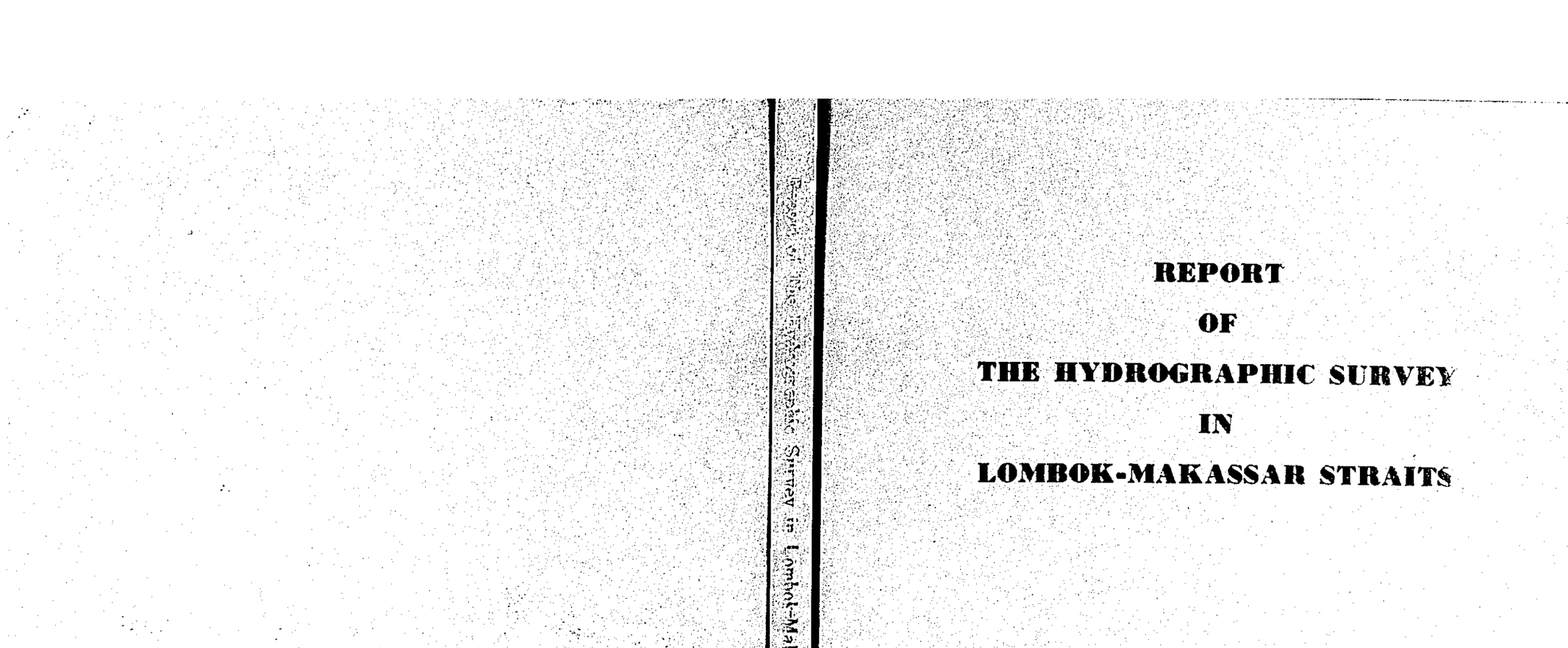
REPORT
OF
THE HYDROGRAPHIC SURVEY
IN
LOMBOK-MAKASSAR STRAITS

December 1975

Hydrographic Survey Team



CORRIGENDA

Page	Line	For	To read
31	4	August 2	August 27
41	5	east of	southeast of
"	6	07°10'04"S - 116° 13'01" E	07°10'.04S - 116°23'.01E
"	7	Areas I and III	Areas I and II

REPORT
OF
THE HYDROGRAPHIC SURVEY
IN
LOMBOK-MAKASSAR STRAITS

December 1975

Hydrographic Survey Team

FOREWORD

1. In pursuance of Memorandum of Understanding and Memorandum of Procedure of the Makassar and Lombok Straits survey between the Indonesian and Japanese Governments, signed in Jakarta on November 1973, the hydrographic survey along both stratis was conducted.

2. The survey was carried out in accordance with:

   a. Operational Order KASURTA ABRI/HANKAM No. PRINOP/03/SPA/II/1974 dated February 15, 1974.

   b. Radiogram MENHANKAM No. T/360/1975 dated April 24, 1975.

   c. Chief of Naval Staff Operational Directives No. JUKLAK/II/IV/1975 dated May 1, 1975.

   d. Operational Order KASURTA ABRI/HANKAM No. PRINOP/06/SPA/V/1975 dated May 2, 1975.

3. a. From February 21 till March 31, 1974, a reconnaissance survey was carried out by survey units of the Indonesian Naval Hydrographic Service with technical assistance from the Japanese Hydrographic Department.

   b. From May 10 till September 2, 1975 the main survey was conducted by survey units of the Indonesian Naval Hydrographic Service with technical assistance from the Japanese Hydrographic Deparmtment.

   c. The reconnaissance survey was carried out using KRI YALANIDHI, while using KRI BURUJULASAD for the main survey.

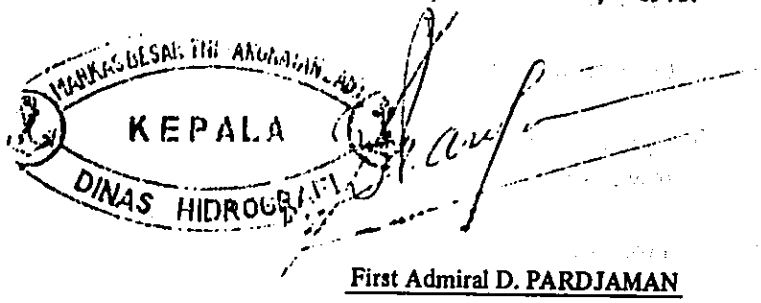
4. Processing of obtained data from the main survey was carried out in Jakarta from September 25 till December 25, 1975 together with a Japanese team, while data of the reconnaissance survey were already processed in May 1974.

5. From the results of the survey and observations and the data evaluated, it is hoped to meet requirements for safe navigation in accordance with the progress and development of seagoing traffic especially for deep draft vessels.

6. Using this opportunity, as Chief Hydrographer and speaking on behalf of the Chief Naval Staff and the Government, I would like to express my sincerest gratitude for all the participating echelons on the Staff as well as in the field for the splendid cooperation and coordination which made the undertaking of this survey possible, with excellent results and exactly according to schedule.

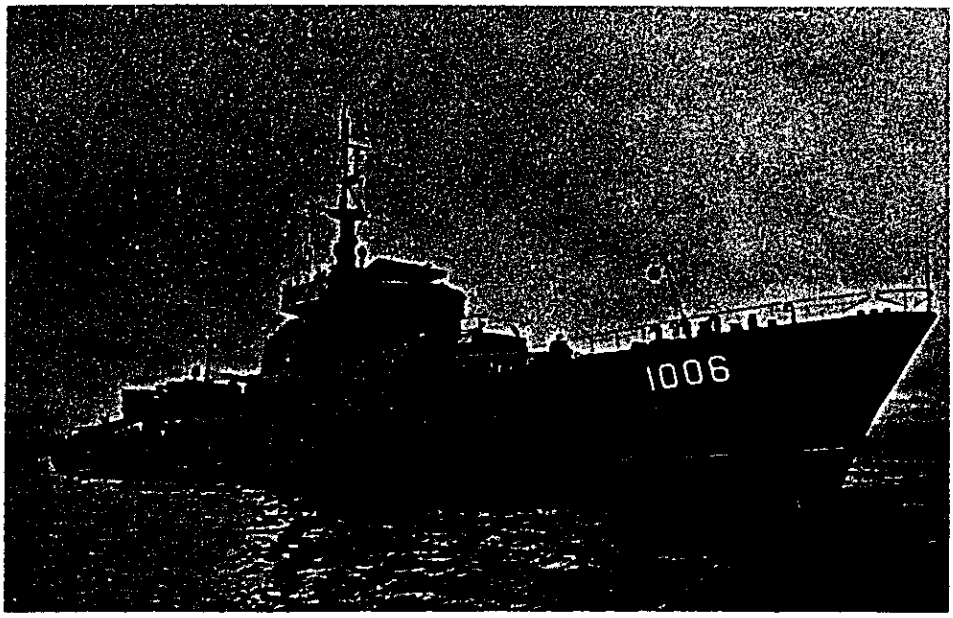
I also would like to convey my deepest gratitude to the Japanese Hydrographic Department and the Malacca Strait Council and to all local Government Officials who gave their assistance, so that the survey and observations could be successfully conducted.

Jakarta, December , 1975.

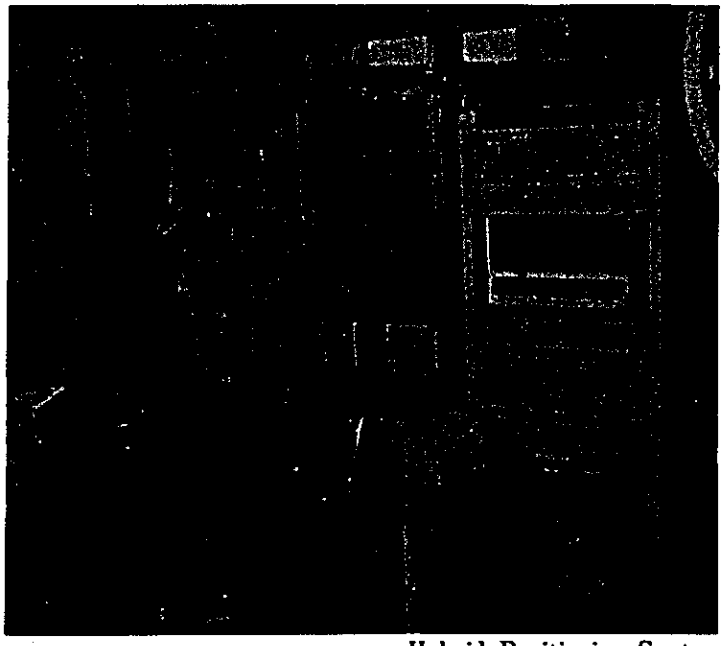


First Admiral D. PARDJAMAN

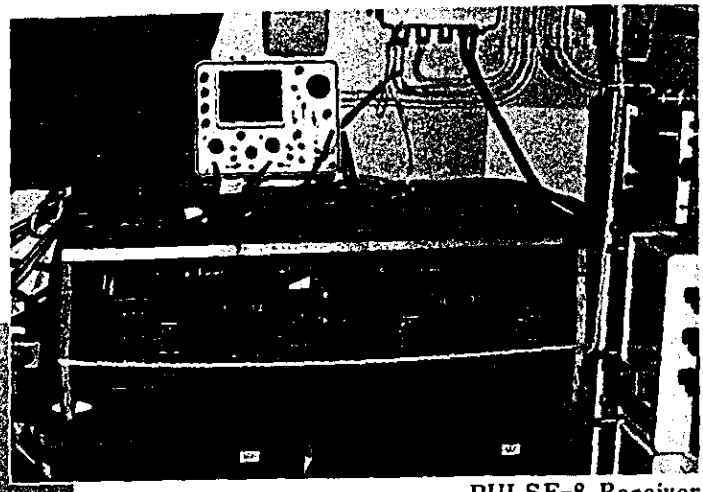
Chief Hydrographer



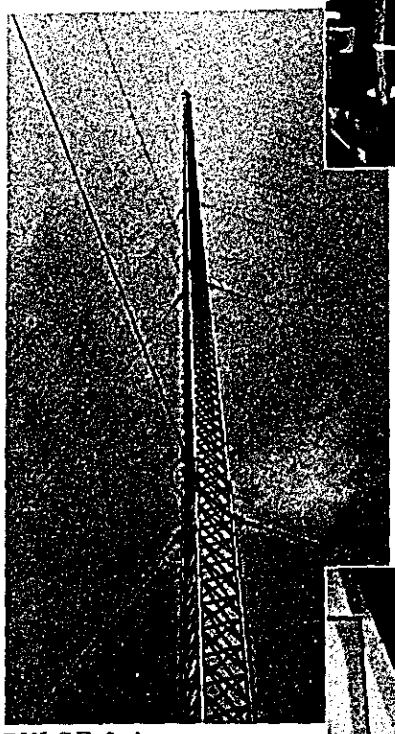
KRI BURUJULASAD



Hybrid Positioning System

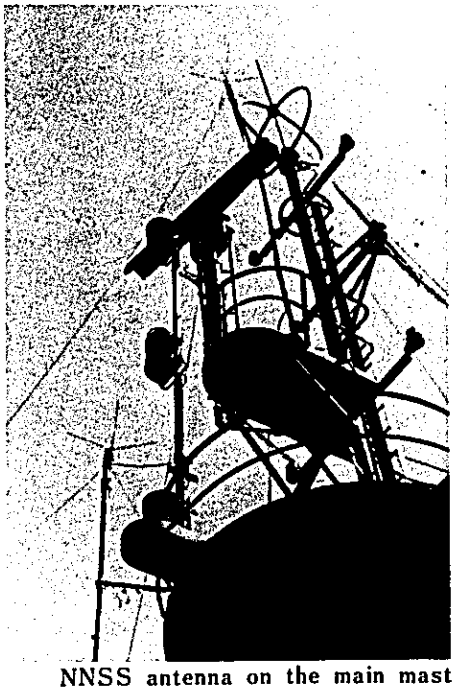


PULSE-8 Receiver



PULSE-8 Antenna
(about 100m high)

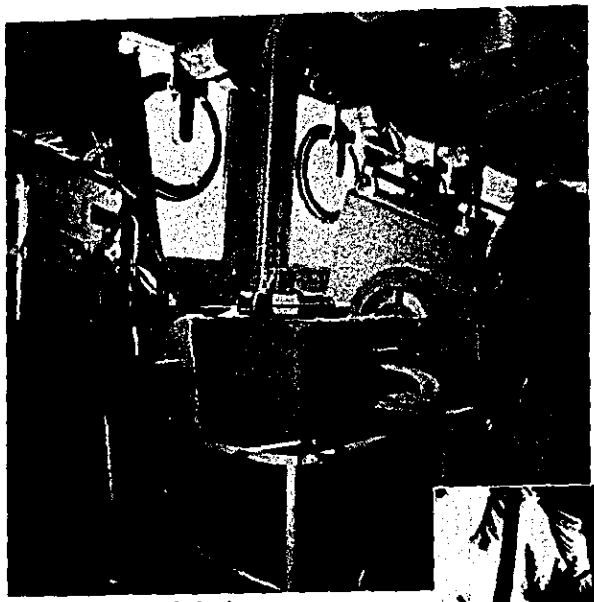
Checking Hybrid Positioning System



NNSS antenna on the main mast

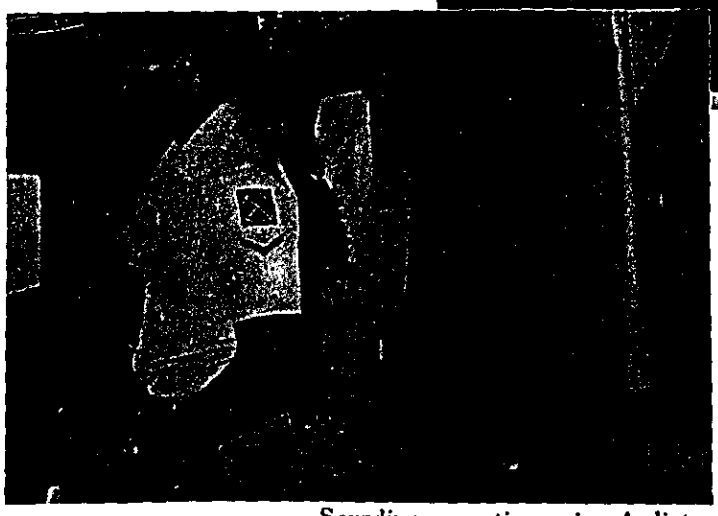
Deep sea echo sounder

Shallow water echo sounder

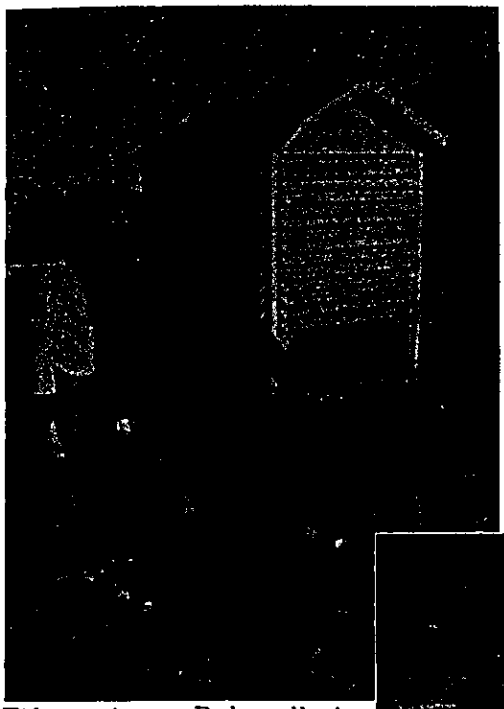


Interrogator of Audister

Responder of Audister
at Pulau Bali

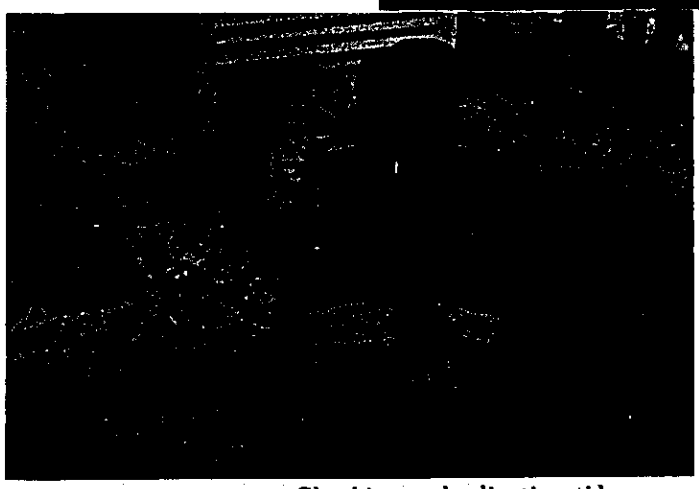


Sounding operation using Audister



Tide station at Padang Baai

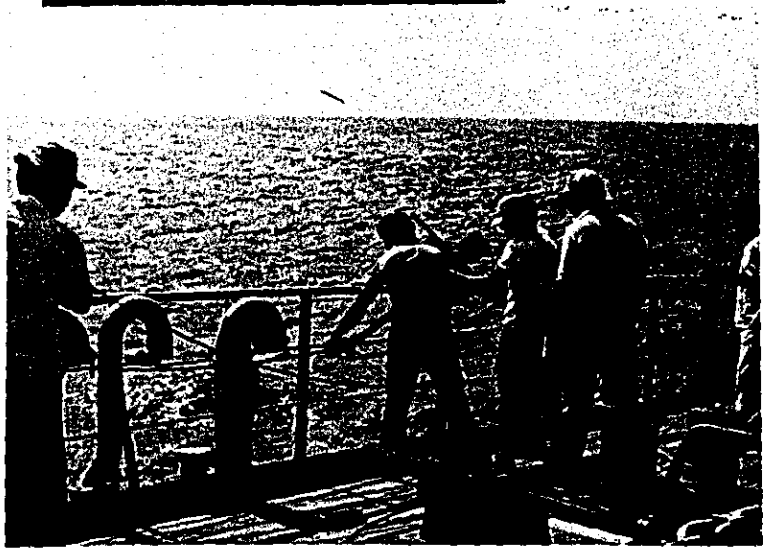
Tide pole at Donggala



Checking and adjusting tide gauge

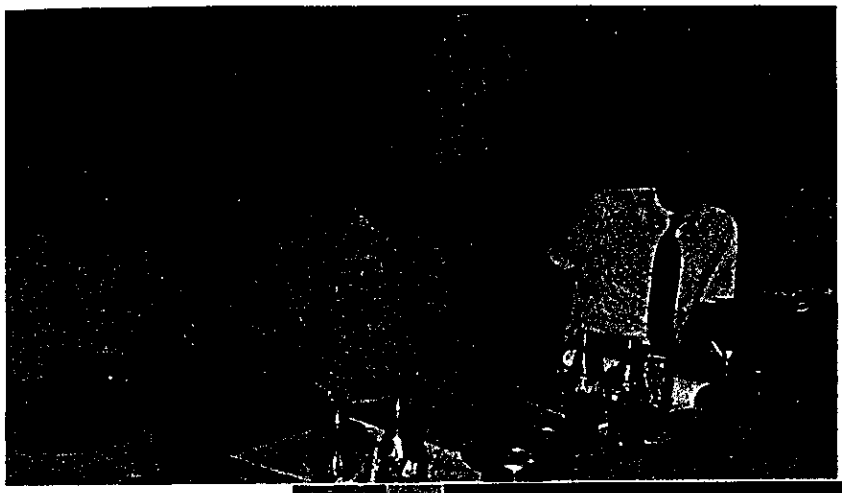
Checking current meter

Precise tide gauge



Setting current meter

Inspection by Chief Hydrographers of Indonesian Navy and Japan



Data processing
at Indonesian Naval
Hydrographic Service

Discussion on data
processing by
computer staff

Processing of data by electronic computer (UNIVAC 1106)

CONTENTS

Page

REPORT OF THE HYDROGRAPHIC SURVEY IN THE LOMBOK AND MAKASSAR STRAITS

1. ORGANIZATION

1 - 1. Introduction.

To promote safety of navigation in the Straits of Lombok and Makassar, primarily a route for merchant vessels including tankers which are unable to navigate safely through other straits, the Government of the Republic of Indonesia and the Government of Japan reached an understanding and agreed to conduct hydrographic survey along the said Straits, as stated in the Memorandum of Understanding and the Memorandum of Procedures signed in Jakarta in 1973.

The reconnaissance was carried out, using KRI YALANIDHI, from February 21 to March 31, 1974.

The main hydrographic survey was carried out, using KRI BURUJULASAD. The survey was commenced on May 10, 1975, and was successfully completed on September 2, 1975.

Data processing of the survey was conducted in Jakarta from September 25 until December 25, 1975.

For the execution of surveys, technical assistance was received from the Government of Japan.

This is the descriptive account of the implementation and results of the main hydrographic survey.

1 - 2. Overall Planning for the Survey.

As in Annex I (Memorandum of Procedures).

1 - 3. Reconnaissance.

Report of the reconnaissance is as in Annex II.

1 - 4. Detailed Survey Plan.

Based upon the results of the reconnaissance, it was necessary to make some modifications to the original plan.

1 - 4 - 1. Survey Area.

For the convenience of the progress of the survey, the area was divided as follows:

Area I : From the northern extremity of the survey area to Majene.

Area II : From Majene to Sibbald Bank.

Area III : From Sibbald Bank to the southern extremity of the survey area.

Area IV (Specified Area) : In the Strait of Lombok, between Pulau Nusa Penida and Pulau Lombok.

1 - 4 - 2. Survey Period.

116 days, from May 10, 1975, until September 2, 1975.

1 - 4 - 3. Survey Team.

The survey is to be conducted by a team of the Indonesian Naval Hydrographic Service with technical cooperation by the Hydrographic Department of Japan.

The team will be composed of 29 members and the ship's complements.

1 - 4 - 4. Survey Ship.

KRI BURUJULASAD.

Measurements:

Length	82.15 metres
Width	11.40 metres
Draught	4.00 metres
Water displacement unloaded	1,800 tons
Water displacement maximum	2,150 tons
Load capacity	189 m^3
Engine power	4 x 1,500 HP
Screw	2
Maximum speed unloaded	19.5 knots
Maximum speed loaded	18.1 knots
Cruising speed unloaded	15.7 knots
Cruising speed loaded	15.0 knots
Cruising range at maximum speed	11,000 miles
Cruising range at cruising speed	14,500 miles

Tank Capacity :

Fuel	742 m^3
Lubricant	20 m^3
Fresh water	280 m^3

Engine :

Main engine . . . . . 3,120 HP 900 rpm
Main generator . . . . . 358 HP 244 cops

Navigation Instruments :

Gyro compass (Anschuts), Magnetic compass (Kelvin Hughes), Radar and two receivers (Decca/T.M. 262), Loran reciever (Loran Redifn 262A Nr. series 0282), Course recoder (Anschuts), Direction finder (1-C, Plath SFP 700/2, 2-C Plath E 500 KT), Echo sounder (Kelvin Hughes), Sallog (Nr. 20470).

Other Instruments :

Hydrodist, Deep sea echo sounder (Kelvin Hughes), Wave recorder (Nr. 1703211), Bathythermograph (Wallace), Nansen bottles, Corer, Velocimeter.

Hydrographic instruments: Kelvin Hughes MS 26J Echo sounders, Wild T2 Theodolite, Wild TO Theodolites, Askania range-finder, etc.

Oceanographic laboratorial equipments: Titration burrets, Salinometer, Thermometer, etc.

Drawing sets: Planimeters, Panthographs, Space finders, etc.

Oceanographic winches.

Cabins :

Captain's cabin	1 room	=	1 person
Officer's cabin	12 rooms	=	12 persons
Scientist cabin	1 room	=	28 persons
Sick bay	2 rooms	=	8 persons
Petty officer's cabin.	12 rooms	=	24 persons
Sailor's quarters	1 room	=	64 persons

Additional Equipments.

For the execution of the survey, KRI BURUJULASAD is to be equipped with additional instruments as mentioned in the Memorandum of Procedures.

1 - 4 - 5. Principles of Field Operation.

Preliminary data processing and the progress report are to be made on board during the survey.

The period of the survey is to be divided into eight phases in accordance with the stages of operation. In each stage, there will be 12 days of operation and two days for supply and replenishment.

Ports for supply and replenishment will be Balikpapan, Ujung Pandang, Surabaya and Benoa.

The survey leader is responsible for any changes in the operational plan for the smooth progress of the survey.

1 - 4 - 6. Method of Survey.

1 - 4 - 6 - 1. Position Fixing.

For position fixing in the survey area, a method of combining NNSS (Navy Navigation Satellite System) as a basic system and Loran C in rho-rho mode for interpolation between NNSS fixes will be adopted. For this purpose, a hybrid positioning system consisting of an NNSS receiver, two Loran C receivers and two small-sized electronic computers (Hitachi, HITAC-10 and INTERDATA Model 70) will be devised. This system will be connected to the gyro compass and log of the survey ship.

Data obtained from the combined positioning system will be based on the spheroid NWL-8D.

In the Specified Area, Audister (Shimada Rika) will be employed for positioning. The sites for Responders of this system were selected at the triangulation station (T. 584) in the south eastern part of Pulau Bali and at Pulau Nusa Penida, for which necessary geodetic surveys were carried out at the reconnaissance.

1 - 4 - 6 - 2. Sounding.

(1) Sounding will be carried out by KRI BURUJULASAD.
Echo sounders to be used are:
Kelvin Hughes Deep Sea Echo Sounder, type MS 26J.
Atlas Medium Depth Echo Sounder, type DESO-10.
NEC Shallow Water Echo Sounder, type NS-39, for depths less than 200 m.
In addition, a side scan sonar will be used for searching and locating any shoals.

(2) Sounding lines will be spaced at 1 mile, running along the straits.
In the adjacent water of Pulau Sekala, the interval will be 0.5 mile.
The sounding intervals in Area IV (Specified Area) will be 200 m and 400 m.

(3) Depths will be shown in meters.

(4) Sounding Datum and Tidal Reductions.
Reductions for soundings will be applied only to depths of less than 200 m.
The sounding datum for tidal reduction is to be determined by harmonic analysis of the four principal tidal constituents obtained form the tidal observations at five

stations on the shore in the vicinity of the survey area.

The values of the seasonal difference of tides at each station are to be adopted from the Admiralty Tide Tables.

(5) Corrections.

Sound velocity correction and stylus revolution correction are to be applied.

1-4-6-3. Tidal Observation.

(1) Observation Stations.

According to the original plan, five stations were selected for tidal observations. However, based on the result of the reconnaissance, it was decided that the observations would be conducted at Donggala, Pulau Kalu Kalukuang and Padang Baai.

(2) Method of Observation.

Three types of tide gauges will be used, a long-term Fuess type automatic tide gauge (LFT), a pressure type automatic tide gauge and a TG-2A tide gauge (using Vibrotron). Depending upon the condition of observation site, either the LFT or the pressure type one will be established in combination with the TG-2A tide gauge so that any blank in recording due to malfunctioning of the automatic tide gauge may be made up. In addition, observation using a tide pole will be concurrently carried out.

1-4-6-4. Tidal Current Observation.

(1) Observation Stations.

Four observation stations were originally selected. However, after careful consideration, it was decided that the observations would be carried out at two stations, one in the south-southwestward of Pulau Kalu Kalukuang (at Sibbald Bank) and the other in the Lombok Strait (East of Pulau Nusa Penida).

(2) Method of Observation.

A long-term self-recording current meter will be used, and in order to make up any blank in recording, Ono's self-recording current meter will be concurrently used. The observations will be made at the 10-metre layer, and data for a month's period will be obtained.

1-4-6-5. Bottom Sampling.

Depths in the survey area shown on the existing charts range from 70 to 3,000 metres. Due to the winding capability of the winch on board the survey ship as well as the length and diameter of the wire to be used, it was decided that the maximum depth where the bottom samples should be collected would be about 2,000 m. Samplers used will be a corer, snapper and dredger.

The number and location of sampling points will be determined *in situ* by taking into account the sea bottom topography and water depth.

2. OUTLINE OF OPERATION

2 - 1. General.

(1) KRI BURUJULASAD and the survey team including the members from Japan left Tanjung Priok for the survey area on May 15, 1975.

(2) The dividing of the survey area was rearranged as follows:

1) Area I : From the northern extremity of the survey area to Majene.
2) Area II : From Majene to Pulau Kalu Kalukuang.
3) Area III : From Pulau Kalu Kalukuang to south of Pulau Sekala.
4) Area IV : From south of Pulau Sekala to the southern extremity of the survey area.
5) Area V (Specified Area) : In the Lombok Strait (between Pulau Nusa Penida and Pulau Lombok).

(3) Due to circumstances, the signal of Loran C from ConSon station to be used in rho-rho mode for position fixing in the Straits of Lombok and Makassar was no longer on air.

Therefore, Okinawa station of Loran C and Decca PULSE-8 stations of West Java Sea were employed.

The Decca PULSE-8 receiver was additionally installed on board KRI BURUJULASAD.

2 - 2. Summary of Operation.

First Stage, May 15 – May 21, 1975.

During this period a tide station was established at Donggala, and sky wave observation in Area I was carried out.

Loran C signals from SS3-Z (Yap Island) and SS3-Y (Okinawa) could be received, although sometimes the reception was poor during the morning and evening twilights for about 2 hours due to the ionospheric conditions.

Second Stage, May 21 – June 3, 1975.

Sounding operation in Area I covered 50% of the area with 1,330 sounding mileage.

Position fixing was made by use of Loran C (SS3-Z and SS3-Y) integrated with NNSS.

Third Stage, June 7 – June 19, 1975.

Sounding in Area I continued.

The tide station at Donggala was dismantled.

KRI BURUJULASAD proceeded to Ujung Pandang for repairs of Kelvin Hughes Deep Sea Echo Sounder.

Fourth Stage, June 19 – June 29, 1975.

Sounding in Area III was carried out by use of Kelvin Hughes Navigation Echo Sounder type MS 26 GKM, the recorder of which was replaced by that of MS 26J.

A tide station was established at Pulau Kalu Kalukuang, and tidal currents of the survey area were observed.

Position fixing was made by use of Decca PULSE-8 (stations Belitung and Balong) integrated with NNSS.

During the stage, sounding lines of 1,500 miles were covered.

Fifth Stage, July 3 – July 15, 1975.

KRI BURUJULASAD continued sounding in Areas IV, III, II and I.

A tide station was established at Padang Baai.

Bottom samples and data on tidal currents were collected from Area III.

By the end of the stage, sounding in Area I covered 3,500 miles whilst sounding in Area III reached 90% covering 2,200 miles.

Sixth Stage, July 18 – July 30, 1975.

KRI BURUJULASAD carried out sounding in Areas II, III and IV, as well as resounding and supplementary sounding in Areas I and III.

Current station was set up eastward of Pulau Nusa Penida in the Lombok Strait.

The tide station at Pulau Kalu Kalukuang and the current station at Sibbald Bank were dismantled.

At the end of the stage, sounding in Area I was completed, covering 3,061 miles.

Seventh Stage, August 3–August 14, 1975.

KRI BURUJULASAD carried out sounding and resounding in Areas II, III and IV.

The current meters set up at current station east of Pulau Nusa Penida were found missing.

A replacement was set up there but later it was also found missing.

Audister Responder stations were established at Bukit Melanting (Pulau Bali) and at Bukit Tunjuk (Pulau Nusa Penida).

Search for the missing current meters using sonar and wire sweeping was unsuccessful.

During this stage, sounding in Areas II, III and IV was completed, covering 3,785 miles.

Eighth Stage, August 18 – August 28, 1975.

Sounding in Area V and Specified Area was carried out.

Audister was used for position fixing.

Efforts to search for the missing current meters gave no result.

Due to unfavourable weather and rough seas often encountered, KRI BURUJULASAD had to take shelter at Labuan Po.

On August 27, 1975, the sounding in the Specified Area was completed, covering 588

miles. Audister Responder stations and the tide station at Padang Baai were then dismantled.

KRI BURUJULASAD proceeded to Benoa for supply and replenishment. After packing the instruments, members from Japan disembarked at Benoa.

KRI BURUJULASAD left Benoa and arrived at Tanjung Priok, Jakarta, on September 2, 1975.

2 - 2 - 1. Abstract of Daily Progress.

May 10 – May 14, 1975.

– Preparation for the operation.

May 15, 1975.

– Left Tanjung Priok for Donggala.

May 18, 1975.

– Testing the function of the instruments.
– En route to Donggala.

May 19, 1975.

– Arrived at Donggala.
– Establishment of tide station at Donggala.

May 20, 1975.

– Sailed for survey area.
– Sounding in Area I.

May 22 – May 23, 1975.

– Supply and replenishment at Balikpapan.

May 24 – May 26, 1975.

– Sounding in Area I.

May 27, 1975.

– Sailed for Balikpapan.

May 28, 1975.

– Installation of Decca PULSE-8 receiver at Balikpapan.

May 29 – June 3, 1975.

– Sounding in Area I.

June 4 – June 6, 1975.

– Supply and replenishment at Balikpapan.
– Sky wave observation.
– Installation of timing unit of Decca PULSE-8 receiver.
– Inspection by Indonesian Naval Chief Hydrographer and Team from Japan.

June 7 – June 11, 1975.

– Sounding in Area I.

June 12, 1975.

– Anchored at Donggala.
– Dismantling of tide station at Donggala.

June 13, 1975.

– Sounding in Area I.

June 15, 1975.

– Repairs of the transformer of Deep Sea Echo Sounder.

June 16 – June 18, 1975.

– Supply and replenishment at Ujung Pandang.
– Minor repairs of the engine.
– Installation of Atlas DESO-10 Echo sounder.

June 19, 1975.

– Sailed for survey Area III.

June 20, 1975.

– Establishment of tide station at Pulau Kalu Kalukuang.

June 21, 1975.

– Sounding in Area III using Kelvin Hughes Navigation Echo Sounder instead of Atlas DESO-10 Echo Sounder.

June 27, 1975.

– Setting up of current station in Area III at 05° 29' .7 S – 117° 25' .7 E.

June 28 – June 29, 1975.

– Sounding in Area III.

June 30, 1975.

– Arrived at Surabaya.

July 1 – July 2, 1975.

– Supply and replenishment at Surabaya.

July 3, 1975.

– Sailed for Padang Baai.

July 5, 1975.

– Establishment of tide station at Padang Baai.

July 6, 1975.

– Sounding in Area IV.

July 7, 1975.

– Sounding in Area III.
– Bottom sampling at Area III.

July 8, 1975.

– Sounding in Area III.

July 9, 1975.

– Sounding in Area IV.

July 10, 1975.

– Sounding in Area III.

July 11 – July 15, 1975.

– Sounding in Areas II and I.

July 16 – July 18, 1975.

– Supply and replenishment at Ujung Pandang.

July 19 – July 29, 1975.

– Sounding in Area II.

July 21, 1975.

– Sounding in Areas II and III.

July 22, 1975.

– Sounding in Areas II and III.
– Setting up current station No. 2 at 05° 47′ .1 S - 115° 47′ .2 E.
– Station shifting from PULSE 8-4 to SS3-Z & PULSE 8-2.

July 23, – July 24, 1975.

– Sounding in Areas IV, III and II.

July 26, 1975.

– Sounding in Areas I and II.

July 27 – July 29, 1975.

– Sounding in Area II.

July 30 – August 2, 1975.

– Supply and replenishment at Ujung Pandang.
– Inspection by Chief Hydrographers of Indonesia and Japan.

August 3 – August 4, 1975.

– Sounding in Areas II and III.

August 5 – August 10, 1975.

– Sounding in Area IV.
– Search for the missing current meter.

August 11, 1975.

– Establishment of Audister Responder 1 at Pulau Bali and Responder 2 at Pulau Nusa Penida.

August 12 – August 13, 1975.

– Testing the functioning and the effective coverage of the Audister.

August 14, 1975.

- Search for the missing current meters of stations No. 2 and No. 2' by sonar and wire sweeping without result.

August 15 – August 16, 1975.

- Supply and replenishment at Benoa.
- A visit of Chairman of the Malacca Strait Council.

August 17, 1975.

- Stay at Benoa.
- Independence Day.

August 18 – August 23, 1975.

- Left Benoa and sounding in Area V.

August 24, 1975.

- Search for the missing current meters without result.

August 25 – August 26, 1975.

- Sounding in Area V.

August 27, 1975.

- Dismantling of tide station at Padang Baai and Audister Responders.

August 28, 1975.

- Supply and replenishment at Benoa.
- Visits of Commodore D.C. Kapoor, Director of IHB and Indonesian Naval Chief Hydrographer.
- Members from Japan disembarked.

August 30, 1975.

- Left Benoa for Tanjung Priok.

September 2, 1975.

- Arrived at Tanjung Priok, Jakarta.

2 - 3. List of Team Members.

1)	Mayor Laut Drs. M.J. Sitepu	–	Indonesian Naval Hydrographic Service.
2)	Mayor Laut Achmad Suwandi	–	– " –
3)	Mayor Laut Soejadi	–	– " –
4)	Kapten Laut M.P. Silaban	–	– " –
5)	Kapten Laut Suarno	–	– " –
6)	Kapten Laut Gunadi Gan	–	– " –
7)	Kapten Laut Asfar Ismael	–	– " –
8)	Kapten Laut Driyo Utomo	–	– " –
9)	Kapten Laut C.M. Sitohang	–	– " –
10)	Kapten Laut Nuchman	–	– " –
11)	Lettu Laut J. Hasibuan	–	– " –
12)	Lettu Laut Rianoe Bunet	–	– " –
13)	Lettu Laut Mulyanto	–	– " –
14)	Lettu Laut Moch. Djaelani	–	– " –
15)	Lettu Laut Mukidin	–	– " –
16)	Mr. Ir. Sem Saimima	–	– " –
17)	Mr. Ir. Frans Supit	–	– " –
18)	Bonar Situmorang	–	– " –
19)	Djoko Tjahjadi	–	– " –
20)	Serda Pelaut Sumaryo	–	– " –
21)	Serda Pelaut Saadi	–	– " –
22)	Serda Pelaut Kamisan	–	– " –
23)	Serda Rawat Dudung	–	– " –
24)	Mr. Nakidi	–	– " –
25)	Mr. Baasimin	–	– " –
26)	Mr. P. Sunuruto	–	– " –
27)	Mr. Abu Bakar	–	– " –
28)	Mr. Age Busono	–	– " –
29)	Mr. Kopda Tulis Unpapar	–	– " –

Officers of KRI BURUJULASAD.

1)	Mayor Laut A. Wungkana	–	Indonesian Naval Hydrographic Service.
2)	Mayor Laut Marsono P.	–	– "–
3)	Mayor Laut Syahrim Han	–	– "–
4)	Kapten Laut Soebekti	–	– "–
5)	Kapten Laut Slamet Soedjono	–	– "–
6)	Lettu Laut Suherman Udia	–	– "–
7)	Lettu Laut Subandy	–	– "–
8)	Lettu Laut Mintardjono	–	– "–
9)	Letda Laut F.R. Tjahjadi	–	– "–

Team from Japan.

1)	Mr. T. Uchino	–	Hydrographic Department, Maritime Safety Agency.
2)	Mr. S. Kozawa	–	– "–
3)	Mr. M. Kawanabe	–	– "–
4)	Mr. K. Shimizu	–	– "–
5)	Mr. T. Imanishi	–	– "–
6)	Mr. S. Uetake	–	– "–
7)	Mr. K. Ochiai	–	Malacca Strait Council
8)	Mr. T. Ogata	–	– "–
9)	Mr. A. Sakai	–	Sena Company
10)	Mr. I. Tsudome	–	Tokyo Shibaura Electric Company.
11)	Mr. S. Aoyama	–	Furuno Electric Company.
12)	Mr. Y. Arita	–	Tokyo Shibaura Electric Company.
13)	Mr. A. Matsumoto	–	Ishikawajima Harima Heavy Industries Company.
14)	Mr. T. Sekiguchi	–	Cinesell Japan Inc.
15)	Mr. K. Sato	–	Cinesell Japan Inc.
16)	Mr. G.M. Joris	–	Interpreter.

2-4. Field Operation.

2-4-1. Position Fixing.

For positioning in the survey area, an automated hybrid positioning system and Audister were employed.

The automated hybrid positioning system consisting of NNSS and Loran C receivers was completed at the end of 1974, and was used for the first time in the Lombok and Makassar Straits survey.

The Loran C chains selected for use in the position fixing were SS3 in the Western Pacific Ocean and SH3 covering Thailand and South Viet Nam.

Immediately before the commencement of the survey, however, the SH3 chain became inoperative infinitely on May 2, 1975. According to the original plan, signals from the station Y of SH3 chain were to be used.

Therefore, it became necessary to work out an alternative plan for the off-air of that chain immediately after the survey operation started.

As it was known that the chain of new positioning system at sea, PULSE-8, was in operation since December 1974 in western Java Sea, the survey team decided to use the chain as a substitute upon the approval of both Government of Republic of Indonesia and Government of Japan.

The PULSE-8 receiver usable in the rho-rho mode was dispatched from London, and it arrived at the survey site late May. This was then equipped on board the survey ship and used for position fixing in the central and southern portions of the survey area.

While, in the northern part of the survey area, the signals form the station Y of SS3 chain were utilized instead of those from the station Y of SH3 chain.

The Audister was used for the Specified Area.

2-4-1-1. Hybrid System.

The outline of the system is explained in the following.

2-4-1-1-1. Composition of the System.

Fig. 1 outlines the composition of the system. The upper part of the figure shows the units of NNSS and the lower part those of Loran C, while the central part is the interface for gyro-compass and log. The electronic computers (A) and (B) compute satellite positioning and Loran C measurements, respectively and independently. Both computers are combined by means of the interface, and mutually exchange necessary information. Now that individual sub-system has its own computer, each of the sub-systems has the positioning capability independently, which has enabled to disperse the loss due to the breakdown of the sub-system.

The main parts constituting this system are: NNSS receiver ZS 2999 E (manufactured by Tokyo Shibaura Electric Co.), electronic computer (A) HITAC-10 (Hitachi, Ltd.), Loran C receiver LR-10 RR (Furuno Electric Co.), rubidium standard oscillator 5065A (Hewlett-Packard) and electronic computer (B) INTERDATA Model 70.

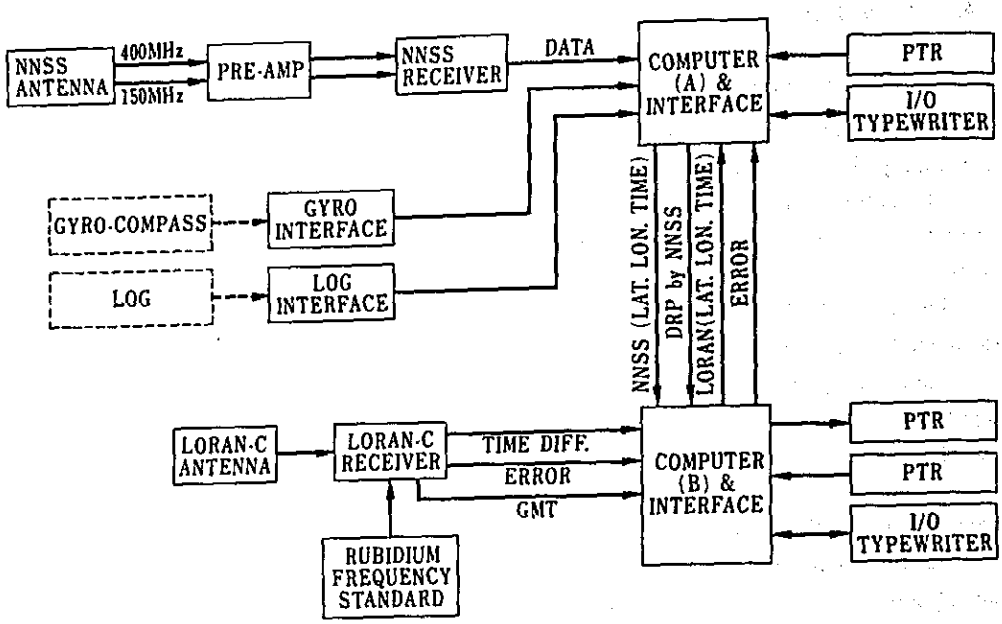


Fig. 1. Block Diagram of Hybrid Positioning System.

2-4-1-1-2. Performance of Each Unit.

(1) NNSS Receiver and Its Data Processing.

It is possible for the NNSS receiver to receive satellite signals on both 150 MHz and 400 MHz frequencies. The Doppler frequency of the signals on 400 MHz band is used for computation of positions, while the Doppler frequency of the signals on 150 MHz is used for corrections to the errors caused by refraction of radiowave propagation path in the ionosphere. The stability of the built-in oscillator serving as the standard for measurement of the Doppler frequency is better than 1×10^{-10}. The measurement of the Doppler frequency by this receiver continues for 24 seconds, and maximum 40 times of continual measurements can be made.

Fig. 2 shows the block diagram of NNSS receiver other than the portion of the 150 MHz circuit. The receiver automatically catches and traces the satellite signals, and detects the Doppler shift of the signals. Also it detects the orbital data of the satellite which are transmitted every 2 minutes, and supplies them to the computer (A) together with Doppler count and time signals. The computer (A) carries out computation of positions on the basis of various data from the receiver and the initial values given in advance.

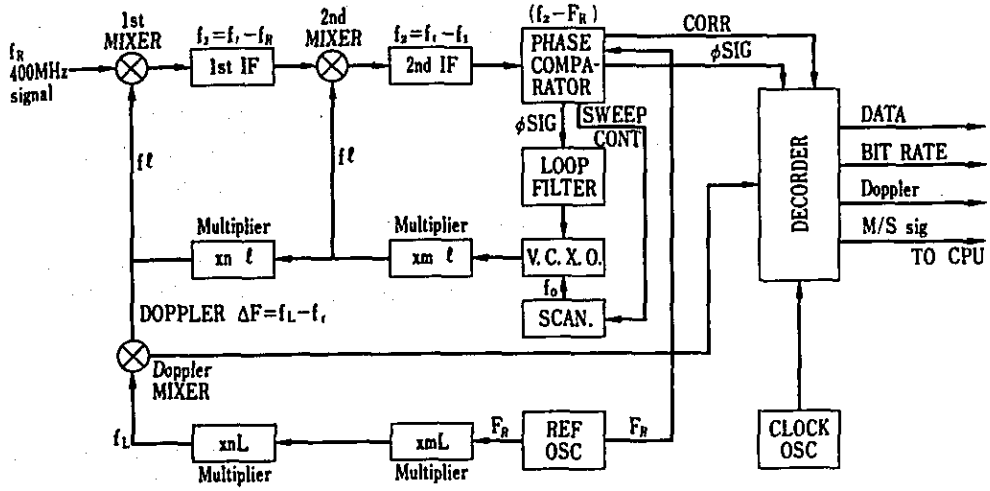


Fig. 2. Block Diagram of NNSS Receiver.

For carrying out the initial computation of positions after the receiver was put into operation, initial setting of various data is necessary. After the first computation on positions is over, the results are retained. While, the position data which are changing with the lapse of time are revised according to one of the following three modes:

(i) Loran C mode: The values of latitude and longitude computed from the Loran C signals are received from the computer (B) through the interface.

(ii) Gyro-log mode: From the ship's course given by the gyrocompass and the ship's speed given by the log put in through the interface, the amount of change in ship's position is computed, and values of latitude and longitude are revised.

(iii) Manual mode: From the estimated ship's course and speed manually put in from the typewriter, the amount of change in ship's position is computed and the values of latitude and longitude are revised.

Each of the above-mentioned three modes will operate according to the manual instruction from the typewriter. When more than two instructions are given, priority will be assigned in the order of (i), (ii) and (iii) above. In case where the computer (A) judges that the data given from Loran C receiver is not good, the computation in the Loran C mode is stopped and is switched over to the other mode automatically, and the computer (A) in return supplies the data on latitude and longitude to the computer (B). When the condition on Loran C side is restored to normal, the computer (A) automatically resumes the operation in the Loran C mode.

The principal functions of the computer program for NNSS positioning are summarized as follows:

(i) To make input of Doppler data, orbital data and course data.
(ii) To make input of position fixed by Loran C from computer (B).
(iii) To make computation of position fixing.
(iv) To make output of the results of position fixing to typewriter and computer (B).
(v) To make recomputation by changing the data of antenna height, ship's speed and course.
(vi) The output data to the typewriter are: time of position fix, latitude, longitude, antenna height, ship's speed and course, angle to elevation of a satellite at its closest proximity, the number of times of convergence computations, satellite number, mode of computation (Loran C mode, gyro-log mode or manual mode), orbital data of satellite, and Doppler count.

(2) Loran C Receiver and Its Data Processing.

It is possible for the Loran C receiver constituting the system to carry out the measurements in the usual hyperbolic mode. However, in case of adopting hybrid measuring system, two-range mode (rho-rho mode) is used. Characteristics of the positioning in the two-range mode are as follows:

(i) Since the lines of positions obtained by the measurement in this mode are circular arcs and the intervals between the lines of positions corresponding to the measurable resolution of 0.1 microsecond is 30 metres, high accuracy can be obtained irrespective of the distance between the position measured and the Loran C transmitting station.
(ii) A position can be fixed by only two stations out of three to five stations constituting a Loran C chain. Accordingly, it is possible to select a pair of stations which constitute better conditions of intersection angle between lines of positions, so that the service area of a chain becomes far wider than that in the hyperbolic mode.
(iii) Although the distance from a Loran C station to the sounding position is given in the unit of time, in this mode only the part of less than 10 microseconds can be made clear out of the time corresponding to the distance. However, continuous measurement is feasible so that changes in the distance according to the ship's movement can be measured. In view of this, in this mode the ship's position at the time of commencing the measurement should be given by another method. This is the reason why this method is also called as "the relative positioning method".

The Loran C receiver, after selecting chains and transmitting stations and adjusting signal phases, will automatically trace the same signal, display the results of measurement to the order of 0.1 microsecond, and supply the data to the computer (B). The stability of the rubidium standard signal oscillator providing the standard for the measurement in the two-range mode is better than 0.1 microsecond/5 hours, wich is deemed satsifactorily compatible with the hybrid positioning system with NNSS.

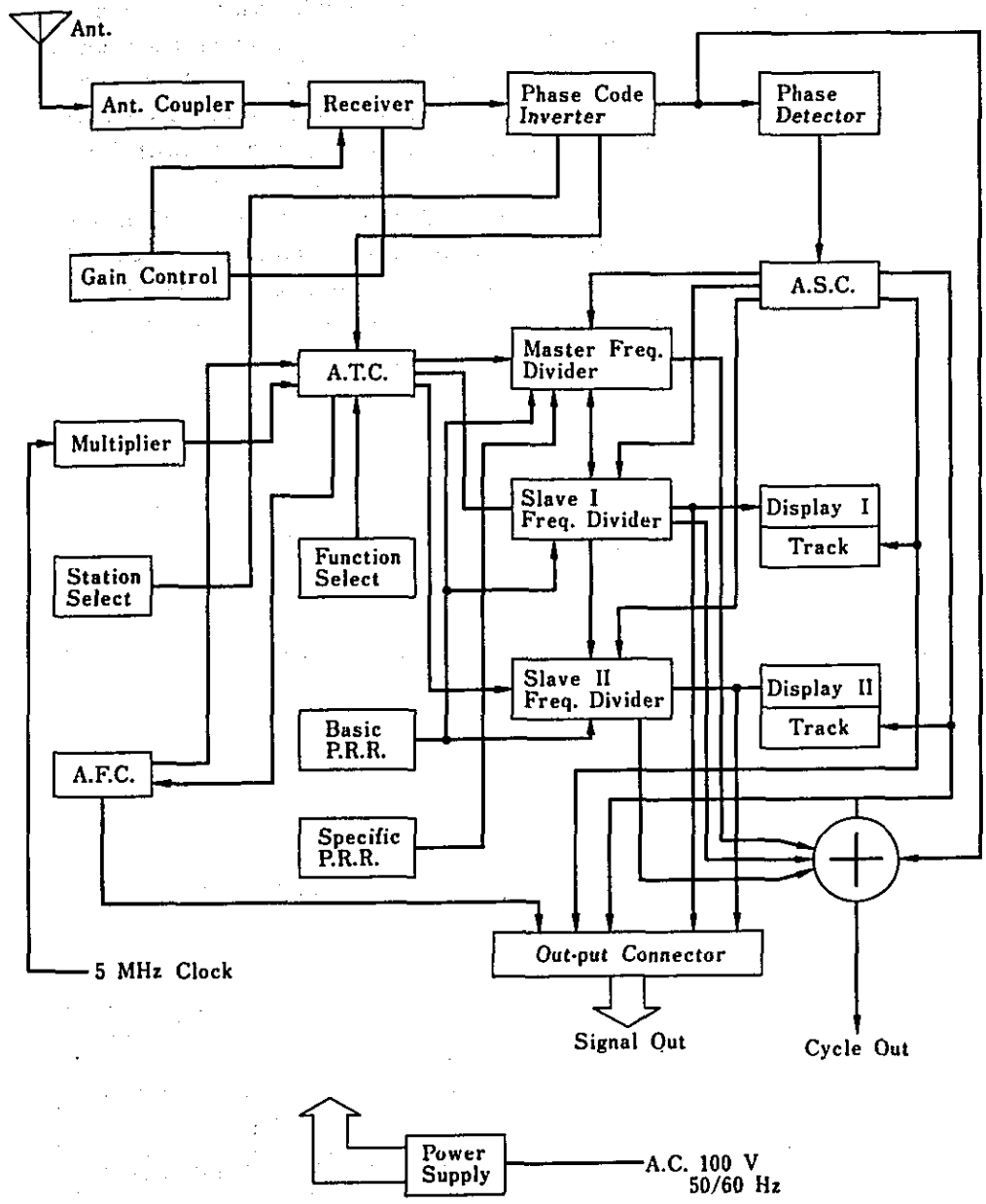


Fig. 3. Block Diagram of Loran C Receiver.

To the computer (B) annexed to the Loran C receiver, the data of ship's position in latitude and longitude at a certain time (those directly obtained from satellite signals) are given as the initial values from the computer (A) on the NNSS side. Then, the computer (B) computes the two distances from the ship to Loran C stations according to Lambert's formula by using the values of latitudes and longitudes of those Loran C stations memorized in advance. On the other hand, the measured value, t_0, by the Loran C receiver at the same time is memorized in the computer (B).

As the ship moves, the measured value by Loran C changes to t_i, and the amount of the change, $\Delta t = t_0 - t_i$, corresponds to the amount of the change in distances between the ship and the Loran C stations. Hence, by adding this amount to the distance value obtained by the initial computation, the distance between the ship's position and the Loran C stations at the time of the measurment can be obtained by the following formula:

$$D = D_0 + C \cdot \Delta t ,$$

where D_0 : Distance obtained by initial computation.

C : Propagation velocity of radio waves.

D : Distance between the ship and Loran C station.

Values of the principal constants used in the above computation are as follows:

(i) Earth's radii : a = 6,378.166000 km

b = 6,356.784282 km

(ii) Earth's flattening : f = 1/298.3

(iii) Propagation velocity of radio waves: 299,692.9 km/sec.

The locations of Loran C stations being used in the Western Pacific are as shown in Table 1.

Table 1.

STATION	LOCATION	LATITUDE	LONGITUDE
SS3-M	IŌ JIMA (JAPAN)	24° 48' 04".22 N	141° 19' 29".44 E
SS3-W	MINAMI-TORI SHIMA (JAPAN)	24° 17' 07".79 N	153° 58' 53".72 E
SS3-X	HOKKAIDO (JAPAN)	42° 44' 37".08 N	143° 43' 10".50 E
SS3-Y	OKINAWA (JAPAN)	26° 36' 24".79 N	128° 08' 55".99 E
SS3-Z	YAP	09° 32' 45".84 N	138° 09' 55".05 E

In general, when utilizing Loran C signals at a point at great distance from a Loran C station, the signals are mostly on the ionosphere reflected waves (sky waves) but not ground waves. In this case, it is natural that corrections based on the difference of propagation paths should be made. Since the altitude of the ionosphere reflecting the Loran C signals is in the function of time varying in accordance with the altitude of the sun, the values of corrections to sky waves also become the function of time. The computer (B) in the system can obtain the constants of quadric equation from the data of sky waves measured in advance, and obtains the sky wave corrections to memorize them.

To the computer (B) necessary initial values are given, such as date and time (in GMT and Local Time), name of selected station, intervals of printout, punching and recording, and estimated position. Then the computer starts the processing of Loran C data. By monitoring the condition of changes in Loran C data, detection of any jumping of data at the order of 10 micro-seconds is made and correction thereof is performed. Then, if the receiving signals are on the sky waves, necessary corrections are made. The ship's position (in latitude and longitude) resulted from a series of computations using those corrected data, as well as the ship's course, speed and distance covered obtained by further computations based on the above-mentioned results are printed out on a format at the designated time interval. The raw Loran C data are punched on paper tapes at the designated time interval for off-line processing.

When the next satellite comes while position fixing by Loran C is being carried out, the computer (B) memorizes the Loran C data within it until the time when the computation results are given from the computer (A) to the computer (B) from the commencement of receiving the satellite signals for recomputation process. The new data of latitude and longitude by NNSS are made as the initial values for the following Loran C position fixing, providing the basis for Loran C positioning computation. Also, from the Loran C data obtained and memorized while NNSS signals are being received, the ship's position during that time is recomputed.

The principal functions of the computation program for Loran C position fixing are summarized as follows:

(i) To make input of measured values and time from Loran C receivers.

(ii) To make input of initially set values of data (names of Loran C stations, DR positions, sky wave corrections, time intervals of printing and punching, etc.).

(iii) To make computation of position fixing every minute, and to make output of them to the typewriter at the designated time intervals (every 1, 2 or 5 minutes). These output data are: time of position fixing, latitude, longitude, measured Loran C value, sky wave correction value, ship's speed, course and distance covered by the ship.

(iv) At the time of NNSS measurement, to make input of position fixing data from the computer (A), and to make recomputation by using the data as the position of reference, and to make output of the results to the typewriter.

(v) To make output of Loran C positioning data (time, latitude and longitude) to the computer (A).

(vi) To make output of Loran C measurements at a designated time interval (every 5, 10

or 30 seconds) to the paper tape puncher together with the time measured.

(vii) To monitor the variation of Loran C measurements, and to detect and correct 10 microsecond jumping (corresponding to 3 kilometres).

The signal to noise ratio of Loran C in the survey area considerably deteriorated at the time of sunrise and sunset. Around the time of sunrise, in particular, there were many days when the measurement of sky wave could not be made for one and half or two hours. On the other hand, the measurement around the time of sunset did not present any appreciable difficulties. Since the Loran C signals receivable in this region are those reflected at the ionosphere (sky waves), measurements at fixed stations were carried out while the survey ship was anchoring in the vicinity of the survey area in order to obtain sky wave correction values. Table 2 shows the coefficients of quadric equations for obtaining sky wave correction values in the real time processing, tabulated according to the date and place of measurement, Loran C transmitting station and the group divided by time to which the quadric equation is applied.

Table 2.

Place name	Balikpapan	Balikpapan	Kalu Kalukuang	Ujung Pandang
Lat. & Long. (approx.)	1° 15.7′ S 116° 47.8′ E	1° 15.7′ S 116° 47.8′ E	5° 09.9′ S 117° 38.6′ E	5° 09.5′ S 119° 28.9′ E
Date of measurement	May 23rd - 24th	June 4th - 5th	June 20th - 21st	July 15th - 16th
SS3-Y	$16^h\ 00^m$ - $20^h\ 50m$	$16^h\ 00^m$ - $20^h\ 40m$	$16^h\ 00^m$ - $20^h\ 40^m$	
Constant term	3308.6101	2859.2026	-849.516	
1st order term	-677.62672	-581.56084	221.9963	
2nd order term	53.092633	45.98315	-20.072670	
3rd order term	-1.8370364	-1.613096	0.7998696	
4th order term	0.0236516	0.0211736	-0.0118729	
	$20^h\ 50^m$ - $10^h\ 50^m$	$20^h\ 40^m$ - $11^h\ 00^m$	$20^h\ 40^m$ - $11^h\ 00^m$	
Constant term	3500.3794	2815.2368	3152.001	
1st order term	-492.63901	-388.17935	-441.4362	
2nd order term	26.584372	20.83937	23.56505	
3rd order term	-0.6398480	-0.500115	-0.5605772	
4th order term	0.0057917	0.0045230	0.0050128	

(Table 2, continued)

	$10^h\ 50^m$ - $16^h\ 00^m$	$11^h\ 00^m$ - $16^h\ 00^m$	$11^h\ 00^m$ - $16^h\ 00^m$	
Constant term	3133.6966	-328.45768	491.857	
1st order term	-945.03935	109.61851	-145.9293	
2nd order term	108.63071	-10.49663	17.40949	
3rd order term	-5.4928710	0.453957	-0.8820924	
4th order term	0.1031498	-0.0075007	0.0161959	
SS3-Z	$15^h\ 00^m$ - $22^h\ 20^m$	$16^h\ 10^m$ - $22^h\ 50^m$	$17^h\ 40^m$ - $21^h\ 30^m$	$18^h\ 00^m$ - $22^h\ 50^m$
Constant term	-806.07570	-3724.1007	-388.453	-1047.107
1st order term	182.55059	790.236797	64.512	192.2845
2nd order term	-14.948409	-61.639995	-3.133948	-12.68236
3rd order term	0.5357452	2.122166	0.049797	0.3725179
4th order term	-0.0070850	-0.027220	0.000064	-0.0041184
	$22^h\ 20^m$ - $09^h\ 30^m$	$22^h\ 50^m$ - $09^h\ 30^m$	$21^h\ 30^m$ - $09^h\ 50^m$	$22^h\ 50^m$ - $09^h\ 10^m$
Constant term	1152.4474	3591.2778	2504.174	7212.122
1st order term	-154.82601	-502.79954	-355.817	-1028.9946
2nd order term	8.1001037	26.79701	19.46179	55.36490
3rd order term	-0.1939643	-0.637059	-0.475698	-1.324180
4th order term	0.0017922	0.005700	0.004380	0.0118772
	$09^h\ 30^m$ - $15^h\ 00^m$	$09^h\ 30^m$ - $16^h\ 10^m$	$09^h\ 50^m$ - $17^h\ 40^m$	$09^h\ 10^m$ - $18^h\ 00^m$
Constant term	-861.28128	-524.18081	232.354	-68.964
1st order term	284.66317	177.730175	-49.551	29.8951
2nd order term	-34.147685	-20.305173	5.345738	-2.67264
3rd order term	1.8109399	1.015377	-0.259159	0.096839
4th order term	-0.0359354	-0.018789	0.004702	-0.0011721

(3) PULSE-8.

The PULSE-8 system, developed by Decca Co. of U.K. for various survey purposes, is a medium range positioning system. Its principle of measurement is similar to that of Loran C. The comparison of specifications between these two systems is shown in Table 3.

Table 3.

Signal characteristic	Loran C	PULSE-8
Carrier frequency	100 kHz	100 kHz
Pulse group	Master : 9, Slave : 8	Master and Slave : 8 each
Basic pulse repetition rate	30, 40, 50, 60, 80 and 100 milliseconds	100 microsecond steps from 20 to 100 milliseconds
Specific pulse repetition rate	Less than the basic pulse repetition rate by 0, 100, 200, 300, 400, 500, 600, and 700 microseconds.	Less than the basic pulse repetition rate by 0, 100, 200, 300, 400, 500, 600, 700, 800, and 900 microseconds.
Pulse length	About 450 - 650 microseconds	About 400 - 450 microseconds
Phase code	16 bits, 2 x 8 matrix	16 bits, 2 x 8 matrix
Peak power transmitted	250 kW - 4 MW	100W; 150-foot antenna 1 kW; 300-foot antenna

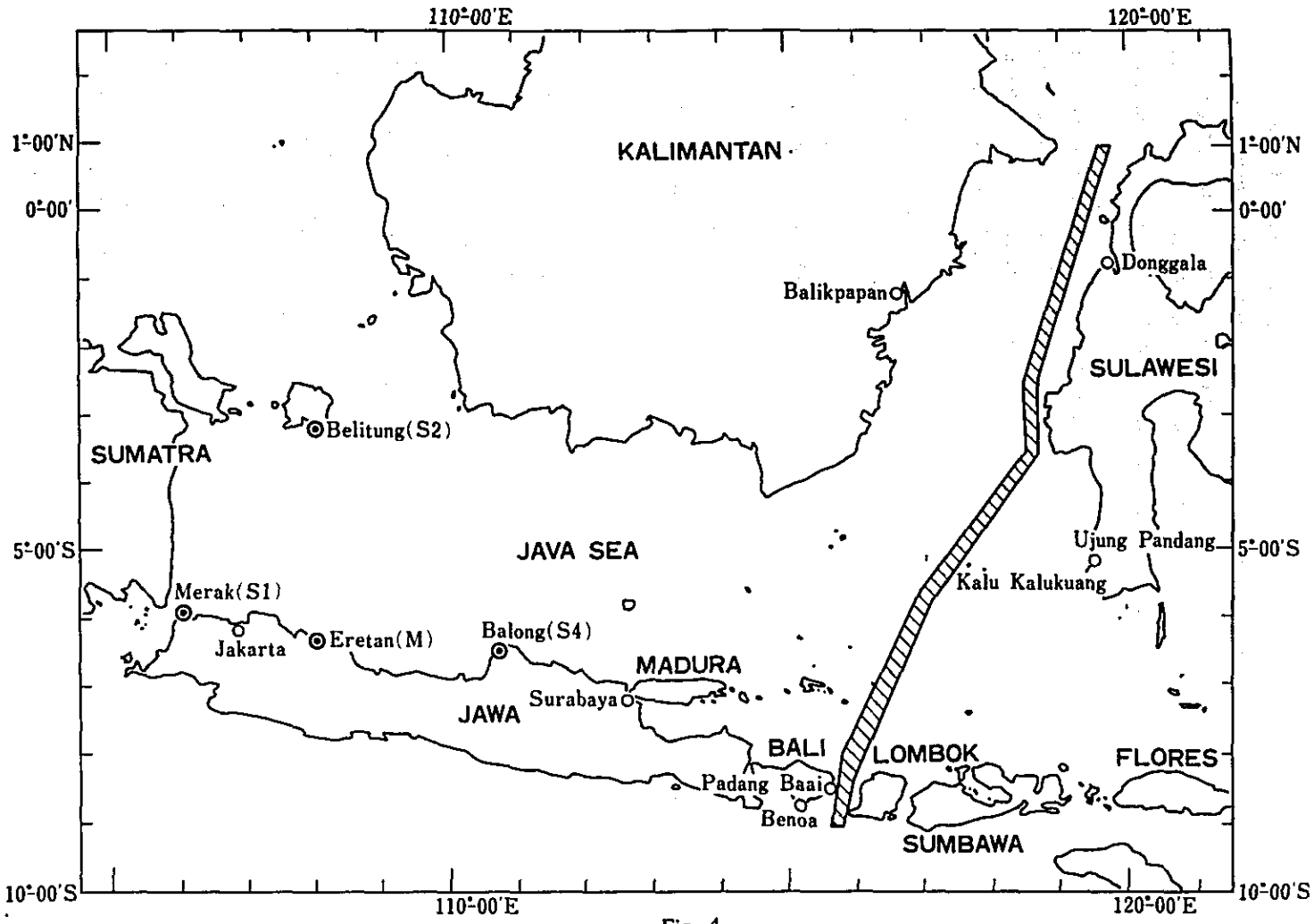

110°-00'E
120°-00'E
1°-00'N
0°-00'
5°-00'S
10°-00'S
KALIMANTAN
Balikpapan
Donggala
SULAWESI
Belitung(S2)
SUMATRA
JAVA SEA
Ujung Pandang
Kalu Kalukuang
Merak(S1)
Jakarta
Eretan(M)
Balong(S4)
MADURA
Surabaya
JAWA
BALI
LOMBOK
FLORES
Padang Baai
Benoa
SUMBAWA

Fig. 4

The deployment of PULSE-8 chain in western Java Sea is as shown in Fig. 4, which is composed of a master and three slave stations. The names of places where those stations are located and their geographical coordinates are shown in Table 4. Of these stations, those signals used in the survey were from the Master, Slave 2 and Slave 4 stations. The latitudes and longitudes of those stations based on the Satellite Datum computed from the results of the reconnaissance are shown in Table 5.

The PULSE-8 was used in the rho-rho mode, but not in the ordinary hyperbolic mode. The composition of the receiver in the rho-rho mode is shown in Fig. 5. This receiver was connected to the computer (B) of the hybrid system in place of the Loran C receiver. Over all the area where PULSE-8 was used, reception of ground waves could be made and the maximum range of propagation attained was 610 miles.

Table 4.

Station – Place name	Latitude	Longitude
Master (PL8-M) Eretan	6° 19' 04.30" S	108° 04' 06.46" E
Slave 1 (PL8-1) Merak	5° 53' 14.87" S	106° 04' 12.80" E
Slave 2 (PL8-2) Belitung	3° 13' 49.99" S	107° 58' 06.01" E
Slave 4 (PL8-4) Balong	6° 26' 51.70" S	110° 47' 49.82" E

Remarks: Indonesian Datum.

Table 5.

Station	Latitude	Longitude
Master	6° 19' 04.386"S	108° 04' 10.593" E
Slave 2	3° 13' 51.204" S	107° 58' 10.167" E
Slave 4	6° 26' 51.719" S	110° 47' 52.770" E

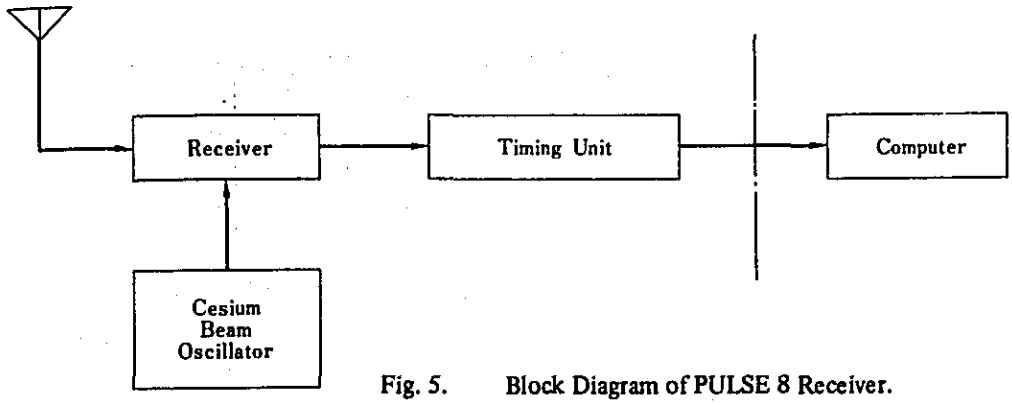


Fig. 5. Block Diagram of PULSE 8 Receiver.

The signal to noise ratio of PULSE-8 in the survey area also deteriorated at the time of sunrise and sunset, but there were not many days when the measurement became impossible. Sky wave observation at fixed positions was not conducted.

The hybrid system including PULSE-8 receiver was equipped on the bridge of the survey ship KRI BURUJULASAD. The electric power for operation of the system was supplied from the main generator on board KRI BURUJULASAD, which was partly stabilized by means of the temporarily equipped automatic voltage and frequency stabilizer. The system was operated by two surveyors, each of them being on watch every four hours alternately.

2 - 4 - 1 - 2. Audister.

The Responders of Audister for positioning in the Specified Area were located as shown in Fig. 6. For the best signal reception, Responder 1 antenna was set up in position 60.5 metres 156.5° from the triangulation station T.584 in Pulau Bali, geographical coordinates of which are as follows:

Lat. 8° 26′ 12″.58 S

Long. 115° 38′ 26″.63 E

The antenna of Responder 2 was erected at the position fixed by the reconnaissance, which is as follows:

Lat. 8° 47′ 01″.47 S

Long. 115° 35′ 39″.08 E.

Clearing up the trees around Responder stations No. 1 and No. 2 was carried out to minimize the disturbance of signal reception.

The range pattern 2 was used for ordinary sounding, while the range pattern 1 for cross sounding.

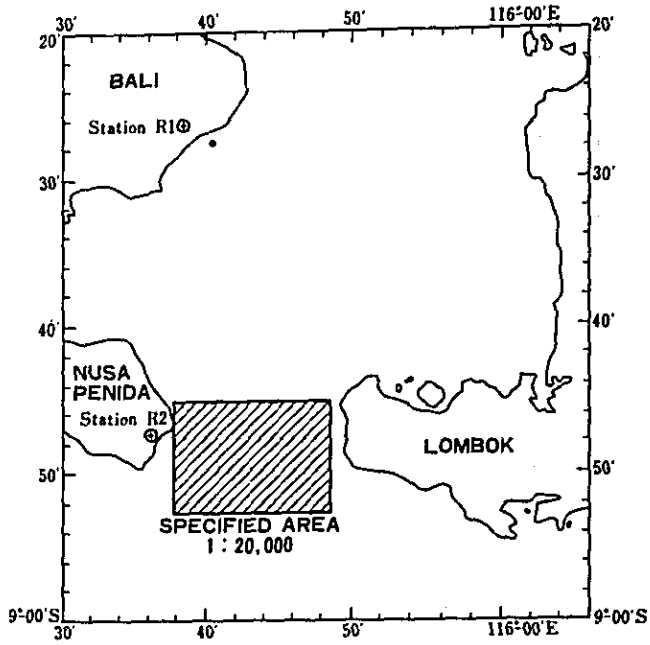


Fig. 6

2 - 4 - 2. Sounding.

The echo sounder used for sounding in waters of more than 200 metres deep was of type MS-26J (Kelvin Hughes) equipped on board the survey ship KRI BURUJULASAD. In order to eliminate any recording error due to hunting of the motor of its recorder, an electronic time interval counter was newly attached to the echo sounder to measure the rotating cycle of the stylus. At the same time of position fixing every 5 minutes, the indicated value on the counter was read out. Then, correction values were obtained from the correction table prepared in advance, and they were added to or subtracted from the sounding values measured. During the course of sounding, the MS-26J type echo sounder became out of order. Accordingly, the recorder and the counter were detached from the broken echo sounder and connected to the transducer, transmitter and receiver of another echo sounder for navigational use. This converted echo sounder was temporarily used. The output transformer which had broken was sent to Surabaya, where repairment was successfully made by exchanging all of the coils and insulators. Sounding thereafter was again conducted by using the MS-26J type echo sounder.

The echo sounder used in the waters of less than 200 metres deep was of type NS-39 (NEC). Its recorder, transmitter and receiver were installed on the bridge of the survey ship, while the transducers were tentatively equipped on the port side of the hull. The frequency of the ultrasonic waves used in the echo sounder was 100 kHz, and the width of the sound beam of the transducer was 16°. The recording scale was 6.5 mm/metre. The width of the recording paper was 30 cm and the recording range was 40 m. The stylus was driven by the synchronous motor controlled by the accurate and stable alternating current generated by the crystal oscillator.

Bar check for correction of the speed of sound in sea water for sounding value was not

conducted. Based on the examination of the data on temperature and salinity of sea water in the vicinity of the Lombok and Makassar Straits filed and stored at the Japanese Oceanographic Data Center, it was decided that a sound velocity correction table should be applied to soundings all over the survey area. The correction values on this table were obtained by computation according to Kuwahara's Method from the oceanographic data. The oceanographic data used and the correction values are shown in Table 6.

OCEANOGRAPHIC DATA AND SOUND VELOCITY CORRECTION

Table 6.

Depth (m)	Temp. (°C)	Salinity (‰)	Sound Velocity Correction (m)
0	28.20	33.82	0.0
10	28.20	33.80	0.25
20	28.12	33.91	0.50
30	28.02	33.97	0.74
50	27.81	34.05	1.24
75	23.38	34.42	1.79
100	20.22	34.60	2.19
125	18.81	34.62	2.50
150	17.47	34.62	2.76
200	14.98	34.57	3.10
250	12.73	34.49	3.22
300	10.87	34.45	3.14
400	8.34	34.50	2.53
500	7.48	34.54	1.62
600	6.70	34.54	0.62
700	5.97	34.54	-0.46
800	5.38	34.55	-1.60
900	4.98	34.55	-2.75
1,000	4.64	34.56	-3.88
1,100	4.35	34.57	-4.98
1,200	4.12	34.57	-6.02
1,300	3.99	34.57	-7.00
1,400	3.88	34.58	-7.89
1,500	3.79	34.58	-8.68
1,750	3.72	34.58	-10.09
2,000	3.66	34.59	-10.99
2,500	3.57	34.60	-10.43

Observation Position: 0° – 49′ N , 119° – 17′ E

2-4-3. Tidal Observation.

2-4-3-1. Northern Part of the Survey Area.

On May 19, 1975, i.e. shortly before the commencement of the survey, two pressure type tide gauges and a TG-2A tide gauge were established at Donggala.

In establishing the pressure type tide gauges, reconnaissance of the site was made, and it was found that the water depth inside the jetty at Donggala was unsuitable as it was too shallow to set the tide gauges. Accordingly, the gauges were established outside the jetty, about 15 metres off the extremity of the jetty. At the same time, a tide pole was erected close to the sensors of the tide gauges. Observation started immediately after the establishment, and good records were obtained for 21 days until June 11 when the gauges were removed. At the time of commencement and ending of the observation, checking of the zero mark of recording papers of tide gauges was made by comparison with the observation record of the tide pole, and it was confirmed that there had been no change in the zero mark during the period of observation. Visual observation of the tide pole was carried out every 30 minutes during the whole period, and the data were compared with the record of the tide gauges.

A bench mark was engraved on the wall of the Port Authority building and was connected to the temporary bench mark on the jetty.

2-4-3-2. Central Part of the Survey Area.

As for the tidal observation station in the central part of the Survey Area, Pulau Kalu Kalukuang was selected. Two pressure type automatic tide gauges and a tide pole were established in position about 50 metres off the shore but inside the coral reef at the western part of the island. One of the two gauges became inoperative shortly after the establishment. Recording of the other gauge also became out of order possibly due to malfunctioning of the sensor from about July 9, but on July 12 the sensor was restored to the normal operation. Accordingly, for 38 days until July 28, good observation records were obtained except the poor recording for those three days.

The zero mark of the recording was connected to the top of a concrete pillar of 0.3 m × 0.3 m × 1.0 m erected near the observation hut. The zero mark of the recording was checked by levelling at the time of commencement and ending of the observation, and it was confirmed that there was no change during the period of observation.

2-4-3-3. Southern Part of the Survey Area.

Utilizing the ferry boat pier at the extremity of the jetty in Padang Baai, an LFT and a TG-2A tide gauge were established on July 5, 1975. The pipe used as a well for the LFT was tightly bound to a pillar of the pier. The recorder was set on the jetty, from which a 7-metre long wire was extended to the well. A tide pole was erected at the same position of the pipe.

The TG-2A tide gauge was established about 4 metres off the pier, where the depth was 3 metres.

At the observation site, swells, though slightly, were coming in the bay from the Indian Ocean through the Lombok Strait. Accordingly, the record caught the vertical motion of the sea level due to the swell, the fluctuation of the tidal curve ranging about 5 cm.

At this site, observation continued for about two months until August 27, and good records were obtained throughout the period.

During the period, the data from the observation of the tide pole every 30 minutes were compared with the record of the tide gauge for checking. Also, at the time of commencement and ending of the observation, the zero mark of the recording was checked by levelling and it was confirmed that there was no change during the period of observation.

As for the bench mark, a temporary B.M. I was engraved at the edge of the pier. At the end of the observation, B.M. II was engraved on the wall of the Port Authority building.

B.M. I and B.M. II were mutually connected by levelling.

2-4-4. Tidal Current Observation.

2-4-4-1. *Central Part of the Survey Area.*

According to the original plan, current meters were to be set near Sibbald Bank south-southwestward of Pulau Kalu Kalukuang. However, water depths and condition of the bottom topography were unfavourable for setting a current meter, so that another site northward of the planned position was selected in position (5° 29′ 40″ S, 117° 25′ 41″ E) about 22 miles south-southwestward of Pulau Kalu Kalukuang, where two long-term self-recording current meters were set at a place where the seabed was comparatively flat.

Since this position was more or less distant from the survey area, exchanging of recording papers was made only twice, on July 10 and 21. The meters were recovered on July 27. Good records of data were obtained for 30 days.

2-4-4-2. Lombok Strait.

On July 22, 1975 two long-term self-recording current meters were set in position (8° 47′ 07″ S, 115° 47′ 11″ E.) in the Lombok Strait. The sea state during the period of survey was unfavourable since in the area extending from the narrowest part of the Strait to the southward, swells from the Indian Ocean entered and, in addition, the currents were very strong.

On August 5, in order to exchange recording papers, the observation station was visited by the survey team, but the current meters could not be found. Judging from the sea conditions in the vicinity, it was considered that the current meters had sunk underwater due to the strong currents. Accordingly, it was decided to move the observation station to a more favourable place, and new current meters were set in position (8° 44′ 12″ S, 115° 49′ 09″ E) about 3 miles north of the former position. However, those current meters also sunk due to strong currents, and it was impossible to recover them. Accordingly, no observation record was obtained.

2 - 4 - 5. Bottom Sampling.

Bottom sampling was conducted only in two positions. It was considered that the bottom of the narrowest part of the Lombok Strait would be of rocky nature and rugged, so that bottom sampling was scheduled to be conducted there. However, due to the strong currents and unfavourable sea condition, bottom sampling was not carried out in the Lombok Strait. The depths at the two sampling stations were about 1,200 m and 150 m. At both stations, all three types of samplers were used, but only the dredger type gave results.

The characteristic of the bottom at the northern station was mud and fine sand while that at the southern one was coral.

3. DATA PROCESSING

3 - 1. Summary of Data Processing.

3 - 1 - 1. General.

(1) Preliminary data processing and the progress report of the survey were made on board KRI BURUJULASAD during the survey period, whilst the final processing was conducted in Jakarta, from September 25 to December 25, 1975.

(2) Six smooth sheets were constructed, five on Mercator and one on UTM Grids (Bessel Spheroid) at the scales of 1 : 250,000 and 1 : 20,000 covering the entire area including Area V (Specified Area).

3 - 1 - 2. Position Fixing.

(1) First phase of data processing was the transferring of NNSS and Loran C raw data from paper tapes onto magnetic tapes. The processing of the data was done by computer. The computer program was designed to perform the selection and adjustment of data obtained and to transform the data on the Indonesian Datum.
The printouts were the coordinates of sounding fixes (φ , λ) and time of sounding.

(2) In Area V or Specified Area, position fixing was made by Audister in two range mode. The ranges at sounding position were automatically recorded.

3 - 1 - 3. Plotting of Position.

(1) Sounding positions, read out from the printouts, were plotted on aluminium-kent papers as the draft for smooth sheets.

(2) The ranges showing fixes of sounding positions in Area V were directly read from the Audister printouts and plotted also on aluminium-kent paper.

3 - 1 - 4. Sounding.

The values of soundings were read out at regular fixes. Shallow water echomarks between the fixes were also read.

(1) Sounding corrections.

The correction values of sound velocity and stylus revolution were applied to the measured depths.

(2) Reductions for Sounding.

The determination of sounding datum was based on the harmonic analysis of tidal constants at each tide station.

Tidal reductions for sounding in Area I were based on the tide data observed at Donggala. For sounding in Areas II and III, tidal reduction was based on the observation at Pulau Kalu Kalukuang.

Sounding in Areas IV and V, tidal reduction applied was based on the observation made at Padang Baai.

Tidal reductions were only applied to depths of less than 200 m.

3 - 1 - 5. Tide and Tidal Current.

3 - 1 - 5 - 1. Tide.

From the data obtained by the observation of tide poles and automatic tide gauges, the hourly values were read out, and harmonic analyses were made.

The periods used for the harmonic analyses were 15 days for Donggala, 30 days for Pulau Kalu Kalukuang and 60 days for Padang Baai.

As two-month observation was made at Padang Baai, the monthly variation was examined, but no appreciable variation was found since the mean sea level was almost at the lowest stage during this two-month period.

3 - 1 - 5 - 2. Tidal Current.

Harmonic analysis was made to the data obtained at the station south-southwestward of Pulau Kalu Kalukuang. From the record, mean values of current directions and velocities every 20 minutes were read out, and the curve of tidal current velocity was drawn. From the curve, the hourly values were read out, and the harmonic analysis was made.

3 - 2. Adjustment and Processing of Rho-Rho Data by Electronic Computer.

3 - 2 - 1. Outline of Processing.

The ship's position (expressed in latitude and longitude) during sounding operation can be obtained every minute by on-line processing. However, there remain some points which cannot be fully processed by the on-line processing. In order to make up these points, it was decided that the rho-rho data would be collected on paper tapes for off-line processing.

The process of computation of ship's position (in latitude and longitude) using the rho-rho data of either Loran C or PULSE-8 is much the same as that of the on-line processing. In the off-line processing, however, it is possible to process all available data *en bloc* to obtain adjusted results.

The outline of the computation and processing is as follows, and is illustrated in Fig. 7:

(i) The rho-rho data punched out on paper tape were moved to MT while they were being checked. Data from sky wave observation (at fixed points) were treated in the same way.

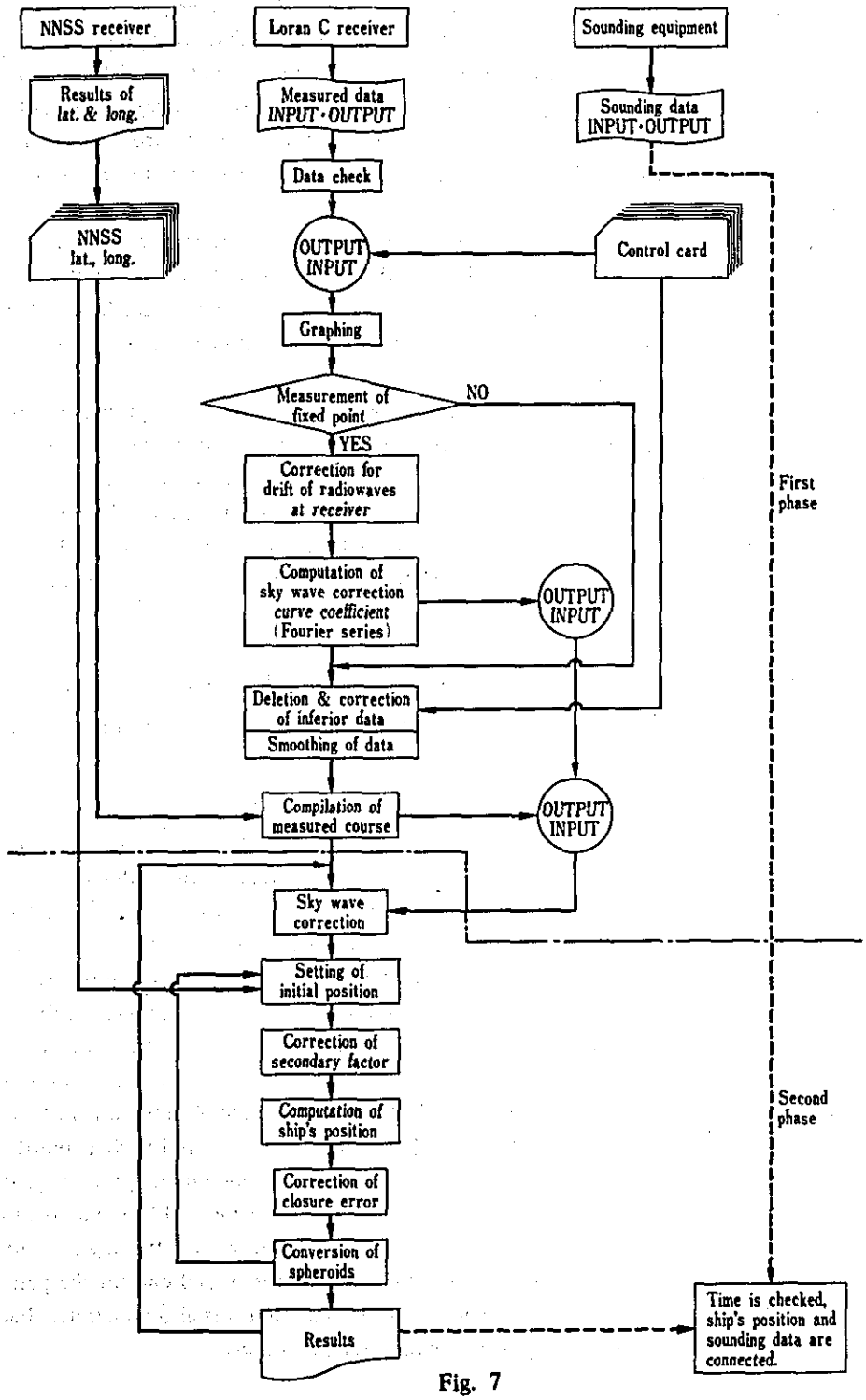

NNSS receiver
Loran C receiver
Sounding equipment
Results of lat. & long.
Measured data INPUT·OUTPUT
Sounding data INPUT·OUTPUT
Data check
NNSS lat., long.
OUTPUT INPUT
Control card
Graphing
Measurement of fixed point
NO
YES
Correction for drift of radiowaves at receiver
Computation of sky wave correction curve coefficient (Fourier series)
OUTPUT INPUT
Deletion & correction of inferior data
Smoothing of data
Compilation of measured course
OUTPUT INPUT
Sky wave correction
Setting of initial position
Correction of secondary factor
Computation of ship's position
Correction of closure error
Conversion of spheroids
Results
Time is checked, ship's position and sounding data are connected.
First phase
Second phase

Fig. 7

(ii) The rho-rho data moved to MT were graphed according to the time series, and inferior data and unnecessary data were detected. Thus, the control data were prepared.

(iii) The data corrected by the control data were smoothed by the exponential smoothing. In the mean time, as for sky wave observation data (at fixed points), coefficient of approximated curves were computed by using the formula of Fourier series curve. Also, the amount of drift due to standard oscillator frequency at the receiver was obtained.

(iv) The rho-rho data thus smoothed out were divided into groups each of which contained about one day's amount of data. The starting time and ending time of the group were linked with NNSS fixes. A few groups of data thus divided were made as a block, to which coefficients of sky wave correction curves were entered. Thus, compilation of data was completed.

(v) To the data compiled, sky wave corrections were made. After computing an initial fix by NNSS, computations of ship's positions were carried on one after another until it was linked with the next NNSS data. Adjustment was made for the difference between the position fixed by NNSS and that by rho-rho data at the linked position. Furthermore, the fixed positions were converted onto the spheroid adopted in the survey area from the spheroid used in NNSS. Then, the final results of fixed positions were printed out.

3 - 2 - 2. Difference between On-Line and Off-Line Processing and Method of Processing.

Although there is no substantial difference between on-line and off-line processing, they are different in the following points:

(i) Processing of sky wave correction values.

Since Loran C stations were located at remote places, the radio waves to be used were those reflected at the ionosphere, whose altitude were varying, which is known as seasonal and diurnal variations. Of them, the diurnal variation shows abrupt changes at the time of sunrise and sunset, but in general, the variation shows a cyclic change for the period of one day. Accordingly, if observation by rho-rho is carried out continuously for 24 hours at a fixed station, the variation in observed rho-rho values will show the variation in altitude of the ionosphere, forming a pattern according to the time series. If corrections are made according to the time series by means of curves approximated to the pattern, the data will be processed as those obtained from radiowaves reflected from a stable ionosphere whose variation in altitude is omitted, and thus the accuracy of measurement will be raised. In the on-line processing, the data for one day were divided into three groups, one for the period from midnight to the time before sunrise when the variation was moderate, one for the daytime from sunrise to sunset at both of which abrupt changes occurred, and one for the period from the time after sunset to midnight when the variation was also moderate. Each group was approximated by a quadric equation for corrections.

On the other hand, in the off-line processing, the data for 24 hours were expressed by a functional equation, for which a Fourier functional equation was used.

The number of terms adopted was 71 each of sine and cosine terms. The residual in this case was within 0.1 microsecond as for the data at 10 minutes' intervals. Thus, good approximated curves could be obtained.

In the on-line processing, based on the data obtained by the observation of sky waves (at fixed stations) carried out in advance of the commencement of position fixing, subsequent corrections were to be made. Accordingly, the correction was a kind of extrapolation. While, in the off-line processing, data obtained before and after the time of position fixing could be used, and thus the correction was as a sort of interpolation.

(ii) Correction of Drift.

In the rho-rho mode, errors in the measurement occur if there is a drift of phase signals of the standard oscillator of the receiver to the phase of signals from the transmitting station. Therefore, the system is so devised that such a drift may be corrected. The amount of drift can be obtained at the time of sky wave observation at fixed stations. In the present survey, however, corrections for the drift were not required.

(iii) Correction of Data.

The raw rho-rho data may contain inferior data due to unlocking caused by non-reception of signals or weakened signals at the time of sunrise and sunset, as well as unnecessary data. In the on-line processing, it was necessary to make initial setting again after the recovery of the signals. On the other hand, in the off-line processing all the data were graphed according to the time series by using an automatic plotter, from which inferior or unnecessary data were detected for correction or deletion.

(iv) Smoothing of Data.

In the on-line processing, 60 values measured every minute were taken and averaged, and were made as the data for every minute. The off-line raw data were collected at 10-second intervals. The scattering of Loran C measurements was in a small range, while that of PULSE-8 was considerably wide. Accordingly, the raw data were smoothed by means of exponential smoothing, and the data of every minute were obtained. In this case, in the on-line processing the data took the form of independent mean, but in off-line processing they could take the form of processing continual values.

(v) Compilation of Data.

The data thus smoothened and corrected were grouped into one day's amount for more effective progress of computation.

(vi) Correction of Secondary factors.

As the assumed propagation velocity of radiowaves of Loran C, 299,692.9 km/sec was used. However, the actual velocity varied slightly mainly due to the variation of the earth's conductivity. Correction for this difference is called the secondary factor correction, whose values can be expressed as the function of distance. In the off-line processing, this correction was made.

(vii) Adjustment Computation.

For computation of positions by using rho-rho data, the initial position was given by NNSS fixed position and the computation was made to adjust those rho-rho positions with the subsequent NNSS fixed position.

In this computation, adjustment was distributed as follows:

$$\Delta\varphi_i = \frac{\sum^{i} \Delta S_i}{S} \quad \Delta\varphi$$

$$\Delta\lambda_i = \frac{\sum^{i} \Delta S_i}{S} \quad \Delta\lambda$$

where :

$\Delta\varphi$ = Difference in latitude

$\Delta\lambda$ = Difference in longitude

ΔS_i = Distance between each rho-rho fix

S = Totaled distance between each NNSS fix

3 - 3. Conversion of Spheroids.

The spheroid on which the survey should be based is that of Bessel (1841) and the geodetic datum should be Indonesian datum. However, the spheroid employed in the hybrid positioning system is NWL-8D. Therefore, during the data processing, conversion of datum was carried out to eliminate the discrepancies derived from using those two spheroids. Accordingly, conversion from the spheroid of NWL-8D to that of Bessel was made by Moldenskii's conversion formula using those constants obtained from the data of NNSS measurements carried out at Pulau Bali during the reconnaissance.

The computation was carried out separately in the off-line processing by a large computer and a computer program for this purpose was newly prepared.

In the off-line processing, the electronic computer UNIVAC 1106 was used, the computation being in charge of the Computer Science Center of the University of Indonesia.

3 - 4. Smooth Sheets of Survey and Specifications.

No.	Feature	Lombok Strait	Makassar Strait
1	Number of sheets	Sheet V and Specified Area (two sheets)	Sheet I, II, III and IV (four sheets)
2	Dimensions of sheets	Sheet V: 66.784 x 96.780 cm Specified Area: 128.31 x 78.32 cm	Sheet I : 66.784 x 95.828 cm Sheet II : 66.784 x 95.882 cm Sheet III : 66.784 x 96.055 cm Sheet IV : 66.784 x 96.348 cm
3	*Graticules or Grids*	Sheet V: Every 10' with 1' tick, outward of border line. Specified Area: Every 1'.	Every 10' with 1' ticks, outward of border line.
4	Overlapping	–	5' and 10'
5	Projection	Sheet V: Mercator Specified Area: UTM	Mercator
6	*Scale*	Sheet V: 1/250,000 Specified Area: 1/20,000	1/250,000
7	Standard parallel of latitude	0°	0°
8	Central Meridian	117° E (Specified Area)	

3 - 5. List of Data Processing Team Members.

(1) Indonesia

1)	Ltk. Laut L.P. Katoppo	– Naval Hydrographic Service
2)	May. Laut M.J. Sitepu	– " –
3)	May. Laut Ir. Suwito Pranoto Utomo	– " –
4)	Kpt. Laut Sutarto	– " –
5)	Kpt. Laut Suarno	– " –
6)	Kpt. Laut M.P. Silaban	– " –
7)	Kpt. Laut Gunadi Gan	– " –
8)	Kpt. Laut Driyo Utomo	– " –
9)	Kpt. Laut Ir. P. Subihanto	– " –
10)	Lettu. Laut Rianoe Bunet	– " –
11)	Lettu. Laut Mukidin	– " –
12)	Lettu. Laut Mintardjono	– " –
13)	Mr. Ir. Sem Saimima	– " –
14)	Mr. Ir. Frans Supit	– " –
15)	Mr. Ir. Joseph F.P. Luhukay	– University of Indonesia
16)	Miss Ir. Aniati Murni	– " –
17)	Mr. Oetoro	– Naval Hydrographic Service
18)	Mr. Basimin	– " –
19)	Mr. P. Sunuroto	– " –
20)	Mr. Age Busono	– " –

(2) Japan

1)	Mr. T. Uchino	– Hydrographic Department, Maritime Safety Agency
2)	Mr. Y. Oyamada	– " –
3)	Mr. S. Kozawa	– " –
4)	Mr. M. Kawanabe	– " –
5)	Captain Y. Saito	– Malacca Strait Council

4. FINDINGS.

4 - 1. Sounding.

(1) Soundings charted on Indonesian Charts No. 111, 120 and 121 mostly agree with those obtained in this survey.

(2) Shallow water area formed of live coral lies about 17 miles east of Pulau Sekala at position 07° 10' 04" S - 116° 13' 01" E, with depths of more than 72 m.

(3) No depth of less than 900 m was found in Areas I and II.

(4) In Area V (Specified Area), no depth of less than 100 m was found. The shallowest depth measured was 126 m.

4 - 2. Tide and Tidal Current.

4 - 2 - 1. Tide.

From the results of the comparison between the harmonic analyses of data at Donggala, Pulau Kalu Kalukuang and Padang Baai and the constants shown in the Admiralty Tide Tables, it was found that there was no significant difference. The sum of the principal constituents at Pulau Kalu Kalukuang was 0.16 m larger than that in the Admiralty Tide Tables. At Padang Baai, it was 0.10 m larger. However, the phase angles were almost the same. The constants obtained from the results of the harmonic analyses are shown in Table 7.

The relationship between the bench marks established in the above three observation stations and the datum level is shown in Figs 8, 9 and 10.

Sounding Datum at each observation station is as follows:

(1) Donggala : 3.801 m below the bench mark on the wall of the Port Authority building.

(2) Pulau Kalu Kalukuang : 2.777 m below the bench mark established on the west coast of the island.

(3) Padang Baai : 3.121 m below the bench mark on the wall of the Port Authority building.

TIDAL CONSTANTS

Table 7. 1

STATION : DONGGALA LAT. : 0 39 30 S LONG. : 119 44 30 E ZONE : 08 h 00 m EPOCH : 1975 5 20 00 h DURATION ; 15 days			
CONST.	Hcm	Kdeg.	Gdeg.
K_1	20.8	259	260
O_1	12.4	266	258
P_1	6.9	259	259
Q_1	1.7	277	264
M_2	51.4	163	155
S_2	32.6	212	213
N_2	7.6	154	142
K_2	8.9	212	213
M_4	0.7	331	316
MS_4	0.5	71	64

STATION : KALU KALUKUANG LAT. : 5 12 17 S LONG. : 117 37 27 E ZONE : 08 h 00 m EPOCH : 1975 6 21 00 h DURATION: 30 days			
CONST.	Hcm	Kdeg.	Gdeg.
K_1	25.2	288.7	291.4
O_1	19.0	265.3	259.2
P_1	8.4	288.7	290.8
Q_1	4.1	267.9	257.5
M_2	17.0	68.5	65.1
S_2	14.7	191.3	196.0
N_2	2.2	358.3	350.6
L_2	1.5	57.6	58.6
K_2	4.0	191.3	196.7
NU_2	0.4	358.3	351.1
MU_2	1.4	182.6	171.1
M_4	1.4	312.4	305.6
MS_4	1.0	13.3	14.7

STATION : PADANG BAAI LAT. : 8 32 00 S LONG. : 115 30 45 E ZONE : 08 h 00 m EPOCH : 1975 7 6 00 h DURATION : 50 days			
CONST.	Hcm	Kdeg.	Gdeg.
K_1	30.8	288.7	293.5
O_1	21.3	264.9	261.0
P_1	10.3	288.7	292.9
Q_1	4.8	276.4	268.1
M_2	35.1	299.8	300.6
S_2	21.8	326.8	335.8
N_2	6.1	284.3	280.8
L_2	0.7	340.1	345.3
K_2	6.0	326.8	336.4
NU_2	1.2	284.3	281.4
MU_2	1.6	190.8	183.5
M_4	1.4	134.9	136.6
MS_4	0.8	315.2	325.1

NON-HARMONIC CONSTANTS OF TIDES

Table 7. 2

POSITION	DURATION	HM+HS	HM-HS	HK_1+HO_1	$\frac{HK_1+HO_1}{HM+HS}$	$\frac{HM-HS}{HM+HS}$	KS-KM	KK_1-KO_1	KM/29	$\frac{KK_1+KO_1}{2\cdot15}$	HM + HS $+HK_1+HO_1$	M.S.L.	M.S.L.+S.C
DONGGALA (POLE)	20/5-3/6	0.838	0.190	0.333	0.397	0.227	50	352	5.586	17.5	1.171	1.000	1.020
(GAUGE)	"	0.840	0.188	0.332	0.395	0.224	49	353	5.621	17.5	1.172	2.140	2.160
KALU KALUKUANG											Z_0 = 1.17		
(POLE)	21/6-20/7	0.318	0.022	0.444	1.396	0.069	124.1	23.1	2.359	18.46	0.762	1.411	1.481
(GAUGE)	21/6-20/7	0.317	0.023	0.442	1.294	0.073	122.7	23.4	2.366	18.47	0.759	1.702	1.772
PADANG BAAI											Z_0 = 0.76		
(POLE)	6/7-4/8	0.574	0.134	0.513	0.894	0.233	27.1	29.6	10.297	18.41	1.087	1.526	1.626
	27/7-25/8	0.568	0.132	0.527	0.928	0.232	27.1	18.9	10.397	18.49	1.095	1.526	1.626
											Z_0 = 1.10		
(GAUGE)	6/7-4/8	0.569	0.135	0.514	0.903	0.237	27.4	29.4	10.279	18.40	1.083	1.837	1.937
	27/7-25/8	0.569	0.131	0.527	0.926	0.230	26.6	18.2	10.393	18.50	1.096	1.837	1.937
											Z_0 = 1.10		

RELATIONSHIP BETWEEN VARIOUS LEVELS
AT
DONGGALA

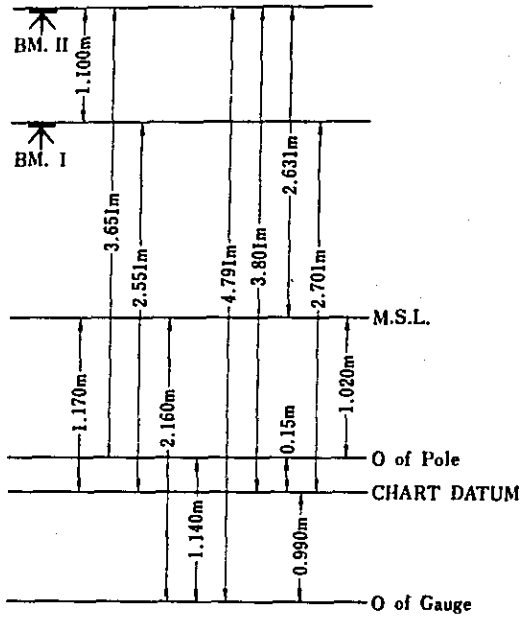


Fig. 8

RELATIONSHIP BETWEEN VARIOUS LEVELS
AT
PULAU KALU KALUKUANG

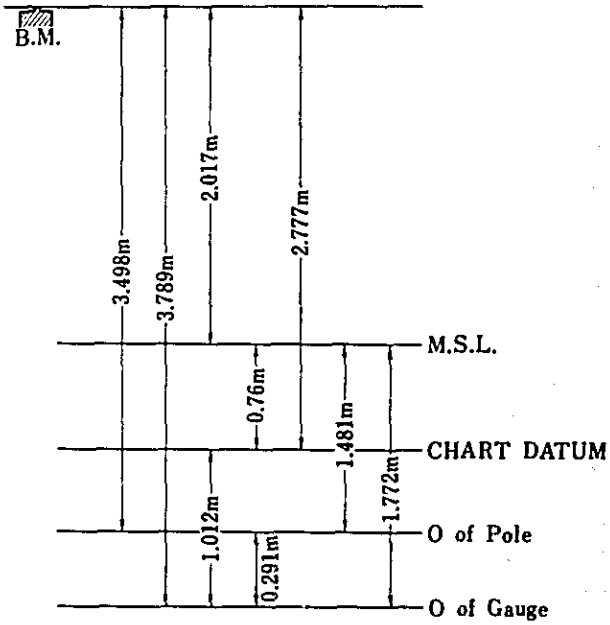


Fig. 9

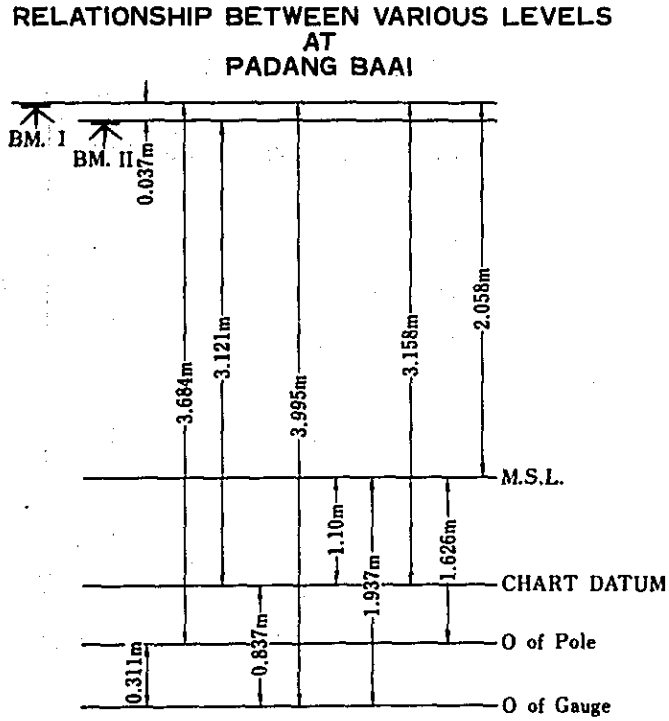


Fig. 10

4 - 2 - 2. Tidal Current.

It was found that at the station south-southwestward of Pulau Kalu Kalukuang the ratio between the diurnal and semi-diurnal tidal currents $(K_1 + O_1)/(M_2 + S_2)$ was 0.93, which was almost the same as that of the tides in this vicinity.

Tidal currents were found flowing in the north-south direction, but weak east-west going currents were also observed.

The maximum velocities measured at the station were 1.30 kn in 340° direction and 1.06 kn in 142° direction. From the result of the analysis, the non-tidal current was flowing at a speed of 0.19 kn in 243° direction. Tidal current constants are shown in Table 8.

TIDAL CURRENT CONSTANTS

Table 8

STATION	:	SSW OF KALU KALUKUANG 22M	
LAT.	:	5 29 40 S	
LONG.	:	117 25 41 E	
ZONE	:	08 h 00 m	
EPOCH	:	1975. 6 27 12 h	
DURATION	:	30 DAYS	
CONST.		HH kn	G deg.	K deg.
K_1		0.217	75.2	78.1
O_1		0.149	42.7	36.8
P_1		0.072	75.4	77.6
Q_1		0.032	35.8	25.6
M_2		0.271	67.7	64.7
S_2		0.122	89.2	94.3
N_2		0.051	38.3	30.9
L_2		0.043	60.5	61.9
K_2		0.034	89.2	95.0
NU_2		0.010	37.9	31.1
NU_2		0.027	47.4	36.3
M_4		0.036	117.4	111.4
MS_4		0.041	209.5	211.7

Direction: (+) 336°

CONSTANT CURRENT -0.011 kn

ANNEX I

HYDROGRAPHIC SURVEY OF THE LOMBOK AND MAKASSAR STRAITS

I. INTRODUCTION

The proposed hydrographic survey will be carried out by Indonesia using Indonesian vessels with assistance from Japan, to promote safety of navigation in the Straits of Lombok and Makassar primarily to survey a route for merchant vessels including tankers, which are unable to navigate safely through other Straits.

II. AREAS TO BE SURVEYED

Whereas the Government of Indonesia has approved to survey the following area as defined by the co-ordinates:

A.	Lat.	09°	00′	00″	S	–	Long.	115°	35′	00″ E
B.		08°	03′	00″	S	–		115°	48′	00″ E
C.		05°	34′	00″	S	–		116°	55′	00″ E
D.		03°	27′	00″	S	–		118°	29′	00″ E
E.		02°	32′	00″	S	–		118°	30′	00″ E
F.		01°	00′	00″	N	–		119°	36′	00″ E
G.		01°	00′	00″	N	–		119°	48′	00″ E
H.		02°	34′	00″	S	–		118°	41′	00″ E
J.		03°	31′	00″	S	–		118°	42′	00″ E
K.		05°	40′	00″	S	–		117°	05′	00″ E
L.		08°	15′	00″	S	–		115°	55′	00″ E
M.		09°	00′	00″	S	–		115°	46′	00″ E

III. EXECUTION OF SURVEY

Method

1. Ellipsoid : Bessel 1841.
2. Projection : Mercator / UTM
3. Scale : 1 : 250.000 , 1 : 20.000
4. Execution

a. Reconnaissance:

1) Purpose of the reconnaissance is :

a) To transform the Fisher spheroid and Mercury Datum to the Bessel spheroid and Indonesian Datum effectual for that area.

b) To determine the position of Tg.Manumbaya at approximately $\frac{00^\circ\ 00'\ S}{119^\circ\ 37'\ E}$ (P. 27).

c) To determine the position of the most eastern point of Bali (T. 615 and/or T. 580).

d) To determine the position of Kalu Kalukuang at approximately $\frac{05^\circ\ 11'\ S}{117^\circ\ 37'\ E}$

e) To check the coverage area and the accuracy of Loran C and the receiving condition of the Omega radiowaves in the survey area.

f) To investigate sites for the establishment of tide gauges and current meters.

g) To determine the geodetic position of electronic positioning devices.

h) To investigate the general trend of sea bottom features, particularly those in the vicinity of coral reefs.

2) Equipment:

a) 1 set NNSS (Navy Navigational Satellite System), land survey.

b) 1 set Loran C (Shipborn reciever).

c) 1 set Omega receiver.

d) 3 sets Tellurometer 101.

e) 2 sets Theodolite Wild T-2.

f) 2 sets Theodolite Wild T-0.

g) 4 sets SSB.

h) 1 set Chainsaw, etc.

3) Floating equipment : RI JALANIDHI and a motor launch.

4) Composition of survey team :

a) Indonesia : 12 men and ship's complement.
b) Japan : 6 men.

5) Survey period :

The reconnaissance will be carried out from February 20th till March 31st, 1974.

a)	Jakarta - Ampenan	:	4 days.
b)	Measurements and observations	:	29 days.
c)	Replenishment (Ujungpandang)	:	3 days.
d)	Ampenan - Jakarta	:	4 days.
			40 days.

6) Data Processing :

a) Discussions and study for development of electronic computer programming for data processing will be made in Japan with 2 Indonesian officials participating from January 21st till February 20th, 1974. *)

b) Data processing will be carried out in Jakarta from April 22nd till May 5th, 1974.

7) Discussions and Study on Electronic Positioning Systems :

Discussions and study on electronic positioning systems will be made in Japan with 2 Indonesian officials participating from January 10th till February 9th, 1974. *)

b. Sounding :

1) Sounding area and sounding space :

a) Sounding line interval every one mile traversing the channel, which is approximately 10 nautical miles wide.

---

*) Due application procedures will be observed in accordance with Japan's Technical Cooperation Scheme.

b) In the vicinity of P. Sekala sounding space every 1/2 mile.
The exact area will be determined on the basis of the findings of the investigations during the reconnaissance and of the one-mile interval sounding.

c) In the narrowest part of Lombok Straits, East of Nusa Besar island with an area of approximately 14 x 20 km, sounding space will be between 200 and 400 metres with a scale 1 : 20,000.

Limits of the area are :

08° 45′ S	–	115° 48′.5 E	and
08° 45′ S	–	115° 37′.5 E	
08° 52′.5 S	–	115° 48′.5 E	and
08° 52′.5 S	–	115° 37′.5 E	

2) Position fixing system :

Instruments to determine sounding position :

a) NNSS (Shipborne receiver).

b) Loran C (Shipborne receiver).

c) Audister.

3) Chart Datum :

a) Chart Datum will be determined based on data from automatic tide gauge to be established at :

(1) Padang Baai.

(2) Kalu Kalukuang.

(3) Donggala.

b) Results will be compared with the chart datum in Indonesian chart of the areas concerned.

4) Current observation :

Current will be observed at the following positions :

a) East of Pulau Nusa Besar.

b) At Sibbald Bank.

5) Equipment :

Floating equipment : RI BURUDJULASAD and motor launches :

a) 1 set NNSS (Shipborne receiver).
b) 1 set Loran C (Shipborne receiver).
c) 1 set Deep Sea Echosounder and 1 set shallow water echosounder.
d) Side Scan Sonar.
e) 1 set Audistor.
f) 2 sets Theodolite Wild T-2.
g) 6 sets automatic tide gauge.
h) 4 sets current meters.
j) 2 sets bottom samplers.
k) Radar of the RI BURUDJULASAD.
l) Gyro Compass of the RI BURUDJULASAD.
m) Drawing materials and stationary.
n) Optical and mechanical measuring instruments.
o) 5 sets SSB.
p) Sallog

6) Composition of Survey Team :

a) Indonesia :
   (1) Survey Team : 30 men.
   (2) Crew of RI BRD.
b) Japan : 10 men.

7) Survey period :

The sounding will be carried out from May 10th till September 2nd, 1975.

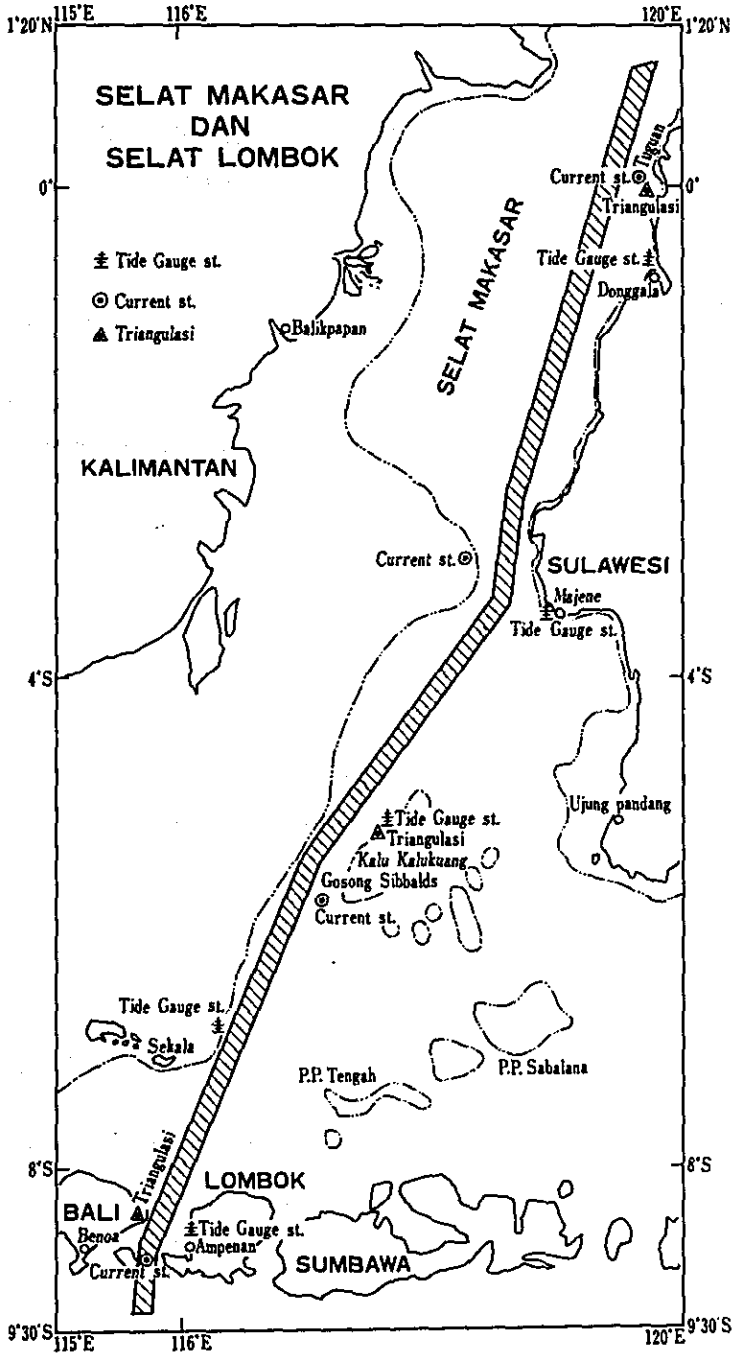
a)	Tanjung Priok – Donggala	=	4 days.
b)	Replenishment (7x)	=	20 days.
c)	Establishment of tide gauges	=	4 days.
d)	Sounding	=	76 days.
e)	Padang Baai–Tanjung Priok	=	4 days.
f)	Spare days	=	8 days.
	Total		116 days.

IV. DATA PROCESSING

1. Obtained data will be temporarily processed during the survey while depths considered dangerous for navigation will be published immediately.
2. Final processing except tides and tidal currents will be carried out in Jakarta from September 25th till December 25th, 1975, with a few members of Japan participating.
3. Reproduction of Reports will be done in Tokyo in the Indonesian, Japanese and English languages.

V. OTHERS

If areas are found which need closer examination, the survey of these areas will be determined later.


SELAT MAKASAR
DAN
SELAT LOMBOK
Tide Gauge st.
Current st.
Triangulasi
Balikpapan
SELAT MAKASAR
KALIMANTAN
Current st.
Current st.
Triangulasi
Tide Gauge st.
Donggala
SULAWESI
Majene
Tide Gauge st.
Ujung pandang
Tide Gauge st.
Triangulasi
Kalu Kalukuang
Gosong Sibbalds
Current st.
Tide Gauge st.
Sekala
P.P. Tengah
P.P. Sabalana
Triangulasi
LOMBOK
BALI
Benoa
Current st.
Tide Gauge st.
Ampenan
SUMBAWA
1°20'N
115°E
116°E
120°E
0°
4°S
8°S
9°30'S

ANNEX II

REPORT OF THE RECONNAISSANCE SURVEY IN THE LOMBOK AND MAKASSAR STRAITS

1. INTRODUCTION

In accordance with the Memorandum of Understanding and the Memorandum of Procedures between the Government of the Republic of Indonesia and the Government of Japan, signed in Jakarta in 1973, it was agreed to conduct a reconnaissance survey prior to the main hydrographic survey of the Straits of Lombok and Makassar, which would be conducted sometime in the year of 1975.

2. OBJECTIVE

The objective of the reconnaissance is to gather hydrographic data and related information to be used in the main hydrographic survey in 1975.

3. SURVEY PLAN

The reconnaissance would be carried out using KRI YALANIDHI for 40 days, from February 20 to March 31, 1974.

The objects of the reconnaissance are:

a. To transform the Fisher spheroid and Mercury Datum to the Bessel spheroid and Indonesian Datum effectual for that area.

b. To determine the position of Tg. Manumbaya at approximately $\frac{00^\circ\ 00'\ S}{119^\circ\ 37'\ E}$ (P. 27).

c. To determine the position of the most eastern point of Bali (T. 615 and/or T. 580).

d. To determine the positon of Kalu Kalukuang of approximately $\frac{05^\circ\ 11'\ S}{117^\circ\ 39'\ E}$.

e. To check the coverage area and the accuracy of Loran C and the receiving conditions of the Omega radiowaves in the survey area.

f. To investigate sites for the establishment of tide gauge and current meters.

g. To determine the geodetic positon of electronic positioning devices.

h. To investigate the general trend of sea bottom features, particularly those in the vicinity of coral reefs.

4. ABSTRACT OF DAILY PROGRESS

February 20, 1974.

- All team members embarked on board KRI YALANIDHI, then she left Tanjung Priok for the survey area on February 21, 1974.

February 24, 1974

- Arrived and anchored at Labuan Amuk, southeast of Pulau Bali.

February 25 - March 4, 1974.

- NNSS measurements at T. 576.
- Selected the sites for tide stations at Pulau Bali.
- Loran C and Omega measurements.
- Selected the sites for Audister Responder stations.

March 5, 1974.

- Sailed for Pulau Sekala.

March 6, 1974.

- Selected the site for tide station at Pulau Sekala.
- Sailed for Pulau Kalu Kalukuang.

March 7, 1974.

- Selected the site for current station near Sibbald Bank Light.
- Arrived at Pulau Kalu Kalukuang.

March 8 - March 9, 1974.

NNSS measurements.

- Selected the site for tide station.

March 10, 1974.

- Sailed for Ujung Pandang.

March 11, 1974

- Arrived at Ujung Pandang.

March 12 - March 14, 1974.

- Supply and replenishment.
- Repairs of motor boat.
- Continued Loran C and NNSS measurements.

March 15, 1974.

- Sailed for Majene.

March 16, 1974.

- Arrived at Majene.
- Selected the site for tide station.
- Sailed for Donggala.

March 17, 1974.

- Arrived at Donggala.

March 18 - March 22, 1974.

- Selected the site for tide station.
- NNSS measurements at P. 25 atop Bukit Silamolo.
- Selected the site for current station near Tuguan Light.

March 23, 1974.

- Left Donggala for Pulau Bali and Pulau Nusa Penida.

March 24, 1974.

- En route to Pulau Bali, selected the site for current station.

March 26, 1974.

- Arrived at Labuan Amuk.
- Geodetic measurements of the sites for Audister Responder stations.

March 27, 1974.

- Selected the site for current station in the Lombok Strait.
- Arrived at Port of Benoa.
- The Japanese members disembarked.

March 28, 1974.

- Sailed for Tanjung Priok.

March 31, 1974.

- KRI YALANIDHI arrived at Tanjung Priok.

5. RESULTS

5 - 1. NNSS Measurements.

(1) At T. 576 (east of Pulau Bali).

	Lat.	Long.	Elevation
T. 576:	08° 27' .100 S	115° 39' .271 E	44.2 + 6.3 m
NNSS :	08° 27' .088 S	115° 39' .285 E	72.2 m
Difference:	0' .012	-0' .014	-26.7 m
	(22.1 m)	(-25.7 m)	

Remarks: 45 measurements.

(2) At Pulau Kalu Kalukuang.

	Lat.	Long.	Elevation
Chart position	05° 11' .933 S	117° 40'.517 E	1.5 + 7 m
NNSS:	05° 11' .850 S	117° 40'.898 E	31.5 m
Difference:	0' .083	-0' .38	-23.0 m
	(152.9 m)	(-702.1 m)	

Remarks: 8 measurements.

(3) At Ujung Pandang.

	Lat.	Long.	Elevation
Chart position	05° 07' .642 S	119° 24' .242 E	
NNSS:	05° 07' .516 S	119° 24' .372 E	
Difference:	0' .126	-0' .130	
	(232.2 m)	(-240.2 m)	

Remarks: 20 measurements.

(4) At P. 25 (Bukit Silamolo).

	Lat.	Long.	Elevation
P. 25 :	0° 28' .486 S	119° 46' .562 E	298.5 + 5.5 m
NNSS :	0° 28' .403 S	119° 46' .695 E	358.2 m
	0' .083	-0' .133	
Difference:	(153.0 m)	(-246.7 m)	(-54.2 m)

Remarks: 31 measurements.

5 - 2. Sites of Audister Responder Stations.

(1) Responder 1 T. 584

Latitude	08°	26′	10″ .770 S
Longitude	115°	38′	25″ .794 E
Height	268.5 m		

Station description:

(a) T. 584 is located on a field, on top of Bukit Melanting about 200 m northeast of temple Melanting.

(b) The pillar marked "T. 584 July 1920" is still in good condition.

(c) It is found that T. 584 meets the requirements for the establishment of an Audister Responder station.
Though it is highly elevated, it is so close to the village that supply is easily available.

(d) Access to the place.

By Sea.

Ship could anchor at Labuan Amuk, then proceeded to Padang Baai by motor boat. From Padang Baai, transportation is available to Kampung Seraya. The temple of Melanting is about 300 m from Kampung Seraya.

(2) Responder 2 At Bukit Tunjuk

Latitude	08°	47′	01″ .467 S
Longitude	115°	35′	39″ .075 E
Height	312.1 m		

Station description:

(a) The station was marked by a temporary pillar, which was erected in front of the temple at Bukit Tunjuk.

(b) Access to the place.
First by motor boat to Kampung Seraya.

Then by land transportation if available to Tanglat, Bukit Tunjuk was accessible only on foot.

(c) The distance between S. 13 and Responder 2 was measured using Telluro-meter MRA 101.

The angle at Responder 2, to S. 13 and T. 643 was measured, using theodolite.

$$\text{T. 643} = \frac{08^\circ\ 46'\ 09''.254\ \text{S}}{115^\circ\ 36'\ 23''.975\ \text{E}}$$

$$\text{S. 13} = \frac{08^\circ\ 47'\ 26''.589\ \text{E}}{115^\circ\ 34'\ 30''.537\ \text{E}}$$

Result of the measurements:

Distance between S. 13 and Responder 2 = 2,233.090 m.

Angle S. 13, Responder 2 and T. 643 = 150° 46' 32".41.

5 - 3. Loran C and Omega Measurements.

The signals from Yap station (SS3-Z), the southernmost station of the Western Pacific Chain (SS3), covered the whole survey area and were measurable continuously for 24 hours. There were some days, however, when the propagation condition deteriorated and the signal strength rapidly decreased for about two hours during the morning and evening twilights.

The signals from ConSon (SH3-Y), the southernmost station of Viet Nam Chain (SH3) could be received all over the survey area.

According to the result of the measurements at fix stations it was found that the signal strength varied continuously during day and night, and signal pahses also varied ranging to 14 microseconds.

No Omega signals from stations Hawai, North Dakota and Norway could be received.

5 - 4. Bottom Configuration

Sounding along the sailing track showed that the bottom topography of the survey area was generaly flat, except in some parts where the inclination reached 5°.

6. REMARKS

6 - 1. Conclusions.

(1) Some modifications of the original plan were necessarily to be made, considering the topographic condition of the field, on the stations for NNSS measurements, sites for tide stations, current stations and also the sites for Audister Responder stations.

(2) Loran C signals from stations Yap and ConSon could be received.

(3) Omega signals from stations Hawai, North Dakota and Norway could not be received.

(4) In the survey area, the sea was considerably rough until the third week of March.

6 - 2. Proposals.

(1) For position fixing, a system consisting of Loran C integrated with Navy Navigation Satellite System (NNSS) is proposed to be used, the system is to be connected to the gyro compass and log of the survey ship.

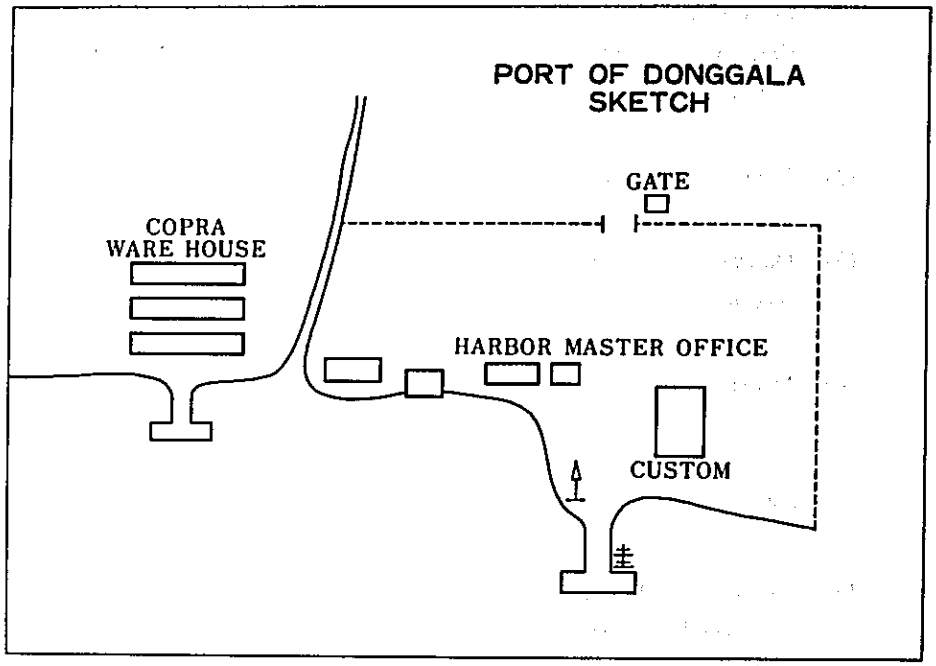
(2) The dividing of the Survey Area is as follows:

Area I	:	From the northern extremity to Cape William (Tg. William).
Area II	:	From Cape William to Sibbald Bank.
Area III	:	From Sibbald Bank to Pulau Nusa Penida.
Area IV	:	Between Pulau Nusa Penida and Pulau Lombok (in the Lombok Strait).

(a) Area I is to be surveyed in the first phase.

Tide station will be set up at Donggala while current station will be at position 00° 35' 10" S - 119° 47' 10" E.

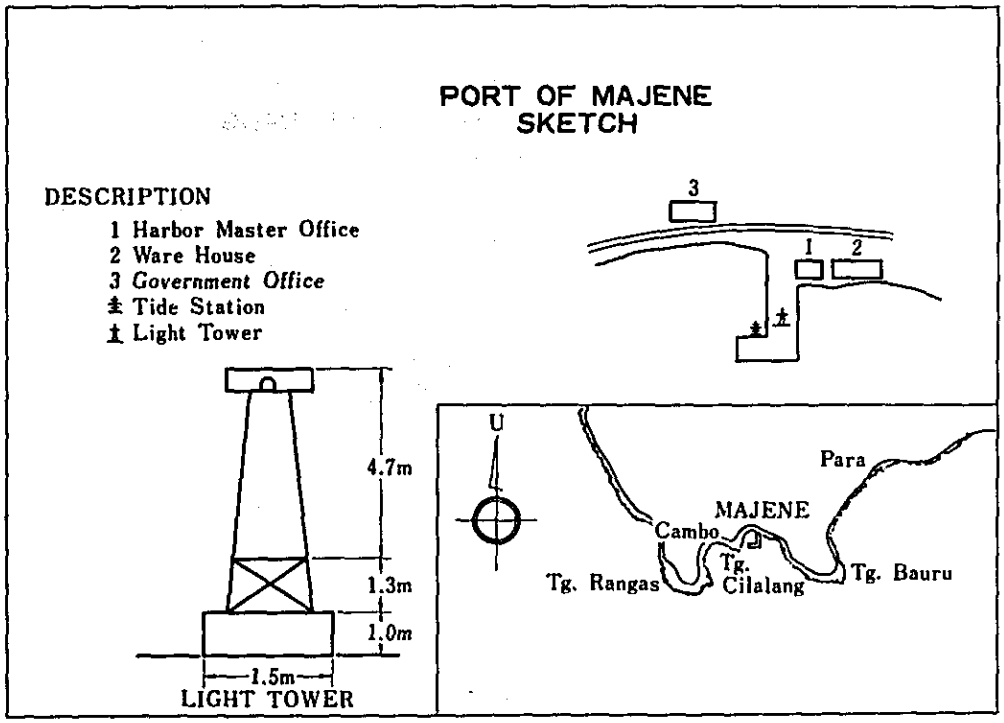
Port for replenishment and supply will be Balikpapan.



(b) Area II is to be surveyed at the second phase:

Tide stations will be set up at Majene and Pulau Kalu Kalukuang while current station will be at positon 03° 07′ 10″ S - 118° 22′ 30″ E.

Port for replenishment and supply will be Ujung Pandang.

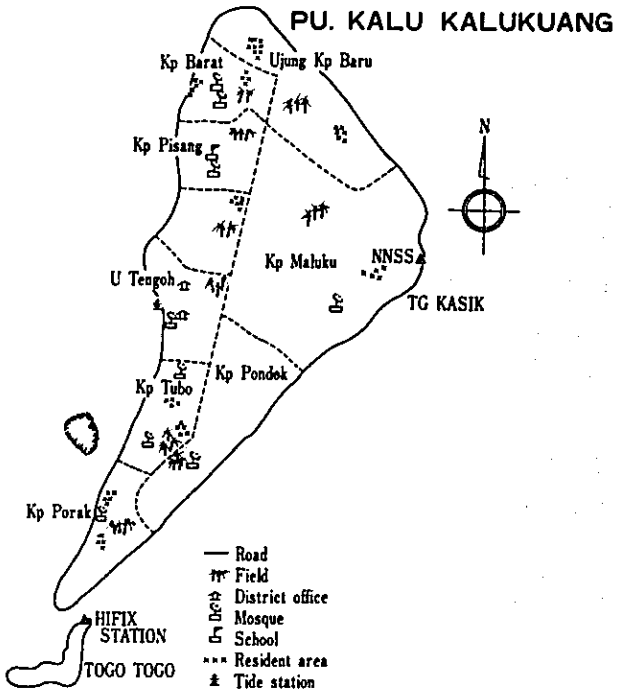


(c) Area III is to be surveyed at the third phase.

Current station will be set up at position 05° 46' 36" S - 117° 06' 50" E.

Tidal reductions for the survey in this area will be obtained from the tidal observations at Pulau Kalu Kalukuang and Padang Baai.

Port for replenishment and supply will be Surabaya.



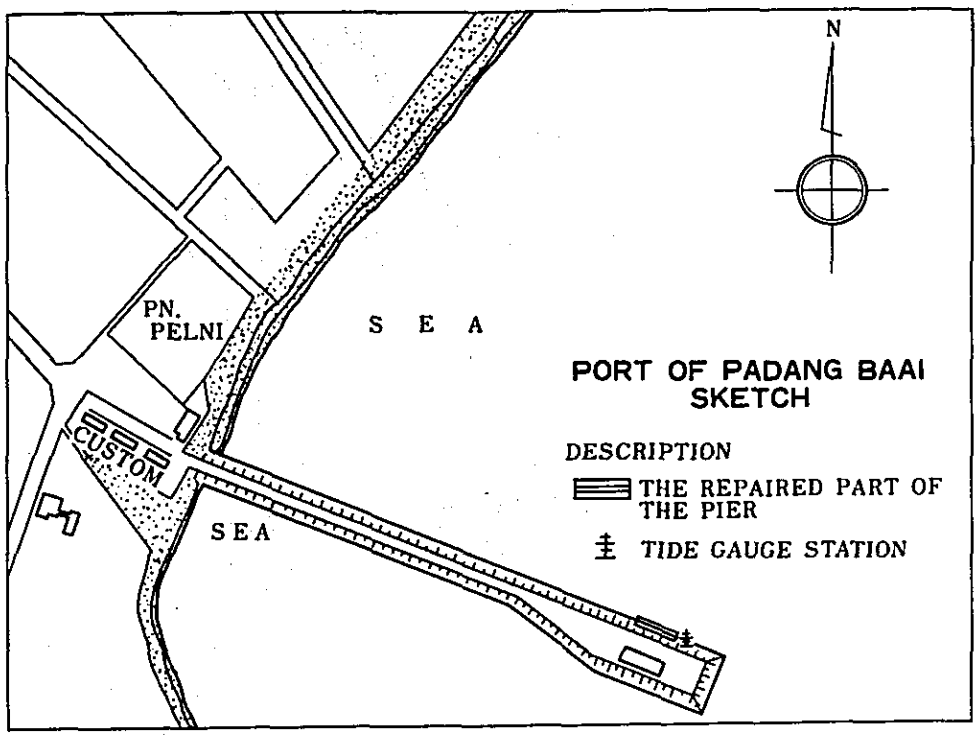
(d) Area IV is to be surveyed in the fourth phase.

Audister Responder stations are Responder 1 (Pulau Bali) and Responder 2 (Pulau Nusa Penida).

Current station will be set up at position 08° 47' 30" S - 115° 47' 00" E.

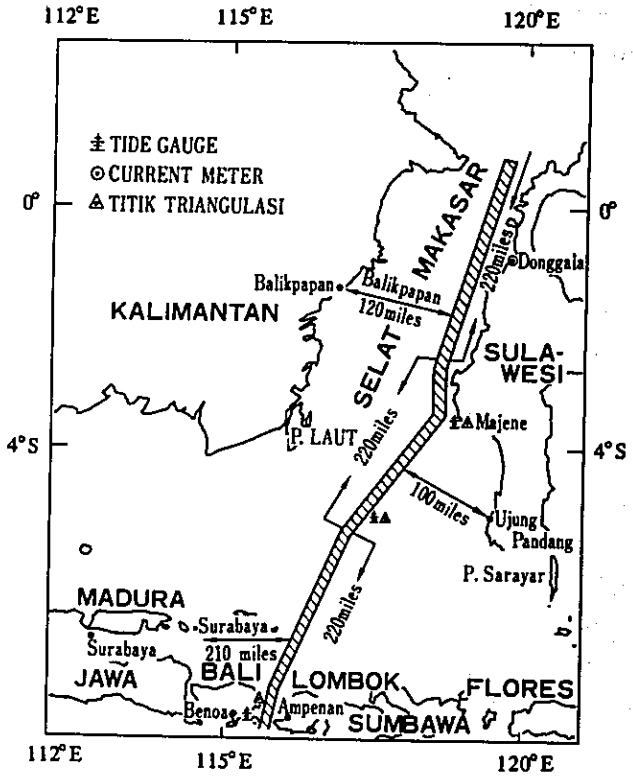
Tidal reduction for the survey in this area will be obtained from the tidal observation at Padang Baai.

Port for replenishment and supply will be Benoa.



(e) Positioning systems to be used in Areas I, II and III will be of Loran C integrated with NNSS, and in Area IV, Audister in two range mode.

(3) Considering the weather condition along the survey area, it is proposed that the main hydrographic survey be carried out after April 1975.



List of Members.

Indonesia.

1. May Laut (P) M.J. Sitepu
2. May Laut (E) Ganda Prasetya
3. Kpt Laut (P) M.P. Silaban
4. Kpt Laut (P) Djati Darmadi
5. Kpt Laut (P) Gunadi Gan
6. Kpt Laut (E) Asfar Ismael
7. Lettu Laut (E) C.M. Sitohang
8. Ir. Frans Supit
9. Serka Mrr Kasimin
10. Serda Pelaut B. Djaelani
11. Jr. Tk I P. Sunuroto
12. Kopda Pelaut Sartono
13. Jr. Tk I Suwarno K.

Japan.

1.	Mr. Takao Uchino	Hydrographic Department of Japan
2.	Mr. Motoji Kawanabe	Hydrographic Department of Japan
3.	Mr. Ryoichi Horii	Hydrographic Department of Japan
4.	Capt. Yoshio Saito	Malacca Strait Council
5.	Mr. Isamu Tomita	Furuno Electric Co., Ltd.
6.	Mr. Minoru Tsudome	Toshiba Electric Co., Ltd.
7.	Mr. Toshio Sekiguchi	Cameraman
8.	Mr. Moriyama	Cameraman
9.	Mr. Ir. M. Yusuf	Interpreter

Officers of KRI YALANIDHI

1. May Laut (P) S.P. Sitorus
2. May Laut (T) M. Sardi
3. Kpt Laut (P) M. Suprapto
4. Kpt Laut (P) Ngadnan
5. Kpt Laut (E) Suwignyo A.S.
6. Kpt Laut (T) Suprapto
7. Kpt Laut (KH) soeroso M. Sc.
8. Letda Laut (P) Ramidjo
9. Letda Laut (P) Ehar Suhardi