TABLES

Table 9.1.1 Studies of Water and Sediment Quality in Bai Chay and Ha Long Bay

Project	Sampling month/year	Proponent/Data Source
1) Cai Lan Port Feasibility Study	12/1992	Department of Hydrology and Meteorology
2) Unknown	01/1993	Centre for Marine Environment, Survey, Research, and Consultation (CMESRC)
3) Cai Lan Port Feasibility Study	02/1994 06/1994	JICA
4) Water Environmental Quality of Ha Long Bay	07/1994	IDRC, VISED, MOSTE
5) Diagnostic Review of State of Coastal and Marine Environment of Gulf of Tonkin	1993	SAREC, MOSTE
6) Water Quality in Ha Long Bay	01/1997	SIDA, MOSTE
7) Pollution Study of Ha Long Bay	07/1997	World Bank, DOSTE

Note: SIDA = Swedish International Development Agency

Table 9.1.2 Water and Sediment Variables of Previous Studies

Physical/Biological	Nutrients	Heavy Metals	Toxics/Pesticides
1. Temperature	1. Total phosphorus (T-P)	1. Lead (Pb)	1. PAH
2. Dissolved oxygen (DO)	2. Phosphate (PO_4-P)	2. Zinc (Zn)	2. Lindane
3. pH	3. Total nitrogen (T-N)	3. Cadmium (Cd)	3. DDT
4. Turbidity	4. Nitrate nitrogen (NO_3-N)	4. Iron (Fe)	
5. Transparency	5. Nitrate nitrogen (NO_2-N)	5. Copper (Cu)	
6. Total suspended solids (TSS)	6. Ammonia nitrogen (NH_4-N)	6. Mercury (Hg)	
7. Salinity	7. Silicate (SiO_2)	7. Arsenic (As)	
8. Conductivity			
9. Total sulphur (TS)			
10. Sulphate (SO_4)			
11. Hydrogen sulphide (H_2S)			
12. Biochemical oxygen demand (BOD)			
13. Chemical oxygen demand (COD)			
14. Bicarbonate (HCO_3)			
15. Total coliform			
16. Fecal coliform			
17. Oil			

Table 9.1.3 Vietnam Environmental Standards for Coastal Water Quality

No.	Parameters and Substance	Unit	Limitation Values		
			Bathing and Recreation Areas	Aquatic Cultivation Area	Others
1	Temperature	°C	30	-	-
2	Odor	-	unobjectionable	-	-
3	pH	-	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5
4	Dissolved Oxygen	mg/ℓ	more than 4	more than 5	more than 4
5	BOD5 (20°C)	mg/ℓ	less than 20	less than 10	less than 20
6	Suspended Solid	mg/ℓ	25	50	200
7	Arsenic	mg/ℓ	0.05	0.01	0.05
8	Ammonia (as N)	mg/ℓ	0.1	0.5	0.5
9	Cadmium	mg/ℓ	0.005	0.005	0.01
10	Lead	mg/ℓ	0.1	0.05	0.1
11	Chromium (VI)	mg/ℓ	0.05	0.05	0.05
12	Chromium (III)	mg/ℓ	0.1	0.1	0.2
13	Chloride	mg/ℓ	-	0.01	-
14	Copper	mg/ℓ	0.02	0.01	0.02
15	Fluoride	mg/ℓ	1.5	1.5	1.5
16	Zinc	mg/ℓ	0.1	0.01	0.1
17	Manganese	mg/ℓ	0.1	0.1	0.1
18	Iron	mg/ℓ	0.1	0.1	0.3
19	Mercury	mg/ℓ	0.005	0.005	0.01
20	Sulfide	mg/ℓ	0.01	0.005	0.01
21	Cyanide	mg/ℓ	0.01	0.01	0.02
22	Phenol compounds	mg/ℓ	0.001	0.001	0.002
23	Oil and fat film	mg/ℓ	none	none	0.3
24	Oil and fat suspension	mg/ℓ	2	1	5
25	Total pesticides	mg/ℓ	0.05	0.01	0.05
26	Coliform number	MPN/100ml	1,000	1,000	1,000

Source: TCVN 5943, 1995

Table 9.1.4 Chemical and Biological Characteristics of Classified Coastal Waters from a Viewpoint of Eutrophication Level

Trophic Level Class / Environmental Parameter	Saprotrophic Water Area (extremely polluted)	Pertrophic Water Area (severely polluted)		Eutrophic Water Area (slightly polluted)	Oligotrophic Water Area (clean)
		Area with a depth of several meters or more	Area with a depth of several meters or less		
WATER QUALITY					
1. Transparency (m)	≤ 3	≤ 3		3 - 10	≥ 10
2. Discoloration	Blackish	Yellow, olive, brownish, etc.		Sometimes temporal and local colouring	No colouring
3. CODMn (ppm)	≥ 10	3 - 10		1 - 3	≤ 1
4. BOD (ppm)	≥ 10	3 - 10		1 - 3	≤ 1
5. DO saturation (%)	0 - 30%; (anaerobic condition from the subsurface layer to sea bottom)	100 - 200%; surface layer (oversaturated) 0 - 30%; bottom layer	100 - 200%; surface layer (oversaturated)	> 80%; surface and middle layer 30 - 80%; deeper layer than several meters	80 - 100% in all layers (saturated)
6. Hydrogen sulphide	Detected at almost layers	Detectable at the bottom layer	Not detectable	Not detectable	Not detectable
7. Inorganic N compounds (μg at. N/ℓ)	≥ 100	10 - 100		2 - 10	≤ 2
BOTTOM SEDIMENT					
1. Colour of mud	Black. Oxidation layer (brownish coloured layer at the surface of mud) not found.	Black. Oxidation layer not found.	Blackish. Oxidation layer found.	Sometimes blackish. Oxidation layer found.	Not blackish. Oxidation layer found.
2. COD (mg/g)	-	> 30		5 - 30	< 5
3. Sulphide (mg/g)	> 1.0	0.3 - 3.0		0.03 - 0.3	< 0.03
ORGANISMS					
1. Bacteria (cells/ml)	≥ 10^5	10^3 - 10^5		10^2 – 10^4	≤ 10^2
2. Phytoplankton (cells/ml)	≤ 10^3	10^3 - 10^5		10^3 - 10^3	≤ 10^2
3. Chlorophyll (mg/m^3)	-	10 - 200		1 - 10	< 1
4. Primary production ($mgC/m^3/hr$)	-	10 - 200		1 - 10	< 1
($gC/m^2/day$)	-	1 - 10		0.3 - 1.0	< 0.3
5. Protozoa	Very high abundance	Considerably high abundance		Low abundance	Low abundance
6. Crustacean zooplankton	-	Low abundance, low diversity		High abundance, high diversity	Low abundance, high diversity
7. Benthic polychaetes worm	Low abundance, low diversity	Low abundance, low diversity	Very high abundance, high diversity	High abundance, high diversity	Low abundance, high diversity
8. Crustacean	-	Low abundance, low diversity		High abundance, high diversity	Low abundance, high diversity
9. Typical water area	The vicinity of sewerage discharge	Enclosed bays with a high pollutant discharge level		Bays and coastal zone with a depth of 30 m or less	Offshore open water areas

Source: Environmental Assessment Handbook for Port Development Projects
The Overseas Coastal Area Development Institute of Japan, 1993

Table 9.2.1 Water and Sediment Variables Measured in the Field Survey

Water Quality Variables		
Temperature	Chemical oxygen demand (COD_{Cr})*	Cyanide (CN)
pH	Chemical oxygen demand (COD_{Mn})	Copper (Cu)
Salinity	Biochemical oxygen demand (BOD)	Lead (Pb)
Dissolved oxygen (DO)	Oil	Zinc (Zn)
Turbidity	Chlorophyll-a*	Cadmium (Cd)
Suspended solids (SS)	Total coliform	Nickel (Ni)
Total dissolved solids (TDS)	Fecal coliform**	Chromium (Cr)
Nitrate nitrogen (NO_3-N)	Manganese (Mn)	Manganese (Mn)
Nitrite nitrogen (NO_2-N)	Phosphate (PO_4-P)	Iron (Fe)
Ammonia nitrogen (NH_4-N)	Total phosphorous (T-P)	Transparency**
Total nitrogen (T-N)	Mercury (Hg)	
Bottom Sediment Quality Variables		
Temperature	Ignition loss (IL)	Arsenic (As)
Composition	Chemical oxygen demand (COD)	Manganese (Mn)
Color	Total organic carbon (TOC)	Mercury (Hg)
Mixed matter	Total nitrogen (T-N)	Zinc (Zn)
Water content	Total phosphorous (T-P)	Chromium (Cr)
pH	Hydrogen sulphide (H_2S)	Cadmium (Cd)
Oxidation-reduction potential (ORP)	Lead (Pb)	

Note: * only in rivers ** only in bays

Table 9.2.2 Environmental Standards for Conservation of the Living Environment (Sea Area)

Classification	Applicable Level	Standard Value				
		Hydrogen Ion Concentration	Chemical Oxygen Demand (COD)	Dissolved Oxygen	Coliform Groups	N-hexane Extracts (grease, etc.)
A	Fishery class-1, bathing, conservation of natural environment and other items listed in B-C	7.8 - 8.3	2mg/ℓ or less	7.5mg/ℓ or more	1,000MPN/ 100ml or less	Must not be detected
B	Fishery class-2, industrial water and other item listed in C	7.8 - 8.3	3mg/ℓ or less	5mg/ℓ or more	–	Must not be detected
C	Environmental conservation	7.0 - 8.3	8mg/ℓ or less	2mg/ℓ or more	–	–

Notes: 1) With regard to the water quality of fishery, class 1 for cultivation of oysters, the number of coliform groups shall be less than 70MPN/100ml.
2) Conservation of natural environment – Conservation of scenic points and other natural resources.
3) Fishery class 1 – for aquatic lives such as red sea-bream, yellow tail, seaweed and for hose of fishery class 2.
Fishery class 2 – for aquatic lives such as gray mullet, laver, etc.
4) Conservation of environment – Up to the limits as which no unpleasantness is caused to the people in their daily lives including a walk along the shore.

Source: Environmental Agency of Japan

Table 9.2.3 General Tropical Guideline

Parameter	Unit	Standard Value
DO	mg/ℓ	≧4
BOD_5	mg/ℓ	≦10
SS	mg/ℓ	≦15
Turbidity	NTU	≦5 to ≦25
PCB	mg/ℓ	≦0.001
Hydrocarbons	mg/ℓ	≦5
Fecal Coliform	MPN/100ml	≦200
T-P	mg/ℓ	≦0.6
Nitrate Nitrogen (NO_3-N)	mg/ℓ	≦0.5

Source: General Tropical Guideline, Clark, 1996

Table 9.2.4 Permissible Limits for Offshore and Onshore Dumping of Dredged Materials

Substance	Offshore Dumping		
	Canada (ppm)	USA (ppm)	Japan (mg/ℓ)[3]
Mercury and its compounds	0.75	0.15	0.005
Cadmium and its compounds	0.6	0.7	0.1
Lead and its compounds	45	33	1
Chromium (IV) compounds	-	-	0.5
Arsenic and its compounds	5-25	12.5	0.5
Cyanogen compounds	-	-	1
Copper and its compounds	45	68	1
Zinc and its compounds	169	105	-
Polyaromatic hydrocarbon	1,000 ppb[1]	680 LMW[2] 2,690 HMW[2]	-

Notes: 1. Sum of 16 compounds
2. Sum of 6 low molecular weight (LMW) compounds; sum of 10 high molecular weight (HMW) compounds.
3. Contaminant concentration in dredged material usually is expressed in micrograms per kilogram (μg/kg) dry weight. The Japanese criteria uses contaminant concentration in micrograms per litre (μg/L) when calculating the necessary dilution factor for the dredged material. To convert the contaminant concentration reported on a dry-weight basis to the contaminant concentration in the dredged material, the dry-weight concentration must be multiplier by the mass of dredged-material solids per litre of dredged material.

Source: Modified from United Nations Economic and Social Commission for Asia and the Pacific, 1992.

Table 9.2.5 Vietnam Standard for Inland Water Quality

Parameter and Substance	Unit	Limitation Value	
		A	B
pH value		6 – 8.5	5.5 – 9
BOD_5 (20°C)	mg/ℓ	<4	<25
COD	mg/ℓ	<10	<35
Dissolved oxygen	mg/ℓ	>=6	>=2
Suspended solids	mg/ℓ	20	80
Arsenic	mg/ℓ	0.05	0.1
Barium	mg/ℓ	1	4
Cadmium	mg/ℓ	0.01	0.02
Lead	mg/ℓ	0.05	0.1
Chromium, Hexavalent	mg/ℓ	0.05	0.05
Copper	mg/ℓ	0.1	1
Zinc	mg/ℓ	1	2
Manganese	mg/ℓ	0.1	0.8
Nickel	mg/ℓ	0.1	1
Iron	mg/ℓ	1	2
Mercury	mg/ℓ	0.001	0.002
Tin	mg/ℓ	1	2
Ammonia (as N)	mg/ℓ	0.05	1
Fluoride	mg/ℓ	1	1.5
Nitrate (as N)	mg/ℓ	10	15
Nitrite (as N)	mg/ℓ	0.01	0.05
Cyanide	mg/ℓ	0.01	0.05
Phenol compounds	mg/ℓ	0.001	0.02
Oil and grease	mg/ℓ	not detectable	0.3
Detergent	mg/ℓ	0.5	0.5
Coliform	MPN/100mg	5000	10000
Total pesticides (except DDT)	mg/ℓ	0.15	0.15
DDT	mg/ℓ	0.01	0.01
Gross alpha activity	Bq/ℓ	0.1	0.1
Gross beta activity	Bq/ℓ	1.0	1.0

Note: - Values in the column A are applied to the surface water using for source of domestic water supply with appropriate treatments.
- Values in the column B are applied to the surface water using for the purposes other then domestic water supply. Quality criteria of water for aquatic life are specified in a separate standard.

Source: TCVN 5942, 1995

Table 9.2.6 Water Quality in the Bays by the Field Survey (1/2)

No.	Layers	Depth m	Temp. °C	Trans. m	pH -	Salinity o/oo	DO mg/l	DO Sat. %	BOD mg/l	CODMn mg/l	COD/ BOD	SS mg/l	Turbidity FTU	T-N mg/l	NH4-N mg/l	NO2-N mg/l	NO3-N mg/l	I-N mg/l	O-N mg/l	T-P mg/l	PO4-P mg/l	O-P mg/l	T-N/ T-P	Chl-a mg/m³	Oil mg/l
1	Upper	0.5	32	1.4	7.9	15	6	83.7	1.1	10	9.1	4.2	7	1.92	0.32	0.017	0.11	0.45	1.47	0.96	0.004	0.956	2.00	2.40	7.20
(9.1m)	Lower	8.1	31		8.1	20.5	4	25.8	1.5	7	4.7	14.9	13	2.53	0.19	0.020	0.10	0.31	2.22	0.52	0.003	0.517	4.87	3.30	6.80
2	Upper	0.5	32	1.4	8.2	16.5	5.9	63.3	1.1	7.2	6.5	1.5	6	1.28	0.26	0.015	0.10	0.38	0.91	0.72	0.007	0.713	1.78	2.60	3.40
(2.4m)	Lower	1.4	31.9		8.2	17.5	4.5	41.7	1.4	7.4	5.3	4	7	1.86	0.28	0.015	0.09	0.39	1.48	0.48	0.009	0.471	3.88	2.50	1.00
3	Upper	0.5	31.2	1.8	8.1	14.5	6.8	103.0	1.3	6.4	4.9	1.3	8	1.41	0.27	0.011	0.09	0.37	1.04	0.85	0.009	0.841	1.66	2.40	1.30
(8.8m)	Lower	7.8	31		8.2	20	4	27.1	1.5	7	4.7	1.1	6	1.47	0.16	0.017	0.12	0.30	1.17	0.80	0.005	0.795	1.84	2.60	1.30
4	Upper	0.5	32.5	1.8	8.1	14	6.7	118.5	1.1	7.6	6.9	3.1	9	1.01	0.28	0.009	0.08	0.37	0.64	0.90	0.011	0.889	1.12	2.50	1.90
(19m)	Lower	18	30.5		8.1	24	4.5	21.5	1.9	7.8	4.1	8.6	9	1.51	0.22	0.019	0.06	0.30	1.21	1.18	0.006	1.174	1.28	2.40	1.80
5	Upper	0.5	31.1	0.5	8.2	4.5	4.1	50.7	1.6	5.6	3.5	9.5	20	0.81	0.01	0.032	0.10	0.14	0.67	0.34	0.020	0.320	2.28	2.50	1.40
(3.4m)	Lower	2.4	31.3		8.1	5	3.8	52.0	1.3	5.2	4.0	18.9	22	0.8	0.01	0.034	0.10	0.14	0.66	0.38	0.047	0.333	2.11	2.60	0.70
6	Upper	0.5	30.9	0.6	8.2	5.5	6.2	93.1	1.5	4.8	3.2	27.9	28	1.06	0.03	0.033	0.06	0.12	0.94	0.14	0.051	0.089	7.57	2.90	0.60
(4.1m)	Lower	3.1	30.2		8.1	8	6	198.6	1.7	5	2.9	36.7	28	1.08	0.02	0.039	0.03	0.09	0.99	0.53	0.098	0.432	2.04	3.00	0.40
7	Upper	0.5	30.3	0.6	8.1	14	6.7	111.2	0.9	7.4	8.2	16	14	1.02	0.02	0.008	0.09	0.12	0.90	0.77	0.024	0.746	1.32	2.30	2.00
(2.3m)	Lower	1.3	31.2		8.1	12	7	238.6	1.3	8.5	6.5	16.4	15	1.05	0.02	0.011	0.07	0.10	0.95	0.84	0.031	0.809	1.25	2.30	0.80
8	Upper	0.5	32.3	1.6	8.2	11.5	7.1	332.9	1.7	4.8	2.8	4.4	9	1.56	0.02	0.008	0.05	0.08	1.48	0.29	0.030	0.260	5.38	2.30	1.10
(10.1m)	Lower	9.1	31.1		8.1	25	4.6	20.8	1.8	12.2	6.8	7.8	9	1.99	0.02	0.058	0.05	0.13	1.86	0.41	0.032	0.378	4.85	2.60	0.50
9	Upper	0.5	31	1	8.3	15	6	81.3	1	11.7	11.7	7.9	8	2.14	0.14	0.013	0.06	0.21	1.93	0.75	0.009	0.741	2.85	2.00	2.10
(12.8m)	Lower	11.8	30.9		8.2	21.5	4	23.5	1.1	10.3	9.4	6	8	3.18	0.17	0.005	0.09	0.27	2.92	1.12	0.008	1.112	2.84	2.30	1.20
10	Upper	0.5	31.2	1.6	8.2	15	4.7	64.1	1.5	7.8	5.2	2.5	6	1.21	0.26	0.009	0.10	0.37	0.84	0.94	0.011	0.929	1.29	2.50	1.40
(6.3m)	Lower	5.3	30.9		8.2	19.5	4.4	31.3	0.3	8.6	28.7	4.5	6	1.92	0.23	0.016	0.08	0.33	1.59	1.22	0.005	1.215	1.57	2.50	1.40
11	Upper	0.5	31.3	1.8	8.2	18.5	6.5	52.3	0.9	11.1	12.3	2.2	6	1.62	0.24	0.014	0.09	0.34	1.28	1.12	0.010	1.110	1.45	2.60	4.70
(--.-m)	Lower		31.2		8.2	20	5	34.1	1.9	9.9	5.2	2.7	5	1.98	0.15	0.015	0.09	0.26	1.73	1.24	0.007	1.233	1.60	2.20	2.10
12	Upper	0.5	32.7	1.7	8.2	12	5.8	206.2	1.6	5.6	3.5	2.4	6	1.55	0.02	0.005	0.02	0.05	1.51	0.67	0.144	0.526	2.31	2.40	2.00
(14.6m)	Lower	13.6	30.2		8.1	29	4.4	15.3	1.7	6	3.5	2.8	8	1.88	0.02	0.008	0.03	0.06	1.82	0.35	0.037	0.313	5.37	2.80	0.50
13	Upper	0.5	32.4	2.8	8.2	17	5.1	51.4	1.8	4.8	2.7	1.8	8	0.74	0.06	0.009	0.06	0.13	0.61	0.32	0.228	0.092	2.31	1.90	1.20
(17.7m)	Lower	16.7	30		8.2	30	4.7	15.5	1.9	8	4.2	1.5	9	0.82	0.06	0.025	0.06	0.15	0.68	0.80	0.030	0.770	1.03	2.60	0.40
14	Upper	0.5	31.5	5.6	8.2	24	5.4	26.5	2.6	9.6	3.7	5.2	6	0.45	0.03	0.014	0.05	0.09	0.36	0.36	0.060	0.300	1.25	2.80	0.90
(15.6m)	Lower	14.6	29.6		8.2	31.5	5	15.1	1	6.4	6.4	8.5	9	0.48	0.04	0.021	0.08	0.14	0.34	0.61	0.136	0.474	0.79	2.90	0.40
15	Upper	0.5	31.3	1.8	8.4	15	4.8	65.6	1.7	6.2	3.6	3.2	10	1.65	0.03	0.023	0.06	0.11	1.54	0.73	0.034	0.696	2.26	2.50	0.50
(21.9m)	Lower	20.9	29.5		8.3	30	5.2	16.9	1.6	9.2	5.8	9.6	14	1.26	0.02	0.029	0.06	0.11	1.15	0.88	0.031	0.549	1.43	2.50	0.20
16	Upper	0.5	32.1	2.4	8.3	23	5.8	31.2	2	13.2	6.6	4.3	7	1.4	0.03	0.008	0.02	0.06	1.34	0.43	0.034	0.396	3.26	2.60	0.40
(7.2m)	Lower	6.2	31.7		8.3	24.5	5.8	27.7	1.6	9.8	6.1	4.5	9	1.12	0.02	0.006	0.06	0.09	1.03	0.57	0.060	0.510	1.96	2.70	0.40
17	Upper	0.5	31.6	4.2	8.4	23	4.5	23.9	0.9	4.7	5.2	0.6	8	0.69	0.02	0.012	0.02	0.05	0.64	0.49	0.022	0.468	1.41	2.50	0.30
(6.7m)	Lower	5.7	31.4		8.4	23	4.1	21.6	0.8	5.3	6.6	0.9	9	1.08	0.02	0.008	0.01	0.04	1.04	0.68	0.066	0.614	1.59	2.70	0.30
18	Upper	0.5	31.8	3.4	8.3	22	5.8	33.5	0.9	4.3	4.8	0.4	7	1.87	0.02	0.007	0.03	0.06	1.81	0.40	0.039	0.361	4.65	2.70	0.70
(8.1m)	Lower	7.1	31.8		8.2	23.5	5.7	29.3	0.9	3.3	3.7	0.8	9	2.91	0.02	0.007	0.03	0.06	2.85	0.48	0.025	0.455	6.06	1.80	0.30

Table 9.2.6 Water Quality in the Bays by the Field Survey (2/2)

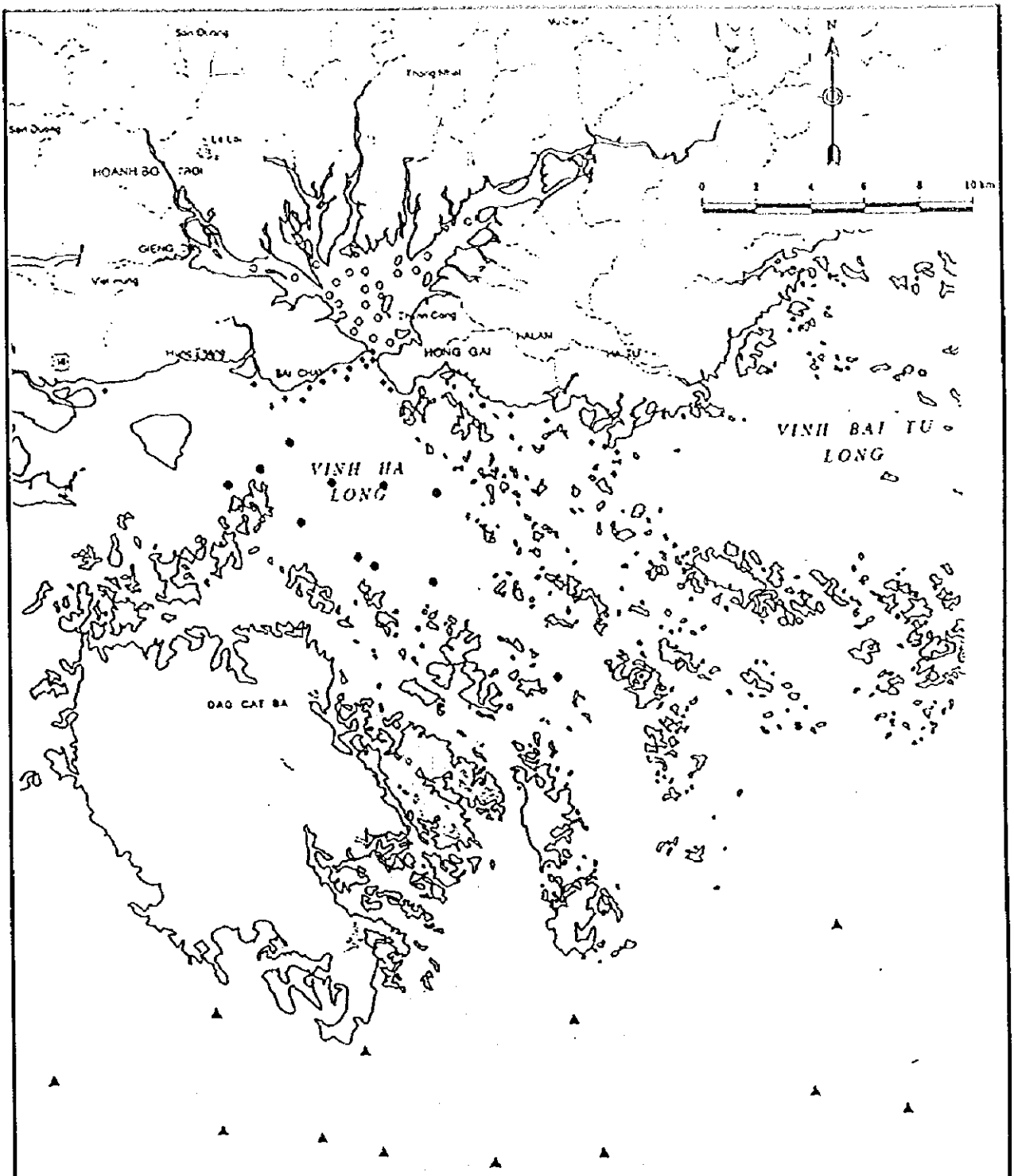
No.	Layers	Depth m	Temp. °C	Trans. m	pH -	Salinity o/oo	DO mg/l	DO Sat. %	BOD mg/l	CODMn mg/l	COD/ BOD	SS mg/l	Turbidity FTU	T-N mg/l	NH4-N mg/l	NO2-N mg/l	NO3-N mg/l	I-N mg/l	O-N mg/l	T-P mg/l	PO4-P mg/l	O-P mg/l	T-N/ T-P	Chlo-a mg/m³	Oil mg/l
19	Upper	0.5	32.2	2.1	8.3	24	6.1	30.6	0.5	4.5	9.0	1	6	0.55	0.02	0.006	0.06	0.09	0.46	0.38	0.023	0.352	1.45	2.50	0.90
(3.6m)	Lower	2.6	32.1		8.2	24	5.9	29.5	0.7	6	8.6	6.5	9	0.89	0.02	0.005	0.07	0.10	0.80	0.40	0.033	0.367	2.23	2.80	0.50
20	Upper	0.5	32	2	8.3	24.5	5	24.0	0.7	3.7	5.3	2.2	9	1.28	0.03	0.007	0.02	0.06	1.22	0.63	0.030	0.600	2.03	2.67	1.20
(4.2m)	Lower	3.2	32		8.3	24.5	4.8	23.1	0.8	3.8	4.8	2.1	11	1.62	0.03	0.008	0.02	0.06	1.56	0.57	0.021	0.549	2.84	2.67	0.80
21	Upper	0.5	32.2	4.2	8.4	20.5	6.2	41.4	0.9	4.5	5.0	0.6	8	1.14	0.02	0.008	0.06	0.09	1.05	0.26	0.023	0.237	4.38	2.90	0.30
(18m)	Lower	17	31.1		8.3	25	5.6	25.4	0.8	3.1	3.9	2.7	10	1.86	0.02	0.001	0.02	0.04	1.82	0.18	0.086	0.094	10.33	2.80	0.30
22	Upper	0.5	31.4	3.1	8.4	22	6.7	38.3	1.7	4.3	2.5	2.5	8	1.11	0.01	0.003	0.09	0.10	1.01	0.49	0.019	0.471	2.27	2.50	0.40
(17m)	Lower	16	30.1		8.2	29.5	4.4	14.9	0.8	3.9	4.9	10.6	12	1.48	0.01	0.004	0.02	0.03	1.45	0.29	0.018	0.272	5.10	2.50	0.30
23	Upper	0.5	31.5	1.6	8.3	14.5	6.7	102.4	1.5	5.1	3.4	4.3	11	0.89	0.01	0.014	0.02	0.04	0.85	0.22	0.023	0.197	4.05	2.80	0.50
(12.5m)	Lower	11.5	29.8		8.2	31.5	5.2	15.8	1.2	3.3	2.8	6.9	14	1.24	0.01	0.008	0.05	0.07	1.17	0.30	0.019	0.281	4.13	2.90	0.80
24	Upper	0.5	32.3	3.5	8.3	22.5	5.9	33.2	0.8	4.5	5.6	0.6	9	1.39	0.01	0.006	0.07	0.09	1.30	0.46	0.026	0.434	3.02	2.90	0.50
(9.5m)	Lower	8.5	31.6		8.3	23.5	5.8	29.6	1.1	4.9	4.5	1	12	2.33	0.01	0.009	0.06	0.08	2.25	0.27	0.030	0.240	8.63	3.00	0.90
25	Upper	0.5	32.1	2.4	8.3	25	6	28.0	1	3.1	3.1	4.8	8	1.85	0.02	0.011	0.02	0.05	1.80	0.82	0.021	0.799	2.26	2.60	0.80
(10.1m)	Lower	9.1	31.3		8.3	25	5.9	26.9	0.9	8.8	9.8	4.9	7	1.97	0.01	0.004	0.01	0.02	1.95	0.72	0.024	0.696	2.74	2.50	0.80
26	Upper	0.5	32.5	2.1	8.1	23	6.3	34.3	1.1	2.9	2.6	1.8	5	1.05	0.04	0.007	0.02	0.07	0.98	0.79	0.017	0.773	1.33	2.50	1.10
(5.7m)	Lower	4.7	31.8		8.2	24.5	5.8	27.7	0.7	3.7	5.3	2.9	6	1.37	0.02	0.009	0.02	0.05	1.32	0.60	0.031	0.569	2.28	2.80	0.50
27	Upper	0.5	32.4	2.2	8.1	15	5.8	31.8	0.9	3.7	4.1	1	5	0.79	0.02	0.009	0.02	0.05	0.74	0.65	0.020	0.630	1.22	2.40	0.70
(7.1m)	Lower	6.1	31.5		8.2	21	5.6	35.0	1	2.9	2.9	1.5	6	0.86	0.02	0.009	0.04	0.07	0.79	0.64	0.017	0.623	1.34	2.50	0.50
28	Upper	0.5	32.1	0.8	8.3	24	3.8	19.0	0.7	3.5	5.0	22.3	19	1.98	0.01	0.006	0.02	0.04	1.94	0.16	0.024	0.136	12.38	2.30	0.30
(0.8m)	Lower																								
29	Upper	0.5	33.1	1	8.1	23	3.8	21.0	0.3	2.5	8.3	8.8	11	2.73	0.01	0.007	0.02	0.04	2.69	0.16	0.018	0.142	17.06	2.80	0.70
(1.1m)	Lower																								
30	Upper	0.5	34.2	0.6	8.2	22.5	4.7	27.8	0.8	3.5	4.4	27.1	23	1.81	0.02	0.008	0.07	0.10	1.71	0.14	0.024	0.116	12.93	2.70	0.90
(1.2m)	Lower																								
	Max.	-	34.2	5.6	8.4	31.5	7.1	332.9	2.6	13.2	28.7	36.7	28	3.18	0.32	0.058	0.12	0.45	2.92	1.24	0.228	1.233	17.1	3.3	7.2
	Min.	-	29.5	0.5	7.9	4.5	3.8	14.9	0.3	2.5	2.5	0.4	5	0.45	0.01	0.001	0.01	0.02	0.34	0.14	0.003	0.089	0.8	1.8	0.2
	Ave.	-	31.5	2.1	8.2	20.2	5.4	55.4	1.2	6.2	5.8	6.4	10	1.45	0.07	0.013	0.06	0.14	1.31	0.59	0.034	0.552	3.4	2.6	1.2
	Med.	-	31.5	1.8	8.2	22.0	5.6	31.2	1.1	5.6	4.9	4.0	9	1.39	0.02	0.009	0.06	0.09	1.21	0.57	0.024	0.510	2.3	2.6	0.8

Table 9.4.1 Bottom Sediment Quality

No.	Water content %	ORP mv	COD mg/g	T-N mg/g	T-P mg/g	Ignition Loss %
2	29.5	-317	51.0	0.50	0.20	2.6
3	60.1	-332	146.5	3.02	0.32	10.1
6	36.5	-322	55.9	2.04	0.27	3.6
7	60.6	-321	107.9	3.02	0.32	6.8
10	63.5	-339	98.5	2.18	0.45	11.5
14	43.6	-308	72.8	0.78	0.30	5.0
15	57.5	-315	82.0	0.84	0.30	5.9
18	55.5	-229	104.5	1.15	0.32	7.2
22	36.6	-258	81.1	0.64	0.31	4.0
25	35.7	-295	42.4	1.04	0.30	6.6
28	39.3	-304	68.9	3.02	0.15	23.5
29	27.7	245	53.1	2.46	0.12	22.3
30	31.1	-303	47.3	1.48	0.12	11.7
Ave.	44.4	-261	77.8	1.71	0.27	9.3

Source: Field Survey by JICA study team

FIGURES



Note: Open circles represent sample sites in "Bai Chay bay", closed squares represent sites in "Nearsbore Ha Long ba (HLB)", solid circles are sites in "HLB-Cat Ba Island", and solid triangles represent sampling sites in "Cat Ba-Gulf of Tonkin".

Figure 9.1.1 Sampling Locations of Previous Studies

The Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam

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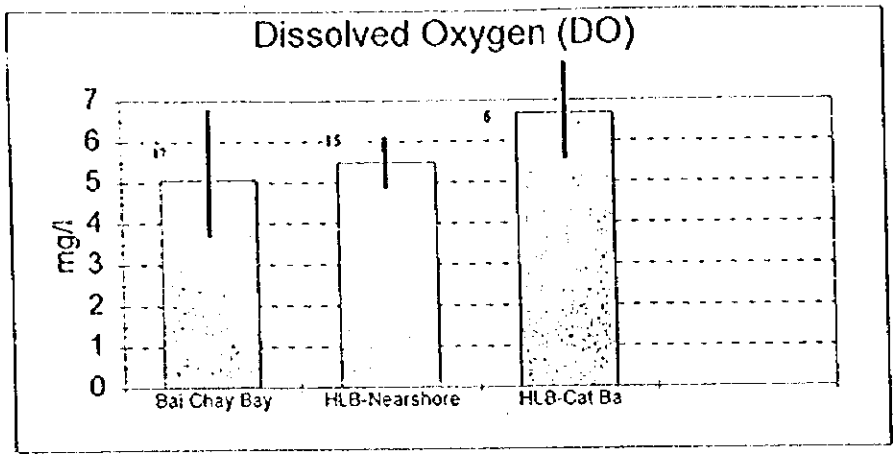
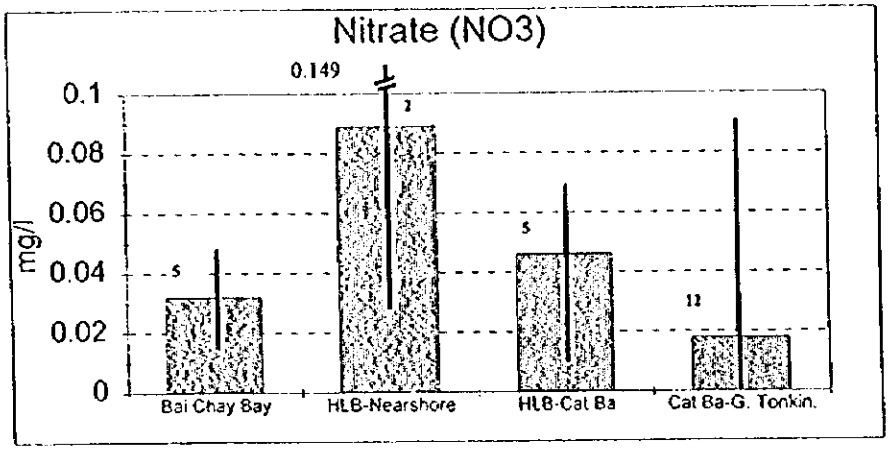
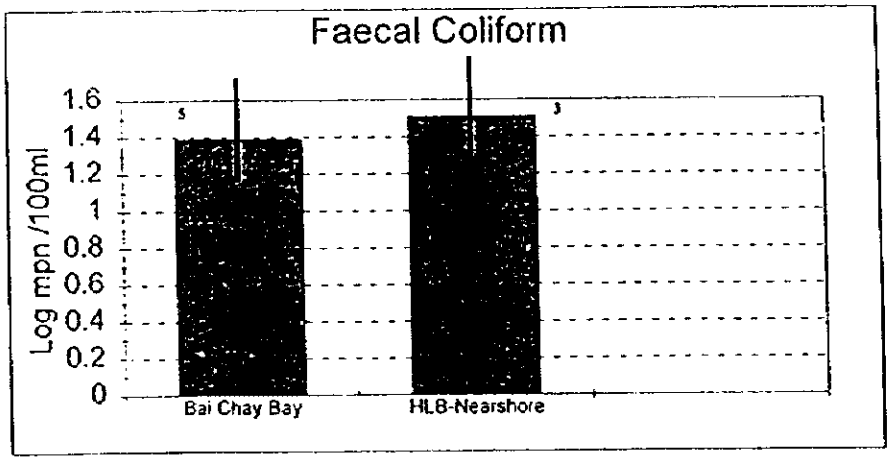
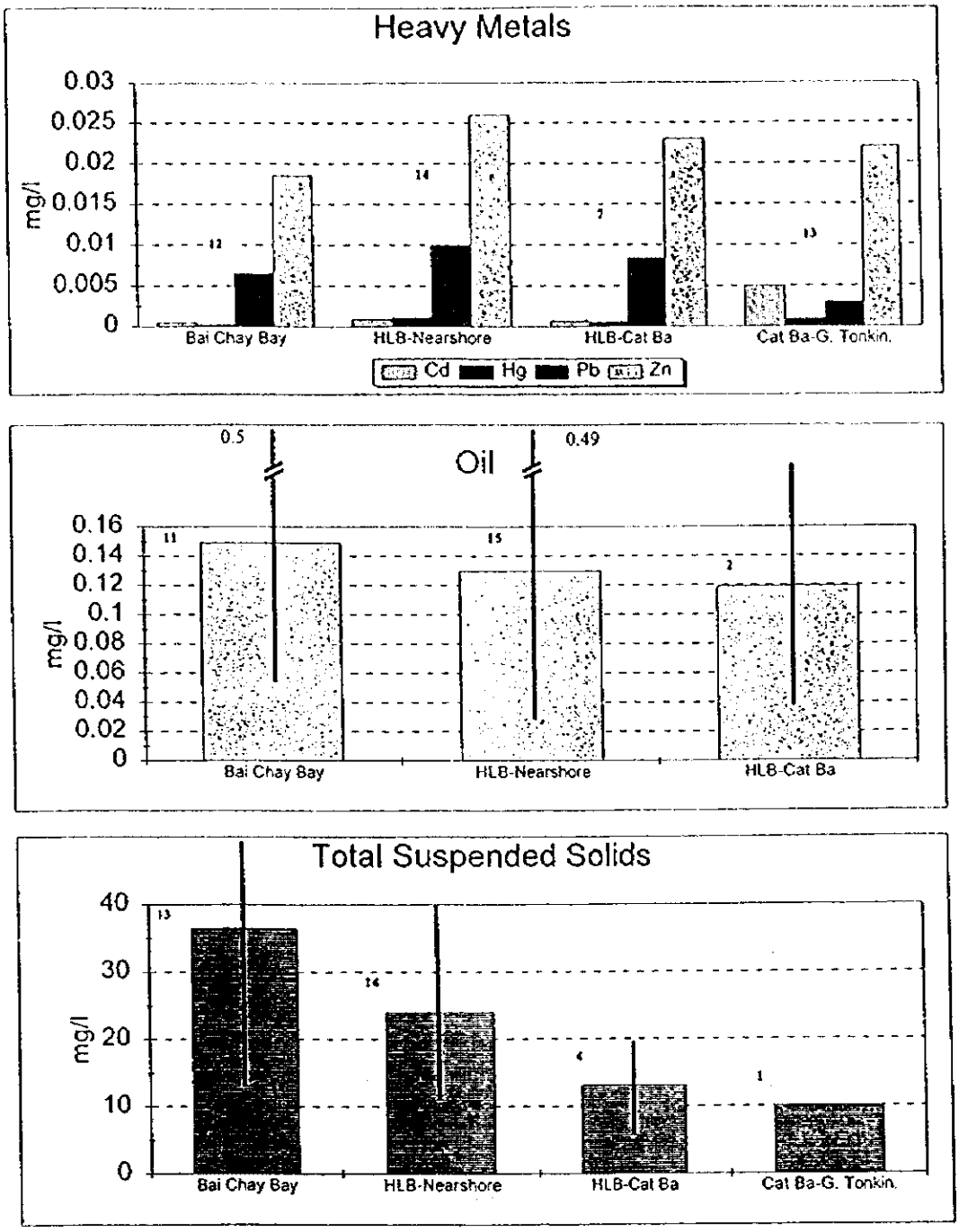






Note: Numbers at top of bars indicate sample size; thin vertical bars show range of maximum and minimum concentrations; and NO_3 plot represents winter data.

Figure 9.1.2 Average Summer DO, NO_3, and Faecal Coliform Levels in the Bays Reported in Previous Studies



Note: Numbers at top of bars indicate sample size; thin vertical bars identify range of maximum and minimum concentrations; and metals plots represents all historic data.

Figure 9.1.3 Average Summer Heavy Metals, TSS and Oil Levels in the Bays Reported in Previous Studies

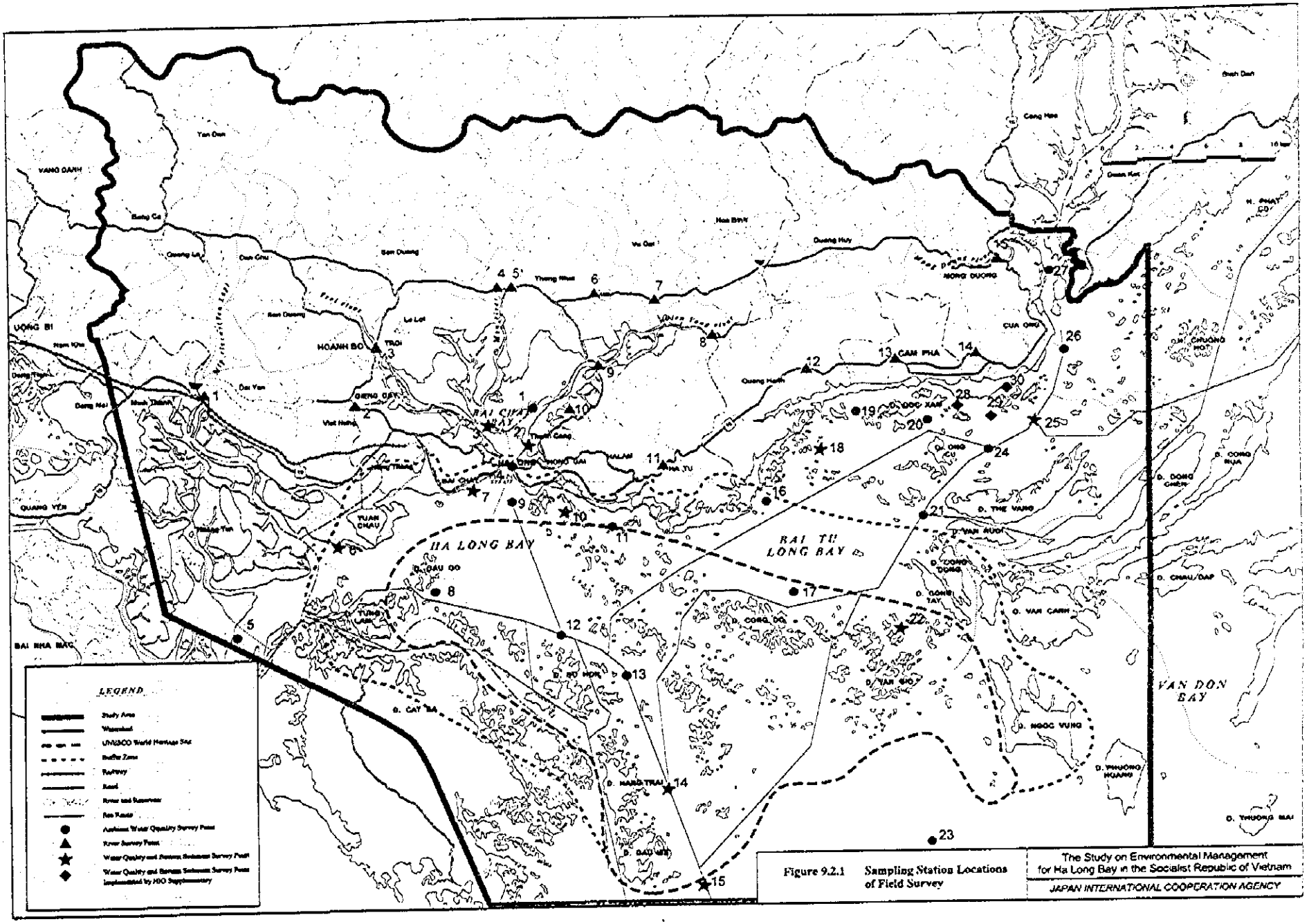


Figure 9.2.1 Sampling Station Locations of Field Survey

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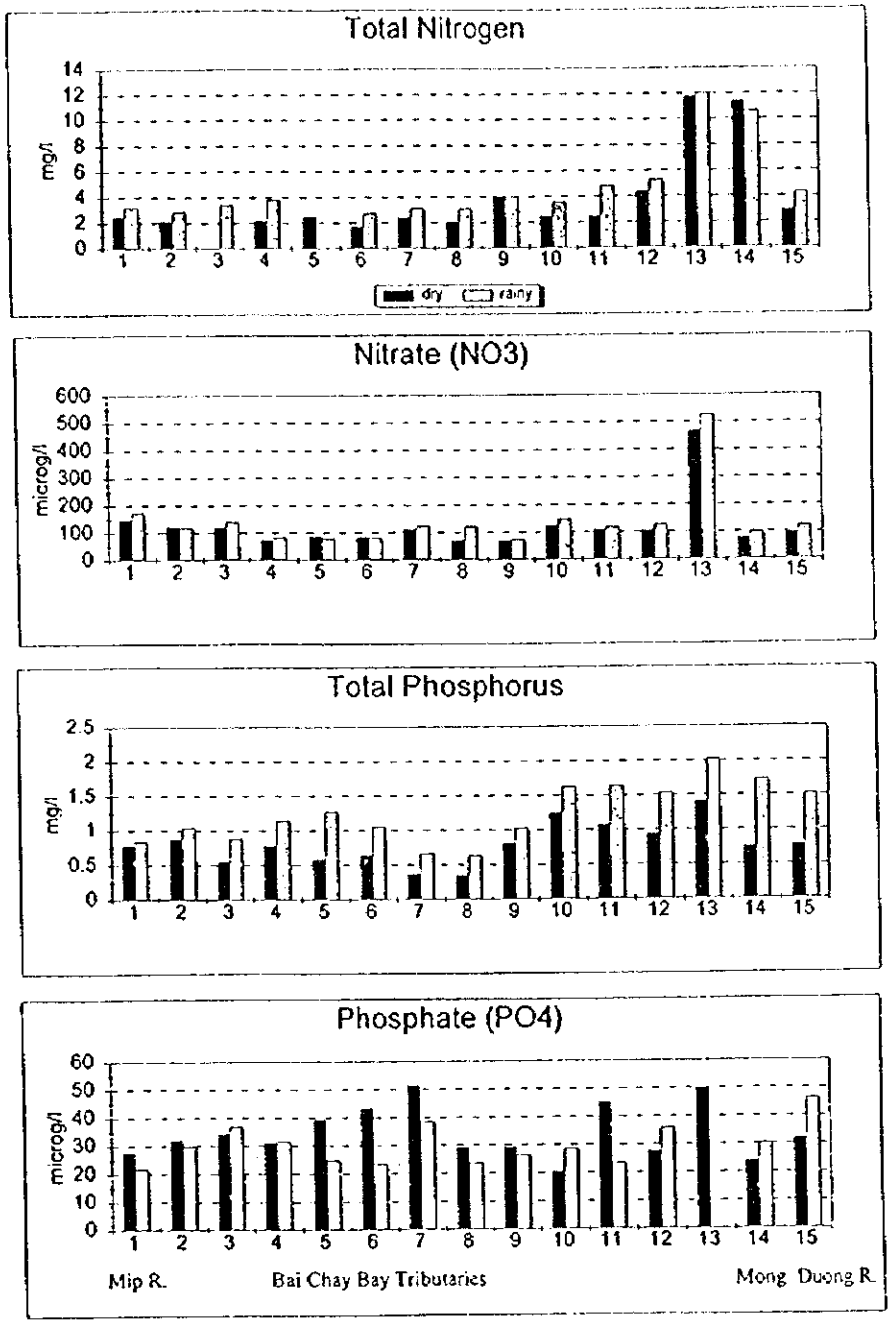


Figure 9.2.2 Water Quality Indicators in Tributaries in Dry and Rainy Conditions

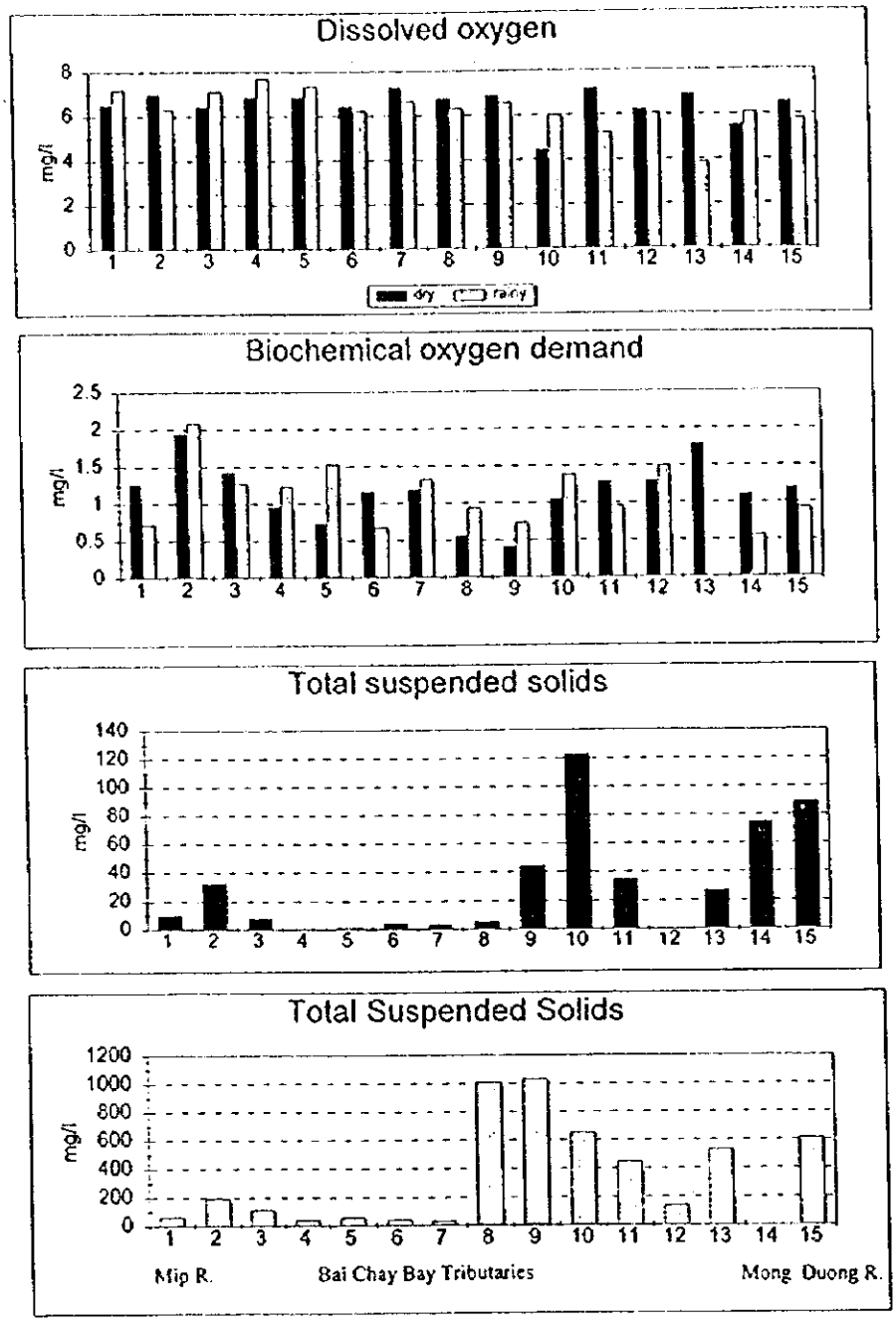


Figure 9.2.3 Water Quality Indicators in Tributaries in Dry and Rainy Conditions

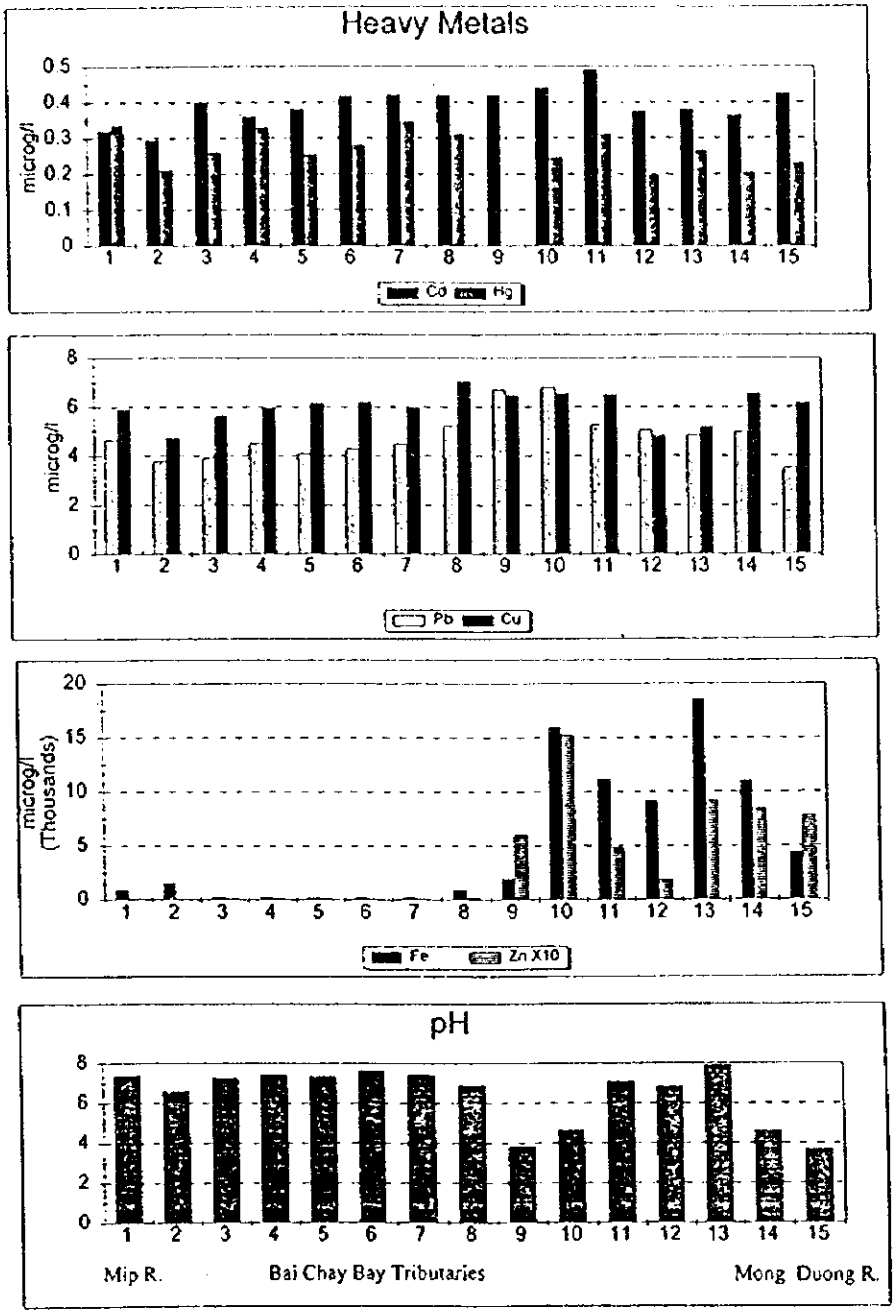
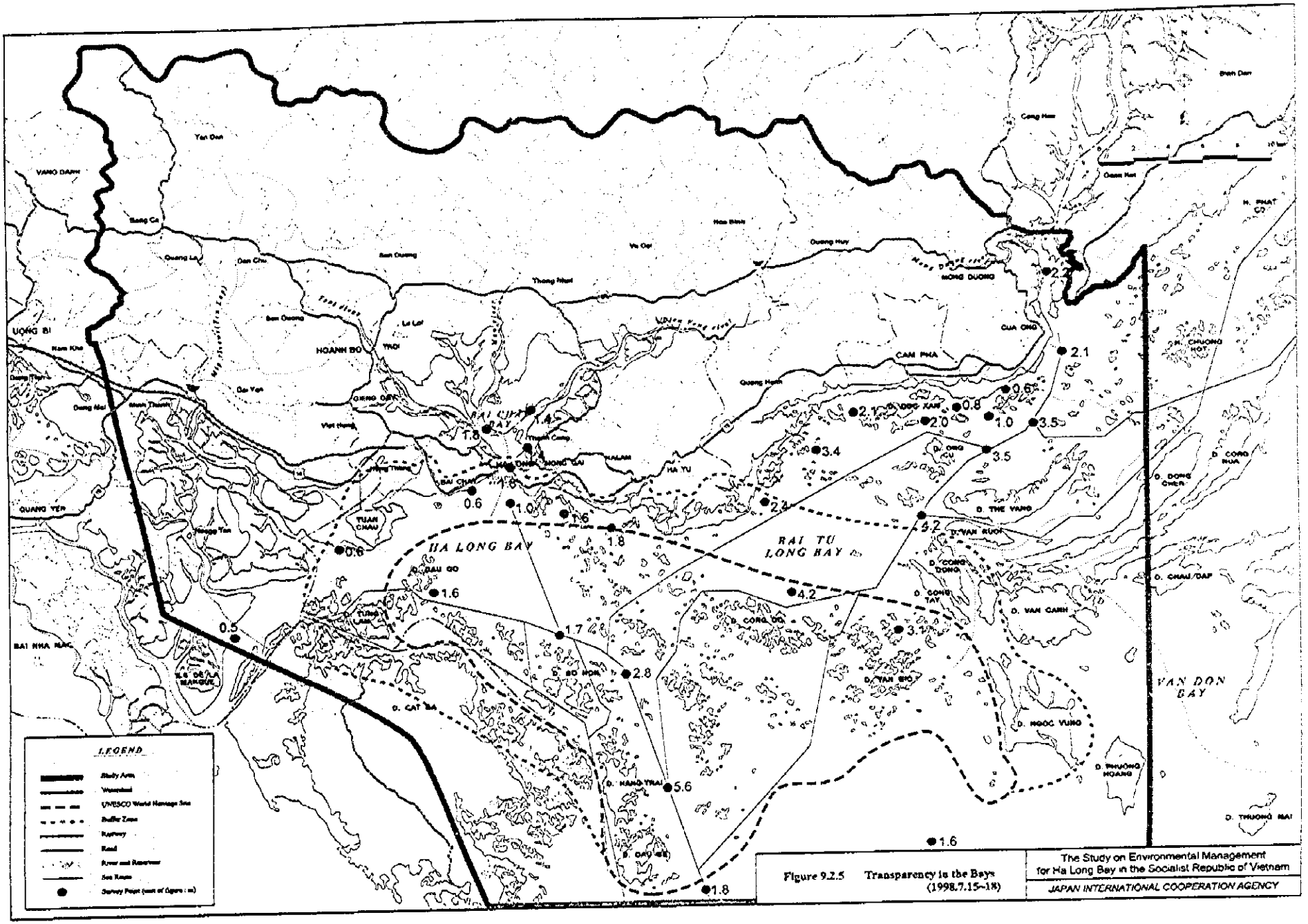


Figure 9.2.4 Water Quality Indicators in Tributaries in Dry and Rainy Conditions


HA LONG BAY
BAI TU LONG BAY
VAN DON BAY
BAI CUT BAY
HON GAI
CAM PHA
MONG DUONG
UONG BI
HOANH BO
QUANG YEN
TUAN CHAU
DO SON
VAN DON
LEGEND
Study Area
Watershed
UNESCO World Heritage Site
Buffer Zone
Railway
Road
River and Reservoir
Sea Route
Survey Point (unit of figure : m)
1.6
Figure 9.2.5 Transparency in the Bays (1998.7.15~18)
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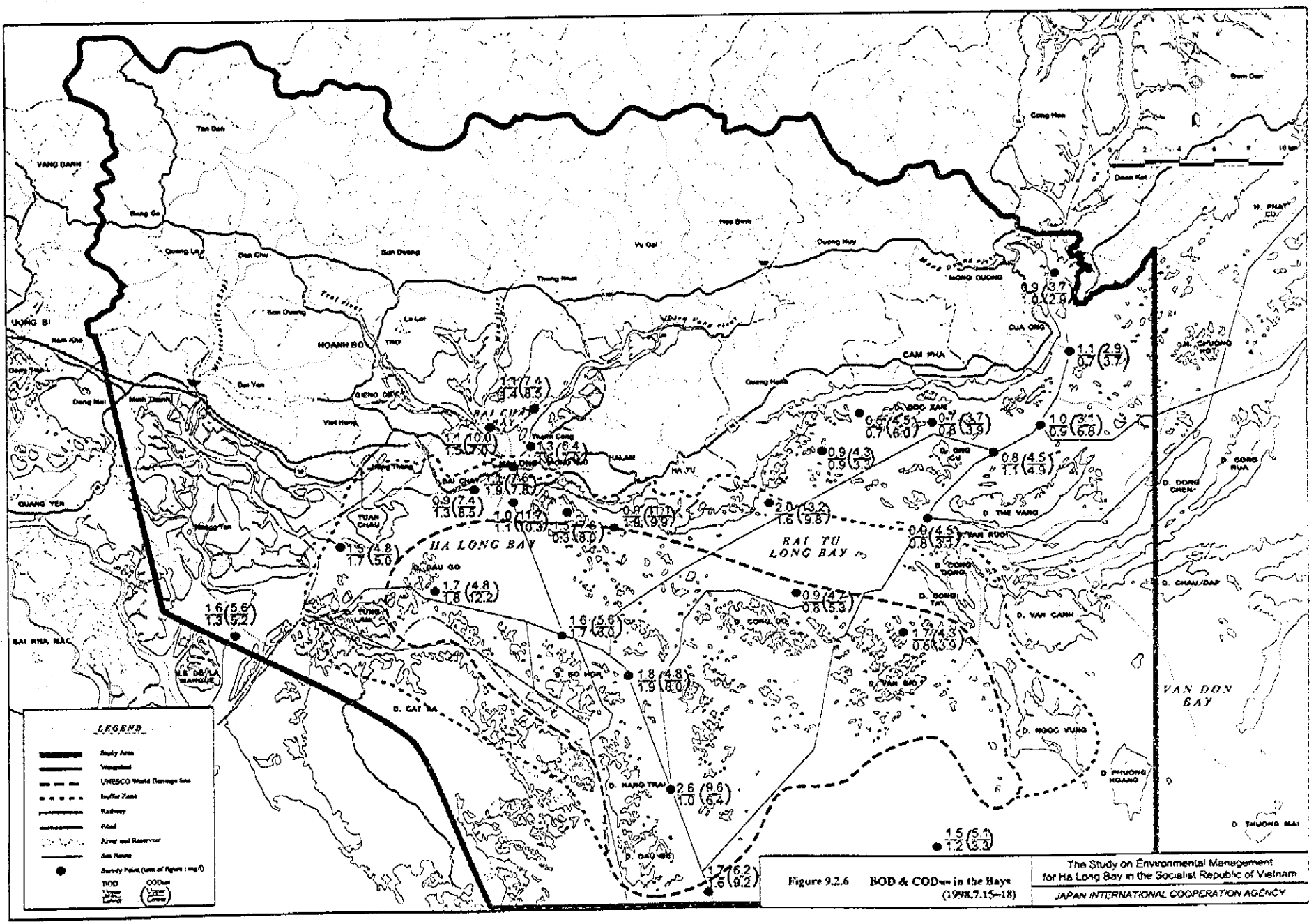

Figure 9.2.6 BOD & COD_{Mn} in the Bays (1998.7.15–18)

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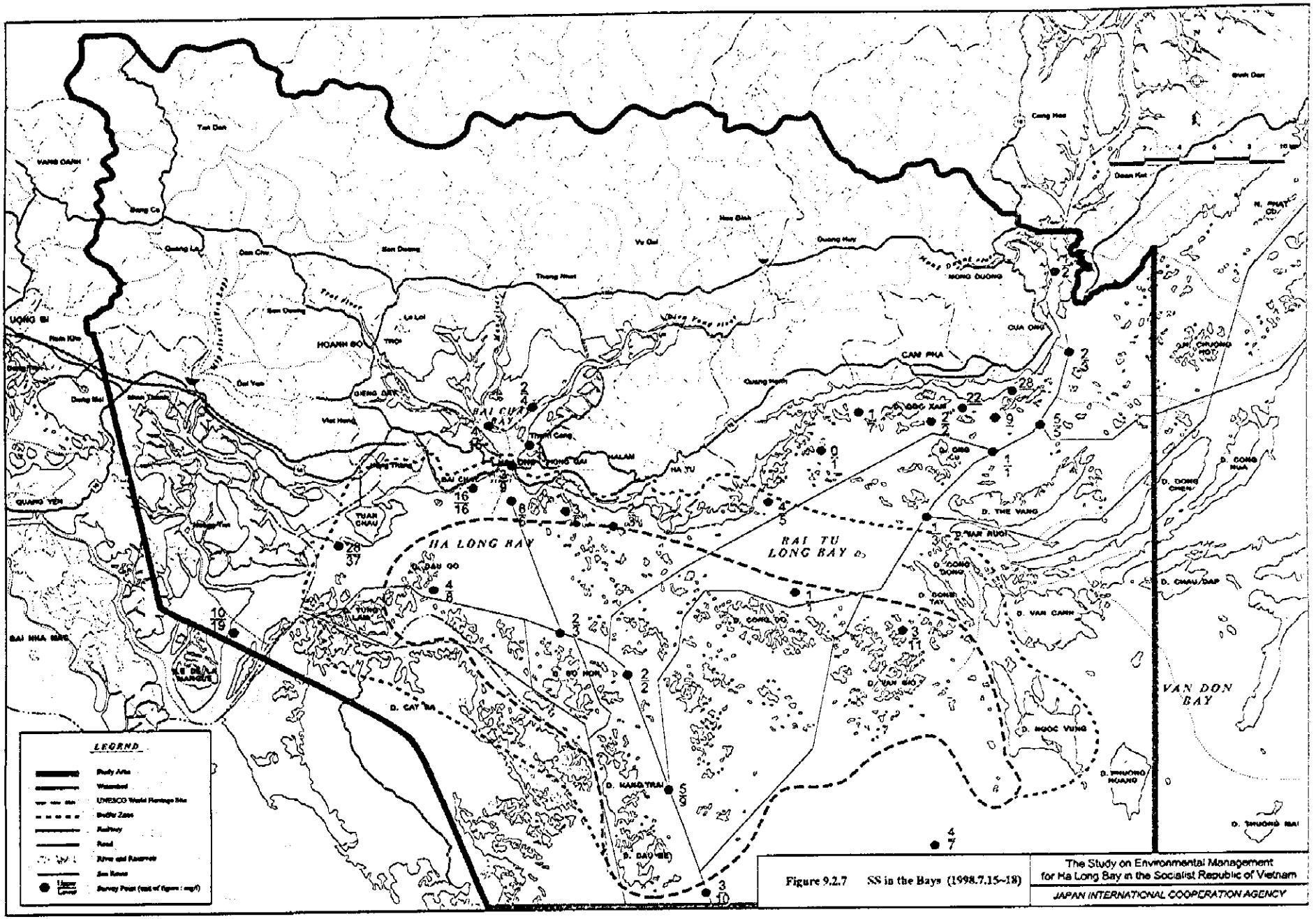

Figure 9.2.7 SS in the Bays (1998.7.15~18)

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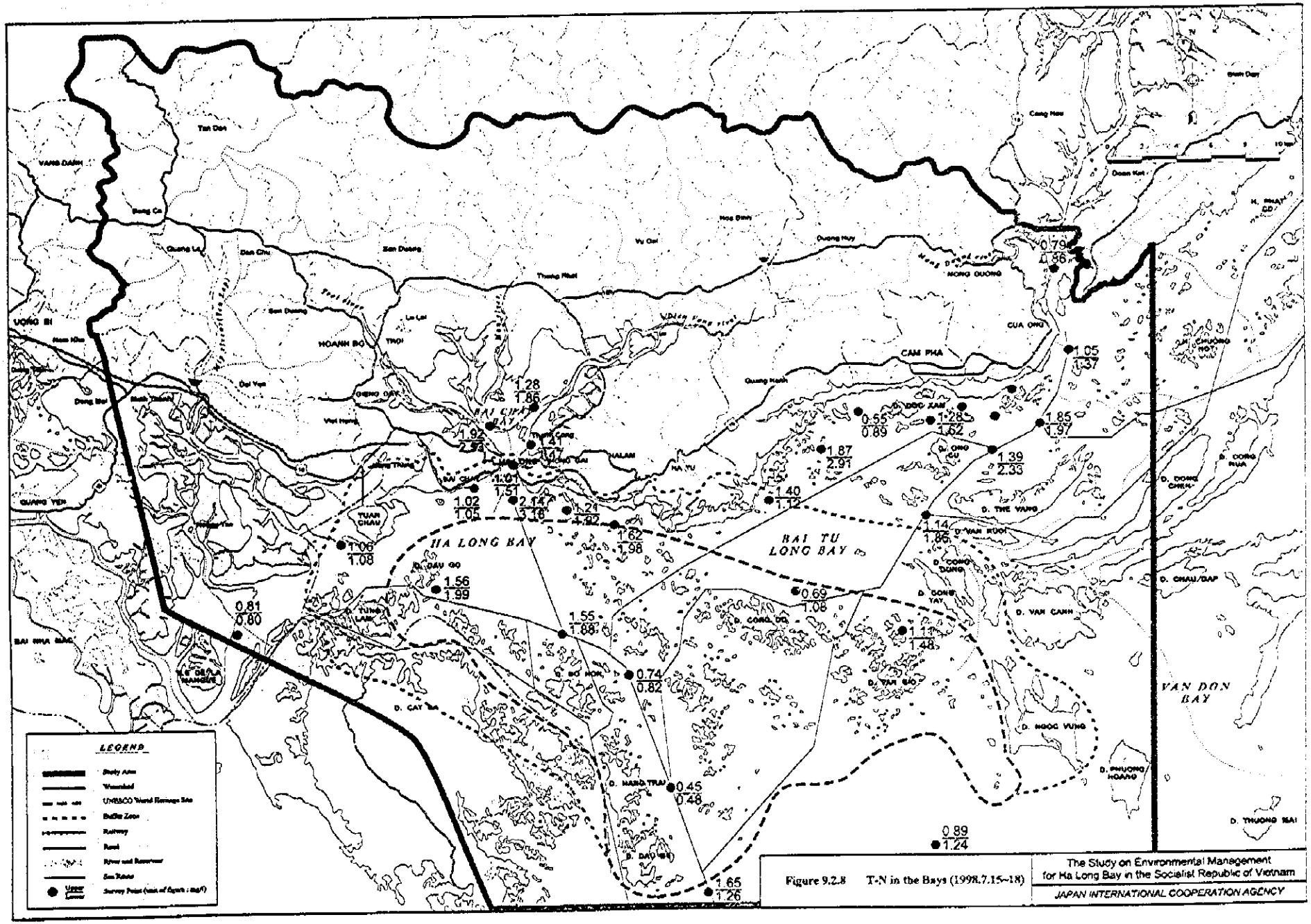

Figure 9.2.8 T-N in the Bays (1998.7.15~18)

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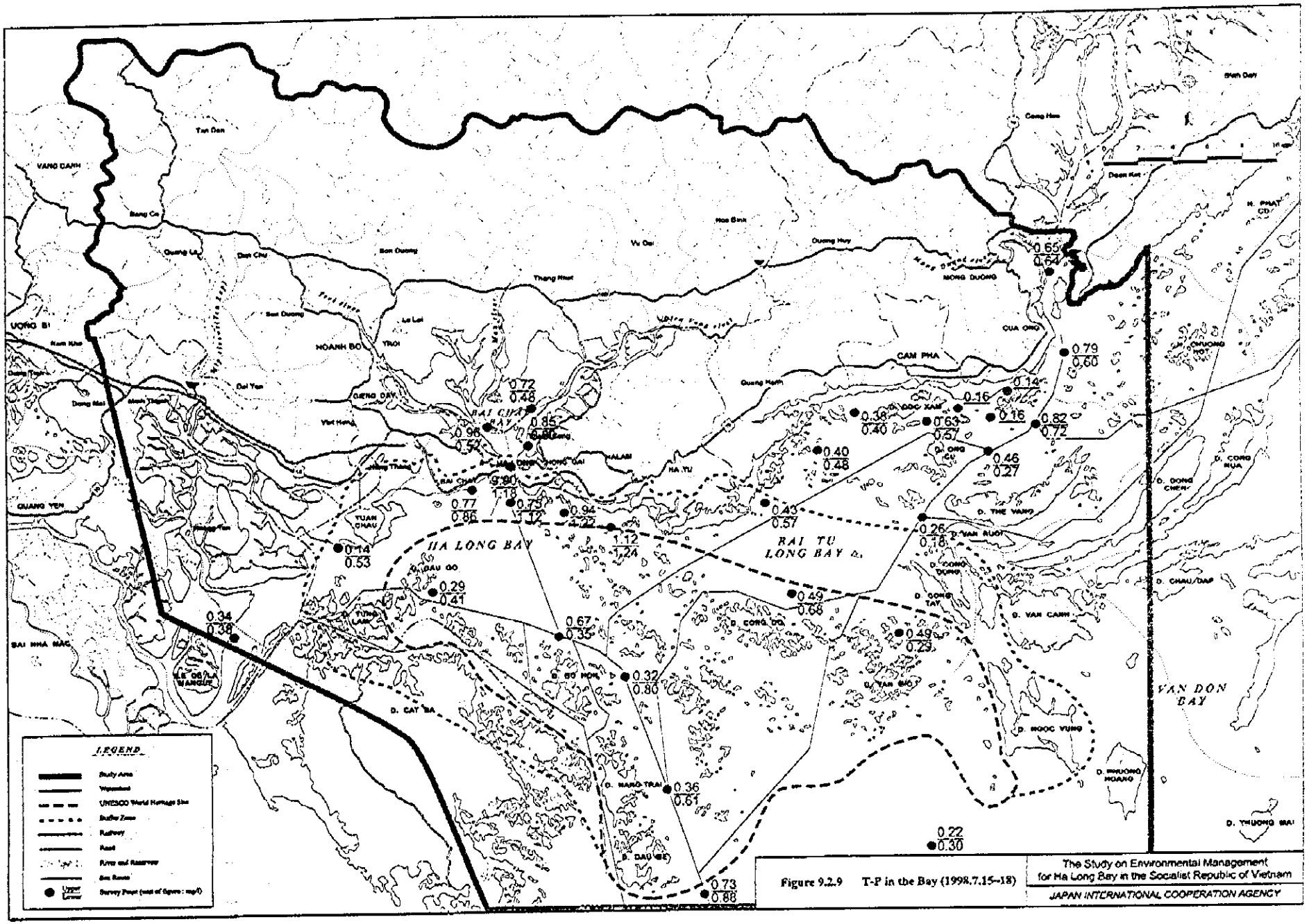

Figure 9.2.9 T-P in the Bay (1998.7.15~18)

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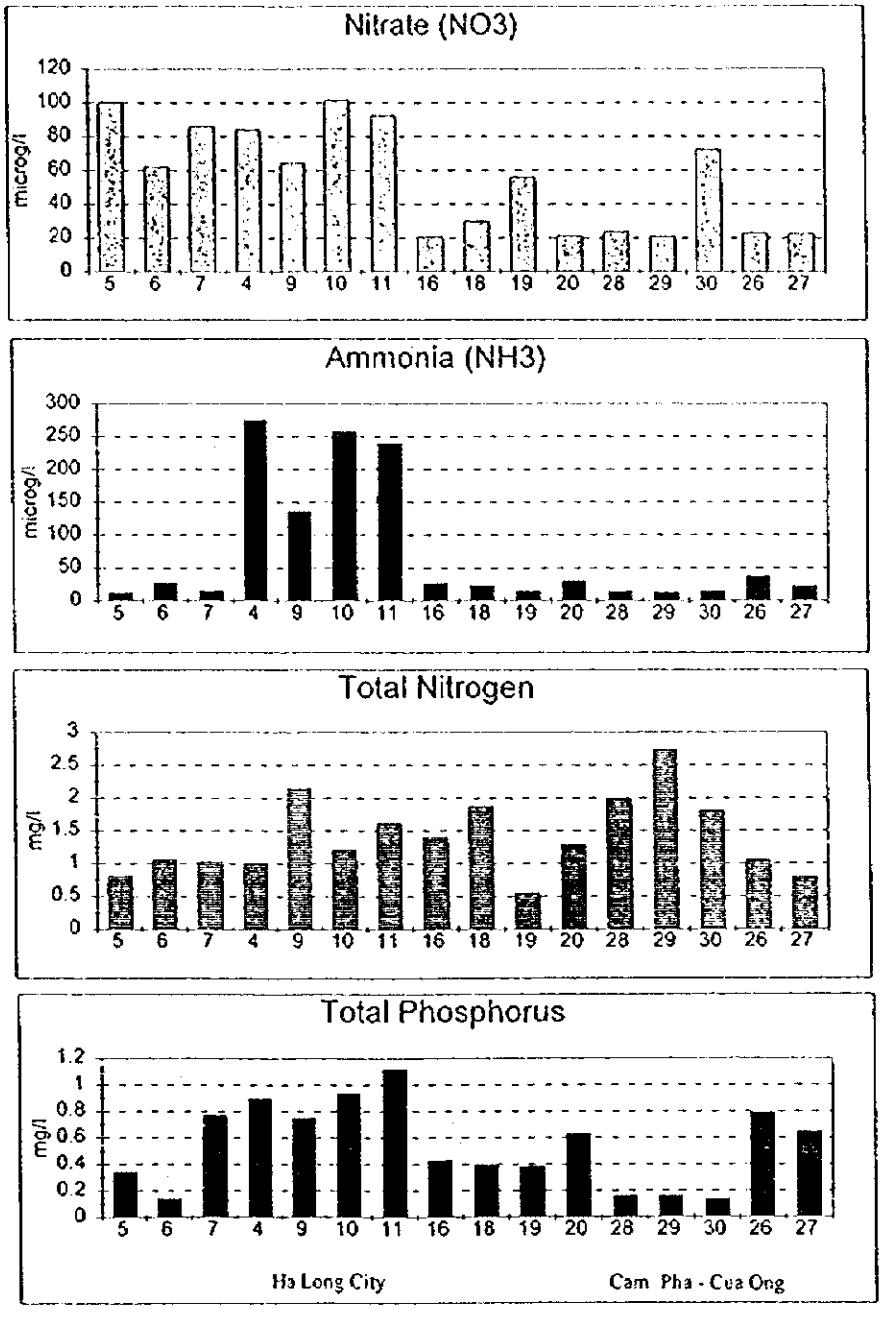


Figure 9.2.10 Surface Water Quality Indicators at Shoreline Sampling Stations in Ha Long Bay and Bai Tu Long Bays

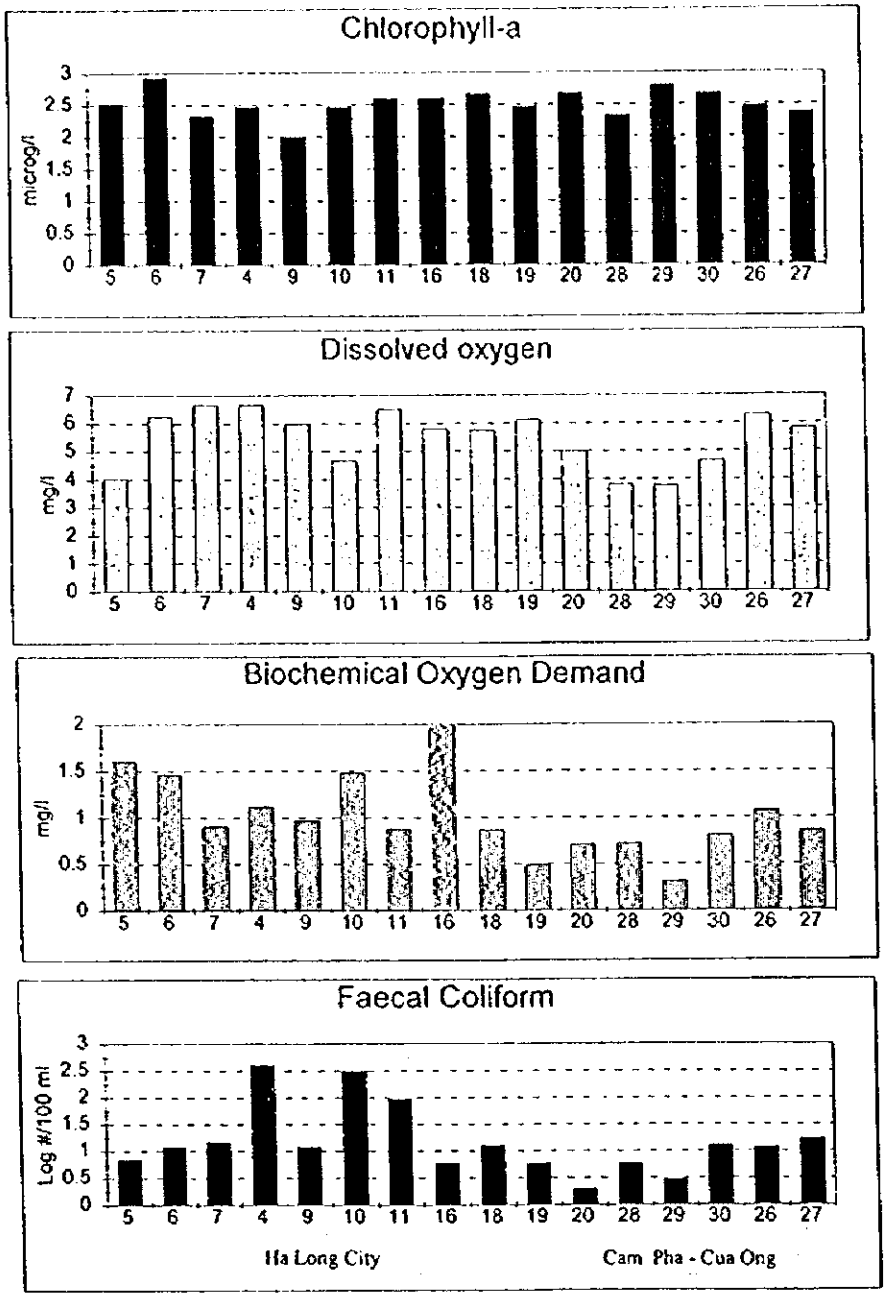


Figure 9.2.11 Surface Water Quality Indicators at Shoreline Sampling Stations in Ha Long and Bai Tu Long Bays

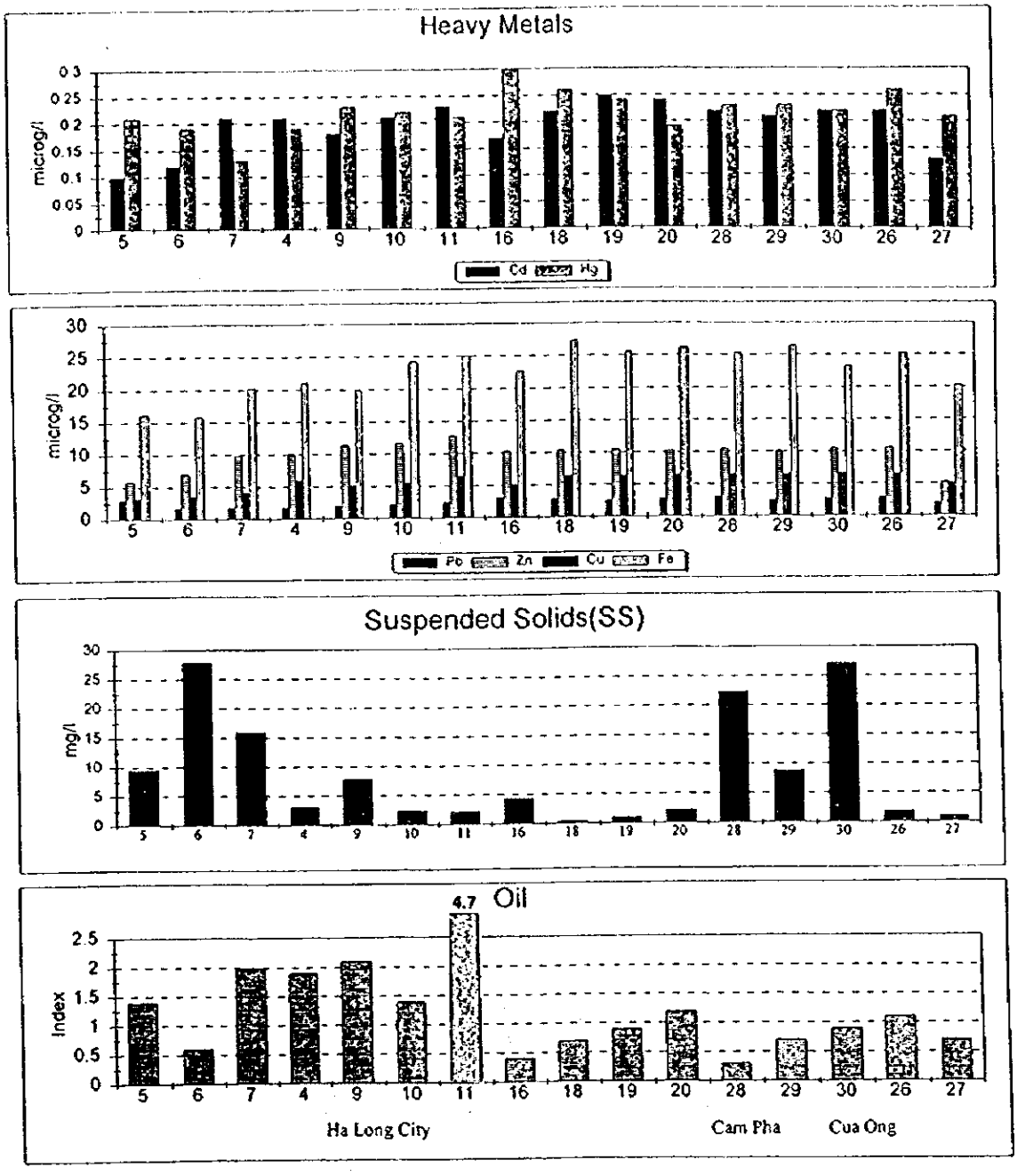


Figure 9.2.12 Surface Water Quality Indicators at Shoreline Sampling Stations in Ha Long and Bai Tu Long Bays

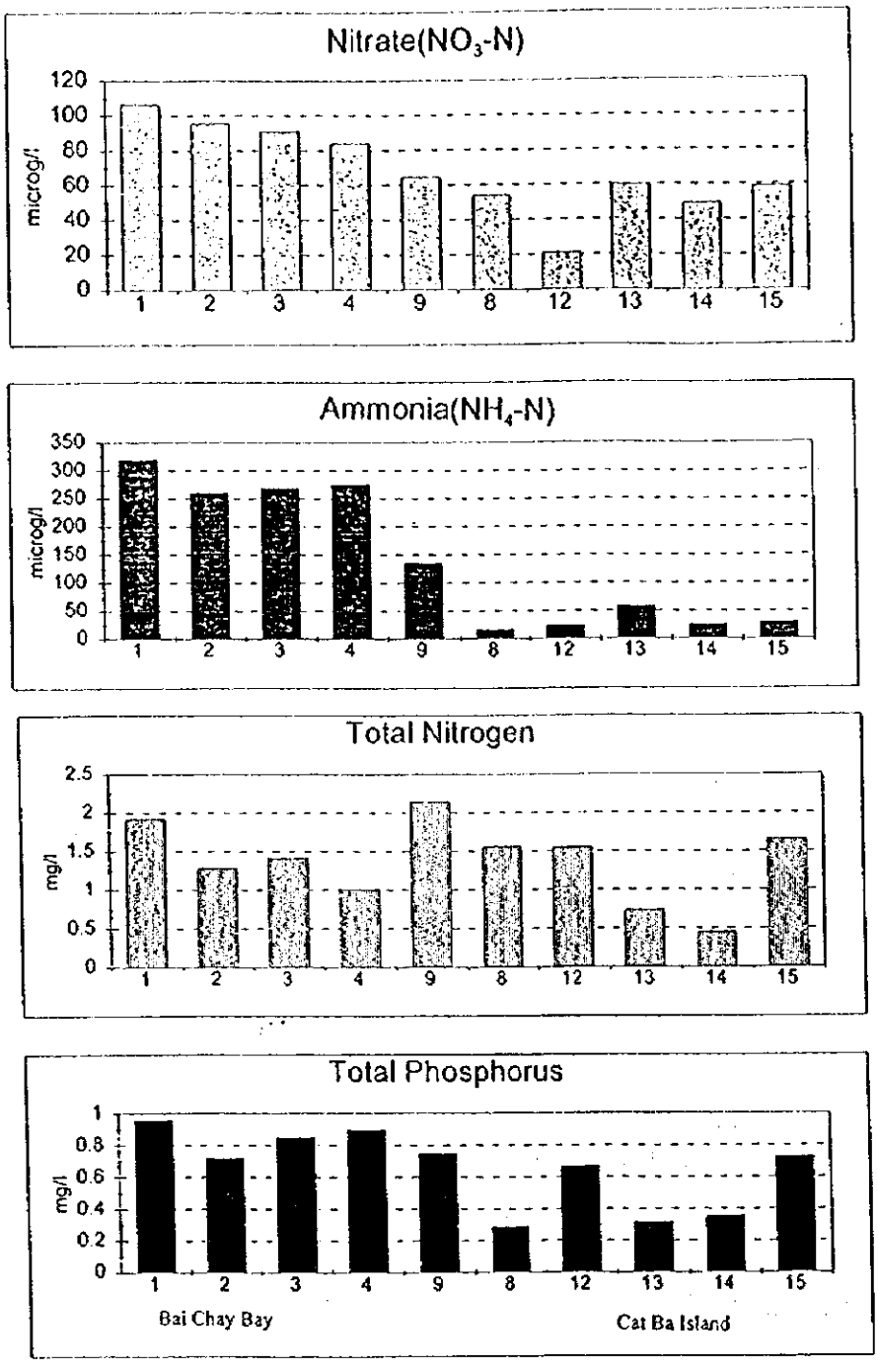


Figure 9.2.13 Surface Water Quality Indicators at Stations from Bai Chay South to Cat Ba Island

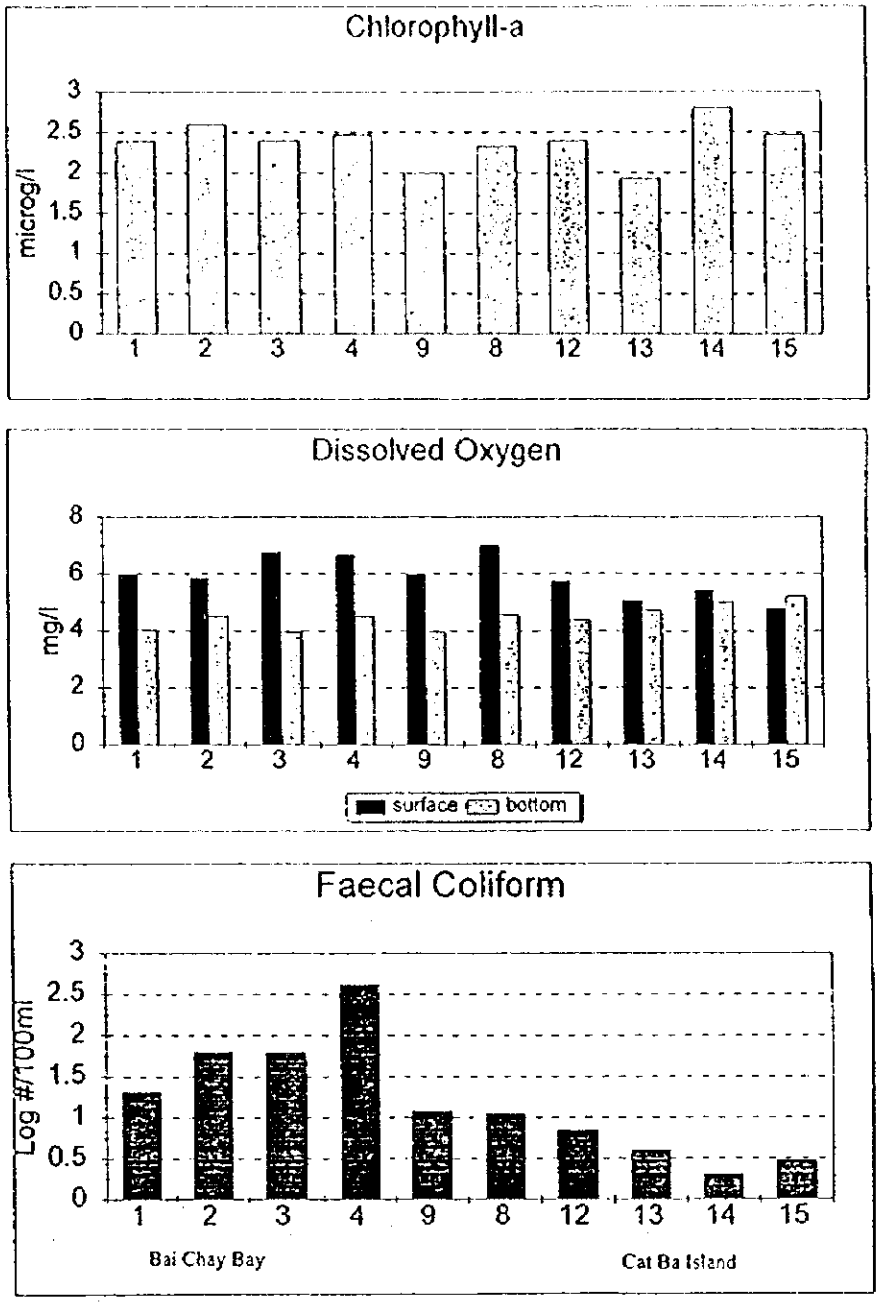


Figure 9.2.14 Surface Water Quality Indicators at Stations from Bai Chay Bay South to Cat Ba Island

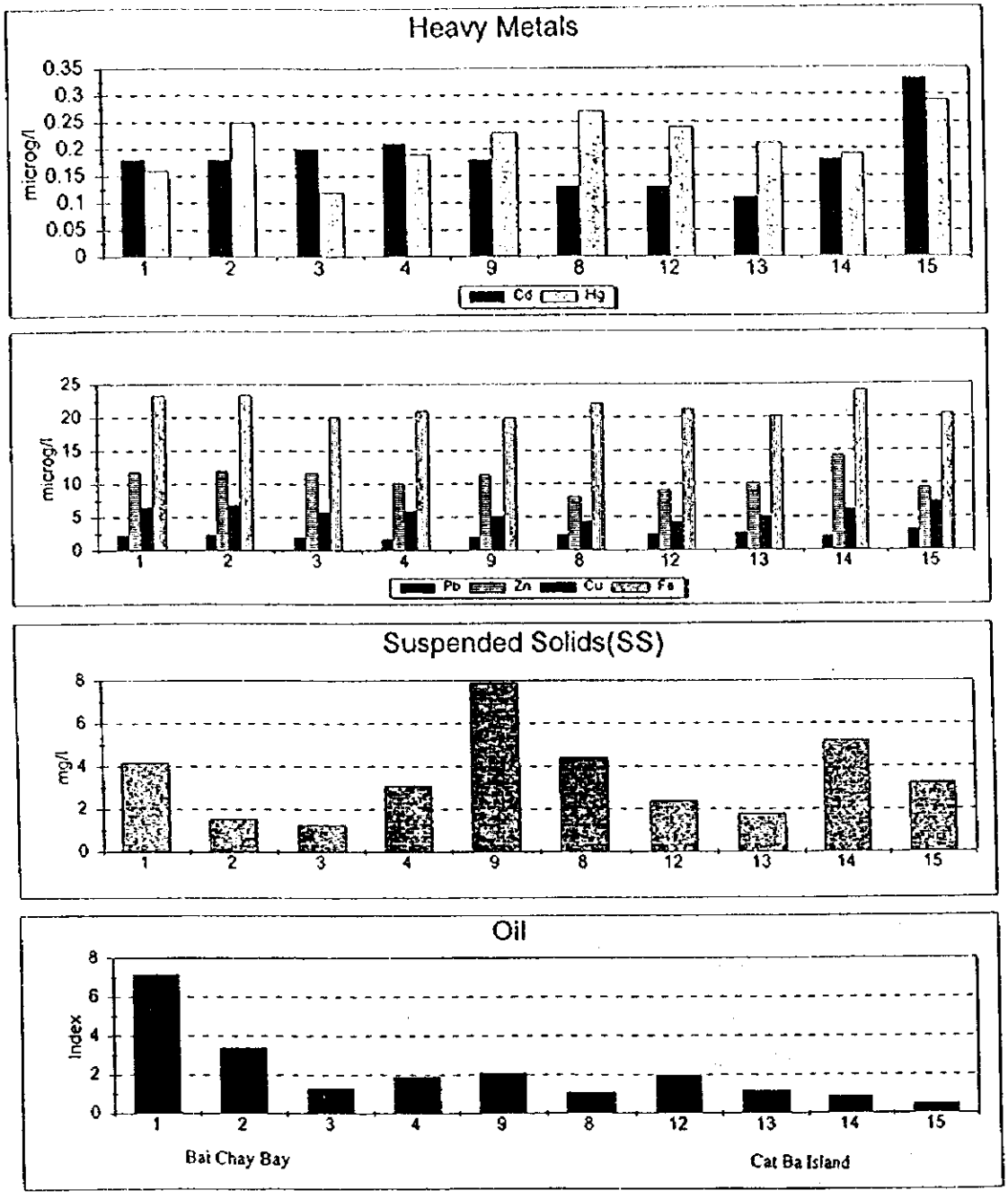


Figure 9.2.15 Surface Water Quality Indicators at Stations from Bai Chay Bay South to Cat Ba Island

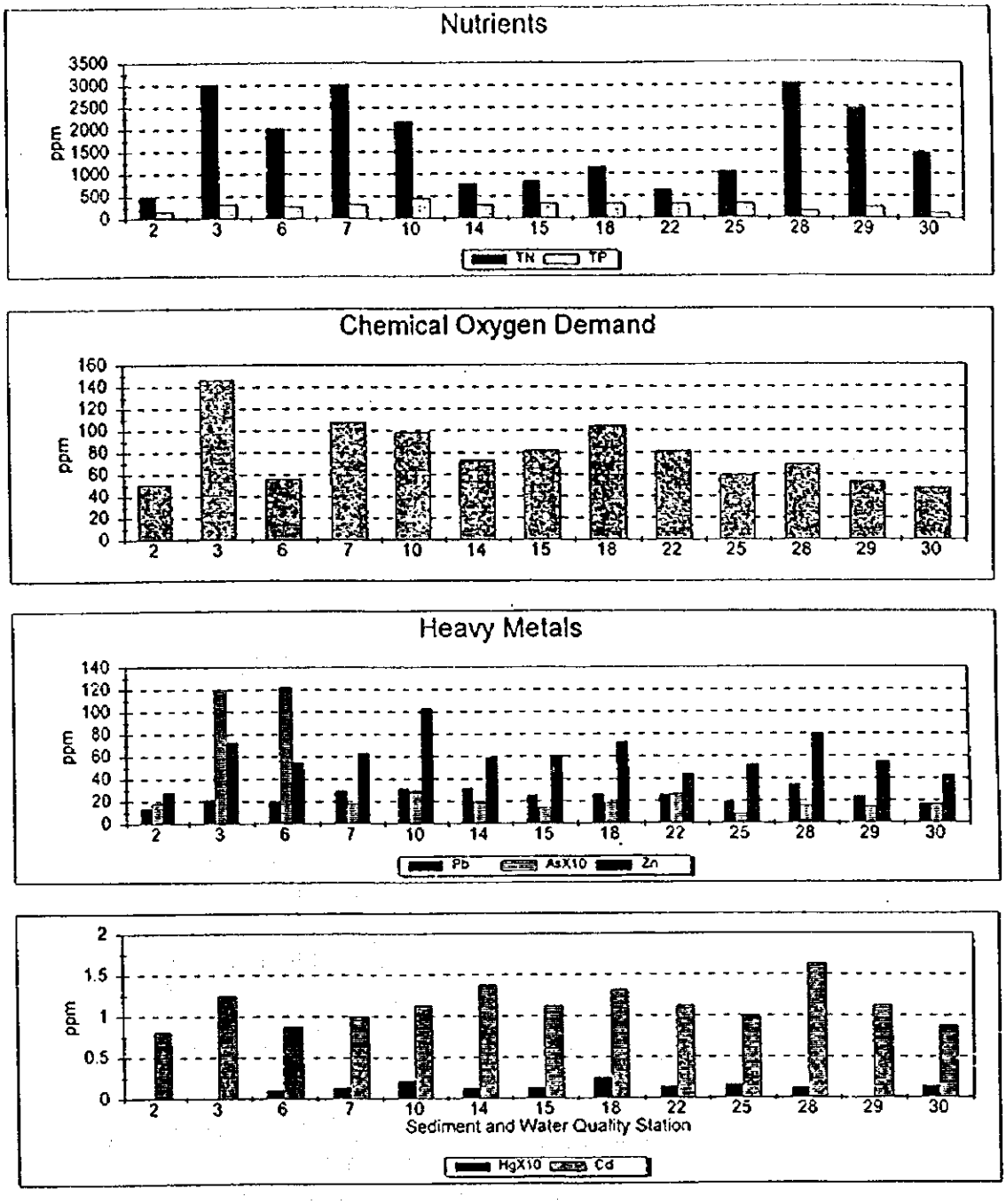


Figure 9.4.1 Sediment Variables at Water Quality Stations

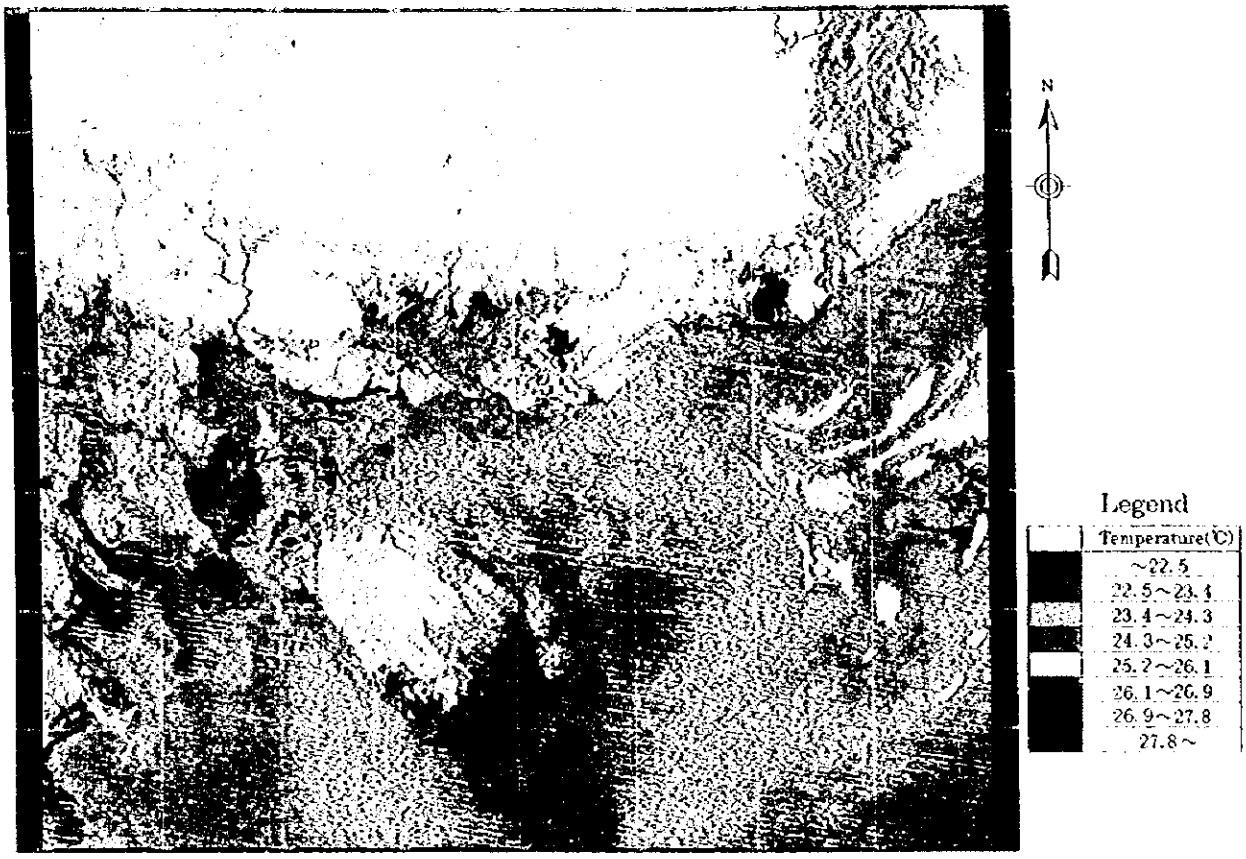


Figure 9.5.1 Water Temperature (1988.11.4 LANDSAT TM band 6)

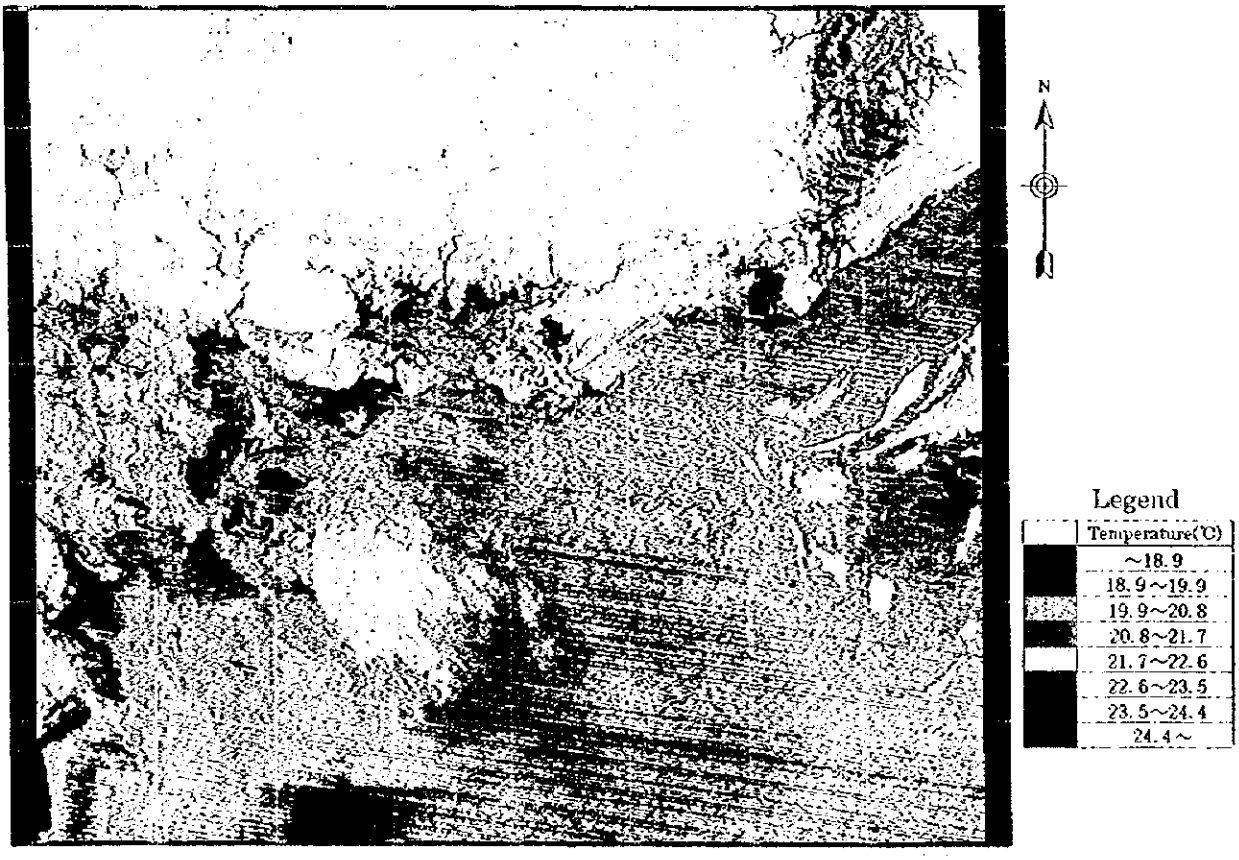


Figure 9.5.2 Water Temperature (1992.12.1 LANDSAT TM band 6)

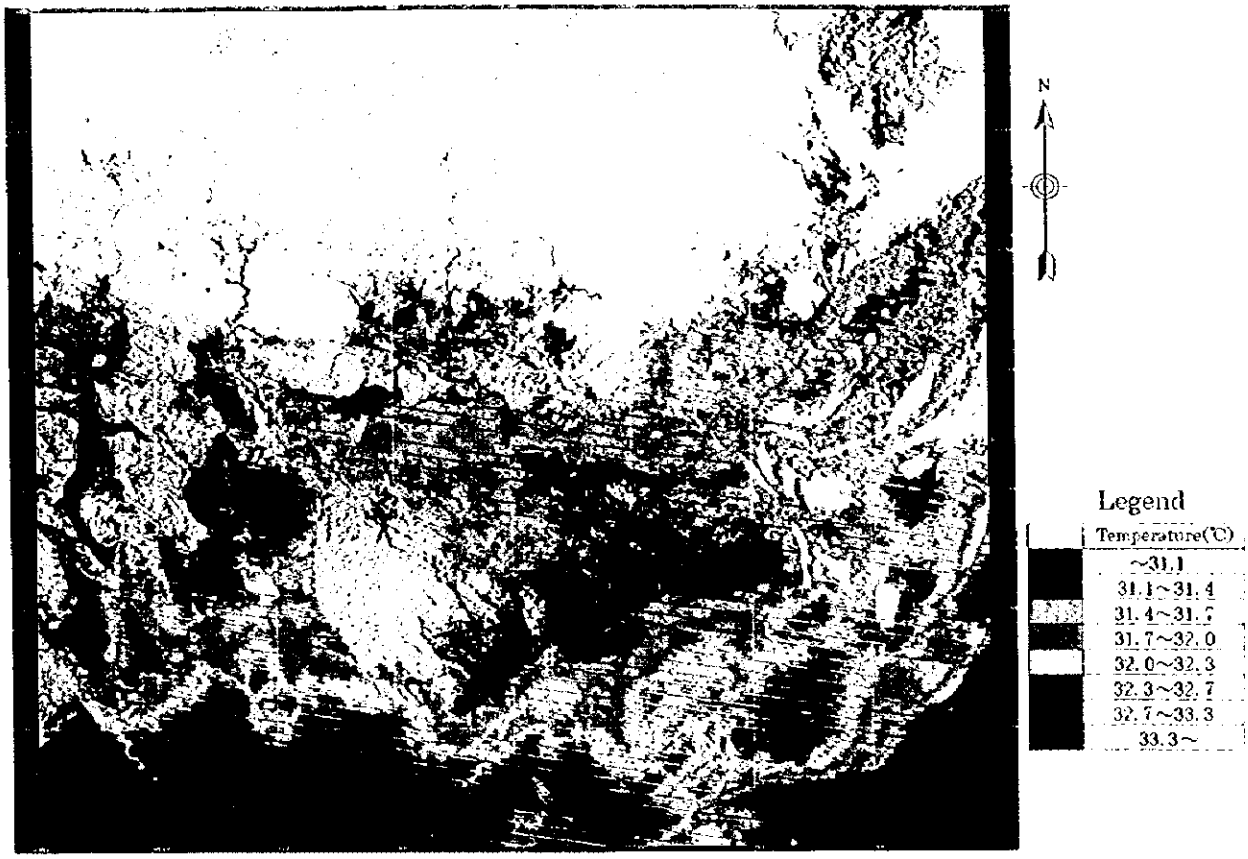


Figure 9.5.3 Water Temperature (1997.6.6 LANDSAT TM band 6)

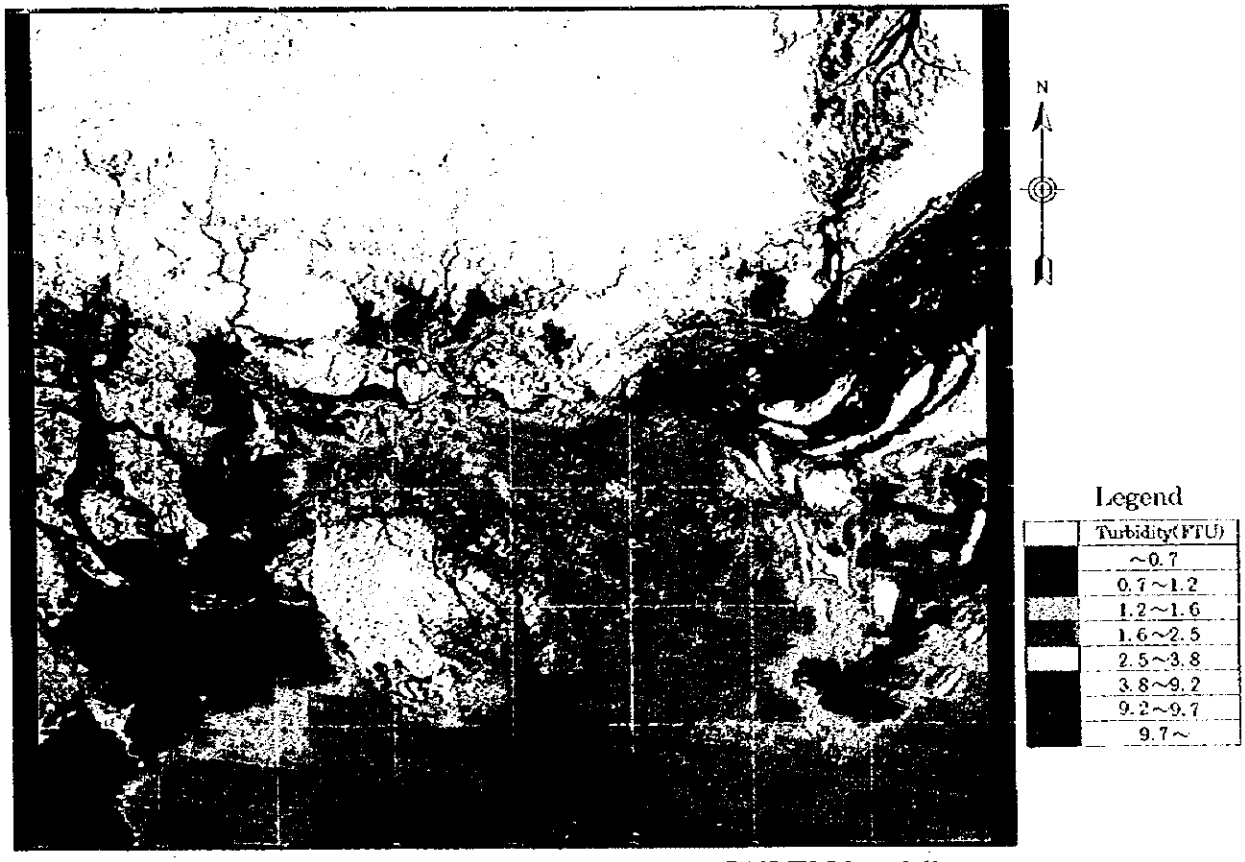


Figure 9.5.4 Turbidity (1988.11.4 LANDSAT TM band 1)

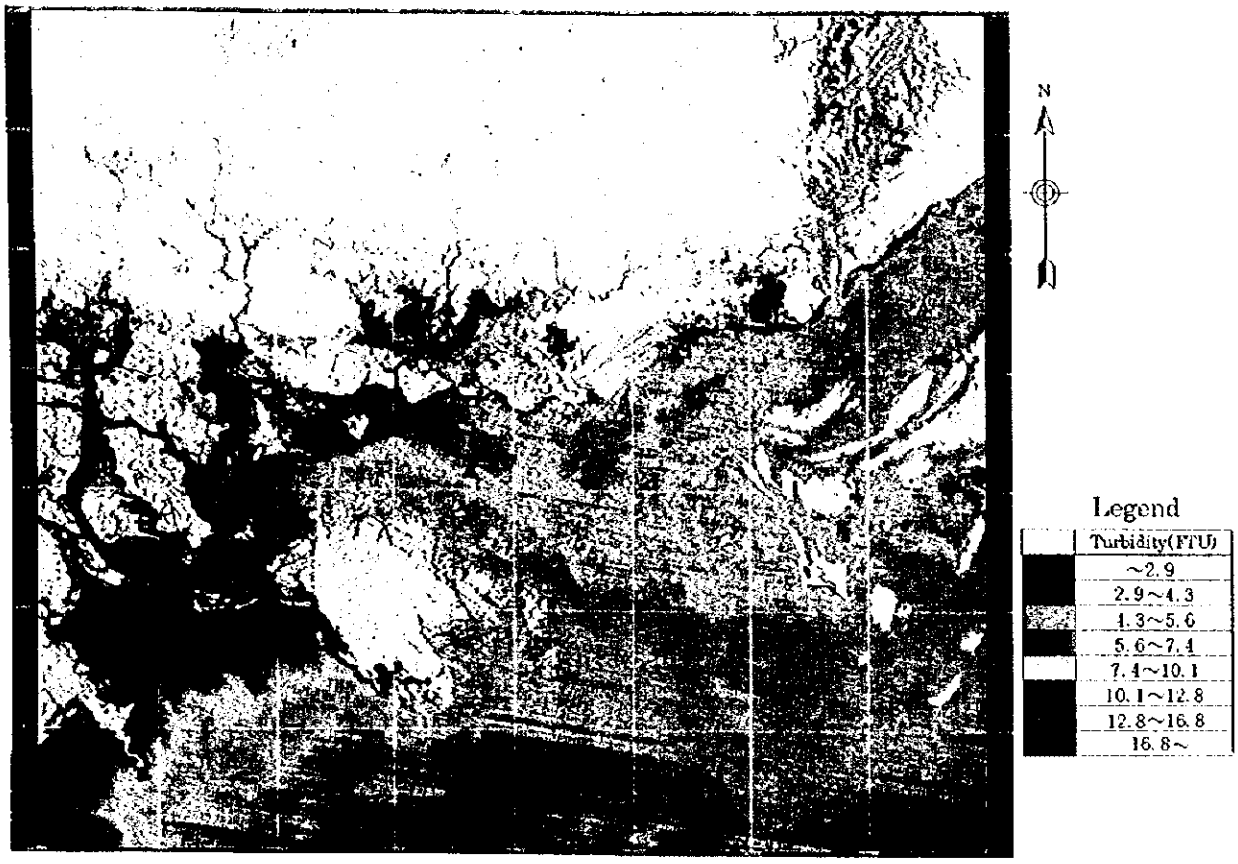


Figure 9.5.5 Turbidity (1992.12.1 LANDSAT TM band 1)

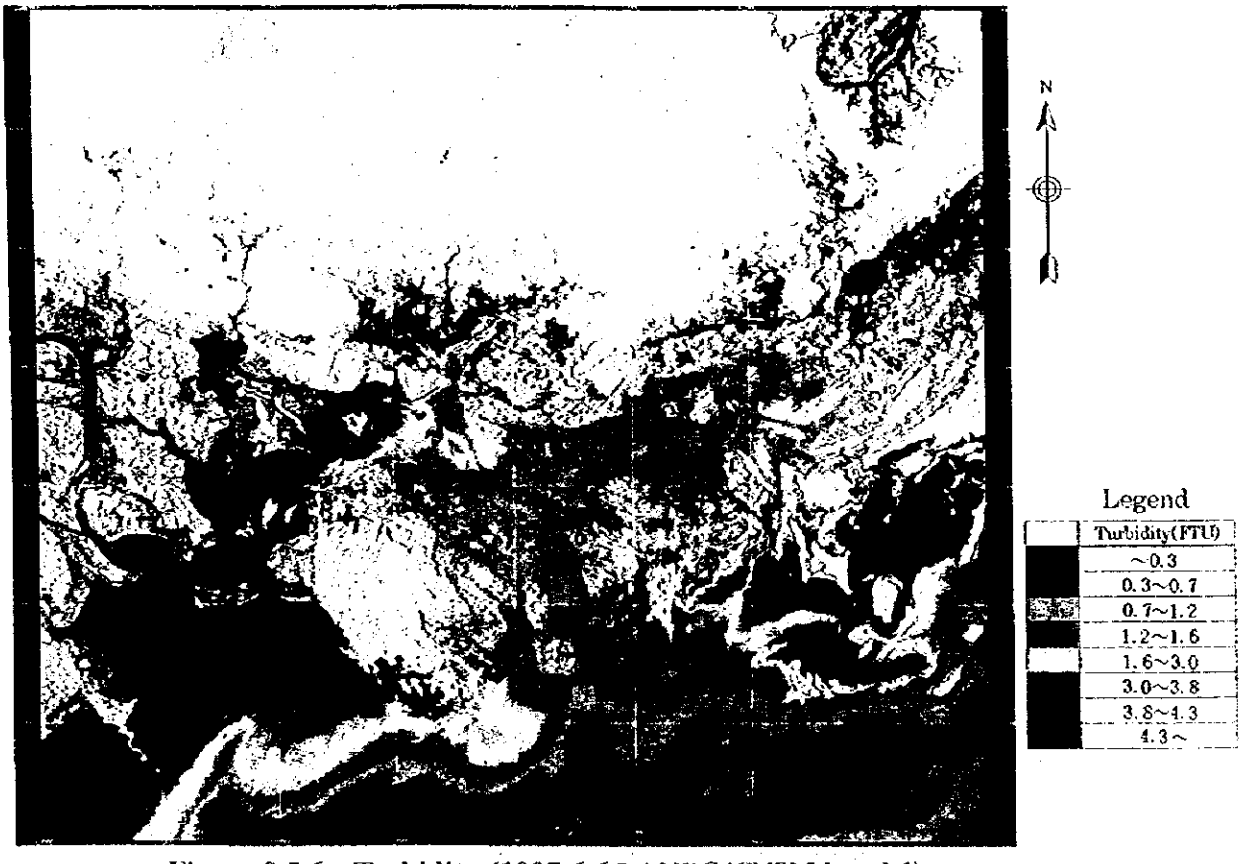


Figure 9.5.6 Turbidity (1997.6.6 LANDSAT TM band 1)

Figure 9.5.7 Chlorophyll-a (1988.11.4 LANDSAT TM band 2)

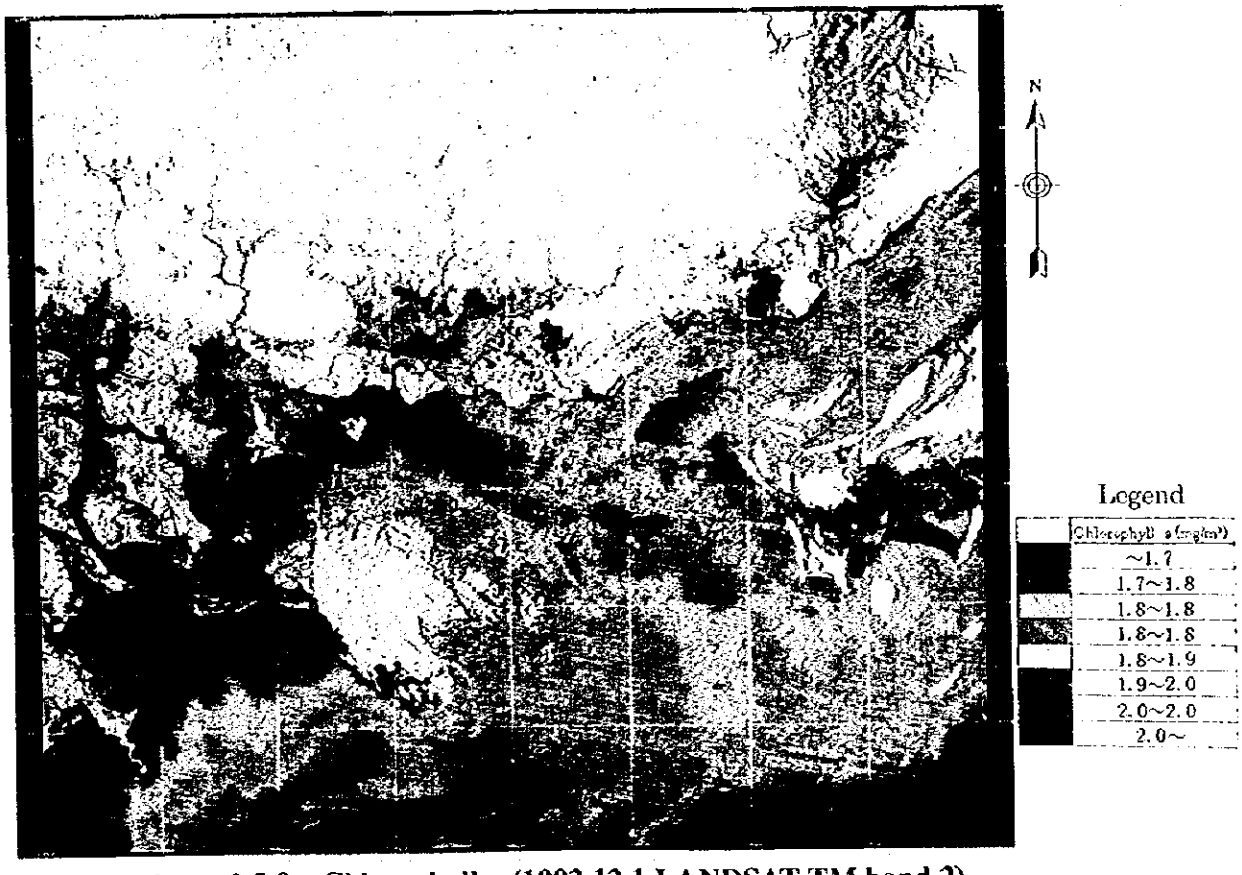


Figure 9.5.8 Chlorophyll-a (1992.12.1 LANDSAT TM band 2)

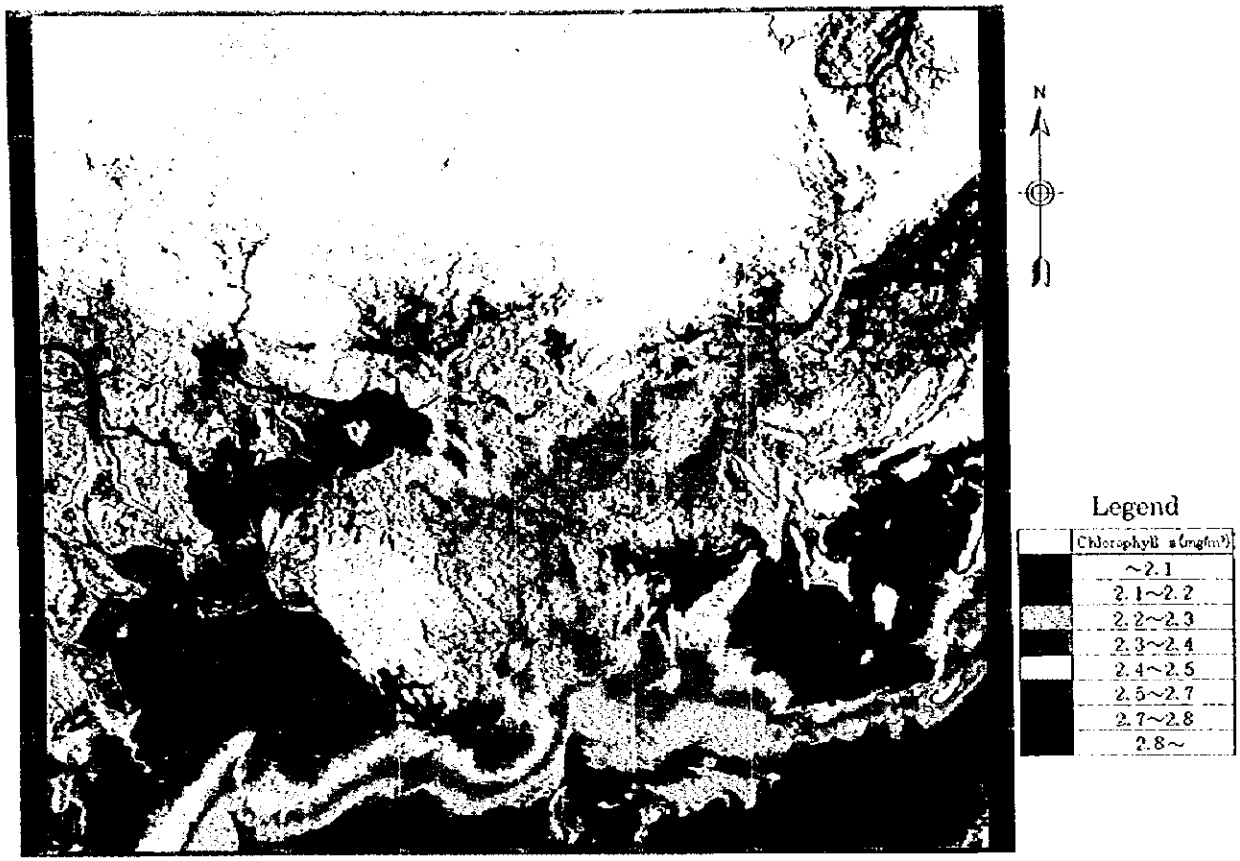
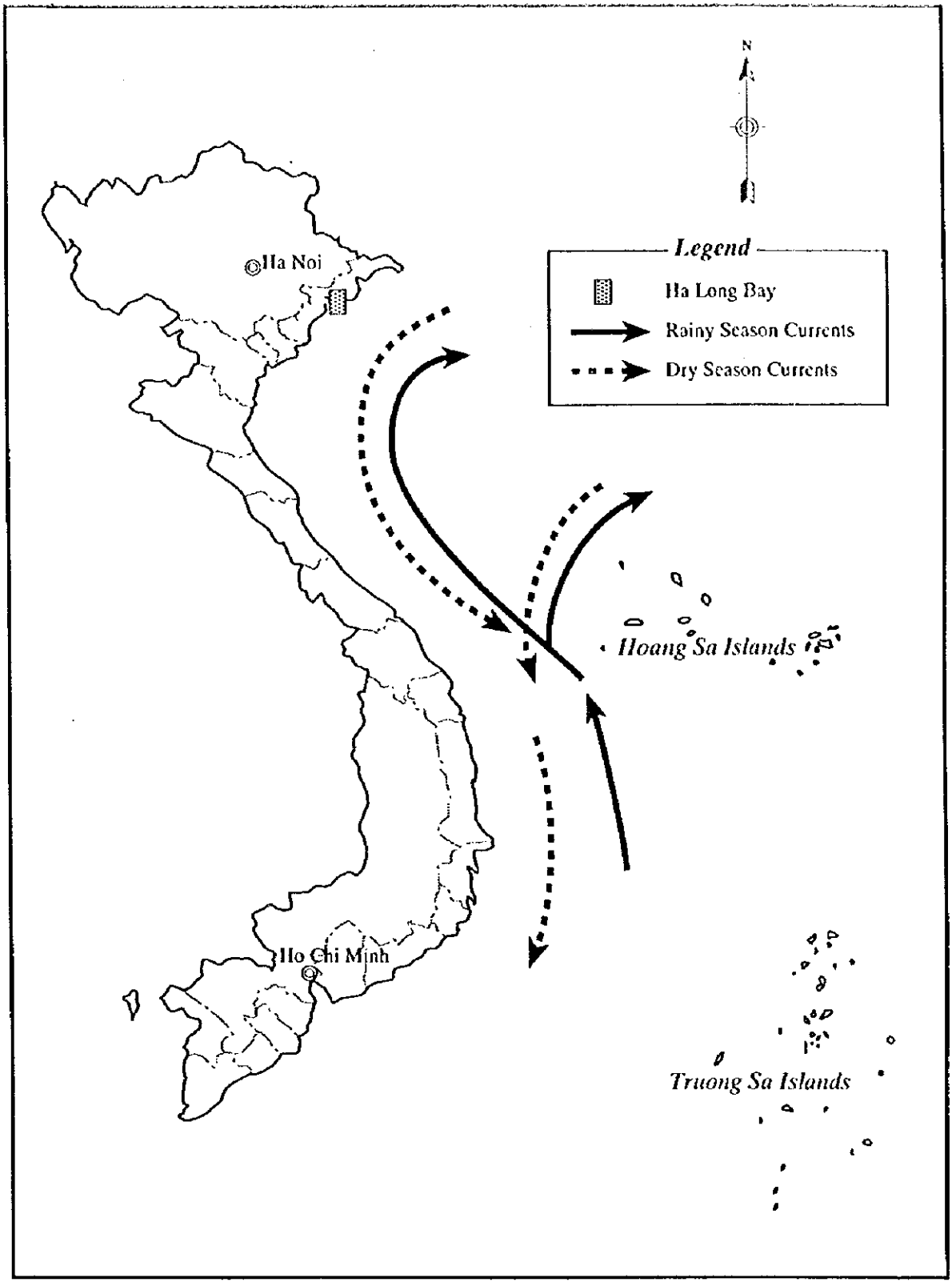


Figure 9.5.9 Chlorophyll-a (1997.6.6 LANDSAT TM band 2)



Source: Resources and Environment State Committee for Sciences

Figure 9.6.1 Tidal Current of the Gulfs of Toukin

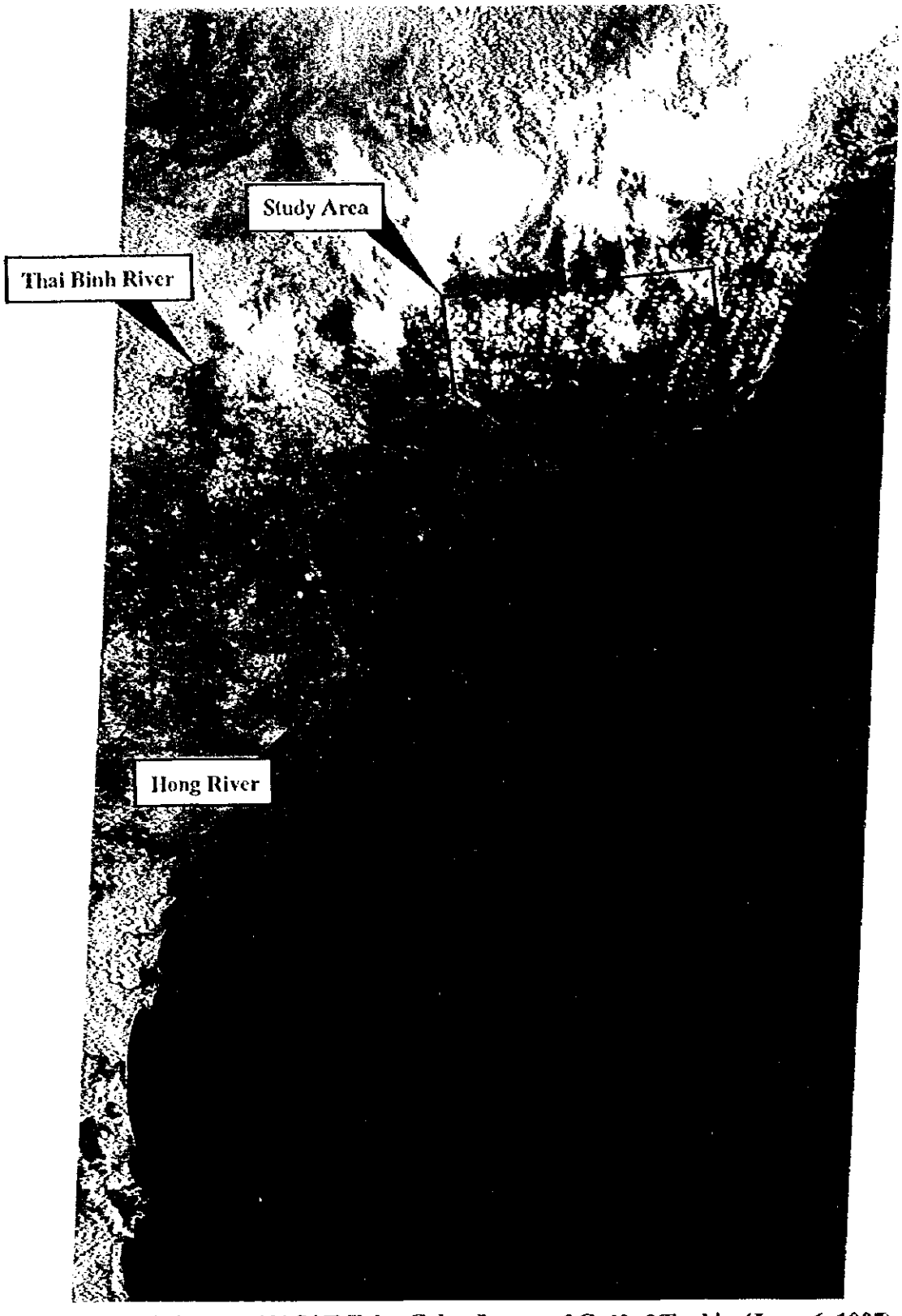


Figure 9.6.2 LANDSAT False Color Image of Gulf of Tonkin (June 6, 1997)

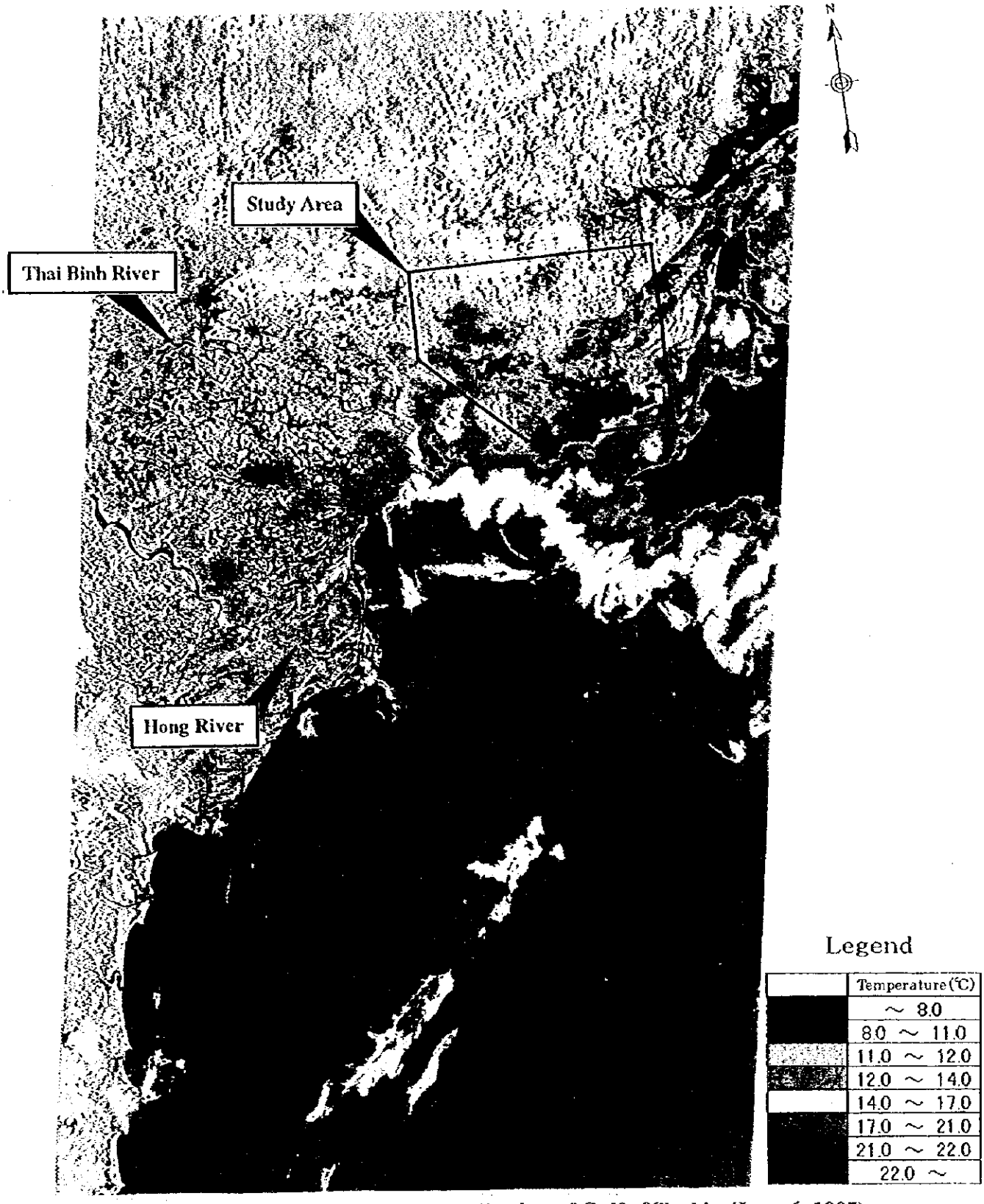


Figure 9.6.3 Water Temperature Distribution of Gulf of Tonkin (June 6, 1997)

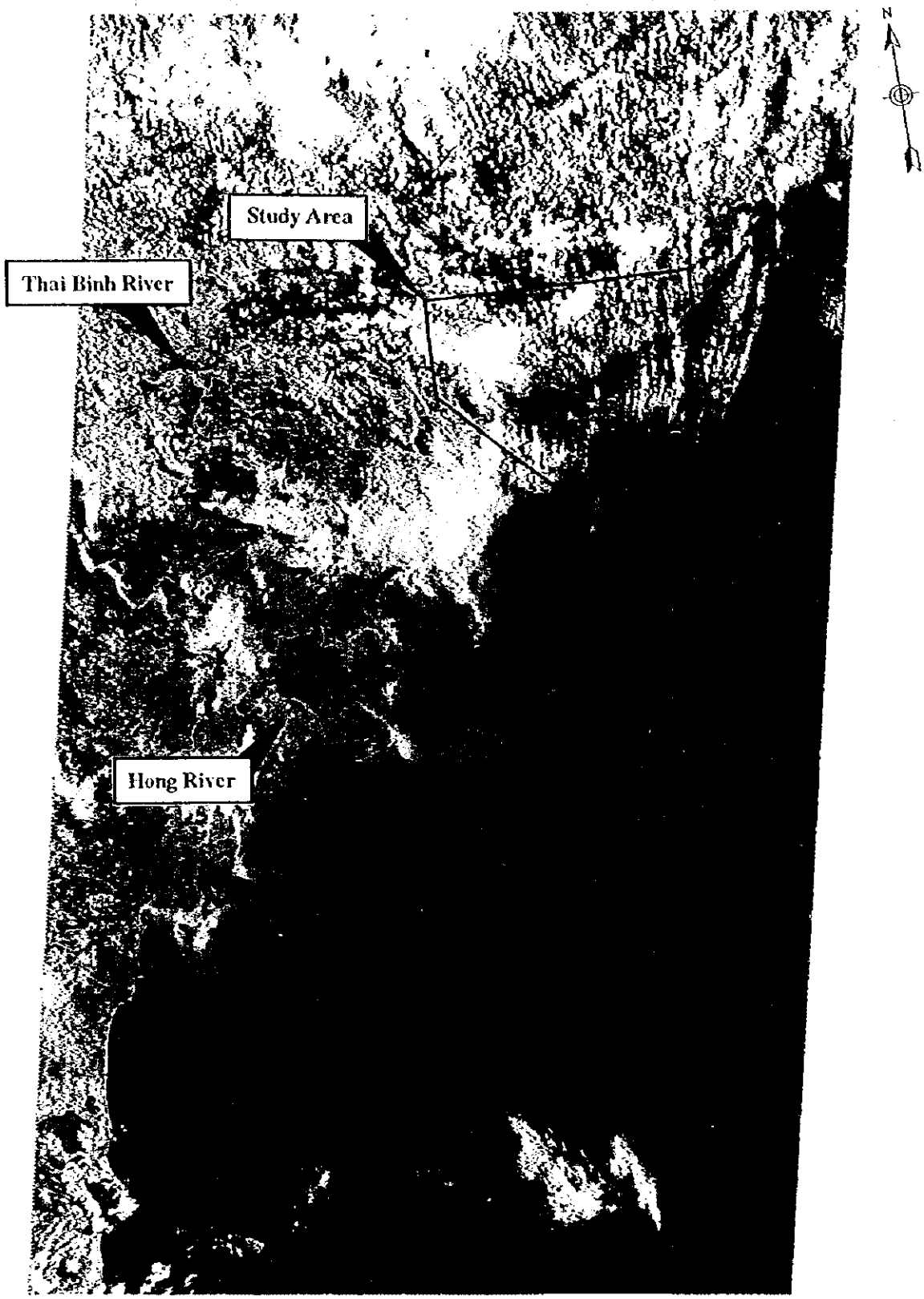


Figure 9.6.4 LANDSAT False Color Image of Gulf of Tonkin (July 11, 1998)

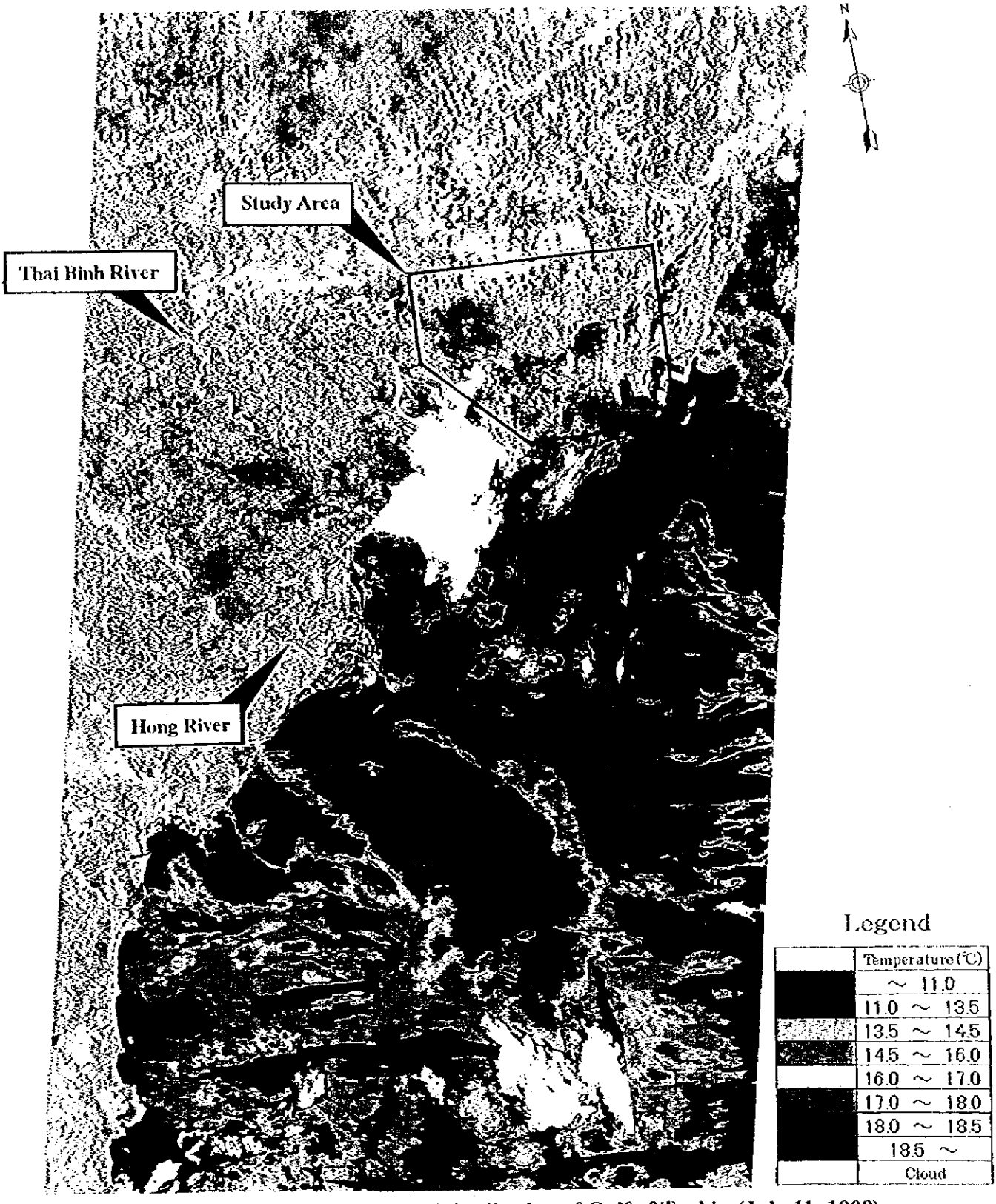


Figure 9.6.5 Water Temperature Distribution of Gulf of Tonkin (July 11, 1998)

CHAPTER 10

CHAPTER 10 POLLUTION SOURCE INVENTORY AND DATABASE

10.1 Pollution Source Inventory

(1) Objectives

There are a great number of pollution sources deteriorating the water quality of the Ha Long bay area. These include industrial wastewater discharges, siltation mainly caused by deforestation, agrochemical, oil pollution from shipping and port facilities, and urban solid waste and wastewater discharge. A first-cut analysis of the water pollution mechanisms is attempted by identifying pollution sources in the Ha Long bay area through establishment of a pollution source inventory.

The pollution source inventory to be developed in the study contributes to the following:

a) Grasp of principal water pollution sources in the EMP area;
b) Estimation of present and future pollution loads from the pollution sources; and
c) Plan of pollution source control for the pollution sources.

In addition to collection of existing data, a questionnaire survey was conducted to obtain detailed data and information for the pollution source inventory in the following manners.

(2) Identification of Potential Pollution Sources

Based on the existing information and field reconnaissance in the Study, types of potential pollution sources in the EMP area were assumed as shown in Table 10.1.1. Information of the potential pollution sources, especially land-based specific pollution sources, (name, address, and type of activity) in the EMP area was collected and listed by DOSTE. Within the list, pollution sources to be surveyed were identified and selected with consideration on types of their activities and feasible number. Also, discussion were made with DOSTE as to whether there is any other type of pollution sources, and whether the classification of pollution sources is suitable in the EMP area.

Among the potential pollution sources, factories (e.g. brewery) and coal related industries (coal mines, coal processing plants, coal shipping port) as industrial pollution sources, hotels and restaurants as commercial pollution sources, and hospitals as institutional pollution sources were selected to distribute questionnaires.

(3) Preparation of Questionnaire Forms

Different kinds of questionnaire forms for different types of the pollution sources were prepared by the study team. Basically the questionnaire form consists of 4 to 6 sections: general information on the pollution sources, water use, wastewater including its treatment, solid waste (overburden for coal mine), pollution control activity. Some specific questions were customized for different types of the pollution sources and added into the questionnaire form. The questionnaire forms for different types of the pollution sources written in English were completed after discussion on their contents with DOSTE. Then, the questionnaire forms were translated into Vietnamese by DOSTE to distribute to the pollution sources. The questionnaire forms are attached in Part III of the Data Book, Volume V.

(4) Distribution of the Questionnaire

The questionnaires in Vietnamese attached with an introductory letter from DOSTE were sent by DOSTE to 127 pollution sources in the EMP area by mail, through relevant agencies and by delivering directly to the pollution sources at the beginning of May, 1998.

(5) Collection of the Questionnaire

The questionnaires were filled out by staff in each pollution source and sent back to DOSTE mostly from middle of May to June, 1998. DOSTE requested for its submission to responsible staff of the pollution sources which was not responded by the submission deadline, and visited to the pollution sources directly to collect the questionnaires sometimes. Finally the questionnaires from 99 pollution sources were collected, which accounted for around 80% of the total number of distributed questionnaires. Statistics of the questionnaires collected is shown below.

Results of Questionnaire Collection

Type of Pollution Sources	Sent	Reply	(%)
1) Coal mine	48	40	83
2) Coal processing plant	2	2	100
3) Coal shipping port	6	2	33
4) Lime stone exploitation site	1	1	100
5) Factory	42	31	74
6) Hotel	16	11	69
7) Restaurant	1	1	100
8) Oil port	1	1	100
9) Hospital	10	10	100
Total	127	99	78

(6) Input of Questionnaire Survey Data into the Pollution Source Inventory

After translated from Vietnamese into English, the answers of the questionnaires have inputted into a personal computer and processed to create a Pollution Source Inventory Sub-database. While inputting data, the study team and DOSTE carefully checked whether it is reasonable data. The Pollution Source Inventory Sub-database is combined into the Environmental Database with other sub-database as explained in Section 10.2.

(7) Water Sampling in Major Pollution Sources

Around twenty major pollution sources such as coal mining and seafood processing factory were selected to conduct wastewater sampling at the end-of-pipe of the each selected facility to obtain data on wastewater quality. The Haiphong Institute of Oceanology (HIO) conducted the wastewater sampling in the middle of July in course of the Field Survey. The results of the analysis for the wastewater samples are applied for estimate of the pollution load for similar type of the industrial facilities (see Part III of the Data Book, Volume V for the results).

(8) Results of the Questionnaire Survey

Data in the replied questionnaires inputted into the database. Statistical results of the questionnaire survey, especially focusing on the data related to the pollution load estimation, are shown as follows.

1) Coal mine

Forty coal mines, which include most of the major-scale open pit and underground coal mines such as Cao Son, Coc 6, Deo Nai, Ha Tu, and Ha Lam replied the

questionnaire. Table 10.1.2 shows data on pollution load from each coal mine. Figure 10.1.1 shows monthly total volume of pumped water from the coal mines. July and August is the rainy season in the EMP area. Therefore, volume of pumped water from coal mines, especially open pit coal mines, are supposed to be largest in those months, but in September. The reason is assumed that some coal mines are closed from June to August based on the answer in the questionnaires.

Data on pollution load from coal mines in each basin is summarized in Table 10.1.3 and Figure 10.1.2. These table and figure show regional characteristics on the coal mines mainly from the geomorphologic point view. For instance, coal production in the basin no.14 is largest since large coal mines such as Cao Son, Coc 6, Deo Nai are concentrated. However, wastewater from those large coal mines is pumped and discharge into basin no.12. These figures do not include the coal mines which stopped exploitation activity or are abandoned.

2) Factory

Answers from 29 factories are summarized in Table 10.1.4. Most of the factories did not answer the questions on the wastewater treatment. Only one factory (Cai Lan Oils and Fats Industries company) applies the bio degradation method though the factory principally does not use water in the manufacturing process, but for cleaning the floor in the factory. Water quality of the wastewater in the most of the factories are unknown.

3) Hospital

All ten major hospitals that were sent the questionnaire responded as shown in Table 10.1.5. Most of the hospitals have septic tank for wastewater and incinerate their medical waste. However, water quality of wastewater discharged and disposal places of the medical wastes which can not be incinerated should be treated in appropriate manner in future.

4) Hotel

Eleven large hotels responded to the questionnaire. As shown in Table 10.1.6, total annual guest number for the hotels is around 194,000 in 1997. All hotels have septic tank to treat wastewater though maintenance activity for septage is

doubtful based on the Field Survey. Tendency of the guest number in 1997 is shown in Figure 10.1.3. The figure shows that there are three peaks of the tourist season in a year.

(9) Update of the inventory

The data in the inventory need to be updated timely to grasp the latest pollution load generation from each specific pollution source and each sub-catchment. Regarding to the specific pollution sources, when new facility or any change of existing facility concerned as a pollution source is registered with Quang Ninh province, DOSTE obtains the information on the facility and should revise the inventory. Data on non-specific pollution sources such as land area for agricultural activities are reviewed at least once a year. Required data on non specific pollution sources is described in Chapter 11.

10.2 Development of Database

(1) Components of the Database

An environmental database (database) is developed in course of the Study as a decision making support tool for the environmental management for Ha Long bay. The database is designed to contribute the following components.

1) Pollution source inventory

The inventory of pollution sources, which principally affect water quality in the EMP area, is stored in the database. The data of the pollution source inventory is utilized for estimation of pollution load from both specific and non specific pollution sources, and for planning pollution control.

2) Hydrology and water pollution analysis

Based on the existing data, pollution source inventory and monitoring data, pollution load from both specific and non specific pollution sources is estimated by using water pollution mechanism module in the database, which is being developed by the study team. Pollution load from each basin is exported into the tide and water quality simulation model.

3) Environmental monitoring

Results of the environmental monitoring, which are mainly water quality relevant data, are recorded at each monitoring activity on the basis of the monitoring plan proposed in the study.

4) Natural environmental and landscape analysis

Existing and monitoring data on the natural environment and landscape is stored.

5) Socioeconomic data analysis

Socioeconomic data which consists of statistical demographic, economic, and social data as basic data for the regional environmental management is collected and stored in the database.

The database consists of four sub-databases: a) Pollution Source Inventory Sub-database, b) Water quality Sub-database, c) Natural Environment Sub-database, and d) Regional Socioeconomic Information Sub-database. The Pollution Load Estimation Module was integrated into the database as the above mentioned. The components of the database are shown in Figure 10.2.1. Data list is shown in Table 10.2.1.

(2) Pollution Load Estimation Module

Based on the estimation of the pollution load from specific and non-specific pollution, a pollution load estimation module was integrated into the database by linking with the pollution source inventory. The module is allowed for users to get latest pollution load generation in each sub-catchment when the pollution source inventory is updated. Also the estimated pollution load generation from each sub-catchment is checked whether it is satisfied with criteria for each sub-catchment. The results of the estimated pollution loads of sub-catchment were applied for the water quality simulation model as input data.

10.3 Utilization of Database

(1) Operation of Database Software

Main features of the database software established in the Study are selective button menu and hyperlink function. Users move from higher rank menu to its sub-menu by clicking the menu button to jump to specific data or information in the same workbook or in another file as shown in Figure 10.3.1. Various types of data forms are used in the database such as table, graph, map, satellite image, and photo. However, the data can be easily edited, revised, exported, and printed out by users since the database software is designed mainly by using basic functions of Microsoft Excel, which DOSTE staff is familiar with.

(2) Updating Data

It is desirable that database be updated periodically to provide users latest data and information, to accumulate data, and to analyze time-series changes of the data. Relevant to the statistical data such as population, it would be updated periodically when new statistics are issued. On the other hand, some data such as pollution source inventory data should be updated as soon as possible when new facility or any change of existing facility concerned as a pollution source is registered or informed. It is recommended that at least one person who is in charge of the database be assigned to update timely and secure the database. Also one computer should be assigned to keep the original database with the latest (updated) data.

(3) Customizing Database

Hyperlink-base structure of the database software allows users to easily edit, revise, and add to the database. When user wants to add data sheet or file, user only add menu button on the appropriate sub-menu and set the hyperlink on the button to link the data sheet or file. Detail information on the database software such as system requirements, installation guide, and customizing method is attached with the package of database software files as a Read Me First file.

TABLES

Table 10.1.1 Classification of Pollution Sources in the EMP area

(1) Specific Pollution Source (Point Source)

1) Domestic Wastewater
- a) Residents in the catchment area
- b) Residents on the sea

2) Industrial pollution source
- a) Coal mining industry
  - a-1) open pit mine*, **
  - a-2) underground mine*, **
  - a-3) coal processing (screening) plant*, **
  - a-4) overburden and coal waste dumping site*
  - a-5) coal shipping port*, **
  - a-6) coal reloading place on the sea
- b) Construction material industry
  - b-1) lime stone exploitation site*
  - b-2) cement factory*
  - b-3) brick factory*
  - b-4) ceramics factory*
- c) Food industry
  - c-1) sea food processing/packing factory*, **
  - c-2) vegetable oil factory*
  - c-3) brewery*, **
- d) Other industries
  - d-1) steel factory*
  - d-2) fertilizer factory*
  - d-3) chemical factory*
  - d-4) others*

3) Commercial and Institutional pollution source
- a) Tourism
  - a-1) hotel including mini-hotel*, **
  - a-2) large restaurant*
  - a-3) tourist boat
- b) Market**
- c) Shipping
  - c-1) freighter for coal, oil, and multi-goods
  - c-2) gas station on the sea
  - c-3) oil port
  - c-4) multi-goods port
- d) Institutional facilities
  - d-1) hospital / clinic*, **
  - d-2) school
  - d-3) governmental office

4) Livestock and Culture pollution source
- a) Livestock
  - a-1) livestock farm
  - a-2) slaughter house
  - a-3) pasturage
- b) Aquaculture
  - b-1) shrimp/fish farm

5) Solid Waste Disposal Site**

(2) Non Specific (Diffused) Pollution Source

1) Land runoff
- a) Forest and grass land
- b) Agricultural land
- c) Bare land (denuded area by coal mining)
- d) Urban area

2) Precipitation

Note: * : Questionnaire Survey was conducted.
** : Wastewater sampling was conducted.
(The results of the sampling are shown in Part III of the Data Book, Volume V.)

Table 10.1.2 (1) Results of the Questionnaire Survey (Coal Mine)

No.	Name of Coal Mine(Company)	Sub-catchment No.	Annual production amount (ton/year)	Water use (m^3/year)	Pumped water from mine (m^3/year)	Wastewater (m^3/year)	Wastewater treatment	Overburden (m^3/year)	Land area (m^2)	Employee (in 1997)
M-17	Hoanh Bo Coal Factory (QN Coal Company)	1	168,000	-	-	-	none	-	-	642
	Subtotal	1	168,000	0	0	0		0	0	642
M-1	917 Factory (Hon Gai Coal Company)	6	59,000	30,945	-	-	-	94,848	300,000	320
M-3	Cao Thang mine (Hong Gai Coal Company)	6	122,700	122,250	-	-	none	-	787,498	1,074
M-7	Suoi Lai Mine (VINACOAL)	6	65,415	-	-	468	none	12,480	1,180,000	317
M-13	Cai Da (Hong Gai Coal Company)	6	51,000	2,630	78,000	78,000	dam, eliminating NH4 by lime clean liquid	-	172,100	442
M-16	916 Company (Geography and Mineral Resources Exploitation Company)	6	72,113	450	-	-	-	67,080	2,892,000	380
M-18	Factory for exploitation & survey (Geography and Mineral Resources Exploitation Company)	6	7,000	36,000	-	43,200	none	-	4,640,000	60
M-21	Khe Tam Mine (QN Coal Company)	6	89,000	16,000	7,000	7,000	sedimentation pond, dykes	270,000	2,761,850	578
M-28	Harang Mine (QN Coal Company)	6	56,200	14,670	-	-	septic hole	4,992	2,800,000	380
M-34	Nam Khe Tam Mine (Dong Bac Company)	6	118,582	2,800	0	0	-	411,840	40,066	532
M-35	KTT 148 Factory (Dong Bac Company)	6	80,000	6,000	0	0	none	42,000	400,000	250
M-36	Coal Exploitation Factory 35 (Cong Ty Dong Bac)	6	106,000	2,496	0	0	none	124,800	600,000	266
M-40	Tay Bai Nga Hai	6	72,000	2,000	1,120	1,120	gas hole	-	200,000	300
M-58*	Dong Khe Sim (Dong Bac Company)	6	(see basin no.11)	(see basin no.11)	-	-	-	124,800	(see basin no.11)	(see basin no.11)
	Subtotal	6	899,010	236,241	86,120	129,788		1,152,840	16,773,514	4,899
M-2	Binh Minh Construction Site -	7	20,000	31,200	3,320	2,170	none	998	160,000	120
M-4	Ha Lan Mine (VINACOAL)	7	467,000	35,000	36,900	72,000	none	300,000	1,680,000	3,392
M-11	Binh Minh Coal Factory (QN Coal Company)	7	54,000	3,000	-	9,360	-	156,000	13,000	-
M-12	Thanh Cong Mine (QN Coal Company)	7	30,000	6,000	20,000	25,000	none	0	3,500,000	350
M-15	Cao Xanh Coal Mine Factory (VINACOAL)	7	70,000	1,900	-	78,000	none	11,232	3,200,000	376
	Subtotal	7	154,000	10,900	20,000	112,360		167,232	6,713,000	726
M-5	Ha Tu Mine (VINACOAL)	9	830,000	200,000	5,100,000	2,500,000	-	4,320,000	7,500,000	2,920
M-6	Nui Beo Mine (VINACOAL)	9	279,498	120,000	1,217,000	1,200,000	-	1,248,000	2,330,000	842
M-8	Tan Lap Coal Mine (Hong Gai Coal Company)	9	470,266	71,543	144,000	235,000	none	312,000	6,800,000	2,074
	Subtotal	9	1,579,764	391,543	6,461,000	3,935,000		5,880,000	16,630,000	5,836
M-33	Khe Sim Factory (Dong Bac Company)	10	50,000	45,000	1,700	1,700	dam	0	17,200	310
	Subtotal	10	50,000	45,000	1,700	1,700		0	17,200	310
M-27*	Deo Nai (VINACOAL)	11	(see basin no.14)	(see basin no.14)	(see basin no.12)	(see basin no.12)	sedimentation pond	2,700,000	(see basin no.14)	(see basin no.14)

Table 10.1.2 (2) Results of the Questionnaire Survey (Coal Mine)

No.	Name of Coal Mine(Company)	Sub-catchment No.	Annual production amount (ton/year)	Water use (m^3/year)	Pumped water from mine (m^3/year)	Wastewater (m^3/year)	Wastewater treatment	Overburden (m^3/year)	Land area (m^2)	Employee (in 1997)
M-31	Thong Nhat	11	332,000	15,000	-	15,000	none	11,856	300,000	1,858
M-58*	Dong Khe Sim (Dong Bac Company)	11	25,000	360,000	-	-	-	(see basin no.6)	3,800	400
	Subtotal	11	357,000	375,000	0	15,000		2,711,856	303,800	2,258
M-26*	Coc 6 Mine (VINACOAL)	12	(see basin no.14)	(see basin no.14)	7,500,000	7,500,000	none	(see basin no.11)	(see basin no.14)	(see basin no.14)
M-27*	Deo Nai (VINACOAL)	12	(see basin no.14)	(see basin no.14)	5,312,960	5,312,960	-	2,700,000	(see basin no.14)	(see basin no.14)
M-49	Xi Nghup Than Cau 20 (Bai Tu Long)	12	-	0	-	0	-	-	-	200
	Subtotal	12	0	0	12,812,960	12,812,960		2,700,000	0	200
M-32	Quang Loi Coal Expolitation Factory (Dong Bac Company)	13	160,100	10,800	-	0	none	748,800	39,000	139
M-45	Via 9 Quyet Thang Khu Bac Quang Loi (Dong Bac Company)	13	116,213	1,500	10,300	10,300	none	-	375,000	400
	Subtotal	13	276,313	12,300	10,300	10,300		748,800	414,000	539
M-25	Cao Son Mine (VINACOAL)	14	1,027,910	113,150	687,000	687,000	none	4,992,000	4,500,000	3,865
M-26*	Coc 6 Mine (VINACOAL)	14	1,455,000	150,000	(see basin no.12)	(see basin no.12)	none	4,992,000	7,340,487	5,164
M-27*	Deo Nai (VINACOAL)	14	1,100,763	693,400	(see basin no.12)	(see basin no.12)	-	(see basin no.11)	922,834	3,367
M-29	Khe Cham Mine (VINACOAL)	14	352,000	64,800	338,400	376,560	none	1,082,016	3,490,000	2,043
M-30	Mong Duong Coal Mine (VINACOAL)	14	328,458	80,000	1,517,200	1,530,700	sedimentation pond	750,000	5,100,000	1,862
M-37	Thang Long (Dong Bac Company)	14	50,000	30,000	57,000	24,000	none	249,600	11,000	120
M-39	397 Factory (Dong Bac Company)	14	115,000	4,560	4,800	4,800	dykes	549,120	300,000	135
M-44	Mong Duong Dong Bac (Geographical Mineral Exploitation Company)	14	124,000	3,000	-	-	-	6,800	11,000	557
M-50	Cam Pha Coal Factory (QN Coal Company)	14	137,000	6,600	-	-	-	1,322,880	960,000	210
M-57	Tay Bac Da Mai (QN Coal Company)	14	40,000	18,000	-	5,200	sedimentation tank	266,198	30,000	100
	Subtotal	14	4,730,131	1,163,510	2,604,400	2,628,260		14,210,614	22,665,321	17,423
	Total		8,214,218	2,234,494	21,996,480	19,645,368		27,571,342	63,516,835	32,833

Source: Questionnaire Survey by JICA study team, 1998

Note : - : not available

M-26 : Coc 6(wastewater=> No.12, production & overburden=>No.14)

M-27 : Deo Nai(wastewater=>No.12, overburden=>No.11:50%&No.12:50%), Production=>No.14)

M-58 : Dong Khe Sim (production=>No.11, Wastewater=>No.6:50%&No.11:50%, overburden=>No.6)

Table 10.1.3 Coal Exploitation Activities in Each Basin

Sub-catchment No.	Coal Production (ton/year)	Water use (m^3/year)	Wastewater (m^3/year)	Pumped Water (m^3/year)
1	168,000	0	0	0
6	899,000	236,200	129,800	86,100
7	154,000	10,900	112,400	20,000
9	1,579,800	391,500	3,935,000	6,461,000
10	50,000	45,000	1,700	1,700
11	357,000	375,000	15,000	0
12	0	0	12,813,000	12,813,000
13	276,300	12,300	10,300	10,300
14	4,730,100	1,163,500	2,628,300	2,604,400
Total	8,214,200	2,234,400	19,645,500	21,996,500
Ratio	1.0	0.3	2.4	2.7

Source: Questionnaire Survey by JICA study team, 1998

Table 10.1.4 Results of the Questionnaire Survey (Factories)

No.	Name of company	Products	Sub-catchmenet No.	Annual production amount	Water use (m^3/year)	Wastewater (m^3/year)	Treated matters	Treatment method	Recycle (m^3/year)	Land area (m^2)	Employee
F-7	Ha Long Ship Building Factory	ship building and repairing	3	25 units	48,000	30,600	-	septic tank	8,200	300,000	1,200
		Subtotal	3		48,000	30,600			8,200	300,000	1,200
F-1	Cailan Oils and Fats Industries Company Ltd	vegetable oils refinery(vegetable cooking oils and shortening)	4	62,400mil.ton	23,664	1,095	oils and grease, suspended solids	bio-degradation	no	40,000	209
F-2	VINAFLOWER Wheat Powder Mill	wheat powder, wheat mash	4	4,476 ton	2,400	0	-	no	no	70,000	158
F-21	Hoanh Bo Forestry Products Processing Workshop	handicraft(plywood)	4	100m3	0	0	-	-	-	100	12
F-23	QN Engineering Factory	engineering manufacture	4	2,013mil.vnd	360	-	-	-	-	14,250	123
F-25	Hoanh Bo Brick Factory	construction materials(air bricks)	4	1,000,000bricks	3,000	-	-	no	no	8,000	30
F-26	Hoanh Bo Printing & Paper Factory	printing cards, producing toilet paper	4	-	720	200	sediment	septic tank	-	10,000	30
F-9	QN Gieng Day 1 Pottery - China Factory	construction materials(baked clay, soil, brick)	4	30,000,000bricks	1,900	-	-	-	-	16,000	443
		Subtotal	4		32,044	1,295			0	158,350	1,005
F-10	QN Gieng Day 3 Pottery - China Factory	brick, tile	7	18,000,000 bricks	5,000	0	-	-	-	50,000	330
F-11	Ha Khou Brick-Tile Factory(Cam Pha Coal Company)	brick, backed clay	7	12,300,000 bricks	3,000	1,500	-	no	-	80,000	231
F-12	QN Gieng Day 2 Pottery - China Factory	construction materials(brick, tile, patterned brick)	7	26,600,000 bricks	5,700	-	-	no	-	77,000	427
F-13	QN Wood Processing & Export Goods Production	wood processing for construction and various wooden products	7	800 m3/year	-	0	-	no	-	12,000	240
F-14	QN Mining Chemical Factory	industrial explosive	7	6,500 ton/year	12,000	1,000	-	septic tank	-	500,000	400
F-24	QN Car Engineering Factory	car engineering and repairing	7	90 car/year	120	120	-	no	-	12,000	194
F-5	QN Beer Company	brewery	7	5,600 mil.liter	17,000	11,200	-	septic tank	no	14,523	401
		Subtotal	7		42,820	13,820			0	745,523	2,223
F-16	Phaemaceutical & Medical Equipment Company	herb medicine	8	1 bil. vnd	-	-	-	no	-	300	35
F-17	QN Ferry Factory	ferry operation	8	-	-	-	-	-	-	-	630
F-3	Frozen Sea Products Processing Plant(QN Fishery Export Company)	fresh frozen and dry sea products	8	1,350 ton/year	30,000	30,000	-	septic tank	-	7,000	331
F-6	Hongai Mechanical Company	coal mine's equipments repairing and manufacturing	8	550 ton/year	8,600	7,600	-	no	2,000	26,943	500
		Subtotal	8		38,600	37,600			2,000	34,243	1,496
F-27	Engineering Factory 3	manufacturing spare parts for drilling, exploring, repairing facilities	10	38 eqipment/year	200	50	sludge	septic tank &sedimentaion pond	150	20,000	105
F-28	Factory of Electric Appliance Manufacturing in Cam Pha	electric appliance, construction of the power station&electric line	10	70,813 unit/year	4,680	936	-	no	468	14,664	429
F-33	Cam Pha Center Mechanical Company	coal mine's equipment repairing and manufacturing	10	13,264 ton/year	54,633	20,000	-	-	65,735	220,000	1,973
F-41	Quang Hanh Mineral Water Plant	beverage producing (mineral water with gas)	10	10,000,000 bottles(0.5l)/year	360,000	50,000	-	-	no	3,500	150
		Subtotal	10		419,513	70,936			60,353	258,164	2,657
F-30	Brewery, Soft Drink Factory	brewery	11	1,700,000 liter/year	31,685	29,000	-	septic tank	-	3,484	190
F-31	Cam Pha Engineering Factory	repairing big ram, truck and diesel engine	11	-	-	-	-	-	-	19,560	520
F-36	Engineering - Power Macinery Assembly Factory	engineering processing, power machinery assembly	11	80 ton/year	500	500	-	no	-	10,000	144
F-40	Hoa Hop (Harmony) Printing Factory	print(binding books, lining paper)	11	1,000,000,000vnd/ year	-	-	-	-	-	192	22
		Subtotal	11		32,185	29,500			0	33,236	876
F-37	QN Ship Building & Repairing Factory	ship building and repairing	12	320 ton/year	-	-	-	-	-	26,070	61
F-43	Factory of Construction No.7	civil and industrial construction (private & public house, office and workshop)	12	-	800	-	-	-	-	2,072	150
		Subtotal	12		800	0			0	28,142	211
		Total			613,962	183,801			76,553	1,55 ,688	9,603

Source: Questionnaire Survey by JICA study team, 1998
Note: - : not available

Table 10.1.5 Results of the Questionnaire Survey (Hospitals)

No.	Name of Hospitals	Sub-catchment No.	Annual patient number (person)	Water use (m^3/year)	Wastewater (m^3/year)	Wastewater treatment method	Medical waste (kg/year)	Treatment for medical waste	Land area (m^2)	Employee
HS-1	Bai Chay Hospital	2	960	2,000	1,600	septic tank	18,000	incineration	5,000	70
HS-6	Hoanh Bo Health Center	4	2,929	5,400	5,400	septic tank	-	incineration	14,000	50
HS-3	Anti-TB Lung Disease Center	7	900	18,000	15,600	no	18,000	incineration	45,000	138
HS-5	QN Traditional Medicine Hospital (Herb)	7	1,112	7,200	4,680	septic tank & sedimentation pond	120	no	10,000	65
	Subtotal	7	2,012	25,200	20,280		18,120		55,000	203
HS-2	Hon Gai Coal Area Health Center	8	185	4,000	300	septic tank	18,000	incineration	30,000	129
HS-4	QN Provincial Hospital	8	-	60,000	21,810	no	12,000	incineration, sterilization	45,000	434
	Subtotal	8	185	64,000	22,110		30,000		75,000	563
HS-7	QN Suoi Khoang Sanatorium Station	10	260	1,800	1,800	septic tank	24	incineration	19,000	23
HS-8	Psychiatric Prevention Center	10	1,807	3,600	3,276	septic tank	3,600	no	15,879	68
	Subtotal	10	2,067	5,400	5,076		3,624		34,879	91
HS-10	Cam Pha Health Center	11	13,237	5,580	4,056	septic tank, sedimentation pond, refining	624	incineration, burying	24,000	181
HS-9	Cam Pha Coal Area	12	-	3,600	15,000	septic tank	-	incineration	-	200
	Total		21,390	111,180	73,752					1,358

Source: Questionnaire Survey by JICA study team, 1998
Note: - : not available

Table 10.1.6 Results of the Questionnaire Survey (Hotels)

No.	Name of Hotel	Sub-catchment No.	Annual guest number (persons/year)	Water use (m^3/year)	Wastewater (m^3/year)	Treatment method	Land area (m^2)	Employee
HT-2	Bach Dang	3	7,376	9,569	7,300	septic tank	4,160	58
HT-3	QN Tourism Company	3	73,237	60,800	83,220	septic tank	104,824	385
HT-5	Heritage Halong	3	10,809	23,127	22,995	septic tank	6,392	210
HT-6	Halong Plaza	3	705	25,000	25,550	septic tank, sedimentation pond	6,500	138
HT-7	Ha Yen Hotel	3	5,634	10,200	10,950	septic tank, sedimentation pond	4,000	15
HT-9	Suoi Mo(Dream Stream)	3	17,000	10,200	-	-	4,470	46
HT-11	Thang Long Hotel	3	1,142	1,727	49,275	septic tank	10,000	13
HT-12	Tien Long Hotel	3	13,026	12,000	7,300	septic tank, sedimentation pond	36,000	42
HT-14	Vuon Dao Hotel	3	29,357	30,000	-	septic tank, sedimentation pond	23,991	26
HT-16	Bai Chay Trade Union Tourism Company	3	31,451	39,484	39,420	sedimentation pond	25,000	87
	Subtotal	3	189,737	222,107	246,010		225,337	1,020
HT-8	Hoang Ngoc Hotel	8	4,013	961	-	septic tank, sedimentation pond	545	21
	Subtotal	8	4,013	961	0		545	21
	Total		193,750	223,068	246,010		225,882	1,041

Source: Questionnaire Survey by JICA study team, 1998
Note: - : not available

Table 10.2.1 Data List

Categorized Item	Name of Data
(1) Socioeconomic Sub-database	
1) Population	Population of Ha Long City
	Population of Cam Pha Town
	Population Growth of Ha Long City and Cam Pha Town
2) Climate	Monthly Average Rainfall in the Study Area and the Vicinity in 1996
	Monthly Average Temperature in the Study Area and the Vicinity in 1996
	Monthly Average Humidity in the Study Area and the Vicinity in 1996
	Monthly Average Hours of Sunlight in the Study Area and the Vicinity in 1996
3) Land Use	Existing Land Use Pattern in the Study Area in 1996
	Classified Area in 1988, 1992 and 1997
	Area Change of Mangrove Forest, Tidal Land and Coal Mining
	Land Use of the Study Area as of 1996
	Land Use Map
	Forest land in Quang Ninh Province in 1996
4) Economic and Financial Indices	GDP Share and its Change of Quang Ninh Province
	GDP Share of Districts in the Study Area in 1994
	GDP of Study Area in 1995
	Employment by Sector in Ha Long City and Province
	Household Groups by Expenditure in Ha Long City and Cam Pha Town
	Economic Indicators of National Level
	Retail Prices of Typical Commodities in Specific Locations
	Typical Service Prices in Hanoi and Quang Ninh Province
	Public Expenditures for Environmental Projects/Programs
	Collected Amount of Water-Supply Levy in the Quang Ninh Province
	Revenue and Expenditures of Quang Ninh Province
5) Tourism	Indicators Related to Tourism in Quang Ninh Province (1990-1997)
	Recent Trends of Tourism in Quang Ninh Province
6) Coal Mine Activities	Estimated Production, Overburden and Mine Wastewater to 2010
	Estimated Coal Production in Quang Ninh by Region
7) Agriculture	Major Agricultural Products of the Study Area in 1996
	Number of Livestock in the Study Area in 1996
8) Sanitary Condition	Estimated Total Amount of Waste
	Coverage of Various Types of Collection in the Main Regions of the Study Area
(2) Natural Environment Sub-database	
1) Wetland ecosystem	Tidal flat in Bai Chay Bay
	Tidal flat in Ha Long Bay
- Mangrove	Mean Height of Dominant Species of Mangrove
	Species Composition of Mangroves in Quang Ninh Province
- Coral Reefs	Location of Survey Sites of Coral Reef in the Study Area
	Number of Species and Coral Cover at Each Survey Site in the Study Area
2) Aquatic Ecosystem	
- Plankton	Survey Points of Plankton in the Study Area
	Number of Species and Cell Number of Phytoplankton
	Number of Species and Individual Number of Zooplankton
- Zoobenthos	Survey Points of Zoobenthos in the Study Area
	Number of Species, Individual Number and Biomass of Zoobenthos in Mangrove Swamps
	Number of Species, Individual Number and Biomass of Zoobenthos in Sublittoral in the Soft Bottom
	Number of Species, Individual Number and Biomass of Zoobenthos in Sublittoral in Coral Reefs
- Fish and shellfish	Main Species of Fish and Shellfishes in Main Fishing Grounds in Ha Long Bay
	Survey Site and Fishing Ground in the Study Area
(3) Water Quality Sub-database	
1) Filed Survey by JICA study team in 1998	Water and Sediment Variables Measured in Field Survey
	Water Quality in the Bays
	Bottom Sediment Quality
	Result of Productivity Test
	Result of Decomposition Test
	Result of Settlement Test
	Result of Elution Test
	Sampling Station Location of Field Survey

Categorized Item	Name of Data
	Water Quality Indicators in Tributaries in Dry and Rainy Conditions
	Transparency in the Bays (1998.7.15~18)
	BOD & CODMn in the Bays (1998.7.15~18)
	SS in the Bays (1998.7.15~18)
	T-N in the Bays (1998.7.15~18)
	T-P in the Bays (1998.7.15~18)
	Surface Water Quality Indicators at Shoreline Sampling Stations in Ha Long Bay and Bai Tu Long Bays
	Surface Water Quality Indicators at Shoreline Sampling Stations in Ha Long Bay and Bai Tu Long Bays
	Surface Water Quality Indicators at Shoreline Sampling Stations in Ha Long Bay and Bai Tu Long Bays
	Surface Water Quality Indicators at Shoreline Sampling Stations from Bai Chay South to Cat Ba Island
	Surface Water Quality Indicators at Shoreline Sampling Stations from Bai Chay South to Cat Ba Island
	Surface Water Quality Indicators at Shoreline Sampling Stations from Bai Chay South to Cat Ba Island
	Sediment Variables at Water Quality Stations
	Results of Analysis of Domestic Wastewater Samples from Field Survey
	Results of Analysis of Industrial Wastewater Samples from Field Survey
	Industrial Wastewater Pollution Loads from Points Sampled in Field Survey
	Results of Dust Survey
2) LANDSAT Satellite Image	Current Tendency on November 4, 1988
	Current Tendency on December 1, 1992
	Current Tendency on June 6, 1997
	Locations of the Current Measuring Stations and Water Level Measuring Stations
	Water Temperature (1988.11.4 LANDSAT TM band6)
	Water Temperature (1992.12.1 LANDSAT TM band6)
	Water Temperature (1997.6.6 LANDSAT TM band6)
	Turbidity (1988.11.4 LANDSAT TM band6)
	Turbidity (1992.12.1 LANDSAT TM band6)
	Turbidity (1997.6.6 LANDSAT TM band6)
	Chlorophyll-a (1988.11.4 LANDSAT TM band6)
	Chlorophyll-a (1992.12.1 LANDSAT TM band6)
	Chlorophyll-a (1997.6.6 LANDSAT TM band6)
3) Monitoring Data	
- Water and Sediment Quality	(to be inputted)
- Biological Indicators	(to be inputted)
(4) Pollution Source Inventory Sub-database	Results of Questionnaire Survey for Factories
	Results of Questionnaire Survey for Coal Mines
	Results of Questionnaire Survey for Coal Processing Plants
	Results of Questionnaire Survey for Coal Shipping Ports
	Results of Questionnaire Survey for Hotels
	Results of Questionnaire Survey for Hospitals and Clinics
	Results of Questionnaire Survey for Restaurants
(5) Pollution Load Estimation Module	Land Use at Each Sub-catchment as of 1996
	Unit Pollution Load of Human Being
	Unit Pollution Load of Livestock
	Unit Pollution Load of Non-specific Pollution Sources
	Domestic Pollution Load Generation
	Pollution Load Generated by Tourists
	Pollution Load Generated by Factories
	Pollution Load Generated by Coal Mines
	Pollution Load Generated by Coal Processing Factories
	Pollution Load Generated by Coal Ports
	Pollution Load Generated by Industries
	Pollution Load Generated by Livestock
	Pollution Load Generated by Non-specific Pollution Sources
	Total Pollution Load Generated
	Run-off Ratios of Pollution Loads
	Run-off Pollution Loads into the Bays