were devoted to aquaculture in the coastal areas of Hoanh Bo district. Aquaculture, as in other parts of Vietnam, is expected to be of increasing importance to the local and national economy.

7.1.4 Existing Infrastructure

The existing infrastructure in Quang Ninh Province, western Bai Chay and in the area directly adjacent to Cai Lan is as follows.

7.1.4.1 Roads

The main east-west route through Quang Ninh Province, Route 18, connects Ha Long City with Hanoi, and via Routes 5 and 10, with Hai Phong and the western hinterland. It meets the Vietnam-China border at Mong Cai. The road is generally 7-12 m wide and mostly paved, though in variable condition. This is the route along which any road traffic to Cai Lan Port would pass, both from the east and from the west.

In the vicinity of Cai Lan the roads are as follows. From a junction at Gieng Day there are two alternative routes to Bai Chay. One of these follows the northern edge of the Bai Chay peninsula, passing Cai Lan Port and winding through hills down to the ferry terminal. This road is unpaved from the Cai Lan Port turn-off to Bai Chay. This is the route along which Cai Lan Port traffic would pass. Houses are present along this road.

The southern route is a paved road following the shoreline of Ha Long Bay and passing through Cai Dam and the main tourist and residential areas. This route is most commonly used by all traffic travelling to the tourist areas and to Bai Chay ferry.

The road which traverses the northern Bai Chay Bay area is Route 18B. This branches off Route 18 at Dong Dang, passes through Hoanh Bo and then through the agricultural area to the north of the estuary. Route 18B and Route 18 re-join each other near Cam Pha, well to the east of the project area.

7.1.4.2 Railway

The Bai Chay peninsula is linked to Kep by rail, but the railway line ends at Ha Long Station, some 3 km west of Cai Lan Port. Two cargo trains and two passenger trains ply this route at present. An itinerant market has grown up around the railway station. Although the rail bed extends to near Cai Lan Port the railway line from Ha Long to Cai Lan was removed approximately 10 years ago. There is no railway near the northern Bai Chay Bay coast line.

7.1.4.3 Air Transport

Air access to Bai Chay is limited to a heliport situated close to the town and a sea plane service. This enterprise which caters for the tourist market is situated on the foreshore near the island of Hone Deu. The province is considering building an airport west of Ha Long City, near Minh Thanh.

7.1.4.4 Water Sources

In the populated areas of Bai Chay and Hon Gai some water resources are supplied from ground water bores. However, much of the population is served by piped water from the Dong Ho water plant, located several kilometres north west of Bai Chay. This has a capacity of 20,000 m^3 per day, less than half of which is currently being used. This pipeline currently supplies Cai Lan and is expected to supply the new port and associated infrastructure.

The Petrolimex facility (B-12 oil port) has a well 100 m deep, drilled 3 years ago, which is capable of supplying high quality drinking water (information from Director of the facility).

7.1.4.5 Waste Disposal

There is no area-wide sewage treatment in the area, and as in most parts of Vietnam, sewage from the populated areas of Hon Gai, Bai Chay, Cai Lan, Gieng Day, Dong Dang and Hoanh Bo is discharged directly to the nearest river or to the sea. In Bai Chay, individual hotels have treatment facilities which are said to be of the septic tank type. Effluent is discharged from these hotels into the channel beyond the mudflats offshore from the tourist area. Mudflats such as these can accommodate this type of pollutant output at low levels.

Stormwater (rainfall runoff) is likewise untreated and flows into the sea.

Solid waste and household garbage is not collected on a routine basis and there is no local landfill. Rubbish is collected from the hotels in Bai Chay, and is dumped beside the road leading from Bai Chay to Cai Lan (Route 18). Generally, household refuse in the more rural areas is composted and used in agriculture.

7.1.4.6 Health

Gieng Day has a 50-bed hospital which serves the Bai Chay Peninsula area, while Hon Gai has a much larger hospital. In small towns there is often a small hospital with 3-4 beds (information from Quang Ninh Planning Committee).

7.1.4.7 Education

Six thousand children are at school in the Bai Chay peninsula area. Generally, each town has a primary school and there is one "middle school" in Cai Dam for children aged approximately 15 - 17. A technical training institute is situated in Bai Chay (information from Quang Ninh Planning Committee).

7.1.4.8 Electricity Supply

Electricity is supplied to the Bai Chay area via the national grid, which provides both 35 V and 110 V power. The main sources of electricity are the Uong Bi and Pha Lai thermoelectric plants.

7.1.4.9 Communication

The area is supplied with numbered short-wave systems and telecommunication systems through the Ha Long Post office. This provides national and international links.

7.1.4.10 Culturally Significant Places

Buddhism is the main religion of the Bai Chay people. While there are no large pagodas on the peninsula, two small pagodas are present on the shoreline close to Cai Lan Port. The closest is less than 100 m east of the existing berth at the port. The second pagoda is another 200 m further along the same shoreline, beside a small estuary. Access to both is along a dyke which follows the edge of the estuary on the perimeter of the port area. This dyke then leads onto the shoreline path to the pagoda closest to the port. Many people visit these pagodas on festival occasions (observed by from Environmental Specialists). Typically, people visit the pagodas on the 1st and 15th of each month and on other special religious occasions. (Plate 7-1-2)

7.1.5 Traffic

7.1.5.1 Road Traffic

Road traffic on the Bai Chay Peninsula is light compared to traffic on the eastern side of Cua Luc Strait (the Hon Gai - Cam Pha area). The proximity of the coal fields and their associated traffic, the location of the provincial government offices in Hon Gai and the much higher population

Plate 7-1-2 The pagodas near Cai Lan Port.

(A) The shoreline pagoda as seen from Cai Lan Port (note the sparse, stunted mangroves).
(B) People walking to the shoreline pagoda.
(C) The estuary pagoda and makeshift motorcycle shelter.

in this area all contribute to a higher traffic volume. By contrast, traffic travelling to within the Bai Chay area is of a more localised nature, apart from the vehicles bringing tourists to the area.

Traffic on Route 18 travelling both east and west of the Ha Long City area was recorded on two days in December 1993, as part of the "Feasibility Study on Highway No. 18". The numbers of vehicles recorded are shown in Tables 7-1-3 and 7-1-4. Most of this traffic would follow the "scenic route" around the southern edge of Bai Chay Peninsula. Traffic on the alternative Route 18 past Lai Lan is very light.

Information from Quang Ninh Ferry Enterprise indicates that the total number of vehicles (cars, trucks and buses) carried in 1993 was 334,107. This gives a mean number of vehicles per day crossing Cua Luc Strait of 915 (Table 7-1-3). The difference between this number and the number of cars, buses and trucks tabulated above may be accounted for as local traffic.

Motorcycle and bicycle traffic accounts for by far the highest number of vehicles (a combined total of approximately 60 % of all traffic).

Traffic movement was considerably heavier on the road between Hon Gai and Cam Pha, with an overall mean of 5,558 vehicles per day. By comparison, an average of 1,571 vehicles travelled between Hon Gai and Uong Bi, west of Ha Long City. These proportions may change as more cargo is moved from the west toward Cai Lan Port. Similarly, the proportion of trucks on the road is likely to increase during and after development of Cai Lan Port, although this is likely to be from local traffic. Cargoes from further afield or outside the province will generally arrive by train.

Table 7-1-3 Vehicle traffic to and from the west of Cai Lan Port, December 1993.

Route	Date Recorded	Vehicle Type					Total
		Car	Bus	Truck	Motor-cycle	Bicycle	
Uong bi-Hon Gai	15.12.93	225	102	245	531	219	1,404
	16.12.93	228	237	239	739	432	1,869
Mean % of Total		*14 %*	*10 %*	*15 %*	*39 %*	*20 %*	*100 %*
Hon Gai-Uong bi	15.12.93	217	298	209	640	236	1,500
	16.12.93	217	196	179	720	189	1,512
Mean % of Total		*14 %*	*13 %*	*13 %*	*45 %*	*15 %*	*100 %*

Source: Feasibility Study on Highway No. 18

Table 7-1-4 Vehicle traffic to and from the east of Cai Lan Port, December, 1993.

Route	Date Recorded	Vehicle Type					Total
		Car	Bus	Truck	Motor-cycle	Bicycle	
Cam Pha-Hong Gai	15.12.93	205	205	971	2,018	2,976	6,448
	16.12.93	205	334	1,048	1,762	2,215	5,569
Mean % of Total		*3 %*	*5 %*	*17 %*	*31 %*	*43 %*	*100 %*
Hon Gai-Cam Pha	15.12.93	189	295	934	1,789	2,273	5,480
	16.12.93	227	262	912	1,559	1,790	4,736
Mean % of Total		*4 %*	*5 %*	*18 %*	*33 %*	*40 %*	*100 %*

Source: Feasibility Study on Highway No. 18

7.1.5.2 Shipping Traffic

There is a great deal of vessel movement in Cua Luc Strait and the surrounding areas of Ha Long Bay. The floating Quang Ninh Port lies just offshore, Hon Gai itself is a busy shipping port and the ferries ply between Hon Gai and Bai Chay. (Plate 7-1-3).

Shipping traffic in the vicinity of Cua Luc Strait has several destinations. Vessel movements include the following:

- Ships mooring at Hon Gai coal berth.
- Lighters or barges carrying coal from the coal berth to the floating port.
- Oil tankers passing through Cua Luc Strait to the Petrolimex B-12 oil port.
- Coal barges moving from Dao Sa To through Cua Luc Strait to the floating port or other destinations.
- Occasional vessels moving through the strait to Ha Long ship yard or Cai Lan port.
- Fishing boats moving into and out of Bai Chay Bay.

In addition to this traffic is the ferry traffic passing across Cua Luc Strait between the Bai Chay and Hon Gai ferry terminals. This traffic is considerable and several vessels are commonly engaged in moving goods and passengers at any one time. These vehicles include six tug boats, three self-propelled ferries and eight passenger ferries, including sub-ferries. The mean numbers of ferry crossings per day are shown in Table 7-1-5.

Plate 7-1-3 Shipping and road traffic.

(A) Ferries in Cua Luc Strait.
(B) Ships at anchor in Quang Ninh Port and ferries in Cua Luc Strait.
(C) Houses along the Gieng Day - Cai Lan portion of Route 18.

Table 7-1-5 Mean numbers of ferry crossings of Cua Luc Strait per day for the years 1989 - 1993.

	Mean Number of Crossings per Day				
Year	1989	1990	1991	1992	1993
Type of Ferry					
Tug Boat	150	166	156	152	150
Self Propelled Ferry	0.7	0.8	13	24	46
Passenger Ferry	35	40	24	54	40
Total	185	207	193	230	236
	Mean Number of Vehicles Carried per Day				
	582	628	563	739	915

Source: Quang Ninh Province (via TEDI)

The mean total of 236 crossings per day illustrates how busy this stretch of water frequently is. The mean number of vehicles carried over the five years summarised increased by 36%, illustrating the increase in the quantity of goods produced and transported in the province over this period.

Quang Ninh Port estimates that approximately two oil tankers pass through Cua Luc Strait per week, each being 22,000 to 25,000 tonnes. The speed at which they travel is very slow, (between 5 and 8 knots). Ferry traffic gives way to the oil ships at present.

The number of movements to or through the channel per day by other vessels has not been recorded.

7.1.6 Amenity Values

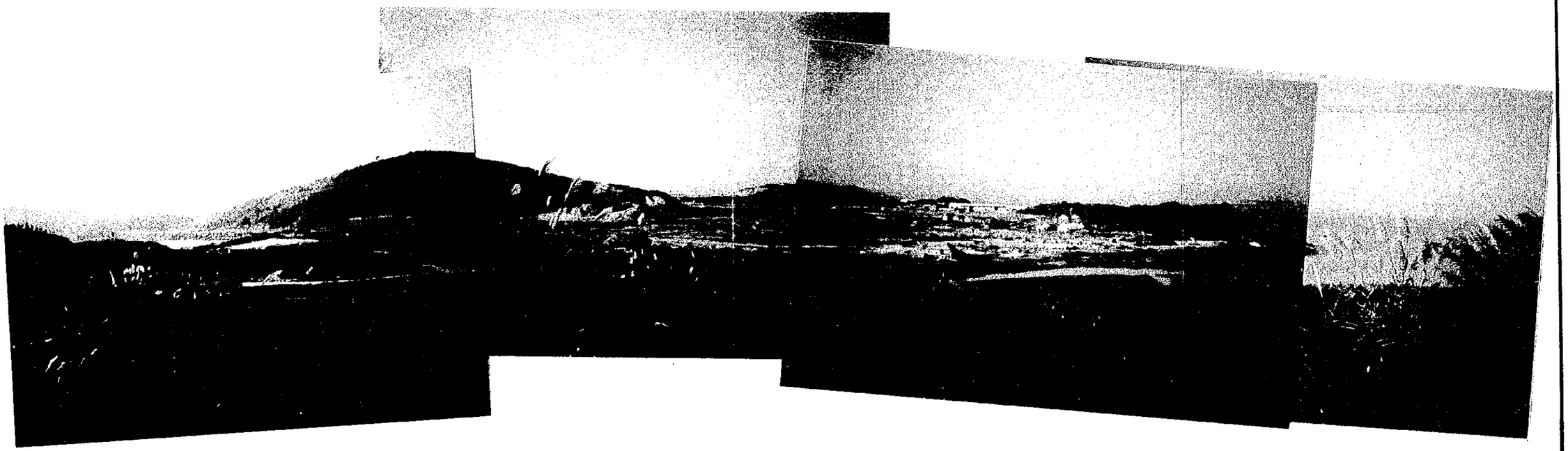
7.1.6.1 Introduction

Amenity factors are important when considering the values the current environment has for its occupants. Factors that go to make up the quality of life for residents in any area include the landscape quality and outlook of the area in which they live, the quality of the air they breathe and the noisiness of the environment. For those who live in a rural area, the rural quality of life may also include access to natural resources such as firewood, and coastal or marine resources nearby. The amenity values of the Cai Lan area which will be most directly affected by the Cai Lan Port Construction Project are described below. The wider context of Bai Chay Bay is discussed where relevant.

7.1.6.2 Landscape Values

Cai Lan residents have a generally rural outlook. Those who live alongside Route 18 have a backdrop of scrub-covered hills and in front of them, to the north, low-lying agricultural land. Beyond this lie the estuarine area which borders the Cai Lan Port area and the bare terrain of the port area itself. The latter is visible only during the approach to Cai Lan from the east, along a hilly portion of Route 18 which affords a view over the whole port area (Plate 7-1-4). The few residents living below this road have views of the port area and face directly out into Bai Chay Bay.

The port cannot be seen from the west, the nearest area being the ship yard at Gieng Day, some 2.5 km west north west as the crow flies. The nearest residents to the north are some 4 km away across Bai Chay Bay, from where the port area is barely visible (observations by Environmental Specialists).



CAI LAN PORT AREA

PLATE 7-1-4

DATE: DECEMBER 1993

7.1.6.3 Air Quality

Air quality in the Bai Chay Bay area is most noticeably affected by dust generated by traffic on the many unpaved dirt roads. Heavy loads of particulate material can be observed on vegetation, houses and sidewalks along such roads. In the residential area near Cai Lan Port, the road is paved but even so the environment is quite dusty, especially during the dry winter. The absence of local heavy industry means that air emissions are restricted almost entirely to agricultural and road dust, and exhaust emissions. At present few residents own motor vehicles and thus exhaust emissions are not high. Exhaust emissions are likely to increase as the economy improves and more people can afford vehicles. The use of low to moderate cubic capacity (cc) 4-stroke motorbikes rather than 2-stroke bikes should be encouraged as emissions from the former are considerably lower. Many of the trucks now in service are diesel fuelled, and have high pollutant output.

Because the Cai Lan Port area itself is sparsely vegetated and there are large areas of dry ground, dust can be entrained if there is sufficient wind. This can be carried in the direction of the residences in Cai Lan.

On the Bai Chay peninsula generally there are no significant emissions of gases from any source other than small scale industry (e.g., smoke and particulate matter from the brick works) and domestic fires.

7.1.6.4 Noise and Vibration

As noted above, Cai Lan is a rural area. It is approximately 3 km from the busy port of Hon Gai and 2 km from the B-12 oil port and the Bai Chay ferry terminus. Noise from these locations is audible in Cai Lan as a low hum and could not be described as an irritant. Louder noise in Cai Lan is generally restricted to local agricultural and vehicular noises of a domestic rather than an industrial nature. Individual vehicles contribute the most noise. In 1993 and early 1994 a dredge was operating offshore of the existing Cai Lan berth. The noise generated by this was audible at a low level near the residences in Cai Lan.

Noise experienced within Bai Chay Town is dominated by traffic noise, with the sounds of Hon Gai Port in the background. Vibration in the vicinity of Cai Lan Port is limited to the occasional passage of heavy vehicles. Plate 7-1-3 shows the proximity to the Cieng Day - Cai Lan portion of Route 18.

7.1.6.5 Access to Coastline and Resources

Fishermen from the local area are entitled to use the surface waters of Bai Chay Bay subject to permission from and taxation by the Quang Ninh Peoples' Committee. Gathering of shell fish also requires permission from the People's Committee. It is unclear whether residents are entitled to freely collect fish and shellfish for their own rather than commercial use. Certainly, resources in the area have been heavily used in the past.

7.1.6.6 Land Tenure

Land is owned by the government. Land tenure is dependent on the decisions of the Peoples' Committee. Residents of land needed for economic development may be relocated elsewhere. There are no residents in the Cai Lan Port area other than port employees, and residents along Route 18 are not in the path of construction for the period up to 2000.

7.2 The Physical and Biological Characteristics of Bai Chay Bay and Cai Lan Port Area

7.2.1 Introduction

This section of the report describes the state of the physical environment in the areas which are likely to be affected by the construction of Cai Lan Port. These include the terrestrial and marine environments in the immediate vicinity of Cai Lan, in Bai Chay Bay, and in the broader area of Ha Long Bay.

Firstly, in section 7.2.2 the physical environment is described. This includes the meteorology, hydrology, geology and seismic characteristics of the environment. An important component of this section is the sediment regime of the Bai Chay Bay catchment and similar catchments in Quang Ninh Province.

Secondly, in section 7.2.3, the vegetation of the Cai Lan area is described. The marine and intertidal environments of Bai Chay Bay and Ha Long Bay are key components of the area which may be affected by the construction of Cai Lan Port. Section 7.2.4 first describes the water and sediment quality of these areas, based on the results of surveys conducted in 1994. It is important to note that current land use practices have already had a considerable adverse effect on the Bai Chay Bay environment and these are briefly discussed in section 7.2.5. The ecology of the mangroves in Bai Chay Bay is addressed in a separate Chapter, Chapter 6. This chapter also covers the mangrove-dependant fauna (including finfish, shellfish, crustaceae and other animal biota).

7.2.2 Physical Characteristics

7.2.2.1 Introduction

Bai Chay Bay is surrounded by low hills to the north and west, with agricultural land on the coastal fringe. To the east, the coastal range of hills rises to a height of around 300 - 500 feet. The hills of Bai Chay peninsula reach a maximum of 185 feet. Five rivers drain into Bai Chay Bay. Cai Lan Port area consists of several hectares of poorly drained flat land, with a number of small hills scattered about the vicinity. The drainage to Cai Lan estuary is blocked along a dyke which runs beside the estuary. There are no streams or rivers in the area. Some scour channels are present in the area of the quarry area, but these tend to drain to the poorly drained flat land, rather than to the sea.

The following section describes elements of the physical environment which are relevant to the EIA.

Information about the physical characteristics in the study area has been derived from a number of sources. A report by TEDI (1988) summarises the meteorological data from 1974 to 1982, including temperature, precipitation, winds and typhoons. Many of these data were recorded at Bai Chay Weather Station, which is located at 20° 58' N and 107° 04' E at an elevation of 37.6 m above sea level. Information was also derived from the Data Collection on Social and Natural Environment of Quang Ninh Province (DCQNP). This includes data on storm surges in the Gulf of Tonkin as well as other meteorological and biological information. In each case the most recent information available has been cited.

7.2.2.2 Sediment Load in Rivers

There is considerable variation in the sediment load in river waters in Quang Ninh Province. Detailed data is not available for all of the rivers entering Bai Chay Bay, except for a tributary of the Dien Vong River. Data from this and other stations within the province are reported below.

Monthly suspended solids and sediment flow were recorded at three stations over the period 1980 to 1990. These were Binh Lieu Station, on a tributary of the River Pho Cu, north-east of Bai Chay; Duong Huy, on a tributary of the Dien Vong River, which drains into Bai Chay Bay; and Bang Ca, on the Yen Lap River, to the west of Bai Chay. Details of the sediment levels and flow rates recorded at each station are presented in the Environmental Impact Assessment along with the average sediment discharge in the same three rivers.

The highest suspended solids loading in the Binh Lieu River was 102 g m^{-3} and in the Bang Ca River, 145.7 g m^{-3}. Both these maxima were recorded in May. By comparison, the maximum suspended solids concentration recorded at Duong Huy which drains to Bai Chay Bay was 49.4 g m^{-3}, recorded in August. In this river, suspended solids concentrations decrease to below 10 g m^{-3} in winter under low flow conditions.

The average annual sediment discharged from the Duong Huy catchment was 91 tonnes per square kilometre, higher than that discharged from the Bang Ca Catchment, but considerably lower than that discharged from the Binh Lieu Catchment (133 tonnes per square kilometre). There are no comparative figures available for the other rivers draining into the Bai Chay Catchment.

7.2.3 Vegetation of Cai Lan Port Area

7.2.3.1 Introduction

The vegetation and ecological characteristics of the Cai Lan Port area were surveyed in February 1994 by the Project Team's Environmental Specialists. The coastal and terrestrial vegetation are described below.

7.2.3.2 Coastal Vegetation

The intertidal vegetation along the shoreline west of the existing berth at Cai Lan Port is limited to a few isolated, squat mangrove trees. The main species found was *Avicennia marina* growing typically as a dwarf shrub less than 0.5 m in height. The laminae (leaf blades) were small, indicating stressed growth in a difficult substrate. This consisted of stones and rocks in the mid and upper intertidal zone with mud and estuarine sediments in the lower littoral. Beyond mean high water were maritime grasses such as *Cyanodon dactylon* and sedges such as *Cyperus malaccensis*. Scattered grasses and occasional opportunist trees such as self-sown *Eucalyptus* sp. occurred behind the coastal patches of *Cyanodon*.

East of the existing berth, a sparse zone of *Avicennia* extends around the stony intertidal area. This grades into a zone of sparse grasses and herbs before leading into the denser grasses and shrubs of the lower hill slopes. A considerable quantity of refuse, mainly plastic bags and other plastic scrap, was present in the upper intertidal zone in this area. A pagoda is present approximately 100 m from the berth along this shoreline and it seems likely that the plastic wrappers and other debris obserbed here were discarded by visitors to the pagoda.

Intertidal macroalgae were poorly represented at the time of inspection (December - January 1994). On the pneumatophores of the sparse *Avicennia* shrubs, colonies of red algae (Rhodophyceae) were occasionally established.

The intertidal and maritime vegetation of the area was of very low value, both ecologically and economically, and could best be described as degraded.

7.2.3.3 Terrestrial Vegetation

The port area is mainly comprised of flat land and some small hillocks, lying between the seashore and the low hills which rise to the south. Considerable areas are bare of vegetation, possibly due to development activities during construction of the existing berth and to earlier activities during the period when the area was used as a navy base. In general, the area could be said to have been completely modified. All of the vegetation is regrowth and no natural forest vegetation is present. Plate 7-2-1 shows the vegetation of the area as seen from a hill behind the port. Table 7-2-1 lists the species identified from this area.

On the small hillocks in the port area the vegetation consists of grasses such as *Panicum maximum* and *Imperata cylindrica*. These contribute up to 90% of the vegetation cover on these hillocks. Occasional trees and shrubs are present such as *Hibiscus tiliacea, Phyllanthis emblica, Psidium guyava* and *Pueraria thomsonii* along with a large vine (Fabaceae). Members of the *Mimosa* family are also present. The dry, clayey soil supports a very sparse ground covering vegetation of grasses and herbs amongst the larger clumps of *Panicum* and the shrubs. There is evidence of burning on the top of one hillock and small craters in the surface (depth approximately 1.5 m).

The umbrella fern *Dicranopteris linearis* has colonised a large part of the side of one of these hillocks and is present elsewhere in the area.

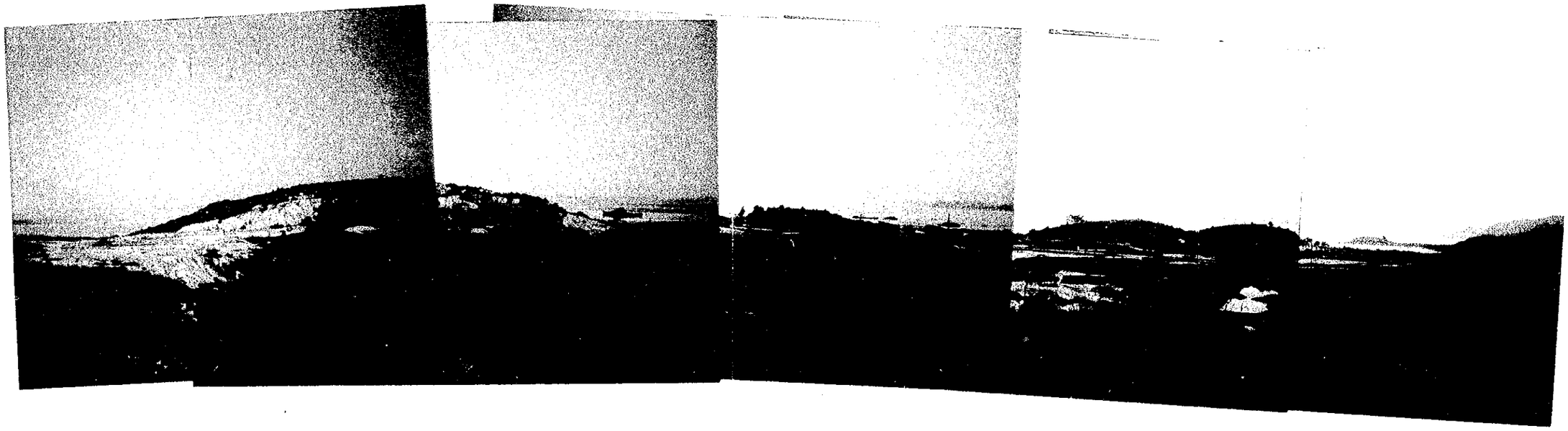
East of the existing berth, the largest of the hillocks supports a denser shrub and forest cover. Species present include many of those found elsewhere on the site, but here the canopy is taller (up to around 5-10 m, and occasionally much larger trees are present. This hill has not been affected by recent activities in the port area, but is likely to have been cleared or burned in the past.

On the flat land around the port the vegetation is generally very sparse, consisting of grasses and herbs. In damp areas some sedges and rushes are present, including *Eleocharis* sp., *Scleria oryzoides* and *Cyperus polystachus*. Occasional clumps of *Panicum maximum* and the large bamboo-grass (?*Mischanthus* sp.) are present and one juvenile palm *Phoenix lancearis* was found. A prostrate member of the Mimosidae was occasionally present on the flat ground near the bases of the hillocks.

Table 7-2-1 Plant species collected at Cai Lan Port site.

FERNS AND ALLIES	Rushes and sedges
Dicranopteris linearis	*Cyperus polystachus*
Lycopodium sernuum	*Eleocharis sp.*
	Eriocaulon hookerianum
MONOCOTS	*Scleria oryzoides*
Monocot herbs	*Spilanthes paniculata*
Phylidrum languinosum	*Stachytaphyta japonica*
Monocot trees	DICOTS
Cuscuta japonica	Dicot trees and shrubs
Phoenix lancearis	*Cassia sp.*
	Catharanthus roseus
Grasses	*Fabaceae*
Cyanodon dactylon	*Hibiscus tillaceus*
Dactylotenium aegyptiacum	*Melastoma candidum*
Eragrostis tremula	*Memecylon edule*
Eragrostis montana	*Mimosoidae*
Eulalia phaeothrix	*Phyllanthus emblica*
Imperata cylindrica	*Psidium guyava*
Leptochloa chinensis	*Pueraria thomsonii*
Panicum maximum	*Rhodomyrtus tomentosa*
Panicum repens	
Saccharum spontanem	
Uraria lagopoides	

Note: Species identified by Biogeography Division, Institute of Geography, Vietnam Centre of Natural Science and Technology, Hanoi.



VEGETATION OF CAI LAN PORT SITE

PLATE 7-2-1

DATE: DECEMBER 1993

FEASIBILITY STUDY FOR CAI LAN PORT CONSTRUCTION

Behind the western-most hillock is a quarry area which is apparently being mined for low-grade coal and may also be used as a source of fill material in the construction of the existing berth and apron area. Here

the ground was cracked and dry and supported very little vegetation. However, in some damp hollows, small stands of sedges such as *Eleocharis* sp. and *Eriocaulon hookerianum* were present. The occasional *Rhodomyrtus tomentosa* shrub was found in the area. On the hill above the quarry escarpment the vegetation was similarly composed of grasses and shrubs as that described above. Some self-sown *Pinus* trees were present.

On the flat ground directly below the eroded slope of the quarry a sward of rushes, sedges, grasses and other monocots was present. In particular, a large area of *Phylidrum lanuginosum* was present growing in marshy ground near a well in the centre of this flat area. Grass and sedge vegetation extended across this low plain to the causeway at the edge of the small Cai Lan Estuary. The topography was uneven over much of the area nearest the causeway and parts of it were flooded. Rush and sedge vegetation dominated this area.

The hills behind the port area support large plantations of fruit crops such as pineapple, and timber plantations, mostly *Eucalyptus* sp. Some of the latter have been very recently planted and there are recent burn scars in areas which are about to be cultivated.

By way of general summary, the whole area has been severely modified by activities including burning, quarrying, forestry and agriculture, as well as the port construction activities themselves. The existing vegetation bears little resemblance to the original forest vegetation which would have covered this area. Although it is likely to provide a habitat for various birds, rodents, invertebrates and other animals, there are large areas of similar habitat on the hills behind Cai Lan and elsewhere in the local area.

7.2.4 The Marine and Intertidal Environment

7.2.4.1 Introduction

In this section of the report the effects of existing land uses on the marine and intertidal environment are described. The historical land use practices that have contributed to the current status are described in section 7.2.4.2. Section 7.2.4.3 describes the overall status of the marine and coastal environment (this is discussed in more detail in Chapter 6). Sections 7.2.4.4 and 7.2.4.5 describe the water quality and sediment quality of the Bai Chay Bay and Inner Ha Long Bay areas. These two latter sections report the results of surveys undertaken by the Centre for Marine Mechanics, Institute of Mechanics, at 20 sites during winter and summer, 1994.

Existing water quality data collected from coastal stations in Quang Ninh Province is presented (information provided by DCQNP) and some additional water quality data provided by Quang Ninh Province is also included.

7.2.4.2 Existing Status of the Environment due to Land Use Practices

The land use practices in the vicinity of Bai Chay Bay have already had an effect on the environment and these are described below. Effects of the development of Cai Lan Port and other new industries will thus be overlaid on the existing effects. The effects of Cai Lan Port development are described in Chapter 7.

As described in Chapter 3, land use around Bai Chay Bay varies from intensive agriculture to aquaculture, forestry, shipping and other industries such as brick and tile manufacturing. In addition there are a number of population centres around the southern edge of Bai Chay Bay, and a large rural population along the northern shoreline. A number of observations can be made about the general effects on the environment that are the result of current and historical land uses around Bai Chay Bay. Of particular importance are land uses that have increased sediment loads in the rivers entering Bai Chay Bay, and the effects of agriculture and harvesting around the shoreline on the intertidal fauna and flora.

The hilly areas north of Bai Chay Bay, originally forested, have been cleared of much of their forest cover. Some re-afforestation has been carried out using plantation species such as *Pinus*, *Eucalpytus* and *Casuarina*. As has occurred in many other areas of Vietnam, removal of forest cover has led to considerable erosion of the hill soils. This is likely to have increased the sediment loads being carried into Bai Chay Bay over the past few decades.

Aerial photographs of the Northern Bai Chay area (1:30,000, 1985) show intensive agriculture across the coastal plans and low foot-hills behind the large mangrove estuary. The flat or gently sloping land available for agriculture in this area is quite limited and agriculture is intensive right to the edges of the estuary. In many places, the local people have reclaimed land along the coastal margin for agriculture.

The intensity of agriculture means that there is no longer any natural terrestrial vegetation bordering much of the estuary and thus the natural filtering effects of this vegetation have been lost. Small-scale coastal erosion is also adding to the increased sediment loads entering Bai Chay Bay.

In the north-eastern hinterland of Bai Chay, some large coal mines are located. It is likely that mine water from this area enters Bai Chay Bay and this may also affect its water quality. Coal stockpiles are present in several locations along the eastern shoreline of Bai Chay Bay. Coal is deposited in these places to await transportation by barge to Hon Gai, or to ships in the floating port. Examples of such sites are Dao Sa To, just north of Hon Gai and in the upper reaches of Dien Vong Channel. Coal is piled directly adjacent to the shoreline in these areas and there appear to be no sediment or water control systems. Sediment control was similarly lacking at the brick works which are located at various places around the estuary, for example, at Gieng Day, a few kilometres west of Cai Lan. Here the clay materials and factory are located beside the water's edge and sediment is freely entrained during rainfall. These coal and brick operations have been present for many years and are probably having a continued deleterious effect on estuarine water quality.

Other land use factors which may be having an adverse effect on water quality within the Bai Chay Bay Estuary, as well as in the coastal waters of Ha Long Bay, are the discharge of sewage and stormwater from the populated areas of Hon Gai, Bai Chay, Gieng Day, Dong Dang and Hoanh Bo. Seawater quality parameters such as suspended solid load, turbidity presence of human-borne bacteria, oil and grease and trace elements such as lead may be adversely affected by effluent from these various sources.

7.2.4.3 Status of the Coastal and Marine Environment

Within Bai Chay Bay there are many hectares of mangrove vegetation. Several species of mangrove are present, including *Aegiceras corniculatum, Avicennia marina, Bruguiera gymnorrhiza, Clerodendron inerme, Excoecaria agallocha* and *Kandelia candel*. These species are used to a greater or lesser extent as a source of firewood by the local inhabitants and also as grazing for cattle. For these reasons most of the mangrove vegetation in the estuary is low and stunted. While these species are capable of reaching a height of several meters in this area, according to local scientists, frequent grazing and cutting means that they rarely reach a height of 2 m and most are much smaller.

Fisheries in the estuary include finfish, shrimp and shellfish. As with many of the estuarine and inshore coastal areas of Vietnam, there is heavy pressure on these fisheries. Fish and shellfish provide a food source for the local populace as well as being marketed elsewhere. No quantitative data about fisheries stocks in these areas was available.

Aquaculture in Bai Chay Bay has also had a large effect on the mangrove vegetation. Development of dykes and ponds to trap water for shrimp farming has had a detrimental effect on

the mangroves. As a healthy mangrove ecosystem is a crucial factor in maintaining good fish stocks, the development of aquaculture may have a detrimental impact on other fisheries in the long term. The marine and intertidal environment of which the mangrove ecosystem is an important component are described in the next section.

7.2.4.4 Water Quality

A sampling programme was designed by the Environmental Specialists to assess the existing water quality both within Bai Chay Bay and in the near-shore coastal waters of Ha Long Bay. The samples were collected and analysed by the Centre for Marine Mechanics.

The results of the water quality survey conducted in Bai Chay Bay, Cua Luc Strait and Ha Long Bay give an indication of the effects that the different land uses around Bai Chay Bay are having on the waters of Bai Chay Bay and Inner Ha Long Bay. The results are generally supported by data provided by Quang Ninh Province which indicates poorer water quality at site 11 between Hon Gai and Cam Pha.

The higher E. coli levels in the vicinity of Hon Gai and Bai Chay, and in the mouths of the Vien Dong and Mon Rivers indicate the effects of discharge of sewage from these populated areas.

For several parameters, namely COD, oil content, phosphate, total sulphur and sulphate, and suspended solids, the sites in Cua Luc Strait, and offshore of Bai Chay and Hon Gai (sites F6, F7 and F8 respectively) have higher concentrations than elsewhere, suggesting that these sites have somewhat poorer quality than those in Bai Chay Bay. This poorer quality indicates the effects of discharges such as stormwater, sewage and other discharges from local industry above entering the water from the port and residential areas.

Concentrations of total phosphorus, phosphate and sulphur were higher at sites F1 and F2 in the north-eastern part of Bai Chay Bay were higher than those in the western part of the Bay. Elevations in these nutrients are likely to be due to agricultural practices in the Dien Vong Catchment.

Suspended solids were higher in Bai Chay Bay, due to the influx of the rivers which drain into the catchment. Elevated hydrogen sulphide concentrations were found in the mangrove ecosystem due to the reducing conditions there. Salinity was slightly lower in Bai Chay Bay, as might be expected in the estuarine environment. The slightly higher temperatures in the open coastal waters probably reflect the temperature dynamics of the open water. Dissolved oxygen was

lower within the Bay than in Ha Long Bay, possibly indicating the better mixing of the waters in the coastal sea than in the tidal inlet of Bai Chay Bay.

Seasonal fluctuations in most of the parameters were recorded, most being explained by the greater rainfall and river discharge into Bai Chay Bay, and higher summer water temperatures.

Data on trace element concentrations provided by Quang Ninh Province indicated that concentrations of cadmium and lead near the B-12 Oil Port were high, relative to international criteria (e.g., USEPA). It should be noted that on the basis of Vietnamese Criteria of 50 ppm the results from sites near B-12 Oil Port are not high. However, other international standards for lead are significantly lower.

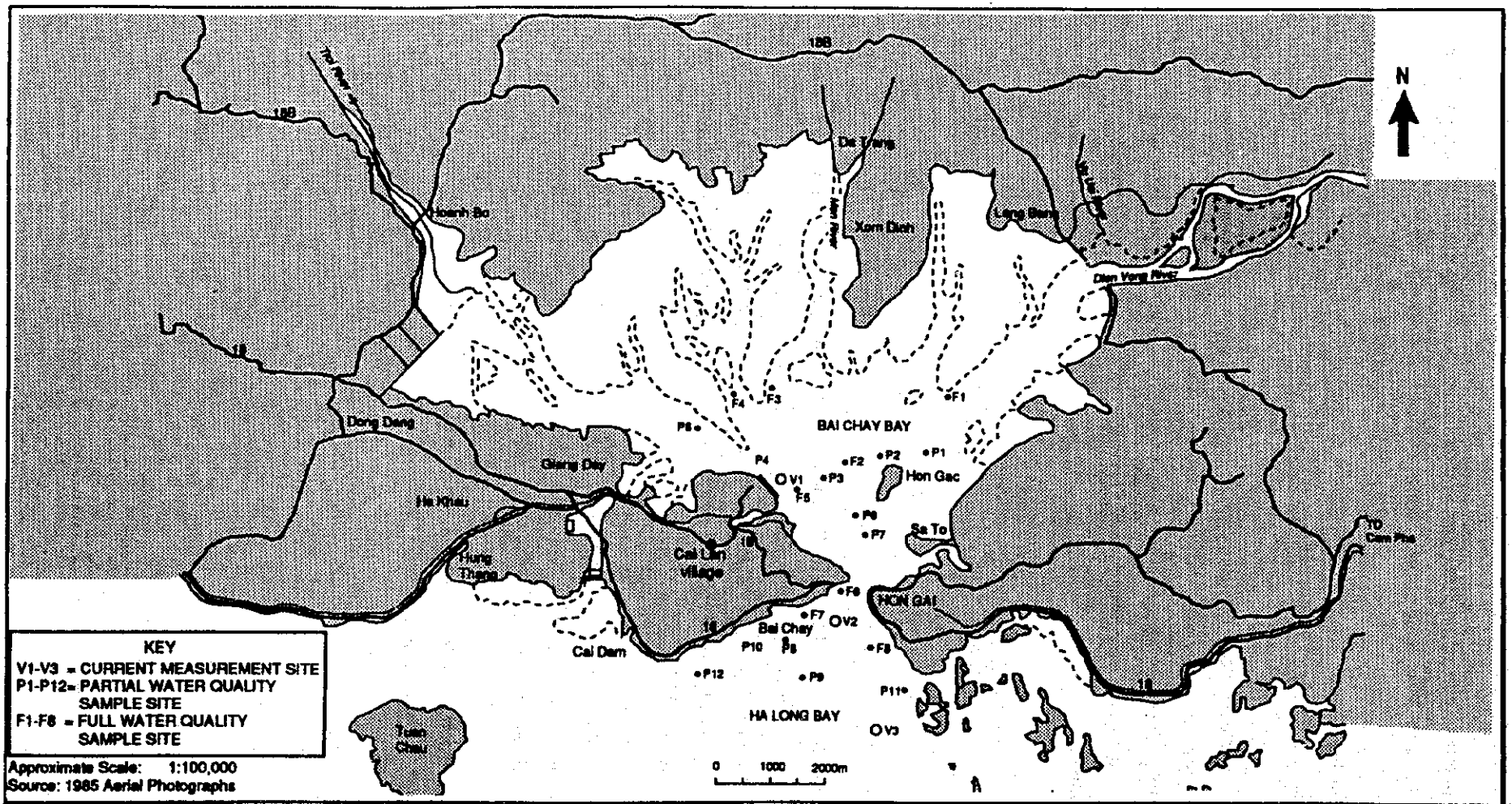
Details of the survey design and results are presented below.

Survey Design

Twenty sites were selected for sampling, to cover the water quality of Bai Chay Bay and Ha Long Bay near river mouths and near possible sources of pollution such as towns and villages. The locations are shown in Fig. 7-2-1. Eight of the sites were designated full water sample sites and twelve were designated partial water sampling sites. The parameters measured at the full and partial sites are shown in Table 7-2-2.

Samples were taken at three depths: surface; 0.5 m; and just above the maximum depth of the water column. The sample depths were selected to cover the estuarine behaviour of fresh versus salt water layering. Samples were taken on the ebbing tide.

For comparison, data collected by Quang Ninh Province at 19 stations in the Province's hydrometeorological network is shown in Table 7-2-3. The sites referred to in the table are shown in Fig. 7-2-5.



LOCATION OF WATER QUALITY, SEDIMENT AND CURRENY SURVEY POINTS

FIG. 7-2-1

FEASIBILITY STUDY FOR CAI LAN PORT CONSTRUCTION PROJECT

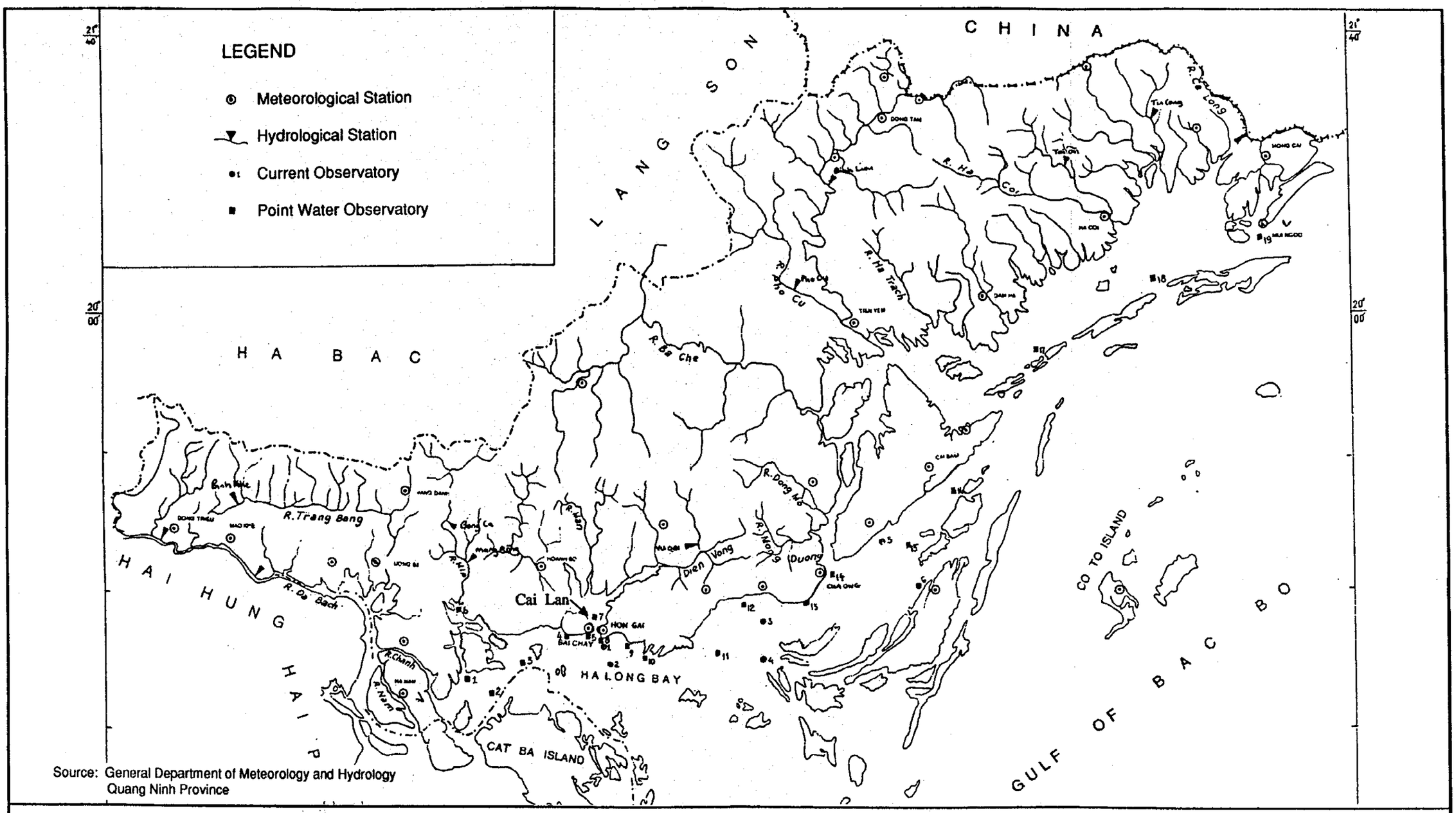
Table 7-2-2 Parameters measured at full and partial water quality sampling sites in February and June, 1994.

Full sampling programme	Partial sampling programme	
Parameter	Parameter	Units
Salinity	Salinity	ppt
pH	pH	pH units
Dissolved oxygen DO	Dissolved oxygen	%
Transparency	Transparency	m
E. coli	E. coli	cells/ml
Redox value		mV
Biochemical oxygen demand BOD		ppm
Chemical oxygen demand COD		ppm
Temperature		°C
Oil content		ppb
Suspended solids		$mg\ l^{-1}$
Phosphate		$mg\ l^{-1}$
Total phosphorus		$mg\ l^{-1}$
Total sulphur		$mg\ l^{-1}$
Sulphate		$mg\ l^{-1}$

Table 7-2-3 Coastal water quality in Quang Ninh Province (all units mg L^{-1} unless stated.)

Site*	Date Dec 92	Time	Temp (°C)	Oil	S (%)	pH	NH_4	P_2O_5	DO	NO_3	SO_4	HCO_3	COD	BOD	Zn	Cd	Hg g l-1	Pd	NO_2	SiO_2
1	30	0830	21.0	0.000	22.2	8.20														
2	28	1345	22.6	0.140	16.8	8.15	0.040	0.118	6.1	0.542	1520	2.400	1.1	0.00					0.070	3.9
3	28	1320	22.6	4.720	23.7	8.21														
4	23	1330	22.8	0.095	34.0	8.33			8.2											
5	-	1430	22.4	0.105	34.0	8.47			7.4											
6	-	1000	22.8	0.195	15.5	8.19	0.000	0.123	7.6	0.548	1480	2.600	2.9	0.6	0.050	0.0016	0.03	0.01	0.063	4.3
7	-	1630	20.6	0.140	33.8	8.40	0.061	0.091	7.0	0.048	2520	2.600	3.4	0.0	0.037	0.0039	0.03	0.012	0.019	2.1
8	24	0830	20.8	0.080	30.5	8.55	0.059	0.101	7.5	0.029	2360	3.100	4.0	0.4	0.030	0.0007	0.03	0.010	0.006	1.2
9																				
10	24	1000	18.2	0.090	32.8	8.59	0.000	0.101	7.3	0.149	2440	2.900	4.5	0.6	0.037	0.0036	0.06	0.075	0.028	1.7
11	28	1145	22.5	1.225	20.0	8.81	0.039	0.085	9.6	0.041	2280	2.500	1.3	2.7					0.016	2.6
12	24	1100	20.0	0.060	31.5	8.68			7.5											
13	24	1030	20.0	0.000	31.2	8.7	0.000	0.075	7.4	0.038	2360	2.850	4.0	0.2	0.037	0.0035	0	0.015	0.010	1.9
14	24	1230	20.0	0.275	30.5	8.66			7.7											
15	28	0950	21.1	0.140	22.7	8.02	0.022	0.101	7.6	0.038	2320	2.500	1.4	0.5	0.043	0.0039	0.02	0.003	0.019	1.3
16	28	0850	22.0	0.145	25.0	0.08														
17	28	0700	22.0	0.215	27.0	8.24														
18	28	0515	22.0	0.000	19.1	8.27														
19	24	1400	15.8	0.130	24.2	9.00	0.026	0.128	8.5	0.136	1960	2.300	1.8	1.3	0.028	0.0004	0.02	0.055	0.029	4.3

Notes: Refer to Fig. 7-2-5 for site locations.



Source: General Department of Meteorology and Hydrology
Quang Ninh Province

HYDROMETEOROLOGICAL NETWORK OF QUANG NINH PROVINCE

FIG. 7-2-5

Survey Results

(1) Parameters measured at both full and partial sites

Four parameters were measured *in situ* at all 20 sites. These were salinity, temperature, dissolved oxygen, pH. In additions, from all 20 sites samples were taken for E. coli analysis. Means and standard deviations for the three sampling depths are given in Table 7-2-4 for the February samples and in Table 7-2-4a for the June samples.

Table 7-2-4 Results for water quality parameters measured at all 20 sites, February 1994: means and (standard deviations).

Site	Location	Salinity (ppt)	Dissolved oxygen (%)	pH	Temperature (^{o}C)	E. coli (cells/ml)
F1	B	30.4 (0.52)	88.3 (1.9)	7.63 (0.02)	19.2 (0.2)	92 (93.5)
F2	B	31.2 (0.20)	83.4 (1.7)	7.66 (0.04)	19.1 (0.2)	17 (18.0)
F3	B	27.4 (0.46)	76.6 (2.7)	7.50 (0.01)	20.4 (0.6)	38 (0)
F4	B	29.7 (0.15)	76.7 (0.6)	7.57 (0.05)	19.3 (0.2)	30 (13.3)
F5	B	30.7 (0.35)	80.3 (0.2)	7.65 (0.04)	18.9 (0.1)	14 (1.7)
F6	C	32.5 (0.1)	87.8 (0.7)	7.80 (0.01)	19.8 (0.2)	146 (93.5)
F7	H	32.7 (0.0)	87.7 (4.1)	7.81 (0.01)	20.2 (0.2)	23 (13.3)
F8	H	32.6 (0.1)	89.3 (0.9)	7.80 (0.02)	19.9 (0.2)	92 (93.5)
P1	B	31.4 (0.06)	87.0 (3.8)	7.77 (0.01)	19.5 (0.6)	23 (14.6)
P2	B	30.8 (0.17)	87.0 (1.0)	7.67 (0.02)	19.1 (0.2)	2 (2.5)
P3	B	29.6 (0.12)	82.4 (0.3)	7.62 (0.0)	19.8 (0.2)	9 (6.5)
P4	B	29.6 (0.91)	80.0 (1.7)	7.59 (0.07)	19.6 (0.5)	10 (5.0)
P5	B	29.4 (1.13)	87.3 (1.5)	7.66 (0.03)	19.5 (1.0)	23 (13.3)
P6	B	31.4 (0.32)	85.3 (0.6)	7.72 (0.02)	19.1 (0.2)	16 (19.9)
P7	B	31.9 (0.52)	88.0 (0.6)	7.76 (0.03)	19.7 (0.2)	70 (113)
P8	H	32.7 (0.0)	87.5 (4.0)	7.80 (0.01)	20.0 (0.2)	10 (9.2)
P9	H	32.2 (0.12)	87.8 (1.5)	7.77 (0.02)	20.0 (0.2)	20 (18.0)
P10	H	32.5 (0.10)	88.8 (2.5)	7.78 (0.02)	19.8 (0.2)	4 (4.7)
P11	H	32.5 (0.0)	86.0 (1.1)	7.83 (0.01)	20.1 (0.3)	28 (16.7)
P12	H	33.0 (0.29)	89.0 (2.1)	7.81 (0.03)	19.9 (0.2)	2 (2.50)

Note: B=Bai Chay Bay; C=Cua Luc Strait; H=Ha Long Bay.

Table 7-2-4a Results for water quality parameters measured at all 20 sites, June 1994: means and (standard deviations).

Site	Location	Salinity (ppt)	Dissolved oxygen (%)	pH	Temperature (°C)	E. coli (cells/ml)
F1	B	24.4 (0.05)	65.5 (3.4)	6.92 (0.02)	30.7 (0.2)	40 (0.0)
F2	B	26.5 (0.09)	60.1 (0.7)	7.08 (0.07)	30.9 (0.0)	14 (6.0)
F3	B	25.5 (0.12)	61.0 (0.0)	6.38 (0.10)	31.6 (0.05)	50 (26.8)
F4	B	26.7 (0.05)	55.4 (0.7)	6.74 (0.01)	30.7 (0.0)	19 (0.9)
F5	B	26.5 (0.14)	62.4 (2.1)	7.08 (0.05)	31 (0.1)	43 (19.7)
F6	C	27.2 (0.36)	76.0 (1.8)	7.41 (0.02)	30.8 (0.0)	20 (0.0)
F7	H	27.9 (0.40)	78.0 (2.0)	7.42 (0.00)	30.6 (0.0)	69 (71.2)
F8	H	26.2 (0.65)	78.4 (2.0)	7.42 (0.02)	30.6 (0.1)	35 (10.8)
P1	B	27.4 (0.05)	59.1 (1.3)	7.41 (0.01)	30.6 (0.0)	45 (0.0)
P2	B	27.1 (0.16)	59.7 (0.8)	7.38 (0.01)	30.7 (0.0)	20 (0.0)
P3	B	27.1 (0.00)	55.8 (1.5)	7.29 (0.01)	31.2 (0.0)	20 (0.0)
P4	B	27.4 (0.09)	55.6 (0.9)	7.41 (0.01)	30.6 (0.1)	20 (0.0)
P5	B	27.1 (0.00)	55.5 (1.5)	7.37 (0.01)	30.7 (0.1)	20 (0.0)
P6	B	27.8 (0.08)	63.6 (3.2)	7.53 (0.01)	30.7 (0.0)	33 (12.5)
P7	B	26.3 (0.28)	73.0 (2.2)	7.16 (0.15)	30.8 (0.1)	50 (7.5)
P8	H	27.6 (0.25)	63.7 (0.2)	7.64 (0.01)	30.3 (0.1)	86 (48.1)
P9	H	28.2 (0.57)	66.1 (0.5)	7.68 (0.01)	30.5 (0.1)	30 (10.0)
P10	H	26.0 (2.01)	77.4 (1.0)	7.02 (0.40)	30.4 (0.1)	45 (0.0)
P11	H	27.1 (1.25)	69.8 (0.8)	7.69 (0.03)	30.5 (0.1)	20 (0.0)
P12	H	25.0 (1.04)	75.2 (4.5)	7.67 (0.00)	30.2 (0.1)	95 (75.0)

Note: B=Bai Chay Bay; C=Cua Luc Strait; H=Ha Long Bay

The results obtained are compared below with standards proposed by the Vietnamese "Provisional Environment Criteria" (Hy *et al.* 1993), and other international standards where relevant or available. Standards consulted include United States Environment Protection Agency, Australian and New Zealand Environment Council, Japanese, Indonesian and Indian guidelines. For some of the parameters discussed below, some of these countries do not have guidelines, or (as in the case of USEPA) the guidelines are narrative and are thus difficult to present simply in direct comparison.

Salinity

Salinity values from the winter survey ranged from a high of 33.2 ppt at site P12, near Cai Dam, and a low of 27.0 ppt in the mouth of the Mon River, at site F3. There was little change in salinity from the surface to the bottom of the water column. Means presented in Table 7-2-4 show that salinity was higher (all sites >32 ppt) in Ha Long Bay, while within Bai Chay Bay all sites were <32 ppt. However, the close salinity values overall indicate good mixing of tidal and riverine waters, at least in the winter waters of this estuarine system. During the summer survey, salinity values were lower overall, reflecting the much higher riverine component in the estuarine waters. The lowest value was 24.4 at site F1, in the mouth of the Dien Vong River, and the highest (28.2) was recorded at site P9 in Ha Long Bay.

Dissolved oxygen

In February 1994, dissolved oxygen measured at the surface ranged from 76.3 % at site F4, in the mouth of the Mip River, and 91.0 % at site F8, offshore of Hon Gai, in Ha Long Bay . The DO measured at the bottom of the water column was a minimum of 73.5 % at site F3, in the mouth of the Mon River and a maximum of 90.0 % at site P1, in central Bai Chay Bay.

The mean values in Table 7-2-4 indicate lower DO values in the mouths of the Mon River and the unnamed river directly to the west. Sites F3, F4, F5 and P4 all had DO values less than 80.5 %. All other sites had mean values greater than 82.0 %, and most were around 86 - 88 %.

The Vietnamese Provisional Criterion for dissolved oxygen is 5 mg l^{-1}. The Australian and New Zealand Environment Council recommend a normal value of >6 mg l^{-1} for marine waters (greater than approximately 80-90% saturation could be considered normal). Dissolved oxygen in winter in the mouths of the Mon River and the adjacent river could therefore be considered to be at the low end of normal levels, DO was much lower than in summer. The other sites were within the normal range of concentrations.

However in winter, within Bai Chay Bay several sites had DO of around 56 %. The maximum values were recorded in Ha Long Bay, at sites F7 and F8 at around 78 %. The lower values recorded in summer reflect the much higher temperatures of the water, decreasing the available oxygen in the water.

The values recorded at the Quang Ninh Province stations (refer Table 7-2-3) show that DO was above the Vietnamese Criterion value at all sites. However, it is only just above that value at

site 2, in Ha Long Bay near the Mip River Mouth (6.1 mg l^{-1}). DO was highest at site 11, offshore and mid-way between Cam Pha and Hon Gai, at 9.6 mg l^{-1}.

pH

In winter, mean pH values tended to be slightly lower in Bai Chay Bay (all sites < 7.77 pH) than in Ha Long Bay (all sites >7.77 pH).

pH ranged from 7.49 to 7.84 overall. Often, but not consistently, pH was slightly higher at the bottom of the water column than at the surface (but by less than 0.1 pH unit). This is within the range for coastal waters provided in the Vietnamese Provisional Environment Criteria, which is 6.5 - 8.5 pH units.

In summer, slightly lower values were recorded at the Bai Chay Bay sites, the lowest being 6.38 at site F3 at the mouth of the Mon River. Within Bai Chay Bay mean pH values ranged from 6.38 - 7.53, while in Ha Long Bay they were slightly higher (7.02 - 7.69). All sites but site F3 were within the range recommended by the Vietnamese Criterion. This site was lowest in winter as well and may reflect activities upstream.

pH values were generally higher at the coastal sites as reported by Quang Ninh Province. All were above 8.0 pH units, with a high of 9 in the north, at Mui Ngoc. The very low pH value at site 16 is likely to be due to a reporting error.

Temperature

In winter, mean temperatures were very similar, ranging from 18.9 to 20.2 °C. At the Ha Long Bay sites, mean temperatures tended to be slightly higher (overall mean 20.0 °C, standard deviation 0.13 °C) while in Bai Chay Bay all sites except F3 has temperatures less than 20.0 °C (overall mean excluding site F3 19.4 °C, standard deviation 0.3 °C). The higher temperature at F3 may be due to warming effects in the shallow estuary, or to warming of the slow-moving river water upstream.

Surface temperatures ranged from 18.9 °C to 21.0 °C over the period of the survey. The lowest surface temperature was recorded at site F5, offshore of Cai Lan Port, and the highest at site F3, in the mouth of the Mon River on the northern shoreline of Bai Chay Bay .

The lowest bottom temperature was recorded at site P5, in Truc Vong River, Western Bai Chay Bay, and the highest bottom temperature was recorded at site F7, offshore of Bai Chay, in Ha Long Bay.

Generally there was a decrease in temperature between the surface of the water and the bottom of the water column, but occasionally the water at 0.5 m below the surface was coldest. The greatest range between the surface and bottom samples was 1 °C, recorded at sites P4, just north of Cai Lan Port and F3 in the mouth of the Mon River.

Over summer, the mean temperature range was 30.2 - 31.6 °C. Temperatures were lower in Ha Long Bay , ranging from 30.2 - 30.6 °C. In Bai Chay Bay they ranged from 30.6 - 31.6 °C. Little temperature stratification occurred, the greatest surface to bottom gradient being 0.5 % at site F1.

E. coli

The E. coli measured in winter, ranged from 0 to 200 cells / ml. There was no consistency of increase or decrease in E. coli between the surface samples and the bottom samples. The highest surface values (38 - 200 cell / ml at all three sampling depths) were found at sites F6 and F8, in Cua Luc Strait and off the Hon Gai Coast respectively. This is not surprising considering that untreated sewage is discharged into the sea from Hon Gai and Bai Chay near these sites. Similar high values were also recorded at sites F1 and F3, in the mouths of the Vien Dong and Mon Rivers (two of the three samples at each site >38 cells / ml). These levels are likely to be due to sewage from populations upstream.

A count of 200 cells / ml was recorded for the bottom sample, site P7. This site is within Bai Chay Bay, but is the site closest to Cua Luc Strait. The higher E. coli level compared to other sites in Central Bai Chay Bay may be due to incomplete mixing of waters entering from near Bai Chay and Hon Gai on the incoming tide.

In summer, E.coli counts ranged from 20 - 170 cells / ml. Samples collected at sites F7, P8 and P12 had high E.coli counts (170, 120 and 170 cells / ml respectively). At site both the surface and middle samples were 120 cells / ml. At all other sites the values were in winter, and at sites F7, P8 and P12 in summer.

The Vietnamese "Provisional Environmental Criteria" for E. coli is 1,000 per 100 ml (100 cells / ml) in the beach zone and 5,000 per 100 ml (500 cells / ml) in "other" zones. The counts recorded for sites F6 and F8 are high by the first standard, but as this area is not a beach zone they

are within acceptable Vietnamese limits. By comparison, the standard for Japan, for sensitive fish, or bathing, is <100 cells / ml. The New Zealand limit for Class B waters is 2 cells / ml. In shellfish, for human consumption, the maximum number of coliform bacteria per 100 g wet weight is 230.

Compared to Hong Kong coastal waters, these Bai Chay values are, at present, indicative of desirable waters in terms of eco-tourism potential.

(2) Parameters measured only at sites F1 -F8

Samples from the F-series sites were analysed for 9 additional parameters (refer Table 7-2-2). Mean values and standard deviations of the three depth samples at each site are presented in Table 7-2-5 and 7-2-5a. The results are described below.

Total Phosphorus

In winter, for all sites, total phosphorus was between 0.01 and 0.04 mg l^{-1}. Sites F6, F7 and F8 had similar values, around (0.031 - 0.038 mg l^{-1}), possibly indicating the effects of pollutants entering the sea in the Hon Gai and Bai Chay areas.

Within Bai Chay Bay the values were more variable. Sites F1 and F2 (0.02 - 0.034 mg l^{-1}) also recorded concentrations above 0.03 mg l^{-1}, but the other three Bai Chay Bay sites recorded lower values (0.01 - 0.02 mg l^{-1}). This may indicate a higher level of phosphorus entering the Bay from the Dien Vong River.

In summer, total phosphorus values ranged between 0.032 and 0.056, generally higher than those recorded in winter. The highest values were recorded at the western end of Bai Chay Bay (site F3 and F4) and offshore at Bai Chay and Hon Gai (sites F7 and F8). These higher values likely reflect the higher runoff component in summer.

Phosphate

In winter, phosphate concentrations ranged from 0.0382 mg l^{-1} at site F5 to 0.1162 mg l^{-1} at site F8. A similar trend in the results for total phosphorus was observed for phosphates. The Cua Luc and Ha Long Bay sites (F6, 7 and 8) and sites F1 and F2 recorded similar slightly elevated levels of phosphate compared to sites F3, F4 and F5, in the western part of Bai Chay Bay.

There was a tendency for mean phosphate concentrations to increase slightly with depth in the water column.

In summer, the values were quite similar, slightly high levels being found at sites F7 and F8, and sites F3 and F4.

Table 7-2-5 Water quality summary statistics, sites F1 - F8, February 1994, means and (standard deviations). (All units mg l^{-1}).

Site		Total-Phosphorus	Phosphate	Sulphate	Total-Sulphur	BOD
F1	B	0.0325 (0.0054)	0.0674 (0.002)	2468.0 (8.5)	885.2 (1.5)	1.27 (0.15)
F2	B	0.0342 (0.0078)	0.0823 (0.006)	2485.0 (2.3)	895.2 (0.2)	1.37 (0.21)
F3	B	0.0228 (0.0038)	0.0519 (0.006)	2366.7 (2.9)	907.5 (7.5)	1.17 (0.25)
F4	B	0.0206 (0.0038)	0.0519 (0.006)	2385.1 (4.3)	837.9 (10.9)	1.2 (0.1)
F5	B	0.0162 (0.0019)	0.0439 (0.01)	2403.6 (21.3)	875.8 (17.4)	1.13 (0.15)
F6	C	0.0361 (0.0073)	0.0853 (0.0)	2487.8 (8.7)	900.6 (2.2)	1.37 (0.21)
F7	H	0.0317 (0.0073)	0.0764 (0.002)	2484.3 (6.9)	881.9 (16.1)	1.4 (0.1)
F8	H	0.0387 (0.0)	0.1162 (0.0)	2494.0 (7.7)	903.3 (5.0)	1.1 (0.15)

Site		COD	Oil Content	Suspended solids	Hydrogen sulphide
F1	B	9.03 (0.14)	0.156 (0.001)	41.5 (1.5)	0.040 (0.014)
F2	B	10.41 (0.88)	0.110 (0.005)	39.0 (1.3)	0.026 (0.007)
F3	B	9.96 (0.57)	0.135 (0.007)	41.2 (1.8)	0.051 (0.002)
F4	B	10.76 (0.86)	0.157 (0.005)	40.9 (4.1)	0.033 (0.009)
F5	B	9.71 (0.88)	0.091 (0.004)	44.5 (5.0)	0.023 (0.005)
F6	C	16.13 (5.55)	0.41 (0.24)	32.2 (4.1)	0.009 (0.001)
F7	H	12.59 (0.74)	0.180 (0.004)	25.6 (0.5)	0.004 (0.001)
F8	H	13.17 (0.64)	0.132 (0.018)	27.4 (2.3)	0.005 (0.002)

Note: B=Bai Chay Bay; C= Cua Luc Strait; H= Ha Long Bay.
Two values for Total-S at site F5 were assumed to be typographical errors and the decimal places have been adjusted accordingly.

Sulphate

In winter, mean sulphate values ranged from 2366 mg l^{-1} at site F3 to 2,494 mg l^{-1} at site F8. As for total phosphorus and phosphate, slightly higher values were found in Cua Luc Strait, at the Ha Long Bay sites F7 and F8 and at sites F1 and F2 in the north-east of Bai Chay Bay than at sites F3, F4 and F5 in the western part of Bai Chay Bay.

In summer, mean sulphate values were lower, ranging from 1951 mg L^{-1} at site F3 to 2129 mg L^{-1} at site F4. No pattern of concentrations could be associated within site location.

There was a slight increase in sulphate with depth at each site.

Table 7-2-5a Water quality summary statistics, site F1 - F8, June 1994, means and (standard deviations). (All units mg l^{-1})

Site		Total-Phosphorus	Phosphate	Sulphate	Total-Sulphur	BOD
F1	B	0.0322 (0.0070)	0.0480 (0.0111)	2052.7 (35.1)	695.8 (13.3)	1.13 (1.14)
F2	B	0.0368 (0.0012)	0.0550 (0.0017)	2040.4 (22.7)	695.7 (8.5)	1.27 (0.06)
F3	B	0.0517 (0.0055)	0.0793 (0.0090)	1951.2 (71.5)	671.7 (23.7)	1.03 (0.06)
F4	B	0.0558 (0.0025)	0.0847 (0.0042)	2129.7 (31.2)	728.5 (13.6)	1.00 (0.10)
F5	B	0.0375 (0.0098)	0.0567 (0.0147)	2079.4 (33.9)	712.1 (12.8)	1.03 (0.06)
F6	C	0.0350 (0.0022)	0.0528 (0.0028)	2113.4 (67.3)	726.4 (23.1)	1.23 (0.06)
F7	H	0.0492 (0.0024)	0.0733 (0.0029)	2071.0 (92.1)	722.4 (19.8)	1.23 (0.06)
F8	H	0.0408 (0.0115)	0.0608 (0.0176)	2103.6 (73.9)	722.9 (25.5)	0.97 (0.12)

Site		COD	Oil Content	Suspended solids	Hydrogen sulphide
F1	B	12.4 (0.8)	0.149 (0.010)	52.1 (02.1)	0.039 (0.007)
F2	B	11.40 (1.00)	0.108 (0.006	49.1 (01.0)	0.029 (0.005)
F3	B	11.03 (0.06)	0.126 (0.004)	50.0 (01.4)	0.041 (0.005)
F4	B	11.33 (0.92)	O.190 (0.047)	52.5 (00.6)	0.041 (0.002)
F5	B	10.13 (0.81)	0.094 (0.009)	47.7 (02.2)	0.023 (0.003)
F6	C	13.07 (1.01)	0.0491 (0.273)	33.0 (03.4)	0.017 (0.002)
F7	H	12.13 (1.42)	0.233 (0.082)	32.5 (00.9)	0.013 (0.001)
F8	H	12.67 (2.57)	0.304 (0.160)	31.8 (00.5)	0.009 (0.002)

Note: B=Bai Chay Bay; C=Cua Luc Strait; H= Ha Long Bay.

Total Sulphur

In winter, mean total sulphur values ranged from a low of 837 mg l^{-1} at site F4 to a high of 907 mg l^{-1} at site F3. Sites F6 and F8 were higher than the other sites, similar to F3. The slight elevation in values at these three sites are likely to reflect activities on land in the Troi River (upstream of site F3) and at Hon Gai.

In summer, values were lower, within a range of 671 mg l^{-1} to 728 mg l^{-1}. Values at sites F6, F7 and F8 were similar and slightly elevated, but site F4 had the highest concentration.

Biochemical Oxygen Demand

In winter, the range of BOD was 0.9 to 1.6 mg l^{-1}. The summer range was 0.9 - 1.3 mg l^{-1}. No trend in the data was found with respect to the site locations. The Vietnamese Provisional Criterion for BOD is 15 - 20 mg l^{-1}, and the values recorded were well within this guideline. Few other countries have promulgated a standard for BOD, but India, by comparison has a criterion of <6 mg l^{-1}. In New Zealand, a level of 3 mg l^{-1} or less would be considered normal. Clearly, the values recorded are within acceptable levels.

At the Quang Ninh Hydrological Stations the BOD concentrations were generally lower (<1.0 mg l^{-1}) than those reported above, with the exception of site 11, offshore between Hon Gai and Cam Pha, where the level was higher at 2.7 mg l^{-1}.

Chemical Oxygen Demand

In winter, COD ranged from a low of 8.97 mg l^{-1} at site F5 to a high of 22.27 mg l^{-1} at site F6 in Cua Luc Strait. As with other parameters reported above, higher values were recorded in Cua Luc Strait and in the Ha Long Bay sites F7 and F8 (mean for the three sites of 14.0 mg l^{-1}) than at the sites in Bai Chay Bay (overall mean of 10.0 mg l^{-1}). No trend of increase or decrease with depth in the water column was found.

In summer, the range of COD was narrow, from 10.13 mg l^{-1} at site F5 to 13.07 mg l^{-1} at site F6.

COD was lower at all of the sites measured in the Quang Ninh Hydrological Network (1.1 - 4.5 mg l^{-1}).

Oil Content

In February, the oil content was considerably higher at site F6, in Cua Luc Strait, with a mean of 0.4 mg l^{-1}. The highest content was found at the surface at this site and the concentration decreased with depth. The higher oil content here is likely to be due to the shipping that occurs in the Strait. A visible sheen is frequently visible on the surface both at Hon Gai and Bai Chay ferry terminals. It should be noted that the difficulty of obtaining representative measurements of oil content are well known. Even with a heavy sheen it is possible to find results of less than 1 ppm.

In June the oil content at site F6 was relatively low at 0.05 mg l^{-1}, while oil content at sites F7 and F8 were highest (0.23 - 0.30 mg l^{-1}).

By comparison, in both February and June sites within Bai Chay Bay were below 0.2 mg l^{-1}, with site F4 the highest of these at 0.19 mg l^{-1} in June. The oil content of the surface water was not consistently higher than that below the surface at these sites.

The Vietnamese Provisional Criterion for oil and grease is 0.3 mg l^{-1}. This is exceeded within Cua Luc Strait but not at any of the other sites. Some comparative guidelines for oil content are <0.5 mg l^{-1} (Japan - common coastal water); <0.1 mg l^{-1} (India - for fisheries) and <10 mg l^{-1} (India - harbour water). The levels are above 0.1 mg l^{-1} at all but site F5. Considering that fishing and aquaculture take place in Bai Chay Bay and are likely to expand in future, the existing levels indicate that better control on oil entering the harbour will be needed.

By comparison, the oil content measured at the Quang Ninh Province sites was similar to the values reported above, (between approximately 0.1 and 0.2 mg l^{-1}), but was much higher at site 3 in the inshore waters near Tuan Chau Island (4.720 mg l^{-1}) and site 11 offshore between Hon Gai and Cam Pha (1.225 mg l^{-1}). Both these values are above the Vietnamese Provisional Criterion.

Suspended Solids

In winter, suspended solids were higher within Bai Chay Bay than in Cua Luc Strait or Ha Long Bay, reflecting the influx of sediments from the rivers entering the Bay. Mean values for sites F1 -F5, within Bai Chay Bay were 39 mg l^{-1} to 44 mg l^{-1}. In Cua Luc Strait the concentration was lower, at 32.2 mg l^{-1}, while at site F7 and F8 in Ha Long Bay the concentrations were 25.6 and 27.4 mg l^{-1} respectively. There was no consistent trend of increasing suspended solids with depth. This was the case at all of the sites within Bai Chay Bay, but not in Cua Luc Strait or Ha Long Bay.

In summer, suspended solids concentrations was higher at all sites than in winter. The range was 31.8 - 52.5 mg l^{-1}, within the concentrations was again higher in Bai Chay Bay.

The Vietnamese Provisional Criterion for suspended solids is 25 - 200 mg l^{-1} and all of the values recorded are at the lower end of this scale. By comparison, the Indonesian guideline is <80 mg l^{-1}.

Hydrogen Sulphide

In winter, hydrogen sulphide ranged from a low of 0.0032 mg l^{-1} at site F7 to a high of 0.0525 mg l^{-1} at site at F3. Similar trends in the data for H_2S were found as for suspended solids, above. The Bai Chay Bay sites had consistently higher concentrations (mean of 0.034 mg l^{-1}) than site F6 in Cua Luc Strait (0.009 mg l^{-1}) and sites F7 and F8 in Ha Long Bay (mean of 0.005 mg l^{-1}). This trend is not unexpected as H_2S is a normal chemical product of sulphide bacteria associated with mangrove.

In summer, the concentrations were quite similar, with the lowest values again recorded at the Ha Long Bay sites, and the highest inside Bai Chay Bay.

Trace Elements

Quang Ninh Province have provided data on trace element concentrations at sites in the hydrometeorological network (refer Table 7-2-3). In addition, data collected in Cua Luc Strait has also been provided by the province (Table 7-2-6).

The concentrations of lead, cadmium, arsenic and mercury are within the limits suggested by the Vietnamese Provisional Criteria. However, compared to other international standards, the concentrations of cadmium, lead and mercury would be considered high. It is unclear what the source of these contaminants would be, but possibilities include acid drainage from coal mine overburden. Considering the high concentrations recorded, it is recommended that tissues of fish and shellfish from Bai Chay Bay and Inner Ha Long Bay be tested to establish the existing levels of trace elements in the fish. This is important from a public health perspective, but also as a baseline measure against which future monitoring of fish tissues can be compared.

The maximum zinc concentration was 3.7 times higher than the guideline figure at Bai Chay Ferry and the B-12 Oil Port. The copper concentration at the oil port was also higher than the criterion.

Concentrations of trace elements reported in the Quang Ninh Province Hydrometeorological Network data set (refer Table 7-2-3) show that, for the sites where samples were collected, the concentrations of all metals were below the Vietnamese Provisional Criteria.

Table 7-2-6 Trace element concentrations in the vicinity of Hon Gai (all units ppb).

Location	Cu	Pb	Zn	Cd	As	Hg
B-12 Oil Port	12.5	12	37	3.9	5	0.03
Bai Chay Ferry	2.7	7	37	0.7	3	0.03
Hon Gai Port	1.2	7	28	0.7	2	0.02
VN Criterion	10	50	10	50	50	1

Source: Urban and Rural Planning Institute, Ministry of Construction.

7.2.6.5 Sediment Quality

To assess the water content and the existing concentrations of organics and trace elements in sediments in Ha Long Bay and Bai Chay Bay sediment samples were collected at the same sites as those used in the water quality sampling programme (refer Fig. 7-2-1). The analyses performed are listed in Table 7-2-7. The results are provided in Tables 7-2-8 and 7-2-8a.

Water Content

Water content (loss on drying) for the 20 sites was lowest at site F3 (15.34 ppm), and highest at site P12 (30.02 ppm). For all other sites however, the values were within a narrow range of 20.35 to 25.80 ppm. There was no apparent trend in water content of the sediment with location.

Table 7-2-7 Parameters measured in sediment samples collected in February and June, 1994.

Parameters	
Water content (loss on drying)	Arsenic (As)
Organic content (loss on ignition)	Phosphorus (P)
Cadmium (Cd)	Sulphur (S)
Lead (Pb)	Chemical oxygen demand (COD)
Mercury (Hg)	

Table 7-2-8 Results of sediment analyses for samples collected at 20 sites, February, 1994 (all units ppm).

Site	Water Content	Loss on ignition	Cd	Pb	Hg	As	P	S	COD	PAH
F1 B	25.80	13.45	1.65	30.40	0.29	0.87	279.6	2256	2815	4760
F2 B	24.63	10.57	1.46	50.82	0.12	0.95	198.2	2153	2431	-
F3 B	15.34	3.02	0.30	15.39	0.10	0.25	105.7	1084	417	85
F4 B	24.06	10.10	1.08	1.92	0.08	0.73	217.4	2457	2535	1060
F5 B	20.95	11.15	2.71	125.71	0.11	0.92	267.3	2105	2316	6530
F6 C	24.15	10.57	4.95	126.27	0.13	1.75	391.3	7108	2502	790
F7 H	22.06	10.17	2.72	126.40	0.17	1.36	366.6	1403	2417	1780
F8 H	24.01	11.15	0.18	0.30	0.14	1.01	465.5	3427	2722	4420
P1 B	23.78	9.99	3.09	129.53	0.54	1.82	229.4	1356	2315	2580
P2 B	22.11	6.85	3.54	84.42	0.78	1.06	224.7	3082	1162	2230
P3 B	21.35	8.08	3.81	71.31	0.12	1.15	198.0	3364	1748	-
P4 B	23.06	10.92	3.54	55.43	0.01	0.94	124.5	1125	2643	-
P5 B	23.12	11.44	3.72	50.85	0.13	1.55	291.6	3330	2872	-
P6 B	30.16	10.92	1.46	56.57	0.01	1.72	254.7	1105	2696	-
P7 B	24.11	13.45	3.30	70.00	0.01	1.14	384.1	1406	2974	-
P8 H	21.62	10.57	4.40	144.92	0.01	0.97	296.0	1300	2547	-
P9 H	24.79	9.69	1.46	55.00	0.30	0.95	217.1	6712	2217	1210
P10 H	24.11	10.11	1.33	78.69	0.01	0.63	341.5	1054	2463	-
P11 H	24.64	10.53	8.31	36.86	0.46	0.76	391.2	4055	2576	-
P12 H	30.02	10.21	5.30	192.00	0.11	1.94	384.0	1352	2472	-

Note: L=Location: B=Bai Chay Bay; C=Cua Luc Strait; H=Ha Long Bay.

Table 7-2-8a Results of sediment analyses for samples collected at 20 sites, June 1994 (all units ppm).

	Water Content	Loss on ignition	Cd	Pb	Hg	As	P	S	COD	PAH
F1 B	20.20	15.37	1.12	30.40	0.28	0.90	288.7	2170	2841	790
F2 B	20.46	10.03	2.10	47.51	0.14	1.12	144.3	1820	2396	1250
F3 B	11.83	5.86	1.10	9.46	0.09	0.36	126.2	1360	593	1060
F4 B	17.64	10.20	1.21	7.58	0.10	0.68	266.2	3020	2555	920
F5 B	17.15	13.13	2.58	134.82	0.18	0.93	244.0	2900	2381	1050
F6 C	18.18	11.72	5.16	116.03	0.17	1.70	380.0	5100	2496	1720
F7 H	19.46	12.05	3.19	117.19	0.06	1.53	366.1	2432	1680	1130
F8 H	15.44	17.08	0.18	10.71	0.18	1.15	476.0	1680	2786	2910
P1 B	20.17	12.76	3.10	122.22	0.84	1.76	288.0	1970	2398	1040
P2 B	18.46	7.15	3.13	9.23	0.78	1.20	220.3	2900	1185	-
P3 B	16.73	7.52	2.15	71.59	0.52	1.17	170.0	4010	1893	-
P4 B	21.00	11.25	2.15	60.72	0.06	1.05	176.5	1130	2696	-
P5 B	22.16	9.17	2.10	52.85	0.16	1.50	254.7	4610	2903	-
P6 B	24.63	11.25	2.16	53.11	0.03	1.51	304.2	1730	2871	-
P7 B	18.47	12.38	3.24	72.13	0.02	1.26	376.4	1280	2981	-
P8 H	15.21	9.98	2.20	132.12	0.02	1.08	288.4	1910	2603	-
P9 H	22.64	12.50	1.21	63.10	0.30	0.94	220.0	6940	2248	2720
P10 H	21.17	12.50	1.20	71.03	0.02	0.67	420.0	2160	2456	-
P11 H	19.35	13.65	6.15	40.19	0.49	0.91	432.0	4480	2611	-
P12 H	25.17	14.60	6.29	198.20	0.04	1.75	366.5	1200	2465	-

Note: L=Location: B=Bai Chay Bay: C=Cua Luc Strait: H=Ha Long Bay.

Organic Content

Trends in the data were consistent between summer and winter organic content (loss on ignition) was lowest at site F3 in both winter and summer (3.02 and 5.86 ppm respectively). Elsewhere the organic content ranges from 6.85 ppm at site P2 to 13.45 ppm at sites F1 and P7 in winter. In summer the values tended to be slightly higher, ranging from 7.15 at site P2 to 15.37 at site F1.

Apart from site F3, the sites with the lowest organic content were are all located in deeper water in channels in Bai Chay Bay or offshore in Ha Long Bay, suggesting that organic materials are normally deposited in shallower water near the shorelines or as the rivers enter Bai Chay Bay.

At the other sites the values are within a narrow range suggesting that the sediment characteristics at these sites are similar. The lower organic and water content at site F3 indicate that this site has somewhat different sediment characteristics than the other sites.

Trace Elements

There was considerable variation in cadmium, lead and arsenic values. For cadmium, relatively high levels were found in winter at sites P8, P11, P12 and F6. In summer, cadmium was highest at sites P11, P12 and F6 showing a similar trend to the winter results. Site F6 in Cua Luc Strait, site P11 is in the vicinity of the floating port. Lead was relatively high both summer and winter at P8, P12, F6 and F7, also all near the shoreline within Ha Long Bay. However, relatively high levels were also found at sites P1 and F5, within Bai Chay Bay. These sites are at a distance from B-12 Oil Port and Hon Gai. The mercury concentrations also ranged quite widely.

Analyses of sediments near in Brunei Darussalam (Seng et al 1990), in an area where pollutants from oil industry and residential sources are present in the water, can be compared with the above results. Cadmium concentrations in the Brunei Study ranged from <10 to 30 ppm. Those in the present study were lower, all were <10 ppm and most were <5 ppm. However, lead values in the present survey, which had a maximum of 145 ppm in the February survey and 198 ppm in the June survey, were much higher than those reported from Brunei (range <2 - 22 ppm). The results for mercury in the present study were relatively low (all concentrations <1 ppm) compared to the Brunei samples where the range was 0.66 - 2.1 ppm.

There was much variation in arsenic concentrations. The values tended to be highest in the vicinity of Hon Gai Port and Cua Luc Strait, with lower values associated with the Inner Bai Chay Bay sites F1 - F4.

Other Parameters

Phosphorus concentrations tended to be higher (>340 ppm) at sites along the Bai Chay Coastline in Ha Long Bay, in Cua Luc Strait and at sites P11 and F8, near Hon Gai in both the summer and winter results. This may indicate an accumulation of phosphorus from runoff entering

the waters in the industrial and residential areas. These results are similar to the water quality results for total phosphorus and phosphate.

The highest sulphate concentrations were found at sites F6 (7108 ppm) within Cua Luc Strait and at site 9 (6940 ppm) in the summer survey. Elsewhere there was considerable variation in the data and no pattern is evident.

COD concentrations at sites F3, P2 and P3 are somewhat lower than those at the other sites, but there is no pattern evident in the data.

Polyaromatic Hydrocarbons

Polyaromatic hydrocarbons in the sediments varied widely across the 10 sites for which analyses were carried out. In winter relatively high values were found at sites within Bai Chay Bay at sites F1 and F5 (4,760 and 6,530 ppb), and also at site F8, near Hon Gai (4,420 ppb). In summer, sites F6 and F8 had the highest concentrations. The relatively high levels found in Bai Chay Bay in winter are difficult to explain. There is no known source of hydrocarbons upstream in any of the rivers which drain into the Bay. It is possible that oils from the B-12 port are entering the Bay and accumulating in the sediments, but in that case it could be expected that other sites within Bai Chay Bay would display a similar response. Further studies are needed to confirm these results.