FIGURES

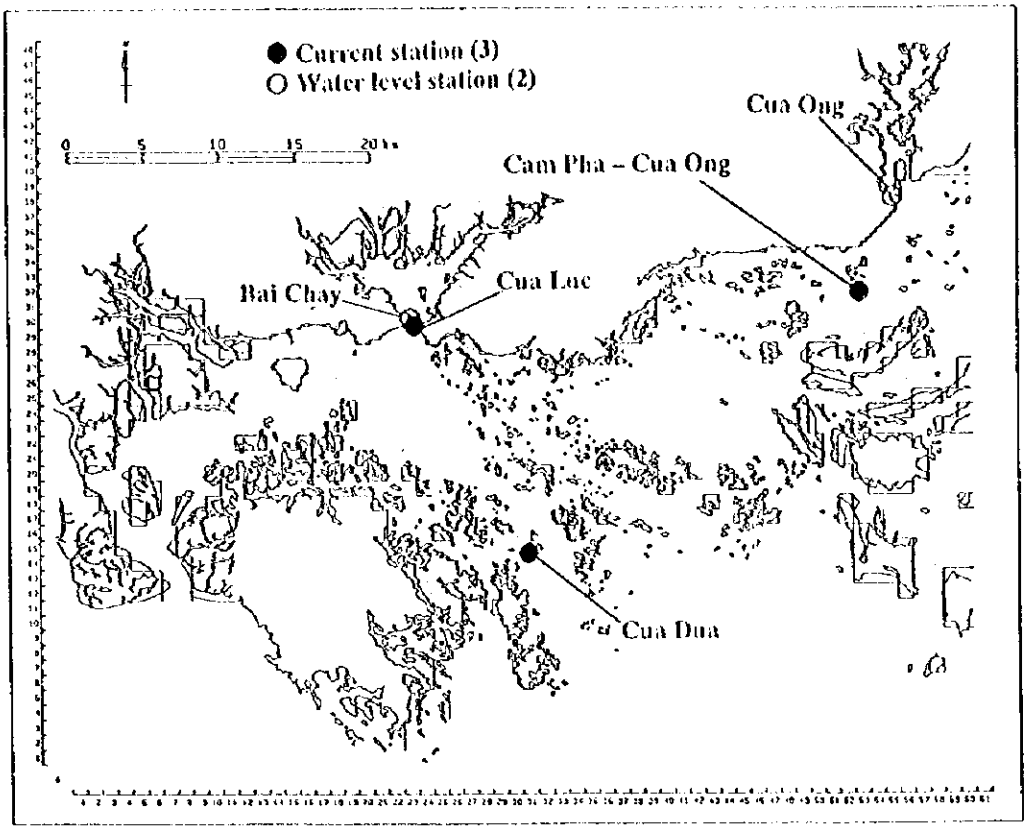

Figure 3.1.1 Locations of the Current Measuring Stations and Water Level Measuring Stations

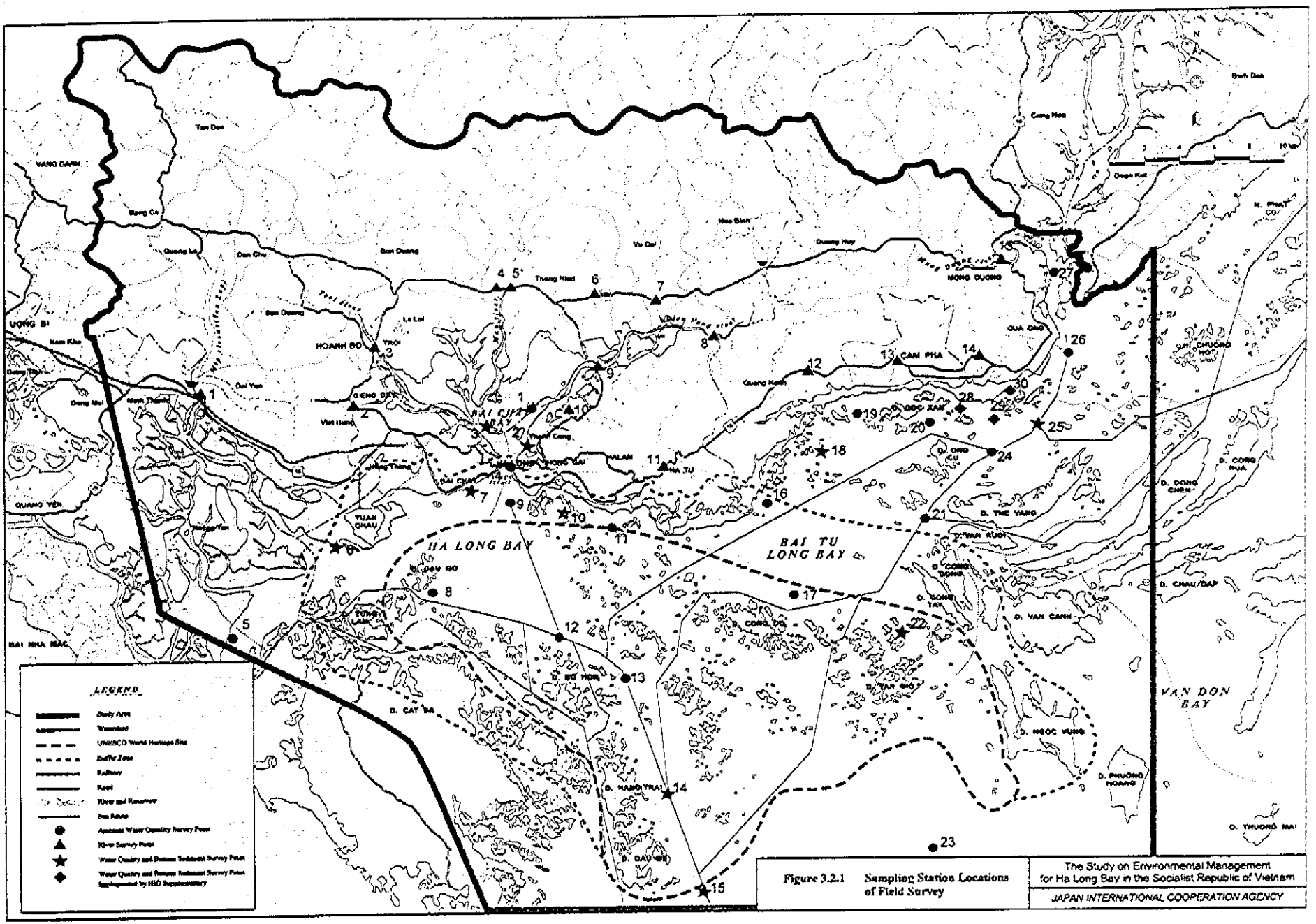

Figure 3.2.1 Sampling Station Locations of Field Survey

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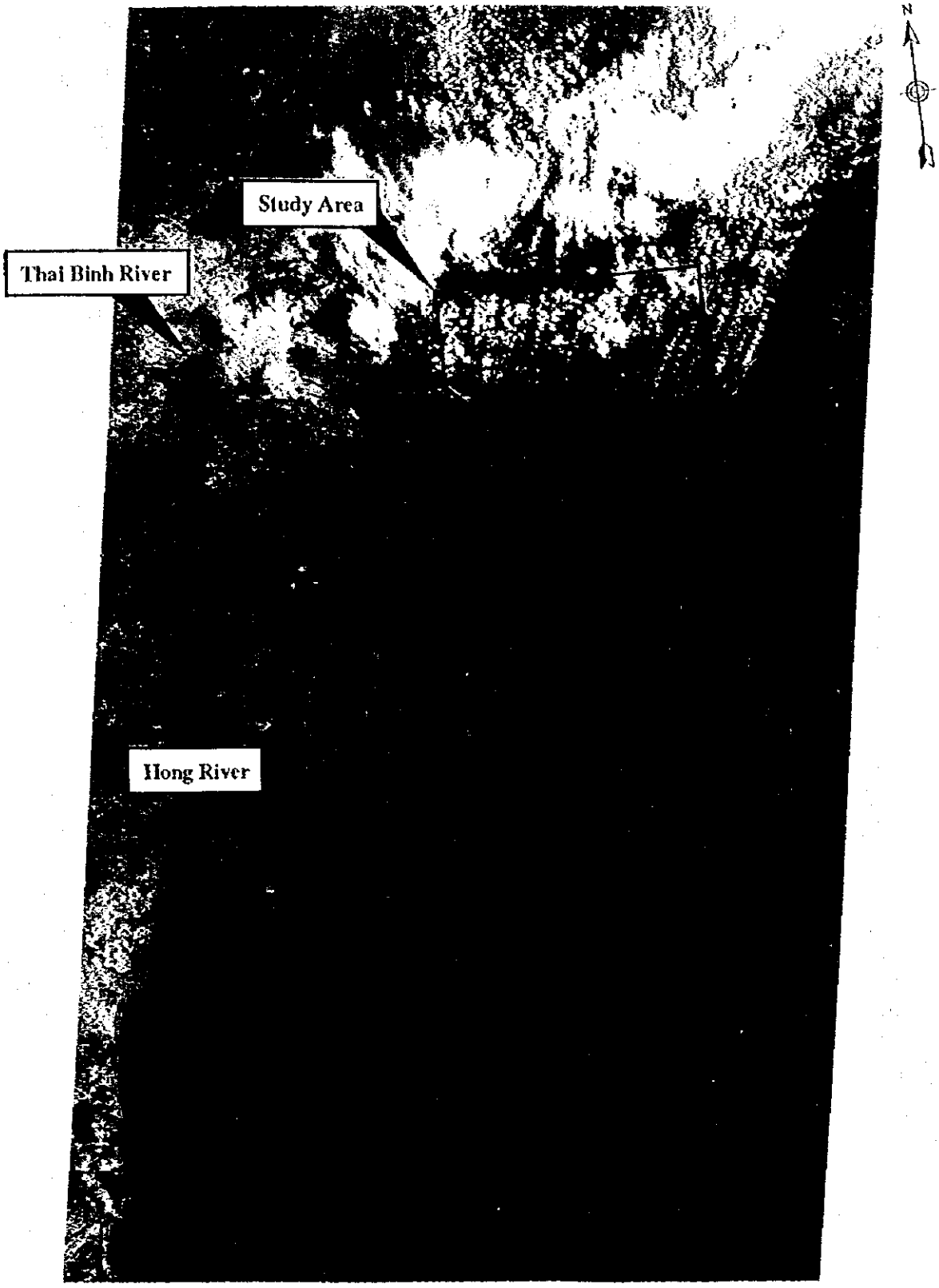

Figure 3.2.2 LANDSAT False Color Image of Gulf of Tonkin (June 6, 1997)

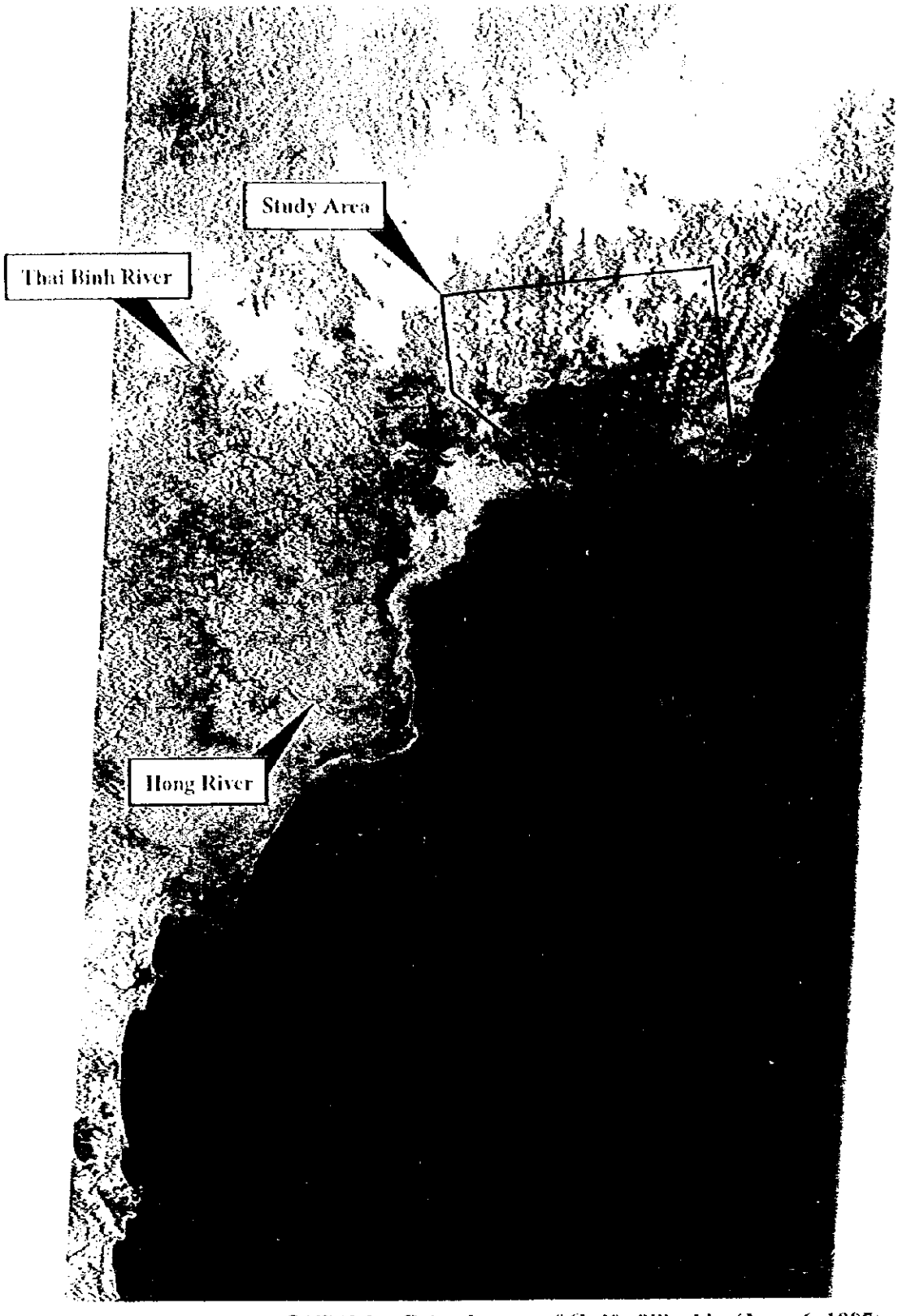

Figure 3.2.2 LANDSAT False Color Image of Gulf of Tonkin (June 6, 1997)

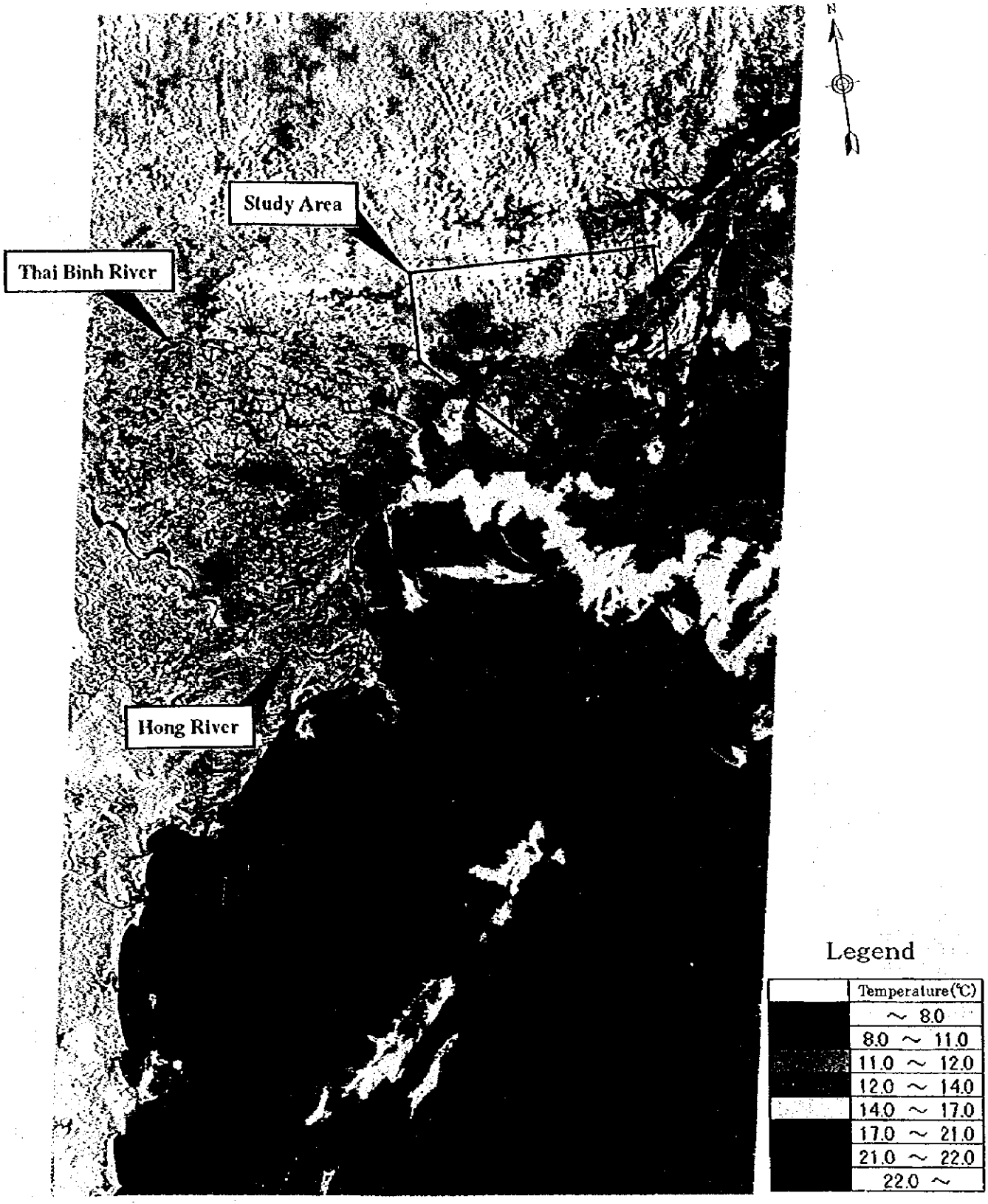

Figure 3.2.3 Water Temperature Distribution of Gulf of Tonkin (June 6, 1997)

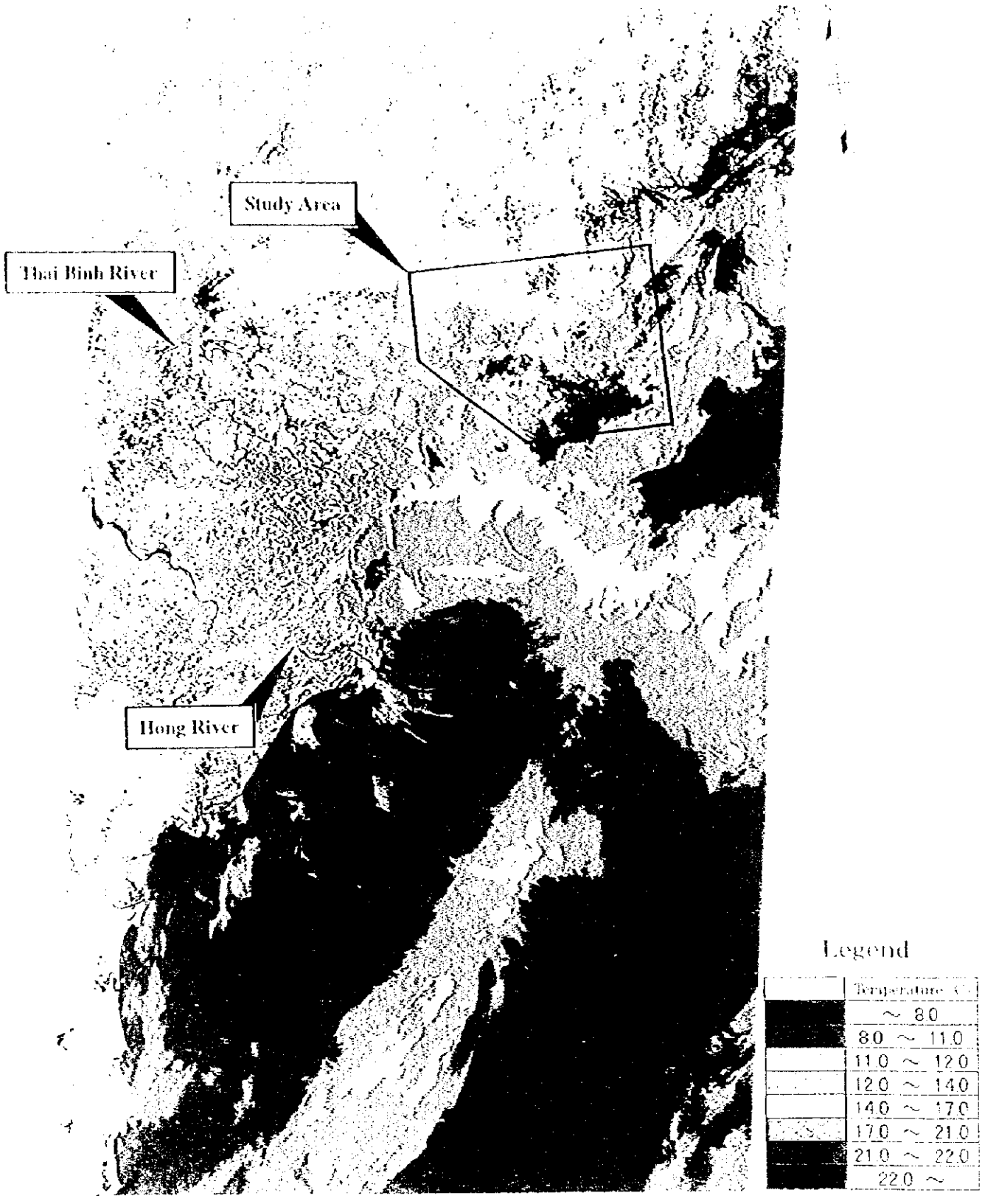

Figure 3.2.3 Water Temperature Distribution of Gulf of Tonkin (June 6, 1997)

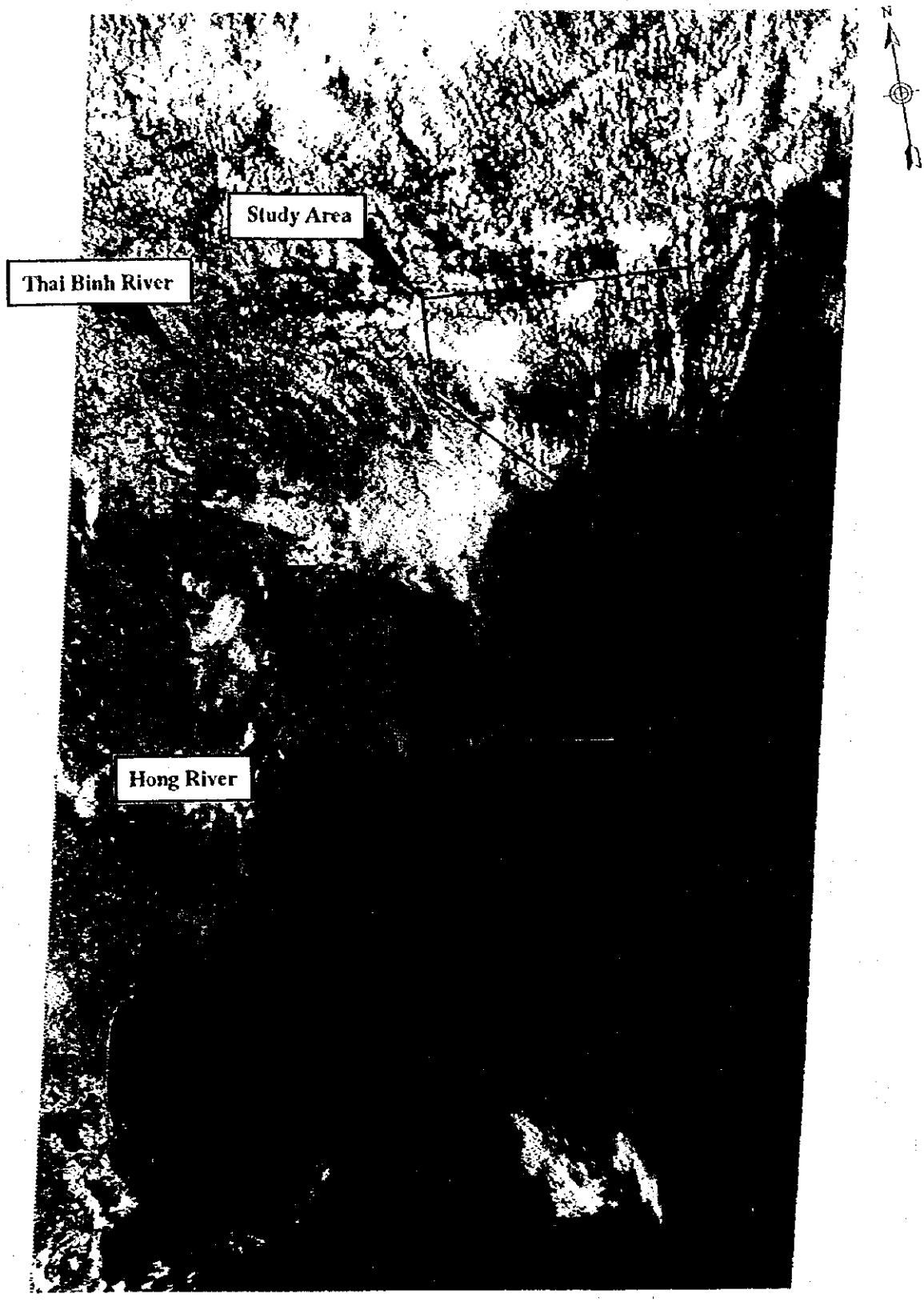

Figure 3.2.4 LANDSAT False Color Image of Gulf of Tonkin (July 11, 1998)

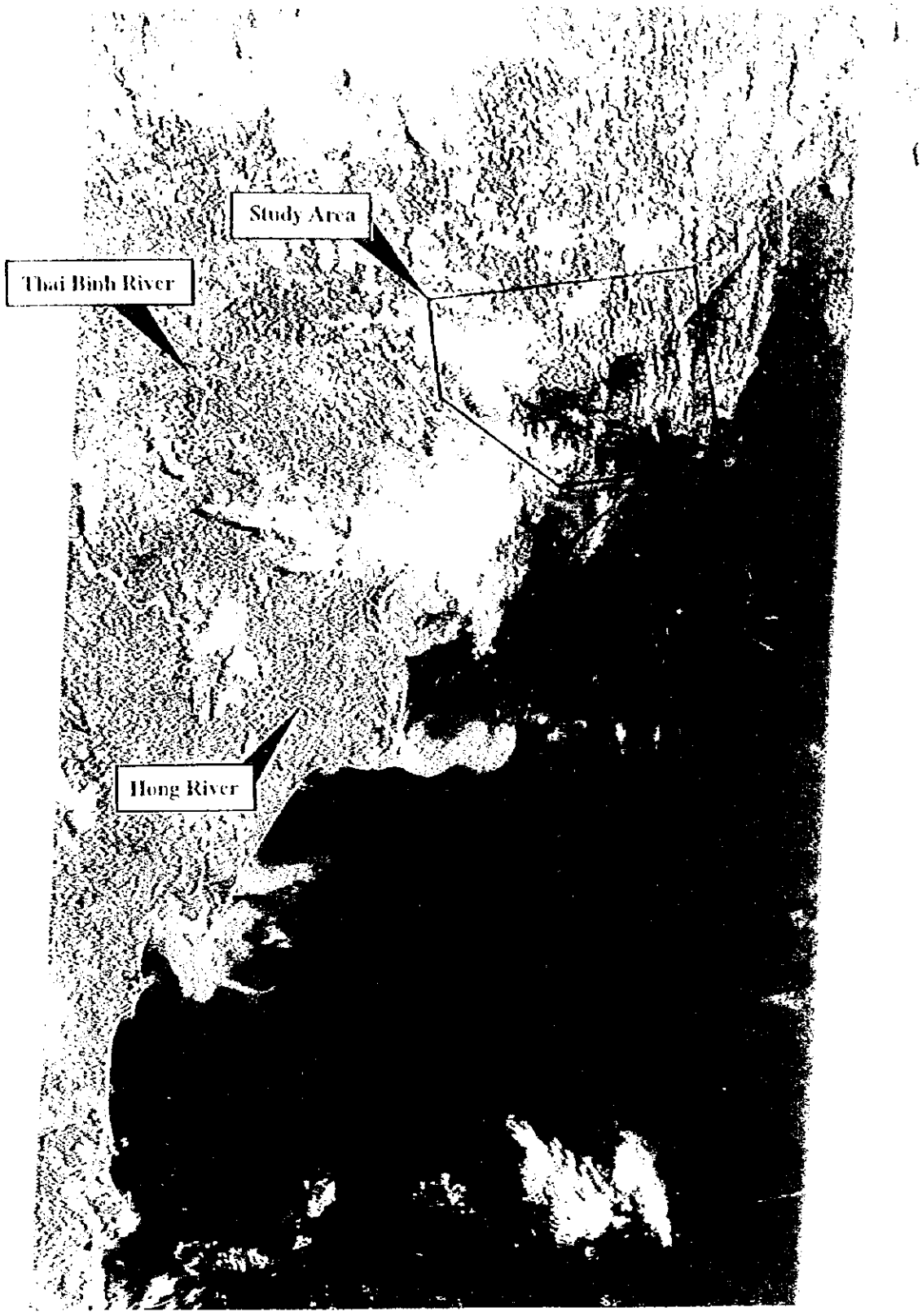

Figure 3.2.4 LANDSAT False Color Image of Gulf of Tonkin (July 31, 1998)

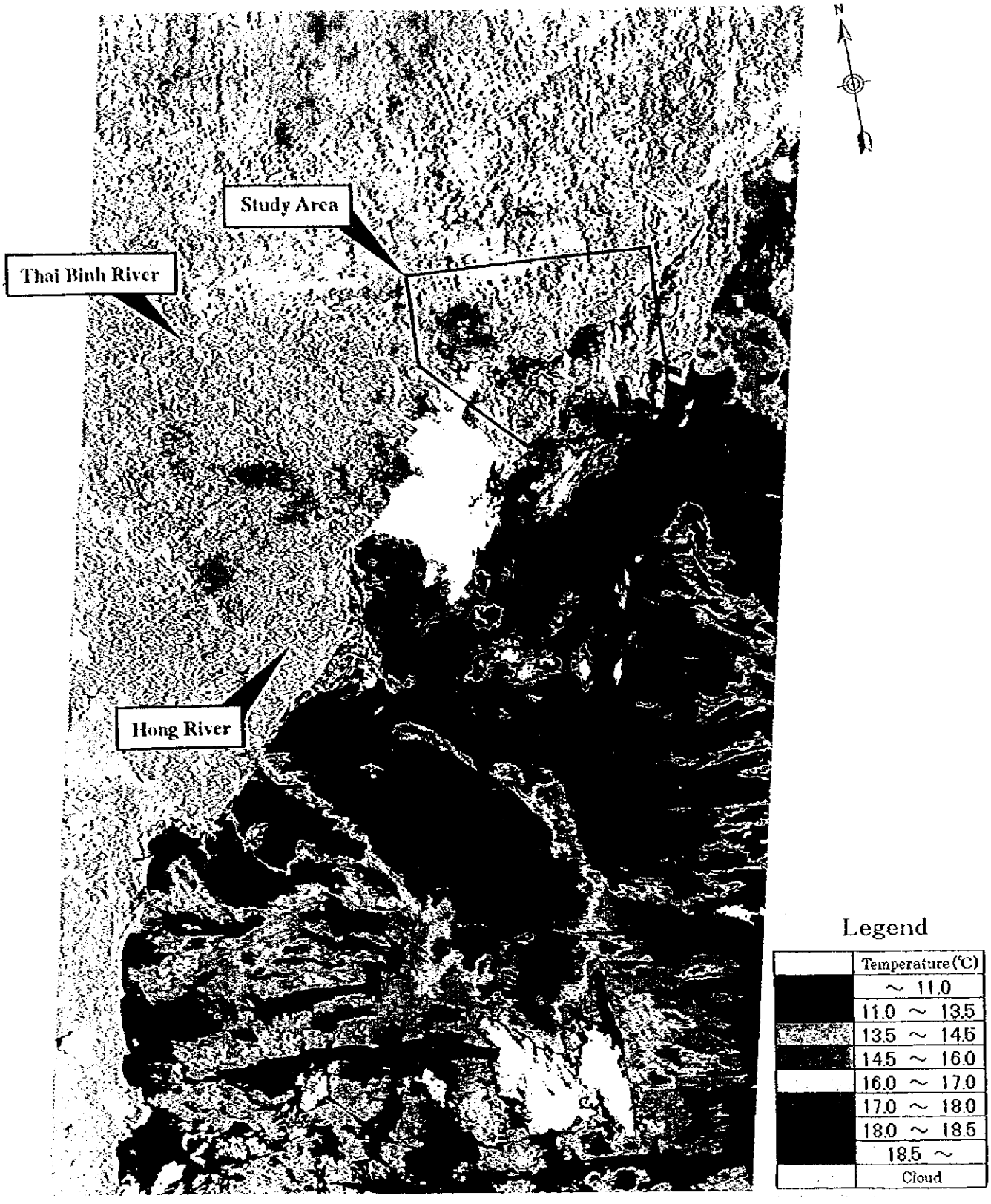

Figure 3.2.5 Water Temperature Distribution of Gulf of Tonkin (July 11, 1998)

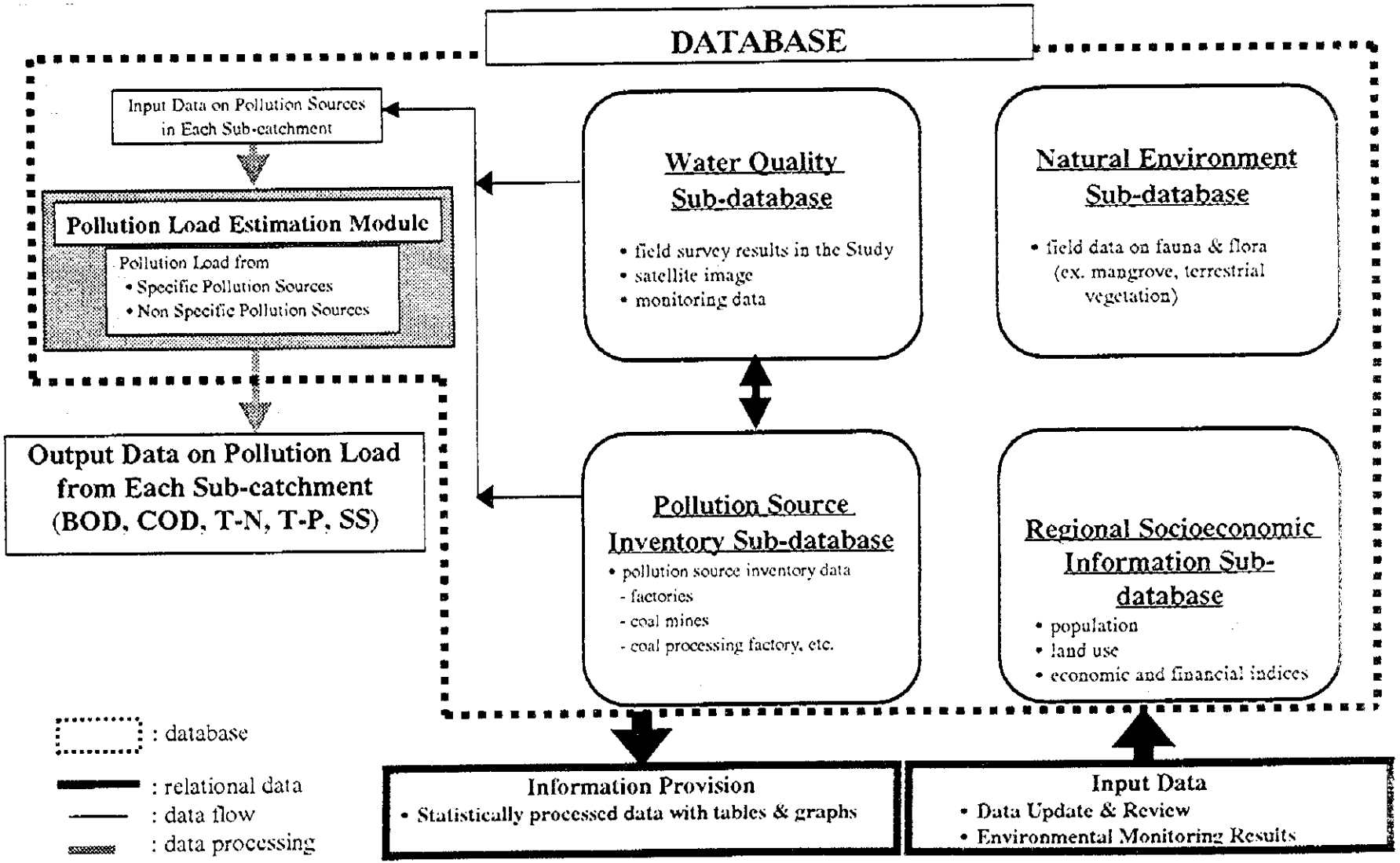

Figure 3.3.1 Components of the Database

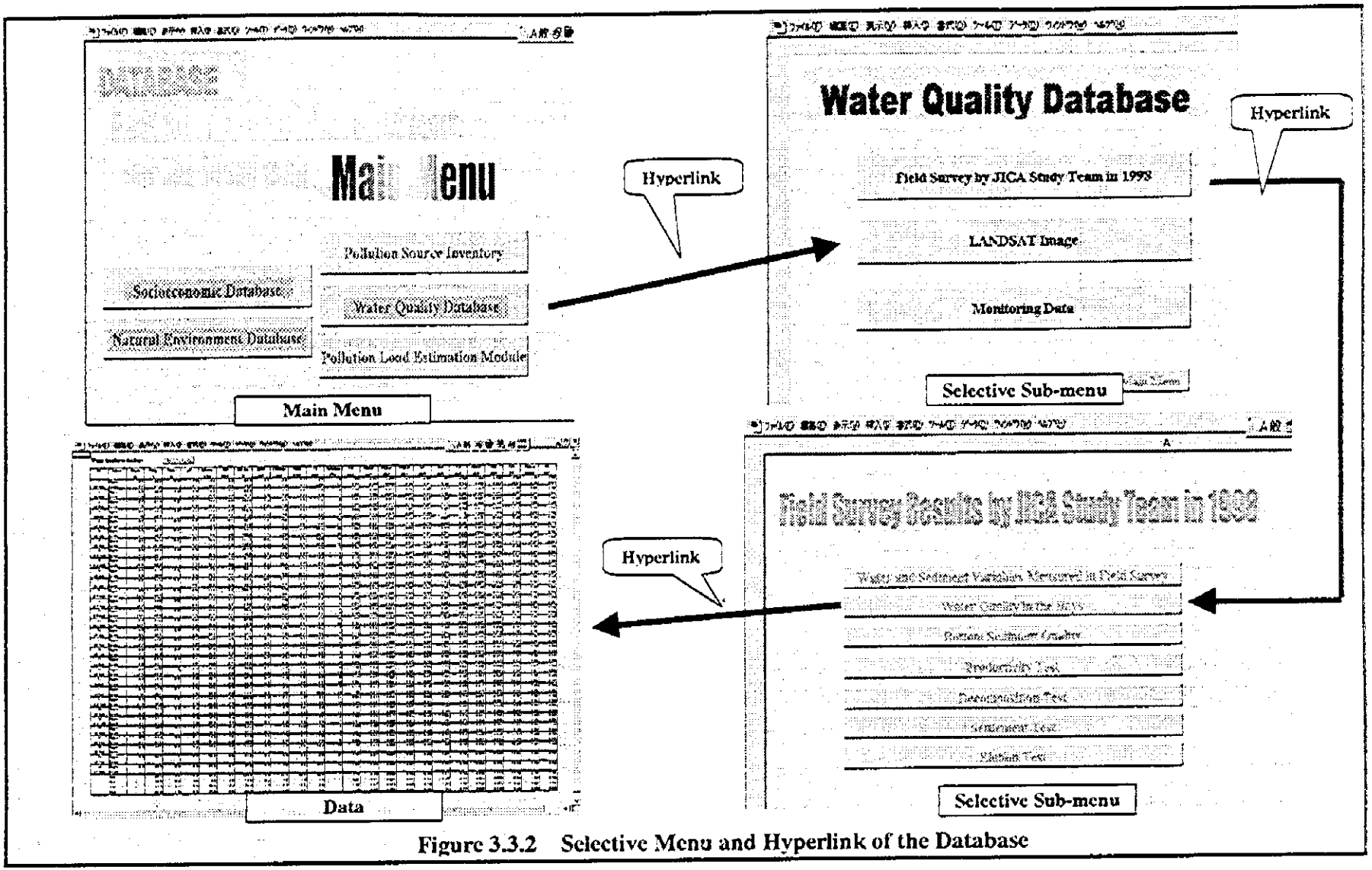

Figure 3.3.2 Selective Menu and Hyperlink of the Database

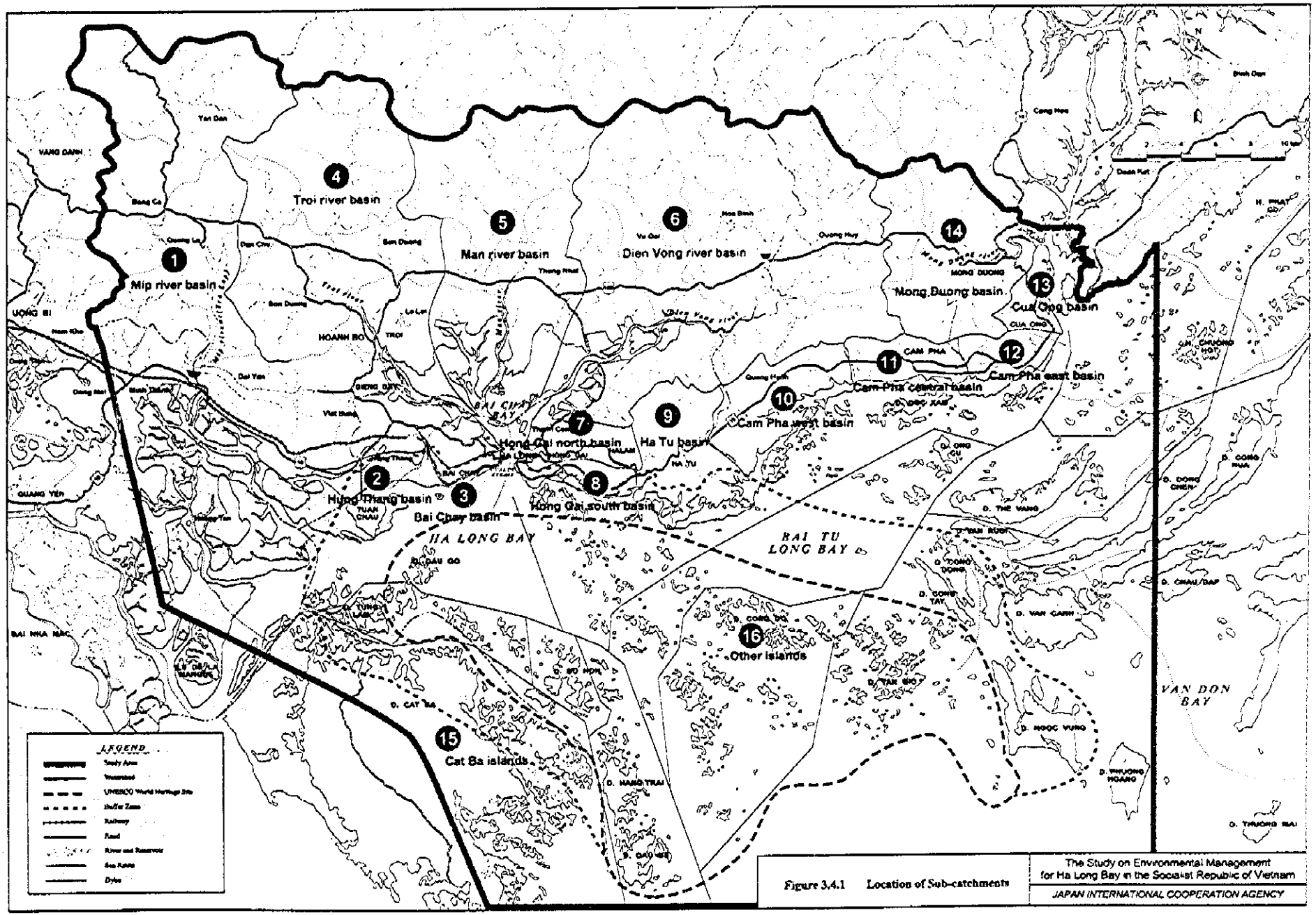

Figure 3.4.1 Location of Sub-catchments

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CHAPTER 4

CHAPTER 4 SIMULATION MODEL DEVELOPMENT

4.1 Structure of the Model

The objective of development of numerical simulation model is to estimate changes in key water quality parameters based on pollution loads calculated for the different environmental scenarios considered in the Study. As a tool for such rational environmental management planning, the numerical simulation model is expected to simulate the hydrodynamics and water quality in the bays by integrating topographic conditions and estimated pollution loads.

4.1.1 Methodology

(1) Development Process

The model should simulate the three processes of hydrodynamics, diffusion, and nutrient cycling in two levels so that it is applicable to the condition of physical and chemical stratification. The equations of the model were shown in the Supporting Report.

(2) Model Area

The model area was set up as shown in Figure 4.1.1 corresponding to the study area. The area extends 50 km in the north and south direction and 60 km in the east and west direction.

(3) Grid Size

Three different grid sizes of 1 km, 333 m, and 111 m were proposed to provide the necessary topographic resolution for the Study as shown in Figure 4.1.1.

(4) Shoreline and Bathymetry

The shoreline and bathymetry used in the model are shown in Figure 4.1.2. For the mapping of the present condition, the map provided by the Counterpart team,

photographs by the helicopter survey in the Study, existing marine charts, and topographic maps were used (see Supporting Report in details).

(5) Depth of the Layer Boundary

The depth of the layer boundary was defined as 2 m below the mean sea level referencing the Field Survey data, which showed the sharp gradients in the vertical profiles of salinity near the surface.

(6) Target Season

The rainy season was selected as a target season of the numerical simulation model analysis, because the water quality during this season is worse than that of the dry season.

4.2 Hydrodynamic Model

4.2.1 Boundary Conditions

(1) Water Levels on the Open Boundaries

The water levels of the offshore open boundaries were induced by diurnal oscillations of 72 ~ 86 cm and semi-diurnal oscillations of 3 ~ 15 cm based on the existing harmonic constants obtained near the points.

(2) River Discharges for Tributaries

The river discharges were set up as shown in Table 4.2.1 based on the estimation in Section 3.5. Locations of the river discharges are shown in Figure 4.2.1.

(3) Wind Direction and Speed

The wind direction and speed at the sea surface were set up as 345° and 3.4 m/s, respectively, based on the Field Survey data.

(4) Densities on the Open Boundaries

The densities of the offshore open boundaries were set up as 0.998 ~ 1.020 based on the Field Survey data.

4.2.2 Coefficients

Coefficients used in the hydrodynamic model were set up as below based on the Field Survey data and the existing study (Horie, 1980).

Symbol	Description	Unit	Value
Ah	Eddy viscosity	cm^2/s	1×10^5
$f=2\omega\sin\varphi$ ω	f: Coriolis parameter, ω: Angular velocity of the	rad/s	$2\pi/(24\times3600)$
φ	rotation of the earth, φ: Latitude	degree	21.9
γ_s^2	Surface friction constant	–	0.0016
γ_i^2	Internal friction constant	–	0.0001
γ_b^2	Bottom friction constant	–	0.0026
Kx, Ky	Horizontal eddy diffusivity	cm^2/s	1×10^5
Kz	Vertical eddy diffusivity	cm^2/s	0.1

4.3 Diffusion Model

4.3.1 Pollutant Variables

Pollutant variables of the diffusion model were SS in the Study. The grain size distribution was not considered in the model because the information was not available during the Study.

Loads of SS were set up as shown based on the estimation in Chapter 3. Locations of the load points were the same as those of the river discharges set up for the hydrodynamic model as shown in Figure 4.2.1.

4.3.2 Boundary Conditions

The boundary conditions were fixed as constant values referencing the Field Survey data as shown below.

- Upper layer : 2 ~ 4 mg/ℓ (east and north boundaries)
  3 ~ 4 mg/ℓ (south boundary)
  10 mg/ℓ (southwest boundary)

- Lower layer : 3 ~ 7 mg/ℓ (east and north boundaries)
  7~10 mg/ℓ (south boundary)
  19 mg/ℓ (southwest boundary)

4.3.3 Diffusion

The effects of diffusion terms depend on the eddy diffusivity. Based on field studies, 10,000 cm^2/s for horizontal eddy diffusivity and 0.1 cm^2/s for vertical diffusivity were used.

4.4 Nutrient Cycling Model

4.4.1 Pollutant Variables

Pollutant variables addressed by the nutrient cycling model were:

a) COD_1 (External)

b) COD_2 (Internal)

c) I-N (Inorganic Nitrogen = Ammonia + Nitrate + Nitrite)

d) O-N (Organic Nitrogen)

e) I-P (Inorganic Phosphorus = PO_4-P)

f) O-P (Organic Phosphorus)

g) DO (Dissolved Oxygen)

Loads for the nutrient cycling model were set up based on the estimation in Chapter 3. Locations of the load points were the same as those of the river discharges set up for the hydrodynamic model shown in Figure 4.2.1.

4.4.2 Boundary Conditions

The boundary conditions were set up as below based on the offshore Field Survey data to reflect the levels of background concentrations in the area.

Variables	Initial values and boundary conditions	
	Upper Layer (mg/ℓ)	Lower Layer (mg/ℓ)
COD_1	3.10	4.60
COD_2	3.10	4.60
I-N	0.11	0.11
O-N	1.54	1.15
I-P	0.03	0.03
O-P	0.69	0.86
DO	4.79	5.23

4.4.3 Diffusion

The effects of diffusion terms depend on the eddy diffusivity. Based on field studies, 10,000 cm^2/s for horizontal eddy diffusivity and 0.1 cm^2/s for vertical diffusivity were used.

4.4.4 Reactions

Constants of the rates on bio-chemical reactions were set up as below based on the pollution mechanism study in Chapter 3, other studies (Jorgensen et al., 1991), and the calibration.

Symbol	Description	Unit	Value
μmax	Maximum growth rate	ℓ/day	3.0
KIP	Half saturation constant of I-P	mg/ℓ	0.003
KIN	Half saturation constant of I-N	mg/ℓ	0.040
DP(l)	Decomposition rate of O-P	ℓ/day	0.003
DN(l)	Decomposition rate of O-N	ℓ/day	0.012
DCOD(l)	Decomposition rate of COD	ℓ/day	0.050
SP(l)	Settling rate of O-P	m/day	0.65*
SN(l)	Settling rate of O-N	m/day	0.65*
SCOD(l)	Settling rate of COD	m/day	0.70*
YP	Release rate of I-P	$mg/m^2/day$	2.3
YN	Release rate of I-N	$mg/m^2/day$	12.4
YCOD	Release rate of COD	$mg/m^2/day$	80.8
DOSH	Consumption rate of DO by the bottom sediment	$mg/m^2/day$	0.000
Kex	Re-aeration constant	ℓ/day	0.300
DOS	Saturated concentration of DO	mg/ℓ	7.680
C1	P/COD ratio by the internal production	-	65.40
C2	N/P ratio by the internal production	-	7.200
C3	DO/P ratio by the internal production	-	142.5

Note: * SP(l), SN(l), and SCOD(l) were set as 0 m/day for the domain of 111 m grid and the next domain of 333 m grid in Bai Chay area based on the calibration.

4.5 Examination of Validation of the Model

4.5.1 Hydrodynamic Model

To validate of the model, the simulated results were compared to the measured data obtained by the Field Survey and the Ha Long Bay Environmental Pollution Study, February 1998 at the station shown in Figure 4.5.1.

(1) Tidal Currents

The diurnal tidal current ellipses of the simulated results were drawn with those of the Field Survey as shown in Figure 4.5.2. The major directions and the maximum velocities of the simulated results met with the measured data except the lower layer at Cua Luc.

The semi-diurnal tidal current ellipses of the simulated results were drawn with those of the Field Survey as shown in Figure 4.5.3. The simulated results met with the high velocities such as measured velocities at Cam Pha - Cua Ong.

(2) Averaged Currents

To highlight the comparison of the measured and simulated average currents, the currents around Cua Luc were shown in Figure 4.5.4 with vectors at the measured point circled. The simulated currents rather met with the measured data for both upper and lower layer. The currents of the upper layer in Figure 4.5.4(1) showed clear outgoing currents from Bai Chay bay while those in the lower layer in Figure 4.5.2(2) showed rather weak or even reverse currents. These suggested that the freshwater from rivers to Bai Chay bay would be transported mainly in the upper layer.

4.5.2 Diffusion Model

(1) Levels of the Concentrations

To validate results of the diffusion model, the simulated results were compared to the Field Survey data. Locations of the sampling stations for the water quality survey are shown in Figure 4.5.5.

The simulated concentrations of SS were plotted with the measured concentrations of SS in Figure 4.5.6. Most of the simulated results met with the measured data at offshore stations while some results at near shore stations showed lower concentrations than the measured data.

The high concentrations measured at near shore stations such as No. 5, 6, 7, 28, 29, and 30 could be the effects of re-suspension from the bottom sediment because of the relatively shallow depths compared to other stations. The depths of these stations measured during sampling were 3.4, 4.1, 2.3, 0.8, 1.1, and 1.2 m, respectively.

(2) Distributions of the Concentrations

The results of the diffusion model are shown in Figure 4.5.7 as the distributions of concentrations. The high concentrations were found near the load points shown in Figure 4.2.1. The concentrations decreased from the load points to offshore and then increased toward the model boundaries of southern and southeastern ends especially in the lower layer. The Field Survey data showed such trend as shown in the concentrations of the station 13, 14, 15, 22, and 23 in Figure 4.5.6. The simulated water quality reflected this trend and suggested that the bays' water could be influenced by the water body with relatively high concentration of SS originating from outside of the study area.

4.5.3 Nutrient Cycling Model

(1) Levels of the Concentrations

To validate results of the nutrient cycling model, the simulated results were compared to the Field Survey data. Locations of the sampling stations for the water quality survey are shown in Figure 4.5.5.

The simulated concentrations of COD (= COD_1 + COD_2) were plotted with the measured concentrations of COD as shown in Figure 4.5.6. The results for other water quality parameters are shown in the Supporting Report.

Although the average levels of the simulated concentrations of COD roughly met with those of the measured data, variations of the concentrations found in the measured data were not simulated enough. The high concentrations measured at the stations 9, 10, and 11 near Hong Gai were not simulated well. This suggested the existence of local pollution sources, which were not reflected well on pollution loads estimation and/or setting load points for the model.

(2) Distributions of the Concentrations

The results of the nutrient cycling model are shown as the distributions of the concentrations for COD in Figures 4.5.8. The results for other water quality parameters are shown in the Supporting Report. The high concentrations of COD were found in Bai Chay bay. The concentrations decreased from the load points shown in Figure 4.2.1 to offshore and then increased toward the model boundaries of southern and southeastern ends. The Field Survey data showed such trend as shown in the concentrations of stations 9, 10, 11, 12, 13, 14, and 15 in Figures 4.5.6. The simulated water quality reflected this trend and suggested that the bays' water could be influenced by the water body with relatively high concentrations of COD, T-N, and T-P originating from outside the study area.

4.5.4 Validation of the Model

On the above grounds, it is concluded that the developed numerical simulation model can be used for the projection of future water quality in the bays.

FIGURES

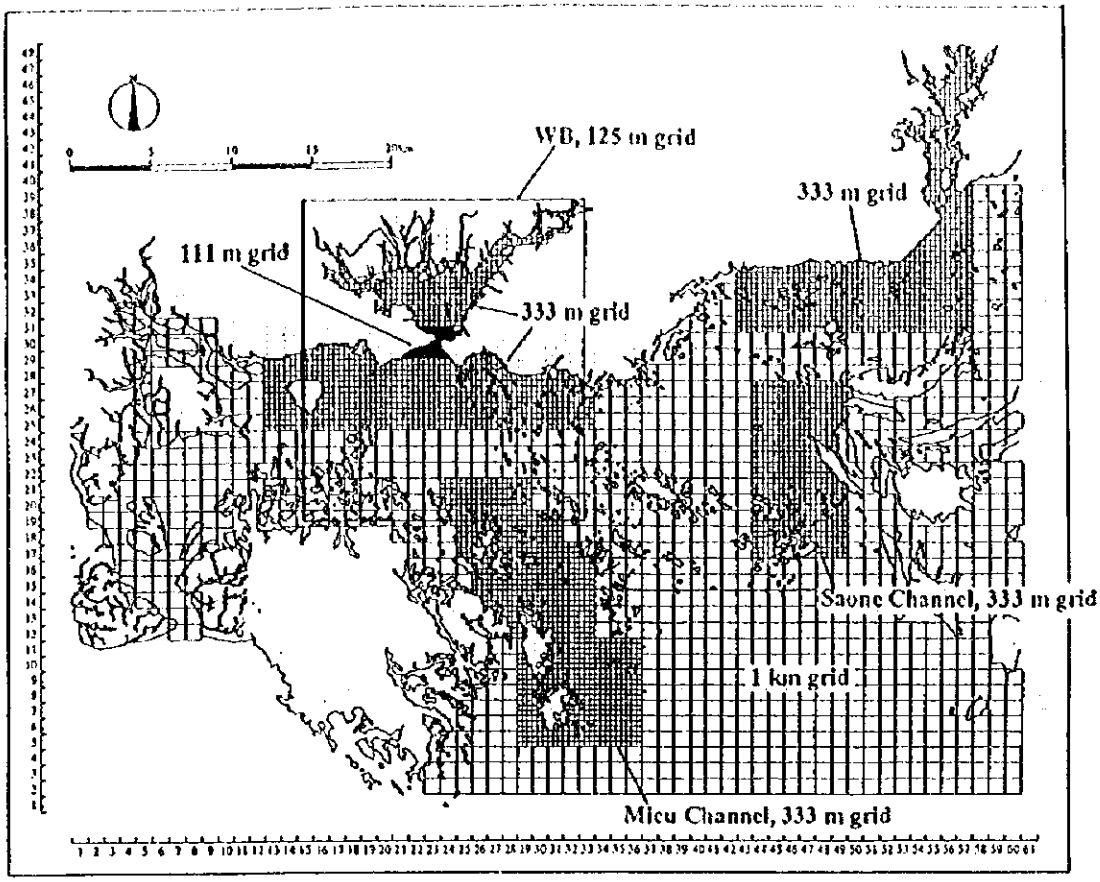


Figure 4.1.1 Model Area

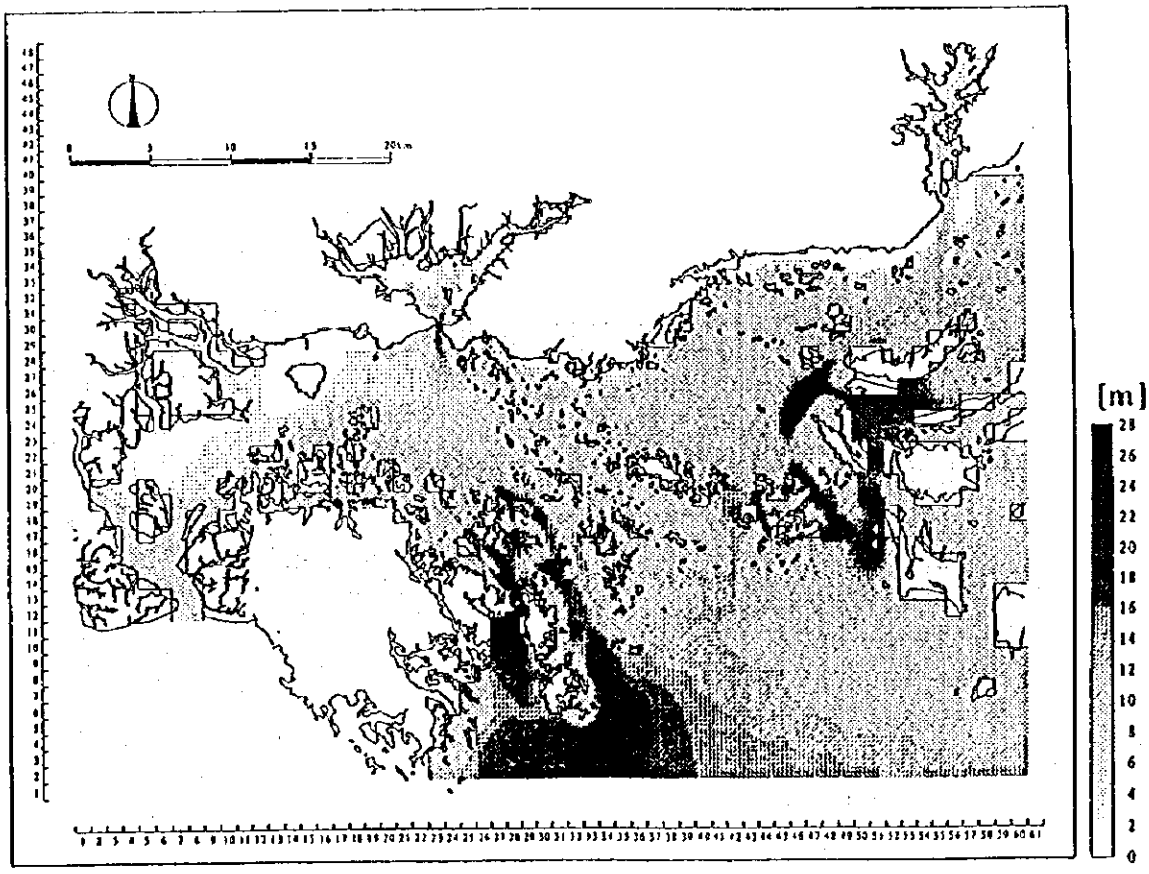


Figure 4.1.2 Bathymetry

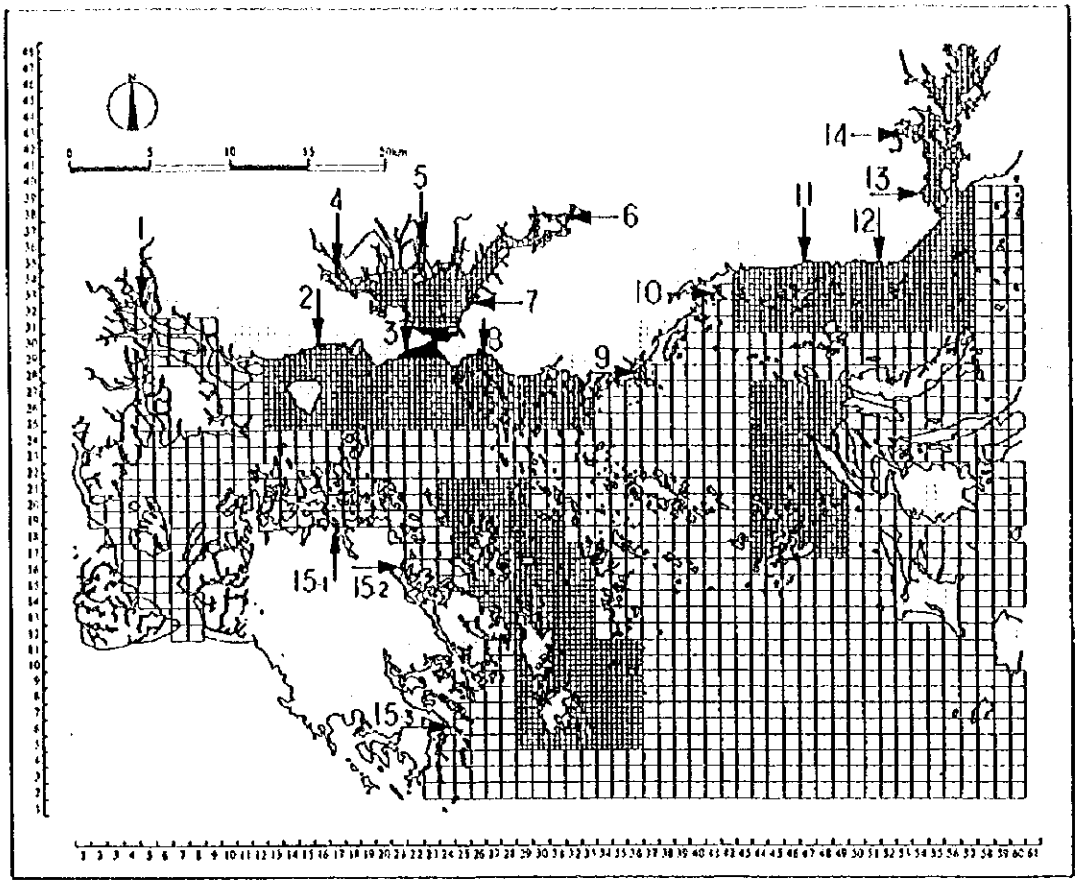


Figure 4.2.1 Locations of the River Discharges

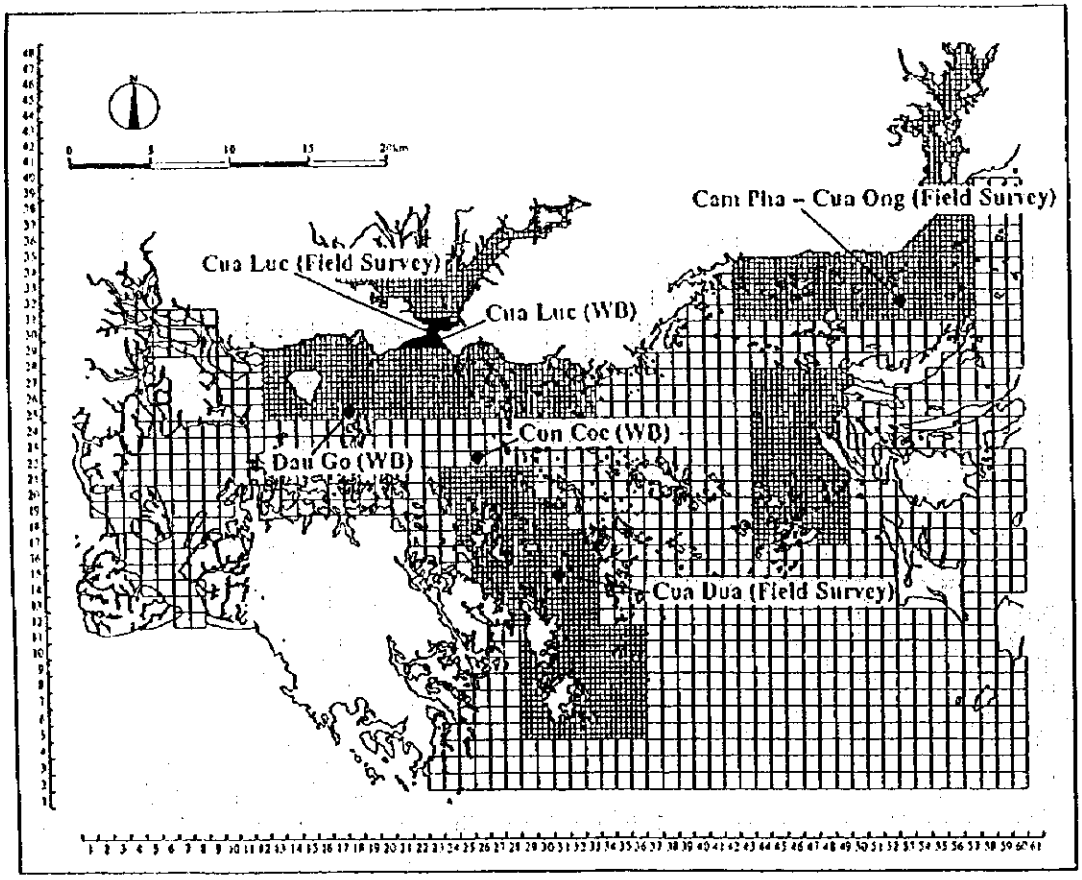


Figure 4.5.1 Locations of the Current Measuring Stations of the Field Survey and WB Study

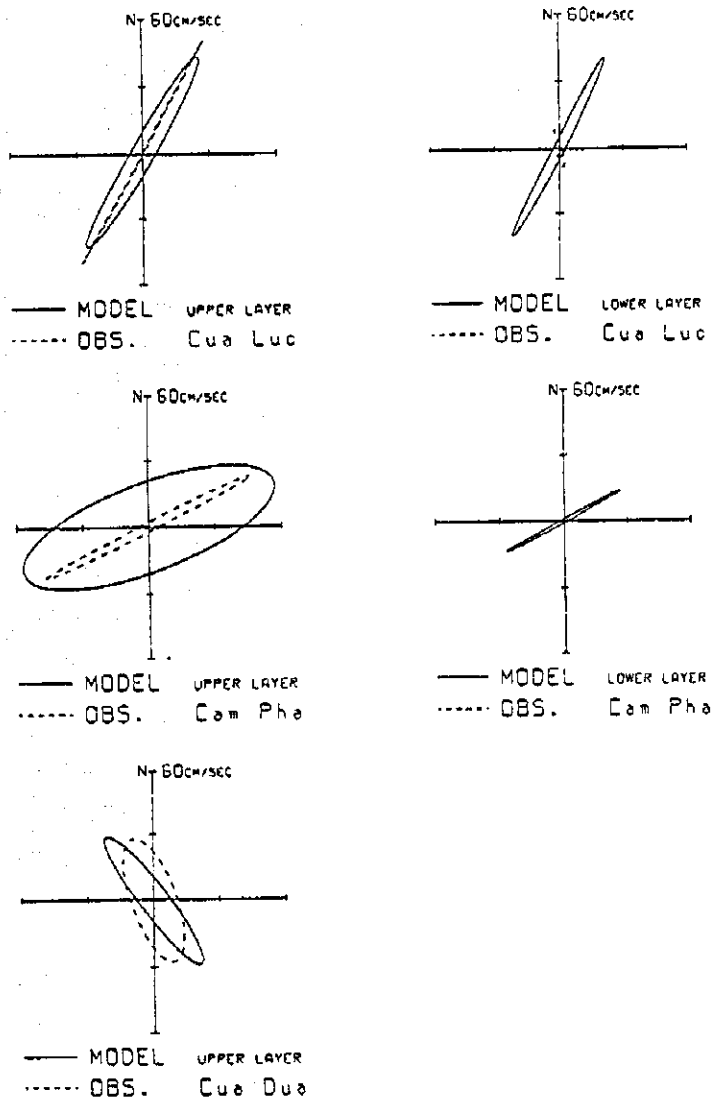


Figure 4.5.2 Comparison of the Measured and Simulated Diurnal Currents

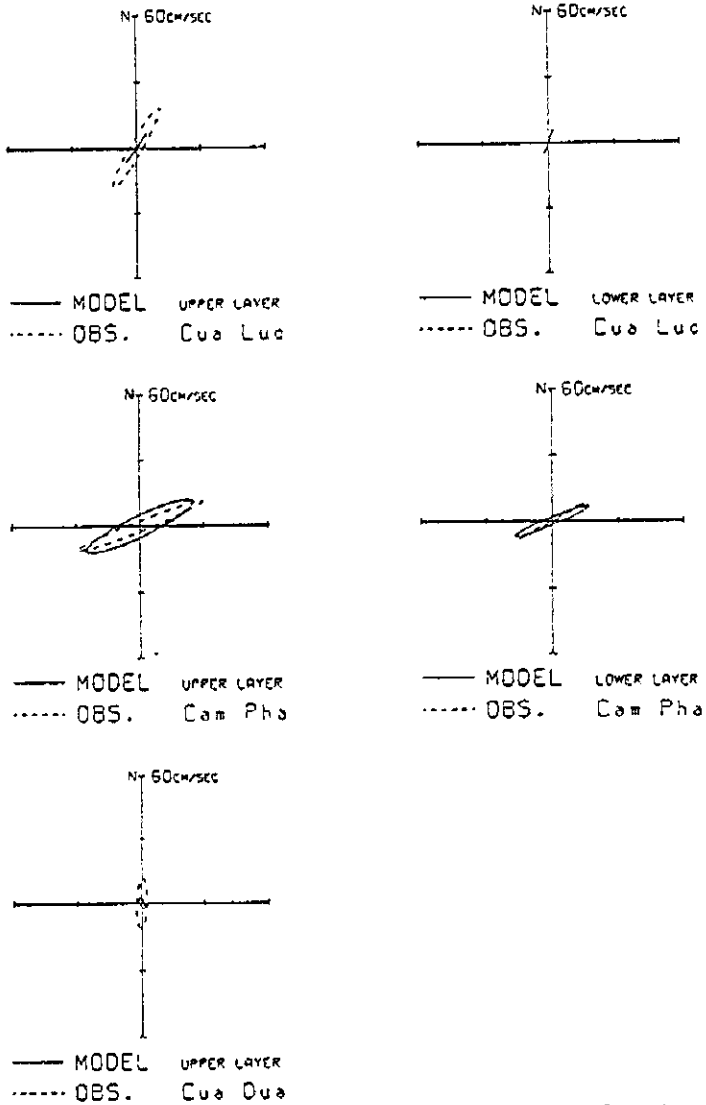


Figure 4.5.3 Comparison of the Measured and Simulated Semi-diurnal Currents

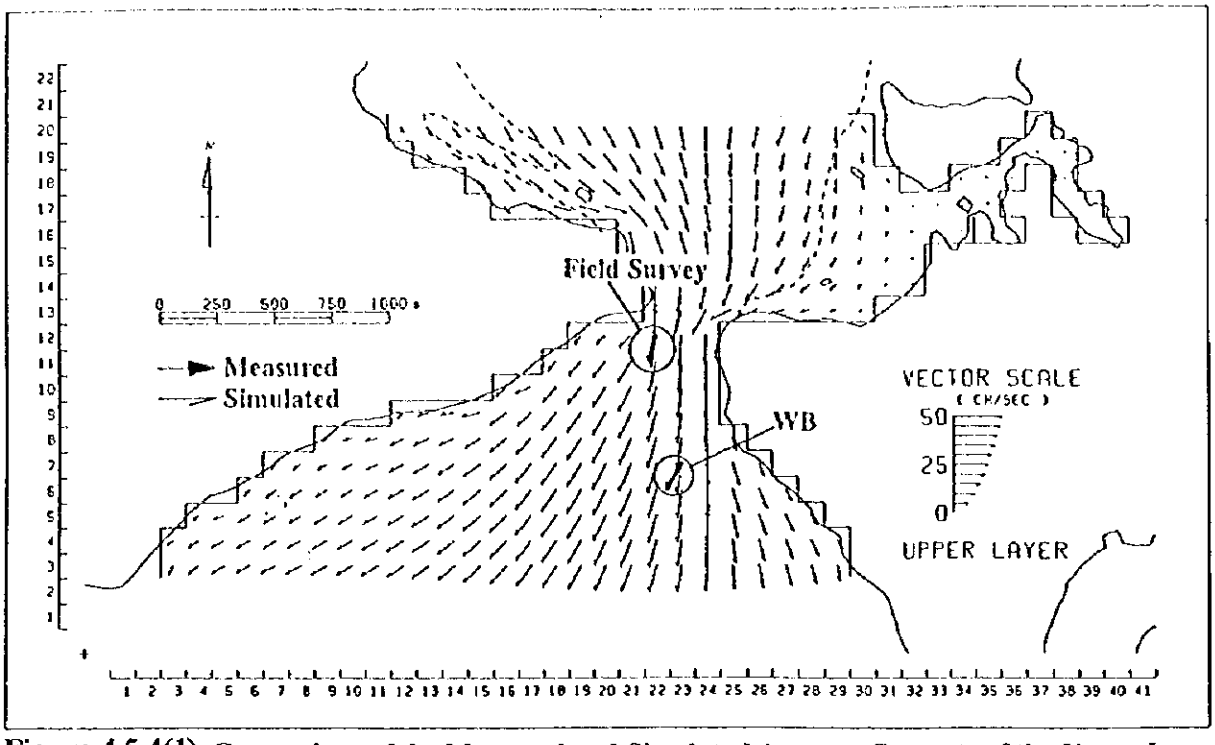


Figure 4.5.4(1) Comparison of the Measured and Simulated Average Currents of the Upper Layer around Cua Luc (Measured Currents: Field Survey Data and WB Study by ESSA & HIO 1997)

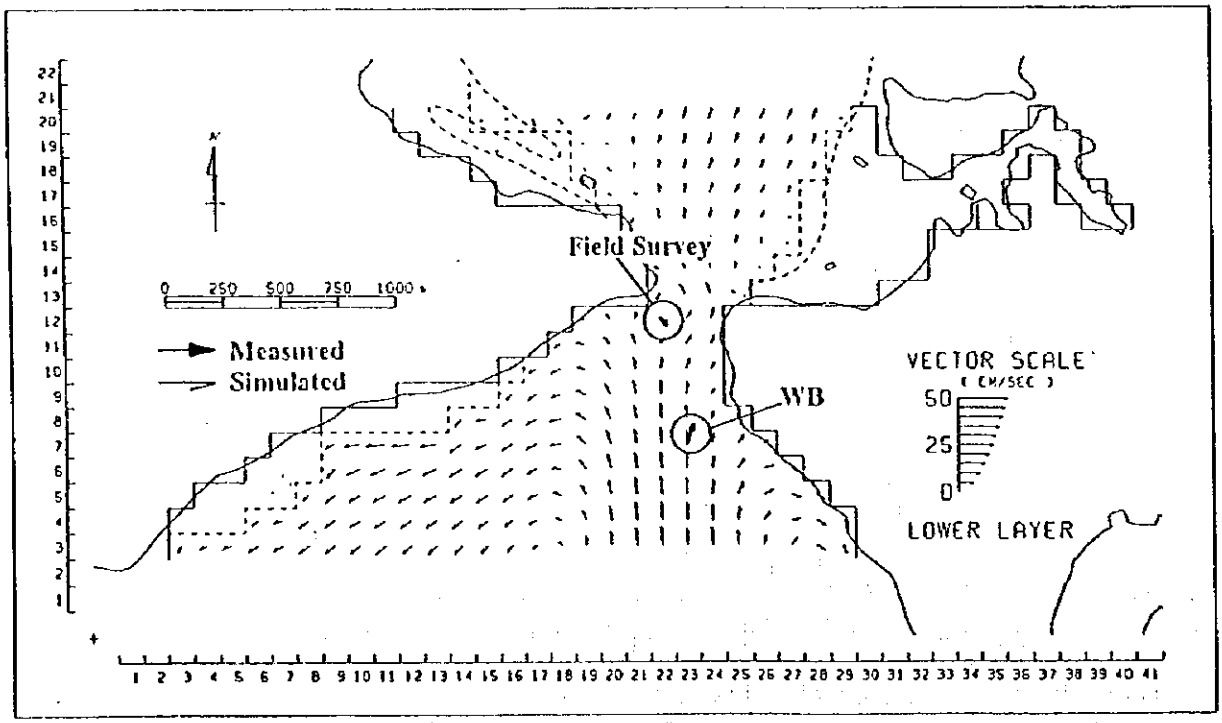


Figure 4.5.4(2) Comparison of the Measured and Simulated Average Currents of the Lower Layer around Cua Luc (Measured Currents: Field Survey Data and WB Study by ESSA & HIO 1997)

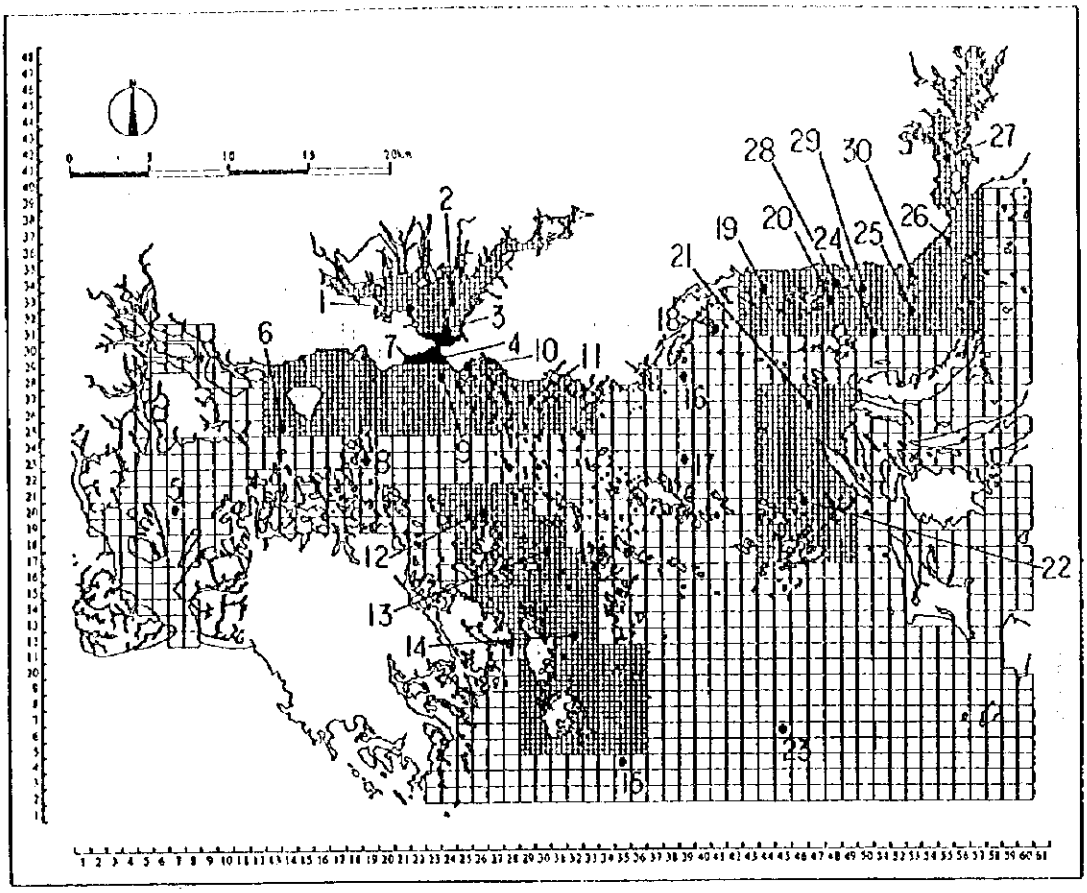


Figure 4.5.5 Locations of the Sampling Stations for the Water Quality Survey

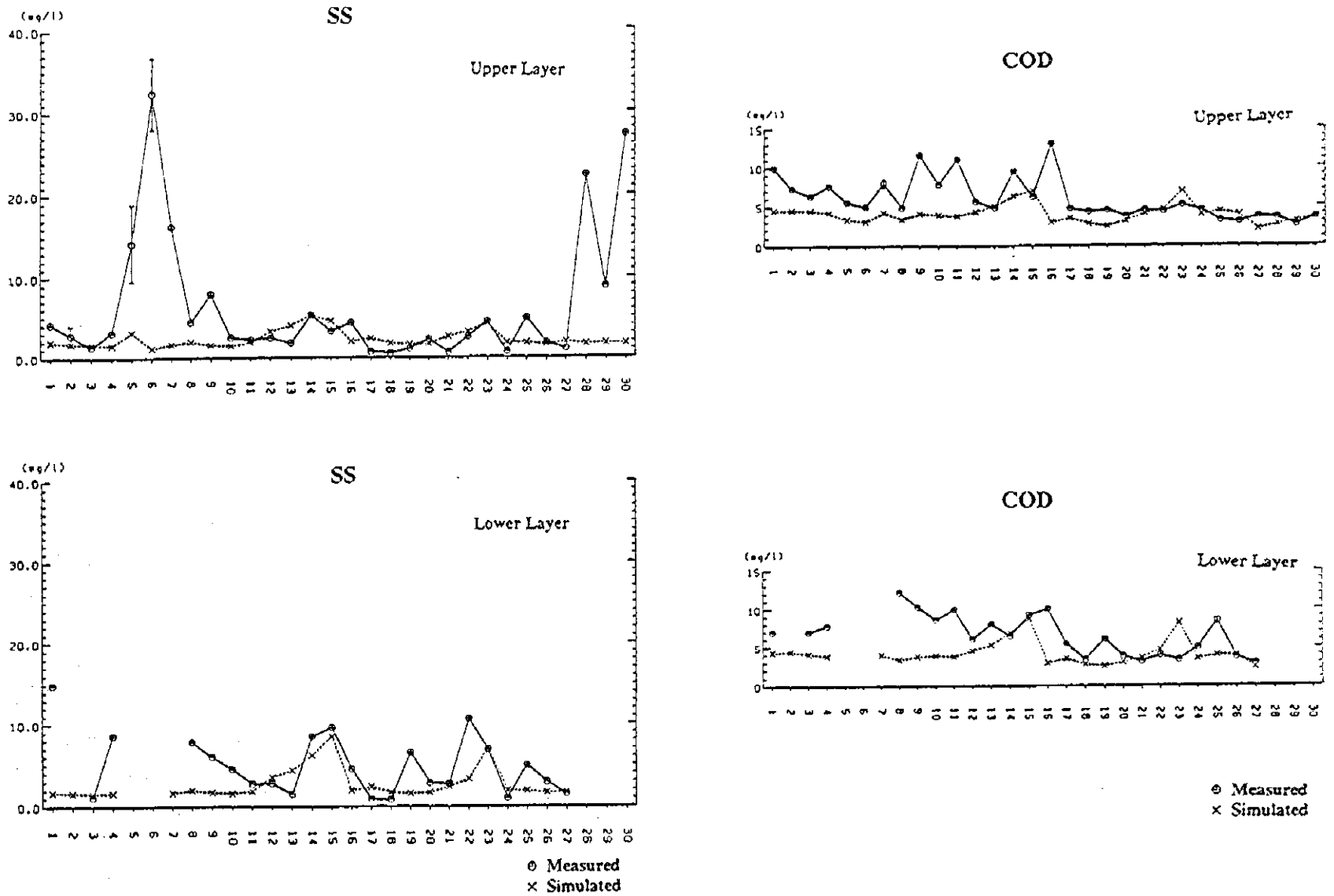


Figure 4.5.6 Comparison of the Measured and Simulated Concentrations of SS and COD

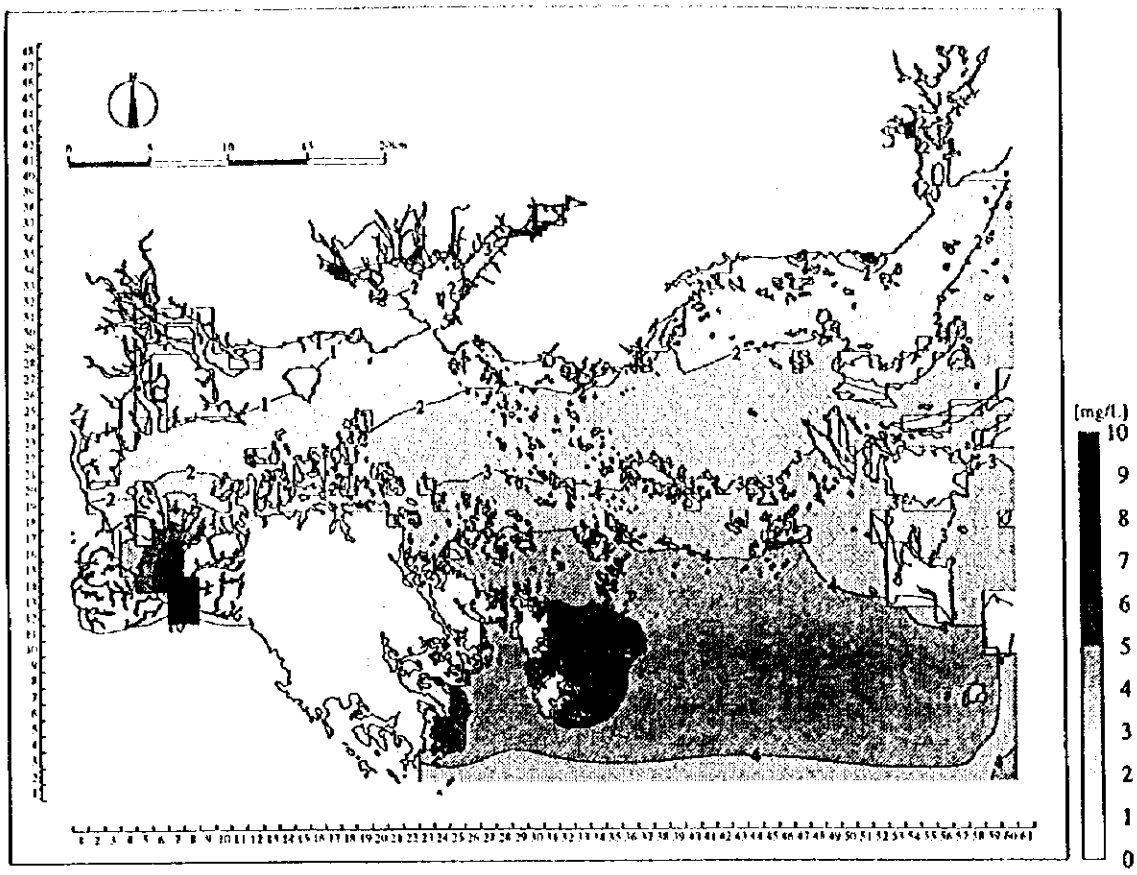


Figure 4.5.7(1) Simulated Concentrations of SS of the Upper Layer

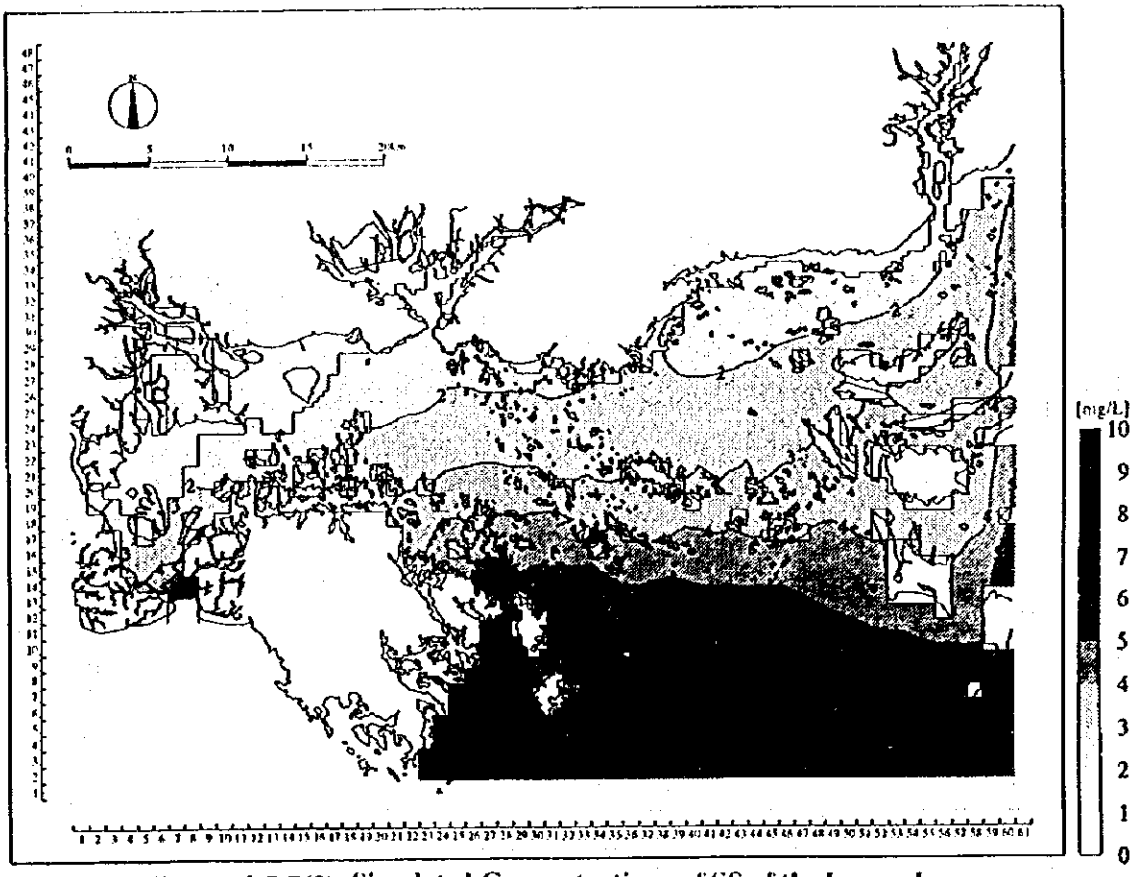


Figure 4.5.7(2) Simulated Concentrations of SS of the Lower Layer

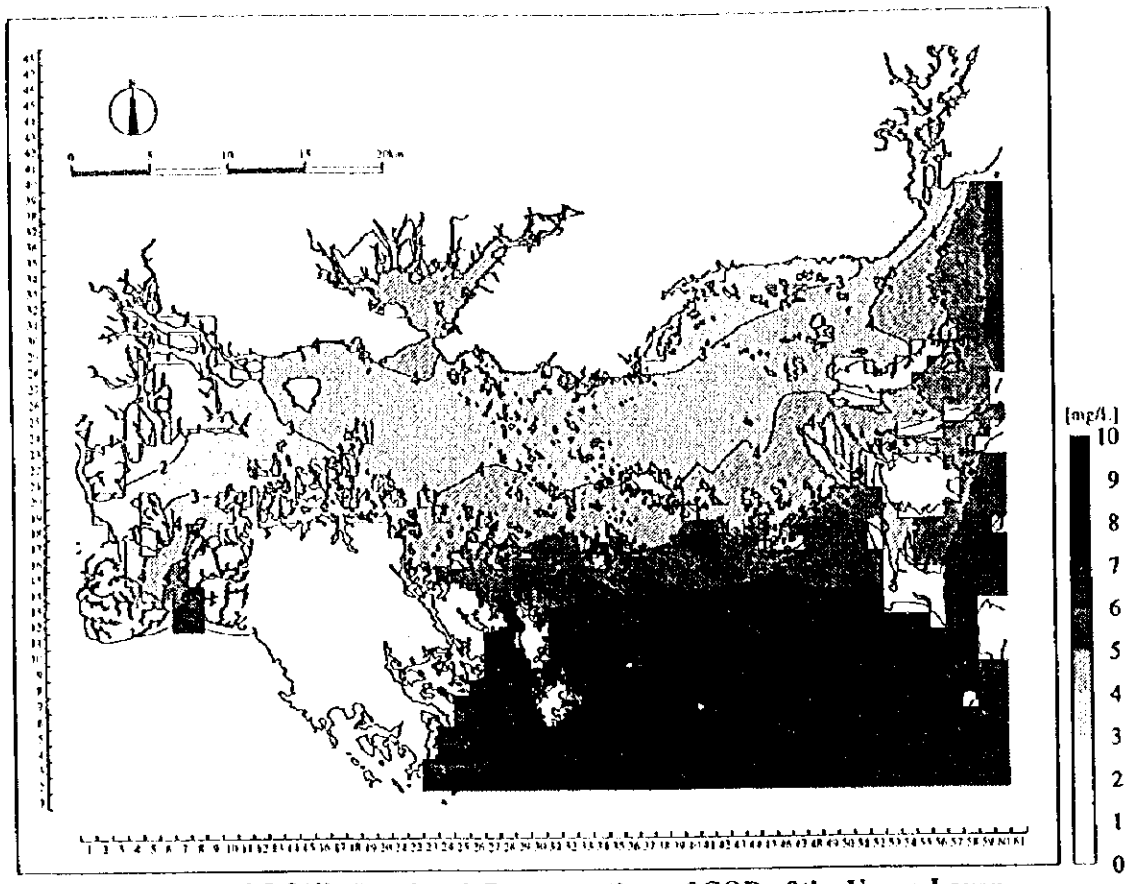


Figure 4.5.8(1) Simulated Concentrations of COD of the Upper Layer

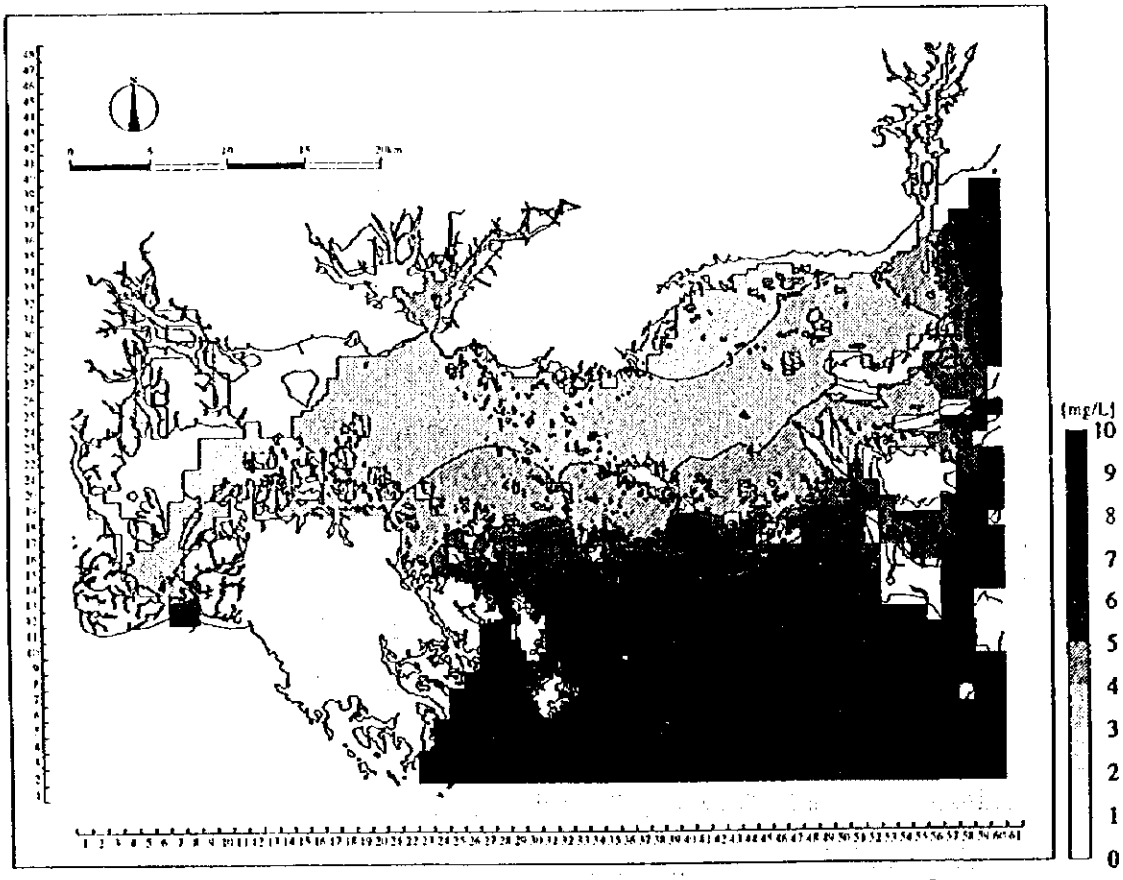


Figure 4.5.8(2) Simulated Concentrations of COD of the Lower Layer

CHAPTER 5

CHAPTER 5 FUTURE SOCIOECONOMIC FRAME

5.1 Review of National, Provincial, and City Development Master Plans

5.1.1 National Development Master Plan

The two key policy documents presented at the Eighth Party Congress in June-July 1996 were "Political Report of the Central Committee" and "Orientation and Tasks of the 1996-2000 Five-year Plan for Socioeconomic Development". The key economic theme of the developments is to promote industrialization and modernization, and the overall goal is to develop Vietnam into an industrialized economy by 2020. The Political Report indicated that Vietnam would continue to develop a mixed economy, and that the State economic sector together with the cooperative sector should constitute the foundation of the economy, while the private sector would account for a considerable proportion. The following three basic economic objectives were identified for the period through 2000:

- High, sustainable, and efficient economic growth
- Macro-economic stabilization
- Long term development of human resources, infrastructure, technology, and institutions.

Regarding social objectives, it is important that economic growth goes parallel with social and cultural development, so as to improve social equity. Social objectives in the medium term include concentrated efforts on employment generation, elimination of food shortage, poverty alleviation, improvement of health care and social services, and improvement of quality of and access to education and vocational training.

An important goal for regional development is to develop the key economic regions: Northern Growth Triangle (Ha Noi, Hai Phong and Ha Long), Southern Economic Focal Area (Ho Chi Minh City, Bien Hoa and Vung Tau), and Central Growth Triangle (Quang Nam-Da Nang, Quang Ngai and Hue), but at the same time avoid large discrepancies in economic growth among the different regions. The major economic goals of the 1996-2000 Five-year Plan are as follows:

- The per capita income will have doubled the level of 1990,

- The annual average growth rate of GDP will reach 9-10%,
- The annual average growth rate of exports will reach 28-30%,
- Industry and construction will be growing at an average of 14-15% annually,
- The share of GDP accounted for by industry and construction will increase to 35% from 23% in 1990, while the share of agriculture will fall to 20% from 38%, and
- The country will invest 33% of GDP compared to 15% in 1990.

5.1.2 Development Master Plan of Quang Ninh Province

The basic planning goal of the Development Master Plan of Quang Ninh Province 1995-2010 is to develop the province into an industrial and tourism province and to become one of the growth poles in the Northern Growth Triangle. The industrial priorities will change drastically between 1996-2000 and 2001-2010. A shift of industrial structure from the traditional industrial sectors to new urban industrial sectors is expected to achieve the goal. The Urban Development Master Plan of Quang Ninh province 1995-2010 (August, 1995) identifies major development projects in urban and suburban areas in the province. The development direction of the study area which includes two major provincial urban centers is determined by the Urban Development Master Plan.

(1) Population Growth

The population growth of the province in the last decade has been mainly due to natural growth whose rate is still over 2.0%. Migration has been negligible. The table below shows the forecast of natural population growth. Ha Long city, Dong Trieu district and Yen Hung district will gain larger natural growth than the others. The geographical distribution pattern of population in the province, however, will remain almost the same as before by 2010.

Natural Population Growth of Quang Ninh Province

(Unit: 1,000 persons)

Area	1994	2000	2010	Incremental Population (1994-2010)
Ha Long City	141.2	156.2	190.6	49.4
Cam Pha Town	138.7	153.3	167.2	28.5
Uong Bi Town	86.9	95.7	117.3	30.4
Binh Lieu District	22.8	27.6	30.8	8.0
Quang Ha District	71.1	85.5	96.0	24.9
Hai Ninh District	39.5	46.3	53.3	13.8
Tien Yen District	40.1	49.2	54.3	14.2
Ba Che District	17.1	21.1	23.1	6.0
Dong Trieu District	137.4	154.9	185.5	48.1
Yen Hung District	122.2	142.0	165.0	42.8
Hoanh Bo District	50.4	61.3	69.9	19.5
Van Don District	32.3	37.0	43.4	11.1
Co To District	2.5	3.1	3.6	1.1
Total	902.2	1,033.2	1,200.0	297.8
Labor Force	470.0	600.0	730.0	260.0

Note: Ha Long will be merged with some of small towns (thi trau) of Hoanh Bo and Yen Hung by 2010. Ha Long in the table covers only the present city area.

Source: Urban Development Master Plan of Quang Ninh Province, 1995

(2) Economic Growth

The economic target figures which seem to be rather ambitious are shown in the table below. The province needs an effective improvement of socioeconomic infrastructures, sufficient foreign investments, and rapid productivity improvement to achieve the targets.

Major Economic Targets of Quang Ninh Province

GDP/capita in 2000	US$ 750
GDP/capita in 2010	US$ 2,600
Export value in 2000	US$ 250-300 mil.
Export value in 2010	US$ 1,300-1,500 mil.
GDP Growth Rate	
1991-1995	11.6 - 12.3%
1995-2000	11.6 - 12.3%
2001-2010	14.0 – 14.5%

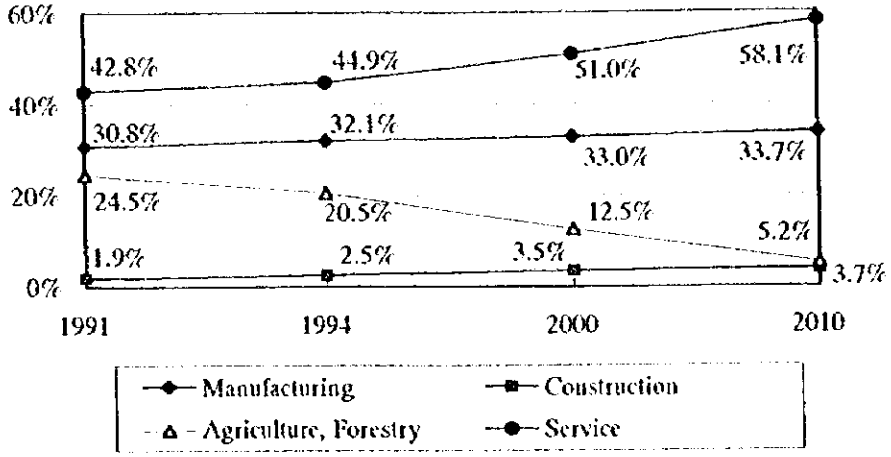
Source: Urban Development Master Plan of Quang Ninh Province, 1995

(3) Industry

1) Forecast of structural change

The forecasted change of GDP share by major economic sector shown in the figure below will follow a rather general process as other developing areas have experienced. The share of the agriculture and forestry sector constantly will decrease on one hand. While, that of the service sector will increase, on the other

hand. The reason of the relatively slow increase of the manufacturing sector is not clear here, however. The expectation of tourism development in the province may influence the forecast to some extent.



Source: Urban Development Master Plan of Quang Ninh Province, August, 1995

Economic Structural Change of Quang Ninh Province

2) Coal mining industry

The coal mining industry in Quang Ninh has played an important role not only in the economic sectors of the province, but also in the national economy. The province is trying to make the industrial structure more diversified, avoiding over reliance on the coal mining industry. However, its importance to the regional economy won't change and it is expected to satisfy the following two targets: to meet the domestic demand for coal and to increase the quantity and quality for export. The next table shows the plan of coal mining production of the three major companies in the province. At present, however, major mines have been transferred to VINACOAL and they have established their own production plans.

Plan of Coal Mining Production

(Unit: mill. tons)

Items	1997	2000	2010
Hong Gai Coal Mining Company	1.4	1.4	1.8
Uong Bi Coal Mining Company	1.2	1.2	1.2
Cam Pha Coal Mining Company	3	4.5	4.5
Total	5.6	7.1	7.5

Source: Urban Development Master Plan of Quang Ninh Province, 1995

3) Agriculture, forestry, and fishery

The agricultural land for rice planting is rather limited in the province and its productivity is still low for lack of proper irrigation system. The rice production is not self-sufficient in the province and the supply will continuously depend on other regions in the future. The advantageous products of the province are those of fruit trees, of trees for industrial materials such as turpentine, and of livestock. As for the forestry, planting of trees for export products such as cinnamon, anise, and turpentine will be expanded. In 10-15 years the production of 2,000 ha turpentine, of 6,000-7,000 ha cinnamon and 7,000-10,000 ha eucalyptus will be achieved.

The potential of fishery in the province is generally regarded as high. The fish stock along the provincial coast which is 250 km long is estimated about 20,000 to 25,000 tons per annum. In addition to this, the province can exploit over 20,000 tons of fish per annum from Bac Bo bay which is located offshore Ha Long bay. Also, the amount of sea products from the tidal areas and around the islands, such as shrimp, crab and squid can reach 25,000 to 30,000 tons/year. Furthermore, there are more than 40,000 ha of tidal flats in the province. The area is favorable for aquaculture of export products, such as shrimp and fish. The application and utilization of advanced technology for intensive aquaculture will be encouraged to promote the provincial fishery sector.

4) Functional Roles of Ha Long City and Cam Pha Town

In the Urban Development Master Plan of Quang Ninh province, the functional roles of Ha Long city and Cam Pha town are defined as follows:

<u>Ha Long city:</u>

- a center for tourism of international level
- a political, economic and cultural center for Quang Ninh province
- a transport interchange, a big regional commercial and service center playing a special role in terms of national defense and security

<u>Cam Pha town:</u>

- an important national center for coal mining and processing
- a concentration of coal mining service industry

- a local political, economic and cultural center for the whole town

The area of Ha Long-Cam Pha-Duong Huy (north of Cam Pha) is also defined as follows:

"Main industries such as coal mining, mechanical industry, construction material, food processing, timber processing, printing and garment are concentrated in this area. The area is a provincial center for the development of seaport economy, tourism, tourism-related services and commerce. It has a great potential for the construction of big concentrated industrial parks."

5) Tourism

The target figures of the tourism development in the province are shown in the next table. The tourism sector is expected to become one of the key economic sectors and, furthermore, to create new job opportunities which may contribute to solving the employment problem in the province.

Tourism Development Frame of Quang Ninh Province

Item	2000	2005	2010	Unit
Number of visitors				
International	530	1,000	1,250	1,000 pers.
Domestic	360	1,100	1,260	1,000 pers.
Total	1,090	2,100	2,510	1,000 pers.
Revenue				
International	68	212	410	US$ mil.
Domestic	270	1,620	2,520	VND bil.
Total	338	1,832	2,930	VND bil.
Employees	8,000	13,900	17,400	pers.
Construction of Hotel Rooms				
International Standard Rooms	950	1,750	1,300	rooms
Domestic Rooms	1,250	1,900	600	rooms
Total	2,200	3,650	1,900	rooms

Source: Urban Development Master Plan of Quang Ninh Province, 1995

5.2 Future Development Plan

The Development Master Plan of Ha Long City for 1994-2010 (HLMP) prepared by the Urban and Rural Planning Institute, the Ministry of Construction provides the orientation of long term socioeconomic and spatial development of Bai Chay, Hong Gai and Cam Pha-Cua Ong in the period of 1994-2010 and further. The major planning goal is to realize a well balanced region harmonizing with various

sectors such as urban development in Bai Chay - Hong Gai area, the coal mining activity, tourism development, and industrial development.

(1) Development Phase and Expansion of City Boundary

The development of Ha Long is divided into the following three phases

First Phase from 1993 to 2000

- to upgrade Hong Gai town to Ha Long city
- to expand the city boundary to Viet Hung and Dai Yen communes (Hoanh Bo district)
- to improve and construct the urban infrastructure
- to promote the construction of tourism infrastructure
- to promote the expansion of the Gieng Day industrial zone (construction material factories and the shipyard)
- to expand the deep-sea port of Cai Lan gradually

Second Phase from 2000 to 2010

- to expand the city boundary to the north and west of Cua Luc, Troi small town and part of the following communes, Le Loi, Thong Nhat, Vu Oai, Son Duong (Hoanh Bo district) and Minh Thanh (Yen Hung district)
- to build Cua Luc export processing zone (at present, Cai Lan concentrated industrial development zone) and the high tech industrial zone
- to construct the urban infrastructure, in particular, relating to transportation, water supply, sanitation and environment protection.
- to continue constructing the tourism infrastructure

Third Phase after 2010

- to expand the city boundary farther to the east, Cam Pha (excluding Cong Hoa and Cam Hai communes) and Bai Tu Long bay
- to concentrate the coal mining industry in Cam Pha area

(2) Population and Land Area

The Forecast of population growth of Ha Long city and Cam Pha town is shown below.

Forecast of Land Area and Population in Ha Long City and Cam Pha Town

Item	1994	2000	2010
Ha Long city			
Total area (km^2)	122.7	212.5	411.7
Inner city	116.9	122.7	175.0
Suburbs	5.8	92.8	336.7
Total Population	141,200	230,000	460,000
Inner city	134,140	210,000	400,000
Suburbs	17,060	20,000	60,000
Cam Pha town			
Population	138,700	153,300	187,245
Area (ha)	48,623	48,623	48,623

Source: Development Master Plan of Ha Long City for 1994 – 2000, 1994

These forecasted figures of population in Ha Long city are based on not only natural growth, but also immigration from other areas and the expansion of the city area. The components of population growth are shown in the next table which indicates Ha Long city will receive a large amount of migration in the period of 2001-2010. The migration population in 2010, 171,000 is equivalent to 73% of the natural growth population in the same year.

As for the employment of Ha Long city, the tertiary industry sector is expected to gain the largest employment growth in the period of 1993-2000, in particular the commerce and tourism and the transport, post and communication. The second sector, in particular the manufacturing, will grow rapidly and its share of employment in Ha Long city will reach 55.9% in 2010 from 38.6% in 2000. It implies the structural change of employment will occur in the period of 2001-2010 from service-oriented to industry-oriented.

(3) Planned Economic Growth in Production

The HLMP doesn't define macro-economic targets such as GDP and GDP/capita. Instead, the regional economic potential and the target of future production by major industry sector are defined as shown Table 5.2.1. The listed industrial activities have been and/or will be important key sectors to the socioeconomic

development of the region. Among them, in particular, the successful implementation of industrial zone development with effective utilization of port facilities will be relatively more crucial to it.

(4) Land Use Change

The future demand for urban development land shown in the next table will grow rapidly. While the total land area of the city will become more than three times (335%) as large as in 1994, the urban land will grow over four times (424%) larger in almost the same period (1993-2010). In particular, the land for industry and housing will expand most rapidly. The growth rate of industrial land is notably highest (12.5% per annum) among the various land uses. Land use change is generally regarded as one of the major determinants of environmental impacts on the surroundings. The impacts on the land use pattern brought about through the industrial development and the residential development in the study area should be more carefully reviewed than the other sectors.

Future Demand for Urban Development Land in Ha Long City

No.	Types of Land	Phase I: 193-2000			Phase II: 2000-010			Phase III: After 2000		
		Area (ha)	%	Average (m^2/capita)	Area (ha)	%	Average (m^2/capita)	Area (ha)	%	Average (m^2/capita)
I	Civil land	636	51.8	30.3	1,425	42.5	36.5	2,458	47.1	43.5
1	Housing	420	33.9	20.0	820	24.3	21.0	1,300	25.0	23.0
2	Public construction	48	.9	2.3	78	2.3	2.5	141	2.7	2.5
3	Park-green space	84	6.8	4.0	234	6.9	6.0	565	10.9	10.0
4	Road - plaza	84	6.8	4.0	293	8.7	7.5	452	8.7	8.0
II	Non-civil land	604	48.7	28.0	1,956	57.5	50.2	2,748	52.9	48.6
1	Office	3	4.3	2.5	90	2.7	2.3	112	2.2	2.0
2	Educational facilities	11	0.9	1.0	39	1.3	1.0	65	1.2	1.2
3	Industry & small-scale industry	170	13.7	8.1	865	25.9	22.2	1,250	24.0	22.1
4	Warehouse	70	5.6	3.3	150	4.4	3.9	170	3.3	3.0
5	Port	185	14.9	8.8	462	13.7	11.9	650	13.1	12.0
6	Tourism land (except islands & mountains)	115	9.2	5.0	350	10.3	7.5	471	9.0	7.2
	Total (I + II)	1,240	100.0	59.0	3,381	100.0	86.6	5,206	100.0	92.1

Source: Development Master Plan of Ha Long City for 1994-2010, 1994

(5) Urban and Infrastructure Development

1) Industrial area development

Major industrial area developments will be concentrated around Bai Chay bay, in particular in the coastal area along the southwest, west and north of the estuary. One of the major projects is Cua Luc industrial area development which includes the following:

- Cai Lan port and port-related facilities (200 ha - 300 ha)
- Cai Lan industrial concentrated zone (100 ha)
- Ha Long shipyard area (existing, 60 ha)
- Construction material (brick and tile) industrial area (existing, 80 ha)
- Dong Dang concentrated industrial zone (150 ha)
- Hi-tech industrial zone (150 ha)
- Cement factory area (Lang Bang, Hoanh Bo district, 180 ha)
- Port of cement shipment and other small ports in the bay.

2) Tourism development area

The major tourism development area will be extended in the west of Ha Long city from Bai Chay to Hung Than, Yen Cu Dai Dan, and Yen Lap lake. A new complex of hotels, villas, commercial and business facilities will be constructed in Hung Thang.

3) Residential development area

The major residential developments are in the following four areas: i) East Hong Gai area, ii) Hung Thang and Kenh Dong area, iii) Dong Dang residential area, and iv) Troi - Le Loi residential area.

4) Urban central area development

The provincial political center will be located at the Coc 8 in the eastern Hong Gai central area. The main central business area will continuously concentrate in the adjacent area to the existing Hong Gai market and form a commercial complex. Furthermore, the site of the old Hong Gai coal screening plant with warehouses will be redeveloped for a main city business center. A new urban center of Ha Long city will also be developed in Hung Thang and the center will include a culture center with theaters, movies, a main library, museums, exhibition halls, etc.

5) Hong Gai coal industry area development

The master plan suggests limiting further exploitation of coal in Hong Gai area for the harmonious development with the tourism industry and conservation of the nature in Ha Long bay. The tunnel-digging method is recommended for further expansion of mining activities in the area. In addition, the opening of Nam Ha Tu new coalmines is requested to be reconsidered.

6) Transportation

Road

The major objectives are to improve and upgrade existing roads, and to construct new roads for increasing the road density and speed-up of the traffic in the area. The major projects are as follows:

- National Highway No.18

  The section of road in the city will be improved and upgraded. In particular, in the section from Bieu Nghi to Dai Dan a separator of bicycles and motor vehicles will be constructed. The width of section in the Hung Thang new residential area will be widened up to 45 m for the tourism industry and be equipped with a lighting system and a combined service duct of optical fiber cables and other pipes.

- Cua Luc bridge

  A suspension bridge will be constructed across the Cua Luc strait.

Railway

The major projects are as follows:

- The 1.435 m rail gauge of the national railway from Kep to Ha Long will be changed to a 1 m gauge.
- The 5 km extension from the Ha Long station to Cai Lan port with 1 m gauge will be implemented.
- Two lines of the coal transport railway between the coal mines and Hong Gai port will be removed after the function of Hong Gai port moves to Nam Cau Trang port.

Port

The following ports will be improved or expanded: Cai Lan port, Hong Gai port, Sa To, and Nam Cau Trang. The master plan predicts that the total capacity of the ports in Ha Long city will reach 30-35 million tons/year.

Airport

Construction of a new airport at Minh Thanh quarter, Yen Hung district is recommended in the master plan. According to the Provincial Department of Planning and Investment, in the first phase a domestic airport with a 1,800m long runway is constructed and in the second phase it is expanded into an international airport. Implementation of a technical study will be approved by the government in near future. The development priority seems to be relatively low at present, however.

7) Electricity

The future demand is forecasted to grow rapidly not only in the industrial sector, but also in the civic sector. The total demand will become over sevenfold larger in 2010 than in 2000. The planning targets of electricity supply per capita in Ha Long city are 77 W in 2000 and 330 W in 2010. Responding to the increasing future demand, the National Electricity Development Plan - Phase III identified the following projects for Quang Ninh province and Ha Long city in particular.

- Expansion of Pha Lai thermal power plant (the capacity will reach from 400 MW to 800 MW)
- Construction of a thermal power plant with a capacity 1,200 MW (4 x 300 MW) in Quang Ninh province.

Future Demand for Electricity in Ha Long City

(Unit: MW)

Sector	Phase 1:2000	%	Phase 2:2010	%
Civil	13.2	25.6	132	36.6
Industry	35.96	69.7	210.96	58.6
Reserve	2.45	4.7	17.1	4.8
Total	51.61	100.0	360.06	100.0

Source: Development Master Plan of Ha Long City for 1994-2010, 1994

At present, the expansion of Pha Lai is under construction with the financial assistance from OECF. As for a new coal thermal power station, the US company,

OXBOW is now preparing a BOT (Build, Operate and Transfer) scheme project (capacity: 300 MW). The location of the site is in Vu Oai in Hoanh Bo.

5.3 Current Trend of Development Activities in the Study Area

The major development projects have been identified and some of them have already been implemented based on the general direction defined by the master plan. Generally speaking, however, the implementation schedule tends to be delayed and, furthermore, the project sizes to become smaller in some cases because of the recent international and, consequently, domestic economic turmoil. The latest list of major development projects (Table 5.3.1) has been compiled through interviews with and hearings from the relevant provincial and national agencies. It shows which development projects are scheduled to be implemented by 2010 at present or will be surely in near future.

5.4 Setting Future Socioeconomic Framework

The socioeconomic development frame defines the fundamental conditions of the environmental management plan. At the beginning stage of the Study, the development frame planned by QNPC was granted to be a given condition for the EMP preparation. However, it is revealed that the existing development frame needs to be partly adjusted, responding to the current change of investment circumstances, results of the EIAs of the concrete projects, etc. In particular, the frame concerning the major development projects needs to be adjusted, i.e., their development scales and schedules.

5.4.1 Population, Employment, and Land Use

The future total population of Ha Long city and Cam Pha town and the change of administrative boundary in the study area are directly adopted from the development master plan of Ha Long city. The population of sub-districts is forecasted based on each sub-district's recent growth rate, as shown in Table 5.4.1. The total population of the year 2010 of the master plan is used as a control total for estimation of the future consolidated Ha Long City. In addition, the following

items, which are already reviewed in the previous sections, are also adopted from the development master plan of Ha Long city. They are:

- the employment change by development phase (Table 5.4.2),
- the economic potential, future production and labor force demand by major industry (Table 5.2.1), and
- the future demand for urban development land in Ha Long city (Figure 5.2.1).

5.4.2 Tourism

The tourism development frame of Quang Ninh province is adopted as a basic frame for the EMP preparation. The number of international visitors to Ha Long is adopted directly from the provincial frame. On the other hand, the average share of domestic visitors in the study area recently accounts for 67.2% of the visitors to the province. This figure is used for the estimation of domestic visitors to Ha Long.

Estimation of Number of Visitors to Ha Long Bay

(Unit: 1,000 visitors)

Item	Month	2000	2005	2010
International	-	300	350	800
Domestic	-	269	336	605
Total	-	569	586	1,405
International	June	30	34	79
	July	30	35	80
Domestic	June	27	33	60
	July	27	34	61

Source: Estimates by the JICA Study Team based on the data from the Department of Tourism, Quang Ninh

5.4.3 Estimation of Sizes of the Major Industrial Development Projects in the Study Area

The industrialization and relevant infrastructure development are regarded as one of possible environmental threats in the study area. The size of the major industrial development projects is one of the crucial factors determining their degree of environmental impacts. For the further steps of the EMP preparation, the sizes of the major projects are estimated as follows:

The estimation is based on location unit per site area of factory building by industry. As data on location unit is currently not available in Vietnam, the

Japanese data are substitutionally adopted for the estimation. The average data from 1977 to 1995 are employed here, because the latest Japanese data may not be directly applicable to the study area and the average data minimize the fluctuation of data in the observation period. However, the data on drainage water are the latest, as the average is not available.

Location Unit per Site Area of Newly Constructed Factories from 1977 to 1996 in Japan

Period	1977 – 1996				1995
Industry	Building Space	Floor space	Employees (pers./ha)	Fresh water Consumption (m^3/day/ha)	Ratio of Drainage to Consumed Fresh Water (%)
Grain milling	0.291	0.412	37	368	48
Edible oil manufacturing	0.263	0.328	20	353	6
Electromechanics	0.184	0.273	79	532	16
Garment	0.240	0.306	123	392	44
Precision instrument	0.196	0.280	68	490	23
Packaging	0.309	0.368	38	198	50
Toy	0.161	0.202	42	476	21
Tile and Brick manufacturing	0.231	0.345	19	12	46
Ship building	0.206	0.243	39	730	15
Cement factory	0.114	0.126	17	343	18

Source: Japan Industrial Location Center, Survey on Industrial Location Unit, 1998

The sizes are estimated by using the data on location unit and the site areas of the major industrial development projects such as Cai Lan concentrated industrial park, Hoanh Bo industrial park, Hoanh Bo cement factory, and Ha Long shipyard. The results are shown in the Supporting Report.

5.5 Regional Development and its Environmental Impacts

5.5.1 Possible Environmental Impacts and Mitigation Measures by Development Project

Regional development projects may cause impacts on environment in the study area through, for example, increase of wastewater and solid wastes, and change of land uses including land reclamation on tidal flats. It should be noted that the impacts caused by the land reclamation on tidal flats and mangrove swamps are significant due to the decrease in their water purification function as well as impacts on aquatic ecosystem. Based on the nature of their impacts on

environment, planned projects can be classified into the following three categories and their combination.

- projects which discharge pollution loads and/or solid wastes into the environment,
- projects which reclaim mangrove area or tidal flat, and
- projects which bring about deforestation and subsequent sediment runoff.

Possible environmental impacts, which may be brought by the future development projects, are shown in Table 5.5.1. Expected necessary countermeasures for the future development projects are shown in Table 5.5.2. Detailed and concrete countermeasures of each development project should be established in the course of each EIA.

5.5.2 Environmental Impacts by Future Socioeconomic Development

(1) Present Progress of Countermeasures

The following environmental measures are set for the future water quality projection, namely "without an Environmental Management Plan" (Scenario I, see Chapter 5.5). The measures were selected from the current progress of environmental controls including planned measures which will have been done by 2010.

- Sewage construction and management project in the Bai Chay area,
- First stage of Ha Long City Water Supply and Sanitation Project (HWSSP),
  - Construction of Gien Day and Deo Sen wastewater treatment plants,
  - Drainage improvement in Hong Gai area,
  - Upgrade of solid wastes collection up to 65% in Ha Long city and 50% in Cau Pha town,
- Present practices of sanitation improvement,
- Wastewater treatment to attain effluent standards for industrial development projects including mining from now on,

- Present reforestation activities, and
- Present pollution control for coal mining activities by VINACOAL.

(2) Future Environment in the Ha Long Bay Area

The projected future water quality "without an Environmental Management Plan" by the developed simulation model is shown in Figure 5.5.1~2.

In case of COD_{Mn}, it was estimated to increase from 4 mg/ℓ to 5 or 6 mgℓ in the upper layer in Bai Chay bay. The increase in COD_{Mn} will be most pronounced in the coastal area form Tuan Chau to Hong Gai areas, and it will extend out to the World Heritage core area. The increased bare areas by the development activities, especially coal mining activities, lead to increase in SS runoff and soil erosion.

Solid wastes generation in the Ha Long bay area in 2010 is expected to be four times as much that of the present. The generated solid wastes can not be collected and disposed well by the present progress of the countermeasures. This situation results in deterioration of water quality as well as sanitation condition, and destruction of landscape.

Land reclamation will decrease in tidal flats and/or mangrove swamps. It is likely that the losses of tidal flats and management swamps lead to decrease water purification capacity, and habitats for fish and shellfish as well as ecosystem in the bays.

Therefore, the present progress of environmental controls is not enough to prevent water quality deterioration and destruction of environmental resources in the Ha Long bay area. Without proper countermeasures, it is possible that the future socioeconomic development would have negative impacts upon the development itself (see Figure 5.5.2).

TABLES

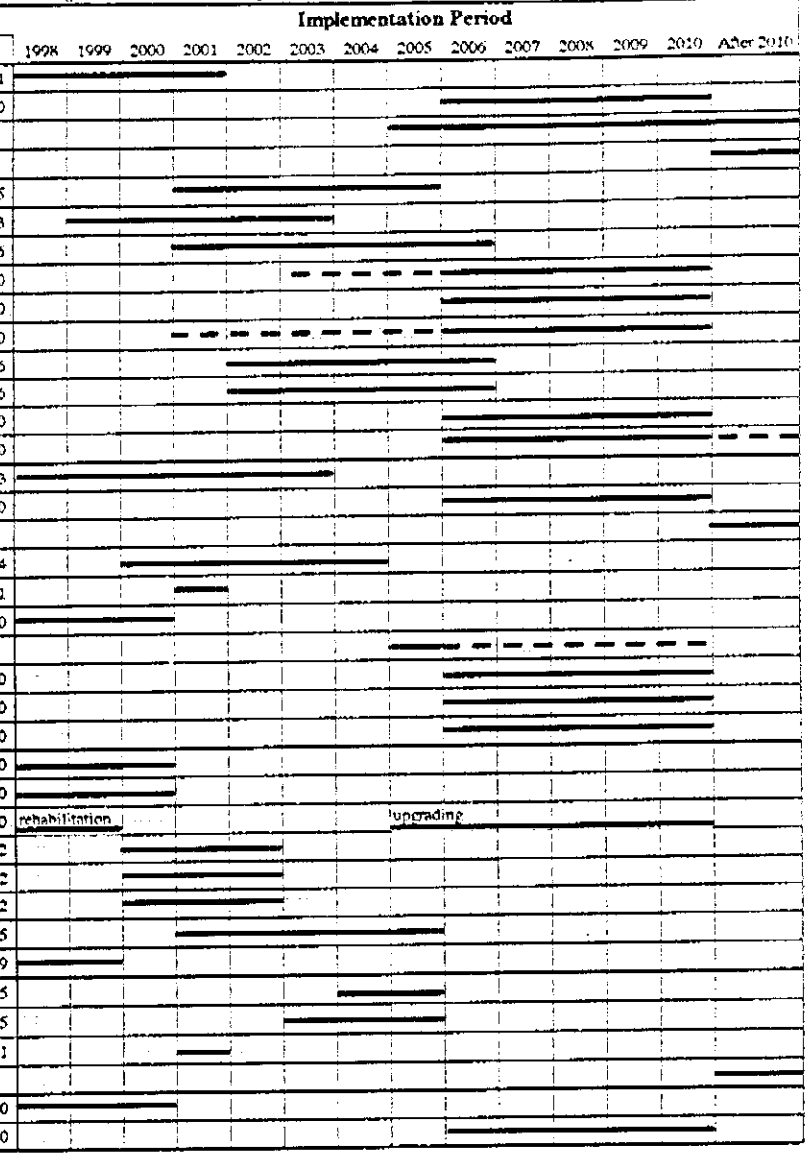
Table 5.2.1 Economic Potential and Future Production by Major Industry

Industry	Potential	1993	Phase I	Phase II	Phase III
Existing Ha Long City Area					
Coal mining (Hong Gai area)	-	1 mil. tons/yr	1.4 mil. tons/yr	1.8 mil. tons/yr	≦1 mil. tons/yr.
Brick	73 × 10^6 m^3 clay	60 mil. bricks/yr.	300 mil. bricks/yr.	400 mil. bricks/yr.	500 mil. bricks/yr.
Tile	-	6.3 mil. tiles/yr.	-	-	-
Cai Lan IP (industrial park)	100-15 ha	-	-	-	-
Ship building & Reporting	2 factories (Ba Lan, Ha Long)	1-35,000 dwt ships + lighters	3-50,000 dwt	4-60,000 dwt	≧60,000 dwt
Port Industry					
(B12 oil port)	-	0.8 mil. tons/yr.	≧0.8 mil. tons/yr.	≧0.8 mil. tons/yr.	removed
(Sa To port)	-	0.35 mil. tons/yr.	0.35 mil. tons/yr.	0.4 mil. tons/yr.	-
(Hong Gai port)	coal export port, transforming to a tourism port	1.5 mil. tons/yr.	1.5 mil. tons/yr.	1.5-3 mil. tons/yr.	≦3 mil. tons/yr.
(Cai Lan port)	deepwater port	-	4-5 mil. tons/yr.	7-15 mil. tons/yr.	15-20 mil. tons/yr.
Coal screening plant	-	500 tons/h	500 tons/h	removal	removal
Mechanical industry	-	38 vehicles/day	38 vehicles/day	50 vehicles/day	200 vehicles/day
Tourism	-	2,500 beds	5-7,000 beds	10-14,000 beds	23,600 beds
Expansion of City Area to Hoanh Bo District in the 2nd phase					
Cement factory	2.5 bil. tons of limestone	5,000 tons/yr	-	4-5 mil. tons/yr	10-12 mil. tons/yr
Hi-tech IP (Le Loi commune)	150 ha	-	-	-	-
Dong Dang IP	150 ha	-	-	-	-
Expansion of City Area to Cam Pha in the 3rd Phase (after 2010)					
Coal mining (Cam Pha area)	identified reserves: 2 bil. tons	2.5 mil. tons/yr	-	-	4.09 mil. tons/yr
Cement factory	-	-	-	-	82 thou. tons/yr
Cua Ong coal screening plant	coal screening for the whole area	500 tons/hour	-	-	700-900 tons/hour
Coal + other goods export port	deepwater port for over 10,000 dwt ships	2.5 mil. tons/yr	-	-	2.5-3.5 mil. tons/yr
Mining Equipments Mechanical Industry	2 units	2.7 tons/hour	-	-	3-5 tons/hour
Central mechanical factory	automobile for coal mining	44,000 tons/yr	-	-	50-80 thou. tons/yr
Automobile repair	2 units	700-1,000 cars/yr	-	-	1,000-1,500 cars/yr

Source: Development Master Plan of Ha Long City for 1994-2010, 1994

Table 5.3.1 Adjusted List of Major Development Projects in the Study Area

Sector		project	Location	Area (ha)	Implementation Period From	To
Industry	1	Cai Lan Concentrated Industrial Park Phase I	Cai Lan	78	Ongoing	2001
		Cai Lan Concentrated Industrial Park Phase II	Cai Lan	300	2005	2010
	2	Hoanh Bo Industrial Park (renamed from Dong Dang IZ)	Dong Dang, Troi	300	2005	
	3	High-tech Industrial Park	Le Loi - Hoanh Bo	300	After 2010	
	4	Expansion of brick and tile factory	Gieng Day, Hoanh Bo		2001	2005
	5	Expansion of ship building factory	Gieng Day		1999	2003
	6	Coal burned thermal power station (300MW), BOT by OXBOW	Vu Oai - Hoanh Bo		2001	2006
	7	Coal burned thermal power station (300MW)	Bridge no. 20 - Cua Ong	50-60	2006	2010
	8	Steel refinery (1.5mil. t/year)	Bridge no. 20 - Cua Ong		2006	2010
	9	Steel mill (0.5mil. t/year)	Cai Lan		2006	2010
	10	Hoan Cau - Taiwan cement	Lang Bang - Hoanh Bo		2002	2006
	11	Hai Long - South Korea cement	Lang Bang - Hoanh Bo		2002	2006
	12	Cement Factory	Thong Nhat - Hoanh Bo		2006	2010
	13	Cement Factory	Quang Hanh - Cam Pha		2006	2010
Transport	14	Cai Lan port -Phase I Stage1 (3 berths)	Cai Lan		1998	2003
		Cai Lan port -Phase I Stage2 (4 berths)	Cai Lan		2006	2010
		Cai Lan port -Phase II	Cai Lan		After 2010	
	15	Bai Chay Bay bridge	Cua Luc		2000	2004
	16	Relocation of Hong Gai port	Hong Gai		2001	2001
	17	Improvement of B12 oil port	Bai Chay		Ongoing	2000
	18	Relocation of B12 oil port			2005	
	19	Nam Cou Trang coal port	Nam Cou Trang		2006	2010
	20	Dien Vong River bridge	Ha Khanh		2006	2010
	21	Bieu Nghi air port	Bieu Nghi		2006	2010
Road	22	Improvement of 18A (Hong Gai - Cua Ong)			Ongoing	2000
	23	Improvement of 18A (Chi Linh - Bai Chay: 35km-118km)			Ongoing	2000
	24	Improvement of 18A (Cua Ong - Mong Cai)			Ongoing	2010
	25	Improvement of 18B (Dong Dang - Lang Bang)			2000	2002
	26	Improvement of Troi - Lang Bang (Hoanh Bo)			2000	2002
	27	Improvement of Hong Gai - Ha Khanh (Dien Vong River)			2000	2002
	28	Highway (Noi Bai - Ha Long)			2001	2005
	29	Causeway and Bridge to Tuan Chau Island	Tuan Chau		Ongoing	1999
Railway	30	Extension (Ha Long - Cai Lan, 4km)	Bai Chay		2004	2005
	31	Improvement (Kep - Ha Long)			2003	2005
	32	Removal of Coal Transport Railway (Hong Gai - Ha Tu)			2001	2001
	33	Coal Transport Railway (Mong Duong - Lang Bang)	along Road 18B		After 2010	
Others	34	Land Reclamation Hung Tang I	Hung Tang	30	Ongoing	2000
	35	Land Reclamation Hung Tang II	Hung Tang	170	2006	2010



Note: The dotted line indicates a possible advanced or delayed implementation peoriod.

Table 5.4.1 Forecast of Population by Subdistrict in the Study Area

No.	Subdistrict	1996	1997	2000	2005	2010
Ha Long						
1	Hong Gai	7,611	na	10,398	13,831	17,246
2	Bach Dang	10,039	na	14,333	20,859	27,385
3	Yet Kieu	6,235	na	8,616	11,738	14,860
4	Tran Hung Dao	7,536	na	10,248	13,619	16,990
5	Cao Xanh	13,262	na	20,114	31,215	42,316
6	Cao Thang	14,126	na	20,821	30,819	40,817
7	Ha Lam	7,677	na	9,771	11,486	13,201
8	Ha Trung	5,939	na	7,833	9,863	11,893
9	Ha Tu	9,524	na	13,195	18,275	23,355
10	Ha Phong	8,690	na	11,913	16,006	20,100
11	Ha Khanh	5,093	na	6,801	8,820	10,839
12	Hong Ha	9,674	na	13,588	19,288	24,989
13	Hon Hai	9,554	na	14,092	20,794	27,496
14	Bai Chay	12,676	na	19,017	28,895	38,773
15	Gieng Day	9,151	na	12,883	18,070	23,256
16	Ha Khau	8,311	na	11,709	16,209	20,708
17	Hung Thang	3,517	na	4,668	6,626	8,583
18	Tuan Chau	1,461	na	1,681	1,743	1,806
	Subtotal	150,076	na	211,681	298,156	384,632
Hoanh Bo		(shaded subdistricts are consolidated to Ha Long city)				
1	Troi	na	7,344	7,627	12,401	17,174
2	Dai Yen	na	7,482	8,505	9,117	9,669
3	Son Duong	na	4,096	4,295	4,908	5,521
4	Viet Hung	na	8,506	9,754	10,415	11,076
5	Le Loi	na	4,385	4,544	5,081	5,618
6	Thong Nhat	na	7,142	7,572	8,839	10,106
7	Vu Oai	na	1,118	1,196	1,419	1,642
	Subtotal	na	40,073	43,553	52,179	60,806
Yen Hung						
1	Minh Thanh	na	9,840	10,630	12,596	14,502
	Total 1	na	na	255,234	350,336	460,000
Cam Pha						
1	Cam Thinh	7,854	na	8,290	8,772	9,254
2	Quang Hanh	15,281	na	17,244	21,427	25,611
3	Cam Dong	9,254	na	9,876	10,444	11,013
4	Cam Son	11,217	na	12,365	13,906	15,447
5	Cam Phu	14,687	na	15,910	17,701	19,492
6	Cua Ong	13,724	na	14,063	14,811	15,559
7	Cam Tay	7,949	na	8,021	7,797	7,574
8	Cam Thuy	8,142	na	8,594	9,022	9,451
9	Cam Thanh	8,077	na	9,039	9,909	10,779
10	Cam Thach	9,602	na	10,179	11,391	12,603
11	Cam Binh	6,234	na	6,865	7,711	8,557
12	Cam Trung	12,896	na	14,892	18,207	21,522
13	Mong Duong	10,478	na	11,217	11,974	12,732
14	Cong Hoa	2,428	na	2,661	2,924	3,187
15	Cam Hai	1,296	na	1,270	1,184	1,099
16	Duong Huy	2,694	na	2,816	3,091	3,365
	Subtotal	141,813	na	153,300	170,273	187,245
	Total 2 (14 & 15 excluded)	138,089	na	149,370	166,164	182,959
Study Area Total (1+2)			na	415,233	529,096	642,959

Notes: 1) The shaded subdistricts in Cam Pha are not included in the study area.
2) The population of Cat Hai commune (15,741 in 1994) in Cat Ba island is not included here because of data shortage at this stage of the study.
3) Estimation was based on the Development Master Plan of Ha Long City for 1994-2010, 1994
na : Not available

Table 5.4.2 Estimation of Employment Change by Development Phase

No.	Industry	1993-2000	2001-2010	After 2010
I.	Sector I	780	4,600	19,600
1	Agriculture & Fishery	-100	1,700	400
2	Forestry	180	300	800
3	Mining	700	2,600	18,400
II.	Sector II	8,100	107,650	19,700
4	Manufacturing	5,400	99,200	14,400
5	Construction	2,550	8,000	5,000
6	Other Products	150	450	300
III.	Sector III	17,728	51,710	54,400
7	Transport, post and communication services	8,000	18,000	8,100
8	Commerce, tourism	8,200	23,400	22,000
9	Housing & public service	40	2,700	1,300
10	Scientific research (R&D)	40	560	500
11	Education service	970	2,000	6,500
12	Culture, art, sports	420	0	12,100
13	Health & social services	100	3,500	1,500
14	Public administration	0	800	700
15	Financial service	0	550	1,500
16	Others	280	200	200
	Total	26,608	163,960	93,700

Source: Development Master Plan of Ha Long City for 1994-2010, 1994

Table 5.5.1 Expected Environmental Impacts Caused by the Future Development Projects

Sector		Project	Location	Possible Environmental Impacts		
				Pollution Load Discharge	Reclamation of Mangrove Area or Tidal Flat	Deforestation and Sediment Runoff
Industry	1	Cai Lan Concentrated Industrial Park Phase I	Cai Lan	A	X	C
		Cai Lan Concentrated Industrial Park Phase II	Cai Lan	A	X	C
	2	Hoanh Bo Industrial Park (renamed from Dong Dang IP)	Dong Dang, Troi	A	B	C
	3	Expansion of brick and tile factory	Gieng Day, Hoanh Bo	B	X	C
	4	Expansion of ship building factory	Gieng Day	B	X	C
	5	Coal burned thermal power station (300MW)	Vu Oai - Hoanh Bo	A	B	C
	6	Coal burned thermal power station (300MW)	Bridge no. 20 - Cua Ong	A	B	C
	7	Steel refinery (1.5mil. t/year)	Bridge no. 20 - Cua Ong	A	X	C
	8	Steel mill (0.5mil. t/year)	Cai Lan	A	X	C
	9	Hoan Cau - Taiwan cement	Lang Bang - Hoanh Bo	B	B	C
	10	Hai Long - South Korea cement	Lang Bang - Hoanh Bo	B	B	C
	11	Cement Factory	Thong Nhat - Hoanh Bo	B	X	C
Trans-port	12	Cai Lan port Phase I Stage1 (3 berths)	Cai Lan	C	C	C
		Cai Lan port Phase I Stage2 (4 berths)	Cai Lan	C	C	C
		Cai Lan port Phase II	Cai Lan	C	C	C
	13	Bai Chay Bay bridge	Cua Luc	X	X	C
	14	Relocation of Hong Gai port	Hong Gai	P	C	C
	15	Improvement of B12 oil port	Bai Chay	P	C	C
	16	Relocation of B12 oil port	(Not Available)	P	P	C
	17	Nam Cou Trang coal port	Nam Cou Trang	C	C	C
Road	18	Improvement of 18A (Hong Gai - Gua Ong)	(Not Available)	X	X	B
	19	Improvement of 18A (Chi Linh - Bai Chay: 35km-118km)	(Not Available)	X	X	B
	20	Improvement of 18A (Hong Gai - Mong Cai)	(Not Available)	X	X	B
	21	Improvement of 18B (Dong Dang - Lang Bang)	(Not Available)	X	X	B
	22	Improvement of Troi - Lang Bang (Hoanh Bo)	(Not Available)	X	C	C
	23	Improvement of Hong Gai - Ha Khanh (Dien Vong River)	(Not Available)	X	X	B
	24	Causeway and Bridge to Tuan Chau Island	Tuan Chau	X	A	C
Railway	25	Extension (Ha Long - Cai Lan, 4km)	Bai Chay	X	X	C
	26	Improvement (Kep - Ha Long)	(Not Available)	X	X	C
	27	Removal of Coal Transport Railway (Hong Gai - Ha Tu)	(Not Available)	X	X	C
Others	28	Land Reclamation Hung Tang I	Hung Tang	X	A	B
	29	Land Reclamation Hung Tang II	Hung Tang	X	A	B

Note: A: Relatively high magnitude of impact is expected. B: Relatively medium magnitude of impact is expected. C: Relatively low impact is expected. P: Positive effect is expected. X: There is no direct relation.

Table 5.5.2 Expected Necessary Countermeasures for the Future Development Projects

Sector		Project	Main Indicators to be concerned	Countermeasures
Industry	1	Cai Lan Concentrated Industrial Park Phase I Cai Lan Concentrated Industrial Park Phase II	Water quality (BOD, COD, T-N, T-P, SS) Industrial solid wastes	- Wastewater treatment - Solid wastes management
	2	Hoanh Bo Industrial Park (renamed from Dong Dang IP)	Water quality (BOD, COD, T-N, T-P, SS), Industrial solid wastes, Environmental resources (tidal flats, mangrove swamps, forest)	- Wastewater treatment - Solid wastes management - Site selection to minimize of land reclamation area - Revegetation of denuded areas
	3	Expansion of brick and tile factory	Water quality (SS), Industrial solid wastes	- Wastewater treatment - Solid wastes management
	4	Expansion of ship building factory		
	5	Coal burned thermal power station (300MW)	Water quality (SS), Air quality (Dust), Industrial solid wastes, Environmental resources (tidal flats, mangrove swamps)	- Wastewater treatment - Dust control - Solid wastes management - Site selection to minimize of land reclamation area
	6	Coal burned thermal power station (300MW)		
	7	Steel refinery (1.5mil. t/year)	Water quality (SS), Industrial solid wastes	- Wastewater treatment - Solid wastes management
	8	Steel mill (0.5mil. t/year)		
	9	Hoan Cau - Taiwan cement	Water quality (SS), Air quality (Dust), Industrial solid wastes, Environmental resources (tidal flats, mangrove swamps, forest)	- Wastewater treatment - Dust control - Solid wastes management - Site selection to minimize of land reclamation area - Revegetation of denuded areas
	10	Hai Long - South Korea cement		
	11	Cement factory	Water quality (SS), Air quality (Dust), Industrial solid wastes	- Wastewater treatment - Dust control - Solid wastes management
Trans-port	12	Cai Lan port Phase I Stage1 (3 berths) Cai Lan port Phase I Stage2 (4 berths) Cai Lan port Phase II	Water quality (SS, Oil)	- Wastewater treatment - Pollution prevention measures
	13	Bai Chay Bay bridge	Environmental resources (forest)	- Revegetation of denuded areas
	14	Relocation of Hong Gai port	Water quality (SS, Oil)	- Pollution prevention measures
	15	Improvement of B12 oil port		
	16	Relocation of B12 oil port		
	17	Nam Cou Trang coal port		
Road	18	Improvement of 18A (Hong Gai - Gua Ong)	- Environmental resources (tidal flats, mangrove swamps, forest) - Water quality (SS)	- Route selection to minimize deforestation, land reclamation areas on tidal flats and mangrove swamps - Revegetation of denuded areas
	19	Improvement of 18A (Chi Linh - Bai Chay: 35 -118km)		
	20	Improvement of 18A (Hong Gai - Mong Cai)		
	21	Improvement of 18B (Dong Dang - Lang Bang)		
	22	Improvement of Troi - Lang Bang (Hoanh Bo)		
	23	Improvement of Hong Gai - Ha Khanh (Dien Vong River)		
	24	Causeway and Bridge to Tuan Chau Island		
Railway	25	Extension (Ha Long - Cai Lan, 4km)	- Environmental resources (forest)	- Route selection to minimize deforestation - Revegetation of denuded areas
	26	Improvement (Kep - Ha Long)		
	27	Removal of Coal Transport Railway (Hong Gai - Ha Tu)		
Others	28	Land Reclamation Hung Tang I	- Environmental resources (tidal flats, mangrove swamps)	- Site selection to minimize decrease in mangrove swamps - Minimization of land reclamation area
	29	Land Reclamation Hung Tang II		