BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR REHABILITATION OF THE TEMA FISHING HARBOUR
IN
THE REPUBLIC OF GHANA

September 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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P R E F A C E

In response to the request of the Government of the Republic of Ghana, the Government of Japan has decided to conduct a basic design study on the Project for Rehabilitation of the Tema Fishing Harbour and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Ghana a study team headed by Mr. Takeshi Kawaguchi, Deputy Director, Planning Division, Fishing Port Department, Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries, from May 22 to June 16, 1988.

The team had discussions on the Project with the officials concerned of the Government of Ghana and conducted a field survey in the Tema Fishing Harbour area. After the team returned to Japan, further studies were made, a draft report was prepared and, for the explanation and discussion of it, a mission headed by Mr. Yuji Nishi, Deputy Director, Disaster Prevention & Coastal Protection Division, Fishing Port Department, Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries was sent to Ghana from August 7 to August 18, 1988. As a result, the present report has been prepared.

I hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Ghana for their close cooperation extended to the team.

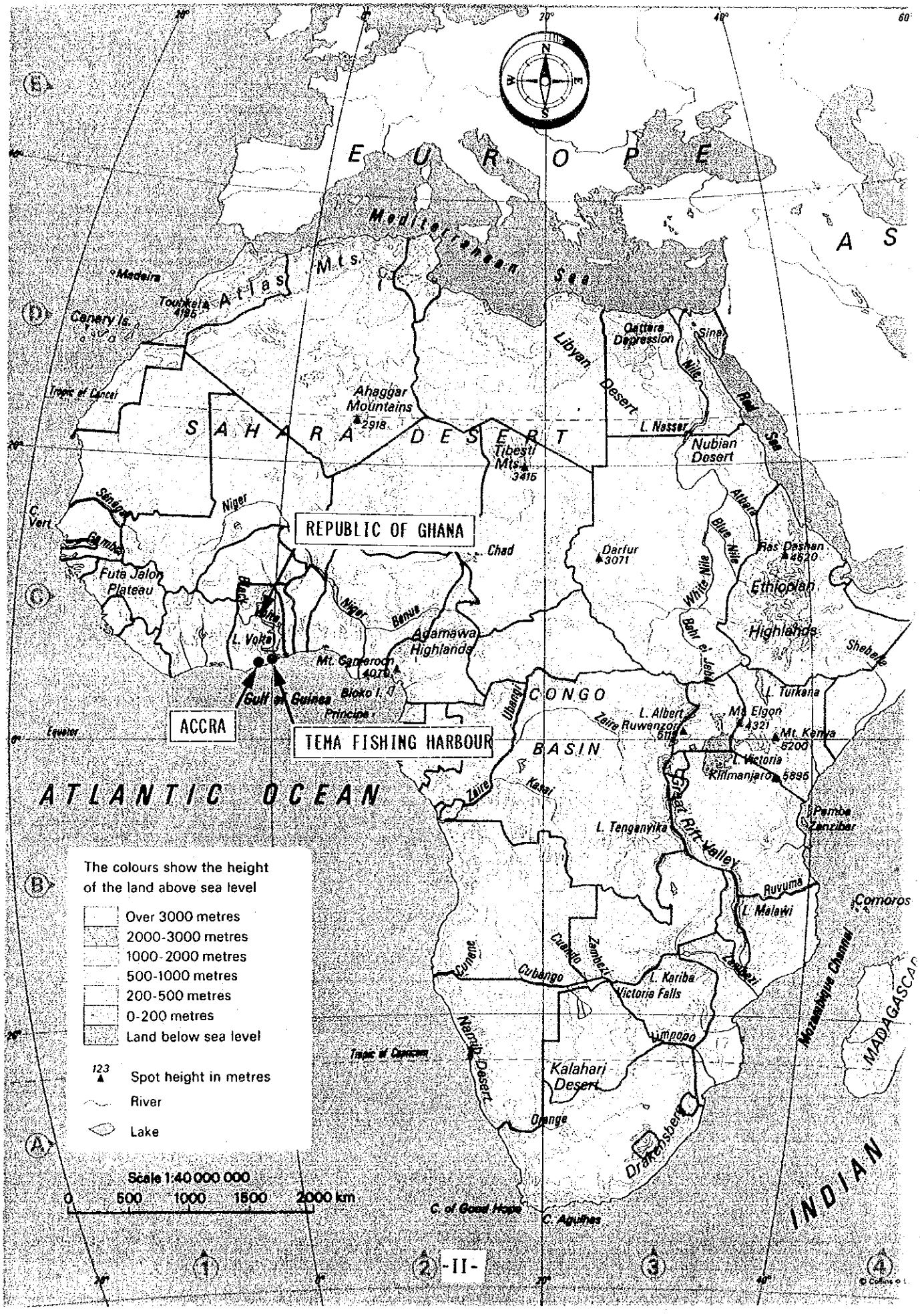
September, 1988

Kensuke Yanagiya

Kensuke Yanagiya

President
Japan International Cooperation Agency

GUIDE MAP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Principe
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L. Malawi
Comoros
Mozambique Channel
MADAGASCAR
Cunene
Cubango
Cuando
Zambezi
Zambezi
L. Kariba
Victoria Falls
Limpopo
Namib Desert
Kalahari Desert
Tropic of Capricorn
Orange
Drakensberg
C. of Good Hope
C. Agulhas
ATLANTIC OCEAN
INDIAN
The colours show the height of the land above sea level
Over 3000 metres
2000-3000 metres
1000-2000 metres
500-1000 metres
200-500 metres
0-200 metres
Land below sea level
123 Spot height in metres
River
Lake
Scale 1:40 000 000
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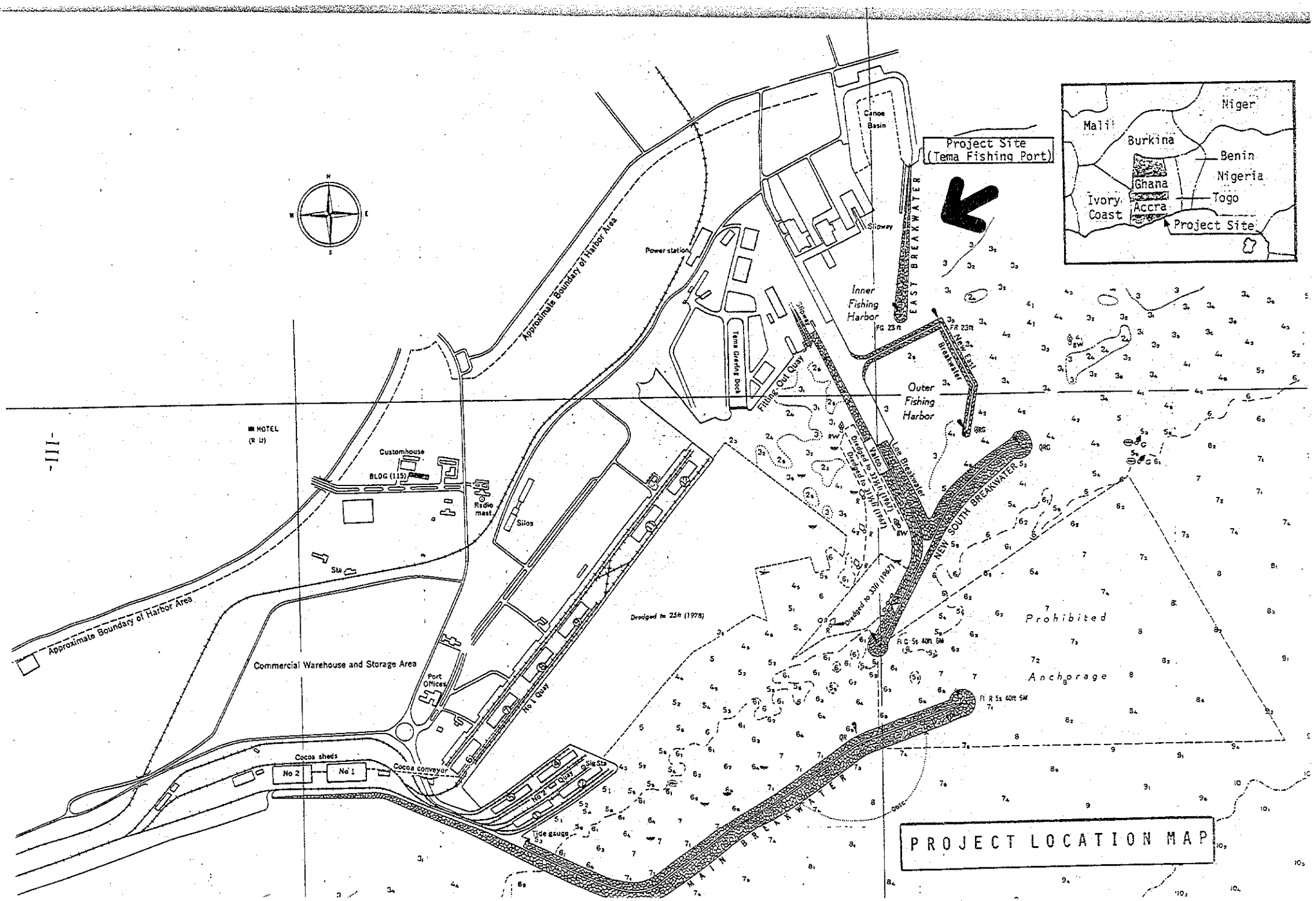
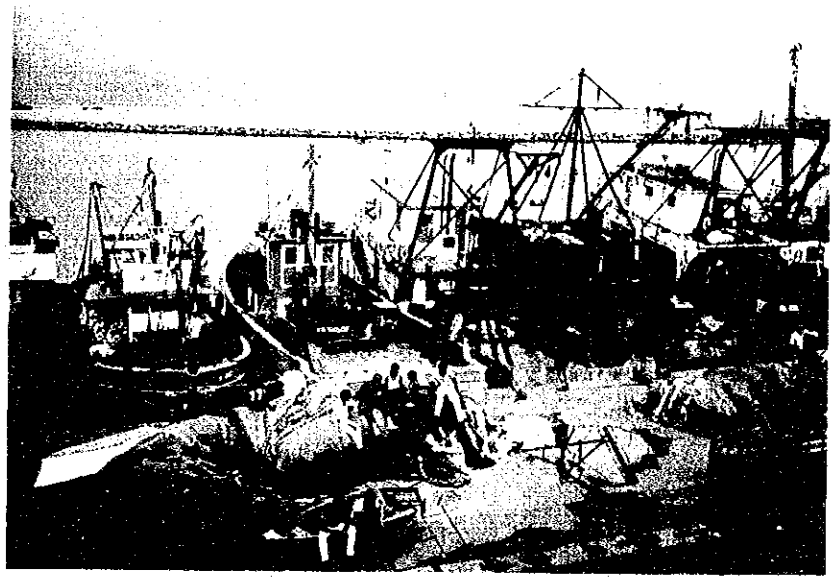

Project Site
(Tema Fishing Port)
Niger
Mali
Burkina
Benin
Nigeria
Ghana
Togo
Ivory Coast
Accra
Project Site
Canoe Basin
Slipway
Power station
Approximate Boundary of Harbor Area
Inner Fishing Harbor
EAST BREAKWATER
Tema Graving Dock
Filling-Out Quay
New East Breakwater
Outer Fishing Harbor
HOTEL
(R L)
Customhouse
BLDG (115)
Radio mast
Silos
Sta
Approximate Boundary of Harbor Area
Commercial Warehouse and Storage Area
Port Offices
No 1 Quay
Dredged to 25ft (1978)
Dredged to 33ft (1967)
Dredged to 37ft (1967)
Lee Breakwater
NEW SOUTH BREAKWATER
Prohibited
Anchorage
Cocos sheds
No 2
No 1
Cocoa conveyor
No 2 Quay
Sig Sta
Tide gauge
MAIN BREAKWATER
PROJECT LOCATION MAP

PHOTOGRAPH

Congested Tema
Inner Fishing Harbour

North-South Wharf
(Middle part)

The wharf is used for lay-by, preparation and vessel repairing place as well as the net storage place.



North-South Wharf
(North part)

The wharf is occupied by non-operational vessels.

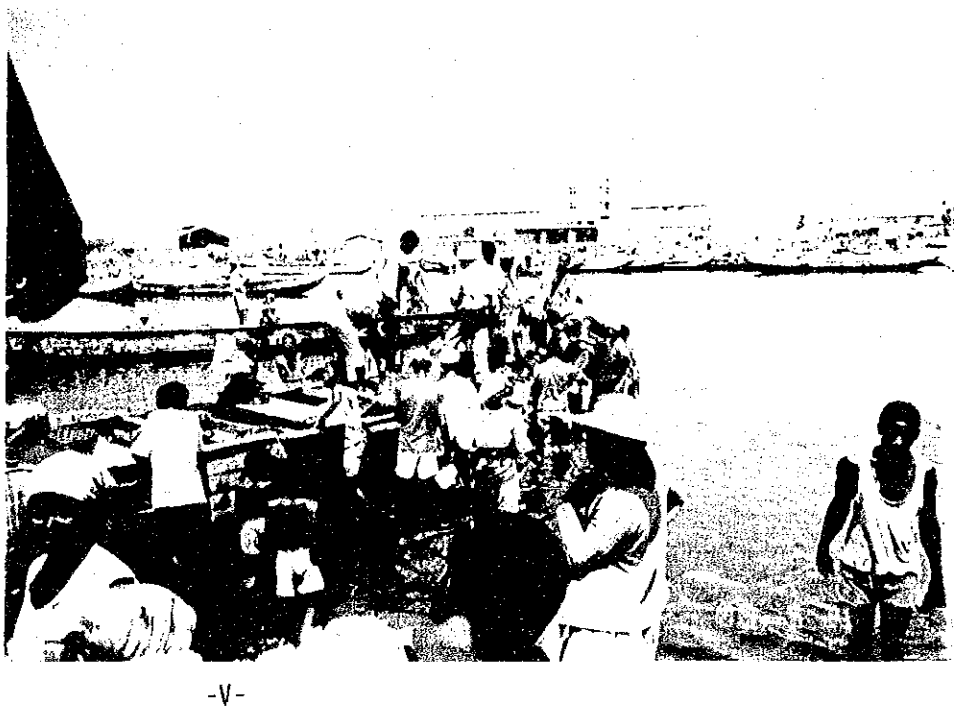
North-South Wharf

Fish unloading and dealing condition

Fish Market

Parking area behind of the fish market hall is used for fish market place.

Fish unloading condition at Canoe Basin



Canoe Basin

About 400 canoes are operating in this place.

Fish market at Canoe Basin

Motor Boat Jetty

Motor Boat Jetty is used for net repairing place.

SUMMARY

SUMMARY

Ghana is located in the middle of West Africa facing the Guinea Bay with a 560 km long coastal line. The country's population in 1987 was estimated at 13,390,000 with an average 2.6% annual increase from 1970 to 1984.

The Ghanaian economy is supported primarily by agriculture, mining, and forestry, which are centered in the south. The agriculture, forestry, and fishing industries make up 44.4% of the GDP. The economy from 1984 showed an improvement marked by an annual average growth rate of the GDP of 5% with the implementation of the Economic Recovery Program (1984-86).

Ghana can be compared with Senegal in the West Africa as a country of fisheries, where the Ghanaian fishing industry plays an important part in the supply of animal protein to the nation with an annual fish consumption per capita of 18 kg. This industry relies on canoe fishing, inshore fishing, deep sea fishing, tuna fishing and inland fishing over the 560 km coast. The fish catch reached 270,000 tons in 1986.

The project site for the Tema harbour including the fishing harbour is located in the Great Accra region in Ghana and is 25 km east of the capital city Accra. Tema harbour is divided by the Lee breakwater into a commercial harbour in the west and a fishing harbour in the east. The fishing harbour is further divided by the south breakwater into an inner fishing harbour for the inshore fishing boats and canoe basin and outer fishing harbour for the larger fishing boats. The project site is located in the inner fishing harbour of the Tema fishing harbour.

The Tema fishing harbour which is the object of this project is the only port in Ghana where large fishing boats more than 10 m long can enter. The fishing method practiced at the Tema fishing harbour are the canoe, inshore, deep sea and tuna fishing. About 50,000 tons of fish were unloaded in 1986,

equivalent to 20% of the total fish catch in Ghana.

Tema fishing harbour is an important base for the Ghanaian inshore fishing since 62% of the whole country's inshore fishing boats or trawlers are operating in the Tema harbour. The fish catch and total sales from this harbour amounted to 48% and 71% respectively of the gross national amounts.

Owing to the importance of the Tema fishing harbour, it is essential to all of Ghana that the harbour operate in an efficient manner. Such is not the case, however, as operations are greatly hindered by the disorder and congestion resulting from numerous fishing boats. Two obvious problems are an increasing number of fishing vessels and essentially inadequate land facilities. Adding to the congestion are the docking of disabled vessels and the shortage of space available for net repairs. Congestion is both the cause and result of structural damage where wooden and steel-hulled vessels operate in such close proximity.

Specifically, the study team recognized the following problems in Tema inner fishing harbour.

(1) Congestion of unloading wharf by non-operational fishing boats.
(2) Congestion of wharf due to an inadequate lay-by wharf
(3) Congestion of the wharf apron due to the lack of a net repairing yard.
(4) Long occupancy of the fish unloading wharf by boats waiting while their catch is sold.
(5) Deterioration of the fish in the open air market in the canoe basin.
(6) Long waiting periods for repairs to fishing vessels due to the shortage of spare parts.
(7) Ineffective harbour maintenance and management.

Due to the above conditions, the Government of Ghana established the need for the development of a plan of the entire fishing industry, including the rehabilitation project of the congested Tema fishing harbour with the assistance of the World Bank during the period from 1984 to 1987. The Government of Ghana requested the Government of Japan to execute this rehabilitation project for the Tema Fishing Harbour under the Grant Aid Program.

In response to this request by the Government of Ghana, the Government of Japan decided to conduct a basic design study of the Project for Rehabilitation of Tema Fishing Harbour. The Japan International Cooperation Agency (JICA) dispatched the basic design study team, headed by Mr. Takeshi Kawaguchi, to Ghana from May 22 to June 16, 1988. The team discussed the request with Government officials and conducted the necessary field investigation and design analysis.

Through its review, the basic design team established the following:

- The fishing season at this harbour is concentrated in July, August and September. During this three month period, there is an average of 45 fishing vessels operating and unloading an average of 5,548 crates of fish per day.

- The number of berths required per day during the fishing season at the fish unloading and preparation wharves is estimated at 9 and 4 respectively.

- Including the use of the existing wharf, the number of additional lay-by berths still required is 68.

- After jet boring, the area reserved for lay-by wharf and jetty was found to be in good condition with a good support strata at a depth of -5 to -6 m.

- From the tide observations, it was observed that Tema harbour

had 2 daily tides with a maximum tide level of +1.5 m.

- From the sounding survey, it was found out that the water depth was -4 m to -6 m. This depth is sufficient for the vessels using this harbour.

- From the current observation, it was found out that the current speed at the entrance to the harbour was 13 cm/sec. This speed is negligible in vessel maneuvering.

- Since there is no fish handling shed, one is planned in front of the fish market hall and one in the canoe basin to retard spoilage.

Through the study of the request of Ghana, the facilities and equipment for Japan's Grant Aid Program are evaluated as follows.

(1) Construction of 100 m lay-by wharf (Net repairing yard will be provided behind the wharf).
(2) Construction of 155 m lay-by jetty.
(3) Mooring facilities for 20 steel vessels at Outer Fishing Harbour.
(4) Rehabilitation of fish market hall.
    a) Rehabilitation of 2300 m^2 roof
    b) Rehabilitation of wall (entrance and exit)
    c) Installation of marketing stalls
    d) Installation of ice storage
    e) Installation of water and electric supply facilities
(5) Installation of fish handling shed (Canoe basin - 1000m^2; in front of fish market hall - 610 m^2)
(6) Construction of fitting-out quay 30 m long
(7) Rehabilitation of motor boat jetty
(8) Rehabilitation of switchgear at sub-stations Nos. 10, 11 and 12
(9) Installation of water and electric supply facilities

This project will be implemented with the cooperation of both governments taking into consideration the mechanism of the Japanese Grant Aid. Estimated construction cost covered by the Government of Ghana is about 1,200,000 cedies for the removal of the existing fence for preparing the construction yard.

After the Exchange of Note (E/N) between the two governments, the project will require 5 months for design and writing of tender documents in preparation for contractor bidding. After the analysis of the bids, the contractor will be chosen and the construction work will begin. The first construction phase will require 12 months with the second phase taking another 9 months. In total, a period of 26 months will be required from the consultation stage until the termination of the project.

The organization responsible for this project is the Ghana Port and Harbour Authority (GPHA) under the administration of the Ministry of Transport and Communications (MTC) which manages and maintains this harbour during and after the termination of the project. The branch office of GPHA at Tema Fishing Harbour has 76 staff for fishing port operation. About 2,000,000 cedies of revenue is obtained by the fishing port tariff per one month which revenue will cover the costs of fishing port operation and maintenance. Tema commercial harbour rehabilitation project is now conducted by GPHA under the financial assistance of the World Bank and OECF.

GPHA is knowledgeable in this field. Maintenance cost of this project is estimated at 580 thousand cedies. This will be covered by the revenue obtained by fishing port tariff.

It is believed that this project will lead to the relief of congestion, reduction of the waiting time for fish unloading, and preservation of product freshness. It should also increase the time available for fishing by speeding dock operations.

It should benefit the overall economy through increased taxable income as well as the development of fishing related industries.

Therefore, the implementation of the project under Japan's Grant Aid Program is extremely meaningful and the early completion of the project is highly recommended.

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CHAPTER 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Objective of the Study

The Ghanaian fishing industry plays an important part in the supply of animal protein to the nation. Canoe fishing, inshore fishing, deep sea fishing and tuna fishing are practised along the Guinea Bay coast. The total fish catch reached 270,000 tons in 1986.

The Tema fishing harbour is the only harbour which can handle boats more than 10 m long in Ghana. However, the existing facilities are either inadequate or outdated, leading to delays in the boats' preparation, damage when maneuvering, and congestion brought about by idle boats, shortage of space for the net storage and repair, and resultant retardation of fishing industry development.

Due to these considerations, the Ghanaian Government undertook for the period from 1984 to 1987 a feasibility study for development of the Tema Fishing Harbour with the assistance of the World Bank. This project is based on the Economic Reconstruction Program and will enable the decongestion of this harbour through a rehabilitation plan leading to the development of fishing industry with the Japanese Government Aid.

The objectives of this study are to confirm the content of the Project requested by the Government of Ghana, to examine and assess the technical and economic viability of the Project under the Grant Aid Program, and to make a basic design for the Project.

1.2 Mission to Ghana

In response to the request of the Government of Ghana, the Government of Japan has decided to conduct a basic design study on the Project. JICA sent to Ghana a study team headed by Mr. Takeshi Kawaguchi, Deputy Director, Planning Division, Fishing Port Department, Fisheries Agency, from May 22 to June 16, 1988 and the Minutes of discussions were made.

After the team returned to Japan, assessment of the studies was made and a draft report was prepared. A mission headed by Mr. Yuji Nishi, Deputy Director, Disaster Prevention & Coastal Protection Division, Fishing Port Development, Fisheries Agency was then sent to Ghana for the explanation of this draft report from August 7 to August 18, 1988. The mission team exchanged minutes of discussions with Ghana Government officials.

1.3 Outline of the Study

The basic design study team carried out the following site survey and met with the cooperation of the Ghanaian authorities.

(1) Study of project background and the contents of project requested by the Government of Ghana.
(2) Study of high ranking project relating to this project.
(3) Study and discussion of project's contents and scale.
(4) Evaluation and investigation of the pervasive effects resulting from this project.
(5) Study of the project operation and management organizations.
(6) Study of the status and problems of the Ghanaian fisheries.

(7) Field investigation of the project site.
(Tide, soil, seabed depth, current, surrounding condition)

(8) Investigation of the related construction.

(9) Collection of the related data.

JICA reviewed the contents of the study carried out by the basic design study team, on the scale of the facilities, construction period and cost and then compiled as the basic design study report (draft final report). JICA, then, sent the team headed by Mr. Yuji Nishi of the Fisheries Agency to Ghana during August 7 to August 18, 1988.

The team submitted and explained the draft final report to the authorities concerned and confirmed the contents of the study. And consequently, the both representatives agreed basically on the contents of the study and then signed the minutes of discussion.

The present report has been prepared based on the above study results.

CHAPTER 2 BACKGROUND OF THE PROJECT

CHAPTER 2 BACKGROUND OF THE PROJECT

2.1 Ghana in Brief

(1) Location and Population

Ghana is a west African country facing the Guinea Bay with a 560 km coastline. As of 1987 there was 13,390,000 inhabitants with a population density of 52 persons/km^2. The annual population increase calculated from the period of 1970 to 1984 was 2.6 %.

(2) Industry and Economy

Most of the Ghanaian agriculture, mining, and forestry industries are centered in the south of the country. The share of the GDP represented by these industry reached 44.4 % in 1986. The Ghanaian economy shrank in total output and was afflicted with high inflation related to the foreign currency exchange rate between 1970 and 1983. This led to a reduction in the number of import and export transactions and GDP reduction of 30 %. However, since the application of the 1984-1986 Economic Recovery Program, the economy improved with an average annual growth of the GDP of 5 %. The average income per person in 1986 was 42,347 Cedis ($474). Trade has increased since 1984 with an export surplus of 7,067 million cedis in 1986. The main export products are cacao, manganese, diamonds and gold, with the cacao exports reaching 60 % of the trade.

2.2 Project Site

The Tema harbour including the fishing harbour belongs to the Great Accra area and is situated 25 km east of the capital city of Accra. The Tema harbour is divided by the Lee breakwater at its center forming a commercial

harbour on the west and a fishing harbour on the east.

The fishing harbour consists of inner and outer harbour separated by a South Breakwater where the outer harbour is for large fishing vessels and the inner harbour for small inshore vessels extending on a 12 ha mooring basin and 5 ha canoe basin. The location of this project is the Tema Inner Fishing Harbour.

2.3 Existing Conditions of the Fishing Industry

2.3.1 Outline of the Fishing Industry in Ghana

(1) Adiministrative Regions

The coastal portion of Ghana is effectively divided into four primary regions, each of which is served by a regional office of the Fishery Department:

1. Western Region
2. Central Region
3. Great Accra Region
4. Volta Region

(2) Fishing Mode

Ghana has a 560 km long coast and has a fishing industry similar to the West African State of Senegal, in that the industry is based on the following five modes:

1. Canoe fishing
2. Inshore fishing
3. Deep sea fishing
4. Skipjack and Tuna fishing
5. Inland fishing

1) Canoe Fishing

Canoe fishing in Ghana comprised 108,000 fishermen and 8,288 canoes in 1986. About 35 percent of all canoe fishing is conducted in the Great Accra region which includes 45 fishing village. 31 percent of the canoe fishing takes place in the Central region in 42 fishing villages; 16 percent is in the Volta region with 41 villages. About 70 percent of all fish landed in Ghana are a result of canoe fishing (See Table 2.3.3 for the fish landing volume).

2) Inshore fishing

Table 2.3.1 and 2.3.2 show the fish catch and number of vessels used in inshore fishing.

Table 2.3.1 Fish Catch and Total Sales of Inshore Fishing

Unit: Ton 1000 Cedis (1000 $)

	Great Accra		Central Region		Westsern Region		Total	
	Fish catch	Total sale	Fish catch	Total sale	Fish catch	Total sale	Fish catch	Total sale
1985	11,947	517,621 (9,520)	3,080	68,884 (1,267)	2,953	83,806 (1,541)	17,980	670,311 (12,328)
1986	10,568	613,049 (6,872)	3,281	96,322 (1,080)	8,045	148,956 (1,670)	21,894	858,327 (9,622)

Table 2.3.2 Number of Inshore Fishing Vessels by Regional Mode

	Western Region	Central Region	Great Accra	Total
Operating	39	117	244	400
Idle	10	98	174	277
Total	49	210	418	677

The fish production statistics from inshore fishing in the Great Accra region comes from Tema harbour, the subject of this project, and represents 43 % (1987) or 66 % (1986) of the total fish landing or 70 % of the domestic fish sales. 62 % of the inshore fishing vessels are registered in the Great Accra region where the Tema Fishing Harbour is located.

3) Deep sea fishing

Trawler type fishing is operated in Ghana and is based exclusively in Tema harbour (See 2.3.3.(3)).

4) Skipjack and tuna fishing

Skipjack and tuna fishing is the most important foreign currency earner. It is conducted only from Tema harbour (See 2.3.3.(4)).

5) Inland fishing

Inland fishing is carried out at the Volta and fish ponds area. The fish landing of this fishery is about 43,000 tons in 1983 according to FAO's data.

(3) Fish Landing

The production of fish by each fishing mode is shown in Table 2.3.3. The total fish landing for domestic consumption is observed to be increasing. The annual fish consumption per capita was 18 kg in 1986 for a population of 13 million. Ghana annual fish consumption will be about 22 kg per capita if fresh water fish consumption is added. This consumption volume can be compared similarly to other West African countries. (Gambia = 23 kg Senegal = 24 kg from FAO data).

Table 2.3.3 Fish Landing Volume by Each Fishing Mode

Unit: Ton

	Canoe Fishing	Inshore Fishing	Deep Sea Fishing	* Skipjack and Tuna Fishing	Total Volume	Domestic Fish Consumption
1983	137,028	19,686	16,812	31,657	205,683	185,000
1984	171,234	14,704	16,429	29,144	231,511	206,000
1985	159,899	17,979	21,933	34,407	234,218	209,000
1986	190,197	21,894	22,344	34,702	269,155	233,000

* The total fish landing includes the exported skipjack and tuna by national registered vessels, except foreign flag fishing vessels.

2.3.2 Fisheries Development Plan

The Government of Ghana established a fisheries development plan for the entire fishing industry with the assistance of the World Bank. The ultimate goal of any program for the development of the fishing industry must be to provide the nation with necessary protein in as fresh a condition as possible.

In this development plan, rehabilitation of the Tema fishing harbour, development of Elmina fishing harbour and installation of ice storage and net repairing yard at Takoradi harbour are recommended to be implemented as soon as possible for improvement of the essential fishing activities in Ghana.

2.3.3 Fisheries based in the Tema Fishing Harbour

The Tema fishing harbour is the only Ghanaian harbour handling fishing vessels exceeding 10 m in length and is the base of canoe, inshore, deep sea and skipjack and tuna fishing. The fluctuation in the catch for each fishing mode are shown in Table 2.3.4. The total fish landed in Tema fishing harbour is 17-25 % of the total amount in Ghana.

Table 2.3.4 Fish Landing by Each Fishing Mode in the Tema Fishing Harbour for the Period 1981-1986 (Fishery Department Data)

Unit : Ton

	Canoe Fishing	Inshore Fishing	Deep sea Fishing	Domestic Skipjack and Tuna Fishing	Total
1981	3,023(8)	9,346(25)	15,381(42)	9,012(25)	36,762(100)
1982	2,843(8)	10,073(28)	12,986(36)	10,500(29)	36,402(100)
1983	2,765(7)	10,003(27)	16,812(45)	7,431(20)	37,011(100)
1984	3,455(10)	8,901(26)	16,429(47)	5,815(17)	34,600(100)
1985	9,004(17)	11,947(23)	21,933(41)	10,700(19)	52,954(100)
1986	7,301(14)	10,568(21)	22,344(44)	10,151(20)	50,364(100)

( ) is the percentage of the fish landing for each fishing mode against the total landing in Tema Fishing harbour.

(1) Canoe Fishing

The 1986 Fishing Department data for canoe fishing shows a total number of canoe fishing vessels of 414 (motorized vessels 245). 4,623 persons are employed in the canoe

fishing based in coastal areas called canoe basins situated north of the Inner Fishing Harbour. Fishing is done by beach seine, ring net, set net and drift gill net. The main fish catch of this fishing method are sardines, grunt, sea bream, and skipjack.

Due to the ubiquitous canoe basins in Ghana (estimated at 200 locations), over 70 % of the annual fish consumption is the result of canoe fishing. Even in the Tema fishing harbour, the principal home for the larger vessels, most fisherman work out of canoes, making canoe fishing one of the most important subjects considered in this rehabilitation project.

(2) Inshore Fishing

The number of vessels used for the inshore fishing and registered in the Tema Fishing harbour is shown in Table 2.3.5.

Table 2.3.5 Number of Inshore Fishing Vessels in Tema (1988)

	Operating vessels			Idle vessels			
	Wooden	Steel	Sub-total	Wooden	Steel	Sub-total	Total
Jan.	79	5	84	48	18	66	150
Feb.	65	6	71	51	19	70	141
Mar.	80	5	85	49	16	65	150
Apr.	70	6	76	63	18	81	157
Average	73	6	79	53	18	71	150

(from Fishing Department Data)

The vessels whose length is less than 9 m (i.e. 50 % of the fishing fleet) and do not have winches, are capable of only manual purse seine operations. The vessels longer than 9 m with winches are used in both purse seine and trawling operations. There are about 3,000 inshore

fishermen in the area, and their main catch is sardines, trigger fish and burrito.

(3) Deep Sea Fishing

Deep sea fishing in Ghana is a trawler type fishing except for skipjack and tuna fishing which is based in Tema harbour only. The total deep sea fleet is 13 operations and 15 idle vessels in 1987. There are about 1,000 fishermen in this field and the main catch is sea bream, herring and squid. These fish represent 40 % of the total landing at the Tema fishing harbour. All of the deep sea fish are frozen on board to preserve freshness for the market.

(4) Skipjack and Tuna Fishing

This type of fishing produces Ghana's most important export, foreign currency earner. It is based only in Tema harbour and is conducted offshore. There are 27 pole and line type fishing vessels and 9 purse seiner vessels bringing the total number to 36. Although there have been several joint ventures between Ghana and Japan involved in this type of fishing, there is now only one Ghanaian/ Japanese joint venture using a fleet of 5 vessels while the remaining operators are mainly Korean. There are about 900 fishermen devoted exclusively to skipjack and tuna fishing. The exportable catch is unloaded in Abidjan in the Ivory Coast while the catch for domestic consumption is unloaded in Tema.

Water, fuel, and provisions are onboaded at the Tema inner harbour.

As indicated above, the various fishing modes which are based in the Tema fishing harbour are leading to increased congestion of the harbour facilities and overflowing over the commercial port.

2.4 Existing Site Condition and Problems

2.4.1 Outline of the Facilities

The outline of the main facilities of the Tema inner fishing harbour is shown below (See Fig. 2.4.1 for the existing facilities at the Tema inner fishing harbour).

(1) Breakwater

There are 2 breakwaters, east and west in the Tema inner fishing harbour. The breakwaters are of stone masonry type and are not damaged, and can be used in their present condition. The top of the east breakwater paved with asphalt 1.0 m wide is used as a net drying and repairing yard.

1) East Breakwater : Length 500 m,
Top Elevation = +4.0 m. Stone piling
2) South Breakwater: Length 300 m
Top Elevation = +6.15 m. Stone piling

(2) Mooring Wharf

There is a south-north wharf, an east-west wharf and a finger jetty in the inner fishing harbour. The structure of these wharves is made up of gravity type concrete blocks; 2 bollards of 10-15 tons made of cast iron are used. The fender is damaged and does not fulfill the present requirements. Consequently, old tyres are used in berthing.

1) South-North Wharf

Length = 327 m
Water depth = -3.5 to -4.5 m
Top elevation = +3.05 m
Apron width = 10 m
Concrete block wharf

2) East-West Wharf

Length = 220 m
Water depth = -2.2 to -4.1 m
Top elevation = +3.05 m
Apron width = 25 m
Concrete block wharf

3) Finger Jetty

Length = 60 m Width = 21 m
Water depth = -4.0 to -5.0 m
Top elevation = +3.05 m
Concrete block jetty

4) Motor Boat Jetty

Length = 122 m Width = 9.75 m
Water depth = -0.2 to -2.2 m
Top elevation = +2.4 m
Wooden jetty

5) Canoe Basin

Water area = 5 ha

(3) Land Facilities

The following land facilities in the fishing harbour were built around 1967 and are more than 20 years old. They are obsolete and the lighting facilities are out of order.

1) Fish maket : Area = 64 x 36 m,
   1-storied structure
2) GIHOC shipyard : 35 to 70 feet long ship building
3) Cold storage and ice making factory
4) Boat owner office: About 210 big and small reliable source owners based in Tema
5) GPHA fish harbour management office
   For the management of the Tema fishing harbour
6) Management office of the Fishing Department
   Ship repair, registration, fish catch estimation, etc.
7) Private workshop
   They are located around the south-north wharf apron.
8) Water and fuel supply facilities
   Water is supplied by Tema City and fuel from GBS.
9) Lighting facilities: 4 locations for the road and facilities lighting

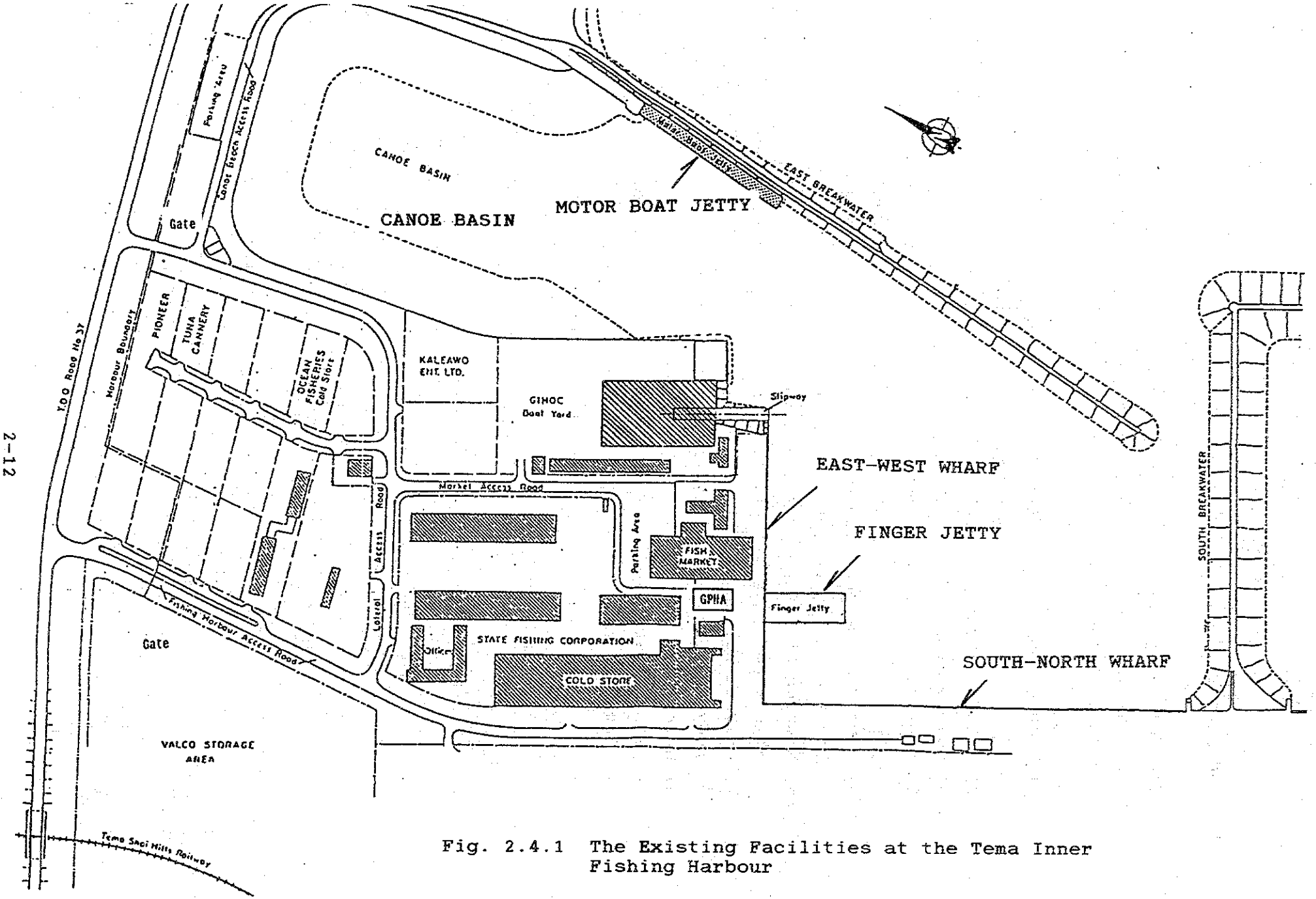


Fig. 2.4.1 The Existing Facilities at the Tema Inner Fishing Harbour

2.4.2 Present Utilization of Wharf

(1) The wharf has no pre-determined use. Large and small, wooden and steel, operating and idle ships are anchored indiscriminately except the tuna fishing vessels which are housed in the center part of the south-north wharf.

(2) The nets are stored on the central part of the wharf apron and finger jetty which are supposed as a net repairing yard. The fish landing location is not clearly defined except where the nets are stored. This is surrounded by a portable fence to prevent intrusion of unrelated people and the area is used for sorting and packing of fish products prior to marketing.

(3) There is no proper wharf for fish unloading and vessel preparation on the wharf.

During the investigation period, the wharf was very congested, causing fish unloading to be a very time consuming operation, with no clear functional definition of wharf areas.

In the present condition, it may be used as a fishing harbour, however, during the fishing season delays of up to 24 hours can be expected for the unloading.

This leads to a quality deterioration of the unloaded fish and a decrease in the intensity of fishing operations due to the limited fishing time.

2.4.3 Existing Condition of the Canoe Basin

(1) The canoe basin extends over 5 ha and is used as a lay-by and canoe salvage area on its east, west and north sides. There is a paved apron of 12 m width and a 6 m wide road surrounding this basin. The south end of the east side road leads to the motor boat jetty. Fish landing can be carried out over the entire periphery.

(2) The motor boat jetty which is damaged in places is used as a net repairing yard. The breakwater is located along the motor boat jetty which is also used as a net reparing yard.

(3) During the investigation, 100 m of the east side apron extention is used for fish landing and marketing. The north side of the apron is used for net repairs and small fish drying. However, since the whole apron is used for fish landing during the fishing season, fish drying cannot be carried out there.

(4) There are fuel supply facilities east of the canoe basin and mobile fuel supply equipment on the motor boat jetty.

(5) Fish buying is carried out by women called "mammie". Fish is unloaded from canoes on to the exposed pavement on the apron.

This fish landing and marketing in the open, leading to quick deterioration of the fish quality is a serious problem, both in economic and health terms.

2.4.4 Existing Condition of Fish Market Hall

The present fish market hall is used as a net storage yard, a relaxation place and a fishing gear store. There are no lighting facilities in the fish market hall and although it is equipped with water taps, the water supply is not adequate. With its has board walls, narrow entrance, and aluminium roof, part of it being open, the fish market hall is dark even in daytime.

There are no available facilities in the fish market hall for fish trading, causing all fish marketing to be carried out in the parking area or outside shops in the open on the wharf congested by the fishmongers and mammie saleswomen.

2.4.5 GIHOC Boatyard

(1) Ghana Industrial Holding Corporation (GIHOC) is a national company consisting of 24 departments, and was established for the purpose of the industrialization of Ghana. The GIHOC boatyard is one of the departments of this corporation and was established in 1952.

(2) GIHOC owns boatyards in Tema, Mumford and Sekondi. Tema's boatyard is the biggest one of the three.

(3) The GIHOC boatyard in Tema handling vessels between 35 and 70 feet can accommodate the construction of up to 12 vessels per year. Now, it builds an average of 6 vessels per year, and recently started exporting wooden shells to Canada.

The following facilities may be found in this boatyard Workshop of iron pillar construction (about 50 x 80 m), slip way, office (2 floor constrution) and stores. There is no fitting-out quay. The fitting-out is carried out in the fishing harbour wharf. This increases congestion of

the harbour.

2.4.6 Fuel and Water Supply Facilities

a. Fuel supply facilities

(1) Ghana Bunkering Service Ltd. (GBS) supplies fuel to the ships, except gasoline for motorized canoes.

(2) GBS has a management office and three tanks of 800 ton capacity in the outer fishing harbour. It supplies fuel to vessels through 11 diesel supply pits situated along the wharf in the outer and inner harbours.

(3) The canoes equipped with outboard engines use gasoline supplied by Tema marinex situated in the canoe basin.

b. Water supply facilities

(1) Water supply pits are installed at 10 places along the wharf in the same manner as fuel supply facilities both managed by GPHA. The water supply for the vessels is charged at a rate of 400 cedis per ton.

(2) The water supply system has minor leakage but is usable in its present condition.

2.4.7 Lighting Facilities

(1) The lights in the fishing harbour found on the street behind the apron are used for lighting roads and harbour sections and installed on steel towers and pillars. Many of road light towers and pillars are damaged. The steel towers are 24 m high, 3 of them are installed along the street on the south-north wharf and the steel pillars of 12 m height are found on the finger jetty. Those flood lights consist of 4 lights of 1 kW each.

(2) The electrical power is supplied by ECG through the sub-stations Nos. 10, 11 and 12 situated at the inner fishing harbour.

(3) Two 500 kVA transformers are installed in the sub-stations 11 and 12 while one 500 kVA and two 1000 kVA transformers are installed in sub-station 10.

Primary side	:	11,000V, 3 phase, 50 cycles
Secondary side:		415V, 3 phase, 50 cycles
		240V, single phase, 50 cycles.

Some of the facilities (such as the ice making factory) are supplied with the high tension power.

2.4.8 Maintenance and Management Systems

GPHA handles the maintenance and management works of the Tema fishing harbour and the Tema commercial harbour. The Tema branch office of GPHA is located in the commercial harbour.

The GPHA fishing harbour management office is an extension of the GPHA dealing with the management and a branch office of the Fishing Department are situated in the fishing harbour.

(1) GPHA Fishing Harbour Management Office

This office manages the fishing harbour with its 76 employees.
The average daily income earned from the utilization tariffs is about 2 million cedis. The national bank handles the income while the management is carried out by the central GPHA. The financial balance of GPHA is in good condition since revenue exceeds expenditure.

(2) Fishery Department Regional Office

This office deals with the registration of fishing vessels, the repair of vessels and fishing gear, fish statistics and promotion of the fishery. It is staffed by 79 employees.
The income of this office comes from the repair and vessel registration as well as tolls levied at a rate of 5 cedis per fish crate (size 45 x 65 x 18 cm).

The fishing activities based in the canoe basin are traditional fishing modes and do not come under the management of the offices indicated above.

2.5 Request of the Government of Ghana

The Ghanaian government undertook the developmental investigation of the Ghanaian fisheries (1984-87) including the congested Tema fishing harbour with Word Bank assistance. Based on the investigation results, Ghana will undertake the rehabilitation works for the Tema inner fishing harbour upon request for a grant aid from Japan.

The details of rehabilitation works requested by the Government of Ghana for Japan Grant Aid Assistance for the implementation of this project are shown below:

(1) Construction of 2 lay-by jetties 200 and 170 m long
(2) Construction of a lay-by mooring for 20 vessels
(3) Repair of a motor boat jetty
(4) Construction of a fitting-out quay (30 m long)
(5) Construction of a net repairing yard
(6) Repair of the fish market hall
(7) Renovation of the boat owners office
(8) Renovation of the security fence
(9) Repair of the service facilities

The plan of the required facilities is shown in Fig. 2.5.1.

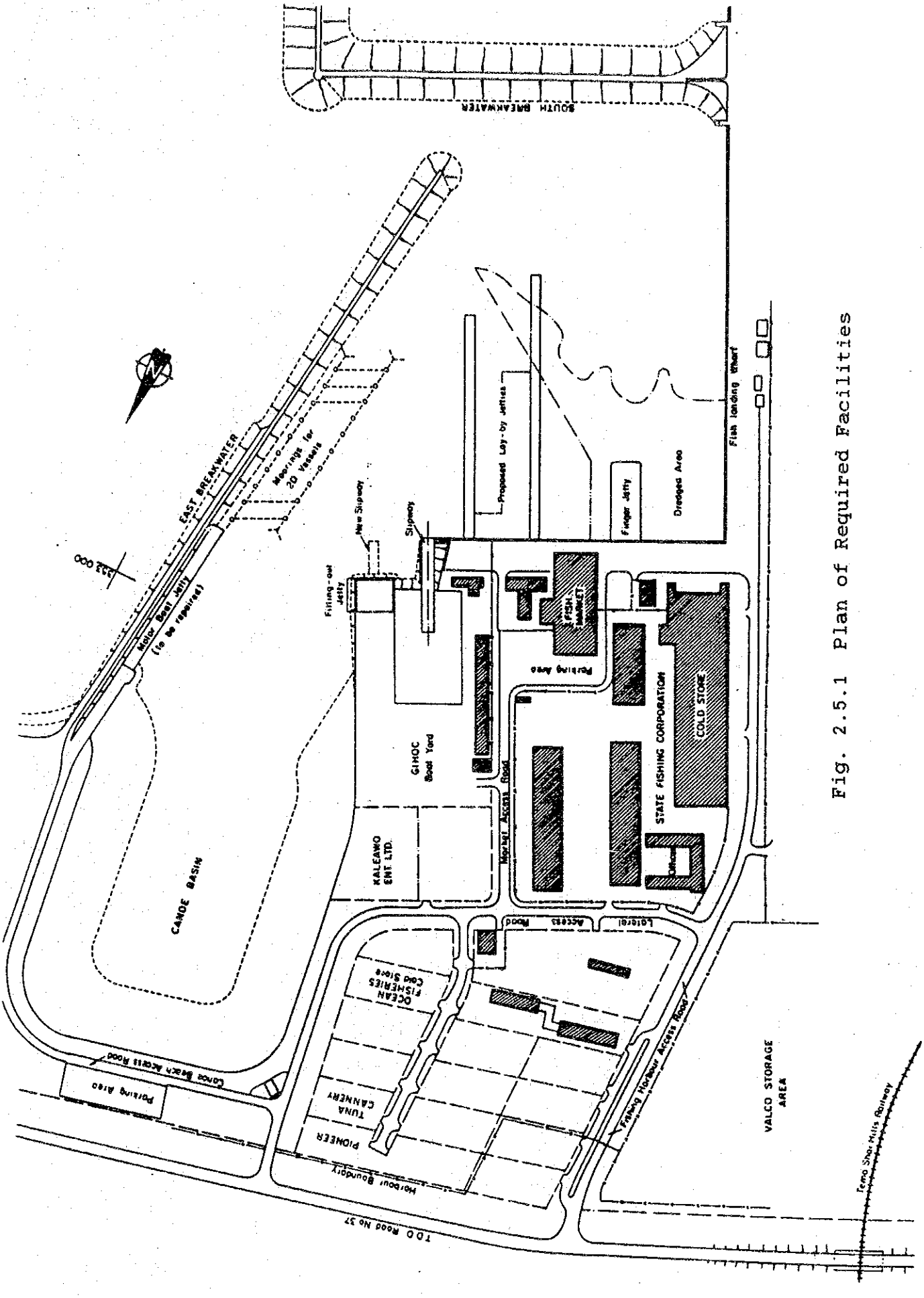


Fig. 2.5.1 Plan of Required Facilities

CHAPTER 3 OUTLINE OF THE PROJECT

CHAPTER 3 OUTLINE OF THE PROJECT

3.1 Purpose of the Project

The purpose of the project is to solve the congestion problems in the Tema fishing harbour and develop the fishing related industries in Ghana.

The problems in the Tema fishing harbour are as follows.

(1) Congestion by fishing vessels in the fish unloading wharf (occupancy of wharf by non-operational fishing vessels).

(2) Congestion of the anchorage area and wharf due to insufficient lay-by wharf.

(3) Congestion of the wharf apron due to insufficient net repairing yard.

(4) Long occupancy of the unloading wharf during fish transactions.

(5) Deterioration of the fish due to open air marketing in the canoe basin.

(6) Long-term berthing of idle vessels due to shortage of spare parts.

(7) Insufficient maintenance and management of the fishing vessels due to shortage of materials.

3.2 Study of the Required Facilities for Rehabilitation

The details requested at the start of the rehabilitation project are shown in 2.5 (Request of the Government of Ghana).

From the site investigation results and a series of discussions with GPHA officials, renovation of the boat owners office and the security fence were excluded from the Grant Aid Program and agreed by both parties. This exclusion is due to the fact that the boat owner's office is privately owned, and therefore the effect of security fence repair is not considered.

Consequently, the following items were required for the project for rehabilitation of the Tema fishing harbour.

1. Construction of a lay-by wharf or jetties
2. Construction of a lay-by mooring for idle vessels
3. Repair of the motor boat jetty
4. Construction of a fitting-out quay 30 m in length
5. Construction of a net repairing yard behind the newly built wharf
6. Repair of fish market hall
   (1) Rehabilitation of the stall facilities
   (2) Roof repair
   (3) Installation of water supply facilities
   (4) Installation of lighting facilities
   (5) Wall repair
   (6) Installation of the ice storage
7. Repair of the service facilities
   (1) Repair of the switchgear in sub-station Nos. 10, 11 and 12
   (2) Installation of lighting tower
   (3) Installation of a fish handling shed

Since no sufficient space is available in the inner fishing harbour for the proposed lay-by mooring for idel vessels, both parties have agreed to build it in the outer fishing harbour. The removal of the existing wooden louvered walls at the fish market hall was deleted by the request of GPHA.

3.3 Outline of the Project

(1) Implementation Office

The organization responsible for this rehabilitation project is GPHA which is a government organization under the Ministry of Transport and Communication (MTC). The organization of MTC, GPHA, and the Fisheries Department is shown in Fig. 3.3.1.

GPGH will carry out the present rehabilitation project of the Tema commercial harbour with the assistance of World Bank and OECF. The Tema fishing harbour rehabilitation project is part of the whole Tema harbour rehabilitation project which includes the inner fishing harbour as Phase-1 of the project.

(2) Basic Plan

Basic plan of this project is as follows:

1) Functional segregation of the wharf for an effective use of the space available.

2) Preparation and lay-by of the vessels should not be carried out at the unloading wharf which should be always clean to maintain efficient operation.

3) Construction of enough lay-by wharf and jetty for the inshore fishing vessels and construction of lay-by mooring for steel vessels in the outer fishing harbour to avoid congestion. New lay-by wharf and jetty will be built so as not to obstruct the passageway of the vessels.

4) In order to reduce the transaction between boat owners and mammie on the wharf apron and to keep the fish fresh, the existing fish market hall must be rehabilitated. A fish handling shed will be installed along the fish unloading wharf in order to retard fish deterioration and provide a better fish handling place.

5) In order to alleviate the congestion of the wharf apron, a new net storage and repairing yard should be set behind the lay-by wharf. And the motor boat jetty should also be repaired for both motor boat and net repairing yards.

6) Construction of a fitting-out quay in GIHOC boatyard to clear the wharf for ship repair.

7) Repair of the sub-station in the fishing harbour for the stable electrical power supply and installation of lighting behind the lay-by jetty for a better management of the harbour.

Fig. 3.3.2 shows a relation between the above basic plan and problems of this project.

(3) Outline of the Facilities

The outline of the facilities required from Ghana are shown below in a priority order.

1) Construction of lay-by jetty

2) Construction of a wharf with enough space for a net repairing yard.

3) Repairing of fish market hall:
   - Installation of a stall spaces
   - Roof repair (Sky-light type)
   - Installation of water supply facilities
   - Installation of lighting facilities
   - Wall repair (front entrance and rear exit)
   - Installation of ice storage facilities

4) Renovation of the fishing harbour service facilities:
   - Repair of the switchgear in sub-station Nos. 10, 11 and 12
   - Installation of lighting tower
   - Construction of a fish handling shed

5) Construction of a 30 m long fitting-out quay

6) Repair of the 25 m long motor boat jetty

7) Installation of lay-by mooring (for 20 vessels)

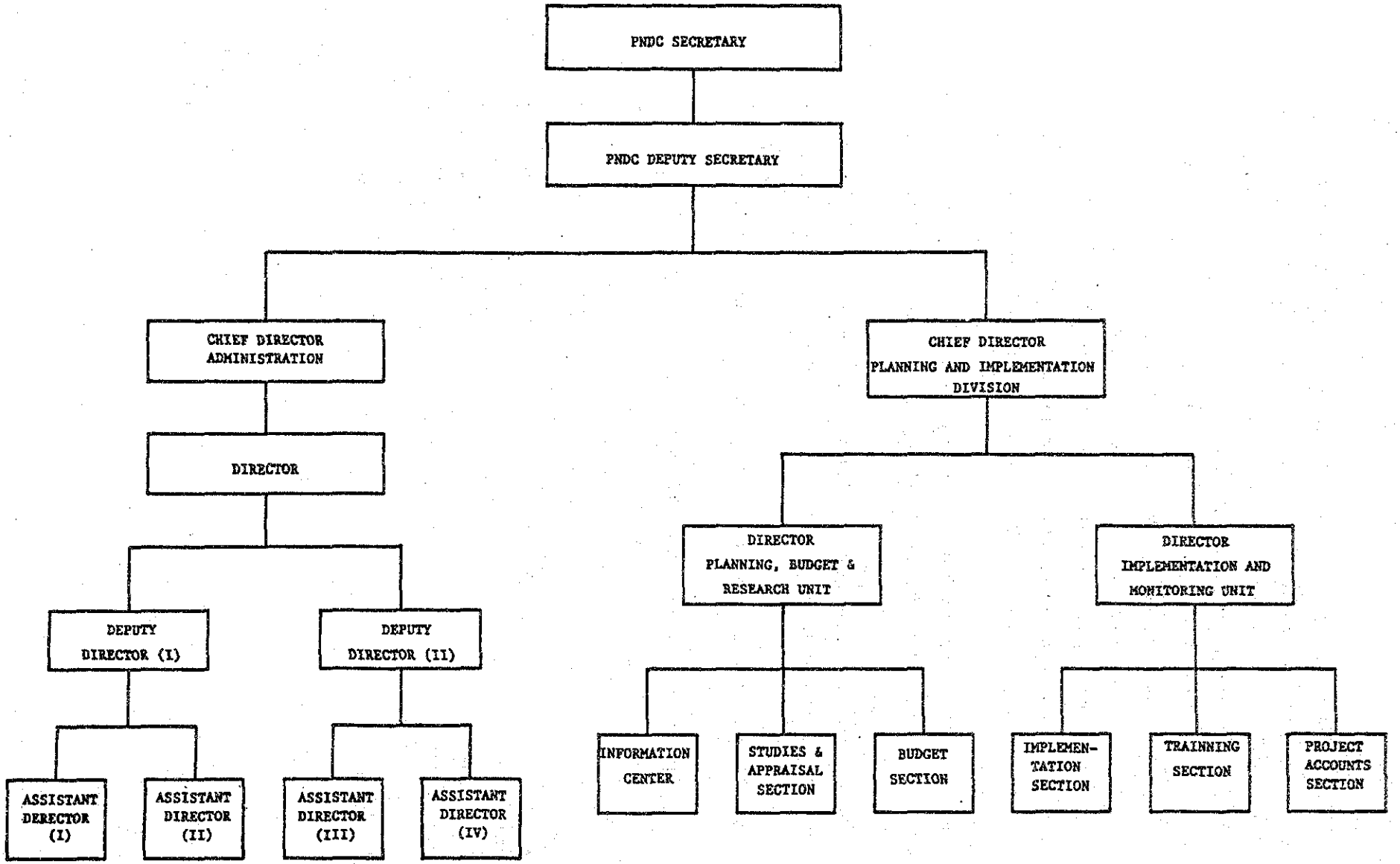


Fig. 3.3.1(1) Organization Structure of the Ministry of Transport and Communications

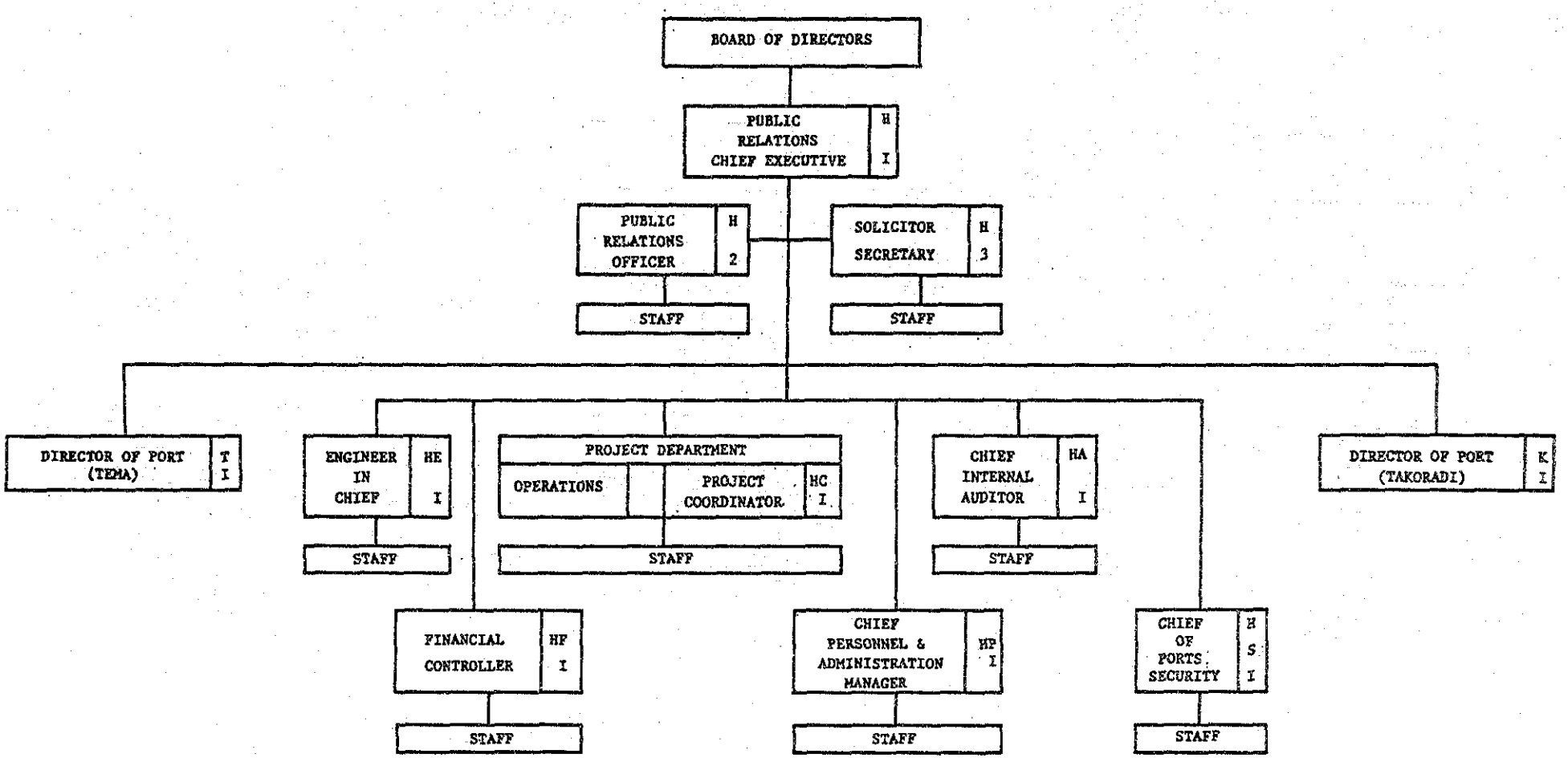


Fig. 3.3.1(2) Organization Chart of Ghana Port & Harbour Authority

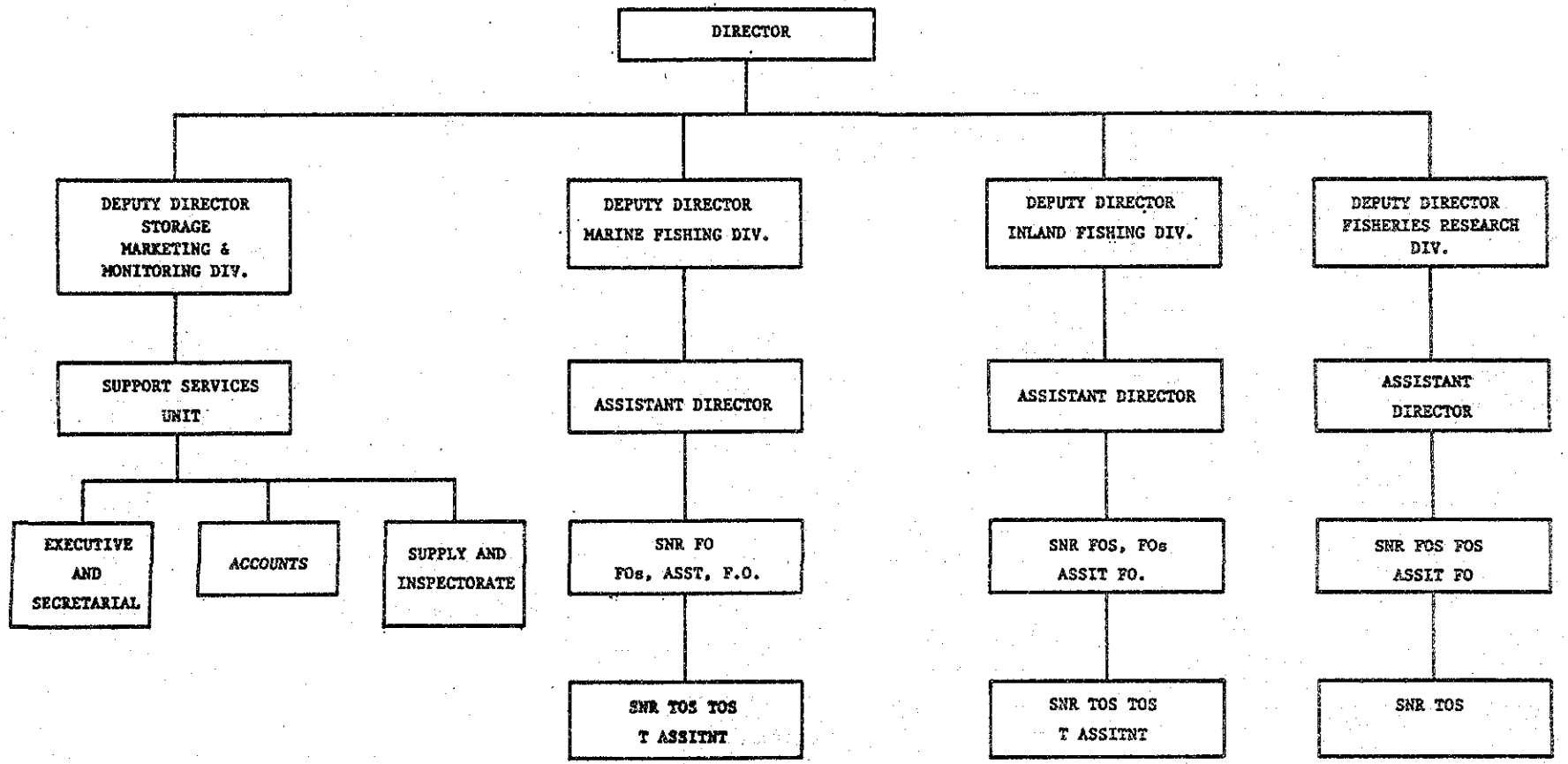


Fig. 3.3.1(3) Organization Chart of Fisheries Department

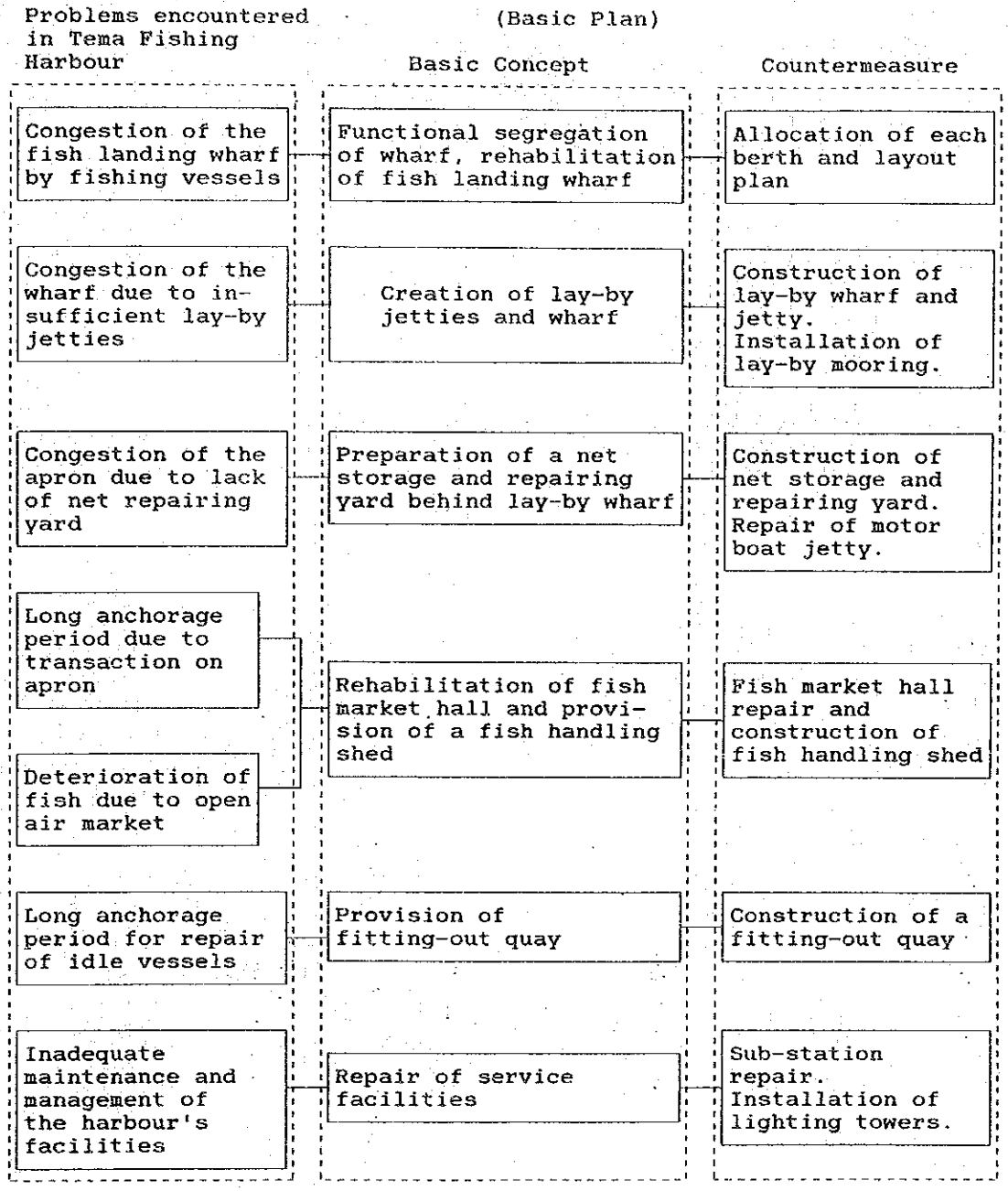


Fig. 3.3.2 Problems and the Basic Plan for the Tema Fishing Harbour

CHAPTER 4 BASIC DESIGN

CHAPTER 4 BASIC DESIGN

4.1 Design Concept

To carry out the project for rehabilitation of the Tema fishing harbour, Chapter 2: Project Background and Chapter 3: Outline of the Project will be taken into account for the basic design shown below.

(1) An adequate scale of the project facilities will be established.

(2) The natural conditions at the project site will be considered.

(3) Proper materials will be chosen along with an adequate construction method.

(4) For the normal working conditions at the harbour, a proper design and proper scheduling of the construction will be taken into consideration.

The details of the above design concept are indicated below:

(1) An adequate scale of the Project Facilities

1) To assist the overall operations of inshore fishing, the scale of the fish unloading and preparation wharf shall be properly chosen.

2) Appropriate scale of lay-by wharf and jetty shall be properly planned as well as the effective usage of the present lay-by wharf and jetty.

3) The required facilities are within the available Japanese Grant Aid Program and within the Ghanaian project framework.

4) The scope of the work carried out with the Japanese financial assistance will be defined by the guideline of the Japanese Government.

5) The details and scale of the planned facilities shall correspond to the requirements of the fish production and marketing structure in Ghana and to minimize operational and management costs.

(2) The Natural Conditions at the Construction Site

The existing condition of the site, tide, current and ground conditions shall be reflected in the basic design.

(3) Adequate Materials and Construction Method

1) The structure is simple for easy maintenance and management in Ghana.

2) The materials and construction methods available in Ghana are given priority for this project.

(4) Consideration for Fishing Vessels and Activities

1) Avoid construction work during the fishing season as far as possible.

2) The reduction of offshore construction method and design shall be applied not to affect fishing vessels and activities.

4.2 Study of the Natural Conditions

4.2.1 Meteorological and Oceanic Conditions

(1) Weather Conditions

a. Precipitation

The weather data for the capital city Accra situated 25 km west of Tema are shown in Table 4.2.1. According to these data, the average annual precipitation for the last 35 years was 851 mm with more than 100 mm falling between April and June, less than 100 m between July and March. From the 1987 data, there was record precipitation of 276 mm in September. The least precipitation in Ghana is found in Accra area.

b. Temperature

Temperature varies between 24^{o}C and 29^{o}C throughout the year. It is a very humid country with an average relative humidity of 95 %.

c. Wind

It is affected mainly by a south-east wind throughout the year. The average wind speed is between 10 and 14 knots. The strongest winds are observed in May while according to the GPHA data it was recorded at a maximum of 50 knots.

(2) Wave Conditions

According to the data from the U.S. Navy Marine Climatic Atlas of the World in 1981, the wave heights were recorded as indicated below for the Tema fishing harbour offshore area. The wave height averages 1.4 m when deviation is taken into account (See Table 4.2.2).

Table 4.2.1 Weather Condition (Accra)

	Rainfall (mm)			Temperature (°C)			Humidity (%)	
							H	H
Month	35Y	1986	1987	35Y	1986	1987	0.600	15.00
1	13.50	-	3.80	27.3	27.2	23.5	94	63
2	25.20	63.70	3.30	27.9	28.3	28.8	95	85
3	62.70	69.50	21.70	27.8	28.1	29.0	94	66
4	101.10	19.80	24.60	27.8	29.0	29.0	94	66
5	104.40	144.10	62.20	27.8	28.0	28.6	94	71
6	254.80	60.70	16.70	25.8	29.5	27.6	96	77
7	53.0	33.10	18.70	24.8	25.3	27.1	96	76
8	26.50	0.80	79.30	24.5	25.2	26.4	95	74
9	57.90	29.90	275.8	25.3	26.1	26.3	95	73
10	75.30	83.10	23.20	26.30	26.5	27.2	96	72
11	29.0	38.50	9.1	27.2	27.3	23.4	95	69
12	16.40	5.50	-	27.3	27.7	-	95	65
Total	851.80	845.20	593.40	-	-	-	-	-

Table 4.2.2 Offshore Wave Height

	1	2	3	4	5	6	7	8	9	10	11	12	Throughout the year
Average (m)	0.5	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.88±0.5m
Deviation (m)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	-
Calculated waveheight (H1/3)													1.4m

4.2.2 Soil Investigation

To determine the site soil condition, jet boring was done for the location of the proposed wharf and jetty as well as a review of the previous data collection.

(1) Previous Boring Data

Judging from the existing port facilities (see Appendix 2.5.1) and previous boring data (See Appendix 4.2.1), the soil structure of the Tema fishing harbour is sandy stratum including mud of 2 to 3 m depth. A stronger conglomerate soil is found below this stratum.

(2) Jet Boring

Purpose : To examine the thickness of the sand stratum and the depth of the conglomerate.

Term : June 6th and 7th, 1988

Method : Using an engine pump with a 13 mm nozzle and a 4 kg/cm^2 pressure.

No. of jet borings : 15 points in site (Refer to Appendix 4.2.2)

Result : After the jet boring, the depth of the conglomerate and the supporting strata was observed as follows :

No.	Position	Depth of the supporting strata
1-5	Corner of south breakwater	-6.5 m
6-8	Side of east breakwater	-4.5 m
9 & 10	Side of GIHOC boatyard	-1.9 m
11-14	Front of fish market hall	-5.1 m
15	Lay-by area in outer fishing harbour5	-6.0 m

Note: Details can be found in Appendix 4.2.3.

(3) Type of Foundation

Based on the above jet boring results, a gravity type of foundation is recommended for the wharf and jetty construction, because of the hard stratum existing in the shallow part of the harbour.

4.2.3 Tide Observation

(1) Observation Period and Location

The tide observation was made for a period of 17 days from May 27th to June 13th for the assessment of the tide at Tema harbour. The float style tide level measurement equipment (Type FL-460) was installed in the tide observation hut at Tema commercial harbour.

The tide height measurement was adjusted by using a BM SGPD, 8/5 (H = 3.416 m) near the tide observation hut. In order to adjust the observed tide height, visual tide observation was made twice a day, morning and evening by using measuring pole.

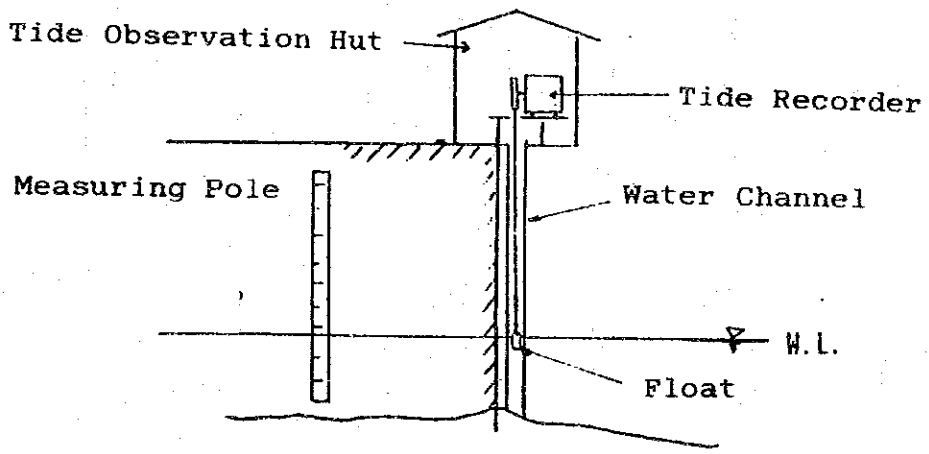


Fig. 4.2.1 Installation of the Tide Measuring Device

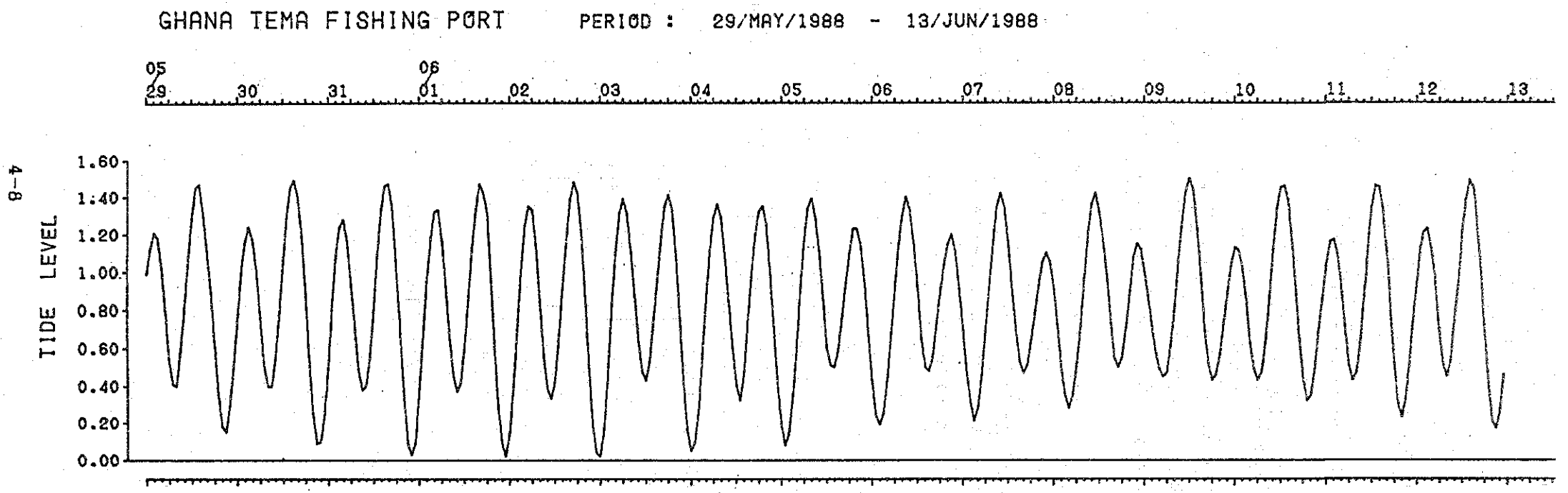


Fig. 4.2.2 Tide Observation Result

(2) Observation Results

The results of the observations are computed from the tide datum line of B.M = 0 as the lowest water level. The observed tide is semidiurnal tide (2 low and 2 high tides per day). The difference in height is small for high tide stages.

According to the tide table in Ghana, difference of tide time and height between Tema and Takoradi ports is zero and +0.10 m respectively. The following are the results of tide observation about tide time difference and tide height difference between Tema and Takoradi.

	Tide Table	Observed Tide
Time difference of tide :	0	0
Height difference of tide:	+0.10 m	−0.05 to −0.10 m

Comparison of the predicted values against the values of the present observation is shown below:

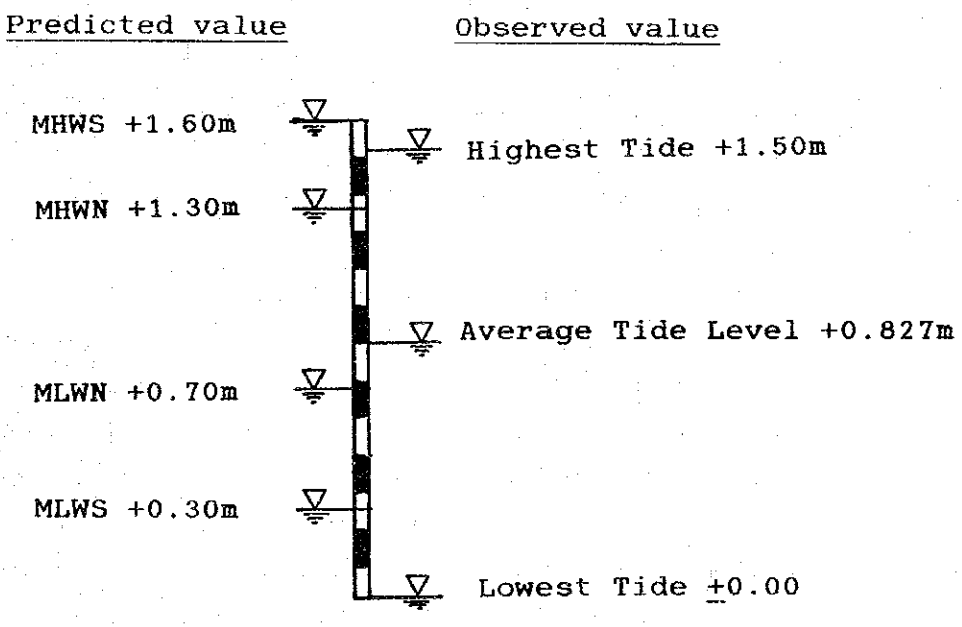


Fig. 4.2.3 Comparison beteween the Predicted Value and the Observed Value

(3) Tidal Harmonic Analysis

The tidal harmonic analysis was carried out for a period of 15 days from May 29th at 0.00h to June 12th at 23:00h in order to determine the 4 major tidal components (M_2, S_2, O_1 and K_1)

From the result of the analysis, the 4 major tidal components were derived as shown below. The resulting amplitude of the 4 major tidal components was 0.809 m which is similar to average tide level at 0.85 m.

M_2 = 0.505 m (Principal lunar semidirunal component)
S_2 = 0.106 m (Principal solar semidiurnal component)
O_1 = 0.021 m (Principal lunar diurnal component)
K_1 = 0.177 m (Luni-solar diurnal component)

(4) Establishment of the Design Tide Level

For the average water level in Ghana, the main lower LW spring tide is applied based at Takoradi harbour situated about 300 km west of Tema harbour.

The average tide level at Tema harbour (Zo = +0.85 m) is similar to the value measured during the investigation +0.827 m. This value is considered as a standard measurement.

According to the quay cross sectional view of the existing wharf (refer to Appendix 2.5.1), the MHWL was +3.0 feet (+0.9149). The average tide level, however, is not well defined. If the average water level shown in the tide table is assumed as +0.85 m, the MHWL at the time of previous construction can be +1.80 m and which coincides with the height of existing wharf elevation +3.05 m confirmed by the topographic survey.

Since the tide does not change with the seasons, the design tide level will be taken as that shown below.

HWL = +1.80 m
MWL = +0.85 m
LWL = ±0.00 m. (DL)

4.2.4 Sounding Survey

(1) Observation Method and Range

The sounding survey was carried out in the basin of the inner fishing harbour as well as at the entrance to the harbour using an echo sounder and sounding lead (See Appendix 4.2.5).

The observation method uses 30 m pitch measuring points on the south breakwater with the observation boat sailing transversally in a straight line and using a sextant (Refer to Fig. 4.2.4).

For the lead observation, the boat position is calculated with the use of a sextant while the boat is setting.

The line intervals of sounding survey are 30 m long pitches while the calibration intervals are usually 20 m and 10 m with a variation position. Tide adjustments were made in order to get the actual depths using tide observation data.

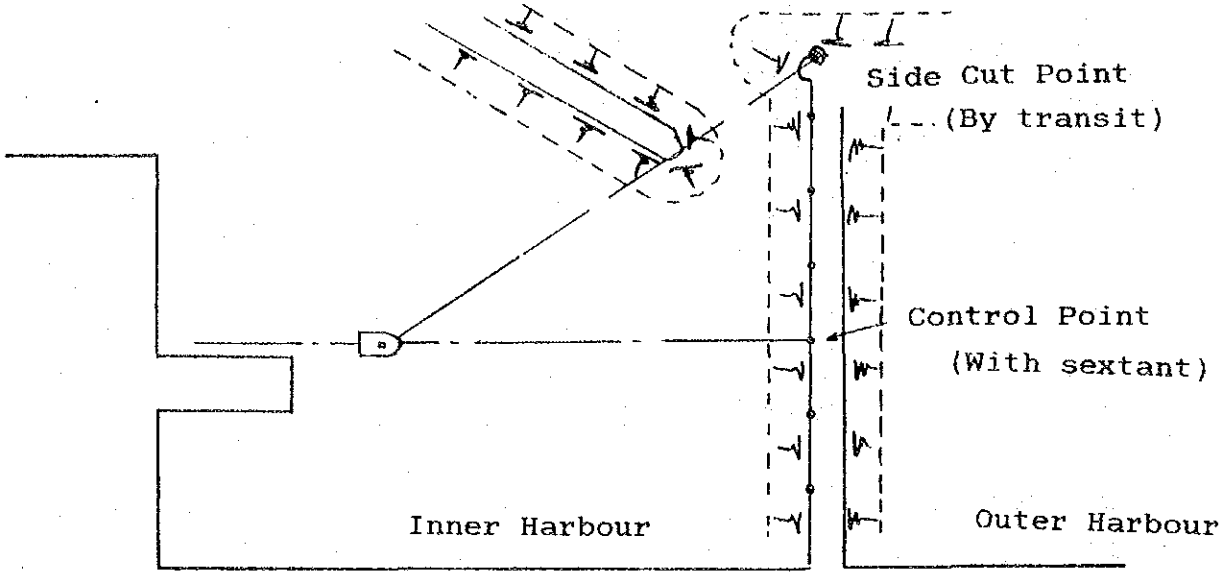


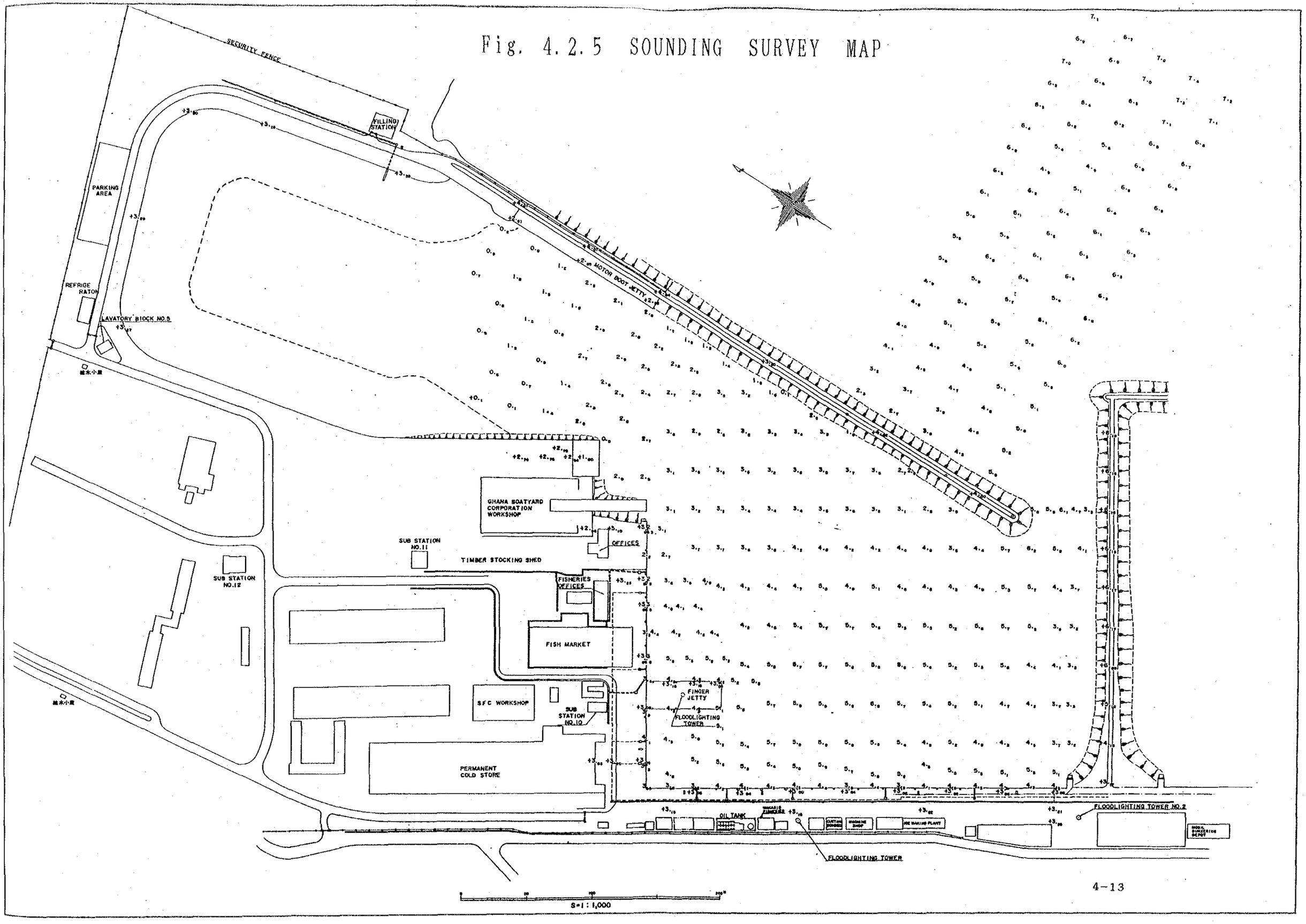
Fig. 4.2.4 Control Method of the Survey Boat

(2) Result of Sounding Survey

The result of the sounding survey is shown in Fig. 4.2.5. Although there are some shallow areas in the inner fishing harbour, the depth of the basin is -4.0 m to -5.5 m. This depth does not affect the maneuvering of the inshore vessels. In general, from the entrance to the harbour inward, the depth decreases especially in front of the motor boat jetty where the depth is less than -2.0 m. At the east-west wharf near the fish market hall the water is shallow and the depth decreases from the fish market hall to the boatyard.

The result of sounding survey were similar to the depth measurements carried out by GPHA in 1986 (See Appendix 4.2.6). Therefore, it is considered that no siltation is expected in the inner fishing harbour.

Fig. 4.2.5 SOUNDING SURVEY MAP

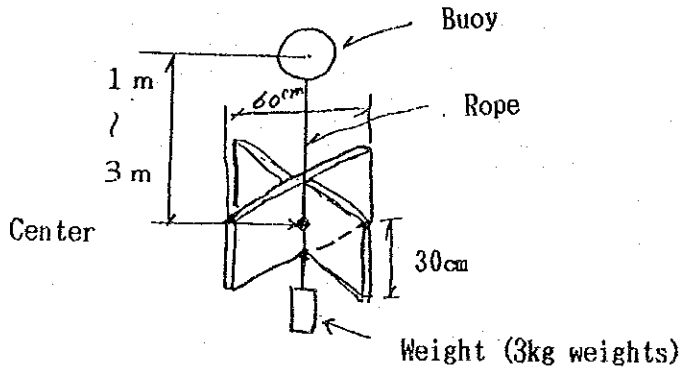


4.2.5 Current Observation

(1) Observation Period and Method

The observation was carried out at the entrance of the inner fishing harbour during ebb tide and flood tide on June 4th when the speed of current are at the highest.

This observation method uses a resistance plate (30 cm depth and 60 cm width) with a float adjusted rope from the center for lengths of 1, 2 and 3 meters from the sea level for measuring currents at 1, 2 and 3 m depths. The float is set from the entrance to the harbour and its position is measured every ten minutes by the sextant.



(2) Observation Results

Current direction and speed of each float at ebb tide and flood tide are as follows:

	Float Position	Current Direction	Current Speed
Ebb tide	1 m deep	158°	0.13 m/s
	2 m deep	163°	0.08 m/s
	3 m deep	191°	0.09 m/s
Flood time	1 m deep	75°	0.04 m/s
	2 m deep	143°	0.01 m/s
	3 m deep	135°	0.02 m/s

From the results, an east current is observed at ebb tide while at flood tide a western associated with a weak eastern current is observed. The float is affected by the west wind during the observation at flood tide (The movement of the float at flood and ebb tides is shown in Appendix 4.2.7).

4.2.6 Topographic Survey

The survey was made to confirm the present site conditions behind the wharf area. Especially important to know is the location of port buildings which were built after the port construction by using the observation points of GPHA HSS-4 and HSS-7. The offset survey was applied.

A topographic survey map was made based on this offset survey results and the previous drawing prepared by GPHA in 1969.

4.2.7 Design Conditions

From the site survey results, the design conditions were determined as follows:

(1) Oceanographic Conditions

1) Tide Level

H.W.L	+1.80 m
M.W.L	+0.85 m
L.W.L	+0.00 m

2) Wave

There is no wave effect due to the existence of the breakwaters.

3) Current

From the site survey result, the current speed is found to be negligible during both ebb and flood tides. Therefore, neglect the current effect.

(2) Weather Conditions

The following weather conditions were determined based on the existing data which were obtained during site investigation.

1) Temperature	: 24°C to 29°C
2) Humidity	: More than 95 %
3) Wind direction and speed	: South-east direction throughout the year Average wind speed=10-14 knots Maximum wind speed=50 knots

4) Design Wind Speed

The design wind speed for the construction work is determined by the Ghanaian building standard calculations:

$$Vs = V \times S_1 \times S_2 \times S_3$$

where

Vs : Design wind speed (m/s)

V : Standard wind speed for each area = 29 m/s

S_1 : This coefficient is determined by the site topography.
In this instance, it is equal to 1.0 due to the sea proximity.

S_2 : This coefficient is determined by the ground condition, building scale and the height of building.

S_3 : This coefficient is determined by life of building, i.e. for 50 years S_3 = 1.0.

Using the above formula, a value of the design wind speed was obtained as shown below.

Fish handling shed

$$Vs = 29 \times 1.0 \times 0.83 \times 1.0 = 25 \text{ m/sec}$$

$$\begin{pmatrix} S_2 = 0.83 \text{ Category 1, Class B} \\ H = 5 \text{ m} \end{pmatrix}$$

Lighting tower

$$Vs = 29 \times 1.0 \times 1.03 \times 1.0 = 30 \text{ m/sec}$$

$$\begin{pmatrix} S_2 = 1.03 \text{ Category 1, Class B} \\ H = 24 \text{ m} \end{pmatrix}$$

(3) Seismic Coefficient

For the seismic coefficient, the Ghanaian building standards were taken into account. For the determination of these seismic coefficient the following formula was used:

$$Kh = A \times S \times K \times I \times F$$

where

Kh : Seismic Coefficient
A : Seismic acceleration value/area (0.04 g)
S : Earthquake response coefficient determined by building size (1.0)
K : Coefficient determined by a type of building structure (2.0)
I : Important factor of a structure (1.0)
F : Foundation factor (1.0)

Using the above formula, seismic coefficient was calculated as shown below.

$$Kh = 0.04 \times 1.0 \times 2.0 \times 1.0 \times 1.0 = 0.08$$
$$\fallingdotseq 0.1$$

Therefore, the design seismic coefficient are determined as shown below:

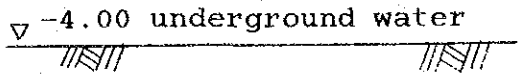
In air	Kh = 0.1
In water	Kh = 0.2

The above indicated coefficient uses the highest value and the design seismic factor is used for all facilities such as wharf, jetty, fish handling shed and lighting tower.

(4) Soil Condition

From the soil investigation results, the soil condition for the lay-by wharf and jetty are determined as follows:

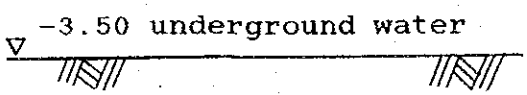
1) Lay-by wharf



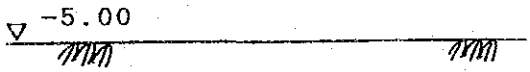
soil of top strata (soft)

gravel or rock strata (hard)

2) Lay-by jetty



soil of top strata (soft)



gravel or rock strata (hard)

(5) Utilization Condition

The design condition of the lay-by wharf and jetty is indicated below:

1) Objective vessel

The dimensions of the objective vessel were determined based on the size of wooden inshore vessels (See Table 4.2.3).

Length of vessels : L = 70 feet
Draft : Df = 6 feet

Table 4.2.3 Dimension of Inshore Fishing Vessels

Total length (m)	9.0	12.0	12.0	14.0	15.0	17.0	17.0	20.0
Maximum width (m)			4.0	4.5	4.6	5.0	5.0	6.0
Maximum draft (m)			1.4	1.4	1.6	2.0	2.0	
Oil tank (m^3)		0.6	0.6	0.6	1.4	1.2	1.2	1.4
Water tank (m^3)			0.3	0.3				1.1
Fish tank (m^3)			13.9	20.6		27.5	41.1	59.5
Fishing mode	S	S/T	S/T	S/T	S/T	S/T	S/T	S/T

* S : Net use, S/T : Net and trawling.

2) Ship berthing speed

V = 0.5 m/sec

3) Mooring force

V = 3.0 t/bit

4) Surcharge

Normal condition : 1.0 t/m^2
Seismic condition : 0.5 t/m^2

(6) Materials

Filling materials : Internal frictional coefficient
$\phi = 30^\circ$
Wall frictional coefficient $\delta = 15^\circ$
Base stone : Internal frictional coefficient
$\phi = 40^\circ$

Unit weight

Reinforced concrete	:	2.45 t/m^3 (In air)
		1.42 t/m^3 (In water)
Plain concrete	:	2.3 t/m^3 (In air)
		1.27 t/m^3 (In water)
Steel	:	7.85 t/m^3 (In air)
Filling Material	:	1.8 t/m^3 (In air)
		1.0 t/m^3 (In water)
Sea water	:	1.03 t/m^3 (In air)

(7) Friction Coefficient

Concrete block against concrete block	:	0.5
Concrete block against stone	:	0.6
Cellular block against stone	:	0.7

(8) Safety Factor

Sliding

1.2 (Normal condition), 1.0 (Seismic condition)

Overturning

1.2 (Normal condition), 1.0 (Seismic condition)

Bearing Capacity

2.5 (normal condition)

(9) Allowable Stress

1) Steel Bar (SD30) $\sigma_{sa} = 1800 \text{ kg/m}^2$

2) Concrete $\sigma_{ck} = 240 \text{ kg/m}^2$

$\sigma_{ca} = 80 \text{ kg/m}^2$

$\tau_a = 9.0 \text{ kg/m}^2$

(10) Reference Standard

1) Fishing harbour design standard (all Japan Fishing Ports Association, edition 1984)

2) Technical Standards for Port and Harbour Facilities in Japan (The Overseas Coastal Area Development Institute of Japan)

3) Ghana Building Code (Building & Road Research Institute)