社会開発調査部報告書

No. 2

JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF SCIENCE, TECHNOLOGY AND ENVIRONMENT
PEOPLE'S COMMITTEE OF QUANG NINH PROVINCE
THE SOCIALIST REPUBLIC OF VIETNAM

THE STUDY ON ENVIRONMENTAL MANAGEMENT FOR HA LONG BAY

FINAL REPORT

VOLUME V DATA BOOK

SEPTEMBER 1999

NIPPON KOEI CO., LTD.
METOCEAN CO., LTD.

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LIST OF VOLUMES

Volume I	Executive Summary
Volume II	Main Report
Volume III	Supporting Report 1
Volume IV	Supporting Report 2
Volume V	Data Book

EXCHANGE RATE

US$ 1 = VND 13,927.5 (as of July 25, 1999) = **Yen 121.46**

THE STUDY
ON
ENVIRONMENTAL MANAGEMENT
FOR
HA LONG BAY

FINAL REPORT

Volume V Databook

Table of Contents

PART I

RESULTS OF FIELD SURVEY

Final Report of Field Survey

TABLE OF CONTENT

INTRODUCTION

In connection with the importance of the Ha Long Bay area, the study on environmental management plan for Ha Long Bay, Vietnam, has been carried out under sponsor of Japan International Cooperation Agency (JICA). The Project Steering Committee includes MOSTE and Quang Ninh People's Committee, Vietnam and JICA Study Team (JST). The field survey in Ha Long Bay and the adjacent area is one of the project's activities. It is implemented by the Work Team of Hai Phong Institute of Oceanology (HIO) according to the contract signed between JST and HIO on June 27, 1998.

In connection with the above contract, the main activities are conducted as follows:

- The 1st step: Reconfirmation of the sampling sites and points, field trip and taking the film rolls pictures by helicopter on July 20, 1998 (JST with HIO).

- The 2nd step: Conducting the Technical Training - Seminar on Marine Environment Monitoring Design and Field Sampling (July 5-6, 1998) for Quang Ninh DOSTE staff, HIO Work Team (HIO experts).

- The 3rd step: Conducting the field survey in the Ha Long Bay area, including the watershed and Cat Ba islands (all Work Team, from July 10 - August 9 , 1998).

- The 4th step: Conducting LAB - Works, data processing and reporting.

The survey activities in the field were carried out under the inspection of the JST experts. The Quang Ninh DOSTE staff also participated in the field survey with the purposes of practical attachment under technical assistance of the Work Team.

The above mentioned activities of the field survey were presented in HIO's progress report to JST on July 31, 1998.

This report is the survey results and major findings and has been completed after the draft final report was considered and commented by JST, but it is still not to be conclusive.

Taking this opportunity, we would like to express sincere thanks to JST for the kind cooperation and technical assistance; to the National Steering Committee and to Quang Ninh DOSTE for their help and facilitation during this survey operation.

1. BACKGROUND

1.1. Geographical Scope

Ha Long is located in Quang Ninh province, Northern Vietnam. It is associated with Cat Ba island in the South and Bai Tu Long Bay in the North, to form a natural system rich in ecotourism potentials. Therefore, the bay has became a famous beauty not only of Vietnam, but also of the world as Natural Heritage recognised by UNESCO on it's 18th Annual Meeting. Ha Long Bay-Cat Ba island area is also rich in unique tropical ecosystems with economically valuable resources such as coral reefs, mangroves, seagrasses, small limestone islands, tidal wetlands and tropical forest etc. So, this area has been adopted by Asia Bureau for Conservation (ABC) as a proposed Marine Protected Area (MPA) by 1995.

This area is also situated within a dynamic economic triangle Ha Noi - Hai Phong - Quang Ninh in Vietnam. Therefore, the human activities are more and more increased and the multiple use is strongly developed. The benefit conflicts relating to the multiple development activities are created and emerged. At the same time, the bays environment will be degraded in the new context of open door policy of Vietnam GOV.

It is necessary for the conservation of Ha Long Bay area to develop an environmental management plan. Therefore, the study on such a plan for the Ha Long Bay area is conducted by JST. Within the framework of the study, the scope of the field survey is defined:

- Ha Long Bay, the portion of Bai Tu Long Bay, Bai Chay Bay (or called the bays with hundreds of chert and limestone islands).
- Cat Ba island area and Cam Pha district.
- Terrigenous rocky hill area in the west as coastal land area including watersheds.

1.2. Issue Scope

The field survey for the study on environmental management plan in Ha Long Bay is involved with the main issues as follows:

- To study on hydrological conditions in the bays and in the rivers.
- To understand the state of the environmental contamination in Ha Long Bay, it's changes and the sources of the contaminants.
- To understand the mechanism of pollution in Ha Long Bay.

- To understand the threats (stress) of coastal development on the bays environment.

- To assess the impacts from development activities on biota systems in this area.

1.3. Objectives

In order to solve the above mentioned issues, this field survey is to be addressed on major objectives as follows:

- ***Short - Term:***

To provide the survey data and information on environmental quality, dynamic and impact for development of environmental management plan in Ha Long Bay area in the framework of JST Tasks.

- ***Long - Term:***

- To contribute to setting up the environmental database for the Ha Long Bay area.

- To maintain the ecological function of this area and the natural systems.

- To conduct the natural conservation and biodiversity in the context of the balance with the development activities.

1.4. Tasks

The field survey for study on environmental management plan for Ha Long Bay is involved with the main tasks as follows:

- ***Hydrology Survey*** in the rivers and in the bays, including current measurement (current direction and velocity by 2 layers - surface and the bottom); sea level measurement; wind direction and velocity at the survey points; and hydrology survey in the rivers implemented by measuring flow section and velocity.

- ***Water Quality Surveys***:

- Ambient water quality in the bays with measured and analyzed parameters such as: Temperature, Salinity, pH, DO, COD_{Mn}, Coliform, faecal coliform, BOD_5, TDS, SS, turbidity, NH_3-N, NO_2-N, NO_3-N, T-N, PO_4-P, T-P, Oil-grease, phenol, CN, As, T-Hg, Cr, Cu, Mn, Zn, Pb, Cd, Fe, Ni, transparency, Chl-a.

- Pollution mechanism in the bays: productivity test (primary productivity rate by phytoplankton); decomposition test (decomposition rate of organic matters); settlement test (settling velocity/flux of organic particles such as detritus); and elution test (release rate from bottom sediment).

- Pollution sources: domestic and industrial wastewater measured and analyzed with water discharge survey.

- ***Bottom Sediment Survey***: the items to be surveyed and analyzed such as: temperature, smell, sediment quantity, color, mixed matter, water content, pH, COD, ORP, grain - size composition, ignition loss, T-C, T-N, T-P, H_2S, Pb, As, Mn, T-Hg, Zn, Cr and Cd.

- ***Dust Survey***: measurement of settled dust quantity, determination of wind direction and velocity, determination of dust sources impacting on the bay environment.

- ***Biological Indicator Survey***: the items of this task are implemented as follows:

- Terrestrial vegetation (distribution, cover, rare and precious species, community structure and threaten level).

- Mangrove (species composition, cover, density, height, size, square area and threats by human activities).

- Plankton (species composition, cells density of phytoplankton in surface and bottom layers including microflagellates, settling volume and density of zooplankton).

- Zoobenthos (species composition of benthic taxonomic groups, biomass and density per m^2).

- Marine fish (species composition, distribution, habitat).

- Algae and seagrass (species composition, distribution and cover).

- Coral and coral reefs (species composition, distribution and status of coral reefs).

1.5. Implementing Organization

Implementing organization structure is presented in the below scheme 1.

- An office has been rented by HIO in Ha Long City (Van Nam Hotel, 31 Vuon Dao street, Bai Chay) during the field survey time in order to keep correspondence between HIO (Work -Team) and JST.

- The Coordinating Body of the field survey has also been established including the members as follows:

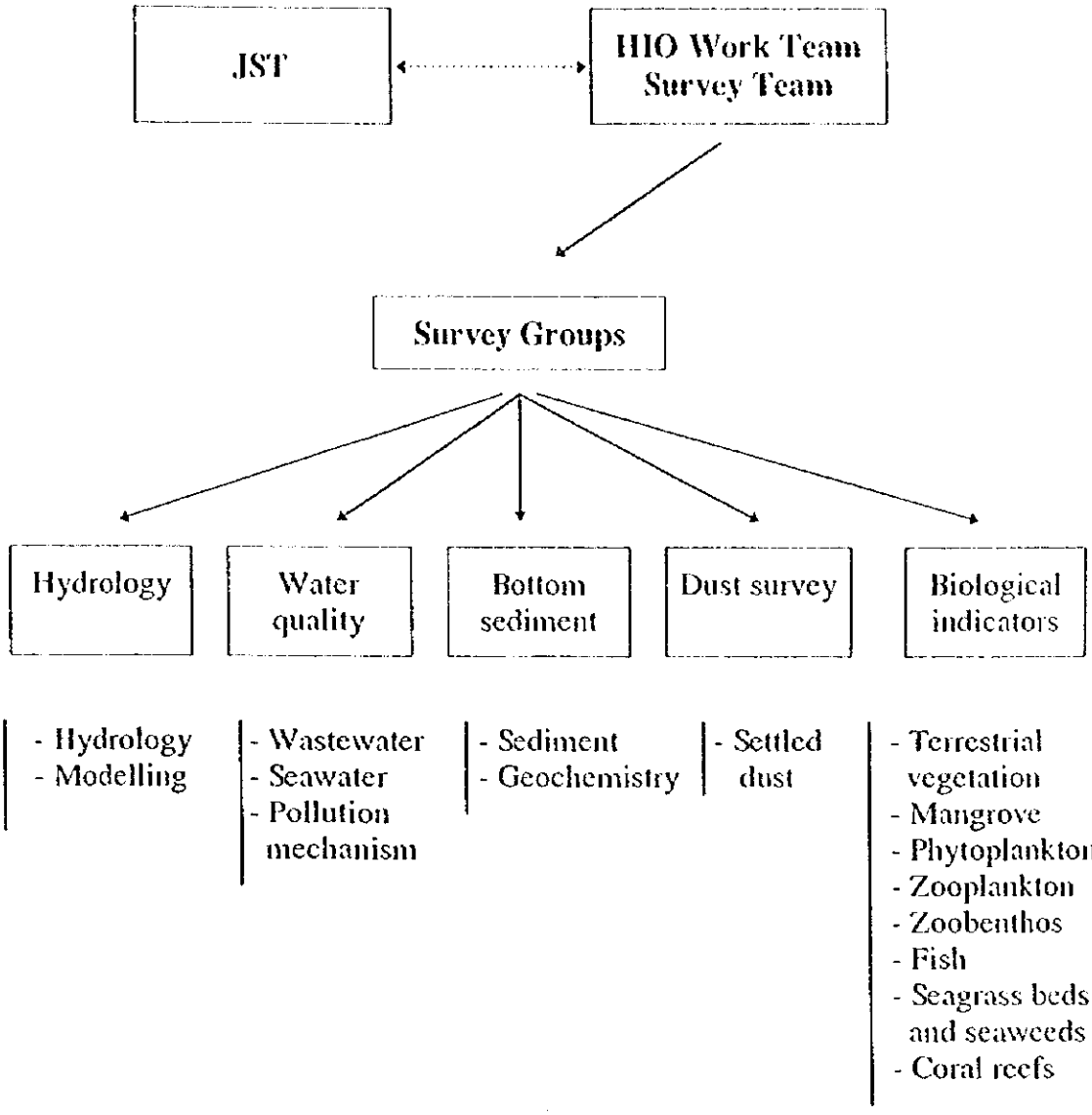
- Prof. Dr. Nguyen Chu Hoi (Team Leader).

- MSc. Tran Dinh Lan (Scientific Secretariat in Charge).

- MSc. Do Dinh Chien (Assistant - Secretariat).

- Dr. Nguyen Duc Cu (Member).
- Dr. Nguyen Huy Yet (Member).

Scheme 1. Implementing Organization Structure



- The field survey works are carried out under leadership of one expertised specialist of the group:

- Hydrology survey group (Dr. Nguyen Minh Son).
- Dust survey group (Dr. Hoang Xuan Co).
- Water quality survey group (Dr. Nguyen Duc Cu).

- Bottom sediment survey group (MSc. Tran Dinh Lan).
- Biological indicator group (Dr. Nguyen Huy Yet).

• Some groups were also devided into the special subgroup:

- Wastewater subgroup (Dr. Dinh Van Huy and MSc. Do Dinh Chien).
- Seawater quality subgroup (Dr. Nguyen Duc Cu).
- Pollution mechanism subgroup (Dr. Luu Van Dieu).
- Sediment subgroup (MSc. Tran Dinh Lan).
- Geochemistry subgroup (MSc. Nguyen Phuong Hoa).
- Terrestrial vegetation subgroup (Prof. Dr. Nguyen Khac Khoi).
- Mangrove subgroup (MSc. Le Thi Thanh).
- Plankton subgroup (MSc. Chu Van Thuoc).
- Zoobenthos subgroup (Dr. Pham Dinh Trong).
- Algae - seagrass subgroup (Dr. Nguyen Van Tien).
- Coral reef subgroup (Dr. Nguyen Huy Yet).

1.6. The Survey Products

Some kinds of survey products are formed, including HIO technical proposal for field survey, the HIO technical training document, the HIO progress report, the survey data reports, the photo reports and the final report (a copy in diskettes attached). They are prepared and written by HIO Coordinating Body in Vietnamese and English. The HIO Coordinating Body and Team Leader are responsible for the field survey results and the quality of all reports submitted to JST.

The list in detail of the survey products is provided as follows:

- Progress report (already submitted),
- Final report of field survey,
- Data report set including maps of the location of sampling points.

Part I: Hydrology in the bays report (38 pages) and appendix,

Part II: Water quality.

Tome 1. Field survey records,

Tome 2. Analysed parameter at each survey point,

Tome 3. Integrated table of analysed parameter.

Part III: Bottom sediment data (17 pages),

Part IV: Settled dust,

Part V: Biological indicators with:

Tome 1. Terrestrial vegetation, Mangroves, Phytoplankton, Zooplankton (183 pages and 18 photos),

Tome 2. Zoobenthos (109 pages and 16 photos),

Tome 3. Fish, Algae, Coral and coral reefs (145 pages and 68 pages) and annex (111 pages).

- Terrestrial vegetation map of the whole catchment area of the bays and the Cat Ba island, 1/200 000,
- Map of locations of stations of hydrology survey, Ha Long and Bai Tu Long Bays, 07/1998,
- Map of water quality and bottom sediment survey point in the bays and rivers,
- Map of domestic wastewater survey point,
- Map of plankton sampling points in Ha Long Bay (7/1998),
- Map of survey sites and fishing ground in Ha Long Bay,
- Map showing survey site of macroalgea in Ha Long Bay,
- Map of mangrove areas on the Hoang Tan island and survey sites in 7/1998,
- Map of survey points and distribution of zoobenthos in Ha Long Bay.
- Map of coral reef survey sites and the coral reef areas in Ha Long Bay,
- Documents:

- Technical Training-Seminar documents,
- Photos plates,
- Video tape.

Final report and data set have sent to JST in DOS text format diskettes.

2. METHODS

2.1. Tidal Current

- ***Field Survey***: The main objective of the hydrology survey is to conduct the current measurement at three stations simultaneously in the Ha Long Bay and Bai Tu Long Bay. These stations were identified by JST

experts and the current measurement was done as required in TOR and agreed at the meeting in Quang Ninh in June 1998. The co-ordinates and depths of the hydrology survey stations are shown in table 1 and on the map.

Table 1. Co-ordinates and Depths of the Stations

Station	*Location*	*Depth (m)*
Cua Luc	107°03'03", 20°57'27"	16.0
Cua Dua	107°08'03", 20°49'21"	11.5
Cam Pha - Cua Ong	107°20'55", 20°58'25"	15.4

At each station, the current measurement (direction and velocity) has been conducted by self-recording current meters of which installed record periods every fifteen minutes at the surface and bottom layers within fifteen days. As required, the current meters were hung and left at each layer by using buoys and anchors to keep them at the exact depth. The mode of the equipment installation is illustrated on the figure 2 (for Cua Luc and Cam Pha - Cua Ong stations) and figure 3 (for Cua Dua station). In order to ensure safety of the survey, the buoys (with a light or a flag as a sign) are connected with the meter set in the bays.

Survey equipment and tools have served for hydrology survey in table 2.

Table 2: Survey Equipment and Tools

Item	Quantity
Self-recording current meter DNC-2M (UK)	6
Anemometer	3
Compass	3
Global Positioning System KGP 912 (Japan)	1
Buoy for current meters	12
Security jacket, hat and attire	9
Flashing lamp	9
Other, such as leads, rope, etc..	

Fig. 4: MAP OF LOCATIONS OF STATIONS OF HYDROLOGY SURVEY, HA LONG AND BAI TU LONG BAYS, 07/1998

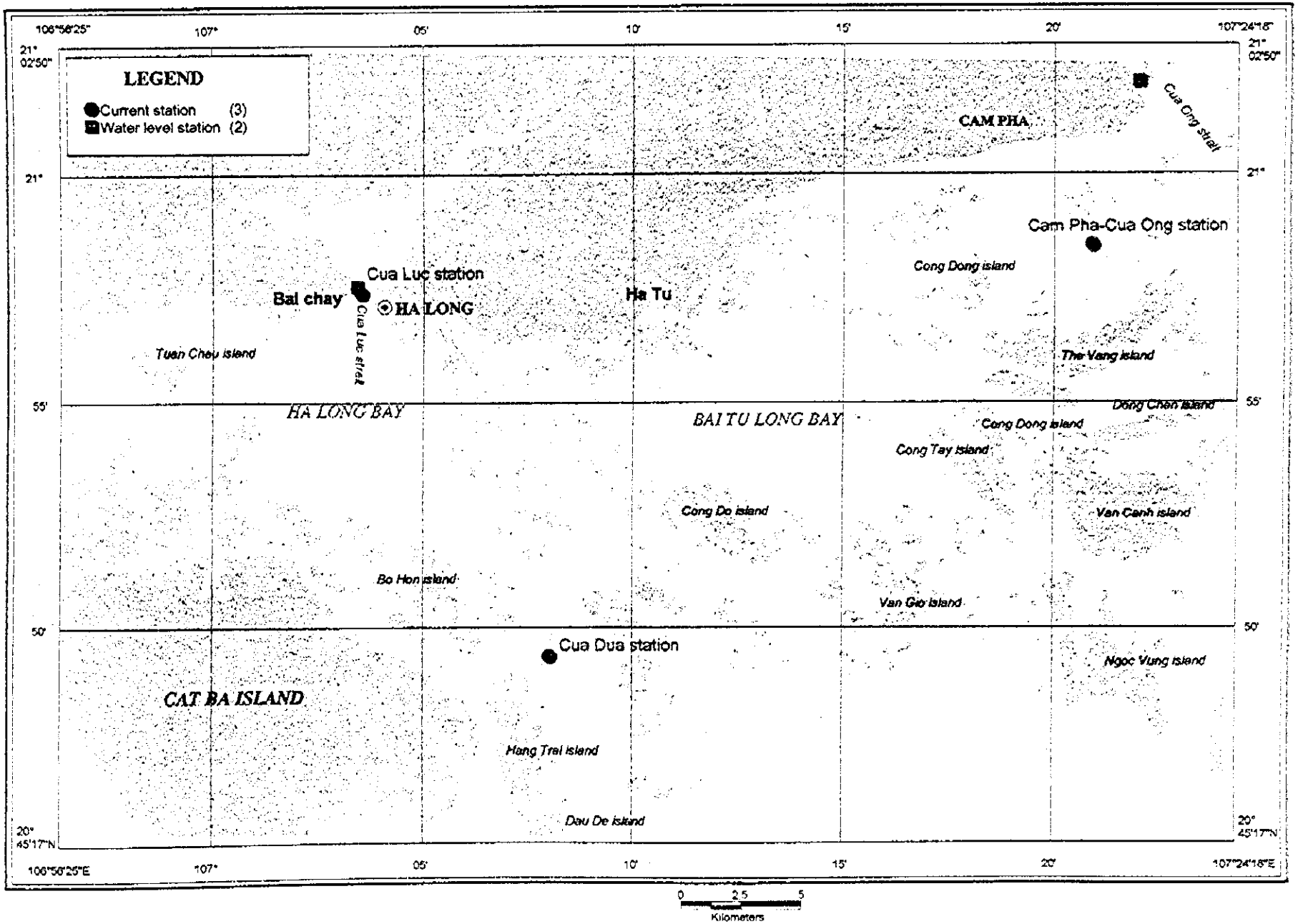
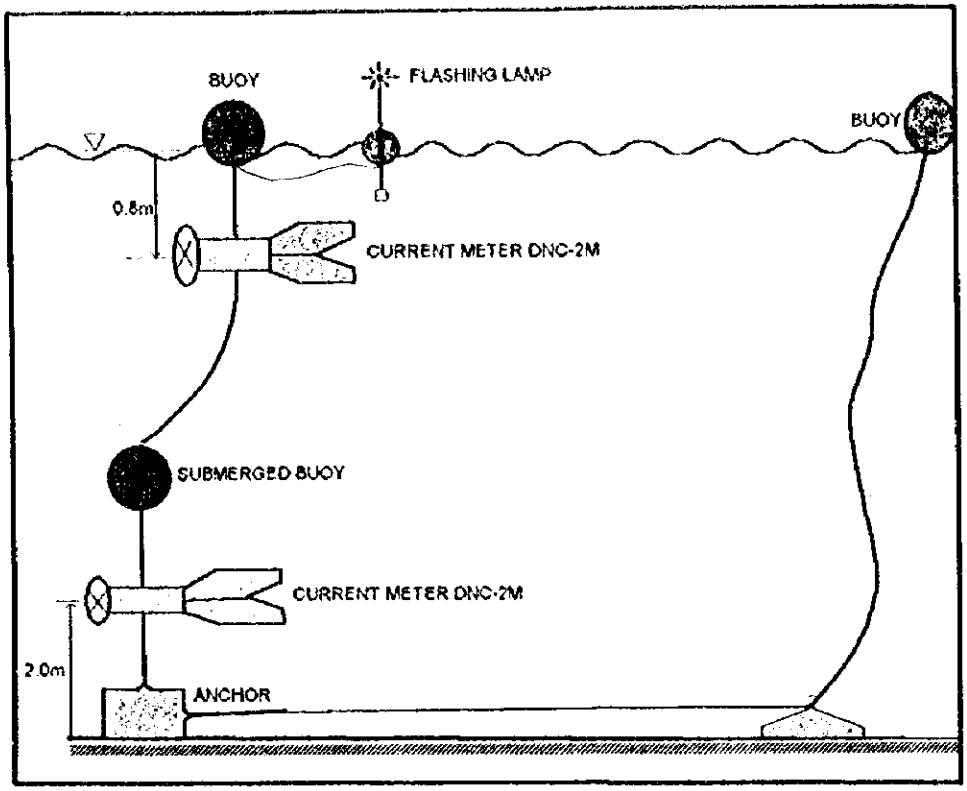
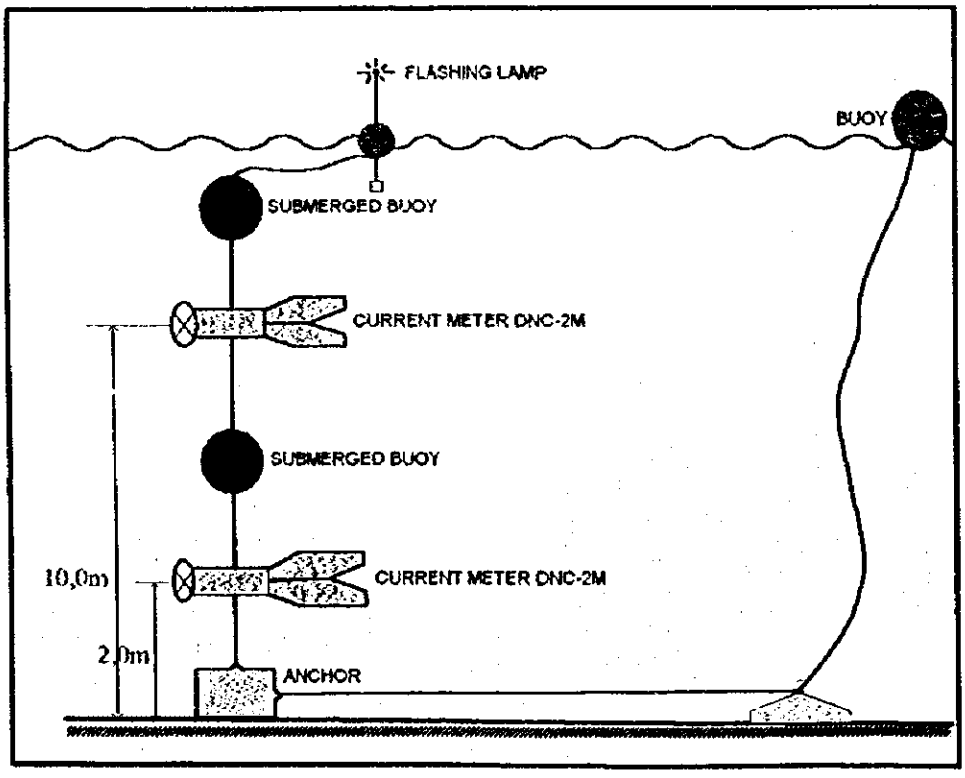


Figure 2: SCHEME OF INSTALLATION OF CURRENT METERS AT CUA LUC AND CAM PHA-CUA ONG STATIONS



Note: The depth (referred to Chart datum)
At Cua Luc station: 16.0m
At Cam Pha-Cua Ong station: 15.4m

Figure 3: SCHEME OF INSTALLATION OF CURRENT METERS AT CUA DUA STATION



Note: The depth (referred to Chart datum) at Cua Dua station: 11.5m

The current meters for bottom current measurement were fixed at the depth of 2m above the bottom at all stations, while those for surface current measurement were hung at 0.8m below the water surface at the Cua Luc and Cam Pha - Cua Ong stations and it was fixed at 10m above the bottom at the Cua Dua station (the water depth at this station is 13.5m referred to as the Mean Sea Level) due to the presence of wave in this area.

The wind direction and velocity was measured every three hours (at 1h, 4h, 7h, 10h, 13h, 16h, 19h and 22h) by anemometers with the aid of a compass at the altitude of about 3m above the sea surface at the three stations during the survey time period. The measured six-hourly (at 1h, 7h, 13h and 19h) water levels at Bai Chay and Cua Ong stations during this time have been collected from the Bai Chay Hydro-meteorological Station.

The measurement activity started from 14 July and ended at 14h30, 30 July, 1998.

- *Data Processing*

The current data collected in the survey at all stations at each layer have been derived from the recording cards of all six self-recording current meters with the aid of Space Technology System Ltd. Software. Two computer programmes have been used:

- CRU5, ver. 1.6, 1991 for producing the data in the ASCII format, and,

- 2MSDL, ver. 2.1, 1989 for transformation of data into the text format.

The data was updated by using the Scanner (Scanlet 4c, HP) for creating the files containing the needed information to prepare the data file for harmonic analysis. The data for harmonic analysis has been created by using a software written in FORTRAN language.

The obtained current data and collected wind data have been preliminary processed by using the statistic method, which applied for calculating the frequency (%) of the current speed in ranges and directions and the frequency tables of the wind. Based on the results obtained, the wind and current roses have been drawn by using some software written in the PASCAL language.

2.2. Water Quality Survey

Field Survey

2.2.1. Bays

2.2.1.1. Ambient Water Quality in the Bays

27 sampling points were decided by JST's experts based on the discussion with HIO experts in the joining trips for location checking of sampling points. There were 3 points implemented by HIO supplementary after discussion with JST (fig. 4). A field survey was done as required by JST (in TOR).

- Depth of water, weather, wind direction and velocity (by anemometer and the aid of a compass), air temperature, water color, existence of oil slicks or floating matters were recorded at the sampling time.

-Field measurement: water temperature, salinity, pH and DO were measured by meters right for each just after opening the water sampler taken out of the layer and transparency - by Secchi disk at sampling points. All meters were calibrated before every working day.

Vertical distribution of water temperature and salinity at each sampling point was measured by means of STD meter provided by JST at the sampling time.

- Sampling:

Samples at each point were taken by two layers, 0.5 m deep from the surface and 1m above from the bottom.

Van Don water samplers and the equivalents were used for sampling. They were cleaned and washed with seawater at the sampling point.

Sample for nutrients analyses (PO_4, NO_2, NO_3) were preserved with ten drops of chloroform in PE container of 0.5 litres and stored in cooling box at 3-5°C. This sample would be filtered and preserved again with the same amount of chloroform right after the sampling time.

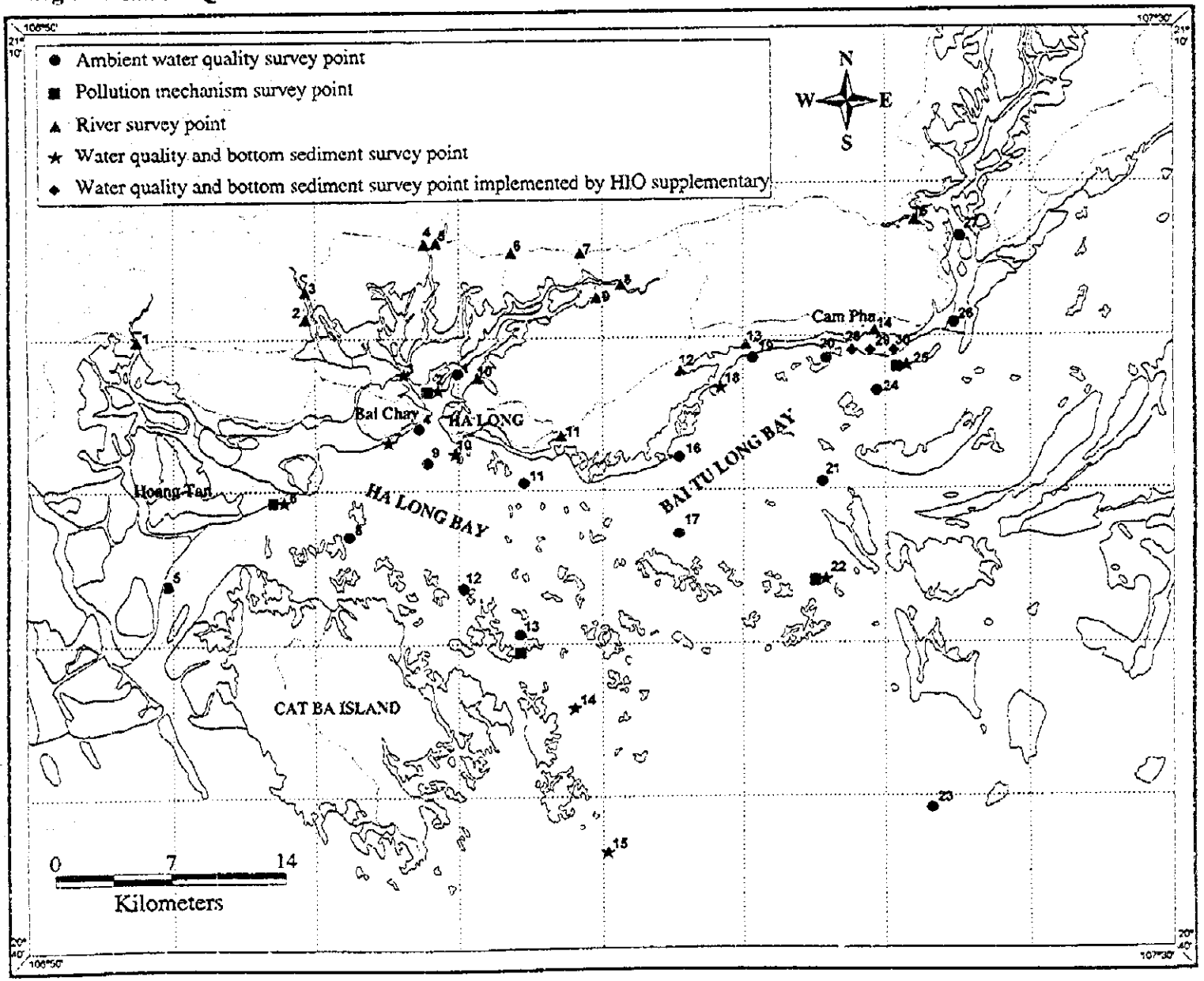
Sample for COD, T-N, T-P, NH_4 analyses was preserved with 1ml concentrated H_2SO_4 in PE bottle of 0.5 litres and stored in cooling box at 3-5°C.

Sample for BOD analysis was contained in PE bottle of 0.5 litres with water amount of 8/10 bottle volume.

Sample for heavy metals analyses was preserved with 2.5 ml of concentrated and pure HCL in 0.5l PE container.

Sample for phenol and CN analyses was contained in 0.5l PE bottle.

Fig.4. WATER QUALITY AND BOTTOM SEDIMENT SURVEY POINT IN THE BAYS AND RIVERS



Sample for SS analysis was preserved with 1ml $HgCl_2$ (50g/l concentration) in 1litre PE container and filtered just after the sampling time with weighed filter paper.

Sample for oil analysis was contained in 1 litre glass bottle and treated with n-hecxan right after the sampling.

Sample for coliform analysis was contained in clean glass bottle of 250ml and analysed just after the sampling time (within 24 hours).

Sample for chlorophill analysis was contained in 1 litre container and stored in cooling and dark box at 3-4 °C, then filtered by membrane and extracted by acetone.

Sampling performances were done in a shaded, cool and clean place. The sample collector had to put gloves on and was not permitted to smoke or eat whilst performing. The containers were washed three times with seawater at the layer of the sampling point and were given sample ID's. Replicate and blank were taken for every 12 samples taken. All items mentioned above, as well as the current status of the sea, were written down on the sampling point record.

2.2.1.2. Pollution Mechanism in the Bays

Five pollution mechanism testing points were identified by JST and HIO experts in combination trips with the aid of GPS and chart (fig.). Field survey and testing equipment installation were done as required from JST (in TOR). The field test items were implemented at the 5 points from July 13 to August 1, 1998. The scheme for pollution mechanism test installation is illustrated on the Figures 5, 6 and 7. The detailed methods of each test are below.

Productivity Test: Light and Dark (LD) bottle method *in situ*. Light oxygen bottles of 250ml were transparent ones and Dark oxygen bottles of the same volume as the light ones were covered with aluminium foil to protect them from light.

Water samples were taken by Van Don water sampler by two layers, at 0.5 m depth and 1 m below from the Secchi disk reading depth which was in large range, minimum 0.6 m at point 6 (Tuan Chau) and maximum 3.0 m at point 14 (Cua Dua).

Three Light and Dark oxygen bottles filled up with samples from each layer were tied on the frame, and were then submerged, hung and left at their original depths for about 5 - 7 hours.

Field measurement: Transparency was measured by Secchi disk firstly to determine the sampling layers and the distance of frame bar at test points. Water temperature, pH and DO of samples in each bottle were

measured by meters before submergence and again after pulling them up promptly. Also, vertical distribution of water temperature and salinity at every 0.5m depth at each sampling point were recorded by STD meter provided by JST at the time of test setting up.

Decomposition Test: Dark bottle method in laboratory

The Dark oxygen bottles of 1 litre covered with aluminium foil were used.

Water samples were taken by Van Don water sampler of 8 litres by two layers, at 0.5m deep and 1m above from the bottom. A total of seven (7) Dark oxygen bottles, including the reserves filled up with water samples from each layer. A bottle of sample was used for measuring and analysing of parameters *in situ* such as: water temperature, pH, DO, COD_{Mn}, T-N, T-P, NH_4, NO_2, NO_3, PO_4. Six (6) remaining ones from each layer were conserved and kept in the box at 25°C and then were brought into HIO laboratory within 6 hours. The mentioned parameters were measured again after 1, 5, 10 and 20 days at the laboratory.

Settlement Test: Settlement sample method *in situ*.

A settlement sampler set composes a stainless steel frame keeping 4 plastic cylindrical tubes with an internal diameter of 0.1m and a height of 0.5m.

Water samples were taken by Van Don water sampler by two layers, 0.5m above from the Secchi disk reading depth and 1m above from the bottom. The tubes filled up with water samples from each above layer were fixed on the steel frames of the test sampler set installed, hung and left at the determined depth within 22 - 24 hours. Four sampling tubes were set at each layer. One test consisted of five times samplings (five days). The setting and sampling were implemented by HIO's SCUBA divers to guarantee the test accuracy.

- Water temperature, pH, DO of samples and transparency were measured by meters at the test points.

- The analysed parameters consist of SS, COD_{Mn}, T-N, T-P, PO_4, NO_2, NO_3, NH_4, ignition loss of the samples which before and after setting up would be analysed .

- Sample for COD_{Mn}, T-N, T-P analyses was preserved with 1ml concentrated H_2SO_4 in PE bottle of 0.5 litres and stored in cooling box at 3-5°C.

- Sample for dissolved nutrients analyses (PO_4, NO_2, NO_3, NH_4) were preserved with ten drops of chloroform in PE container of 0.5 litres, then

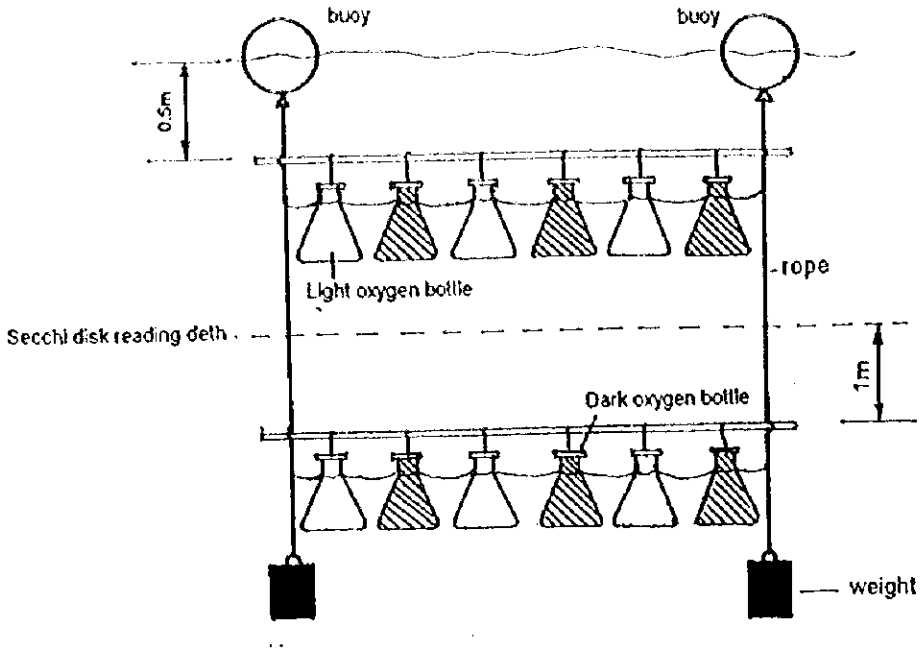


Figure 5. Scheme for Productivity Test (Light and Dark bottles)

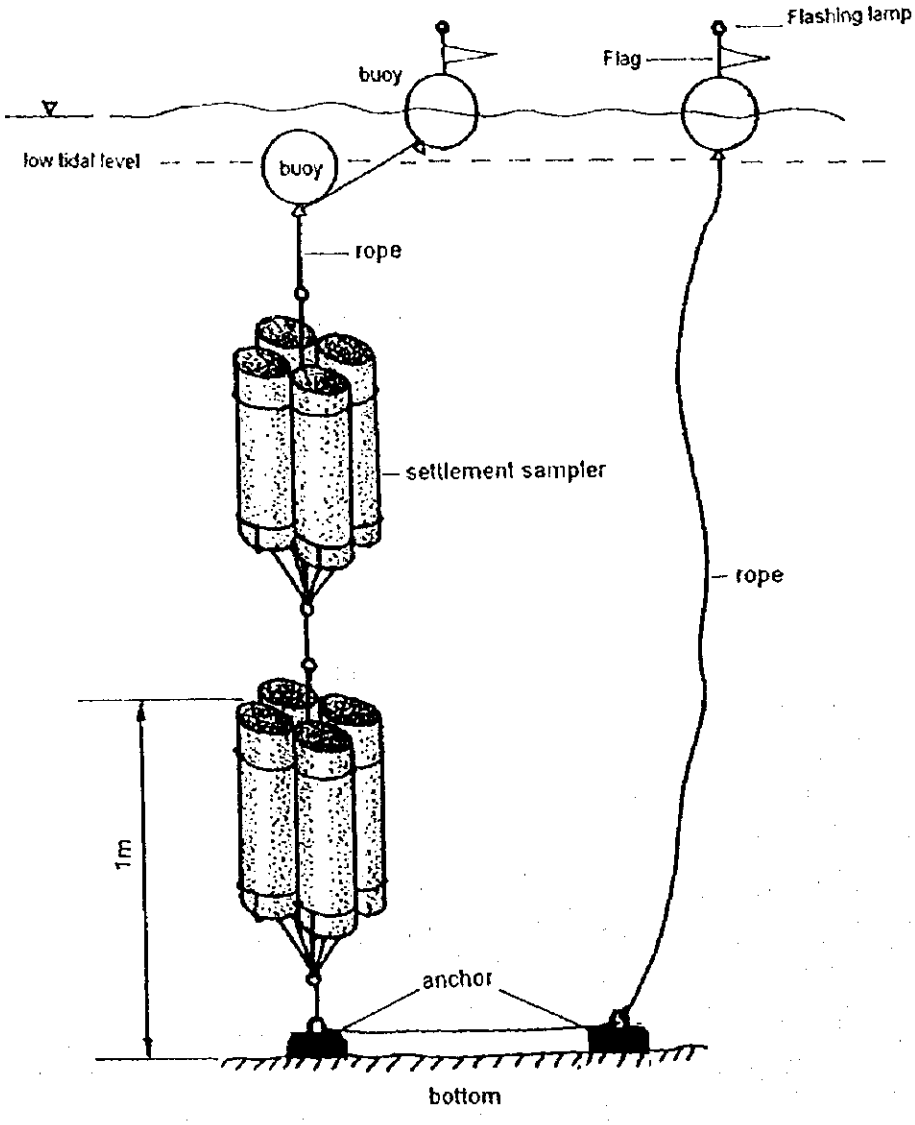


Figure 6. Scheme for Settlement Test (Settlement Sampler)

were filtered to remove suspended matters and stored in cooling box at 3-4°C right after the sampling time.

- Sample for SS analysis was preserved with 1ml $HgCl_2$ (40g/l concentration) in 1.5 litre PE container.

Elution Test: Experimental water tank method at laboratory.

- Five experimental water glass tanks (the Tanks) with 0.5m in width, 1m in length, and 0.75m high were used for the elution test.

- Bottom sediment samples at all 5 points were taken from the bottom by HIO SCUBA divers with resin receptacles of 20 litres. Three full resin receptacles of bottom sediment were taken at each point.

- Water samples at 1m from the bottom were taken by pump with the tip of the pipe at 1m above from the bottom. Two hundred and sixty (260) litres of water were contained in vessel at each point.

- Both sediment and water samples were conserved and kept in the place at 25°C and then were brought into HIO laboratory immediately.

- Bottom sediment samples were put on the bottom of the Tanks gently with sediment depth of 0.1m. The Tanks filled up with water taken at sampling points were kept at 25°C with aeration at laboratory. DO value would basically be equal to that at the sampling time during experimental time with the aid of aeration pumps.

- Water temperatures, pH, DO, COD_{Mn}, T-N, T-P, NO_2, NO_3, NH_4, PO_4 were measured immediately after sampling, and after 1, 5, 10, 20 days.

2.2.2. Rivers

15 sampling points were identified by experts from JST and HIO in combination trips (fig.4). Field survey was done as required from JST (in TOR).

- River water discharge amount (m^3/s) is the product of flow velocity and area of flow section. Flow velocity was measured by river current meters typed SL-25 or float at three positions of each flow. Area of flow section was obtained by multiplying the depth and width of the flow. At each point, depth was measured at many positions with measurement intervals of 0.5m or 1m.

- Wind direction and velocity were measured by anemometer and with the aid of a compass. Air temperature, water color, existence of oil slicks and floating matters were recorded at the time of sampling.

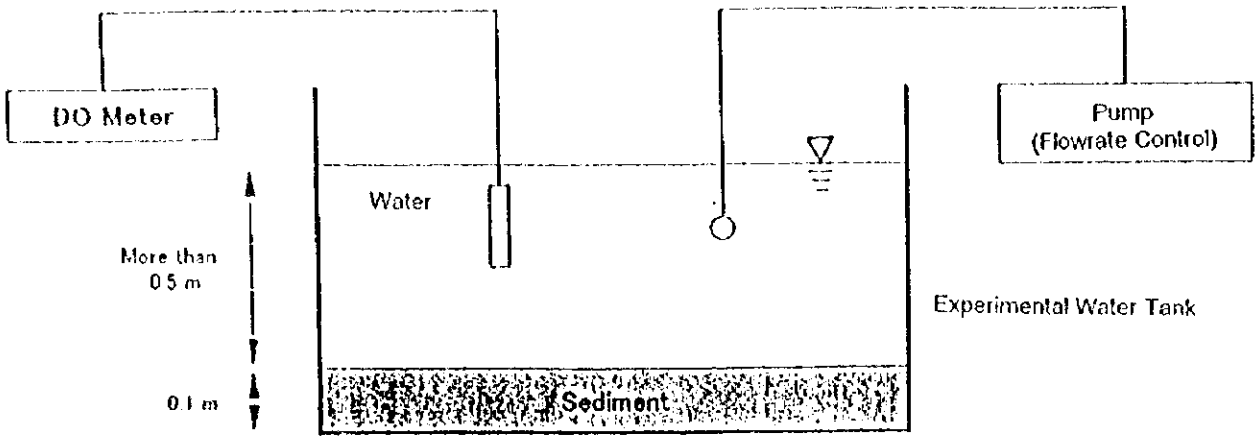


Figure 7. Scheme for Elusion Test (Experimental Water Tank)

- Field measurement: Water temperature, pH, DO and TDS were measured by meters right for each at the sampling time. All meters were calibrated before every working day.

- Sampling: The collector with clean rubber gloves used a clean plastic container of 15 litres for surface layer sampling. Sharing sample into parts for analyses were done in a shaded, clean and dust free environment. Sample containers were washed three times with water from the flow at sampling point. Sample for nutrients analyses was preserved with ten drops of chloroform in PE bottles of 0.5 litres. Samples for analyses COD, T-N, T-P and NH_4 were preserved with 1ml concentrated H_2SO_4 in PE container of 0.5 litres. Sample for heavy metals analyses was preserved with 2.5 ml of pure and concentrated HCL in PE container of 0.5 litres. SS sample was contained in containers of 1 litre with 1ml $HgCl_2$ solution (50g/l concentration) and filtered within 24 hours. Samples for BOD, CN, phenol were contained in PE containers of 0.5 litres (8/10 volume of the bottle for BOD). Coliform sample was contained in glass bottle of 250 ml and analysed within 24 hours. Oil sample was put into glass container of 1 litre. Samples were stored in cool and dark boxes. Replicate and blank were sampled every 12 samples taken. Containers were given sample ID's. All of the above mentioned items were written down on the sampling point record.

2.2.3. Pollution Sources

20 sampling points of industrial wastewater and 14 (8 for 2 times/low tide and 6 for 4 times/24 hours) of domestic wastewater (fig.8) were decided by experts of JST and HIO in joining trips. Field survey was done as required from JST (in TOR).

-Wastewater discharge (m^3/s) was calculated by the same way for river discharge (mentioned above). However, for some points the wastewater discharge was not calculated because it was impossible to measure the flow sections (points at Vung Duc coal port and at the dock of ship building factory, for example).

-Field measurement and sampling were done the same way as for the rivers. (described above).

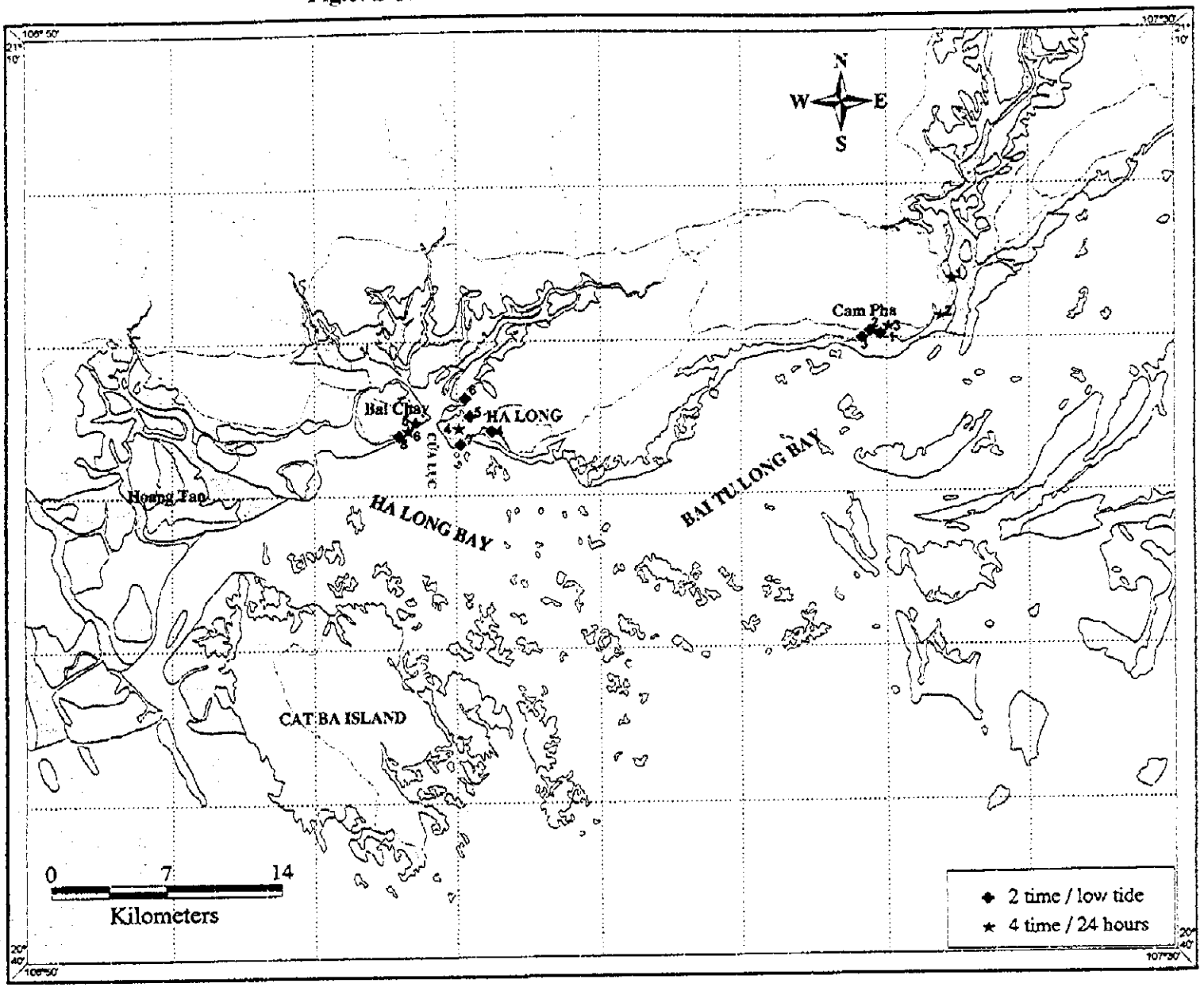
Analysis

Analyses are followed methods described in the books "Standard Methods of AWWA, 1992" and " Standard Methods of ASTM, 1992"

- **SS:**

-Filter membrane of 0.45 minipore is washed by 20 ml distilled water when applying vacuum. Remove the filter and place it on the aluminium

Fig.8. DOMESTIC WASTEWATER SURVEY POINT



planchet. Dry it in oven at 103-105°C for hour. Store the membrane in desiccator until used. Weigh it before use.

-Take 1000ml of sample (or large volume if total residue is low). Filter the sample under vacuum. Wash the filter carefully with distilled water until all traces of Cl^- ion are completely removed. Put the filter into aluminium planchet and dry it in oven at 103-105°C for one hour. Cool it in desiccator and then weigh. Repeat the drying until getting constant weight.

$\delta = \pm$ 5.2mg/l at 15mg/l

MDL (method detection limit)= 3.6 -15.6mg/l

Standard material: waste water.

- **TDS:**

A well mixed sample is filtered through the filter. The filtrate is evaporated in a weighed dish and dried at 180°C until getting constant weight.

$\delta = \pm$ 5.2mg/l at 15mg/l

MDL =15.6mg/l

Standard material: waste water.

- **COD_{Mn}:**

Sample is distressed Cl^- ion by using silver salt, then acidified with H_2SO_4 and digested with a known excess of potassium permanganate.

$\delta = \pm$ 0.5mg/l at COD = 5mg/l

MDL =1.5mg/l

- **COD_{Cr}:**

Sample is digested in strong acid solution with a known excess of potassium dichromate for two hours. After that, the remaining potassium dichromate is titrated with ferrous ammonium sulphate to determine the amount of potassium dichromate consumed and the oxidizable matter is calculated in terms of oxygen equivalent.

$\delta = \pm$ 0.5mg/l at 5mg/l

MDL =1.5mg/l

Standard material: KHP.

- **BOD_5:**

There are three methods as follows.

1) Direct method for relatively unpolluted water (BOD_5< 8mg/liter). BOD_5 is determined by measuring the dissolved oxygen before and after incubation period of five days at 20°C ± 1 (used for sea water and river water).

2) Unseeded dilution method for polluted water (BOD_5 > 8mg/l). Sample is diluted with water saturated with oxygen. The dissolved oxygen content is determined immediately after dilution and after incubation. This method is for domestic wastewater.

3) Seeded dilution method for polluted water which contains bactericidal substances like industrial wastewater.

BOD_5 of seawater is determined by using the direct method; of domestic wastewater - dilution method; and of industrial wastewater - seeded dilution method.

$\delta = \pm 0.7$mg/l at 5mg/l

MDL = 1.1mg/l

- **NH_3-N:**

Indophenol blue method is used.

Sample is treated in an alkaline citrate medium with sodium hypochlorite and phenol in the presence of sodium nitroprusside which serves as a catalyst. The blue indophenol color formed with ammonia is measured by spectrophotometer at 640nm.

$\delta = \pm 0.4$µg/l at 10µg/l

MDL =12µg/l

Standard material: nutrients (QC SPEX.NUT).

- **NO_2-N:**

Nitrite of sea water is allowed to react with sulfanilamide in an acid solution. The resulting diazo compound is reacted with N- (1-naphtyl)-ethylenediamine and forms a highly colored azo dye. The extraction of the dye is measured at 543nm.

Accuracy: ± 0.1µgN/l at 15mgN/l

MDL = 0.15µg/l

Standard material: nutrients (QC SPEX.NUT).

- **NO_3-N:**

Nitrate of seawater is reduced almost quantitatively to nitrite when sample is run through a column containing cadmiun filling coated with

copper metal. Nitrite is determined by diazo dye method on spectrophotometer. Previous nitrite of sample is recorded.

Accuracy: ± 2.5µgN/l

MDL = 0.7µg/l

Standard material: nutrients (QC SPEX.NUT).

- **T-N:**

In the presence of sulfuric acid, potassium sulphate and catalyst (sulphate), organic nitrogen is converted to ammonium sulphate. The ammonia is distilled from an alkaline medium and absorbed in boric acid when using kieldahl apparatus. Ammonia is determined by colorimeter.

δ = ± 4µgN/l at 10µgN/l

MDL =12µgN/l

Accuracy: 1.9µgN/l

Standard material: nutrients (QC SPEX.NUT).

- **PO_4-P:**

The method is based on the reaction of the phosphate ions with molybdate reagent to a phosphomolybdate complex. The heteropoly complex is reduced by stannous (II) chloride (newly prepared). The blue solution is measured at 885nm.

δ = ± 0.5µgP/l at 10µgP/l

MDL =1.5µgP/l

Standard material: nutrients (QC SPEX.NUT).

- **T-P:**

Sample is digested by potassium persulfate. After that phosphate is determined by molybdate method (mentioned above).

δ = ± 1.2µgP/l at 10µgP/l

MDL =3.6µgP/l

Standard material: nutrients (QC SPEX.NUT).

- **Chlorophil A:**

1.5 litres of seawater sample are filtered on to a synthetic filter. Pigments are extracted from filter in 90% acetone and their concentration is estimated by using spectrophotometer at the extinction of the following

wavelength: 750,664,647 and 630. The 750nm from 664, 647 and 630nm absorption correct each extinction for small turbidity by substracting.

$\delta = \pm 0.07$ mg/m^3

MDL = 0.2mg/m^3

- **Phenol:**

Determination of Phenol-type substances which are capable of coupling, in natural waters, with p- nitroaniline.

The water sample of 200 ml (or an appropriately smaller volume which is then made up to 200 ml with distilled water) is treated with 30 ml 1m sodium carbonate solution in a 500 ml separating funnel and the pH brought to approx. 11 by adding 30% sodium hydroxide 60 drop by drop.

After adding 20 ml diazotized p-nitroanaline solution the mixture is allowed to stand for 20 min. and the coloured substance which has been formed is then extracted by shaking with 50 ml n-butanol.

After a further 10 min., the aqueous phase is separated off and extinction of the butanol extract is measured against a blank test which is carried out in parallel.

- **Cyanide:**

Method for determination of CN^- concentration.

Spectrophotometric method of analysis using acid - pyridine in the distillate.

This method can be used after preliminary distillation to measure cyanide concentrations of between 0.005 and 0.05 mgCN^- /l in surface water. This range corresponds to a cyanide content of 2.5 to 25 µg in 10 ml absorption solution.

Where the total cyanide concentration in the water sample is higher, it is necessary to dilute the sample or use smaller quantities of sample.

Transfer 10 ml of the absorption solution from the 25 ml measuring flask to another 25 ml measuring flask and in turn exactly 2 ml buffer solution pH 5.4; 4ml - 1m hydrochloric acid and 1 ml chloramine T solution, but not more than 5 min.. Now add 3 ml barbituric acid - pyridine reagent, top up to the 25 ml mark with distilled water and shake well. After 20 min., carry out photometric analysis at 578 nm using a reference solution which is prepared.

- **Heavy metal of seawater:**

***Determination of soluble metals*: Cu, Pb, Cd, Zn, Fe, Ni, Cr, Mn.**

- This method describes the determination of solution copper, lead, cadmium, zinc, chromium, nickel, manganese and iron in seawater and other saline water by the simultaneous extraction of their complexes with ammonium pyrirolidine dithiocarbamate into methyl isobutyl ketone and by the atomic absorption spectrophotimetry with the graphite tube technique.

- Filter the seawater sample through 0.45μm millipore filter and acidify with HNO_3 to a pH of 4 - 5. Place a 750 ml aliguot of the filtered, acidified seawater into a 1 - litre - polypropylene flask. Add 35 ml of MIBK followed by 7 ml of 1% APDC mechanical shaker. Separate the organic layer in a separatory funnel and store in a polypropylene bottle.

The extracts should be analysed within 3 hrs.

Save the aqueous layer for the preparation of standard solution.

- **Arsenic**

Determination of arsenic using the hydride AAS technique.

Using sodium borhydride, arsenic ions are reduced to arsenic hydride, transferred to a heated quartz cuvette with the aid of a current of inert gas, decomposed thermally and the absorption spectrophotometer PE - AAS 3300 USA, by using of MHS - 10.

- **Mercury**

Mercury AAS with cold vapour method mercury ions are reduced to metallic mercury with $NaBH_4$. The metallic mercury is transferred into a quartz cuvette with the aid of a current inert gas and the absorption of the atoms is measured in the beam of the PE - AAS - 3300, USA by using of MHS - 10.

EDL : 0.001μg/l.

Detection Limits for Analysis with AAS

With Graphile Furnace Atomic Absorption:

Cd: 0.003 μg/l

Cr: 0.01 μg/l

Cu: 0.02 μg/l

Fe: 0.02 μg/l

Pb: 0.05 μg/l

Ni: 0.1 µg/l

Mn: 0.01 µg/l

Zn: 0.05 µg/l

With hydride:

As: 0.003 µg/l

Hg: 0.003 µg/l

Equipment: PERKIN - ELMER AAS 3300 USA.

- **Coliform/Faecal Coliform**

Perform analysis within the holding time, i.e. in the field

For total coliform analysis use m-Endo media with the membrane filteration method and confirm results using Lauryl Tryptose and BGB media

For Faecal coliform analysis use m-FC media with the membran filteration method and confirm results using Lauryl Tryptose media

For wastewater sample dilute the sample with sterile water and analyse. (So as to keep the total colonies less than 200).

2.3. Bottom Sediment Survey

- ***Field Survey***: 10 sampling points were decided by JST experts. There were 3 points implemented by HIO supplementary after discussion with the JST (fig. 4). Field survey was carried out as required from JST.

- Sampling point positioning: using GPS.

- Equipment: stainless steel grab branded Petite Ponar, plastic trays, plastic sample containers, cooling boxes, plastic spoons for sample mixture, casks and brushes.

- Field measuring meters: pH meter for pH and ORP measurement, thermo-meter and distilled water for cleaning electrodes and tools.

- Sampling process:

Three grabs of sample at each point were taken. Field measuring parameters (pH, Eh, temperature, color, smell, sediment quantity, mixed matter) were measured immediately by using meters, vista and smelling in the shade. After mixing sediments from the three grabs, sediment sample was divided into parts and put into containers for analyses of different parameters. Samples were in cooling boxes during survey time. Field description, numbering and characterizing at each sampling point were done. Grabs, other tools and meters were always washed and

cleaned when the sampling at each point had been finished. Meters were calibrated before every working day.

One replicate sampling at point 22 was done for QA/QC.

The sampling bottom sediment in the bays meets JICA requirements in technique and on schedule.

- *Analysis*

- Grain size composition was analyzed by using sieving and pipette method (Anderson method) in combination. Five to ten grams of sediment sample are taken for analysis. After treating sample with NaOH 1N at about 80 - 90 °C for an hour and waiting for sample to be at laboratory temperature, sample is sieved by the sieve with mesh of 0.1mm to get two portions (larger than 0.1mm one and less than 0.1mm one). Portion larger than 0.1mm is analyzed by using sieving set with mesh of 1mm; 0.5mm; 0.25mm; 0.1mm. The rest portion is analyzed by using pipette system.

- Water content was determined by drying sample in oven at 105°C for 24 hours.

- Ignition loss was determined by igniting sample in oven at 500°C until getting constant weight of the ignited sample.

- TOC by Walkey - Black method.

- T-N was analysed by method in "Standard Methods of ASTM, 1992". Digest sediment sample with catalyst mixture (K_2SO_4 + Se) and of concentrated sulphuric acid. Determine the ammonium Nitrogen in solution by distillation.

- T-P was analysed by method in "Standard Methods of ASTM, 1992". Digest sediment sample with H_2SO_4 +$HClO_4$. Determine the phosphorus in solution by colorimeter methods, reduction of Mo^{+6} by potassium antimontartrate and asscorbic acid mixture.

- Heavy metal: digest sediment sample with HNO_3 + HCL + H_2O_2 in normal condition for 4 hours and then in heat condition for 8 hours. Determine elements in solution by AAS. Use AAS Perkin-Elmer 3300 with detection limit as follows.

Element	Detection limit
Pb	0.19 ppm
Cd	0.028ppm
Cr	0.078ppm

Zn	0.018ppm
Mn	0.067ppm
As	0.95ng
Hg	4.70ng

- COD_{Mn}: analysis method referred to JIS hand book, 1995. p. 1892-1895

- H_2S: analysis method referred to APHA. Standard Method. p. 4-126

• ***Data Computation***: Data was computed by TUBO PASCAL programming

2.4. Dust Survey

• ***Field Survey***: 5 sampling points decided by JST were taken.

Sampling was carried out with the same method at all sampling points. In order to get more detail on the change of settled dust quantity versus time, at some sampling points, five-day and daily sampling were carried out parallely. At some other points, based on preliminary tests, only five-day sampling was taken due to low quantity of daily settled dust.

Wind direction and velocity at sampling points were also measured stailemously, four times (obs.) per day, at 1, 7, 13 and 19 h.

Detailed procedure for the measurement of settled dust and wind is as follows:

Measurement of Settled Dust

- The measurement is followed TCVN (Vietnam Standards) 5498 - 1995:

- Height of measurement: 1.5m.

- Put and collect the dish at 7am daily and every five days as follows:

- Cover the dish to be collected with its upper part. Clean the external surface of the dish with tissue.

- Put the dish into plastic bag and seal.

- Open a new dish and put it on the same place of the former one. The upper part of the new one is put back into the plastic bag.

- Record the number of dishes to be collected and newly placed.

- Place vertically collected dish in a safe, cool place. Do not touch anything on the internal surface of the dish.

- Give samples to designated staff when requested.

- Stop sampling when unusual things such as rain, fire, etc occur. Sampling can only be resumed when unusual things have completely finished.

- Record the period of unsampling time.

- Check metering equipment daily.

Measurement of Wind

Wind is measured following the World Meteorology Organization:

- Height of measurement: 2m above the ground.

- Portable wind meter.

The direction of wind is determined by self-made equipment.

- Period of measurement: 4 obs/day at 1, 7, 13, 19h every day.

- Five minutes before the observation, put wind meter in required place and record initial number of the meter.

- Record the direction of wind.

- At the right time, start the wind meter and timer. Keep them operating for about 100 seconds and then stop them at the same time. Record final number of the wind meter and interval of sampling time.

- Stop sampling when unusual things such as rain, fire, etc occur.

Sampling Point Locations are Described as Follows:

Bai Chay Point (Point 1) is located on a plain area of Bai Chay beach.

- South East: Ha Long Bay, 70 m from the Beach No. D of Bai Chay.

- North West: 60 m from the road No. 18A and 100 m from Khe Doi hill.

- South West: 1500 m from Reu island.

- North East: 80 m from the construction site of Royal Company.

It can be seen that, sources of settled dust which can have effect on this sampling point are local and low ones, mainly from construction and transportation activities. In some cases, the sampling point may be affected by far sources such as factories in Gieng Day area, coal mining activities in Ha long city and vicinities.

Hong Gai Point (Point 2) is located in the garden of the Cultural Hall of Quang Ninh province.

- North West: 15 m from the road no. 18A.

- South East: 10 m from the sea.
- North East: 50 m from petrol station.
- South West: 60 m from the road entering the Cultural House.

Sources of settled dust which can have effect on this sampling point are mainly from local construction and transportation activities. Besides that, farther sources such as Hon Gai coal processing factory and coal mining activities in the region can also affect the sampling point. However, during sampling period, these sources were located at the downstream of prevalent wind directions.

Cam Pha Point (Point 3) is located in the garden of Cam Pha Hospital.

- East: 15 m from Thanh Nien road.
- North: 30 from three-storey building of the Hospital.
- West: 20 from two-storey building of the Hospital.
- East: 20 m from low trees.

At present, construction and transportation activities are low in this area. Other sources of settled dust, which are located far from the sampling point and at the downstream of prevalent wind directions, did not affect the sampling point significantly.

Cua Ong Point (Point 4) is located on a hill.

- South East: 40 m and 55 m from road No. 18A and the railway. Next is sea.
- East: 300 m from the waste site of Cua Ong coal screening factory.
- North West: 30 from the local residence.
- South:15m from low trees.

In general, coal exploitation and transportation activities from the West and North West to the East in this region are strong, while roads are in bad quality. So the sampling point may be significantly affected by these sources.

Cua Ong Temple Point (Point 5) is located in front of the Cua Ong Low Temple.

- North: 50 m from a motorway.
- East: 10 m from low trees.
- South: 20 m from the residence.
- West: 50 m from The Low Temple.

This sampling point was located not far from Cua Ong Coal Port so coal transportation activities can affect it. However, the affect can be reduced by trees nearby.

- *Analysis*

The preparation of Petri dishes and the analysis settled dust quantity after sampling were done at the Laboratory of Standard, Measurement and Quality Branch, Department of Science, Technology and Environment of Quang Ninh province.

Meteorological data related to the survey was obtained from the Meteorological Station of Quang Ninh province.

2.5. Biological Indicators Survey

2.5.1. Terrestrial Vegetation

- ***Gathering Available Data and Documents.***

- Data and documents from the investigations in recent years and some records and specimens preserved in the Herbarium of Institute of Ecology and Biological Resources.

- Data and documents on vegetation and forest from dissertations, from the Institute of Agriculture and the Forest Investigation and Planning Institute, Institute of Geography and reports for Cai Lan Port and Hoanh Bo electricity building plans (1996 - 1997), in which aerophotographs (1995) and SPOT satellite images (1995 and October 27, 1996) were used.

- ***Additional Investigation***

- Investigations for the examination of species composition, vegetation formations and distribution (in order to show how they have any change) and the correction of vegetation formation delimitation through consulting the Hoanh Bo and Cam Pha Forest Protection Boards and making lines based on a newly delineated draft of vegetation map were conducted by HIO experts in July 1998.

- *Analysis*

- All data and documents on plant are inventoried and assembled in order of taxons, associated with descriptive information on their distribution, values and threats.

- Vegetation formations are described and mapped in a scale of 1/200,000 according to UNESCO's International Classification of vegetation cover issued in 1973.

- Vegetation formation percentage is examined and estimated on the spot in the additional investigation with vista and quadrat methods.

- Mapping with computer.

2.5.2. Mangrove

- ***Gathering Available Data and Documents***

The data and documents of previous studies are:

- "Ha Long Bay biological study" of HIO in 1994;

- "Assessment of exploitation ability of marine ecosystems for tourism activities in Ha Long - Cat Ba" of HIO in 1997.

- According to JICA team request, this survey would be concentrated in Hoang Tan Island area. Besides, a checking survey in Bai Chay Bay area was made.

- ***Field Survey***: 3 sites with 3 quadrats on each.

- Quality sampling method: To collect the leaves, flows, roots and observation of trees and root systems.

- Quantity sampling method: at Hoang Tan Island, the quantity sampling processes were done on 3 transects on East, South - East and North of the island. The transects were perpendicular to the shore line. The quantity samples were collected on 3 quadrats: two at high tidal band and one at middle tidal belt. The quadrat have a size of 3m x 3m. On quadrats, we collected the following parameters:

Species composition,

Dominant species,

Salinity tolerant species from mainland,

Mainland species taking part in mangrove forests,

Vegetation cover,

Number of trees of every species,

To measure a size (height and diameter) of trees,

To determine the vertical distribution of mangroves.

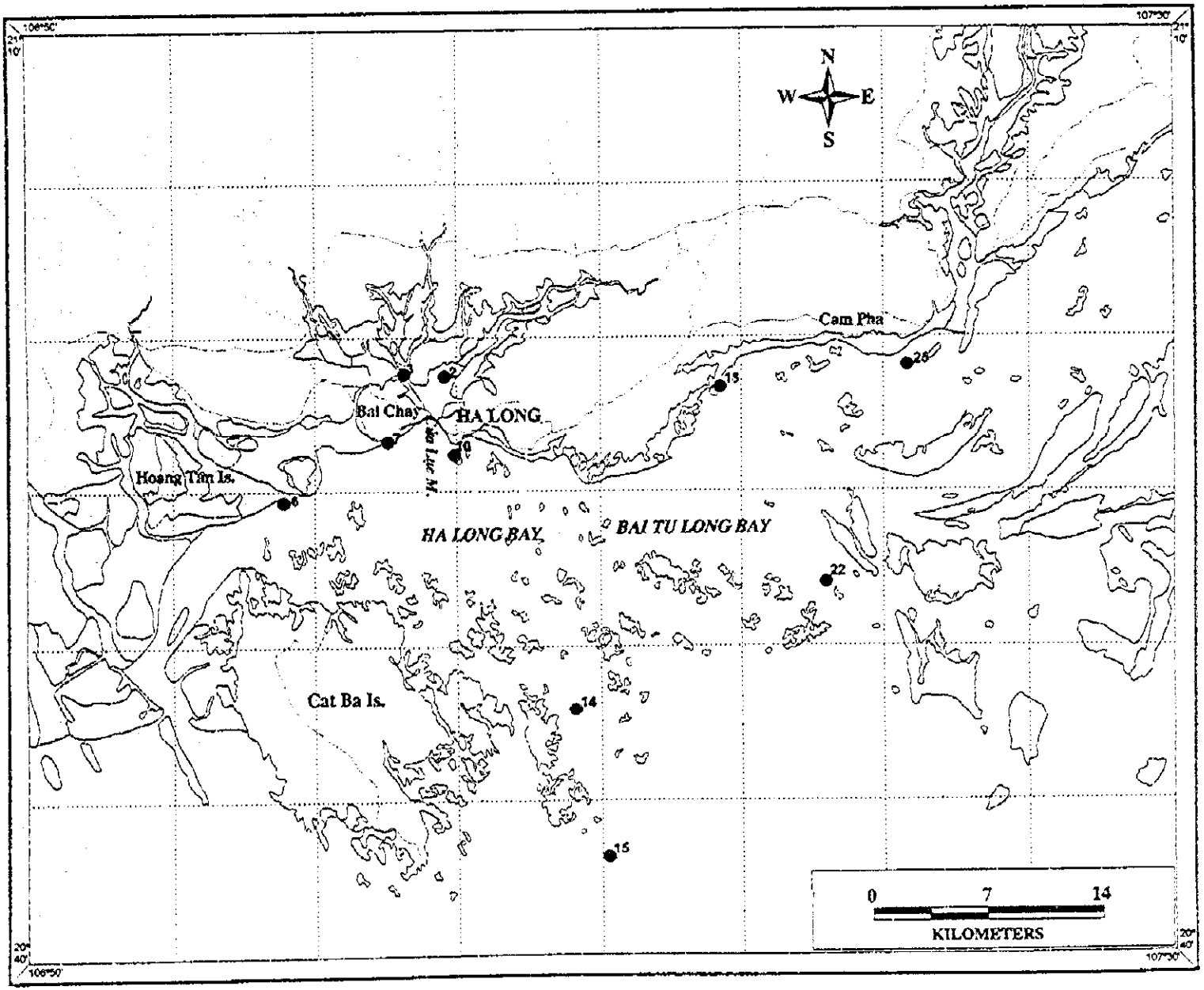
- ***Analyzing of samples***

The species identification follows the guide book of Dr. Phan Nguyen Hong (1970, 1971).

2.5.3. Phytoplankton

- ***Field Survey***: 10 sites, in combination with Ambient water quality survey in the bays (fig. 9).

Fig.9. PLANKTON SAMPLING POINTS IN HA LONG BAY (7/1998)



- Quantitative Sampling: The samples were collected by water sampler of one litre from surface layers (0.5m below surface) and bottom layer (1m above the bottom). Then, the samples were preserved by lugol (2- 4ml lugol/1litre water sample) immediately and transported back to the laboratory.

The phytoplankton samples were collected at the same time of water quality samples.

- *Analysis*

- Transfer the samples into cylindrical bottle. Allow the fixed specimen to settle down on the bottom of the bottle for one night.

- Take out supernatant water slowly, using a siphon. Distal end of the siphon in water should be bent upward 2 to 3cm. This step must be done carefully enough not to resuspend the specimens retained on the bottom of the bottle. Siphonation should be ceased when resuspension occurs.

- Transfer remaining water in the bottle to the smaller size bottle. Allow the fixed specimens to settle down on the bottom. Again, take out supernatant water by using siphon until water amount of the sample becomes very small (10, or 20 ml depending on the density of cell/water sample).

- Take out 1ml concentrated water sample from bottle to Sedwick - Rafter by pipette for counting cell in the part, or half of counting room, or whole of counting room depending on density of cells. The density of cells are counted by inverted microscope (LEICA) with zoom range 40 - 400 times.

- The taxon identification was based on some taxonomy documents, such as: "Taxonomy of Bacillariophyta plankton in marine waters of Vietnam" (Truong Ngoc An (1993); "Illustrations of the marine plankton of Japan (Isamu Yamaji, 1973); Atlas of phytoplankton in Japan sea by G.V. Konovalova et all ("Nauka" publishing house, 1989), Identifying marine Diatom and Dinolagellates (Carmelo R. Tomas, 1996), etc.

2.5.4. Zooplankton

- ***Field Survey***: 10 points, in combination with Ambient water quality survey in the bays (fig. 9).

- Sampling: zooplankton samples were collected at the same time of water quality samples by plankton net NGG 54 drawn vertical from the bottom to the surface to collect qualitative and quantitative samples. Samples were preserved in the plastic bottle of 0.5 l volume with formalin of 5 %.

- *Analysis*

Fig.10. SURVEY SITES AND FISHING GROUND IN HA LONG BAY

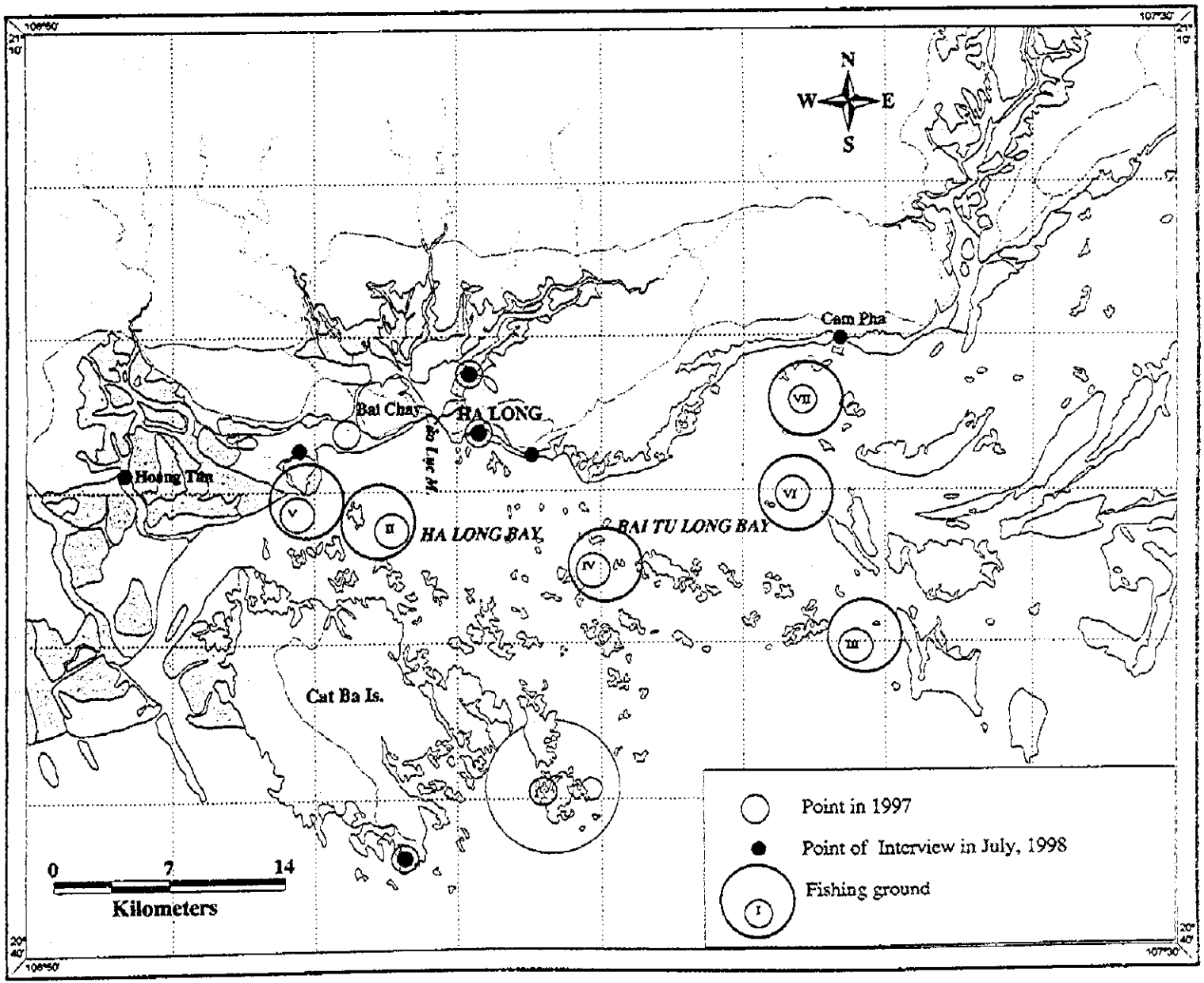


Fig.11. MAP SHOWING SURVEY SITE OF MACROALGAE IN HA LONG BAY

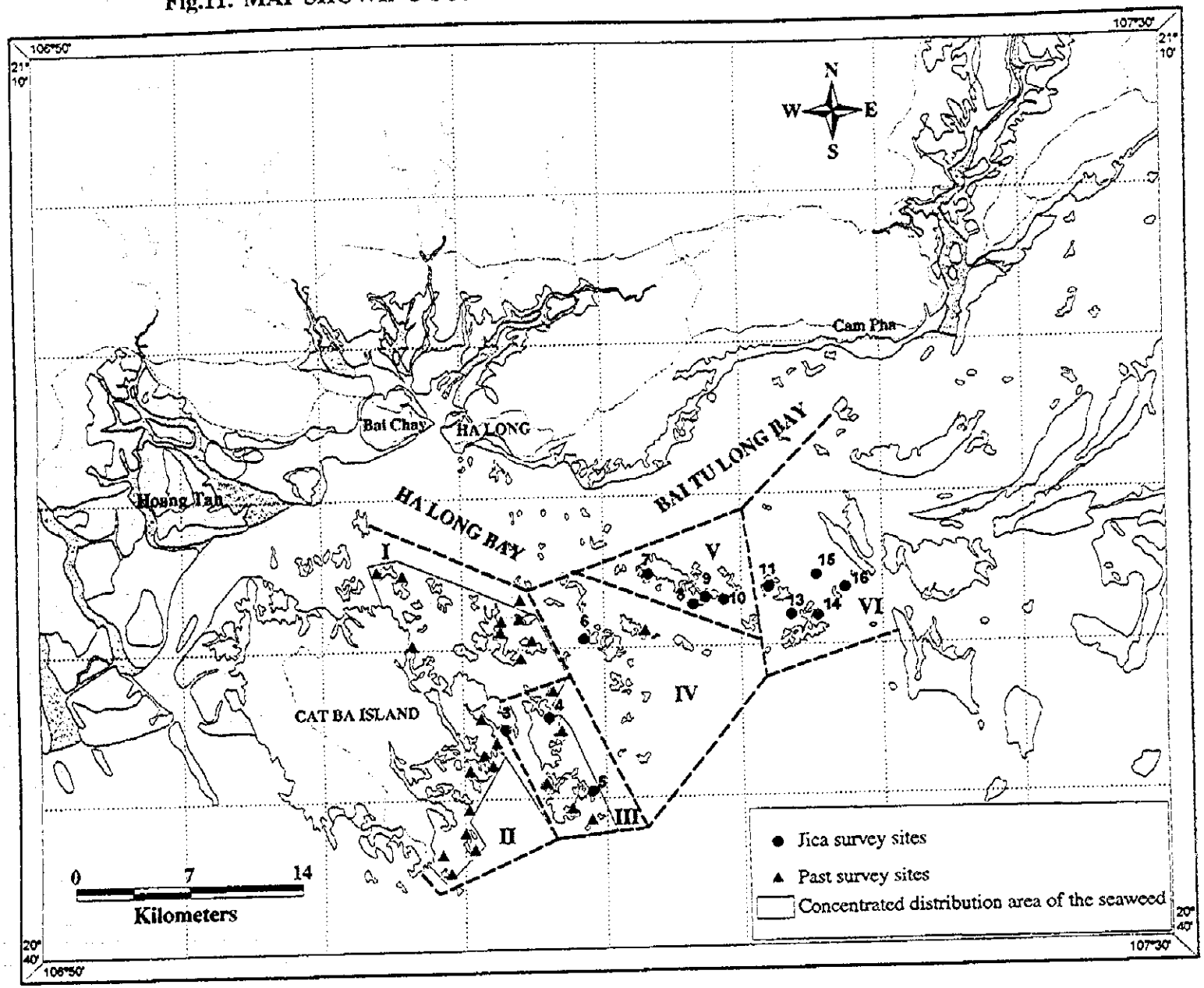


Fig.11. MAP SHOWING SURVEY SITE OF MACROALGAE IN HA LONG BAY

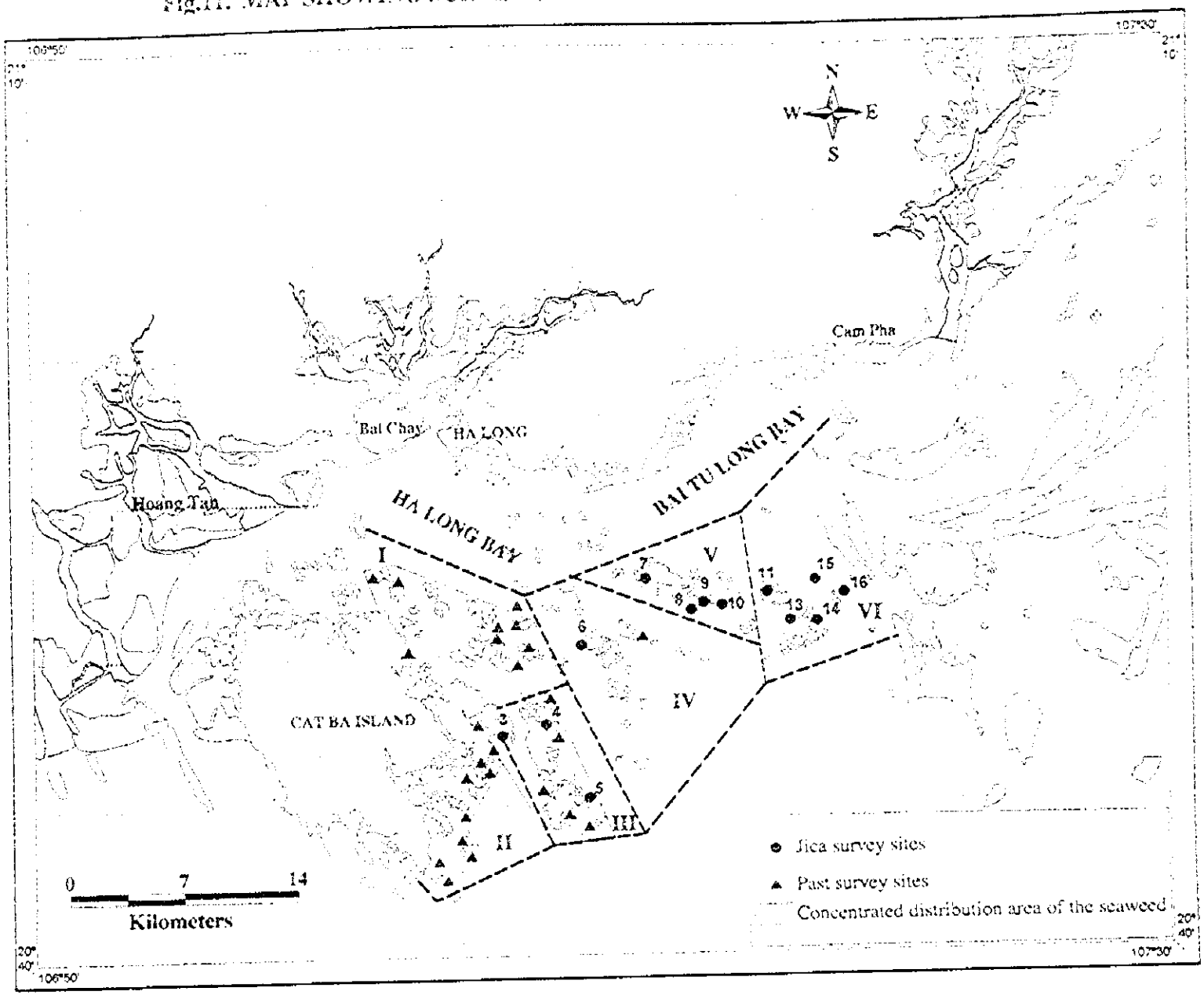


Fig.12. MANGROVE AREAS ON THE HOANG TAN ISLAND AND SURVEY SITES IN 7/1998

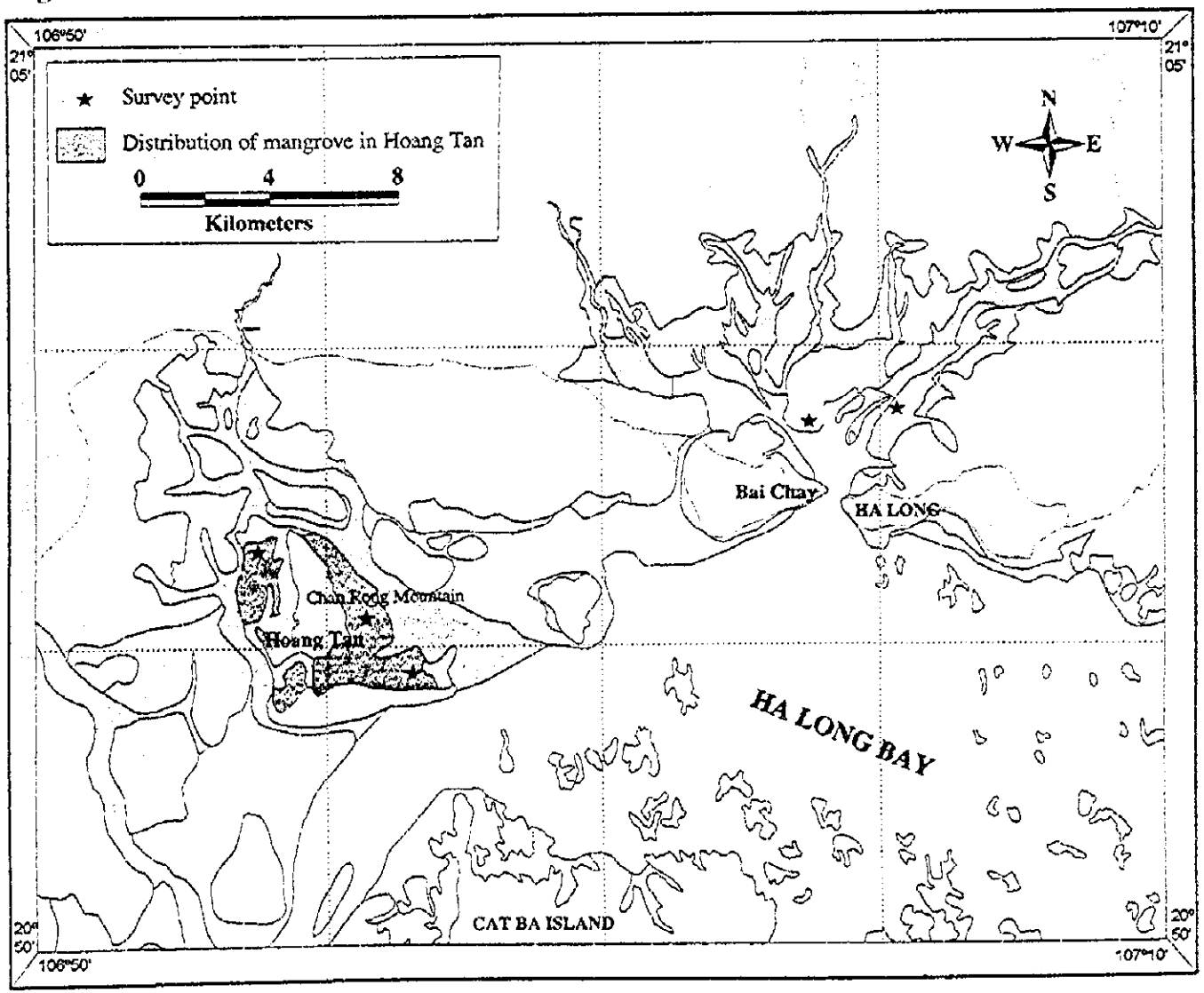
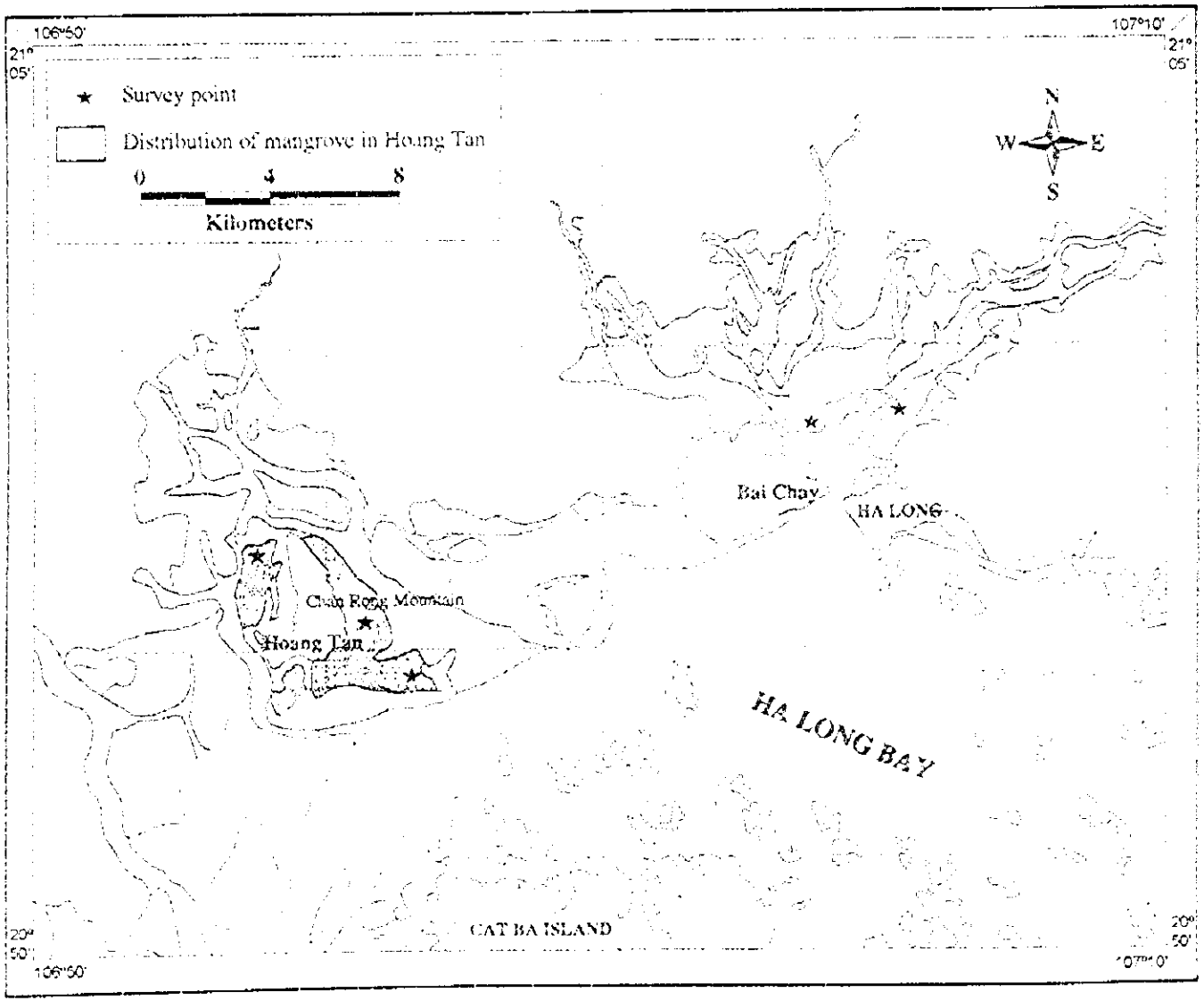


Fig.12. MANGROVE AREAS ON THE HOANG TAN ISLAND AND SURVEY SITES IN 7/1998



- Qualitative Analysis : Concentrate sample to 50 ml volume and put it on Petri disk under stereomicroscope to identify groups. Species identification was done by microscope with reference on monographs of Nguyen Van Khoi (1994) "Subclass Copepoda in the Tonkin Gulf", Isamu Yamaji (1973) "Illustration of the marine plankton of Japan", W. J. Dakin and A. N. Colefax "The plankton of the Australia Coastal Waters off New South Wales", etc.

- Quantitative Analysis:

Mix regularly 50 ml samples, take out 3 - 5 ml concentrated samples by pipette, put it into counting room.

Count the number of individuals by stereomicroscope 3 times. If number of individuals was few, the counting would be made with the whole samples.

Clean zooplankton individuals out of waste matters, individuals of Coelenterata. Samples are filtered by filter paper, then total weight of every sample is balanced by electric balance to measure their biomass.

2.5.5. Zoobenthos

- ***Gathering Previous Documents***

Since 1994, there have been many survey activities on zoobenthos living on littoral, sublittoral and coral reefs in the Ha Long area. In 1997, a small project entitled "*Assessment on exploitation ability of marine typical ecosystems for tourism activities in Halong - Catba*" was carried out. This project consisted mostly of data from previous surveys and new survey results, so it is a valuable reference document for this JICA project.

- ***Choosing of survey points***

Because Ha Long Bay is diverse in biotopes, the zoobenthos study was carried out on these biotopes as follows:

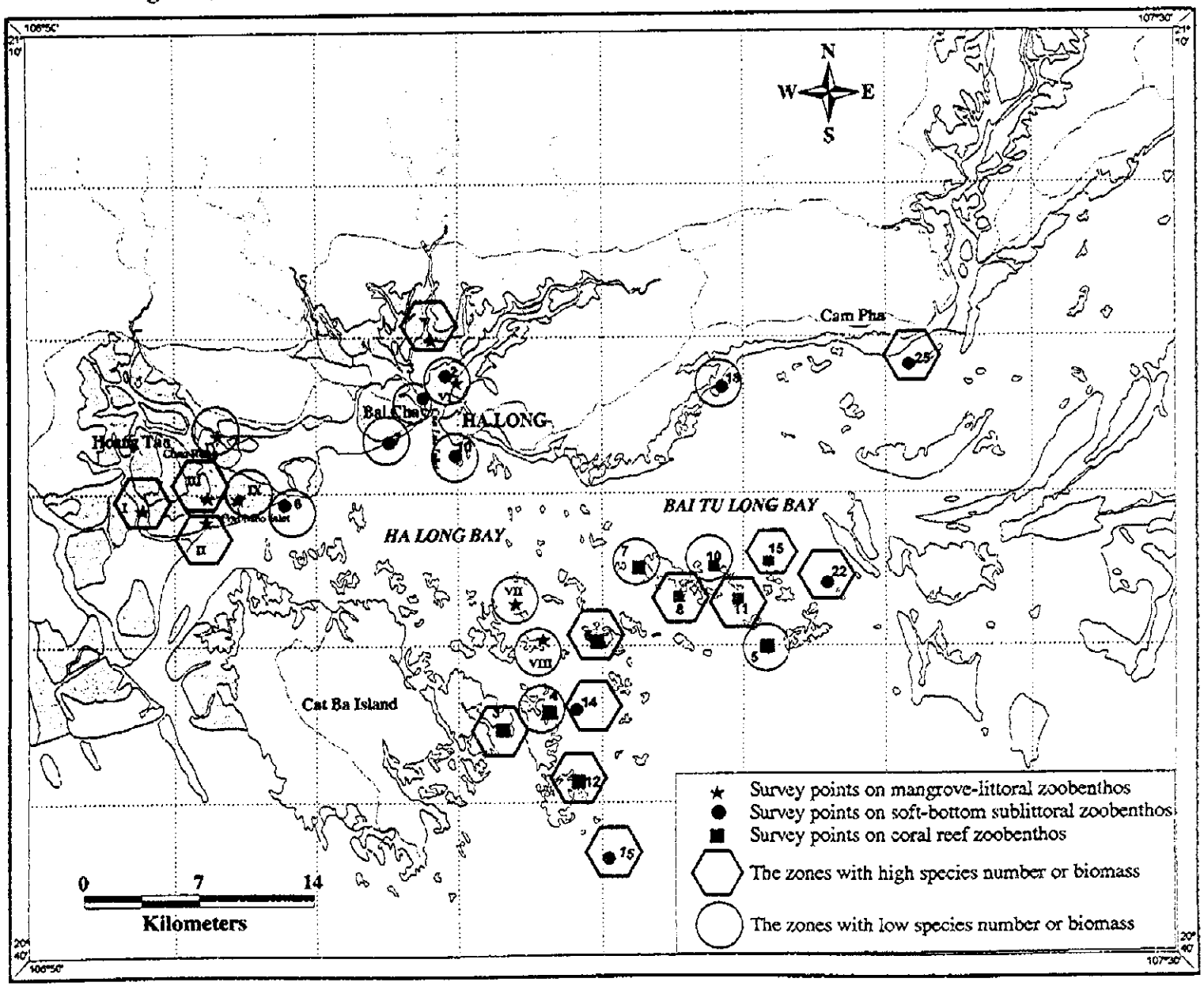
- Soft bottom littoral in mangroves (in shortcut: littoral - mangrove). These biotopes distribute at Hoang Tan, Dai Yen and Cua Luc inlet. Here, 6 points from I to VI were surveyed.

- Hard bottom littoral (rocky littoral) with 3 points surveyed at Bu Xam, Co Ngua and Con Meo inlet (equal point name: VII, VIII and IX).

- Coral reefs: Zoobenthos was surveyed at 10 points with separate coordinates (table 3).

- Soft bottom sublittoral: Zoobenthos was surveyed at 10 points with separate coordinates (table 4).

Fig.13. SURVEY POINTS AND DISTRIBUTION OF ZOOBENTHOS IN HA LONG BAY



All points are shown on the map (fig. 13).

Table 3. Point - Coordinates of Coral Reefs Survey

Number of the points	Point name	Co-ordinates
3	Ba Trai Đao	$20^0$47'37" - $107^0$06'00"
6	Hon Hang Cao	$20^0$60'13" - $107^0$09'20"
7	Hon Cong Đo	$20^0$52'35" - $107^0$10'52"
12	Cat Đa To	$20^0$50'15" - $107^0$15'20"
15	Hon Gieng	$20^0$52'40" - $107^0$16'33"
11	Cong Đong Nam	$20^0$52'06" - $107^0$15'18"
10	Gian Muop	$20^0$52'12" - $107^0$13'10"
8	Cong Tra San	$20^0$51'51" - $107^0$12'24"
5	Đau Be (Cong La)	$20^0$45'30" - $107^0$08'36"
4	Hang Trai	$20^0$48'03" - $107^0$07'26"

Table 4. Sublittoral Soft Bottom Area

Number of the points	Co-ordinates
2	$20^0$59'02" - $107^0$04'02"
3	$20^0$58'11" - $107^0$03'39"
6	$20^0$58'20" - $106^0$58'20"
7	$20^0$57'06" - $107^0$02'57"
10	$20^0$56'58" - $107^0$04'46"
14	$20^0$47'33" - $107^0$08'45"
15	$20^0$43'30" - $107^0$10'26"
18	$20^0$58'01" - $107^0$13'45"
22	$20^0$52'17" - $107^0$17'01"
25	$20^0$58'38" - $107^0$20'59"

- *Field Survey*

In general, survey methods were discussed in Technical training course. But every ecosystem was carried out in detail as follows:

- Soft bottom littoral - mangrove: surveyed at 6 points. Of those, 4 points in Hoang Tan - Dai Yen; and 2 points in Cua Luc inlet. On every point, at least 1 station must be located in the middle of a mangrove forest with the marks such as: II_0, III_0, etc. The rest of the stations are out of mangroves.

Quantitative samples were sampled for 4 times with quadrats of square of $1/16m^2$.

- Rocky littoral: at the points VII, VIII, IX that is at inlets H. Co Ngua, H. Bu Xam and H. Con Meo, specimens were observed and collected with the same methods of the mangrove - littoral.

- Soft - bottom sublittoral: samples were sampled 4 times by Grab Ponar dredge with its opening square of $0.05m^2$.

The unit of density and biomass of Zoobenthos communities in 3 above biotopes is calculated by the number of individuals and wet weight per m^2 of substratum.

- Coral reefs: Based on methodology of David Dudgeon and Brian Morton (1998), the coral masses were collected and then they were scaled and broken to pick out specimens. Density and biomass of Zoobenthos in coral reefs are calculated by unit of individuals and wet weight per kg of coral pieces.

All quantitative samples were fixed in alcohol of 70^0.

- *Analysis*

According to the method of Institute of Hoang Hai Sea Product, China (1972) for calculating wet fresh weight of zoobenthos, it is described as follows:

It is difficult to weigh and identify directly the specimens in the field conditions up to every species, so they were fixed by alcohol etanol solution of 70^0 after anaesthetizing. In this solution, some water in the body of specimens would be lost with various rates depending on the body structure of species groups. The lost water quantity of some zoobenthos groups are as follows:

Amphipoda: 66.7%

Anomura: 15.7%

Isopoda: 33.7%

Brachyura: 6.9%

Lamellibranchia: 16.4%

Gastropoda: 11.1%

Opisthobranchia: 65%

Ophiuroidea: 25.7%

Holothuroidea: 44.4%

Polychaeta: 18.1%

Based on specimens weight in alcohol, the wet weight would be calculated by formula:

$$\text{The fresh weight} = \frac{\textit{The weight of specimen in alcohol}}{\textit{1 - lost water quantity of fresh specimen}}$$

2.5.6. Fish

- ***Gathering previous data and documents*** was done (fig. 10) as JST's suggestion.

- ***Field Survey***: In combination with coral reef study group in collecting data from the photographs and videotape of coral reef fishes. Questionnaire to the local agencies and fishermen to collect the following information:

1. What types of fishing gear do you use ?
2. How do you use the fishing gear ?
3. When is the fishing season ?
4. What are the fishing hours ?
5. How many days do you go fishing a month ?
6. What kinds of fish and shellfish do you catch ?
7. How much volume of fish and shellfish do you catch a day ?
8. Where is the fishing ground ? Please specify it on the map by target species ?
9. What is the depth in the fishing ground ?
10. What size of fish and shellfish do you catch ?
11. Do you have any information about the spawning area and nursery of your target species ?
12. Have you ever seen dugons (sea cow) or sea turtles in Ha Long Bay ?

If yes, which species ?

Where ?

When ?

How many ?

13. Do you think the fishing catch is changing in quantity ?

If yes, which species ?

Increasing or decreasing ?

Since when ?

Causes that you suppose ?

2.5.7. Algae

- ***Gathering previous data and documents*** was done and given in Part V, Tome 3.

- ***Field Survey:***

- Qualitative sampling: Several methods from Guidelines for surveying and sampling macroalgae issued by the State Committee for Scientific and Technical Management (now Ministry of Science, Technology and Environment), 1981 have been used to collect specimens with references of other authors' Research Methods (Loya 1978, Phillips et al 1990, English et al 1994 etc.)

At each site (fig. 11), macroalgae from 3 replicate vertical transects and 1 contour transect (parallel to the shoreline) are studied. In each vertical transect, the sampling is made from 3 belts of littoral: upper, middle, lower and from sublittoral at 13 sites. Contour transects will help to collect completely macroalgae specimens. For species identification, specimens collected should have full elements (demography) : holdfast, stalk, main stem, branches, branchlets and proliferations. Additionally, specimens of *Sargassum* species should have leaves, vesicles, receptacles. All gathered specimens are fixed dryly on herbarium papers or preservative in 5% solution of formalin in seawater.

The Sorrenson index (S) is calculated as follows:

$$S= C/A+B$$

Where A, B : Species number at sites A and B

C : Common species number to both sites A and B

- Quantitative sampling

+ Biomass: At each station (upper, middle, lower belt of littoral) quantitative specimens are collected from 0.25 m^2 gridded quadrats randomly placed along transect (at least 4 quadrats) for calculating average biomass with the help of diving equipment (SCUBA) and underwater cameras, videos.

Following procedures should be taken:

- Samples should be collected completely inside quadrats.

- To clean adhering debris off the samples and to weigh all species inside quadrats.

- To sort the collected samples into species and to weigh every species separately.

- To combine all data from the 4 quadrats samples at each station and to transfer into 1 m^2. The mean value of 12 replicate quadrats is the average biomass for the studied transect. Do the same way for every transects.

+ Cover: The 0.25m^2 quadrat should be subdivided into 25 sectors (10 x 10 cm). Each sector is the 10 centimetre grid (10x10cm). Classes of percentage cover are defined on table 5 (English et al, 1994):

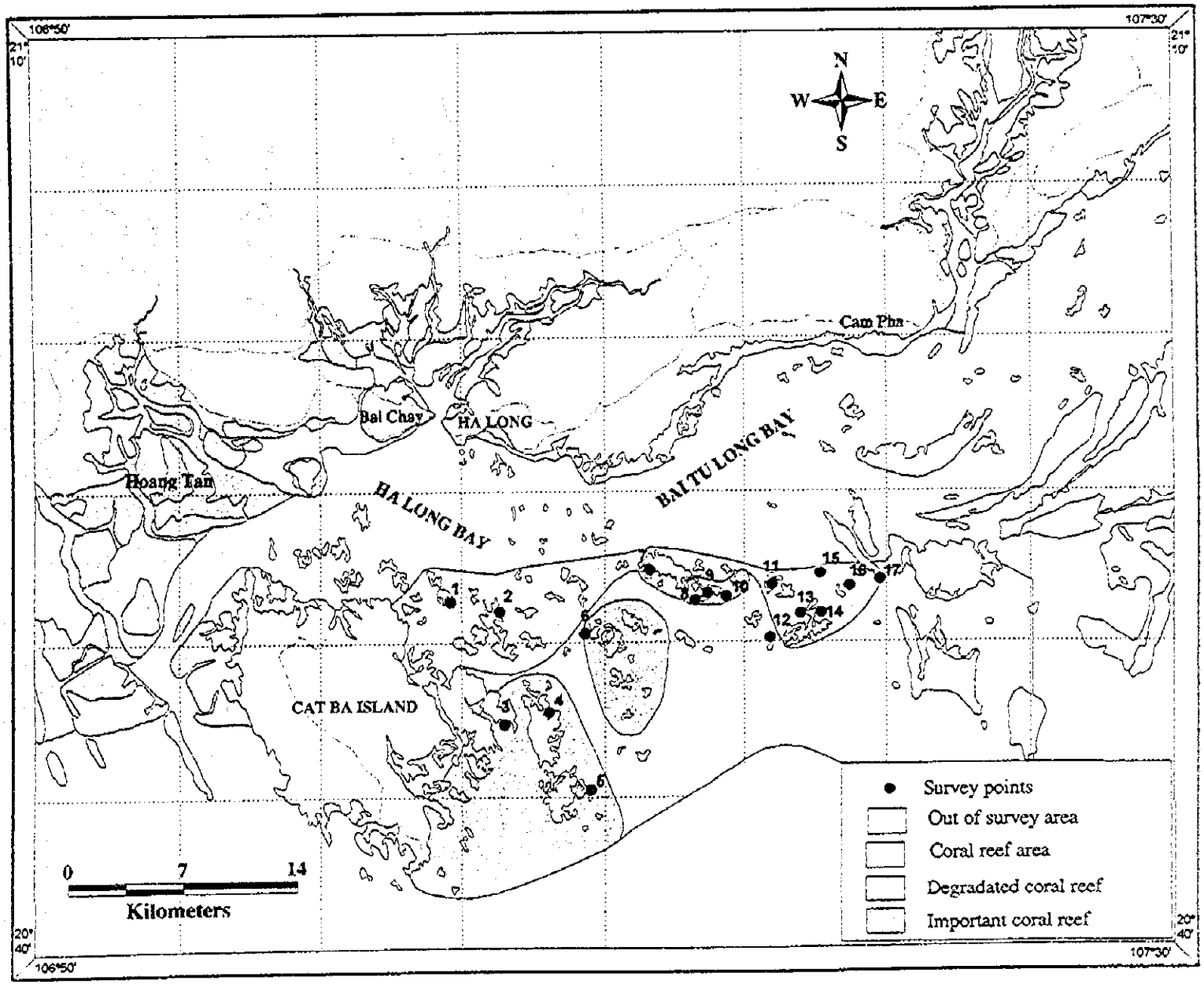
Table 5: Classes of Percentage Cover

Class	Amount of substratum covered	% substratum covered	Mid point %(M)
5	1/2 to all	50-100	75
4	1/4 -1/2	25-50	37.5
3	1/8-1/4	12.5-25	18.75
2	1/16- 1/8	6.25-12.5	9.38
1	less than 1/16	< 6.25	3.13
0	absent	0	0

The coverage (C) of each species in each quadrat is calculated as follows:

$$C = \frac{\Sigma (Mi \times fi)}{\Sigma f}$$

Fig.14. CORAL REEF SURVEY SITES AND THE CORAL REEF AREAS IN HA LONG BAY



Where Mi: mid point of class i

f: frequency of sectors with the same class i

+ Distribution area

- Use large scale Navy maps (1/25,000) to preliminary determine the distribution area of algae vegetation. It is better to have Aerial photographs.

- Field trip will help to identify the real distribution and extent of algae, after defining cover.

+ Reserve (stocks)

The reserve (W) of macroalgae in studied region is calculated as follows:

$$W = B.S$$

Where W: reserve

B: average biomass

S: real distribution area of macroalgae.

Average biomass:

$$B = \frac{b_1 + b_2 + ... + b_n}{n}$$

Where $b_1, b_2, .., b_n$: randomly biomass in each 0.25 m^2 quadrat 1,2,.. , n

n : Total quadrats counted

Some main ambient parameters (transparency, salinity, sediment etc. in relation to macroalgae growth are recorded for each transect during field trips. The distribution by depth of macroalgae is defined, basing on tidal belt division criteria of Feldmann (1937), Stephenson (1949), Pham Hoang Ho (1962), Gurjanova (1972).

In the laboratory, the species identification was based on outer morphology and inner anatomy dissections, with the help of lens and optical microscope "Studio II" of 1350 magnitude.

References for species identification of macroalgae are a series of taxonomic guides (taxonomic books, illustrations, atlas.), some of which are of Vietnamese algologists (Nguyen Huu Dinh et al 1993, Pham Hoang Ho 1969), many others are of foreign researchers (Okamura 1936, Segawa 1962, Taylor 1960, Zheng C.K 1983, Setchell 1936, Kylin 1956, Zinova 1967,Vinogradova 1974. etc.

2.5.8. Coral reefs

- *Gathering previous data and documents*: mainly of HIO. Based on these, the studying sites for this survey were determined.
- *Field Survey*: 17 sites

Table 6. Survey sites of coral reef

No	Islands	Co-ordinates	Parameters
1	H. Dam Nam	20°51'40" - 107°04'00"	Species composition, living and non-living cover
2	H. Cong Go	20°51'23" - 107°05'38"	Species composition, living and non-living cover
3	H. Ba Trai Đao	20°47'37" - 107°06'00"	Species composition, living and non-living cover
4	H. Hang Trai	20°48'03" - 107°07'26"	Species composition, living and non-living cover
5	H. Cong La	20°45'30" - 107°08'36"	Species composition, living and non-living cover
6	H. Hang Cao	20°50'13" - 107°09'20"	Species composition, living and non-living cover
7	H. Cong Đo	20°52'35" - 107°10'52"	Species composition, living and non-living cover
8	H. Cong Tra San	20°51'51" - 107°12'24"	Species composition, living and non-living cover
9	H. Tra San	20°52'07" - 107°12'45"	Species composition
10	H. Gian Muop	20°52'12" - 107°13'10"	Species composition, living and non-living cover
11	H. Cong Đong Nam	20°52'06" - 107°15'18"	Species composition, living and non-living cover
12	H. Cat Đa To	20°50'15" - 107°15'20"	Species composition, living and non-living cover
13	H. Cong Đam	20°51'08" - 107°16'22"	There are not corals
14	H. Van Gio	20°51'19" - 107°17'07"	Species composition
15	H. Gieng	20°52'40" - 107°16'33"	Checking, all corals are dead

16	H. Mat Men	20°52'13" - 107°17'54"	There are not corals
17	Cong Tay	20°52'25" - 107°18'50"	Species composition, living and non-living cover

- In the field: the Quadrat - transect method was used. A detailed description of this method is as follows:

One 50 - 150 meters transect with marked meter number will be perpendicular to shoreline. One or two coral expert-divers will be swimming along the transect to identify species composition of the corals. One or two expert-divers will use quadrat frame (1m x 1m), divided in to 25 parts to determine substrate composition (coral, algae, mud, sand ... cover) by randomly placing on 10 - 15 points of the transect depending on length of transects. The total percent of cover of living corals will be calculated from all the parts covered by living corals. Based on living coral cover, the quality of coral reef will be identified according to 4 categories:

0.0 - < 25 % - poor reef;

25.0 - <50 % - fair reef;

50.0 - <75 % - good reef;

75.0 - 100 % - excellent reef.

The coral reef distribution will be identified by survey; by morphological maps of large scale (1/50,000); and by inquiries to local fishermen and persons working at institutes and agencies. The data would then be drawn up on the map.

3. ACHIEVEMENT OF THE SURVEY

3.1. Field Survey Implementation

To implement the field survey as scheduled, a lot of work had been done such as meetings with the JST experts to detail the items; to confirm methods for field surveys and lab analyses; HIO and JST's field trips for sampling point reconfirmation and getting an overview of the survey area; testing and calibration of meters; purchase of equipment, tools, chemicals, materials and protective clothes; and office rental for running field survey. On July 10, 1998, the first themic groups started the field survey. Up to July 13, 1998, all issues of the field survey, including tidal current, water quality, bottom sediment, dust and biological indicators, were to be implemented (table 7). Some adjustments of sampling points were noticed and accepted by partners timely. The progress report was completed and

sent to JST on time. HIO responded promptly the requests from JST on conduct faecal coliform in the bays and river survey on rainy days (from August 6-9, 1998).

Laboratories arrangement for analyses in accuracy included preparing places for the tests (decomposition and elusion) and getting in touch with other standard laboratories in Hanoi for some parameter analyses.

Data obtained was arranged in data tables and presented by data report set.

Table 7. Survey and Analysis Progress

Item	Field survey	Analysis	Note
1.Hydrological survey	Started on July 13, 1998 and finished by July 30		
2.Water quality and analysis			
2.1. Ambient water quality in the bays	Started on July 15 and finished on July 20, 1998	Started on July 17, and finished by Aug.10, 1998	
2.2. Pollution mechanism			
2.2.1. Productivity test	Started on July 23 and finished on July 29, 1998	Started on July 25, and finished on Aug. 10, 1998	
2.2.2. Decomposition test	Started on July 12 and finished on July 15, 1998	Started on July 14, and finished on Aug. 10, 1998	
2.2.3. Settlement test	Started on July 21, finished on Aug. 1, 1998	Started on July 23, finished on Aug. 10, 1998	
2.3.4. Elusion test	Started on July 12 and finished on July 15.1998	Started on July 14, and finished on Aug. 10.1998	
2.3. River survey			
2.3.1. For fine days	Started on July 13 and finished on July 20, 1998 (two times)	Started on July 17, finished on Aug. 1998	
2.3.2. For rainy days	Started on Aug. 8 and finished on Aug. 9, 1998	Started on Aug. 9 and finished August 25, 1998	
2.4. Pollution sources			

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2.4.1. Industrial wastewater	Started on July 22 and finished on July 27, 1998	Started on July 25, finished on Aug. 10, 1998
2.4.2. Domestic wastewater	Started on July 25 and finished on July 30, 1998	Started on July 27, finished on Aug. 10, 1998
3. Bottom sediment survey	Started on July 15 and finished on July 20, 1998	Started on July 22, finished on Aug. 10
4. Dust survey	Started on July 14, finished on Aug. 14, 1998	Started on July 15 and finished on Au. 15, 1998
5. Biological indicator survey		
5.1. Terrestrial vegetation	Started on July 20 and finished on July, 28, 1998	
5.2. Mangroves	Started on July 10 and finished on July 17, 1998	Finished on Aug. 5, 1998
5.3. Plankton	Started on July 15 and finished on July 20, 1998	Started on July 21 and finished on Aug. 5, 1998
5.4. Zoobenthos	Started on July 10 and finished on July 20, 1998	Started on July 21 and finished on Aug. 5, 1998
5.5. Fish	Started on July 10 and finished on July 20, 1998	
5.6. Algea	Started on July 10 and finished on July 20, 1998	Started on July 21 and finished on Aug. 5, 1998
5.7. Coral and coral reefs	Started on July 10 and finished on July 21, 1998	Started on July 22 and finished on Aug. 5, 1998

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3.2. Comments

3.2.1. Hydrology Survey

Water Level: The measured sea water levels on July at the Bai Chay and Cua Ong Stations are presented in tables 1.1 and 1.2 in Part I. Hydrology Survey. The tidal levels in July at the stations derived from the Tidal Table, 1998 are shown in table 1.3 and 1.4 in the same Part. The comparison of these levels during the survey time from 14 to 30 July is illustrated in figures 1.2 and 1.3 in the same Part. It can be seen that the difference is small in general and it is larger at Bai Chay compared with that at Cua Ong.

Wind: The wind data measured during the survey period is given in tables 1.5, 1.6 and 1.7 in Part I. Hydrology Survey. The analysis on the wind roses has been conducted. Tables 2.1 - 2.3 and figures 2.1 - 2.3 in the same Part are the frequency tables and wind roses at the three stations for the period from July 14 to 30, 1998. It is shown that the wind direction and magnitude are in agreement with the South and Southeast dominant summer wind field in the study area. The direction with the highest frequency of occurrence is the S composed of 51.9% at the Cua Luc, 71.9% at Cam Pha-Cua Ong and 65.1% at Cua Dua Station. The wind magnitude increases seaward.

Table 8: Velocity and Direction

Station	Vmax(m/s)	Direction
Cua Luc	7.8	S
Cam Pha - Cua Ong	8.1	S
Cua Dua	11.0	S

Current: The data series were obtained with the frequency of 15 minutes. From the data series recorded by the current meters, the current roses have been drawn. Like for the wind roses, the statistic method has been applied for calculating the frequency (%) of the velocity ranges in different directions and then the total frequency (Total %) for every direction and total frequency for velocity ranges (F%). Besides, the average and maximum current speeds (Vmed, Vmax) for the directions were also derived. Some results of analysis are given in tables 3.1 - 3.6 and figures 3.1 - 3.6 in the Part I, which represent the frequency table and current roses at three stations and at surface and bottom layers. Due to the morphological feature of the area, the current has two dominant

contravesary directions. The flow regime is strongly affected by tide. Current speed decreases from the surface to the bottom.

- At Cua Luc Station: The surface current was rather strong. The strongest one has been recorded of about 130cm/s during the ebb tide in SW direction. Two dominant flow directions are N and SW at the surface and N and S at the bottom (see the tables 3.1, 3.2 and figures 3.1, 3.2 in Part I).

- At Cam Pha - Cua Ong Station: The average current speed is about 20cm/s at the bottom and 45 cm/s at the surface. The maximum value is 81.1 cm/s in SW direction at the surface and 47 cm/s at the bottom. The dominant flow directions are E, SE, N and SW (see tables 3.3, 3.4 and figures 3.3, 3.4 in Part I).

- At Cua Dua Station: The flow has two main directions N and S with Vmax of 65 cm/s at the surface and 35 cm/s at the bottom (see tables 3.5, 3.6 and figures 3.5, 3.6 in Part I).

In general, the recorded flow in the study area is the combination of tidal and non - tidal components with the main role being the tidal one. Therefore, the flow direction varies in time during a day and has two contravesary dominant directions depending on the tide phase. The current speed also varies in time and decreases from the surface to the bottom. In space, the variation level of the current speed depends on the morphological character of the locality where the station is. At the Cua Luc Station, the strong current has been recorded (130 cm/s), which is the result of the discharging water through the Cua Luc inlet.

The results of current analysis for the harmonic analysis at three stations and two layers are given in the Appendix of the Part I. Hydrology survey.

3.2.2. Water Quality

3.2.2.1. Bays

The field survey was carried out in the ebb tide with a little tidal range of 0.3-0.6m, so water quality parameters obtained were quite different from each other from area to area.

Salinity increased from Hoang Tan area (4-5‰) to Cua Ong (23-24‰) and seaward but decreased outside of the bays waters. For example, at point 22 salinity was 21‰, at point 23 - 16‰, at point 14 - 23‰, and point 15 - 18,7‰ (surface layer). Salinity of the bottom layer which was higher than that of the surface layer showed the strong effect of the Red River water on the waters of the bays, particularly in spring tide in rainy season.

The contaminants concentration of the bays water was not high. Oil content, coliform and faecal coliform of the surface layer were much higher than those of the bottom layer. It can be said that contaminants sources mainly come from the hinter land. CN^- concentration was high, from 5.5-10.5µg/l on average. Because CN^- of the bottom layer was higher than that of the surface layer, it is said that CN^- concerns some human activities in the bays and ambient areas.

Heavy metals concentration was low. However, it was higher at the bottom layer compared to that of the surface one. Perhaps heavy metals mainly come out by elusion.

Pollution Mechanism in the Bays

From the results of the decomposition test, it is stated that the self-cleaning mechanism in the bays is quite strong. Inorganic process of organic matters becoming inorganic nutrients (NO_3, NO_2, NH_3,) increased 2-5 times at all 5 points and COD_{Mn} was 2-3 times decreased.

Settlement test results showed the same status of self-cleaning mechanism. After 24 hours, the amount of SS organic matters as well as the concentration of nutrients and COD_{Mn} were much remarkable at 5 points

Pollution level was low at all points when looking at the results of the productivity test. The productivity was on average of 0.8-1.2µg/Corg.l.h and lower than that derived from modelling outcome.

The potential elusion of substances to bays water is considerable. After 20 day elusion test, all parameters increased. For example, inorganic nutrients were 5-10 times accelerated, organic nutrients - 2 times, COD_{Mn} - 1.5-2 times.

3.2.2.2. River

On Fine Days

Discharge was low at all sampling points. Particularly, at Yen Lap Dam point (point 1) water discharge was very much dependent on the gates opening or closing controlled by people who are responsible for Yen Lap Lake.

Water was clear with no garbage at point 3,4,5,6,7,8 and 9

pH value was around 7 except for point 9 with pH of round 3

On Rainy Days

Because the precipitation was very little, river water status was not so different from that on fine days during the first field survey for rivers.

But this status was quite different for the second field survey after one night heavy raining of Aug. 8, 1998. Comments on rivers on rainy days based on the second survey are as follows:

Discharge of rivers in north area of Bay Chay bay was remarkably increased. Flow velocity was high (> 2m/s at point 3).

Water of rivers in north Bai Chay Bay area became reddish brown with a lot of garbage (grass, leaves and branches of trees...). Meanwhile, most rivers in Hon Gai and Cam Pha-Cua Ong areas got dark (color of coal) with plenty of suspended matters (mainly coal debris) coming from coal mine areas.

Water quality of rivers in north Bai Chay Bay is good (points of 1-7). Pollutants concentration was quite low. Meanwhile, water quality of the remain rivers (points of 8-15) was bad. At points 8-15, SS was high and pH was low (acid media). Heavy metals (Fe, Mn, Cu, Pb, Zn, Ni, Cr,) at these points were high, especially Zn concentration of 1,132µg/l at point 13 and 1,632µg/l at point 14. Pollutants of river water on rainy days were higher than those on fine days.

3.2.2.3. Pollution Sources

Industrial Wastewater

Discharge was minimal at most sampling points during the sampling time.

Wastewater from coal mines and coal processing factories was black, turbid and contained a lot of mixed matters. Meanwhile, it was very stinky, fishy and dirty, containing organic matters at sampling points from beer factories, markets, hospital, hotels and a frozen seaproduct processing factory. At other points, it was clear in general, sometimes with rubbish or oil slicks.

Turbidity, SS, COD, BOD_5, oil, coliform were 1.5-10 times higher than those in bays water, particularly heavy metals and phenol contents. Heavy metals of water from mining areas were increased and phenol of water from hotels, markets, hospitals were also accelerated.

Domestic Wastewater

Discharge in general was little.

There were a lot of solid wastes such as plastic containers, old papers, pieces of brick, organic matter from dead animals and human waste on the drainage channels.

Wastewater was mostly dark and dirty with a stinky and fishy odor.

Drainage channel beds were often covered with a very dark mud layer.

The value of pH of wastewater ranged from 4-8. At each point, however, this value was not so fluctuated.

DO in general was low at most sampling points, except for 3 points at Cam Pha - Cua Ong area (point 1 and 3 of two sampling times and point 3 of four sampling times). At these points, the DO value was of a range from 5-6.5 mg/l, similar to that in river water on fine days.

SS, COD, BOD_5, oil, coliform and faecal coliform were so high. Especially, nutrients (organic and inorganic) were 5-10 times higher than those in bays water.

3.2.3. Bottom Sediment

Bottom sediments taken at sampling points in the bays are muddy samples with sandy fraction of from 1 to 30%, except for points 29 and 30 where sandy sediment was observed. Particularly, sediments at point 29 are almost all coal debris of sandy grain size.

Most of the sediment samples constitute coal debris with different concentration, shell fragments and organic matter.

At points 6, 3, 14, 15, 22, a very thin layer (0.5-2 mm) of semi-liquid mud covering the bottom sediment surface was recorded. Perhaps this layer is formed during the rainy season, with sediments discharged from rivers.

At points 3, 10, 18, 7, small muddy lenses were found in bottom sediment. These lenses contained a lot of black organic matter with stinky odor.

Temperatures of samples taken in shallow waters were very similar to water temperatures ranging from 32-33°C. The rest of the samples were lower than that, ranging from 30-31°C. Eh value was from - 300 to - 332 mv, except for point 29 with this value of +245 mV. Value of pH was in the range of 7-7.35.

3.2.4. Settled Dust

Field sampling and analysis were carried out paralelly from July 14 to August 13, 1998 at five selected sapling points. In total, 142 settled dust samples (daily and five-day sampling) were taken and analysed.

Wind direction and velocity were measured four times (obs.) per day during the whole period of sampling time.

Comments in detail and data obtained on settled dust and wind are given in data set, part IV.

3.2.5. Biological Indicators

3.2.5.1. Terrestrial Vegetation

In general, all over this area, close forest formation does not take up a large area, mainly on Cat Ba island, one part in Hoanh Bo and a small area in Uong Bi, Cam Pha. Shrub formation takes up most of the area, particularly in Hoanh Bo, Cam Pha. Savannah formation has not a large area and is dispersed.

In cultivated vegetation, Pinus and Eucalyptus formations take up the most area. Other cultivated types of vegetation cover a small area but are separated from each type, as well as alternating between each type.

On the other hand, there is protected and green vegetation only in Cat Ba island. Mainland vegetation cover (Uong Bi, Hoanh Bo, Cam Pha, Bai Chay, Hon Gai) suffered serious damage and is exhausted. The main reason is over exploited plant resources and coal mining dating back centuries ago.

This state has had a bad impact on the Ha Long Bay environment such as climate, coastal erosion of the bay and islands, water, etc.

It is needed to give solutions to protect and restore vegetation cover in this area.

Until now, 1,027 species belong to 171 families, 6 phylum were recorded in the area, most of them belong to *Magnoliophyta*, 143 families (occupied 83% of total number of families) with 951 species (92% of total species number). Others have a much less number. They are *Polypodiophyta* - 18 families (10%) and 58 species (5.5%); *Pinophyta* - 6 families (4.5%) and 11 species (1%); *Lycopodiophyta* - 2 families (1,5%) and 5 species (0.5%); The last are *Psilotophyta* and (*Equisetophyta*) - 1 family and 1 species in each.

The result of the species study on distribution areas showed that mainland community consists of 475 species (occupied 47%). The highest number was on Cat Ba islands community - 749 species (57%), among them, many species distribute on Cat Ba only.

The estimation on used values showed that, 35 % of the total has a medicinal value; 1.7% (17 species) give an excellent wood; 6% of species give ordinary woods; and 24% of species have various values such as food, vegetables, oils, ornamental values. Among them, many species belong to rare and endangered groups, especially 19 species were listed in Vietnam Red Book (1996) which are under threat of disappearing and must be protected.

3.2.5.2. Mangroves

This study on mangroves has focused on Hoang Tan Island area, the mangroves in Cua Luc was checked only (fig. 12). As a result, 19 species of mangroves were recorded in two areas, occupying 65.5 % of the total number recorded in the Project Area up until now. Among them are 16 species in Hoang Tan and 13 species in Cua Luc.

The result of the quantity survey on mangroves showed that the percentage cover in Hoang Tan area is high, reaching 75 - 100% on upper tidal zone and 10 - 30% on middle tidal zone.

The preliminary survey on all of the Ha Long Area showed that the mangroves here are restored due to replant. For example, 500 ha of mangroves are planted in Hoanh Bo and Yen Hung districts. At present, the mangrove forest area in Yen Hung district is 1147 ha.

3.2.5.3. Phytoplankton

The result of analyzing the samples collected at 10 points revealed 166 species of 6 phytoplankton phylums, among them the *Bacillariophyta* has the highest number, 128 species (occupied 77.1% of total number); then are the *Dinophyta* - 33 species (19.9%); and *Cyanophyta* - 2 species (1.2%). 3 other phylum: *Chlorophyta, Euglenophyta* and *Chrysophyta* have only one species each (0.6%).

The quantity distribution of phytoplankton at points is different. The highest number is at point 22 (mean number is 114,090 cells/l), and the lowest is at point 6 (only 14,650 cell/l). The density distribution by layers has the same tendency as that of the density of cells in the bottom layer is higher than the surface, but at point 2, maybe the depth here is smaller, 2.4 m only.

Of *Dinophyta,* 10 species belong to harmful algae, but their density is low, the highest number is 800 cell/l belonging to *Dinophysis caudata.*

3.2.5.4. Zooplankton

The analyzing result of samples collected in July 1998 revealed 47 species, occupying 44.7% of the total recorded number at Ha Long Bay (105 species). *Copepoda* has the highest number, 25 species (occupying 53.2% of total revealed species); then are Crustacean larvae, 10 species (21.3%); *Cladocera* and Mollusks larvae, 3 species (6.4%) in each; and *Chaetognatha* - 2 species (4.3%). The others; *Coelenterata, Ostracoda, Tunicata* and fish larvae; have one species (2.1%) only.

The number of species is the highest at point 15 (28 species) and the lowest - station 10 (6 species).

The mean density at all stations is 140 individuals/m3, the highest - at point 25, 429 indiv./m^3 and lowest - point 10, 6 indiv./m^3. The mean biomass is 27.0 mg/m^3; the highest biomass is at point 2, 76.3 mg/m^3 and lowest - point 6, 1.1 mg/m^3 only.

3.2.5.5. Zoobenthos

From samples collected (fig.13), 208 species of zoobenthos were recorded, occupying 68.8 % of the total number of known species from the study area. In comparison with the previous data, 26 new species were recorded for the area. Among zoobenthos, the mollusks have the highest number consisting of 92 species (occupied 44.2% of total number); then are Annelids (*Annelida*) - 78 species (37.5%); Crustaceans (*Crustacea*) - 23 species (11.1%); and the echinoderm has the lowest number, only 15 species (7.2%).

The counting for various habitats showed that there are 169 species on littoral - mangroves; 104 species in soft bottom in sublittoral; and 99 species in hard coral reef.

The density of individuals on various habitats were as follows: on the littoral - mangroves, from 110 to 4,242 indiv./m^2; in the soft bottom in sublittoral: 85 - 530 indiv./m^2; and in hard coral reef bottom: 9 - 98 indiv./kg dead corals.

Of zoobenthos, 63 species are economic values and 12 species are rare and precious but in the survey period, these were very rare.

3.2.5.6. Fish

From previous and present survey data 189 species belong to 124 genera, 66 families were recorded for the Ha Long - Bai Tu Long - Cat Ba Area.

There are 5 important habitats for fishes. These are mangroves, coral reefs, rocky reefs, bays and embayments and sandy - mud bottom areas. Every habitat is characterised with some typical species.

Based on results of the questionnaires to fishermen and local agencies, there are 7 fishing grounds in the Project area. These are Dau Be, Dau Go, Hon Soi Den - Ngoc Vung, Cua Dua- Cong Do, Tuan Chau, Cong Dong - Cong Tay and Hon Net - Hon Ong Cu.

There are 3 spawning areas in the Project Area. These are Cua Luc - Tuan Chau - Dau Bê (for drift fishes) on coral reefs and adjacent waters (for bottom fishes) and Ngoc Vung - Cong Đo (for groupers and snappers).

3.2.5.7. Algae

In JICA survey in July 1998, only 11 species of sea algae were found from the 129 previously known species because the algae season is over.

31 species with economic value and 11 dominant species were known in this area from the previous data and documents.

3.2.5.8. Coral Reefs

The JICA survey in July 1998 on coral reefs (fig.14) revealed 122 species belonging to 41 genera of Scleractinians, occupying 71.8 % of known species in this area (122/170).

Among 17 studying sites only two sites belong to excellent reefs with a cover of living corals over 75 %; 2 sites belong to good reefs (cover ranging from 50 to 75%); 6 sites belong to fair reefs (cover varying from 25 to 50%); and 4 sites belong to poor reefs (the cover is lower 25%). Among them, only one site is covered with dead corals and at two sites there have not been any corals.

In the studying period we found many hard, soft and gorgonian corals which are dead recently. In some sites the percentage of dead corals is very high, for example, at site No 8 the percentage of dead corals is 58.8%; at site No 7 - 58.1%; at site No 1 - 58.4%; at site No 5 - 57.5%; at site No 2 - 50.8%; and especially at site 15, where all of the corals are dead.

There are important areas for corals at Hang Trai - Dau Be, South - East of Cat Ba island, Vung Ha - Bo Hung and Cong Đo. The most threatened reefs distributed at south Ha Long Bay, Van Gio - Cong Tay and along the navigation channels.