BATHYMETRY SURVEYS OF AIRAI BAY
AND NGEDERRAK REEF, PALAU

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Manual for Future Research

Appendices:

   Research Area, Bathymetric Information, Depth Contour Chart,
   Bottom Structure Map
1. Objectives

The coastal waters of Republic of Palau has been surrounded by highly rich tropical coral reef resources. In view of the environmental and industrial importance of this precious resources, the government has established the Palau International Coral Reef Center (PICRC) in 1997 to act as the National basis for the research and education center for conservation purpose. The center thereafter had been reinforced with various instruments and facilities being supported by the grand aid scheme given by the Japanese government, and initiated its practical activities in 2001. The Center is now designated a regional base station for Micronesian Region of the Global Coral Reef Monitoring Network (GCRMN) and a Japanese funded project on Reinforcement of PICRC Activity Project will be initiated soon.

Under these circumstances, the government of the Republic of Palau has been implementing the monitoring survey and establishment of Geographic Information Systems (GIS) approaches for coral reef research as a part of the global appraisal of the resources since the establishment of the PICRC. However, technical competence of PICRC is not enough right now for collecting basic information towards the subject, which includes the technical know-how on data collection for the precise distribution pattern of coral reefs in relation with bathymetry and bottom structures.

It is essential for PICRC to acquire fully such technical know-how to commence the research on coral reefs for the conservation purposes. Therefore, this particular project aims at improving technical competence of PICRC in terms of bathymetric approach with GIS procedure, for which technology transfer will substantially be made so that PICRC will enable to make up their research program on their own in the future to really contribute to the improvement in research for conservation of coral reefs.

2. Research Period

From: 6 October 2002  
To: 9 November 2002  
Total duration: 35 days

The itinerary during the research period is shown by research item in Table 1.

3. Research and Research Guidance Areas

The research areas and those associated with guiding activities of the Japanese project staff are shown on Figure 1. Each of the research areas extended to some extent as is described with denotation of “Zone” in the next section.
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Figure 1. Research and Research Guidance Areas in the Republic of Palau waters.
4. Research Items

Items of research employed in the project activity were comprised of following four fields, including (1) Survey on bathymetric features, (2) Survey on bottom structure, (3) Survey on water flow and (4) Standardizing data with GIS approach.

1) Survey on bathymetric features (3 zones with 50m interval)
   Zone A: Measured area in Malakal Bay, -A-
   - Latitude 7º 18´ 43˝ Longitude 134º 24´ 23˝
   - Latitude 7º 18´ 43˝ Longitude 134º 25´ 43
   - Latitude 7º 17´ 28˝ Longitude 134º 25´ 43
   - Latitude 7º 17´ 28˝ Longitude 134º 24´ 43

   Zone B: Measured area in Malakal Bay, -B- (without Zone A)
   - Latitude 7º 18´ 43˝ Longitude 134º 26´ 43˝
   - Latitude 7º 18´ 43˝ Longitude 134º 28´ 13
   - Latitude 7º 15´ 03˝ Longitude 134º 28´ 13
   - Latitude 7º 15´ 03˝ Longitude 134º 26´ 43

   Zone C: (Measured area in Airai Bay)
   - Latitude 7º 22´ 47˝ Longitude 134º 33´ 13˝
   - Latitude 7º 22´ 47˝ Longitude 134º 34´ 03˝
   - Latitude 7º 20´ 03˝ Longitude 134º 34´ 03˝
   - Latitude 7º 20´ 03˝ Longitude 134º 33´ 13˝

2) Survey on bottom structure
   Ten stations in Airai Bay (sampling by means of dredging)

3) Survey on water flow
   One station in Airai Bay as specified bellow
   - Latitude 7º 20´ 49.8˝ Longitude 134º 34´ 18.4” down to 30 m deep
   (observations for continuous fifteen days-and-nights)

4) Standardizing data with GIS approach
   All the data obtained (bathymetric features, depth contour, and bottom structure) are standardized with GIS standard methods, and are rearranged as data-bases.
5. Research Methods

5.1 Basic Line of Research

1) Selection of survey areas for both research purpose and for guidance oriented activities

After going through the examination of information on bathymetric features, which were transformed to prepare for the mapping chart around Republic of Palau, discussion with PICRC staff was made to decide the possible site of research. (Reference: Navigation Chart No. 81151, based on U.S. Navy’s survey in 1969 and Japanese survey in 1915-38, being kept by the Defense Mapping Agency.)

The sites were then finally selected taking result of a preliminary site survey into consideration, which was conducted together with PICRC researchers by research vessel equipped GPS, those were to be the “A”: Malakal Bay-(A) for the first site for research purpose, “B”: Malakal Bay-(B) and “C”: Airai Bay for guidance oriented two supplementary sites.

2) Extension of area for bathymetric survey and decision made on scale models

It was agreed upon by the both parties that (1) the extension of survey area be 1 km square or 1 km x 2 km in Airai area and 4km x 5km in Malakal extension area include the training area, and the (2) measuring cast line be every 50 m interval, which are applicable to both the research and guidance areas. The reason for deciding this was due to the difficulty in measuring procedures and expected accuracy to be required.

3) Daily working hours

It was also agreed on setting up the daily working hours to be 08:00-17:00 except Saturdays and National Holidays for which those would be completely days off.

4) Major lines of guidance activity

Basic concept involved in the bathymetric survey, handling of tools, methods and techniques to be employed, recording criteria, and drawing or mapping technique were all well taught to PICRC’s technical staff spending enough teaching time in both the meeting curriculum and practicing on the job at site, so that intensive technology transfer would have been achieved.

As it was considered that the depth measurement and mapping of the results would be the most important segments in the course of training, guidance on those two segments were given most. To achieve this within a short time available, two separate teams were organized, the one for positioning task force team on one side and measuring task force team on the other. The exchanges of the tasks between the two teams were made at the intermediate times when trainees appeared to have acquired more or less techniques practiced.

With regard to the surveys on current-flow and bottom structures, major techniques such as the deployment of survey tools and sampling procedures were taught with the practice on dong-it-your-self methods, the over-all arrangement with analytical approach of data acquired were also taught in due course.

The drawing and mapping techniques, and standardization with GIS approaches were finally guided in the course of practicing comprehensive survey techniques.
5.2 Instruments Employed

Following machinery were employed in the research, while the “HYPACK” for depth data processing, software for tidal current data processing and “ArcView” were applied for supplementary tools for processing each data.

i) Laptop Computer for recording 1 set
ii) GPS (GP-1650D) 1 set
iii) Echo-Sounder (PDR1300) 1 set
iv) Electromagnetic Current-Meter (Compact EM) 1 set
v) Bottom Sampler (Dredger) 1 set

5.3 Bathymetric Measurement

1) Geographic positioning of measurement
   - Assurance on proper functioning of tools was firstly checked. The explanation of the utility of GPS machinery was given to the PICRC staff at the PICRC’s west side quay where its positioning with coordinate value was already known in GIS map, then checking the machinery and calibration work were done with the staff. As to the GPS, the World Geodetic Standard WGS84 was applied.
   - Explanation to the PICRC staff on modifying the GPS’s coordinate axis into an arbitrary rectangular coordinates was made to make the positioning vessel and mapping procedures easy to operate.
   - Positioning vessel was made practically by illustrating the point on coordinating grid of latitudes and longitudes.
   - The boat operator then proceed straightly along the defined transit line to the desired position making use of GPS’s monitor as auxiliary aids. Vessel speed was fixed generally at 4-5 knot. The measuring area was delimited down to 2 m deep to prevent from to run ashore.

2) Measurement of depth
   - The GPS instrument was installed on the vessel, then echo-sounder and Check Plate of were on board for the preparation.
   - When the vessel arrived at deepest position of the survey area, the transducer of echo-sounder was fixed on the broadside of the vessel 50 cm beneath the waterline, while the position was adjusted to shallower level in case of measuring shallower waters. A remote display was set in the wheelhouse as measuring machineries were placed on the vessel far from the steering house.
   - The level of waterline on the recording sheet of echo-sounder was adjusted after the tool had been in operation. The sound velocity in the sea were measured and adjusted through the reflection record obtained from the “Check Plate”, for which the position was shifted with up-and-down in the sea to obtain the data from various depth.
- The daily assignment on the sea was terminated anticipating port arrival at 16:00 every day. Checking the every day’s recording and keeping them in order, charging the battery of echo-sounder, discussing for next day’s provision, all those things had been done together with the local staff at the PICRC campus after the disembarkation.

- The first priority was given to fulfill the bathymetric survey at site, then all the works accompanied such as arrangements of data collected and drawing various maps and figures including daily tracking records, depth distribution, and depth contour, etc. were subsidiary made after finishing site survey. During such desk works, identification of bottom substances were made classifying them into rocky (including coral reef), sandy, muddy bottoms judging from the echo-sounder’s record. Supplementary surveys were often conducted when needed after the examination of mapping obtained.

- After the all the surveys had terminated for the Research Area, the activities resembling to those were repeated for the Guidance Area to give instructions on bathymetric survey and mapping techniques.

3) Adjustment for tidal level

- As the fundamental principle of adjusting tidal level, the “Tide Tables 2002. High and Low Water Predictions. Central and Western Pacific Ocean and Indian Ocean. Issued 2001, Published by Lighthouse Press.” was adopted.

- A Tide-Mark had defined on the wharf of port closely adjacent to PICRC to check the data to be collected. Then the difference between the levels actually observed and that of Tide Table were checked for generally every 30 minutes interval during one spring tide day (October 21st).

- To accord the measured records with the depth officially recorded on the authorized chart, adjustment was made by subtracting the value of Tide Tables plus 30 cm form the measured records, which were defined as adjusted depths at the measured position.

5.4 Research on Bottom Structure

- The location of sampling spots for collecting bottom materials were defined mostly to be those of dredging station, and were spotted on the depth contour map being based on the distribution map of bottom structure carried out in the bathymetric survey. The number of the stations for sampling was limited to around 10 in total, and a dredger was used for bottom sediment sampler.

- After the vessel had moved to the sampling spot by aids of GIS instruments, sampling of bottom materials were made paying out dredging rope 2-3 times of depth. The rope would sometimes be cut off if the vessel did not leave its move as wind blew, or pull the instrument up with dead slow.

- The sample collected were visually sorted out into several categories such as sand, fine sand, middle sand, rough sand, gravel and rock (including coral), and recorded on a field note. Being based on those information, a bottom sediment chart was prepared.
The similar activities were undertaken in the Guidance Area too.

5.5 Research on Water Flow

- The one spot was selected where survey on water-flow would be carried out on consultation with PICRC staff. As the current meter was only one set, a current meter was deployed at middle layer (about 1/2 of the depth). The fixing cables and supplemental tools were prepared on land for which PICRC staff participated in for training purpose of the preparation.
- For the purpose of practice given to PICRC staff, a preparatory settings for the current meter were deployed without installing meter itself at the designated spot located by GPS. The practice was done when the work-plan for principal task was not busy and when a set of sequential programs was terminated.
- When it was considered that the staff would have been gone through those techniques after the repetitious training for 2-3 times, the realistic measurement was made with installing the current meter actually. Then a series of intensive task on measurement trial was performed for sequential 15 days and nights observation.
- The current meter employed was recovered after the above mentioned trials. A series of tasks were completed with the completion of data collection, analyses of data, mapping of time-series change in water-flow, etc.

5.6 Standardizing data with Geographic Information Systems (GIS)

- All the data collected for bathymetric survey and bottom materials were arranged in order, and were build up into a data-base.
- A depth-matrix was firstly produced for the bathymetric data collected, then a depth contour map was secondly drawn on a GIS layer, on the basis of above mentioned data-base, for which the spatial-analysis function of GIS was taken into account.
- The record of bottom materials and its geographic positioning information had been transformed into a matrix form, and the distribution map of bottom materials by category was drawn on a GIS layer with “PolyGon” form.
- In the course of the above processing, for the data impossible to be supplemented by interpolation methods of GIS were prepared by the other software, then incorporated into the final outcomes of GIS layer giving geographic information to the outcomes.

6. Outcomes of Research

Final outcomes were comprised of the followings.
- (1) Airai Bay Bathymetric Chart (Scale: 1/13,000)
- (2) Airai Bay Depth Contour Map (Scale: 1/13,000)
- (3) Airai Bay Bottom Materials Distribution Map (Scale: 1/13,000)
7. Provision on Future Research

7.1 Current Status

The Republic of Palau is now on its process of establishing the GIS system on coral reef data for conservation purpose as a part of the National Monitoring System of Coral Reefs since the establishment of PICRC. It is very important to promote the conservation of coral reefs that the research on various ecological features should be made clear, which includes the acquisition of information on distribution, living status in relation with bathymetric geomorphology and water flow, as well as the larval emigration route of spiny-starfish and other corals in relation with the environmental conditions. It is also important to arrange those information with a systemized data-base so that the research results should be expanded widely to the future studies.

The information on bathymetric distribution pattern of coral reefs in a mapping form as well as those of bottom structure are indispensable to describe coral reef distribution with GIS layer.

The technical capability to meet with the requirements in those research purpose is unfortunately insufficient at present in PICRC. Not only the deficiency in technical know-how to acquire the data and to manage them, and available machinery and tools for the purpose as well, but infrastructure and administration are also rather weak and appear to be not functioning sufficiently enough. Moreover, it should be noted here that any of the research staff of PICRC are actually a specialist in neither ocean research nor bathymetry.

A provision on the future research is given here, firstly taking the above mentioned status of PICRC into account, and secondly being based on the experiences encountered by the Japanese personnel during this particular assignment on research and guidance.

7.2 Dual Level Approaches

The methods concentrating in the acquisition of bathymetric and mapping technique will be focused to be introduced in this provision as these two are the most important fields of the subject. The sea area of reef flat is generally shallow, and topographic feature is uneven with sharp up-and-down structures. The topographic feature in a lagoon or offshore areas is generally deep and flat on the other. In the former area small craft is more convenient to go and echo-sounder with single transducer is generally used for survey purpose, while in the latter a bathymeter with multi-transducer (SEABAT: a bland name of such a tool) would be effective for survey purpose. However, SEABAT is rather expensive and requires sophisticated operation techniques, for which a high level training would be needed, though is highly effective and precise for survey purposes.

Therefore the two levels of survey methods, the one is a principal method
employing a single transducer bathymeter and the other employing SEABAT, will be examined and guidance necessary for each will be introduced here.

1) **First phase (1-2 years from the beginning)**

   - Providing with the hand carried machineries should be done as soon as possible, with which the surveys were actually performed and the guidance were given during this assignment.
   - Selection of the survey area will be decided by PICRC on its own.
   - Definition of Base Point of DGPS will be decided nearby the survey area as is defined under the PICRC’s initiative under the cooperation with the GIS Systemizing Project for which the republic of Palau is now undertaking.
   - The tide-mark will be established at an appropriate position and tide-level will periodically be measured to coordinate with the tide-table employed in present survey.
   - Make the PICRC staff will be engaged in as many survey as possible utilizing the machinery provided by this project, so that the staff become to be getting familiar with the bathymetric measuring techniques and with the operation of tools, which resulted in accumulation of their experiences.
   - PICRC would proceed onto the consolidation of planning the second-phase activity.

2) **Second phase (3 years and onward)**

   - The activity will go into second phase at when the progress in the first phase has reached satisfactory stage and the staffing of technical component as well as the administration appear to be promising.
   - PICRC will take an initiative to plan for building up the Charts for survey purpose in which the classified survey area are incorporated.
   - Making sure the coverage of the planned area included in DGPS.
   - PICRC examine its reform into three team structure of (i) Land area team, (ii) Near-shore area team and (iii) Off-shore area team. Each team would share their task load by their responsible field and will well collaborate with for their comprehensive matters, for which reference is made of the publication entitles as “Principle of Definition of Sea Area” edited by the Japanese Hydrographic Department of the Maritime Safety Agency. The Teams would be engaged in the survey for about 1.5 months comprising by 12 personnel in total, for which a part of the tasks could be supported by the Japanese government.
   - Under the presumption of employment of SEABAT, the necessary technical training will be organized to be held in Japan.
   - The survey items to be employed includes bathymetric measurement, bottom material survey and water-flow survey. The outcomes of the survey will be made available to public as a Chart (Mapping), for which standardization with GIS will be coordinated with land based GIS.
   - PICRC and responsible section in Japan will hold a meeting for discussion and
consultation with regard to the plan of activities and provision of machineries.

7.3 Infrastructure of Research System

It is needed to initiate active researches frequently after the decision was made on annual survey plan upon the establishment of infrastructure in PICRC is made, if the machineries and tools were provided by the Japanese government. Following steps would be taken to accomplish this;
- As the survey structure, personnel responsible for entire project and for research activities should firstly be decided, and the annual survey plan should secondly be established.
- The target area to be surveyed, timing of survey (season of favorable sea condition), cruise itinerary and sharing task scheme of staff in each of survey cruises are all decided beforehand.
- The acquisition of base position for DGPS and use of DGPS on a rental scheme should be examined.
- Training of the machinery provided by the Japanese government will be undertaken.
- The technical subjects and problems will be extracted which are to be involved in the survey plan at the second phase by PICRC staff.

7.4 Instruments Required

The following set of equipment will be provided by the Japanese government.

1) First phase period

The equipment compatible to those brought in the present survey period and the GPS machinery capable of receiving differential data as well as a tide level measure are *inter alia* required during the period. The specifications, make as an example, and number of tools required are given below;

i) Mono transducer echo-sounder   PDR1300 Sennbon Electric Co.   1 set
ii) Bar-check Board   1 piece
iii) DGPS   MX421   LEICA   1 set
iv) Computer (Laptop model)   PANASONIC   1 set
v) Electromagnetic current meter   ALEC Electronics   1 set
vi) Bottom Sampler (dredge)   RIGOUSHA   1 set
vii) Tide level meter (UWLR-2)   Union Engineering   1 set
viii) Battery (chargeable)   1 piece
ix) Mooring buoy (with automatic on-and-off light) ZENIRAITO Buoy   3 pieces
x) Plotter (A1 size) DesignJet 750C Plus HEWLETT PACKARD   1 set
2) **Second phase period**

After the appraisal is made on the performance and outcomes of first phase, it is desirable that a multi-transducer echo-sounder, SEABAT is introduced into the project site. A schematic illustration of this is given on Figure 2, for which some data on its specification is given as appendices for your information at the end of this report.

![Diagram of SEABAT](image)

### 7.5 Software to be employed

1) **First phase period**

   Software for data processing and current-flow analysis are considered to be installed, which had been employed during the current assignment period. Also some software for mapping and mathematical processing aids are needed. They includes;
   
i) Mapping for bathymetric data soft
      
      HYPACK MAX Coastal Oceanographics Inc. 1 set
   
   ii) Current flow analyzing soft
       
       Alec Electronics Co. 1 set
   
   iii) Equivalency Transforming Three-Dimensional soft
       
       Surfer 7 Golden Software Inc. 1 set

2) **Second phase period**

   It is wiser to think about the introducing new software if needed in the process of this stage as the development of those tools is tremendously large in recent days.

### 7.6 Arrangements needed for supporting Research
The training given to PICRC staff on techniques on bathymetric, bottom structural, and current-flow analyses has been successfully completed in its initial level. Those data will become hereafter not only their study materials with systematized GIS for their own purposes but also become to be utilized on a world wide basis. It is hoped that PICRC would be a sort of “Mecca” with regard to the coral reef studies are concerned.

However, since this project stand right now merely on the very beginning stage, for which various aids from foreign states are necessary even in the immediate future. Followings are the proposals on which Japanese side would be possible to cooperate to assist the Republic of Palau in strengthening PICRC’s activity in the future.

1) Support and assistance to the Phase 1 activity will be made as soon as possible with holding frequent consultation on planning future activities of PICRC.

2) Japan would take a part of commencing establishment of DGPS’s base station and transmittal station for differential wave, if the Republic of Palau is enable to establish those soon.

3) It is hoped that current meter would be provided with enough spare sets, hopefully double of necessary sets, as it is apt to be lost by rough environment. This will give PICRC more opportunity on implementing intensive research with much more stations.

4) When the second phase is in the sight of its implementation, the training of PICRC staff in Japan should be taken in the consideration of training scheme. The staff if accepted, could receive the training at the Hydrographic Department of the Maritime Safety Agency, where intensive training on high level bathymetrical matters, of course this will includes private sectors as well.
Figure A  Time scale chart of current property
Figure B  Time scale chart of Temperature
Unit: cm/s
Location: Airai Bay

Figure C  Tidal ellipse
Average current velocity by direction

Current frequency by direction

Unit: cm/s
Location: Airai Bay

Figure D  Current speed and direction frequency
SeaBat 8125
PRODUCT SPECIFICATION
ULTRA HIGH RESOLUTION FOCUSED MULTIBEAM ECHOSOUNDER SYSTEM

- Focused 0.5º beams
- 240 beams
- 2.5 cm near field resolution
- 6 mm depth resolution
- 120º swath coverage

The SeaBat 8125 is the first wide-sector, wide-band, focused multibeam sonar ever to be deployed. Utilizing 240 dynamically focused receive beams, the system measures a 120º swath across the seafloor, detects the bottom, and delivers the measured ranges at a depth resolution of 6 mm. The backscatter intensity image is displayed in real time on the sonar display.

The 8125 can be controlled through its native graphical user interface, or through an external control like the 6042 data collection and navigation software package.

The system can be mounted on a survey vessel or deployed on an ROV at depths down to 1500 m. The high-speed data uplink is carried on a standard SeaBat copper cable for surface installation. A fiber-optical interface is available for ROV deployment.

Two 8125 systems can be configured as a dual-headed system, with Option 011, and for complete control the 6043 image fusion and controller merges the images of the two sonar heads into one.
# SeaBat 8125 SYSTEM SPECIFICATIONS

## SYSTEM PERFORMANCE

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>455 kHz</td>
</tr>
<tr>
<td>Depth Resolution</td>
<td>6 mm</td>
</tr>
<tr>
<td>Swath Coverage</td>
<td>120°</td>
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<tr>
<td>Max Range</td>
<td>120 m</td>
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<tr>
<td>Number of Beams</td>
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<td>Along-Track Beamwidth</td>
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<tr>
<td>Across-Track Beamwidth</td>
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</tr>
<tr>
<td>Accuracy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IHO Special Order</td>
</tr>
<tr>
<td></td>
<td>U.S. Army Corps of Engineers Special Order</td>
</tr>
<tr>
<td>Operational Speed</td>
<td>Up to 12 knots</td>
</tr>
<tr>
<td>Max. Update Rate</td>
<td>40</td>
</tr>
<tr>
<td>Transducer Depth Rating</td>
<td>600m (Standard) 1500m (Optional)</td>
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</table>

## INTERFACE

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Supply</td>
<td>115V/230V 50/60 Hz, 350W max</td>
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<tr>
<td>Video Display</td>
<td>SVGA, 800 x 600, 72 Hz</td>
</tr>
<tr>
<td>System Control</td>
<td>Trackball or from Ethernet</td>
</tr>
<tr>
<td>Data Output</td>
<td>10 MB Ethernet or serial RS232C</td>
</tr>
<tr>
<td>Data Uplink</td>
<td>High-speed digital coax with fiber-optic option</td>
</tr>
<tr>
<td>Sonar Head Supply</td>
<td>24V, 4A (from ROV or sonar processor)</td>
</tr>
<tr>
<td>Temperature</td>
<td>Operating: 0° to +40° C Storage: -30° to +55° C</td>
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</tbody>
</table>

## MECHANICAL INTERFACE

<table>
<thead>
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</thead>
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<td>Dimensions (HWD):</td>
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<tr>
<td>Sonar head</td>
<td>192 x 499 x 383 (depth includes projector)</td>
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<tr>
<td>Processor</td>
<td>177 x 483 x 417</td>
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<tr>
<td>Transducer Weight</td>
<td></td>
</tr>
<tr>
<td>600m aluminum version:</td>
<td>24.3 kg (dry) 8.6 kg (wet)</td>
</tr>
<tr>
<td>1500m titanium version:</td>
<td>35.2 kg (dry) 19.1 kg (wet)</td>
</tr>
<tr>
<td>Processor Weight</td>
<td>20 kg</td>
</tr>
</tbody>
</table>
The latest Leica Marine GPS/ DGPS receiver is going to be a surprise to everyone, not the least our customers. It doesn’t look like a receiver, it doesn’t even really look like an antenna, because it’s not either, it’s both.

Leica and IBM Join Forces

Put quite simply, there is no other GPS/DGPS receiver-antenna on the market that is so advanced; with IBM’s SiGe Technology, a built in 12 channel GPS receiver, and Leica’s proprietary multi-path mitigation technique.

Built to Withstand The World’s Oceans

The Smart Antenna is also extremely rugged with a well sealed, waterproof enclosure and a heavy duty connector. It’s built to withstand the toughest environments.

Top Quality Antenna

The Smart Antenna features superior multi-path rejection, and boasts RF jamming resistance and uncompromised phase center stability.

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As your requirements change, Leica Geosystems will continue to provide you with new, innovative solutions, whether you’re a fair weather sailor or a seasoned mariner you’ve got it all covered. All the cables and fixtures are included and, of course, the Smart Antenna is backed by Leica Geosystems, with the largest service and support network of any survey instrument manufacturer in the world. Contact us today to learn more about this revolution in the making.
**Features At A Glance**

Leica’s latest GPS technology developed jointly with IBM brings you the “World’s Most Accurate Smart Antennas”.

- Built-in high precision 12 channel GPS receiver.
- Submeter DGPS accuracy and better than 3 meters in autonomous GPS mode.
- Optional 5 Hz update of position (MX421B).
- Optional 1 PPS output.
- Output of raw data, code and phase (MX421L).
- Integrated dual channel beacon receiver and unique toroidal H-field beacon antenna design (MX421B).
- Rugged enclosure.
- Stainless steel threaded insert.
- Entirely waterproof.
- Flush or pole mount.

**Configurations:**

- **MX421:** Autonomous GPS sensor for connection to any NMEA device.
- **MX421L:** Autonomous GPS sensor for output of raw data (code and phase) in compressed binary format, referred to as Leica Binary (LB2).
- **MX421B:** DGPS sensor for connection to any NMEA device. Can also be set to output GGA at 5Hz.

**GPS Receiver:**

- **Type:** L1 frequency, C/A Code (SPS), 12 channel Leica receiver, manufactured with IBM’s leading SiGe Technology. Employs Leica’s famous technology for multipath rejection, ionosphere modeling and robustness in positioning.
- **Sensitivity:** -143 dBm Costas threshold.

**DGPS Beacon Receiver/Antenna:**

- **Frequencies:** 283.5 – 325 kHz in 500 Hz steps.
- **Minimum Signal:** 15 _V/m.
- **Station Selection:** Automatic or manual on the primary receiver channel.
- **Dynamic Range:** 90 dB.
- **Adjacent Channel Rejection:** 40 dB (500 Hz).
- **Antenna:** H-field, toroidal (Patent pending).

**System:**

- **Accuracy:** GPS better than 3 meters RMS.
- **DGPS 1 meter RMS.**
- **Position output:** 1 Hz. Optionally 5Hz (MX421B).
- **Output:** NMEA GGA, GLL, GRS, GSA, GSV, GST, RMC, VTG, ZDA, MSS (MX421B), Leica Binary, LB2 (MX421L).
- **Input:** GLL, ZDA, MSK (MX421B), Setup commands, Leica Binary, LB2 (MX421L).
- **Environmental:** IEC 60945 compliant “exposed category”.

**Physical:**

- **Operating Temperature:** -25 to + 60 degrees C.
- **Mount:** Stainless Steel Insert 1” x 14 threads per inch, Flush mount or pole mount.
- **Cable:** 10 meters (25) Feet. Shielded 8 conductor.
- **Power:** 10.5 to 32 VDC, 200 m/A at 12 VDC. 230 m/A at 12 VDC.
- **Weight:** 660 g (MX421B).
- **Size:** H x Dia. 3 inch (89mm) x 7 1/8 inch (182mm).
- **Environmental:** IEC 60945 compliant “exposed category”.

**Options and Accessories:**

- **Extra cable.**
- **Connector box:** 1PPS output.
- **Antenna Mount:** Stainless steel precision mount.
- **Antenna Pillar:** Stable antenna base.

---

**Total Quality Management**

Our commitment to total customer satisfaction.

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[Leica Geosystems Website](www.leica-geosystems.com)
Now in its fourth generation, the new DMS leads the world in performance and reliability. The DMS is designed specifically for the motion measurement needs of the marine industry. Whether it is achieving IHO standard survey from any size of vessel or providing safety critical monitoring of offshore platforms, large vessels, helidecks, cranes and positioning systems. The new DMS provides accurate motion measurement in all sea conditions, incorporating an enhanced external velocity and heading aiding algorithm for improved accuracy during dynamic maneuvers.

All-new solid state angular rate sensors offer high reliability and a revised complementary blending algorithm has proven that the new DMS is the highest performance vertical reference unit ever produced by TSS. TSS’ unique heave algorithm is respected and acknowledged as the world’s most accurate. By maintaining a more accurate vertical reference across a wider dynamic spectrum our heave accuracy is taken to a new level of performance.

DMSView is an intuitive Windows™-based operating program that enables installation, set-up, and integrity checking and monitoring of the sensor. The user can select from a series of frequently used data protocols or configure a bespoke output from a selection of variables. Despite its compact size the unit is depth rated to 3000m, alternatively surface-mount versions are available. The new unit can also be supplied in various configurations for integration with towed vehicles and other bespoke applications.

As with all TSS systems the DMS is certified to meet all current and anticipated European legislation for electromagnetic compatibility and electronic emissions. Backed by the largest global support network of any manufacturer, TSS has complete repair, test and calibration facilities in the UK and the USA aided by factory trained service engineers on every continent.
The Edgeport USB-to-serial converter is an intelligent, stackable expansion module designed for the enterprise user who requires reliability in mission-critical applications. The Edgeport connects to a PC, thin client, or server via the Universal Serial Bus (USB) port, providing instant COM port expansion for peripheral device connectivity. Unmatched operating system support and reliable performance make the Edgeport perfect for applications such as point-of-sale, kiosk connectivity, and mobile computing.

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- Tri-state LED displays device status and COM port activity
- Automatic port reacquisition
- USB 1.0 and 1.1 compatibility; backwards compatibility for version 2.0
- Plug-and-play compliant; hot-swappable
- Full hardware and software flow control support
- UART: 64-byte FIFOs per port per direction
- No additional IRQ or memory address requirements

**SYSTEM REQUIREMENTS**
- Windows 95 (OSR2), 98, SE, 2000, Me, CE, XP; XP Embedded, NT 4.0, NT Embedded, Linux; Macintosh
- 1 USB type A (downstream) port

**POWER REQUIREMENTS**
- Serial, Industrial, and Edgeport/21 converters: no external power supply (USB-powered)
- Edgeport/421 and Edgeport/416 ship with plug mounted 5VDC power supply with input voltage requirement of 120VAC, 60 Hz (domestic) or 230VAC, 50 Hz (international)

**ENVIRONMENTAL REQUIREMENTS**
- Ambient temperature: 32°-131°F (0°-55°C)
- Relative humidity: 0-95% non-condensing

**CERTIFICATION AND SAFETY**
- FCC Part 15 Class B
- CE Certified
- EN55022, Class B
- EN50082-1
- EN55024
- EN60950
- UL 1950
- CSA No. 950

**SYSTEM REQUIREMENTS**
- Windows 95 (OSR2), 98, SE, 2000, Me, CE, XP; XP Embedded, NT 4.0, NT Embedded, Linux; Macintosh
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- CE Certified
- EN55022, Class B
- EN50082-1
- EN55024
- EN60950
- UL 1950
- CSA No. 950

---

**NAME** | **PART #** |
---|---|
Edgeport/1 | 301-1001-11 |
Edgeport/2 | 301-1000-02 |
Edgeport/4 | 301-1000-04 |
Edgeport/4/DB-25 | 301-1016-01 |
Edgeport/8 | 301-1002-08 |
Edgeport/416/DB-9 | 301-1000-10 |
Edgeport/416/DB-25 | 301-1016-16 |
Edgeport/2/Mac | 301-1006-02 |
Edgeport/2/Mac/DB-9 | 301-1006-29 |
Edgeport/4/Mac | 301-1006-04 |
Edgeport/4/Mac/DB-9 | 301-1006-49 |

**NAME** | **DESCRIPTION** | **PART #** |
---|---|---|
Edgeport/2i | 2 RS-232 serial, 1 parallel | 301-1000-12 |
Edgeport/4i | 4 RS-422 serial DB-9 | 301-1000-24 |
Edgeport/8i | 8 RS-422 serial DB-9 | 301-1000-28 |

All models ship with 1 meter USB cable. Rack mount kits and PCI-to-USB expansion cards available.

*Denotes part number for models with international power supply.

For dimensions and weights, see:
http://www.ionetworks.com/products/dimensions.html

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MANUAL
For
BATHYMETRY SURVEY ON CORAL REEFS
Masao Watanabe

November 2002
Fuyo Ocean Development and Engineering Co., Ltd.
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Objectives

This manual describes the techniques required to achieve the basic oceanographic research for the staff members of the Palau International Coral Reef Center (PICRC). The purpose of issuing this manual is therefore to assist the staff members of PICRC in enabling them to employ research machineries operation on their own on the sea so that to acquire the necessary data with GIS approaches. The manual will concentrate in explaining the bathymetric survey techniques, which are the most important segments for the survey purpose.

2. Planning for Bathymetric Survey

2.1 Purpose of the Survey

The benefit of utility of bathymetric survey extends to broad areas including the planning of port construction, controlling construction procedure and various kinds of survey purposes, the practical aspects actually involved in the respective survey varies in its kinds and natures depending on the purpose of its utility. For example, the period/season, areas, frequency, accuracy and machinery to be employed in the survey should be chosen appropriately in accordance with the measuring purposes. The two major elements involved in bathymetric survey are the positioning of the point to be surveyed and the measurement of depth. There are several important preparatory surveys to be done beforehand prior to obtain proper bathymetric survey data, which include (i) control point survey (base point for DGPS, while the independent positioning by GPS were employed in this particular survey), (ii) tidal survey (tidal observation, Tide Tables were applied in this survey), (iii) coast line survey (have not yet been applied), (iv) bottom structure survey, and etc., for all of which require various sophisticated survey techniques.

The survey to be conducted this time aims particularly to perform a principal survey. It is necessary to select the above mentioned segments, such as survey methods, survey area, machinery and tools to be employed, survey vessel and timing/season of the survey as appropriate to meet with the survey purpose.

2.2 Practical Procedures

i) Measuring space

According to the extent of survey area, the consideration on measuring space is needed to be decided as appropriate, taking the time for cruising required to and from survey area with 4-5 kt cruising speed, anticipating roughly 30-40 km in daily measuring in total distances into consideration on one hand, and probable total duration of survey period on the other.

ii) Measuring distance
Measuring distance should be decided according to the required accuracy, depth to be measured, bottom topography and performance capability of machinery. For example in the topography, the magnitude of interval distance should be fine when measuring uneven bottom like coral reef and/or rocky zone, while it could be rough for flat bottom like sand or mud. Though the measuring distance is tentatively set at 50 m since the target area of this particular survey is coral reef zone, it could be further fine with 25 m if more accuracy is required.

iii) Accuracy in positioning defined

The accuracy realized is generally about ±1 m when DGPS is employed, while it is between several meters and 10 m when GPS is separately applied. The accuracy involved in a single transducer echo-sounder is taken up here for your examination, and then the natural characteristics involved in the relation between beam-width and expected its accuracy will be explained. There are various types of beam-width in acoustic sounders applicable in accordance with its survey objectives, while the accuracy is generally good with higher frequencies of transducer being facilitated by narrower beam-width, however sounding capacity in depth is shallower. On the other hand, lower in frequencies would result in lower accuracy with wider beam-width but the sounding capacity reaches deeper in the sea in this case. The echo-sounder of PRD1300 employed in this particular research has the frequency at 200 KHZ and 6° of half diluted beam angle (beam angle in which transit power becomes a half), and 250 m deep of vertical explorable ability, which appears to be suitable in both accuracy and capability for the survey purpose in shallower waters. In the case much more accuracy is needed, the machinery specified with frequency of 400 KHZ and 3° of half diluted beam angle should be involved. A general feature of the beam-width of a single transducer is schematically shown in the Figures 2.1 and 2.2.
Figure 2.1 Transmit Beam Pattern from Transducer

Figure 2.2 Beam Width and Relation of Record Accuracy
3. Positioning

The radio positioning system or GPS is generally used when conducting the bathymetric survey, and the use of GPS will be explained here. It is necessary to employ the DGPS when high accuracy is required, however, considering current status of its availability, the separate use of GPS is only explained.

The measurement by means of GPS is basically stands on the triangular point system composed of satellite system, in other words, GPS measures its position utilizing the differences in arriving time of radio wave among the three satellites located at triangular points. GPS receives various position information from GPS-satellites and identify extremely accurate data in both the geographic and altitudinal position in question. GPS measure comprises of the two ways of point-positioning and interferometric-positioning, in which the latter involves static-positioning method and kinematic-positioning methods. The former method bears high accuracy and utilized mostly for the measurement of control point survey on land, while the latter is capable of measuring with real time system and used frequently in ocean research though the accuracy is less compared to the former. The system DGPS refers to the latter.

Following drawing gives a schematic illustration of GPS measurement system.

![Figure 3.1 GPS Measurement System.](image-url)
Produce employed in Independent Single Measurement Method

i) The frame of references refers to the World Standard Axis of Coordinates WGS84.

ii) GPS is in operation at the point known to the WGS84 system on land more than 3 satellites (4 satellites will be the best) are supplemented to the system.

iii) After the measurement is done for about continuing 15 minutes, the position is checked with the location of base point.

iv) The calibration will be made with the coordinates of known point if some errors are detected.

v) It is an ideal way that the bathymetric survey is done on operational status and check the result obtained at the known position afterwards.

Following drawing gives an imaging illustration on DGPS measurement method for the future application of receiving a differential data from a known position.

![Figure 3.2 DGPS Measurement Method](image-url)
Adjustment of Tide Levels

What level would be chosen as the standard level of the sea is the important choice to be decided beforehand in conducting the bathymetric survey as the sea level is moving up-and-down all the time. The standard level of the authorized navigational chart is selected as the basic level in this application. Here the tidal observation is necessary to examine the tide level when producing a navigational and/or a marine construction charts, however, the tide tables defined in the “Tide Table 2002, high and low water predictions, Central and Western Pacific Ocean and Indian Ocean Issued 2001, published by Lighthouse Press has been selected as the standard level, since the major purpose of this trial is limited to survey purpose. The adjusted tide level by subtracting the value in which 30 cm are added to the Time Table is defined as the standard basis of the nautical chart employed in this survey. Furthermore, when substantial difference exists in the locations between specified tide table and survey area, the variance in the sea level should be examined by applying tide gauge because the time difference for tide and height ratio would be different by the location.

① Tide gauge should be placed at the place where facing to the survey area and less effective with waves.
② Observation should be made at the time when difference in tidal variation during spring tide is minimal.
③ Observation should in principle be made every 10 minutes interval for at least 24 hours.
④ Tidal correction should be made on time difference of high water and low water as well as the difference in tide height by comparing the Tide Table and value on tide gauge.
⑤ It is desirable that the observation will be made referring to the value of tide gauge placed on the survey area.

Bathymetric Survey

5.1 Preparation

① One day before undertaking the survey, the survey area, times for departure and arrival, and survey time will be decided taking weather forecast into consideration. In addition, contact place and communication methods are decided before departure for emergency, and those are announced to the contact person together with anticipated survey area and time.
② Machinery to be used such as, battery, recording papers and safety facilities are checked before hand.
③ Confirmation of the weather and commencement of survey are made on the morning of survey day.

5.2 Installation of Machinery on Board
i) The antenna for GPS, remote display of GPS and recording part of bathymetric apparatus are 
installed respectively at appropriate places; at an appropriate position (where not making radio 
interference) on the mast for the first, in the wheel house for the second and in a measuring 
room for the third on the research vessel.

ii) The attaching clamps for the transducer of bathymetric machinery are fixed at one third behind 
from bows alongside vessel (place where less flow noise).

iii) After all the personnel have been on board (when waterline became stable), the transducer is 
fixed at 50 cm beneath the waterline (in general), and a waterline marking label by a vinyl tape 
is put on the steel pipe of fixing transducer.

iv) The two tension ropes are attached to just above the transducer at its front and behind side, 
fixing their other side at the stem and stern making those ropes as tension beam, then ascertains 
the magnitude of firm fixation of transducer. The transducer is electrically connected with 
main part of bathymetric apparatus afterwards.

v) Checking everything after the entire instrument is put in an operational status.

vi) When suffered from lot of noises on record, take an earth lead line from recording part of 
instruments and connect its other side at transducer.

vii) All the preparation has been assured to be in a good condition, then the transducer is pull up to 
the safety position and then cruise to the site of survey.

![Vibrator Setting Method](image.png)

Figure 5.1 Vibrator Setting Method
5.3 Adjustment of Sound Velocity

A bathymetric instrument is a machinery which detects the reflecting sounds from the materials existed under the vessel including bottom itself, which has been projected from the transducer of the vessel, the distance between the transducer and the materials are measured firstly by the time spend for running to and from the materials, and secondly transformed into distance between the two, thus the depth of the materials are finally estimated. Generally the speed of sound in the sea is defined as 1,500 m/s for the basis of the above mentioned assumption. However, the sound velocity in water varies being affected by various causes, which includes water temperature, salinity and water pressure, etc. The water temperature affects most especially in shallower waters, in higher temperature with slower speed resulted in deeper estimates in depth, and vice versa. Generally there is even a seasonal difference existed in the speed by several percent plus or minus in shallow waters.

In addition, the error arises from bathymetry inherent phasing effect, which is transforming values of sound into distance, and is resulting in the bias in recorded depth from actual one. It is necessary therefore checking the machinery periodically by applying the Check Plate (reflecting plates with multiple boards of fixed distance interval) examinations to adjust such biases. In general, it is done before and after the survey and once more at the deepest survey point, for which at least one time examination is indispensable.

i) Stop the vessel at the deepest survey station.

ii) Set the Check Plate horizontally just exactly beneath the transducer (directly under the projection beam).

iii) Set the Check Plate vertically at 2 m sharp deep as the plate is composed of similar reflecting board with 2 m interval down to 10 m deep.

iv) After obtaining the reflection records for 2 m interval down to 10 m deep, the trial is continued to further deeper zones of another 10 m deep and all the reflecting records should be taken. When it approaches at near bottom, the reverse trial should be made to shallower depths. In doing this trial, two personnel should be engaged in two different tasks, the one watching record and the other performing Check Plate operation. The two person need to cooperate closely in each other so that all the performances be kept in harmony. And all the trials should be done as quick possible as quick to prevent from the research vessel’s shifting by tide which might be resulted in the change in its position.

v) The record of the Check Plate operation should be examined carefully after entering port, and the correction with sound velocity should be done to correct the record of depths measured.
Following drawing gives a schematic illustration of Check Plate operation.

**Check Plate Operation**

- Check Plate should be put down after the ship has completely stopped its move.
- Be careful not to be shifted Check Plate by tidal current.
- First 2 m mark of rigging cord should firstly be held, then tell operator to commence the operation.
- Check Plate is then put down to the numbers given by operator.
- The rigging cord should be held for a while at 10m deep, then tell operator.
- Putting down and pulling up operations should be done as quicker as possible.

**Warning**

- Don’t thrust your body too much forward.
- Keep close communication with operator.
- Check all the time drifting status of Check Plate under the sea.

*Figure 5.2  Schematic illustration of Check Plate operation.*
Figure 5.3 Check Bar Record Example
5.4 Measuring Methods

The software HYPACK for a computer can transform the latitudinal/longitudinal data form of survey area into the form of axis of coordinate, which makes the data processing afterwards much more easier to deal with the illustration with the value of GPS into the ordinate and abscissa values of vessel position operated. The actual vessel operation is done ascertaining the present position of vessel and anticipated transit line of next station anticipated.

i) Cruising speed during survey activity will be set at about 4-5 kt.

ii) Vessel shall be carefully proceeded not so meandering as far as possible, for which taking earlier setting of reverse steering so that the vessel would proceed onto along the anticipated transit line.

iii) When the vessel wound largely its way, it would better taking steering slightly so that the vessel recovers its own way gradually. However, when the vessel run off largely by 20 percent of the interval distance, it would be better making the cruising operation again.

iv) To make sure the vessel is moving correctly, it is advisable to put a check mark at every defined position on the recording sheet of echo-sounder.

v) The recording should be taken by both the digital and analog type sounders to assure the recording.

vi) After finishing the survey along one transit line, it would be better taking a little bit detour turning around, then lead to next transit line.

vii) Vessel should be stopped when changing the recording sheet of the echo-sounder, once going back to the position by several meters from the stopped position, then lapping over the former position.

Following figure shows a schematic illustration of vessel leading along an anticipated transit line on a computer display.
Figure 5.4 Transmit Line on a Display
5.5 Checking the Data obtained

The recording of bathymetric survey is made by both the digital and analog (recording sheet) type as was explained in the previous section. The digital type is basically chosen, however, its accuracy is not always assured. Because, the reflections from various materials other than sea bottom, that from uneven bottom and the rolling/pitching of vessel caused by sea waves and heaving, all of those sometimes distort the results of sounding when displayed on the computer which made ultimately the estimates of depths different from actual depths. It is necessary to examine carefully the record of analog type recorder to check those phenomena. In addition, special treatment would be required to make the results reflecting real topographic status of the sea. Those include the citing of depths shown in a certain distance (between the two points to be surveyed) as the estimate of the depth in question. Supplemental examinations on up-and-down depths within the distance adopted and the depth at slope transformation point are also required to be supplemented to the correction of data in this case.

i) Checking the zero-line (surface-line), waterline and range-shift errors on the record of analog recorder should be made.

ii) Examining the record of analog data, checking the digital record on special point where an abnormality is probably shown should secondly be made.

iii) When there are large waves and/or swells existed, adjustment of the depth would be made estimating to be one third value from the apex of up-and-down record of analog data.

iv) Select the location of the station from analog record to be measured as supplement.

Following figures give the examples of checking procedure of analog data.
Figure 5.5 Examples of Checking Procedure of Analog Data
Figure 5.6 One Third Value from the Apex of up-and-down Record of Analog Data.

Figure 5.7 Example of Supplementing the Depth Value between Positioning Point
5.6 Arrangement of Data collected and Preparation for Mapping

The software of HYPACK will be employed.

i) Tidal correction and sound velocity correction will be made for the data after their checking have been finished.

ii) Track charts will be produced, and unnecessary cruise records and lapping are deleted.

iii) Bathymetric charts will be produced from the results of positioning and depth surveys. The data on which lapping is illustrated will be deleted. It is advisable in performing this job to fill in such data in the chart as the bearings, scales, latitude and longitude, metrical system employed (WGS84), bathymetric standard and date of survey performed.

iv) Depth contour maps will be produced from the data utilized in producing bathymetric charts. The contour line of even depths will be written in thick line, say every 5 m or 10 m, to make them visually clear to understand.

v) The track chart, bathymetric charts, depth contour maps produced will be printed with suitable scale.

Following figures give examples on a track chart and a depth contour map.
Figure 5.8 Track Chart

Figure 5.9 Contour Chart
6. Bottom Structure Survey

The bottom structure survey is done by a simple method applying a lead attaching adhesive grease on the bottom surface to collect bottom sediments adhered to. The collected samples are visually investigated and identify the structure of the bottom. When grain size analyses is required, sampling will be done by dredging or scooping type apparatus. Since the trails employed here are those for coral reef nature, corals and sand/gravel substance appear to consist of the majority of samples. Dredging method will be therefore employed with supplemental aids of bathymetric data (from which the kinds of bottom substance could be roughly estimated from the topographic feature of sea bottom).

6 From analog record, the bottom nature will be classified into coral reefs and sandy-mud structures which are marked on tracking chart. Then the survey position will be selected where the sampling will be performed to investigate the sand/mud structure.

7 The operation of vessel should be carefully made to leave the move of vessel as wind blows, or tow the dredger with dead slow speed in this case, otherwise the rope would be cut.

8 The samples collected are visually identified, then classified into mud (M), fine sand (fs), middle sand (ms), coarse sand (cs), gravel (G), rock (R) and coral (Co), and recorded on field notes.

9 The results obtained will be incorporated on the depth contour map, and produce bottom material map with suitable coloring.

Following figure gives a schematic illustration on dredging techniques.

![Figure 6.1 Sample Collection by Dredger](image-url)
7. Water Flow Survey

The tide arises by gravitation of the moon and sun, which makes sea level rise periodically then resulted in the change in tide level. The move of water masses accompanies with this tidal force is tidal flow which occurs in offshore area and bay region. To understand this tidal current, it is necessary to investigate into the four principal constituents of the tide, namely, Lunisolar diurnal tide (K1), Principal lunar diurnal tide (O1), Principal lunar semi-diurnal tide (M2), Principal solar semi-diurnal tide (S2), for which continuous observation for 15 days and nights is generally needed to investigate. The machinery to measure the tidal flow is current meter, in which Propulsion Current Meter, Electromagnetic Wave Direction Meter and Acoustic Doppler Current Profiler are involved.

The general procedure to deploy a Electromagnetic Wave Direction Meter is explained here.

i) The position where the water flow survey is made will be firstly decided on a chart together with the data on depth.

ii) The layer to be surveyed is selected and decided single or plural layers among the surface (2-3 m deep), middle (one half of the depth) and bottom (1 m above the bottom). If the depth is shallower than 10 m deep, no need to survey for the middle layer.

iii) Install battery on the machinery and measuring interval is defined.

iv) The necessary attachment will be prepared with appropriate numbers including the lighted buoy, rope, shackle, swivel, anchor (or sinker) and flag mark, and they will be tightly connected together. Do not forget to attach fixing appliances to shackles and greasing the screwing part of appliances.

v) Setting all the attachments in order on the vessel to make the cruising operation easy (example of casting order : anchor- lighted buoy- measuring machinery- buoy- fag mark-anchor).

vi) The vessel moves with dead slow speed while materials are casing into the sea, the last anchor should be pulled a little bit to give a tension to some extent, releasing them when every thing has appeared to be stretched.

vii) Checking the state of setting a few days after casting had been made to ensure any trouble would not happened.

viii) After the completion of the continuing survey for 15 days, the appliances will be recovered on board with just opposite order to that employed in casting.

ix) On recovery, the data collected are all read, and processing with software will be completed.
Mooring of Current Meter

Figure 7.1 Mooring of Current Meter (Middle Layer)

Figure 7.2 Mooring of Current Meter2 (Surface/Bottom Layer)
Figure 7.3 Time Series of current Data
Figure 7.4  Four Principal Constituents of the Tidal Current Ellipse
Figure 7.5  Histogram of Current Direction, Averaged Current Velocity, Current Velocity