### 3.3.2 South Makassar Basin

The South Makassar Basin which occupies the most part of the eastern side of survey area has the width of 130 km and the depth of 1600 to 1800 m along the cable route crossing the Basin.

The deepest part locates in the area of the west side of Basin and its depth shows 1896 m. The portion of the both slopes up to the Jawa and Sulawesi Shelf shows the steep gradients, but the seabed of the Basin area is generally smooth.

At the eastern part of Basin, there is a mountain with relative height of about 300 m on the top (1360 m depth). However, this mountain is not an isolated one but a part of the most end of risen topography (spur) which extends WNW-ward from the Southwest end of Sulawesi Island. The most end of this crosses the route from south to north. On the way upward slope to the Sulawesi Shelf, the seabed in the area between 534 km and 600 km shows a wide terrace topography (plateau). The characteristics of seabed topography are summarized as follows: (Refer to Fig. 3-7)

(1) The section from 397 km to 420 km

The gradient of downward slope to the Basin from the east margin of Jawa Shelf is generally steep (maximum 1/5(11°) but the gradient becomes gradually gentle (1/55(1°)) as increasing the water depth. After that, the downward slope reaches to the portion of 500 m water depth and undulations disappear on the slope. The topography of terrace is formed with width of 4 km at the portion of 500 m water depth. Two undulations with relative height of each 45 m exist on the terrace.

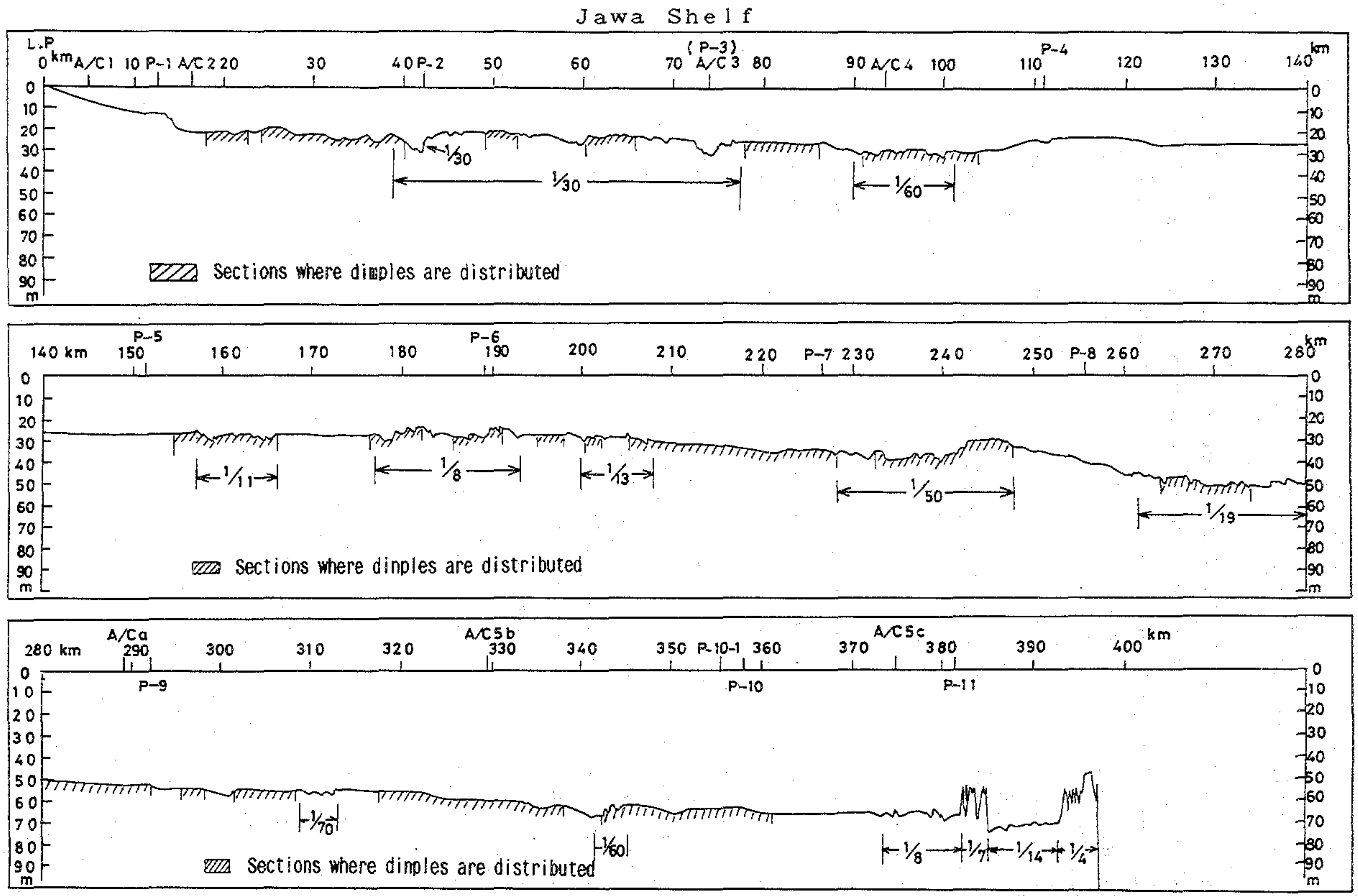



Fig. 3-6 Seabed Profiles, Undulations and Dimples Along Selected Cable Route

Note: Fraction shows max. gradient of undulations in each section.

The gradient of these undulations are 4° to 5°. Beyond this point, the downward slope reaches to the portion of 1500 m in depth with a steep gradient in 8° to 9° (1/17-1/6).

(2) The section from 420 km and 546 km

1) The slope becomes extremely gentle (max. 1/4) at the west end of the Basin and reaches the deepest portion of 460 km.

The seabed of deep portion in the basin is generally smooth and has some up down with gentle slope and with a long wave-length. And the seabed proceeds to a gentle up slope at the portion of 508 km and this condition continues up to the portion of 532 km (1700 m in depth). Some gentle undulations appeared on this smooth seabed, are 10-20 m in relative height and 2 to 4 km in wave-length.

2) The seabed goes up rather steep slope at the portion of 532 km with maximum gradient 1/10 (6°) and reaches to the top of spur (1300 m in depth). The scale of spur is about 4 km width at the foot and about 400 m at the top.

The downward slope of the spur together with undulations of 20 m in relative height reaches to the valley.

The gradient of downward slope is smaller than that of upward slope and is max. 5°(1/11). The width of the valley is not so wide and the seabed goes up again.

3) The section from 546 to 600 km

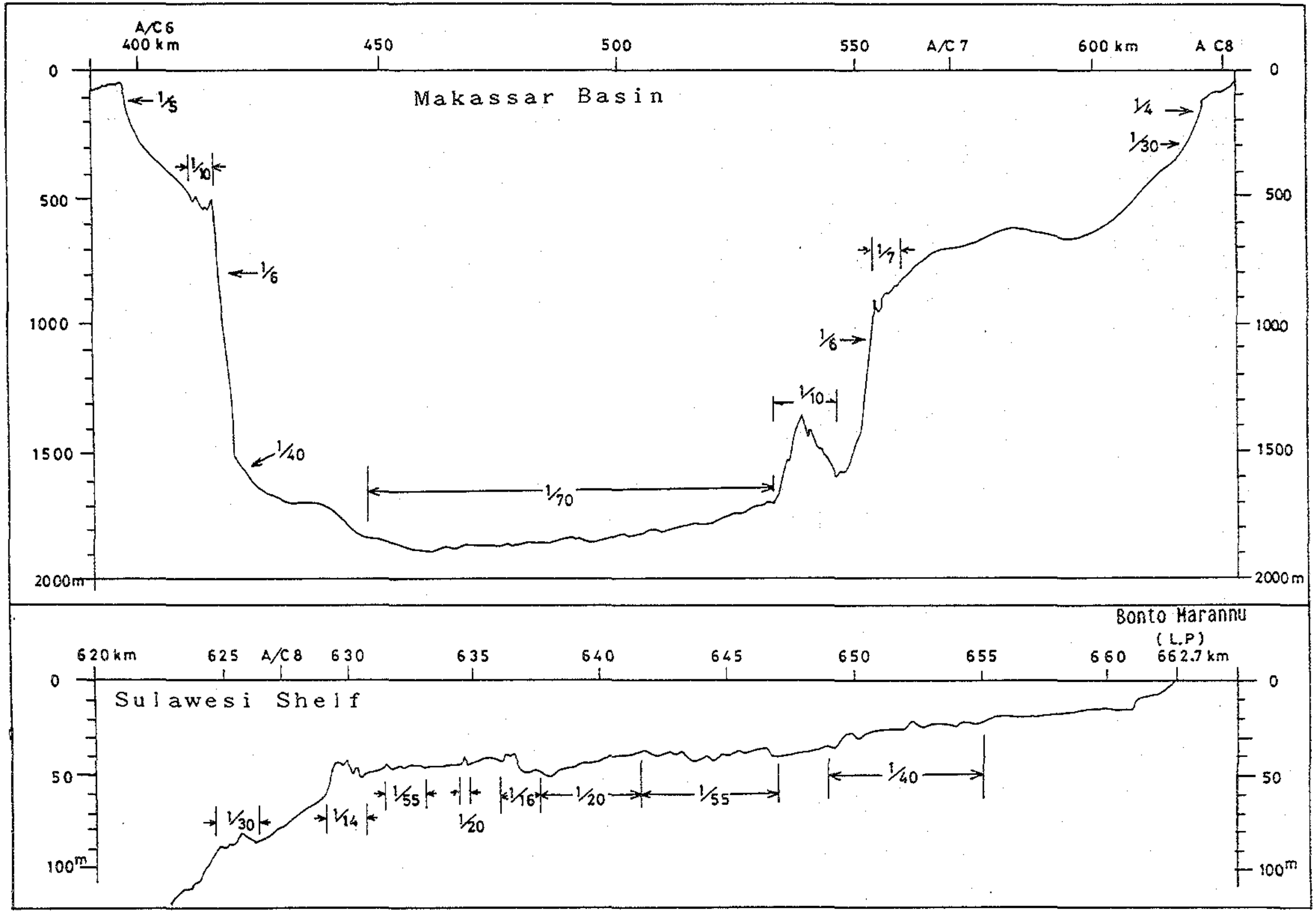
The topography in this section are represented as the vast terrace with smooth seabed and gentle slope.

Several undulations are found in 6 km at the west end of the terrace. The maximum relative height of 57 m and maximum gradient 8°(1/7) exists in those undulations.

The water depth is 622 m at the shallowest part on the terrace and the seabed goes up again the slope adjacent to the portion of 600 km.

(4) The section from 600 km and 623 km

The upward slope to the Sulawesi Shelf is gentle and its mean gradient is less than 1°(1/60). The slope proceeds to steeper one at the portion adjacent to the west margin of Shelf. The gradient of this slope reaches to the maximum values of 13°(1/4).




Note: Fraction shows max. gradient of undulations in each section.

Fig. 3-7 Seabed Profiles and Undulations Along Selected Cable Route

### 3.3.3 Sulawesi Shelf

The sea area around both sides of the cable route is shallow water portion where many large and small coral reefs including the Taka Coseiya etc. are distributed. The distributed area expands to the west margin of Shelf at 40 km off the coast of Bonto Marannu.

As the results of the survey, the aforementioned condition were found on the route. However, the scale of the appeared undulations in this section are comparatively smaller and more gentle than that of the coral reefs found in the east margin of Jawa shelf. The undulations on the seabed disappears at the portion adjacent 655 km (8 km from B.L.P) and the route reaches to the Bonto Marannu inshore area.

The characteristics of seabed topography in this section are summarized as follows:

(1) The section from 623 km to 629 km

The mean gradient of gentle slope, which goes up at the portion of water depth 117 m in the east margin of Sulawesi Shelf, is less than 1/115. The seabed surface is smooth, but some undulations with gentle slope less than 1/30 are found in the area around 616 km.

(2) The section from 629 km and 658 km

1) The mean gradient of seabed in this section is about 1/900, and some large and small undulations were formed by existence of coral reefs.

These characteristics of undulation are summarized in Table 3-5.

2) The outcropped area of the remarkable coral reefs exist from 629 km to 637 km of this section. The maximum gradient of undulation in the area is 4°(1/14) with rather steep slope. No remarkable undulations appear from 637 km to 658 km of this section.

3) The dark spotted patterns were observed by the side scan sonar in this section. This shows that the rock exists at near under the seabed. Especially, in the sections from 641 km to 643 km and from 650 km to 657 km, the outcropped rock are observed.

Table 3-5 Characteristics of Undulation (629 km to 658 km)

| Section (Distance (from T.L.P) | Height | Width | Gradient | Condition |
|---|---|---|---|---|
| 629-630km | 3.5-7.5m | 270-330m | Less than 3° (1/19) | Upward slope with a gradient of 4° goes up to level of (-) 64 m. The top of outcropped coral reef is accompanied with some undulations. |
| 630-647km | (1) 0.5-35m<br>(2) 2.0-8.0m | 50-150m<br>270-850m | 1° - 3° (1/14)<br>1° - 3.5° (1/16) | Two different ((1), (2)) undulations are distributed.<br>One to two undulations of them are distributed at 1 km interval except small undulation with relative height lower than 1 m |
| 647-658km | 2-5m | 460-580m | Less than 1.5°(1/40) | Several undualtions are found at area between 647 km and 655 km, but seabed is generally smooth. |

## 3.4 Submarine Geology

The geological feature was analysed along the selected cable route, based on the result of sub-bottom profiling with taking the results of sampling, sea bottom profiling and sea bottom scanning into consideration.

The route is divided into three portions such as (1) Jawa Shelf, (2) Makassar Basin and (3) Sulawesi Shelf by the topographical and geological view points.

The geological feature in each portion is described as follows.

(1) Jawa Shelf (refer to Fig. 3-8)

In this area, the seabed consists of three layers, surface layer, lower layer and coral reef, accoustically.

The surface layer which correspond to I layer in the inshore area of Takisung, consists of the Holocene and later Pleistocene sediment. This layer is thin at almost area. And this layer has the sandy and muddy sediment at the upper portion (see Table 3-7, Fig. 3-11) and has the clayey sediment at the lower portion.

These sediments are loose and suitable for cable burying. However, the area which has thick sediment more than 1 or 2 m continuously, is few, except the area (317 km - 342 km) nearby A/C 5b and (345 km - 373 km) nearby P-10-1.

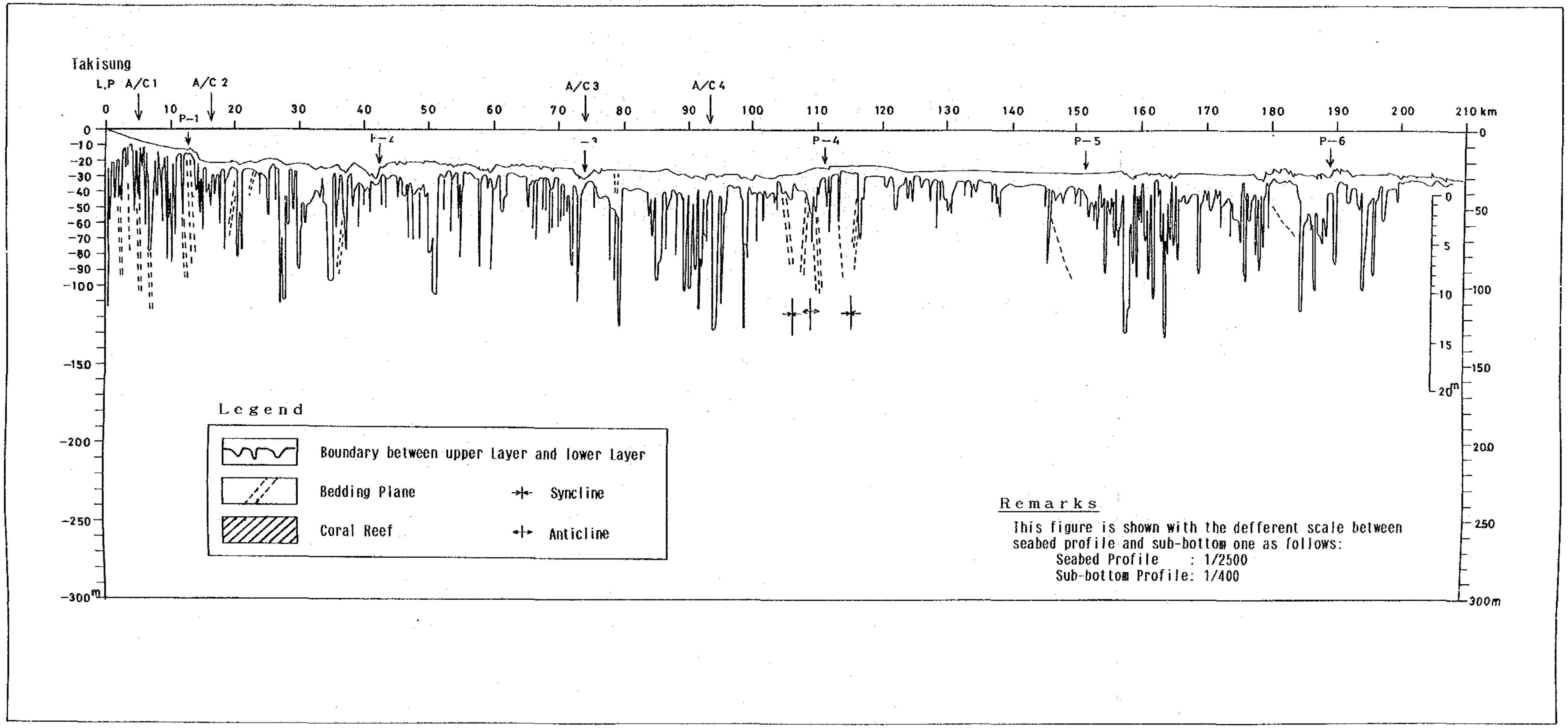



Fig. 3-8 (1/2) Seabed and Sub-bottom Profile in Jawa Shelf

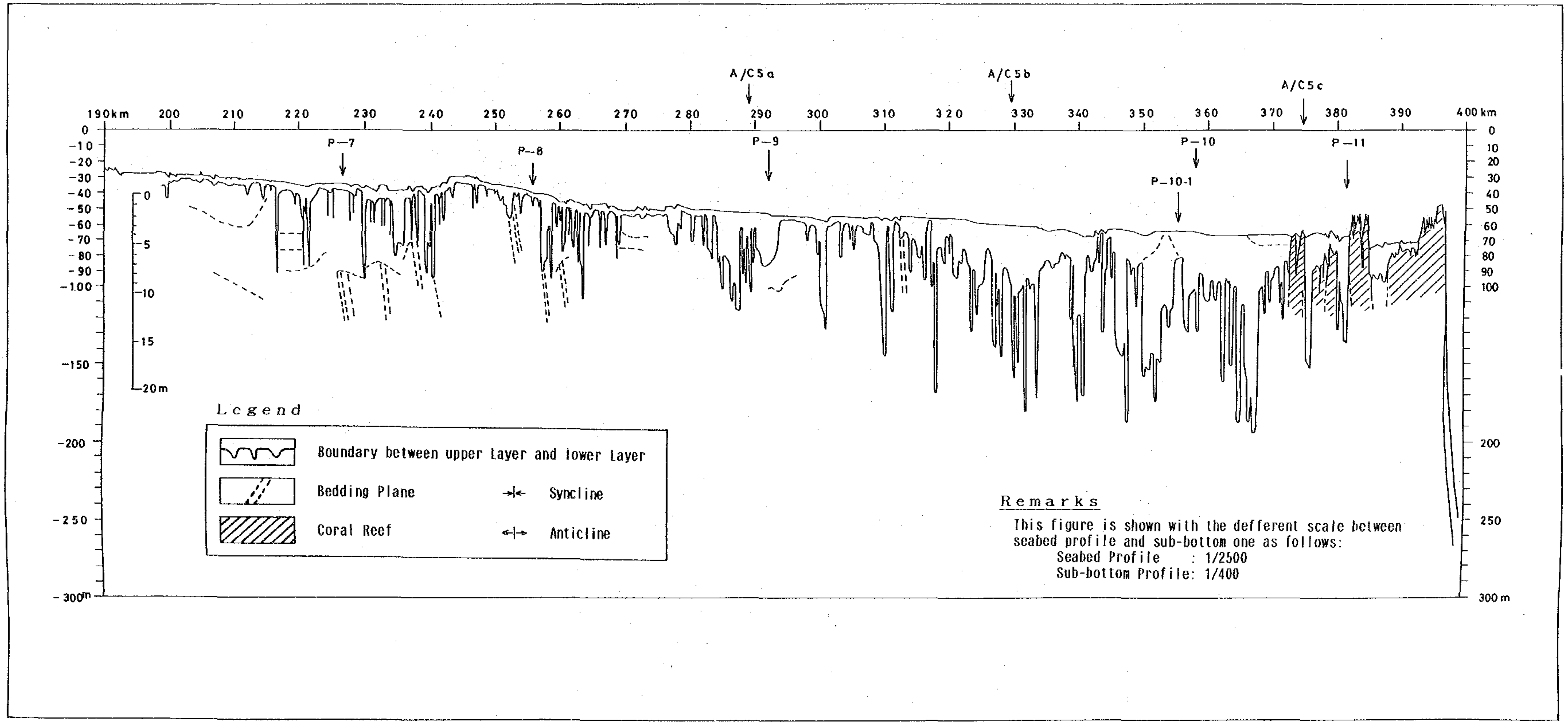



Fig. 3-8 (2/2) Seabed and Sub-bottom Profile in Jawa Shelf

The lower layer corresponds to II and III layer in the inshore area. The II layer consists of the early and middle Pleistocene sediment and the III layer is mudstone with the holding bedding plane.

So, there is the difference of hardness between the II and III layer. However, the top of III layer has been weathered. Therefore it is difficult to identify the boundary between the II and III layer at some area, and the hardness of III layer seems to be the same as that of the II layer at the upper portion. Accordingly cable buring might be possible at the shallow portion in 1 or 2 m under the seabed.

The II layer is stiff and sticky clay, and its hardness is sometimes over 0.34 kgf/cm of full scale of portable vane sheare tester which was used for the test onboard (refer to Table 3-6). And these values listed on this table are estimated smaller than actual shear strength, because the testing sample has been always disturbed during the sampling.

So, the cable burying may have a difficulty at the area where the lower layer appears at the seabed.

The coral reef including buried one which is shown with the oblique line in Fig. 3-8, appears at the area from 373 km (from T.L.P) to the shelf margin.

The surface of coral reefs is extremely uneven. And the cable will be laid without burying in this area. Therefore, enough protection for the laying cable should be considered in this area.

(2) Makassar Basin (refer to Fig. 3-9)

This portion can be divided into three parts, western slope, basin and eastern slope.

The sedimentary condition throughout this area is shown in Table 3-6.

Table 3-6 Sedimentary Condition at Makassar Basin

| Distance from T.L.P | Sedimentary conditon | Area |
|---|---|---|
| 397-398 km | Outcrops of coral reef | Jawa Shelf edge |
| 398-411 | Thick sediment | Western upper slope |
| 411-419 | Outcrops of rock and coral reef | Western terrace<br>Western lower slope |
| 419-531 | Thick sediment | Bottom of basin |
| 531-558 | Outcrops of rock | Spur, Eastern lower slope |
| 558-587 | Thin sediment | Basin spur<br>West part of eastern terrace |
| 587-606 | Thick sediment | Eastern slope teerace<br>East part of eastern terrace |
| 606-623 | Outcrops of rock and coral reef | Eastern upper slope |

The outcrops of coral reef at the Jawa Shelf margin continue to the western slope up to 60 m in depth. The western upper slope between the point of 200 m in depth and the western terrace has a smooth surface. The seabed in this area has a sedimentary layer. This upper layer has nearly 5 m thickness, and lower one seems to be very thick.

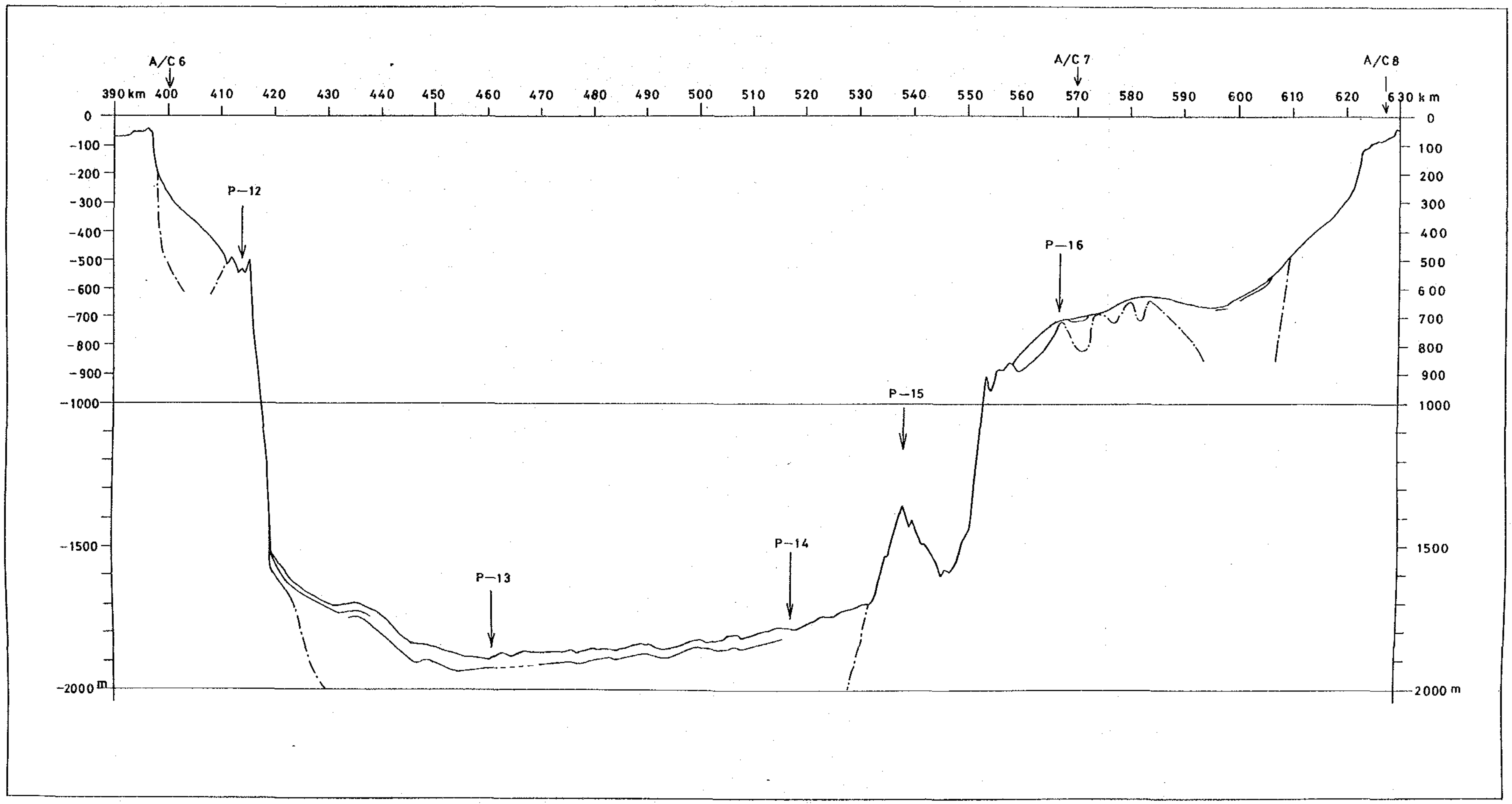



Fig. 3-9 Seabed and Sub-bottom Profile in Makassar Basin

At the western terrace, the seabed is uneven, and the sampling result (P-16) shows that the outcrops of coral reef appears on the seabed.

The basin has thick sedimentary layers. The upper part of this layer has thickness of 20-60 m, and the lower part seems to have quite large thickness. According to the sampling result (P-13, P-14), the seabed consists of soft mud.

The seabed has some undulations in this area, although being covered with soft sediment. This seems to show the creep phenomenon that the large amount of sediment slides toward the lower portion during long geological time.

At the spur located at the eastern part of the basin, outcrops of rock appear on almost area. But the sampling result (P-15) shows that seabed is covered with muddy sediment at some area.

At the eastern lower slope from the spur to the eastern terrace, the seabed almost consists of the sandy sediment as shown in the sampling result (P-16), and the thickness of layer changes in range of 0 cm to 50 cm, depending on the up and down of basement rock. The outcrops of rock appear on the seabed at the limited area of the slope with the small relative height of less than several meters.

At the eastern terrace, the seabed has a smooth surface. And the sedimentary layer is divided into two parts, and the upper one has a thickness of 5 m approximately, and the lower one seems to be very thick.

At the eastern upper slope from the terrace to the Sulawesi Shelf margin, some outcrops of rock appear with the relative height of less than 5 m.

(3) Sulawesi Shelf (refer to Fig. 3-10)

In this area, the seabed consists of three layers, surface layer, lower layer and coral reef, accoustically.

The surface layer corresponds to I and II layer in the inshore area of Bonto Marannu (refer to Fig. 2-10). The upper portion of this layer consists of fine sand or coral sand, and has a little muddy material. The lower portion of this layer which is filling up the depression of basement rock, seems to consist of muddy material, mainly.

This layer has the thickness more than 10 m at some area, but the continuous thickness more than 1 or 2 m might not be expected.

The lower layer which consists of mudstone is distributed at the area up to 13 km from B.L.P. And the condition of it is not clear at the further area, because of covering with the coral reef.

This layer has a clear bedding plane which was influenced by the holding, and seems to be the same as the mudstone appearing at the northern shoreline of B.L.P.

It seems to be very difficult to bury the cable in this area, because this layer appears at the shallow portion of less than 1 m under the seabed, even if the upper portion of mudstone has been weathered.

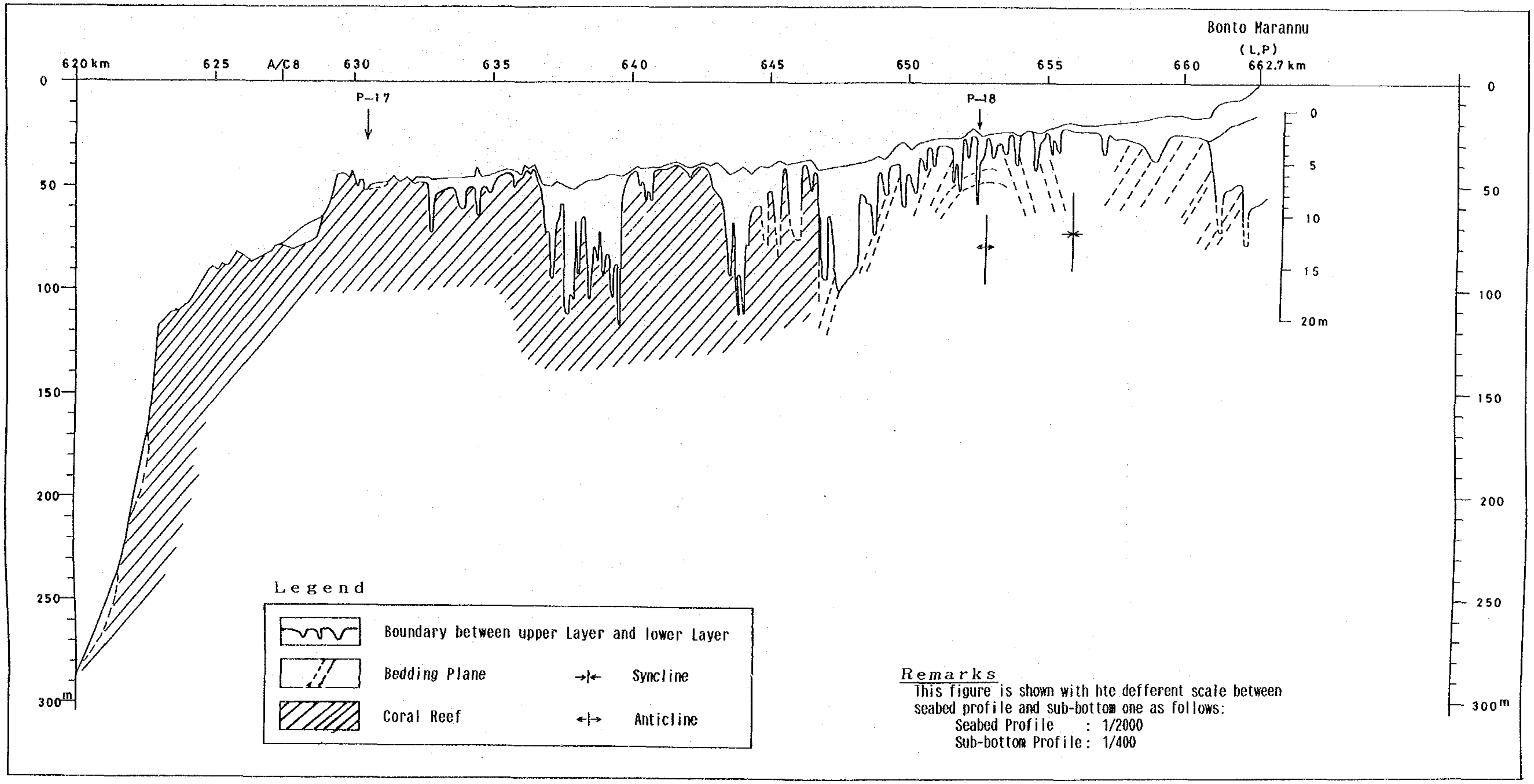



Fig. 3-10 Seabed and Sub-bottom Profile in Sulawesi Shelf

The coral reefs and the buried ancient one as shown with the oblique line in Fig. 3-10, are distributed at the area further than 13 km from B.L.P.

The surface of reefs has severe undulation, therefore the cable burying is impossible. Accordingly, enough protection for the laying cable shall be considered in this area.

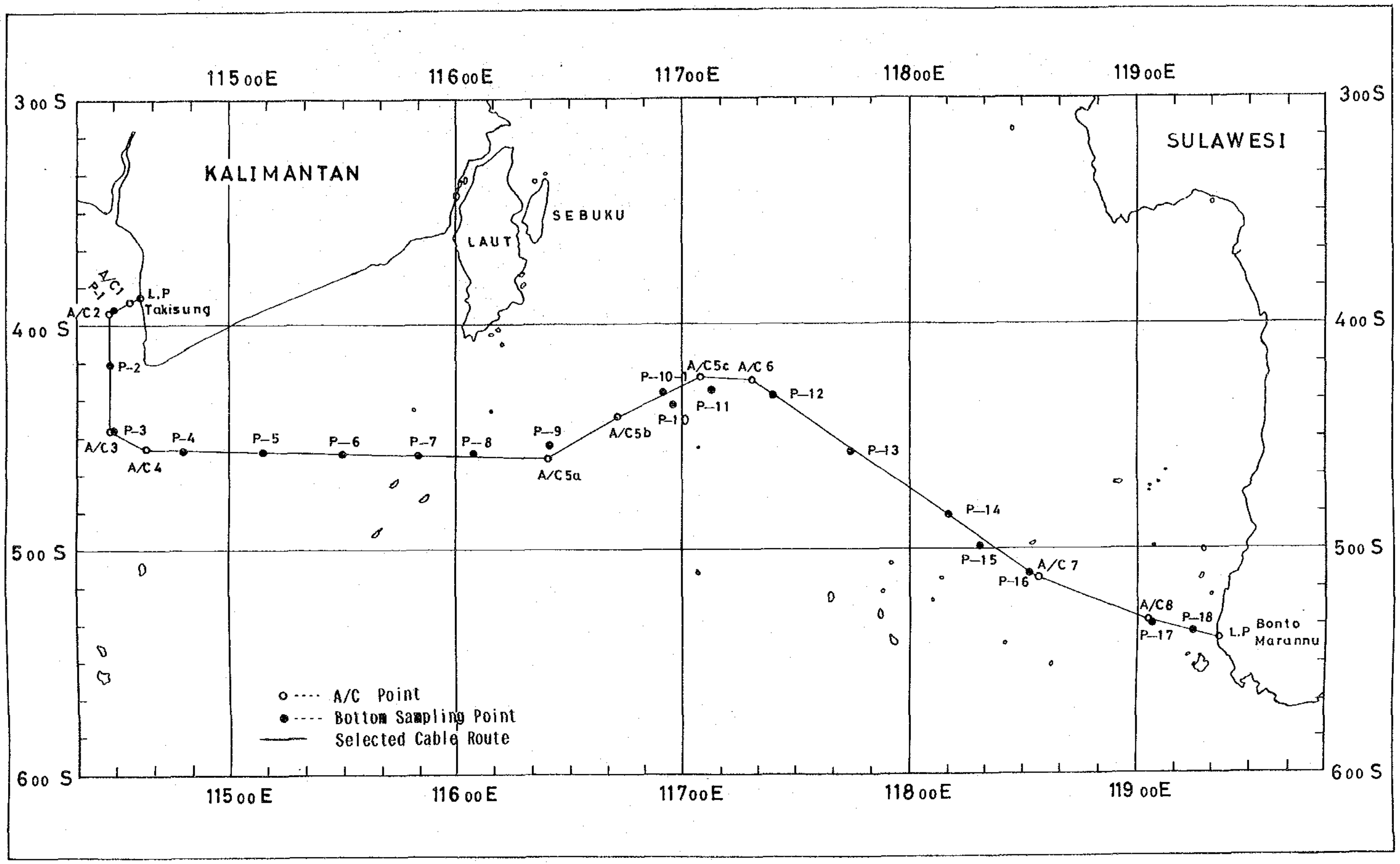



Fig. 3-11 Positions of Sampling

## Table 3-7 (1/3) Sampling Data in Ocean Area

| Item \ Location | P-1 | P-2 | P-3 | P-4 | P-5 | P-6 | P-7 |
|---|---|---|---|---|---|---|---|
| Sampling Date | Jul.20 | Jul.20 | Jul.19 | Jul.19 | Jul.19 | Jul.18 | Jul.18 |
| Position (Lat. :S)<br>(Long.:E) | 3° 55.70'<br>114° 30.65' | 4° 10.89'<br>114° 28.66' | 4° 27.97'<br>114° 29.00' | 4° 33.22'<br>114° 47.81' | 4° 33.78'<br>115° 09.81' | 4° 34.27'<br>115° 30.00' | 4° 34.61'<br>115° 50.12' |
| Water Depth (m) | 15.0 | 22.0 | 28.5 | 25.5 | 26.5 | 27.5 | 33.5 |
| Sampling Device | V | V | V | V | P | P | P |
| Bottm Material (Clay, Silt, Sand, Gravel) | Muddy Sand 25<br>Stiff Clay | Sand 25<br>Stiff Clay | Muddy Sand 10<br>Stiff Clay | Fine Sand 20<br>Muddy Sand 125<br>Fine Sand | Fine Sand 20<br>Stiff Clay | Muddy Sand 80<br>Clay | Fine Sand 20<br>Stiff Clay |
| Core Length (cm) | 225 | 245 | 181 | 142 | 75 | 166 | 65 |
| Photo ◎, Current ● | ◎ | | ◎ ● | | | ◎ | |

Remarks: Sampling Device (V=Vibro Corer P=Piston Corer D=Dredger)
Photo: Sea Bottom Photographing Current: Current Observation

Table 3-7 (2/3) Sampling Data in Ocean Area

| Item \ Location | P-8 | P-9 | P-10 | P-10-1 | P-11 | P-12 | P-13 |
|---|---|---|---|---|---|---|---|
| Sampling Date | Jul.18 | Jul.15 | Jul.14 | Jul.17 | Jul.14 | Jul.13 | Jul.13 |
| Position (Lat. :S) (Long.:E) | 4° 35.04'<br>116° 05.90' | 4° 31.59'<br>116° 25.34' | 4° 22.25'<br>116° 57.69' | 4° 18.48'<br>116° 55.63' | 4° 18.46'<br>117° 08.02' | 4° 19.43'<br>117° 24.93' | 4° 34.35'<br>117° 45.19' |
| Water Depth (m) | 36.0 | 50.0 | 37.0 | 63.0 | 49.0 | 495 | 1913 |
| Sampling Device | V | V | D | P | P | P | P |
| Bottm Material (Clay, Silt, Sand, Gravel) | Fine 20 Sand<br>Stiff Clay | Mud<br>Stiff Clay | Rock | Mud | Rock | Rock | Mud |
| Core Length (cm) | 240 | 185 | | 45 | | | 150 |
| Photo ◎, Current ● | ◎ ● | | ◎ | | ◎ ● | | ◎ ● |

Remarks: Sampling Device (V=Vibro Corer P=Piston Corer D=Dredger)
Photo: Sea Bottom Photographing Current: Current Observation

Table 3-7 (3/3) Sampling Data in Ocean Area

| Item / Location | P-14 | P-15 | P-16 | P-17 | P-18 | | |
|---|---|---|---|---|---|---|---|
| Sampling Date | Jul.13 | Jul.12 | Jul.12 | Jul.11 | Jul.11 | | |
| Position (Lat. :S)<br>(Long.:E) | 4° 51.51'<br>118° 10.55' | 4° 58.61'<br>118° 19.36' | 5° 06.75'<br>118° 32.60' | 5° 19.59'<br>119° 04.41' | 5° 22.40'<br>119° 16.21' | | |
| Water Depth (m) | 1806 | 1285 | 711 | 49.5 | 22.5 | | |
| Sampling Device | P | P | P | V | V | | |
| Bottm Material<br>Clay<br>Silt<br>Sand<br>Gravel | Mud<br>90<br>Clay | Sandy Mud | Fine Sand | Coral Sand | Fine Sand | | |
| Core Length (cm) | 273 | 105 | 50 | 77 | 12 | | |
| Photo ◎ Current ● | | ◎ | ● | ◎ | | | |

Remarks: Sampling Device (V=Vibro Corer P=Piston Corer D=Dredger)
Photo: Sea Bottom Photographing Current: Current Observation

Table 3-8 Results of Vane Shear Test

| Sampling No. | Shear Strength (kg/cm²) | | | | | |
|---|---|---|---|---|---|---|
| | 0.1 m | 0.6 m | 1.1 m | 1.6 m | 2.1 m | 2.6 m |
| P-1 | - | >0.34 | >0.34 | >0.34 | >0.34 | |
| P-2 | 0.164 | >0.34 | >0.34 | 0.191 | 0.140 | 0.150(2.35m) |
| P-3 | 0.215 | >0.34 | >0.34 | >0.34 | | |
| P-4 | - | 0.314 | 0.253 | | | |
| P-5 | 0.072 | 0.30 | | | | |
| P-6 | 0.048 | 0.038 | 0.085 | 0.12(1.5m) | | |
| P-7 | 0.065 | >0.34 | | | | |
| P-8 | - | 0.30 | >0.34 | 0.24 | | |
| P-9 | 0.015 | 0.44 | >0.34 | 0.35(1.5m) | | |
| P-10 | | | | | | |
| P-10-1 | 0.031 | | | | | |
| P-11 | | | | | | |
| P-12 | | | | | | |
| P-13 | 0.012 | 0.029 | 0.27 | | | |
| P-14 | 0.014 | 0.029 | 0.38 | 0.027 | 0.041 | |
| P-15 | 0.075 | 0.082 | 0.11(0.95m) | | | |
| P-16 | - (>) | | | | | |
| P-17 | - (>) | | | | | |
| P-18 | - (>) | | | | | |

## 3.5 Currents and Water Temperature

### 3.5.1 Currents

(1) Shallow Sea

The shallow sea area is located on the north-east of Jawa Shelf where the water depth is shallower than 50 m. Current observation stations were established at three points in this area.

The observation layer at each station was 3 m above seabed.

The following table is the results of current observation at each station.

Results of Current Observation in Shallow Sea Area

| | P-3 | Dist | P-8 | Dist | P-11 |
|---|---|---|---|---|---|
| Observation time | July 19th 22:00-22:50 | about 179 km | July 17-18th 23:30-00:30 | about 115 km | July 14th 05:30-06:50 |
| Observation layer | 3 m above seabed | | 3 m above seabed | | 3 m above seabed |
| Range of appeared velocity | 18.5-15.7 cm/s | | 17.7-16.0 cm/s | | 36.4-32.2 cm/s |
| Appeared direction | W'ly | | W'ly | | WNW'ly |
| Depth | 28.5 m | | 36 m | | 49 m |

It has been reported that the dominant current direction changes in accordance with the monsoon wind directions two times through a year. In the NW monsoon from November to March, the current direction of ESEward dominates generally and in the SE monsoon from May to September, the current direction of WNWward dominates.

The current observations at this time were conducted in July of the SE monsoon season. According to the afore-listed table, the observed current directions at the seabed layer were generally westward.

And the velocities at each station were within 15 cm/s (0.3 knots) to 36 cm/s (0.7 knots). These current observations were carried out for more or less than one hour, so that the current variation in time series, such as periodical or turning direction, were not clarified.

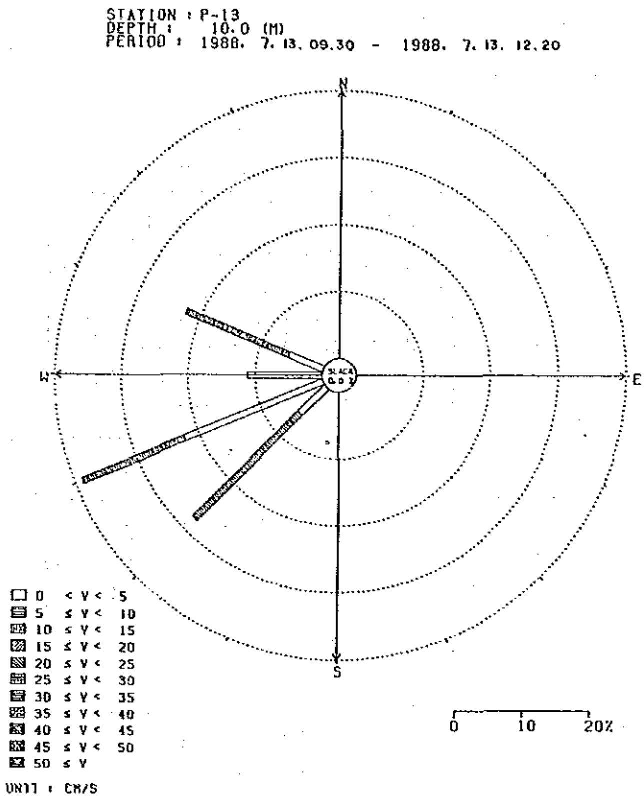
However, it seems that the actual measured currents at seabed are similar to the surface currents direction.

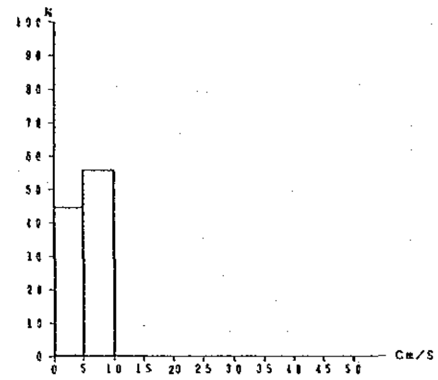
For reference, the current conditions at Jawa Sea in NW monsoon season were described in the Report of Subaraya - Banjarmasin Submarine Cable Route Survey which was conducted on February, 1986 by JICA.

(2) Deep Sea Area

The following table is the results of current observation at P-13 and P-16. The P-13 locates in the deepest part of Makassar Basin and P-16 locates on the desending slope of Sulawesi Shelf to the Basin. The current velocity/direction frequency distributions are shown on Fig. 3-12.

## Offshore(Deep Sea Area)

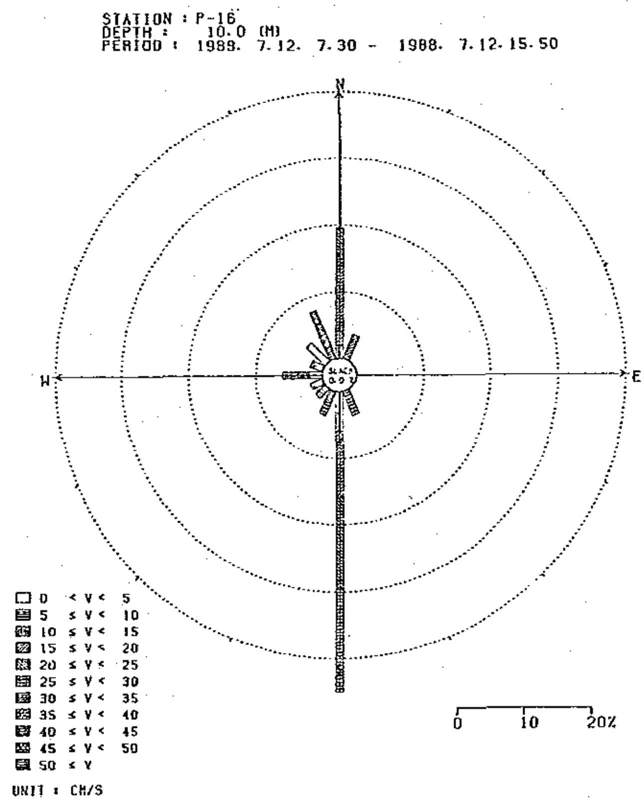


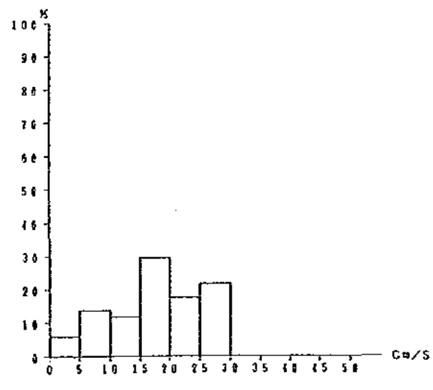




P-13

Water Depth: 1913m
Observation Layer: 10m above Sea bottom

## Offshore(Deep Sea Area)




P-16

Water Depth: 711m
Observation Layer: 10m above Sea bottom

Fig. 3-12 Current Velocity/Direction Frequency Distribution (Deep Sea Area)

Results of Current Observation at Deep Sea Area

| | P-13 | Dist | P-16 |
|---|---|---|---|
| Observation time | July 13<br>09:30-12:20 | about<br>89 km | July 12<br>07:30-15:50 |
| Observation layer | 10 m above seabed | | 10 m above seabed |
| Max. velocity | 7.5 cm/s | | 29.0 cm/s |
| Min. velocity | 1.8 cm/s | | 5.0 cm/s |
| Mean velocity | 5.4 cm/s | | 17.7 cm/s |
| Appeared direction | WSW'ly | | N'ly and S'ly |
| Depth | 1895 m | | 711 m |

1) P-13

The current observation at P-13 was conducted for 2 hours and 50 minutes (from 09:30 to 12:20) on July 13th with 10 minutes interval. According to the result of current observation, the appeared max. velocity at seabed layer was 7.5 cm/s (0.1 knots) and the min. velocity was 1.8 cm/s (0.03 knots). Thus, the current velocity was extremely small. By examining the current velocity/direction frequency distribution (Fig. 3-12), the appeared current directions show between SW to WNW. Especially, the WSW-ward direction appeared at high frequency.

2) P-16

The current observation at this station was conducted for 8 hours and 20 minutes (from 7:30 to 15:50) with 10 minutes interval on July 12th.

The appeared max. velocity was 29.0 cm/s (0.6 knots) and the min. was 5 cm/s (0.1 knots). The appeared current direction was mainly N and S. The current velocity/direction frequecy distribution (Fig. 3-12) shows that dominant currents appear in the northern and southern direction. As the observation period was limited, the existence of tidal effect or periodical variation in the currents was not clarified.

It has been generally considered that there is no existence of a tidal effect in the deep sea. However, in the current measurement at this point of 711 m deep, a turning direction in the current variations were observed. This fact might occur by the effect of tidal current.

### 3.5.2 Water Temperature

The water temperature measurements were carried out at 5 stations in the offshore area (3 stations in shallow sea area and 2 stations in deep area). The water temperature variations in the vertical section at each station were shown on Fig. 3-13, 3-14 and 3-15.

And also, the vertical water temperature variations were made by the Marsden Square data between 100 m under seasurface layer and 10 m above seabed. Because, the measurements were only conducted adjacent to the surface and the bottom layer.

(1) Shallow Sea

The results of the surface and bottom layer in the shallow sea are shown in the following table:

Water Temperature at Shallow Sea Area

| Station | P-3 | Dist | P-8 | Dist | P-11 |
|---|---|---|---|---|---|
| Observation time | July 19th 21:50 | about 179 km | July 17th 23:30 | about 115 km | July 14th 05:05 |
| 0.5 m under surface | 28.0° | | 28.0 | | 27.5 |
| 3 m above seabed | 28.0° | | 28.0 | | 26.9 |
| Depth (m) | 26.5 m | | 36.0 | | 49.0 |

And also, the water temperature variation in vertical sections were drawn in Fig. 3-13. According to the above listed table, the temperatures at the surface layer were in the range of 27.5 to 28.0°C at each station.

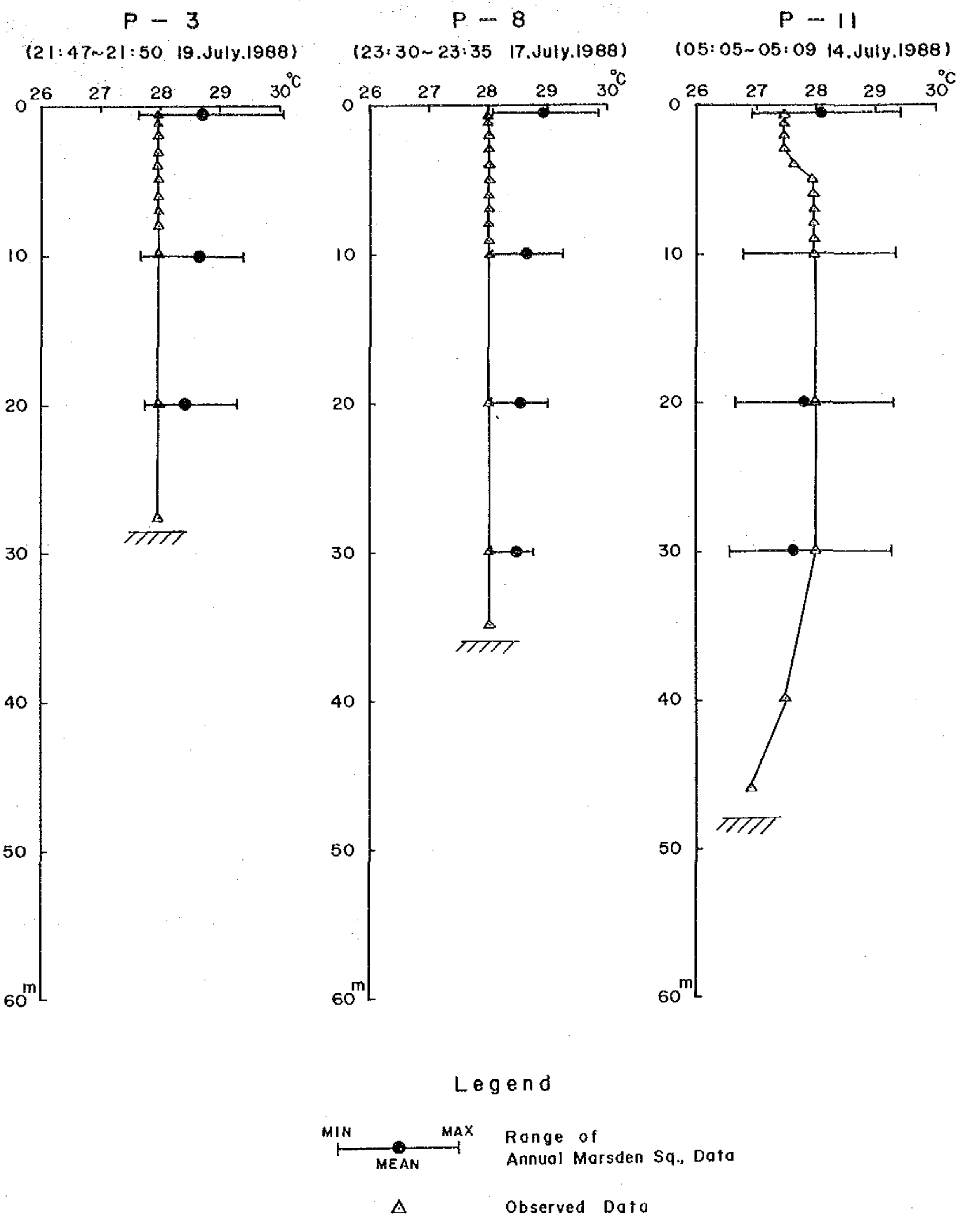



Fig. 3-13 Water Temperature Variation in Vertical Section
(Shallow Sea Area)

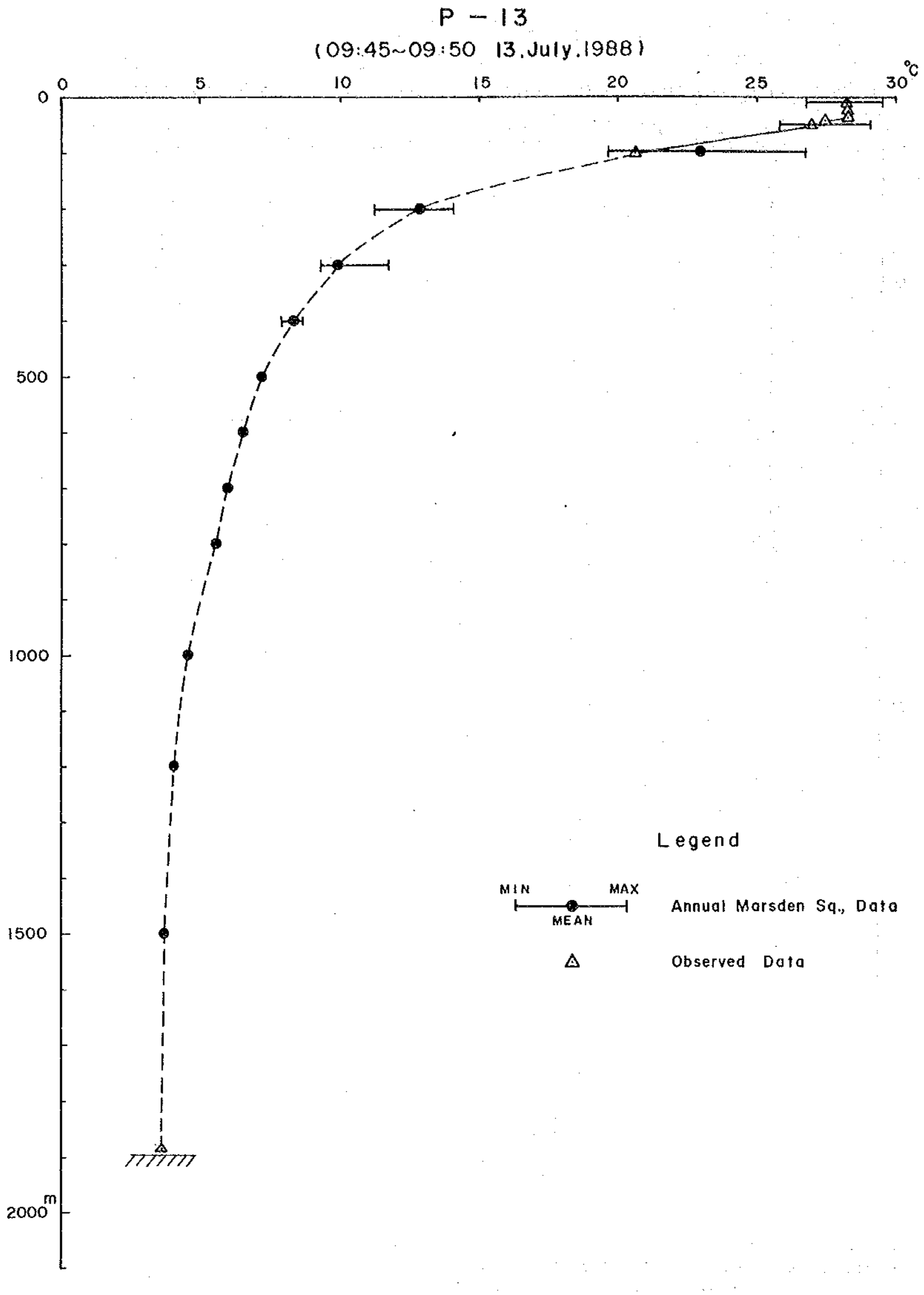



Fig. 3-14 Water Temperature Variation in Vertical Section (Deep Sea Area)

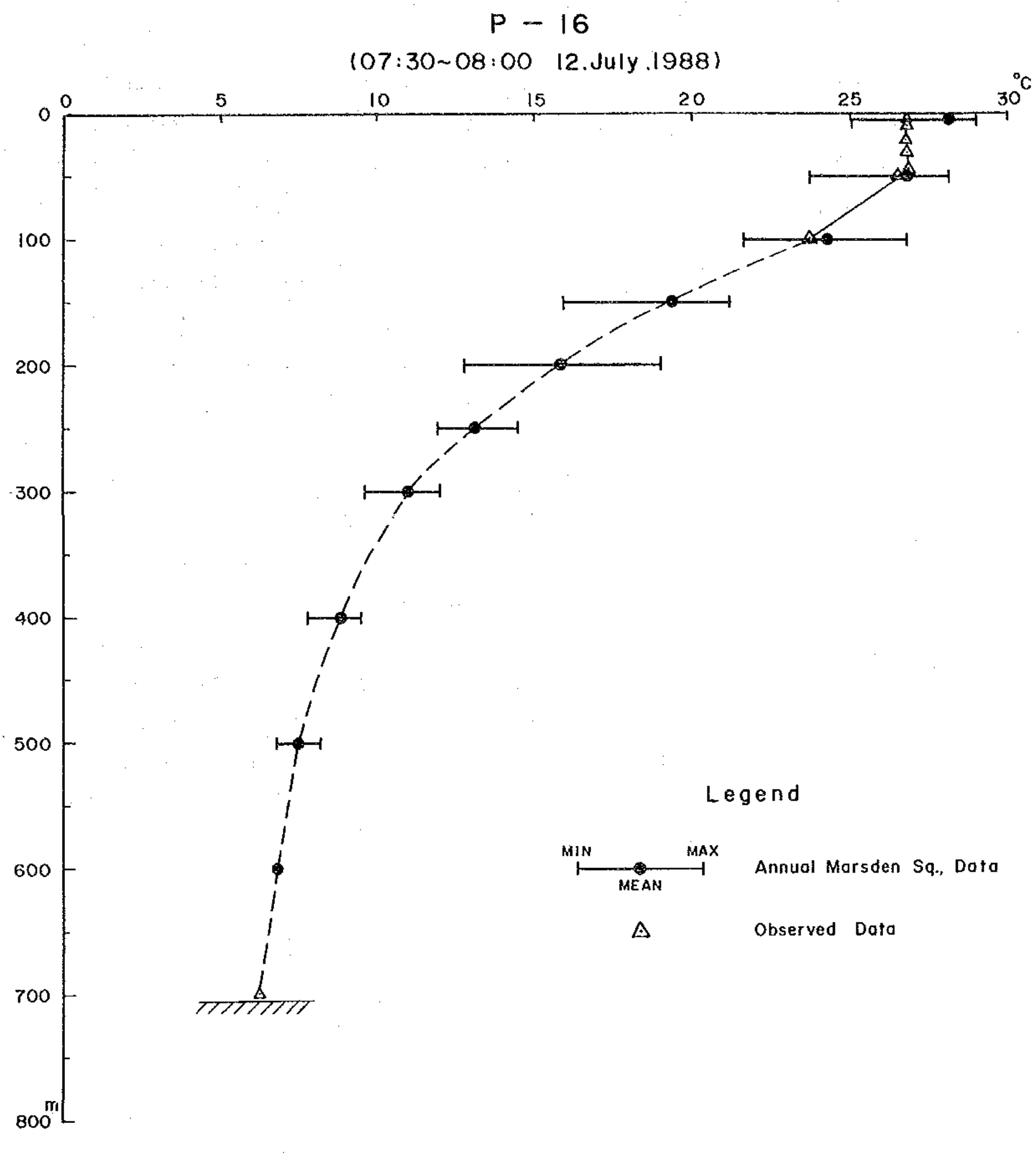



Fig. 3-15 Water Temperature Variation in Vertical Section
(Deep Sea Area)

The temperatures at the seabed layer of each station were in the range of 26.9 to 28.0°C.

Examining the water temperature variation in vertical section of Fig. 3-13, the temperatures at P-3 and P-8 showed no change adjacent to the surface layer, but the temperature at P-11 reversed to 28.0°C from 27.5°C with the difference of 0.5°C. As to Fig. 3-13, the temperature at P-11 showed no change at the layers deeper than 4 m up to 30 m with 28.0°C and went gradually down at the layers deeper than 30 m up to the seabed layer. The temperature at the seabed layer of P-11 was 26.9°C.

As mentioned above, a little difference of temperature was observed at P-11 comparing with other stations. The reason for this might be that the measurement at P-11 was conducted before dawn when the surface water temperature being influenced by the cooling effect at night time. The temperature variations in vertical section (Fig. 3-13) at each station were plotted by the annual range of temperature from the Marsden Square data. And comparing with the data obtained and Marsden Square data, all temperature obtained data at each layer were within the range of the Marsden Square data. Therefore, the temperature in these stations will vary within the annual range of the Marsden Square data.

(2) Deep Sea

In the deep sea area, 2 stations were set up, they are P-13 (Depth 1895 m) in the deepest of Makassar Basin and P-16 (Depth 711 m) on the Sulawesi Shelf slope.

The results of water temperature at the surface and the bottom layer of P-13 and P-16 are shown on the following table.

Water Temperature at Deep Sea Area

| Station | P-13 | P-16 | Remarks |
|---|---|---|---|
| Observed time | 09:50, July 13 | 07:40, July 12 | The distance between P-13 and P-16 is about 90 km |
| 0.5 m under surface | 28.3°C | 26.8°C | |
| 10 m above seabed | 3.7°C | 6.3°C | |
| Depth (m) | 1895 m | 711 m | |

According to the above table, in comparison with the surface temperatures at P-13 and P-16, the former was 1.5°C higher than the latter. The distance between P-13 and P-16 is about 90 km, therefore the difference of surface temperature may be caused by the difference of current condition at both stations (of current in deep sea area).

The observed temperatures at the bottom layer were 3.7°C at P-13 (depth: 1895 m) and 6.3°C at P-16 (depth: 711 m).

On the temperature measurement in the deep sea area, the actual measurement was conducted at the surface layer of 0.5 m - 100 m and the layer of 10 m above the seabed. The water temperature variations in vertical section (Fig. 3-14 and 3-15) were drawn by using the actual data mentioned above and the data of Marsden Sqaure between 100 m under the surface layer and 10 m above the seabed. According to Fig. 3-14 and 3-15, the temperature variation adjacent to the surface layer up to 40 m, is very few at the both stations, but there are thermocline which the temperature varies suddenly at the depth of 40 m to 500 m layer.

At the thermoclines, the water temperature goes down rapidly, and then the temperature becomes lower gradually in the deeper layer. And the Marsden Square data value approaches to the actual temperature adjacent to the seabed.

The values of water temperature in max, min, and mean annually from the Marsden Square data were plotted on the Figure of Water Temperature in Vertical Section (Fig. 3-14 and 3-15).

In comparison with the actual measured data and the Marsden data at the same depth layer, the actual value exists within the range of annual variation or near the range. Judging from the above mentioned fact, annual variation of the water temperature might be within the range of Marsden Sqaure data.

### 3.6 Vessel's Position Fixing

It is the most important factor in every ocean survey to determine the position of survey vessele. Generally a submarine cable route survey is carried out by dividing into the offshore and inshore portion. And then the instruments of position fixing have to be selected by the required accuracy of the inshore and offshore survey.

The following ship's positioning instruments are considered to be available to fix the ship's position among the eastern portion of Jawa Sea, Makassar Strait and Sulawesi Shelf.

* Middle Range Electronic Positioning System: ARGO, Hifix, Pulus 8, Raydist, Syledis
* Satellite Positioning System: GPS, NNSS

The middle range electronic positioning system has high accuracy of 25 m to 300 m and the range is 250 km to several hundred km. However, these instruments are required to set up more than two fixed stations on the land.

It is required to clarify the following points in the long distance cable route survey for this project.

(1) The number of fixed station and their arrangement in order to cover the whole route

(2) The selection of fixed stations position and the measurement of their accurate position

(3) The construction of fixed stations and the transportation of materials and personnel

(4) The analysis of economy

In case of the satellite positioning system, it is easy to access the satellite by installing a receiving antenna together with a receiver and no fixed stations are required. Among them, GPS which is under development in USA, is the most accurate positioning system with the precision of several 10 meters on the ship under going. This GPS system can be accessed by any location and anytime on the earth with real time bases, however, this system has limitation of access time due to the number of available satellites which is not enough to cover the 24 hours bases at present.

At the planning stage of a submarine cable route survey, the ship's positioning instrument must be selected carefully among the above mentioned points.

On the offshore portion, especially the deep sea portion, the accuracy of positioning becomes worse in comparison with that of the inshore portion because the offshore portion is normally located far from inshore portion. In addition, it is difficult to control the cable laying position precisely by a cable ship. Accordingly, on the offshore portion survey, the wide width measurement of the seabed condition is required along the cable route except a rough seabed.

Thus, the high accuracy of positioning on the offshore portion is not required in comparison with that of the inshore.

After deep consideration of the above-mentioned points, it was decided that the micro-wave positioning system, which has the accuracy of a few meter should be used at the inshore, and then the satellite positioning systems of GPS and NNSS shall be used mainly at the offshore portion, on the ocean survey of the Kalimantan - Sulawesi Submarine Cable. During the survey, the available time of GPS was 8-9 hours a day (from 6 pm to 4 am) and also the available time of NNSS was one time every 2 hours. Therefore, the positioning of vessel was carried out in the following manner on the offshore survey.

- . 1st priority — GPS
- . 2nd priority — NNSS (for the time period when GPS is not available)
- . 3rd — Dead reckoning navigation method

The track charts for the survey were made by the Mercator's Projection with applying the standard latitude of 5°S and the WGS-72 (World Geodetic System 1972) for the geodetic system.

### 3.7 Cable Burying Survey

The cable burying survey area was chosen on the selected cable route at the latitude of 4°35'S, the longitude of 115°40' to 50'E where the seabed geological condition was typified at the cable ground of northern portion of Jawa Sea (Fig. 3-16).

The 1/2 scale multi plow type burying machine was used on this survey.

According to the results of sub-bottom profilling, sampling and side scanning, the seabed geological and topographical condition of the survey area (205 km - 226 km apart from the Takisung landing point) were as follows:

(1) The seabed surface is covered by a fine sand and sandy mud with the thickness of less than 1 meter. The shear strength of surface layer is 0.1 $kgf/cm^2$.

(2) The lower layer consists of a stiff clay of Pleistocene with more than 0.34 $kgf/cm^2$ shear strength.

(3) On the sea bottom, it is observed that small depressions are distributed at whole area.

The number and size of these depressions are counted as follows.

* At the area of 211 - 226 km apart from the Takisung landing points, the average of depression size is 8 x 24 m and the number of depression is 5/$km^2$.

* At the area of 205 - 211 km apart from Takisung landing point, the average of depression size is 13 x 29 m and the number of depression is 5 - 20/$km^2$.

The results of the cable burying survey is shown on Fig. 3-16.

As shown on Fig. 3-16, the digged out depth was 60 - 100 cm and the pulling tension of the burying machine is almost 1-2 tons.

However, it was recorded that the pulling tension was varied rapidly by the range of 1-3 ton's at the area of 211-220 km. This variation will be caused by the depressions and the stiff clay layer.

From the results of cable burying survey, this area is suitable for the buring cable under the sea bottom. But, the pulling speed must be controled carefully for the rapid tension increase due to the depressions and thickness of the bottom surface sediments.

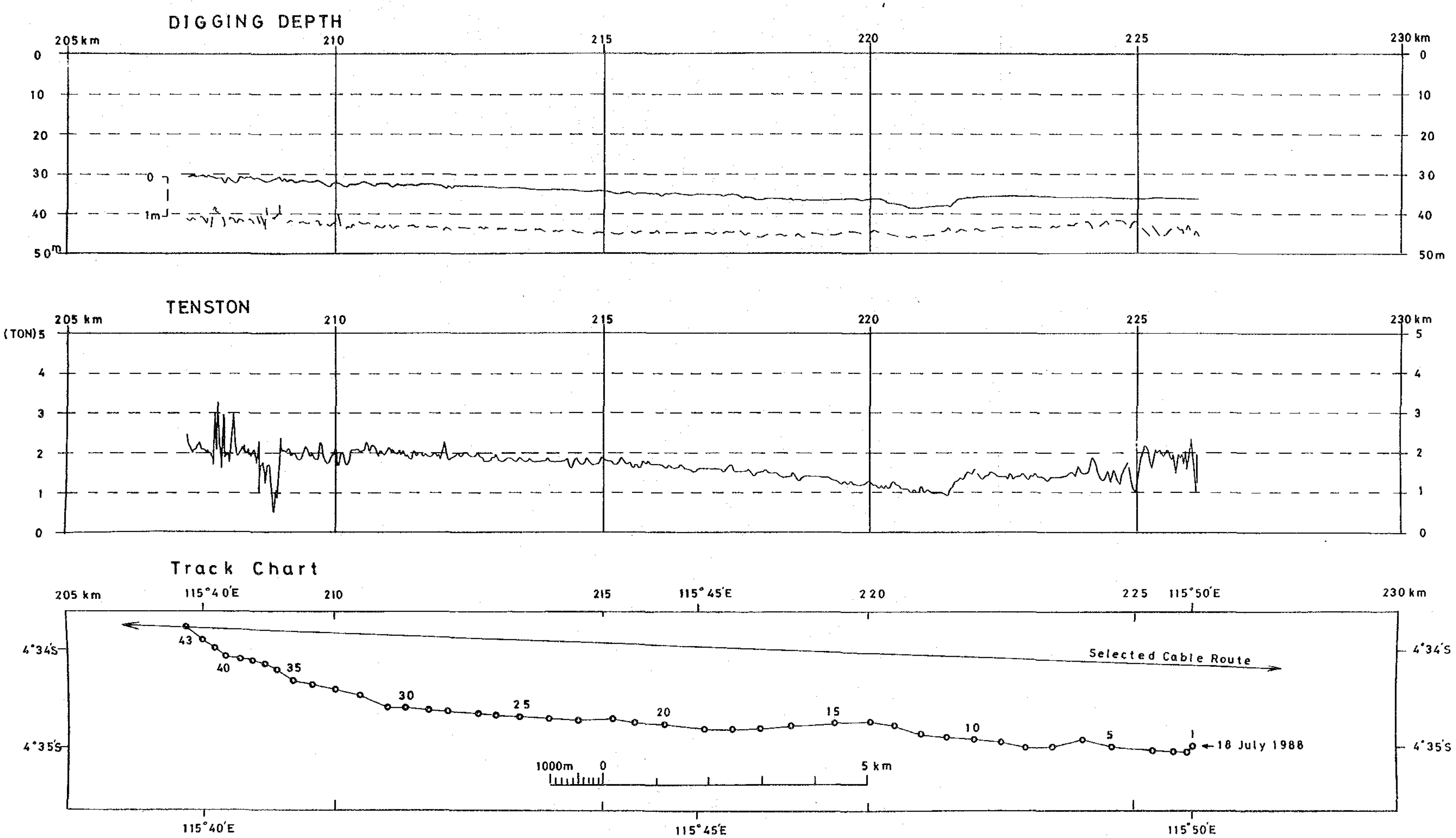



Fig. 3-16 Burial Records of Cable Burying Survey

# CHAPTER 4 LANDING POINTS AND CABLE ROUTE

# CHAPTER 4 LANDING POINTS AND CABLE ROUTE

## 4.1 Cable Landing Points

The cable landing sites for the Kalimantan - Sulawesi Submarine Cable were decided as Takisung for Kalimantan and Balang for Sulawesi on the Phase-I Study. However it becomes clear that the geographical position of Balang landing site belongs to Bonto Marannu on the Phase-II Sutdy. Accordingly, Bonto Marannu is used as the designation of Sulawesi landing site in this reports.

The position of cable landing points at both landing sites were measured by GPS as shown below.

* Takisung: 3°52'.42 S, 114°35'.61 E
* Bonto Marannu: 5°23'.74 S, 119°21'.53 E

These values have very high accuracy because of the low value of tolerance of GPS.

The both landing sites are sandy beaches and have enough space for the cable landing works and local labores can be obtained easily at the villages. However, due to the poor condition of access roads from the main road to the both landing sites, the transportation of heavy instruments and the tools will meet with a difficulty.

At the beach of both landing sites, it was observed an erosive action by the sea water, therefore the protection of the beach portion cable might be required such as increasing buring depth, attaching iron pipes, etc.

## 4.2 Cable Route and Route Condition

The selected submarine cable route, seabed profile between Kalimantan (Takisung) and Sulawesi (Bonto Marannu) and its coordinate are shown on Fig. S-1, 4-1 and Table 4-1, respectively. This route is slightly changed on the planned cable route due to the topographic and geological condition of the sea bottom by taking the results of this ocean survey into consideration.

The seabed profile and its topographic and geological condition are shown on Fig. 3-1 and 3-8.

As to the seabed profile of the selected cable route, nearly 70% of whole length is on the Jawa and Sulawesi Shelf where the sea depth is less than 200 meters, and the residual 30% is deep see portion of crossing the Makassar Strait.

The topographical and geological condition of the seabed is described in detail on the Chapters 2 and 3. So that, this section describes the seabed profile, topographic and geological condition of along the selected cable route from a standpoint of the cable laying and burying.

(1) Takisung to the margin of Jawa Shelf (400 km). The seabed is quite flat, however there are rock outdrops at 372-397 km apart from the T.L.P, and the cable burying is impossible.

    The other portion of the seabed is covered by the sediment such as mud, sand and clay.

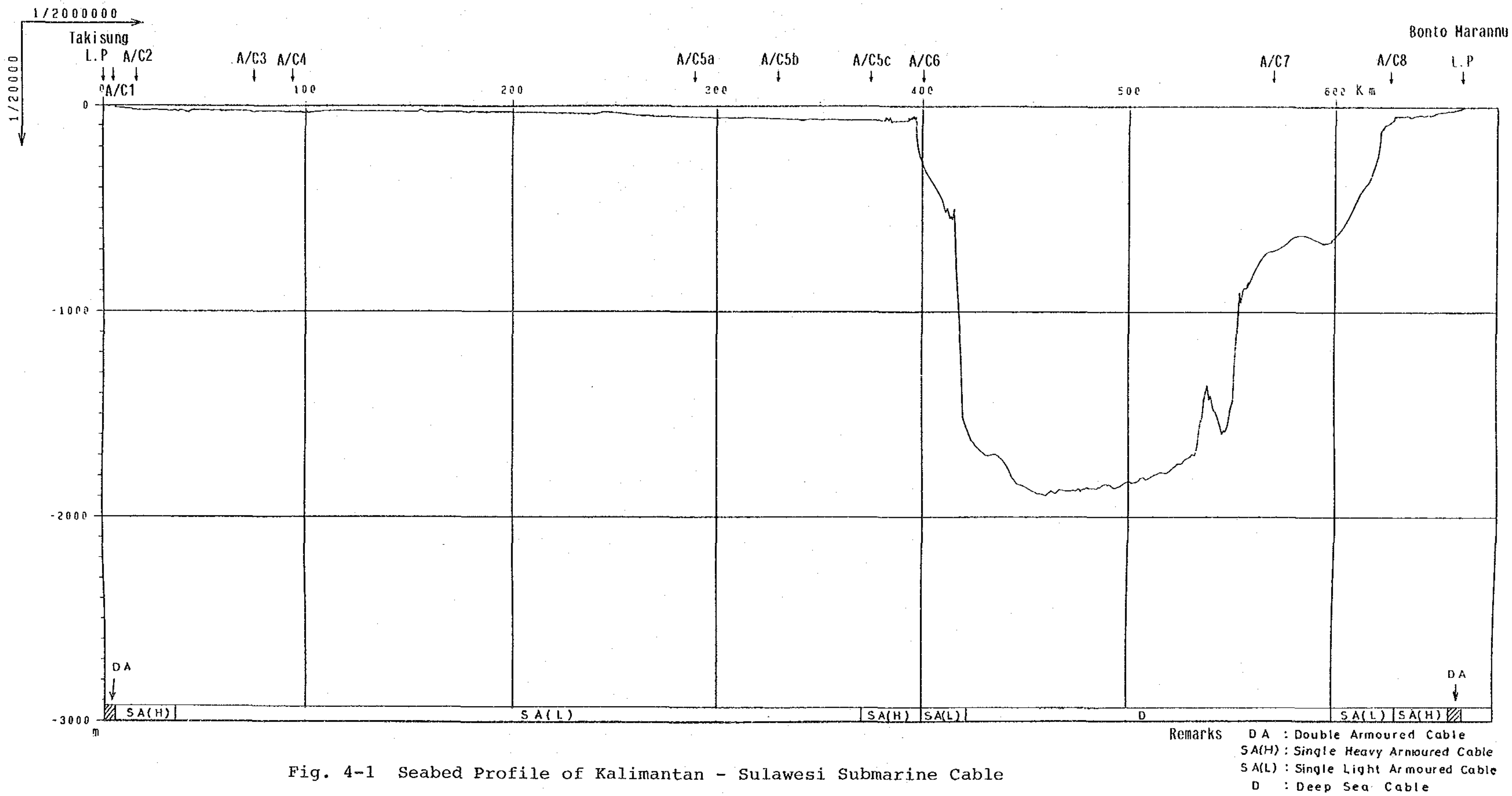



Fig. 4-1 Seabed Profile of Kalimantan - Sulawesi Submarine Cable

The thickness of these sediment is mostly more than 1 meter, however it was observed that the stiff clay layer approaches to the seabed at many portions.

Accordingly, the cable burying will meet some difficulty on these portions.

The seabed gradient is also gentle except the eastern edge of Jawa Sea, but there are small up and down (height varies 2-7 m with 2-7° gradient) on the seabed. The cable buring survey was carried out at 205-235 km apart from the T.L.P. During this survey, the pulling tension varied in 1-3 ton's range and sometimes it over 5 ton's. This tension variation may be occurred by the seabed up and down, and also the stiff clay layer.

(2) Crossing portion of Makassar Strait

The down slope from the eastern edge of Jawa Shelf to the bottom of Makassar Strait is rather steep with gradient of 8°-11° and the ancient coral reef appears mostly along the slope. Therefore it will be required to strengthen the cable armour wire between 372 km (depth 120 m) and 440 km (depth 700 m) from the T.L.P. The seabed of Makassar Strait is covered by mud and the depth is mostly more than 1500 m. The deepest point is recorded as 1896 m. At the eastern end of the bottom of Makassar Strait, there is a rocky spur with 300 m height and the skirt of this is expanded about 12 km with the gradient of 5-6°. At the up slope from the bottom of Makassar Basin to the Sulawesi Shelf, there is also steep slope with gradient of 8-9° up to the depth of 900 m (545 km - 555 km from T.L.P). Then beyond this steep up slope, the gradient of slope becomes comparatively gentle with less than 5°, however the up slope nearby the Sulawesi Shelf was recorded as 13° gradient.

The seabed condition of this up slope from the bottom of Makassar Basin to the Sulawesi Shelf is mostly ancient coral reef. Therefore the strengthening of cable armoured wire shall be required up to the depth of 700 m.

(3) The eastern edge of Makassar Basin to Bonto Marannu (Sulawesi Shelf)

The seabed condition of the Sulawesi Shelf is covered with thin coral sand and the lower layer is basement rock or ancient coral reef, therefore the cable burying is possible only 8 km from the Bonto Marannu beach. The sea bottom is flat with small up and down.

As discribed in the Chapter 1.9, several kinds of sharks are living in Makassar Starit up to the depth of less than 500 m, therefore a countermeasure should be taken on the deep sea cable to protect it from the fish bite. The selected cable route length is 662.715 km as shown on Table 4-1 and the required cable length is calculated as follows:

| Section | | | Required Slack (%) | Required Cable Length (km) | Remarks |
|---|---|---|---|---|---|
| | From | To | | | |
| Takisung Land Cable | Landing Point | Landing Station | | 0.15 | 0.104km+0.046km (Slack Pit) |
| | Takisung Landing Point | 372 km | (372 km) 2% | 379.44 | |
| | T.L.P 372 km | 430 km | (58 km) 7% | 62.06 | |
| | T.L.P 430 km | 530 km | (100 km) 2% | 102.00 | |
| | T.L.P 530 km | 560 km | (30 km) 7% | 32.10 | |
| | T.L.P 560 km | 630 km | (70 km) 5% | 73.50 | |
| | T.L.P 630 km | Bonto Marannu Landing Point | (32.715 km) 2% | 33.37 | |
| Bonto Marannu Land Cable | Landing Point | Landing Station | | 0.29 | 0.235km+0.055km (Slack Pit) |
| Required Cable Length | | | | 682.91 | |

Based on the seabed topographic and geological condition and seabottom profile along the cable route, the Study Team selects a type of cable as shown on Fig. 4-1 (bottom line) for the reference.

Table 4-1 Coordinate and Route Length of Selected Route

| A/C Point | Lat.(D.K.) | Long.(D.M.) | Dis.(km) | Cum.(km) |
|---|---|---|---|---|
| Takisung L.P. | 3°52.42' | 114°36.61' | | |
| | | | 5.0036 | 5.004 |
| A/C 1 | 3°52.42' | 114°34.13' | | |
| | | | 11.4327 | 15.436 |
| A/C 2 | 3°56.80' | 114°28.90' | | |
| | | | 57.5020 | 73.938 |
| A/C 3 | 4°26.00' | 114°29.00' | | |
| | | | 19.5143 | 93.453 |
| A/C 4 | 4°33.00' | 114°38.30' | | |
| | | | 195.5425 | 288.995 |
| A/C 5a | 4°35.50' | 116°24.00' | | |
| | | | 40.4114 | 329.407 |
| A/C 5b | 4°24.50' | 116°42.90' | | |
| | | | 45.2352 | 374.642 |
| A/C 5c | 4°14.00' | 117° 5.00' | | |
| | | | 25.6002 | 400.242 |
| A/C 6 | 4°15.00' | 117°18.80' | | |
| | | | 169.7229 | 569.965 |
| A/C 7 | 5° 7.80' | 118°34.00' | | |
| | | | 57.4277 | 627.393 |
| A/C 8 | 5°19.01' | 119° 3.00' | | |
| | | | 35.3227 | 662.715 |
| Bonto Marannu L.P. | 5°23.74' | 119°21.53' | | |

# APPENDICES

# APPENDIX 1

## SUMMARY OF SURVEY VESSEL'S LOG BOOK

Appendix 1 Summary of Survey Vessel's Log Book

The vessel's log contained in this appendix covers a period from entry into the Banjarmasin port on June 27, 1988 up to departure for Japan on July 24, 1988, and the descriptions of survey works in each day, as stated follows, are an excerpt of the Wakashio Maru log.

## Summary of Survey Vessel's Log Book

(Notice)

N.P ... Noon Position
Wr ... Weather
W.D ... Wind Direction
W.F ... Wind Forces
S.C ... Sea Condition

The Observation was made at noon.

1988

Jun. 27th Mon. N.P: Banjarmasin port
Wr: fine sky, W.D: S, W.F:2, SC: smooth

12:15 Survey vessel (Wakashio Maru) entered Banjarmasin port.
Supply of fuel, fresh water and food.

Jun. 28th Tue. N.P: Banjarmasin port
Wr: fine weather, W.D: SE, W.F: 2, S.C: smooth

11:00 Embarkation (Survey team: 16, counterpart: 3, Naval officer: 3)

13:00 Preparation for survey

16:15 Left Banjarmasin port (for Takisung offshore)

21:15 Dropped anchor at offing of Takisung

Jun. 29th Wed. N.P: 3°57'7"S, 144°30'0"E
Wr: cloudy sky, W.D: NNW, W.F: 2, S.C: smooth

08:00 Commencement of landing site and inshore survey.
Survey items: Control point survey
Topographic survey
Sounding, Sub-bottom profiling
and side scanning (L.P to 5 km)
by local boat.

Jun. 30th Thu. N.P: 3°57'7"S, 114°30'0"E
Wr: rain, W.D: SE, W.D: 3, S.C: smooth

08:00 Landing site and inshore survey
Survey items: Costal line survey, topographic
survey
Sounding, sub-bottom profilling
and side scanning.

Jul. 1st Fri. N.P: 3°57'7"S, 114°30'0"E
Wr: rain, W.D: S, W.F: 2, S.C: smooth

08:00 Inshore survey
Survey items: Sampling, photographing, Penetration test by steel pipe and Water
temperature measurement

13:00 Preparation for Ocean Survey

22:50 Commencement of going run survey
Survey items: Sounding, Sub-bottom profiling
and Side scanning

Jul. 2nd Sat. N.P: 4°33'5"S, 114°44'0"E
Wr: fine, W.D: SE, W.F: 5, S.C: moderate

Continuation of going run survey
(∿ A/C 2 ∿ A/C 4 ∿)
Survey items: Sounding, Sub-bottom profiling and Side scanning

Jul. 3rd Sun. N.P: 4°35'1"S, 114°09'5"E
Wr: fine weather, W.D: SE, W.F: 5,
S.C: moderate

Continuation of going run survey
(∿ A/C 6 ∿ A/C 7 ∿ 200 m in depth)
Survey items: Sounding, Sub-bottom profiling and Side Scanning

Jul. 4th Mon. N.P: 4°15'0"S, 117°19'2"E
Wr: fine sky, W.D: SE, W.F: 3, S.C: slight

09:15 Recovery of Sub-bottom profiler (Sonoprobe) and Side scan sonar

13:15 Resumption of going run survey
Survey items: Sounding and Sub-bottom profiling (3.5 kHz)

Jul. 5th Tue. N.P: 5°20'0"S, 199°07'5"E
Wr: fine weather, W.D: SE, W.F: 5,
S.C: moderate

Continuation of going run survey
(∿ A/C 7 ∿ A/C 8 ∿ L.P)
Survey items: Sounding and Sub-bottom profiling

08:30 Outfitting of sub-bottom profiler (Sonoprobe) and Side scan sonar

09:00 Resumption of going run survey

16:00 Supplementary survey (A/C 8 ∿ L.P)

Jul. 6th Wed. N.P: Ujungpandang port
Wr: fine weather, W.D: WNW, W.F: 2,
S.C: smooth

03:50 Completion of going run survey

04:30 Sailing for Ujung Pandang port

09:00 Survey vessel entered Ujung Pandang port
Entrance procedure

Jul. 7th Thu. N.P: Ujung Pandang port
Wr: fine weather, W.D: W, W.F: 2,
S.C: smooth

08:00 Clearance formalities

13:00 Left Ujung Pandang port (for Bonto Marannu offshore)

15:15 Arrived at offing of Bonto Marannu

16:00 Commencement of magnetic survey at anchorage for survey vessel

16:50 Dropped anchor

Jul. 8th Fri. N.P: 5°23'2"S, 119°20'3"E
Wr: fine weather, W.D: S, W.F: 4,
S.C: moderate

08:00 Commencement of landing site and inshore survey by small boat at Bonto Marannu
Survey items:
. Control point survey and topographic survey at landing site
. Magnetic survey and setting up of current meter at inshore

Jul. 9th Sat. N.P: 5°23'2"S, 119°20'3"E
Wr: fine weather, W.D: S, W.F: 4,
S.C: moderate

06:30 Landing site and inshore survey (L.P to 5 km)
Survey items:
. Topographic survey, coastal line survey and earth resistivity measurement at landing site
. Sounding, Sub-bottom profiling and Side scanning at inshore

Jul. 10th Sun. N.P: 5°23'2"S, 119°20'3"E
Wr: fine weather, W.D: SSE, W.F: 6,
S.C: rather rough

06:30 Inshore survey (L.P to 5 km)
Survey items:
. Coastal line survey
. Magnetic survey, penetration test by steel pipe, sampling, seabed photographing and water temperature measurement

Jul. 11th Mon. N.P: 5°23'3"S, 119°20'8"E
Wr: fine weather, W.D: W, W.F: 2, S.C: smooth

08:00 Inshore survey
Survey items:
. Photographing at landing site
. Recovery of current meter

09:30 Completion of inshore survey at Bonto Marannu

10:00 Preparation for return run survey

15:40 Commencement of return run survey (5 km ∿ A/C 8)
Survey items: Sounding and Sub-bottom profiling

17:22 Point survey at P.18
Survey items: Magnetic survey and sampling

17:55 Return run survey (∿ A/C 8 ∿)

19:24 Point survey at P.17
Survey items: Sampling and seabed photographing

21:10 Return run survey

Jul. 12th Tue. N.P: 4°57'0"S, 118°21'5"E
Wr: fine weather, W.D: SE, W.F: 5,
S.C: moderate

Continuation of return run survey (∿ A/C 7 ∿)

06:30 Point survey at P.16
Survey items: Water thermometry, current observation and sampling

07:50 Resumption of return run survey (A/C 7 ∿ A/C 6)

20:24 Point survey at P.15
Survey items: Sampling and seabed photographing

22:30 Return run survey (A/C 7 ∿ A/C 6)

Jul. 13th Wed. N.P: 4°35'5"S, 117°41'5"E
Wr: fine weather, W.D: SSE, W.F: 5,
S.C: moderate

Continuation of return run survey (A/C 7 ∿ A/C 6)

01:22 Point survey at P.14
Survey items: Sampling

02:50 Return run survey (A/C 7 ∿ A/C 6)

08:40 Point survey at P.13
Survey items: Water thermometry, current observation, seabed photographing and sampling

15:40 Resumption of return run survey (A/C 7 ∿ A/C 6)

20:45 Point survey at P.12
Survey items: Sampling

21:50 Return run survey (∿ A/C 6 ∿)

Jul. 14th Thu. N.P: 4°23'0"S, 116°51'0"E
Wr: rain, W.D: NW, W.F: 2, S.C: smooth

Continuation of return run survey

04:49 Point survey at P.11
Survey items: Water thermometry, current observation, seabed photographing and sampling

07:40 Resumption of return run survey (A/C 6 ∿)

13:50 Point survey at P.10
Survey items: Photographing and sampling

15:50 Supplementary survey (around A/C 6)
Survey items: Sounding, Sub-bottom profilling and Side scanning

Jul. 15th Fri. N.P: 4°33'5"S, 116°28'3"E
Wr: rain, W.D: SWE, W.F: 4, S.C: moderate

Continuation of supplementary survey (around A/C 6)

05:10 Completion of supplementary survey

07:40 Resumption of return run survey

13:53 Point survey at P.9
Survey items: Sampling

15:40 Return run survey (A/C 6 ∿ A/C 5a)

21:00 Discontinuation of return run survey

21:30 Sailing for Kotabaru port

Jul. 16th Sat. N.P: 3°17'0"S, 116°25'5"E
Wr: cloudy sky, W.D: SSW, W.F: 3, S.C: slight

07:00 Entered Kotabaru port and dropped anchor

07:30 A counterpart disembarked due to stomachache

11:00 Left Kotabaru port

18:15 Arrived at near A/C 6

19:00 Resumption of return run survey

Jul. 17th Sun. N.P: 4°25'0"S, 116°43'7"E
Wr: fine weather, W.D: SSE, W.F: 3,
S.C: slight

Continuation of return run survey
Survey items: Sounding and Sub-bottom profiling

07:58 Point survey at P.10-1
Survey items: Sampling

09:10 Return run survey
Survey items: Sounding, Sub-bottom profiling and Side scanning

23:04 Point survey at P.8
Survey items: Water thermometry, current observation, photographing and sampling

Jul. 18th Mon. N.P: 4°34'7"S, 115°43'0"E
Wr: fine weather, W.D: ESE, W.F: 3,
S.C: smooth

01:20 Resumption of return run survey

06:00 Preparation of cable buring survey

08:00 Commencement of cable buring survey

15:00 Completion of cable buring survey

18:45 Point survey at P.7
Survey items: Sampling

19:30 Return run survey

22:47 Point survey at P.6
Survey items: Current observation and sampling

23:40 Return run survey

Jul. 19th Tue. N.P: 4°31'5"S, 114°33'7"E
Wr: fine weather, W.D: SE, W.D: 4,
S.C: moderate

Continuation of return run survey

03:35 Point survey at P.5
Survey items: Sampling

04:10 Return run survey

08:30 Point survey at P.4
Survey items: Sampling

09:40 Return run survey

21:41 Point survey at P.3
Survey items: Water thermometry, current observation, photographing and sampling

23:30 Return run survey

Jul. 20th Wed. N.P: 3°55'0"S, 114°28'0"E
Wr: cloudy sky, W.D:SE, W.F: 2, S.C: smooth

Return run survey

03:21 Point survey at P.2
Survey items: Sampling

04:20 Return run survey

08:00 Point survey at P.1
Survey items: Photographing and sampling

09:00 Sailing for offing of Banjarumasin port

11:00 Arrived at Pilot station and dropped anchor

14:25 Sailing for Banjarumasin port

17:15 Entered Banjurmasin port

18:43 Clearance formalities
Data processing and survey instrument clear up

Jul. 22nd Fri. N.P: Banjarumasin port
Wr: cloudy sky, W.D: SE, W.F: 1, S.C: calm

15:30 Survey vessel moored clong side the pier

. Survey data processing was made and survey instruments were cleared up.

. Water was supplied.

Jul. 23rd Sat. N.P: Banjarumasin port
Wr: cloudy sky, W.D: SW, W.F: 1, S.C: calm

10:20 Survey team members, counterparts and naval officers disembarked

. Food and fuel were supplied.

Jul. 24th Sun. N.P: Banjarumasin port

09:30 Left Banjarmasin port and sailed to Japan

# APPENDIX 2

# SURVEY VESSEL

## Appendix 2 Survey Vessel

The survey vessel "Wakashio Maru" with sufficient functions and facilities was used in this cable route survey. The principal particulars of vessel are given below, and general arrangement of "Wakashio Maru" is shown in Fig. A-1.

Particulars of Survey Vessel "Wakashio Maru"

Dimensions

| | |
|---|---|
| Length o.a. ............................ | 49.00 m |
| Breadth (mld) ............................ | 8.80 m |
| Depth (mld) ............................ | 4.05 m |
| Draught (designed) ........................ | 3.20 m |

Tonnage

| | |
|---|---|
| Gross Tonnage ............................ | 493.59 tons |

Machinery

| | |
|---|---|
| Main Engine ............ | 1,000 BHP x 2 sets = 2,000 BHP |
| Generator ............ | AC 445 V x 375 kVA x 2 sets |
| | AC 440 V x 60 kVA x 2 sets |
| Propeller .............. | Controllable Pitch Propeller (CPP) x 1 set |
| Bow Thruster ........... | 180 HP x 1 |
| Capstan ................ | 2 sets |

Navigation & Communication

Radar, NNSS, Log, Loran, Echo Sounder for deep sea, Echo Sounder for shallow water, Sub-bottom Profiler for deep sea, VHF, Auto Pilot, Radio Telephone, SSB Internal Telephone, MARISAT.

Complement

| | |
|---|---|
| Crew .................................. | 14 persons |
| Passenger ............................. | 24 persons |

Seed

| | |
|---|---|
| Cruising .............................. | 15.2 Knots |

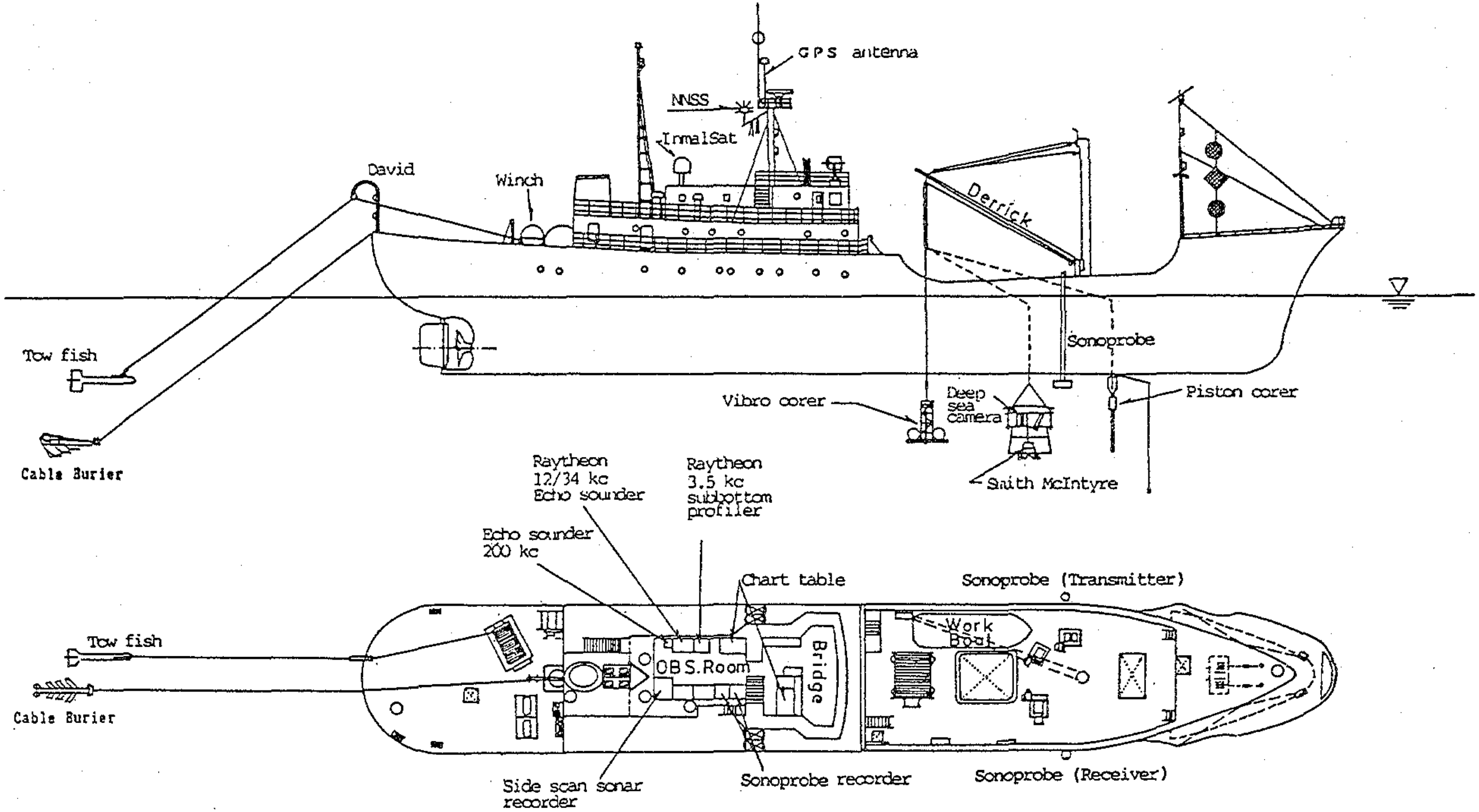



Fig. A-1 Outfitting of Wakashio Maru

# APPENDIX 3

# SURVEY EQUIPMENTS AND SURVEY METHODS

Appendix 3 Survey Equipments and Survey Methods

(1) Positioning

1) GPS (Global Positioning System)

GPS is a satellite navigation system known as NAVSTAR (Navigation System with Time and Ranging) which is being developed by Department of Defence, USA. This system consists of the space segment (satellite), the control segment (tracking station) and the user segment (receiver), as shown in Fig. A-2.

GPS, when it is completed, four or more satellites will always be in position at any time and location by arranging eighteen (18) satellites at proper intervals at an orbiting altitude of about 20,000 km, as shown in Fig. A-2. In this way, real-time continuous positioning will be possible for twenty four (24) hours a day.

GPS uses 1575.42 MHz wave (about 1.5 GHz (L1 band)) and 1227.6 MHz (about 1.2 GHz (L2 band)), which are higher than NNSS operating frequencies of 400 MHz and 50 MHz. Two types of coded signals (called C/A and P) are respectively used in bands L1 and L2 as wave signals. Band L2 and code P are for the military use, and confidential. Therefore, only code C/A of band L1 is available for the ordinary positioning.

NNSS utilizes the Doppler effect on waves, but GPS measures distances between satellites and a receiver using a method called PSK (Phase Shift Keying) spectrum distributed modulation using PRN (Pseudo Randam Noise) codes. For this method, a position

(Latitude, Longitude and Altitude) is fixed at the distances between an receiver and four satellites. The various types of information on orbiting, time, etc., are sent from the satellites in the form of coded signals.

The positioning accuracy of this method is nominally specified as less than sixteen (16) meters when using two waves of bands L1 and L2 and code P. The general positioning accuracy when only using code C/A of band L1 is several tens of meters.

At least, four satellites are required to locate a three-dimensional position (consisting of Latitude, Longitude and Altitude). However, when positioning at sea, a two-dimensional position consisting of Latitude and Longitude is only required. In this case, only three satellites are required and the available period for positioning elongates. At present, the number of operated satellites is seven (7).

In addition, two-dimensional positioning can be done using two satellites and a special receiver with an atomic clock (rubidium oscillator). Accordingly, the available period elongates more.

Currently, this system is not fully operational, and the available period for positioning by GPS in time zones adjacent to Indonesia is about twelve (12) hours in case of three satellites, and about sixteen (16) hours in case of two satellites based on the data of Trimble Navigation. Due to this fact, a receiving system with an atomic clock is much more effective than conventional recievers.

The completion on the construction of GPS system is expected in 1989 to 1991 at present.

2) NNSS (Navy Navigation Satellite System)

The Navy Navigation Satellite System (NNSS) consists of five navigation satellites currently in operation and a command earth station capable of measuring orbits of the satellites and transmitting their orbital data to the satellites.

These satellites all fly on a circular polar orbit which passes just above the north and south poles located at both ends of the axis of the earth. The satellites fly around the earth at an altitude about 1,100 km and cycles of about 108 minutes, and the earth rotates on its axis eastward by about 26.5° during this period. The five satellites can, therefore, be successively used one by one as the earth rotates on its axis (refer to Fig. A-2).

The area where the survey was conducted is located in a range between the latitudes of 3° S and 6° S, and the number of satellites which fly over this area is about twenty (20) per one day.

The positioning principles of the NNSS are as follows: A satellite of the NNSS transmits signals of two frequencies; $f_1$ = 399.968 MHz and $f_2 = 3/8 \cdot f_1$ = 149.988 MHz and time signals as well at two-minute intervals and data required for calculating the satellite position, as illustrated in Fig. A-2.

The satellite transmits time signals at positions (time) of $t_0$, $t_1$, $t_2$ ..... rotating on a circular orbit. Consequently, the time of $t_1 - t_0$, $t_2 - t_1$, ..... $t_i - t_{i-1}$ are all two minutes. At this time, the satellite gradually approches the earth in the order of $D(t_0)$, $D(t_1)$ ..... $D(t_i)$, leaving the earth thereafter in the reverse order, and sinking below the horizon. The receiving frequency is counted at this time. Applying the Doppler effect to the above proves that a doppler shift is zero when the distance between the satellite and the earth becomes minimum, and accumulation at one cycle is counted, assuming that the transmitting frequency of the satellite is 399.968 MHz x 2 minutes. On the other hand, since the satellite always moves in reality, the accumulated value differs from the value mentioned above. In other words, variations of the distance between the satellite and a receiving point can be found if the wavelength of radio wave is known.

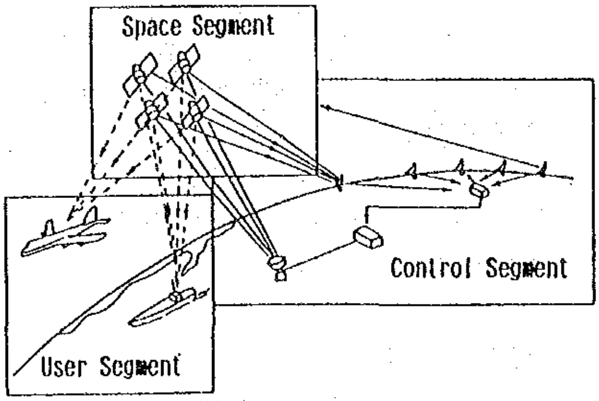
A locus of point where the distance difference $D(t_i) - D(t_{i-1})$ thus obtained becomes constant form a hyperboloid of revolution, and considering the condition that a ship is on the surface of the earth, a line on which the hyperboloid and the surface of the earth cross each other represents a positional line of the ship. The positioning principles of the NNSS is a sort of hyperbolic navigation similar to the Loran or OMEGA system.

Specification of Satellite Navigation System FSN-70

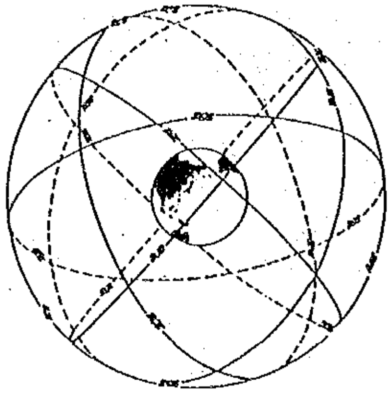
| | |
|---|---|
| Positioning accuracy: | 0.1 nm when ship is at rest.<br>0.2 nm to 0.5 nm when ship is cruising. |
| Power: | DC 10 to 40 V below 19 W<br>AC 100/220 V 30 VA |
| Operating temperature: | 0°C to 50°C<br>-25°C to 70°C (antenna section) |

<u>Receiver</u>

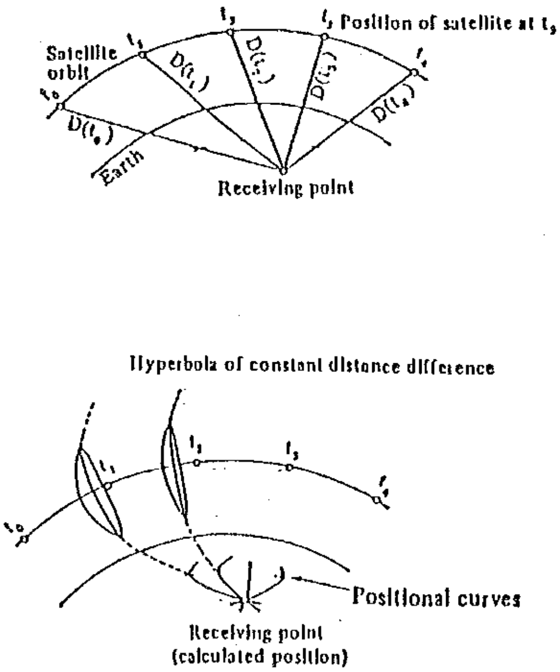
| | |
|---|---|
| Receiving frequency: | 399.968 MHz ±10 MHz |
| Tuning: | Automatic tuning |
| Sensitivity: | -145 dB |
| Dynamic range: | -140 to -80 dB |



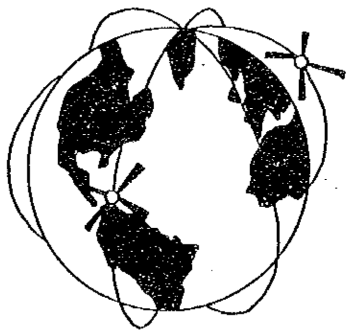

System Configuration



Orbit of G P S Satellite




Measure Principle



Orbit of NNSS Satellite

Fig. A-2 G.P.S and NNSS

3) Micro Wave Positioning System

Micro Wave Positioning System used for the survey is a portable system, and can establish a temporary positioning chain in the coastal area for various private activities. This system consists of a mobile station (Interrogater) onboard and two or more land stations (Responder) on land.

A principle of the positioning by this system is to measure two sets of distances simultaneously between a mobile station and two land stations (called two-range system). Both distances are calculated based on the phase differences of microwave. The lines of position obtained by this system become concentric circles with the control points (land stations) as the center of such circles, and the position of the mobile station is decided as a cross-point of 2 lines of position.

The positioning system used for this survey is MRD-I (Telullometer) with the range mode, and Specifications of the system is given below:

<u>MRD-1</u>

| | |
|---|---|
| Maximum measuring distance: | 100 km |
| Maximum indicating value: | 99999.9 m |
| Measuring accuracy: | 1 m $\pm 3 \times 10^{-6} D$<br>(D: measured distance) |
| Frequencies: | Master 2977 MHz<br>Slave (1) 3010 MHz<br>Slave (2) 3020 MHz |

| | |
|---|---|
| Power output: | 1 W |

Power voltage and consumpted power

| | |
|---|---|
| Master: | 10.5 to 34 V DC 90 W |
| Slave: | 10.5 16 V DC 40 W |

(2) Echo Sounding

A pulse of sound is projected to the seabed and the time interval between the transmission of the pulse and receipt of the same pules reflected from the seabed is converted to distance and indicated in depth on a paper trace or C.R.T. This is the principle of all sonars, echo sounders are simply sonars with a beam fixed in a vertical axis. An echo sounder measures time (between transmission and receipt of a pulse) and converts this to range by multiplying half the time (the pulse makes a two way journey) by an assumed speed of sound in water.

The echo sounder used for the route survey are the digital echo sounder (DSF-6000), the portable echo sounder (PDR-101) and the deep sea echo sounder (Raytheon 12/34 kHz).

Specifications of these echo sounders are as follows:

- PDR-101 type echo sounder

| | |
|---|---|
| Recording range: | 0 to 60 m (shallow sea)<br>0 to 120 m (deep sea) |
| Accuracy: | ±3 cm + D/1000 (D: depth m) |
| Beam angle: | 6° (beam width) |
| Frequency: | 200 kHz |
| Power: | DC 24 V 1.5 A |

- DSF-6000 type digital echo sounder

| | |
|---|---|
| Recording range: | Low frequency 2.5 to 2000 m at 40 kHz<br>High frequency 1 to 500 m at 200 kHz |
| Accuracy: | Water depth recorded x ±0.1% ±max. 0.7 m |
| Resolution: | 0.025% Scale measured |
| Beam angle: | 20° at Low frequency<br>10° at High frequency |
| Power: | DC 24 V or 12 V, about 90 W |
| Digital expression: | a number of 4 figure |

- Raytheon 12/34 kHz type echo sounder

| | |
|---|---|
| Frequency: | 12 kHz, 34 kHz |
| Recording range: | 0 to 10,000 m, 0 to 3,000 m |
| Resolution capacity: | 30 cm, 30 cm |
| Beam angle: | 30°, 10° |

(3) Seabed Scanning

The side scan sonar is a device for investigating uneven conditions of the seabed surface, and its fundamental functions are the same as an echo sounder. In the case of a echo sounder, a transmitting transducer positioned near the sea surface emits an acoustic pulse downward just below it in a narrow beam. On the other hand, in the case of a side scan sonar, a pulse is emitted obliguely to the seabed from a transmitting transducer attached to a "tow fish" which is towed near the seabed surface.

Transmitting and receiving transducers are arranged on both sides of the "tow fish" so as to their head is faced at a right angle to the towing direction, and an acoustic pulse is transmitted to cover the seabed with wide angle of several ten degrees in vertical, and an angle of about one degree in horizontal.

Acoustic waves reflected from the seabed are continuously received with corresponding to the time delay of the distance between a "tow fish" and an acoustic wave reflecting seabed point. Since an acoustic wave is attenuated according to the propagation distance, the difference in receiving signal intensity is equalized by a time equalizer, the gain of which varies with time.

Output signals of the receiving amplifier are recorded on the chart paper at positions corresponding to the distance between the "tow fish" and the acoustic wave reflecting point. As fish is towed, the conditions of the seabed surface are recorded in two dimensions just like a photo showing light and dark patterns corresponding to the unevenness of the seabed surface. It also has such functions that the strain of a seabed record is corrected real time, depending upon the range and ship's speed and that the record is scaled down by an aspect ratio of 1:1, and also that the topography of the seabed is shown like an aerial photograph.

The specification of the side scan sonars for shallow sea (MARK 1B and SMS-960) are as follows:

| | MARK 1B | SMS-960 |
|---|---|---|
| Range scale | 50,100,125,200,250,500 m | 100,150,200,300,400,500 m |
| Scale line | Every 25 m | Every 25 m |
| Input power | 24 - 30 V DC, 4 - 8 A | 115 V AC |
| Recording paper | Wet, 28 cm x 39 m | Dry, 28 cm x 50 m |
| Weight | 38 kg | 75 kg |
| Dimensions | 28 cm x 84 cm x 44 cm | 94 cm x 72 cm x 45 cm |

| | 272 Tow Fish |
|---|---|
| Operating frequency | 105 ±10 kHz |
| Pulse duration | 0.1 mm/sec |
| Peak output | 128 dB |
| Horizontal beam pattern | 1.2° |
| Vertical beam pattern | 20 or 50° wide |
| Operating depth | 0 to 600 m |
| Normal tow speed | 0 to 15 knots |
| Weight | 24 kg in air 16 kg in water |
| Dimension | 140 cm length, 30 cm height, 11.4 cm in diameter |

(4) Sub-Bottom Profiling

A low-frequency acoustic wave with a large output is used for investigating the geological structure under the seabed. Although a part of it is reflected from the seabed, this low-frequency large-output acoustic wave penetrates under the seabed, and gradually attenuates while repeating reflection at each boundary between strata.

On the other hand, acoustic waves reflected from the seabed are amplified after having been received by the transducer, to depict a geological profile on the recording paper. Theoretically speaking, lower the frequency, or the larger the output is, the deeper the exploration range reaches, but, on the other hand, the resolution deteriorates, and it becomes difficult to grasp a minute geological structure.

Seismic profiler used for the route survey is a magnet striction and vibration type (Sonoprobe) and electro-striction type (3.5 kHz Raytheon). They are used according to their prospecting capabilities. Outlines of these seismic profiler are described below.

1) Magnet Striction and Vibration Type (Sonoprobe)

The principles of device are that the acoustic pulse is transmitted from a transmitting-transducer, fixed on ship's side, and that the pulse propagate through the sea down to the seabed and under the seabed, reflected from an acoustic boundary and returns again into the water.

The refrected acoustic wave is received by the hydrophone, and converted into an electrical signal and send to amplifier. In amplifier, this feeble signal is used for amplification, processing signal, control and power amplification. This light and dark patterns are recorded on the recording chart.

Specifications of sonoprobe are as follows.

| | |
|---|---|
| Recording system: | Straight line recording by belt |
| Recording range: | Shallow 0 to 25 m<br>Deep 0 to 50 m |
| Shifting step: | Shallow 5 m x 20 steps<br>Deep 10 m x 20 steps |
| Recording chart: | Dry chart width 150 mm, length 10 m |
| Chart feed speed: | Shallow 80 mm/min,<br>Deep 40 mm/min |
| Oscillation: | Shallow 360 mm/min,<br>Deep 180 mm/min |
| Amplification: | Straight amplification |
| Transmission-Reception: | Independent pulse transmission & reception |
| Power supply: | AC 100 V, 50/60 Hz, 2 kVA |

2) 3.5 kHz Raytheon

This device has such features that nine elements of electro-striction type are combined together in parallel, and transmitting output is large, while a directive angle is small as a whole. It consists of a recorder, transducer, signal processor, etc. Its center frequency is 3.5 kHz, and since this value is relatively high as a sub-bottom profiler, as compared with other types, its resolution is high.

This device is therefore, suitable for the stratum investigation near the surface of the seabed of mid and deep seas. It is not different from other types of devices in operating principle. A transmitting acoustic wave (sweep wave) is generated by a transmitting trigger signal applied from the recorder. A reflected signal received by the receiver undergoes amplification, signal processing and comparison detecting, and then sent to the recorder. A record can be enlarged according to the depth.

Specifications of the 3.5 kHz Raytheon are as follows.

| | |
|---|---|
| Frequency: | 3.5 kHz |
| Transmitting output: | 0 to 2 kW |
| Beam angle: | 30° to 80° (depending upon the number of transducers). |
| Operating water depth: | 0 to 10,000 m |
| Resolution: | 30 cm |
| Towing speed: | 0 to 12 knots |

(5) Bottom Sampling

A vibrocorer and piston corer were used for sampling sediments of the seabed.

Outlines of these bottom samplers are described below.

1) Vibrocorer

The vibrocorer is a bottom sampler utilizing the principles of liquefying phenomenon of sand caused by vibration, unlike conventional types of bottom samplers. It consists of an hydrolic vibrator, a hydraulic hose, battery, a hydraulic control unit, etc.

The vibrocorer suspended from a survey ship down to the seabed samples the sandy sediments of the seabed by the vibrator actuated at the upper end of the corer by operating the hydraulic control unit, which is submerged in the sea, from an ultrasonic device mounted aboard the survey ship.

Specifications of the vibrocorer are as follows:

| Specification | |
|---|---|
| Power for vibration | 1000 kgs |
| Frequency of vibration | 1500 cpm |
| Dia. of core barrel | 76.3 mm |
| Length of core barrel | 4 m, 8 m |
| Dia. of core | 58 mm |

2) Piston Corer

The piston corer is dropped down to the seabed from 2 m above the seabed by the lever action. When lifting up the piston corer, the piston sacks up the sediments of the seabed into an acryl pipe and holds them.

A stainless steel catcher at a part of the corer also serves to prevent the sediments from flowing into the water during recovery of the piston corer by means of such a mechanism as that allows an object to move only in the inward direction. The seabed excavating depth of a cable burier can be roughly estimated from the seabed penetrating depth of the piston corer.

(6) Current Observation

Instruments used for the current observation are an Aanderaa Current Meter and underwater automatic release. After current meter were recovered, the recorded magnet tape (MT) were analyzed by a computer which had been placed in vessel's observation room. The results were used for preparing an Progress Report. Also, the MT was brought to SHS's head office in Tokyo, and noises in the record were removed and then the records were analyzed.

The final results were used for preparing a Final Report.

1) Aanderaa Current Meter Model 4 and Model 5

The specifications of the current meter are as follows.

| Measurement Items | Measurement Range |
|---|---|
| Current direction | 0° to 360° |
| Current velocity | 2.5 to 250 cm/sec |
| Water temperature | -0.34 to 32.17°C |
| Electric conductivity | 0 to 70 mmho/cm |

A measuring interval is selectable to 0.5 to 30 minutes. An especially designed 9 V battery is used for a power supply, which allows this current meter to be usable time of 10,000 intervals. The pressure with-standing depth is 2,000 m.

2) Underwater Automatic Release (manufactured by EG&G Sea-Link Systems)

This release is indispensable for recovering a current meter installed in the rising system which is the optimum current meter mooring system using submerged buoys. It releases an anchor weight by a supersonic command, thus making a measuring device surface automatically.

- EG&G Sea-Link Digital Acoustic Command System

(Specifications)

Shipboard Unit (Model 701)

| | |
|---|---|
| Size: | 48 x 18 x 13 (cm) |
| Weight: | 16 kg |
| Transponder Interrogate Frequencies: | 9 and 11 kc |

*Underwater Dacs Release/Transponder* (Model 723A)

| | |
|---|---|
| Operating Depth: | 6,000 m |
| Reply Frequencies: | 8 frequencies |
| Size: | dia 6.6 x L 43.0 (inches) |
| Weight: | 31.8 kg |
| Operating Temperature: | -10°C to +60°C |

(7) Seabed Photographing

The deep sea camera is a 35 mm deep pressure resistant type consisting of a camera and a flashgun.

The flashgun illuminates the seabed with the flash of a xenon tube, and supplies a shutter pulse and driving power for taking up a film to the camera. The camera consists of a film take-up, shutter, lens and date chamber. When even taking a photograph, power is supplied from the flashgun to the film driving motor, and a film is taken up one frame.

The photographing distance and depth of focus are set by using a knob on the lens shutter mount. A date, hours, minutes and seconds of photo-taking, and the station No. are displayed.

The bottom switch parts consist of a main body, a weight and joining ropes for combining them.

At the same time, the weight is landed on the seabed, the rope tension got slack, acting on the bottom switch now the shutter pulse is transmitted. With the rope length adjusted in advance for photographing from a point 3 m above seabed, the camera is moved up and down at the photographing point to carryout photo-taking.

Specifications of the deep sea camera are as follows:

Camera

| | |
|---|---|
| Type: | Benthos model 372 |
| Standard number of films for taking photographs: | 800 photos |
| Film length: | 30.5 mm (100 ft) |
| Shutter speed: | 1/50 sec. to 2/5 sec. |
| Power: | DC 28 ±5 V 1 A; supplied from flashgun model |

Flashgun

| | |
|---|---|
| Type: | Benthos model 382 |
| Flash bulb input: | 100 W/sec. |
| Number of flashing: | 3,200 times when fully charged |
| Flash time: | 1/1000 sec. |

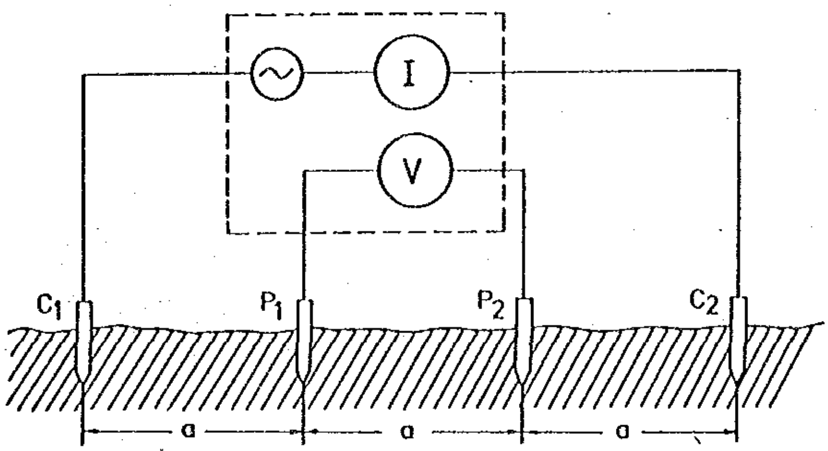
(8) Earth Resistivity Measurement (Geological Search by Wenner's Method)

There are several methods of measuring earth resistivities (specific earth resistances), most of which are variations of the method originally conceived by Wenner. In Wenner's four driven-rod electrode method, four electrical contacts are made with the ground by driving into the ground the metal spikes, called electrodes, $C_1$, $P_1$, $P_2$ and $C_2$ placed in a straight line at equal intervals of a (m). Between the current electrodes $C_1$ and $C_2$, a current I (A) is passed and the resulting voltage drop (V) between the potential electrodes $P_1$ and $P_2$ is measured. If the ground has uniform resistivity $\rho$, an equation of measurement is attained:

$$\rho = 2\pi aV/I = 2\pi ar \ (\Omega.m) \qquad R = V/I \ (\Omega)$$

Where R is the resistance measured between the potential electrodes. The above equations are called Wenner's formula, which proved to be very practical in case the depth of driven electrodes is within 1/20 of the electrode interval separation a. Therefore, earth resistivity $\rho$ can be calculated from the measured value of R.

The earth resistivity $\rho$ in the wenner's formula is constant irrespective of the electrode separation distance if the ground has a uniform structure. However, the ground is generally composed of more than one layer involving rocks of differing resistivity. Therefore, the resistivity calculated from the above formula will not refer to any specific rock or layer, but will be a mean value of the individual resistivities of distributed rocks and layers. Such a measured value is called "apparent resistivity" which varies depending upon the electrode separation a and the position of the electrode system. By obtaining the relations between a and ρ with respect to a particular ground, it is possible to roughly conjecture geological structure, layer formation and location of underground water supplied. Standard and auxilliary curves showing the relation between a and ρ are available, and by placing upon them an a-ρ curve made from actual measurement, the approximate resistivity and depth of each layer involved may be easily be obtained on the curve. The resistivity thus obtained is generally taken as a guide for elucidating the nature of the layer.




L-10 Type Specific Earth Resistance Tester M55401
(Yokogawa Electric Works Ltd., Japan)

Specifications

| | |
|---|---|
| Method of Measurement: | Wenner's four-electrode method |
| Operating Principle: | AC potentiometric system (free of polarization, and capable of direct reading of specific earth resistance) |
| Method of Power Supply: | Hand drive of generator |
| Measuring range: | 0 - 0.3/3/30/300 Ω |
| Measuring Dial Scale: | 0 - 30 Ω, 1 Ω/div |
| Multiplier Dial: | X0.01, X0.1, X1, X10 |
| Accuracy: | ±3% of indicated value in the scale range of 10 to -30 Ω<br>±1% of full scale value in the scale of less than 10 Ω |
| Output Voltage: | 350 V at more than 150 rpm |
| Measuring Frequency: | more than 65 Hz/s |
| Accessories: | 5 pcs of earth spikes/as electrode with landwires |

(9) Cable Burying Survey

In order to avoid a cable damage on the continental shelf (shallow water portion) caused by fishing activities and ship's anchoring, the cable burying method is widely applies at present. Accordingly, it becomes one of the important item of cable route survey to investigate a suitability of the sea bottom for cable burial. The cable burying survey is one of the most practical way to know the it.

The cable burying survey method applied on this survey is as follows.

1) Put on the cable burier (KS-2) in the sea bottom.
2) Survey vessel pull the burier by wire rope along the survey route.
3) Sensors mounted on the burier send the information of digged out depth, pulling tension, etc., to the onboard measuring equipments through the control cable.

The outline of the cable burier is shown as follows:

<u>Cable Burier</u>

Cable burier used in the survey is KDD model (1/2 scale). Specifications of this cable burier are as follows:

1) Digging Part
   - Output of Clinometer: -5 to +5 V, 0.1 per degree
   - Tension Meter: 0 to +5 V, 1 V per ton and 5 tons in maximum

2) Micro Computer

| | |
|---|---|
| - CPU Board: | Z 80 CPU (2.5 MHz) with 4 kbytes ROM and 2 kbytes RAM |
| - A/D Converter: | 8 bit 256 resolution Accuracy is 0.5 degree. |
| - I/O: | 20 mA current loop, centronics parallel, RS-232C half duplex |

Dimension

- $A = 232$ cm
- $B = 75$ cm
- $C = 20$ cm
- $D = A \sin\theta + B \cos\theta - C$

  D : Digging depth (cm)

Particular

- Length 4.1 m
- Width 1.28 m
- Weigth 850 kg
- Digging depth (max.) 55 cm

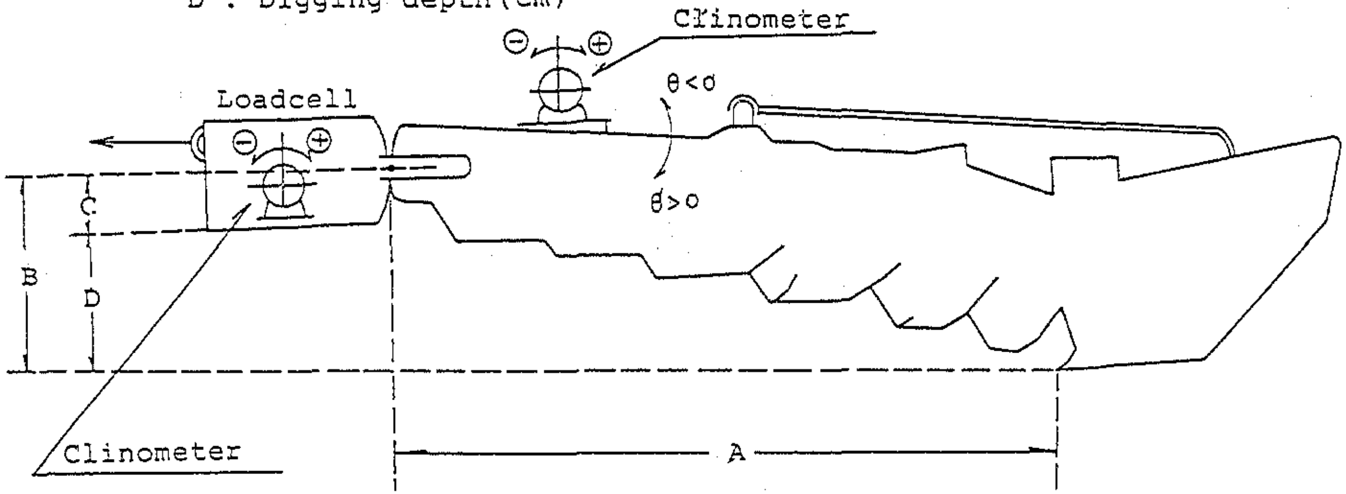



Fig. A-3 Cable Burier (KDD Model 1/2 Scale)

# APPENDIX 4

## RESULTS OF PHYSICAL AND CHEMICAL ANALYSIS FOR BOTTOM MATERIAL

## SAMPLING TABLE

| INSHORE AREA | | | | | |
|---|---|---|---|---|---|
| Takisung Inshore | | | Bonto Marannu Inshore | | |
| Sampling No. | Distance from L.P | Bottom Material | Sampling No. | Distance from L.P | Bottom Material |
| T-500 | 500 | silty Clay | B-500 | 500 | silty Sand |
| T-1000 | 1000 | silty Clay | B-1000 | 1000 | Sand |
| T-2000 | 2000 | silty Clay | B-2000 | 2000 | silty Sand |
| T-3000 | 3000 | silty Clay | B-3000 | 3000 | silty Sand |
| T-4000 | 4000 | silty Clay | B-4000 | 4000 | silty Sand |
| T-5000 | 5000 | sandy Clay | B-5000 | 5000 | silty Sand |
| T-1500 | 1500 | Rock | | | |

| OCEAN AREA | | | | |
|---|---|---|---|---|
| Sampling No. | Position | | Water Depth (m) | Bottom Material |
| | Lat. | Long. | | |
| P-1 | 3° 55.70' | 114° 30.65' | 18.0 | sandy Gravel |
| P-2 | 4° 10.89' | 114° 28.66' | 24.7 | clayey Sand |
| P-3 | 4° 27.97' | 114° 29.00' | 30.0 | sandy Clay |
| P-4 | 4° 33.22' | 114° 47.81' | 27.0 | fine Sand |
| P-5 | 4° 33.78' | 115° 09.81' | 28.1 | muddy Sand |
| P-6 | 4° 34.27' | 115° 30.00' | 29.0 | muddy Sand |
| P-7 | 4° 34.61' | 115° 50.12' | 35.0 | muddy Sand |
| P-8 | 4° 35.04' | 116° 05.90' | 38.8 | fine Sand |
| P-9 | 4° 31.59' | 116° 25.34' | 52.7 | sandy Silt |
| P-10 | 4° 22.25' | 116° 57.69' | 39.0 | Rock |
| P-10-1 | 4° 18.48' | 116° 55.63' | 65.0 | silty Clay |
| P-11 | 4° 18.46' | 117° 08.02' | 51.0 | Rock |
| P-12 | 4° 19.43' | 117° 24.93' | 498 | Rock |
| P-13 | 4° 34.35' | 117° 45.19' | 1885 | silty Clay |
| P-14 | 4° 51.51' | 118° 10.55' | 1798 | silty Clay |
| P-15 | 4° 58.61' | 118° 19.36' | 1280 | sandy Silt |
| P-16 | 5° 06.75' | 118° 32.60' | 714 | sandy Silt |
| P-17 | 5° 19.59' | 119° 04.41' | 51.5 | Sand |
| P-18 | 5° 22.40' | 119° 16.21' | 24.0 | fine Sand |

Remark: T-1500 ( on the previous planned route )

## Results of Physical Test
## (Granular Variation, Specific Gravity, Moisture Contents)

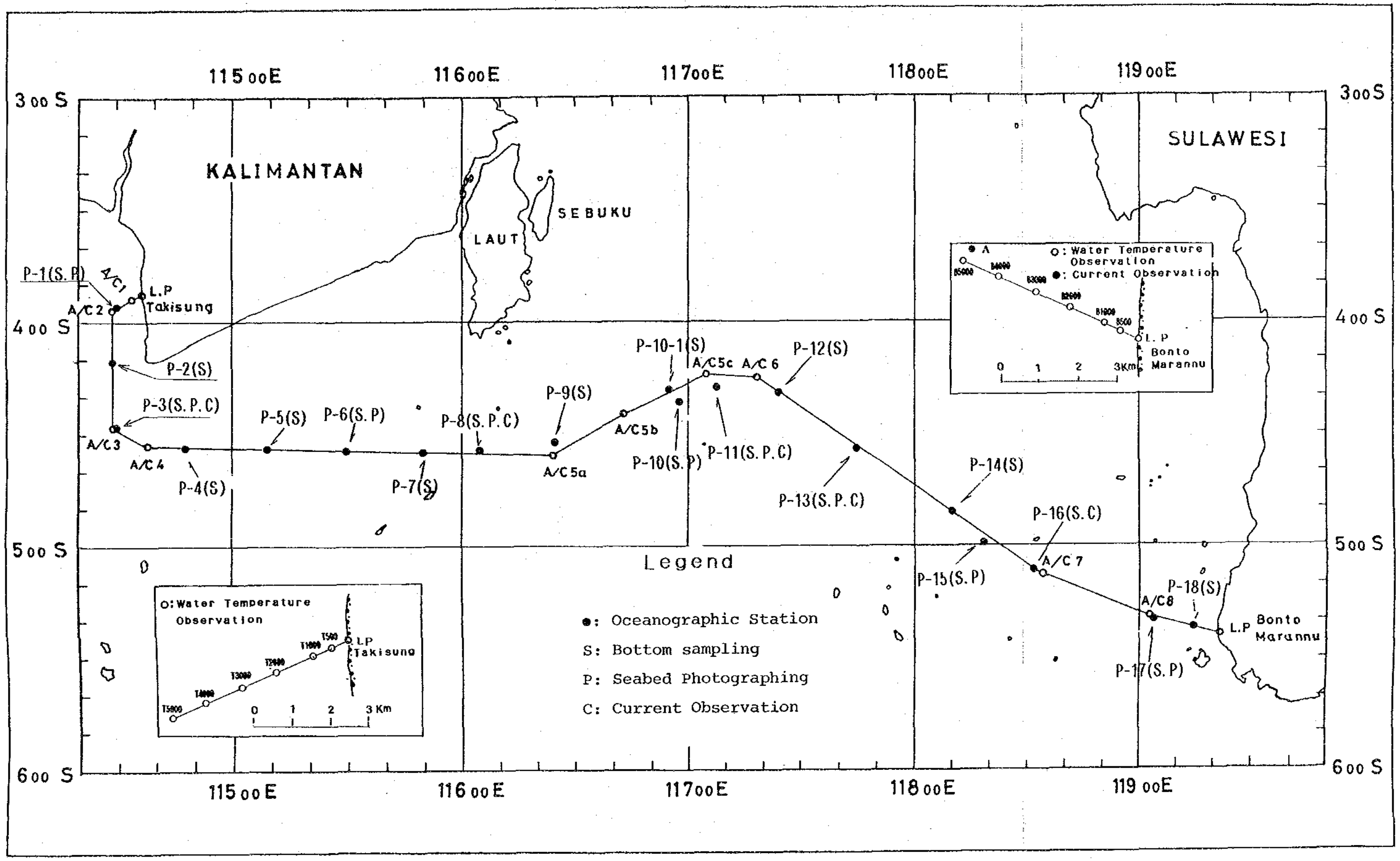
| Sample No. | Depth (m) | Granular Variation | | | | Specific Gravity | Moisture Contents |
|---|---|---|---|---|---|---|---|
| | | Gravel | Sand | Silt | Clay | | |
| T-1000 | Surface | 0.0 | 2.7 | 32.1 | 65.2 | 2.774 | 187.6 |
| T-3000 | Surface | 0.6 | 18.8 | 23.9 | 56.7 | 2.766 | 140.3 |
| T-5000 | Surface | 0.0 | 23.9 | 21.3 | 54.8 | 2.768 | 117.7 |
| B-1000 | Surface | 0.1 | 86.2 | 7.8 | 5.9 | 2.849 | 33.5 |
| B-3000 | Surface | 0.0 | 62.7 | 29.5 | 7.8 | 2.824 | 34.6 |
| B-5000 | Surface | 0.2 | 55.4 | 31.5 | 12.9 | 2.839 | 34.4 |
| P-1 | 0~0.1 | 47.7 | 34.6 | 9.8 | 7.9 | 2.745 | 31.9 |
| | 1.8~2.0 | 0.0 | 1.3 | 16.8 | 81.9 | 2.667 | |
| P-2 | 0~0.2 | 10.5 | 48.3 | 15.0 | 26.2 | 2.782 | 50.9 |
| | 0.5~0.7 | 0.0 | 9.3 | 27.5 | 63.2 | 2.804 | 33.9 |
| | 1.8~ | 0.0 | 5.3 | 20.4 | 74.3 | 2.776 | 54.8 |
| P-3 | 0~0.1 | 0.4 | 39.6 | 29.3 | 30.7 | 2.709 | 32.1 |
| | 1.0~1.2 | 0.3 | 4.3 | 39.6 | 55.8 | 2.698 | |
| P-4 | 0~0.2 | 13.9 | 65.4 | 13.0 | 7.7 | 2.710 | 34.7 |
| | 0.5~0.7 | 0.0 | 58.0 | 19.9 | 22.1 | 2.686 | 21.3 |
| | 1.25~1.42 | 0.0 | 74.7 | 15.2 | 10.1 | 2.671 | 22.5 |
| P-5 | 0~0.1 | 0.5 | 69.4 | 22.3 | 7.8 | 2.706 | 44.3 |
| | 0.6~0.75 | 0.8 | 17.5 | 23.3 | 58.4 | 2.800 | |
| P-6 | 0~0.2 | 0.0 | 50.2 | 34.4 | 15.4 | 2.738 | 45.8 |
| | 0.5~0.7 | 0.0 | 41.6 | 34.3 | 24.1 | 2.734 | 50.1 |
| | 1.5~1.66 | 0.0 | 3.1 | 27.4 | 69.5 | 2.652 | |
| P-7 | 0~0.2 | 0.3 | 67.3 | 20.6 | 11.8 | 2.745 | 42.1 |
| | 0.5~0.7 | 0.5 | 30.3 | 25.3 | 43.9 | 2.829 | |
| P-8 | 0~1.0 | 3.7 | 75.4 | 13.0 | 7.9 | 2.768 | 34.7 |
| | 0.8~1.0 | 0.0 | 6.5 | 32.8 | 60.7 | 2.811 | 44.3 |
| | 2.2~2.4 | 0.0 | 3.8 | 30.3 | 65.9 | 2.737 | 63.3 |
| P-9 | 0~0.2 | 0.0 | 30.0 | 39.9 | 30.1 | 2.757 | 86.4 |
| | 0.8~1.0 | 0.0 | 21.4 | 38.6 | 40.0 | 2.783 | 67.8 |
| | 1.65~1.85 | 0.0 | 1.4 | 22.9 | 75.7 | 2.825 | |
| P-10-1 | 0~0.2 | 0.0 | 9.9 | 37.3 | 52.8 | 2.757 | 137.5 |
| P-13 | 0~0.1 | 0.0 | 1.9 | 31.9 | 66.2 | 2.734 | 260.5 |
| | 1.3~1.5 | 0.0 | 0.8 | 36.1 | 63.1 | 2.732 | 196.5 |
| P-14 | 0~0.2 | 0.0 | 0.8 | 34.5 | 64.7 | 2.743 | 222.7 |
| | 1.5~1.7 | 0.0 | 1.0 | 29.8 | 69.2 | 2.760 | 191.6 |
| P-15 | 0~0.2 | 0.0 | 30.4 | 43.0 | 26.6 | 2.778 | 111.4 |
| | 0.85~1.05 | 0.0 | 26.4 | 37.9 | 35.7 | 2.771 | 100.8 |
| P-16 | 0~0.2 | 0.0 | 47.9 | 38.2 | 13.9 | 2.749 | 129.3 |
| P-17 | 0~0.2 | 3.8 | 76.9 | 13.0 | 6.3 | 2.741 | 21.8 |
| | 0.6~0.77 | 44.7 | 44.2 | 11.1 | | | 27.3 |
| P-18 | 0~ | 1.1 | 80.0 | 12.8 | 6.1 | 2.754 | 37.1 |

## Results of Chemical Test (Hydrogen Sulfide)

| Sample No. | Depth (m) | Contents (mg/g) | Sample No. | Depth (m) | Contents (mg/g) |
|---|---|---|---|---|---|
| P-1 | 0 | 0.00014 | TA-0 | 0 | 0 |
| P-2 | 0 | 0.0013 | TA-500 | | |
| P-3 | 0 | 0 | TA-1000 | | |
| P-4 | 0 | 0 | TA-2000 | | |
| P-5 | 0 | 0 | TA-3000 | 0 | 0.0472 |
| P-6 | 0 | 0 | TA-4000 | | |
| P-7 | 0 | 0 | TA-5000 | 0 | 0 |
| P-8 | 0, 1.5 | 0 , 0.00186 | | | |
| P-9 | 0 | 0 | BA-0 | 0 | 0 |
| P-10 | | Rock | BA-500 | 0 | 0 |
| P-10-1 | 0 | 0 | BA-1000 | | |
| P-11 | | Rock | BA-2000 | 0 | 0.0102 |
| P-12 | | Rock | BA-3000 | 0 | 0.0199 |
| P-13 | 0 | 0 | BA-4000 | 0 | 0.0595 |
| P-14 | 0 | 0 | BA-5000 | 0 | 0.0103 |
| P-15 | 0 | 0 | | | |
| P-16 | 0 | 0 | | | |
| P-17 | 0 | 0 | | | |
| P-18 | 0 | 0.00421 | | | |

# APPENDIX 5

# LOCATION MAP FOR OCEANOGRAPHIC OBSERVATION STATION




Location Map for Oceanographic Observation Station

# APPENDIX 6

## SAMPLING SHEET

# SAMPLING SHEET

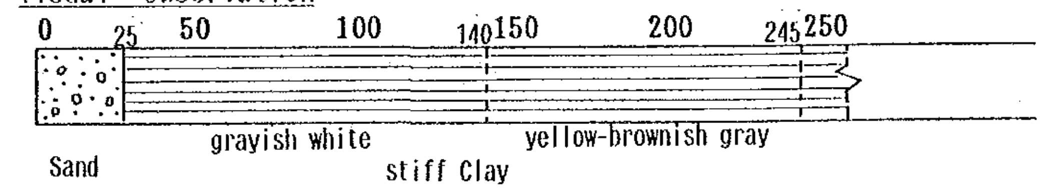
| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-1 | 18.0 | Vibro Corer | 225 | |

Visual Observation


0: gravelly Sand with mud. soft. greenish gray.
much pieces of shell (10-20mm)
50: stiff Clay. grayish white with reddish parts. sticky.
a few clod (1-2mm)
100: stiff Clay. dark brownish gray. homogeneous. hard. few sand.
150: 〃 〃 〃 〃 〃
200: 〃 〃 〃 〃 〃
225: 〃 〃 〃 〃 〃

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-2 | 24.7 | Vibro Corer | 245 | |

Visual Observation

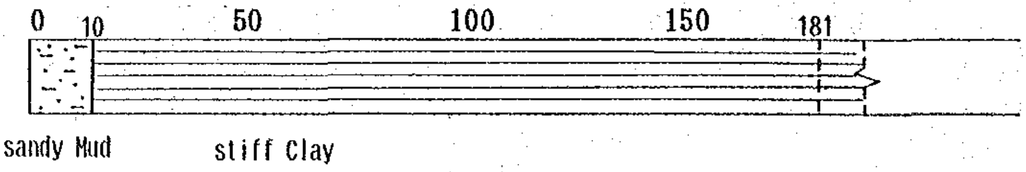



0: Sand with gravel. gravel consists of clod of iron (5-30mm)
sand size is middle - coarse. containing mud material and shells.
50: stiff Clay. grayish white with reddish parts. dotted clod(1-2mm)
100: stiff Clay. 〃
150: stiff Clay. yellow-brownish gray. homogeneous.
200: stiff Clay. 〃 〃
225: stiff Clay. 〃 〃

# SAMPLING SHEET

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-3 | 30.0 | Vibro Corer | 181 | |

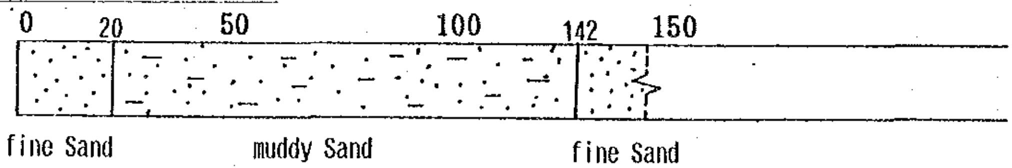
Visual Observation




0: sandy Mud (0-10cm). yellowish gray. sand size is middle - coarse
50: stiff Clay. grayish white with reddish parts. sticky.
100: stiff Clay. 〃 〃
reddish brown clods (1-2mm) as like weathered gravels.
150: stiff Clay. grayish white. reddish brown clods (1-2mm) as like weathered gravels.
181: stiff Clay. 〃 〃

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-4 | 30.0 | Vibro Corer | 142 | |

Visual Observation

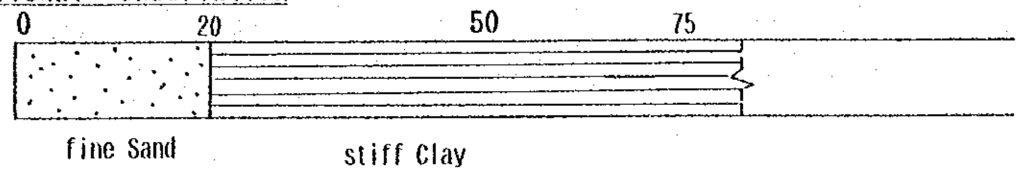



0: fine Sand with a few middle size. greenish gray. much shells and coral (middle sand size - 3mm). a few mud material.
50: muddy Sand. grayish white with reddish brown parts.
reddish brown clods (several mm - 10mm) as like weathered gravels
100: muddy Sand. grayish white (95cm- ). stiff.
142: fine Sand with mud. yellowish gray (135cm- ). homogeneous.

# SAMPLING SHEET

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-5 | 28.1 | Piston Corer | 75 | |

Visual Observation

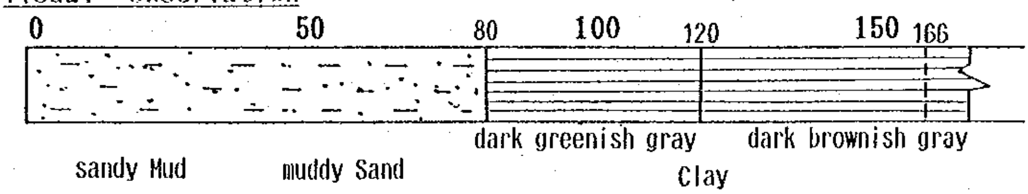



0: fine Sand with a few mud. greenish gray. much pieces of shell and coral (middle sand size - 3mm).

75: stiff Clay. gray with reddish brown parts. homogeneous gray ( - 60cm).

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-6 | 29.0 | Piston Corer | 166. | |

Visual Observation

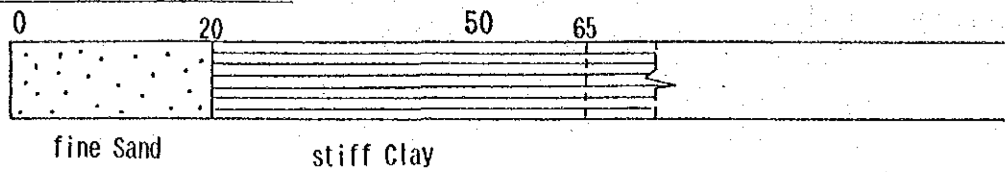



0: sandy Mud. greenish gray. a few shell. little bit sticky.
50: muddy Sand. increasing sandy material at lower part. greenish gray.
100: Clay. dark greenish gray. very few sand. very sticky.
166: Clay. dark brownish gray. sticky.

# SAMPLING SHEET

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-7 | 35.0 | Piston Corer | 65 | |

Visual Observation

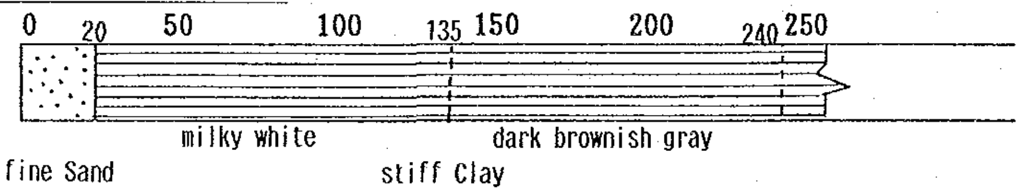



0: fine Sand. greenish gray. much pieces fo coral and shell.

65: ftiff Clay. milky white with reddish parts.
dotted clods (several mm). sticky.

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-8 | 38.8 | Vibro Corer | 240 | |

Visual Observation

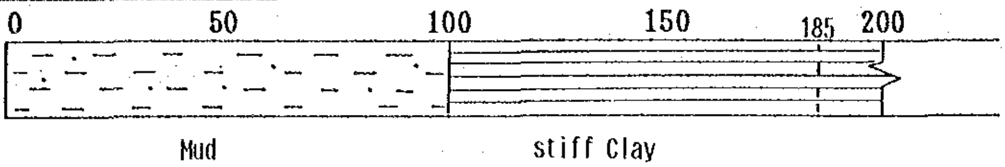



0: fine Sand. greenish gray with black spots. a few coral pieces
(middle sand saze - 3mm)
50: stiff Clay. milky white with reddish parts. little bit sticky.
reddish clod (as like a concreted iron).
100: stiff Clay. milky white. homogeneous. little bit sticky.
150: stiff Clay. dark brownish gray. homogeneous. little bit sticky.
200: stiff Clay. 〃 〃 〃
240: stiff Clay. 〃 〃 〃

# SAMPLING SHEET

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-9 | 52.7 | Vibro Corer | 185 | |

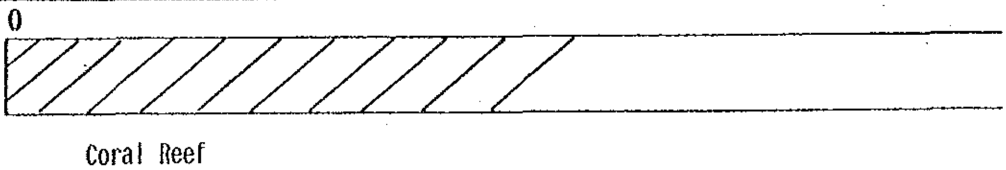
Visual Observation




0: Mud with a few sand. dark greenish gray. little bit sticky.
50: Mud with a few sand. 〃 〃
a few piece of shell.
100: stiff Clay. yellowish gray. sticky.
150: stiff Clay. yellowish gray with white spots. sticky.
185: stiff Clay. 〃 〃

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-10 | 39.0 | Dredger | | |

Visual Observation

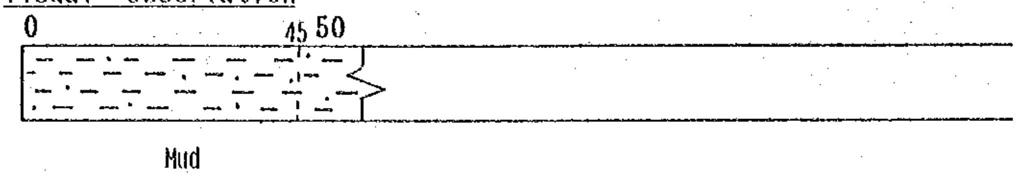



Coral Reef. massive Coral (about 10cm $\phi$)---------white
netlike Coral (about 40cm square)----red
coral sand--------------------------white

# SAMPLING SHEET

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-10-1 | 65.0 | Piston Corer | 45 | |

Visual Observation




0: Mud with a few sand. greenish gray.

45: Mud with a few sand. 〃

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-11 | 51.0 | Piston Corer | | |

Visual Observation

Coral Reef. massive coral (several cm $\phi$) ----- white

# SAMPLING SHEET

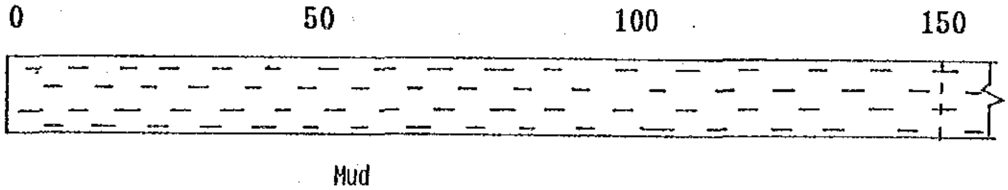
| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-12 | 498 | Piston Corer | | |

Visual Observation

Coral Reef

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-13 | 1885 | Piston Corer | 150 | |

Visual Observation

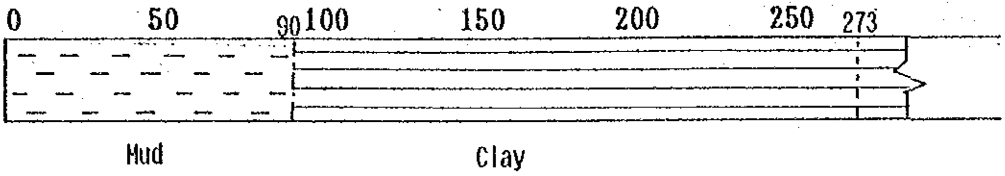



0: Mud with a few sand. brownish gray at surface (several cm). greenish gray at lower part. soft.
50: Mud with a few sand. greenish gray. soft.
100: Mud. greenish gray. soft.
150: Mud. 〃 〃

## SAMPLING SHEET

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-14 | 1798 | Piston Corer | 273 | |

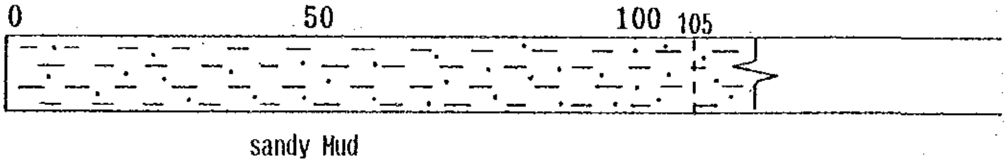
Visual Observation




0: Mud with a few sand. dark yellow-greenish gray at upper part (10cm). dark greenish gray at lower part. little bit sticky.
50: Mud with a few sand. dark greenish gray. sticky.
100: Clay with a few sand. 〃 〃
150: Clay with a few sand. 〃 〃
200: Clay. 〃 〃
250: Clay. 〃 〃
173: Clay. 〃 〃

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-15 | 1280 | Piston Corer | 105 | |

Visual Observation

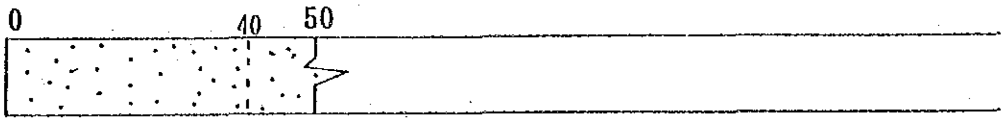



0: sandy Mud. dark brownish gray at surface part (several cm). greenish gray at lower part. little bit sticky.
50: sandy Mud. greenish gray. little bit sticky.
105: sandy Mud. greenish gray. little bit stiff and sticky.

# SAMPLING SHEET

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-16 | 714 | Piston Corer | 40 | |

Visual Observation

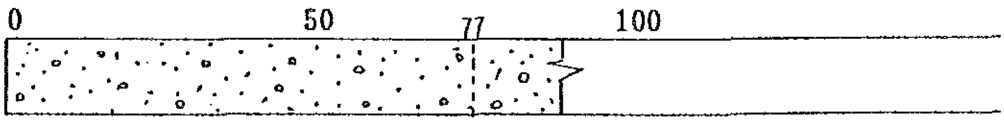



fine Sand

0: fine Sand. yellowish gray. much coral sand with middle sand size and white colour.

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-17 | 51.5 | Vibro Corer | 77 | |

Visual Observation




coral Sand

0: coral Sand with much coral gravel (2-10mm, white and red). grayish white.

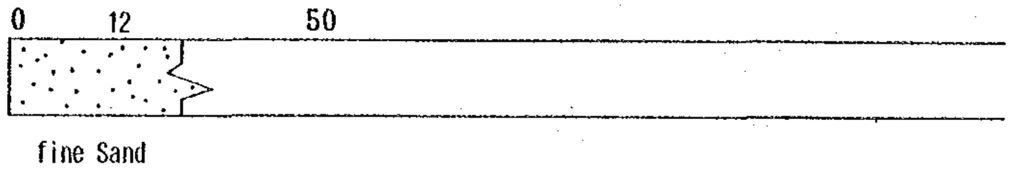
50: Sand with much coral (middle sand size - 5mm). grayish white.

77: coral Sand. grayish white. coral gravel ( - 10mm)

## SAMPLING SHEET

| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| P-18 | 24.0 | Vibro Corer | 12 | |

<u>Visual Observation</u>




0: fine Sand - middle Sand. middle sand contains much pieces of coral and shell. greenish gray.

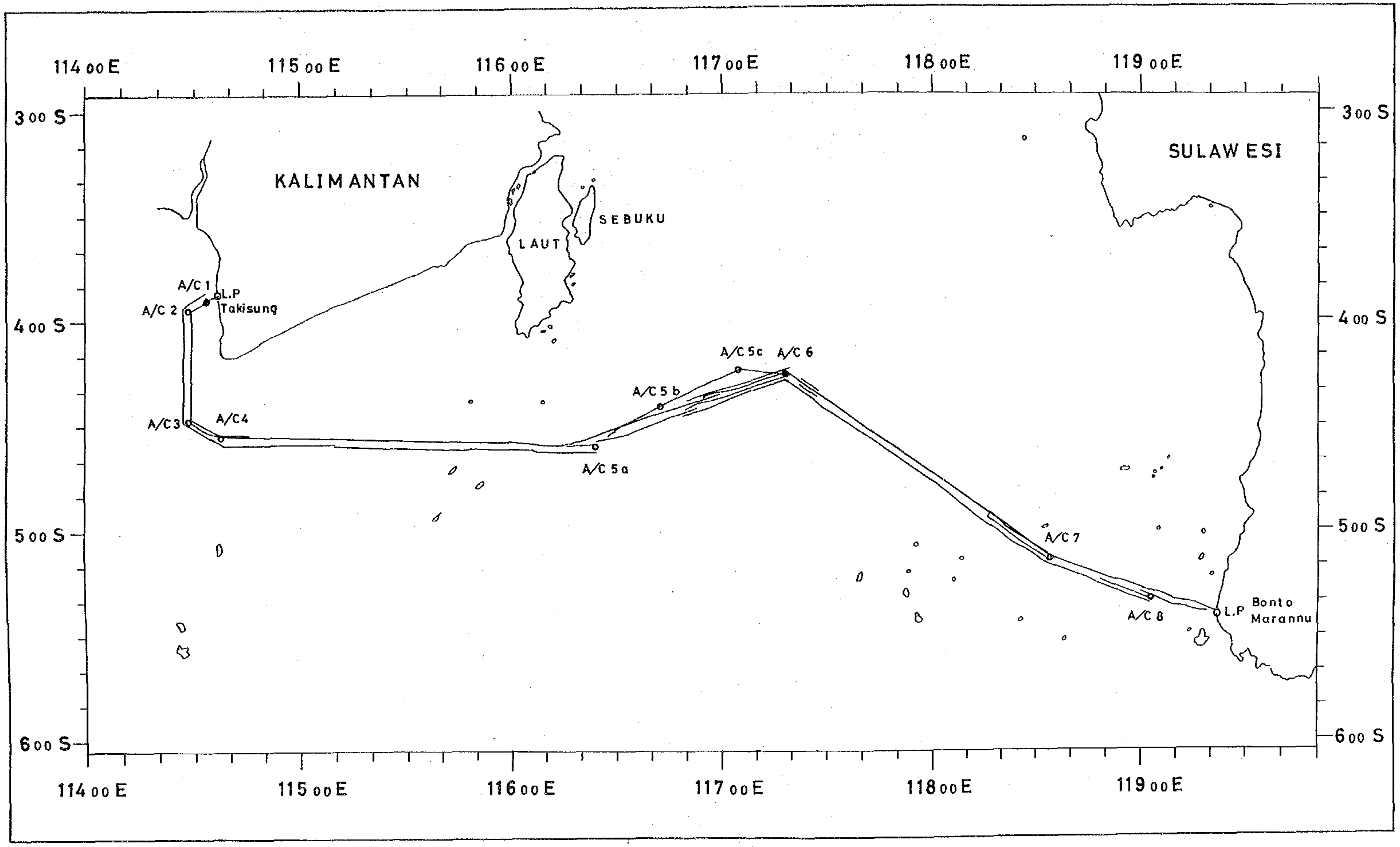
| Sample No. | Depth (m) | Device | Core Length | Remark |
|---|---|---|---|---|
| | | | | |

<u>Visual Observation</u>

# APPENDIX 7

## SURVEY TRACKS (OCEAN AREA)

Appendix 7




Survey Tracks (Ocean Area)

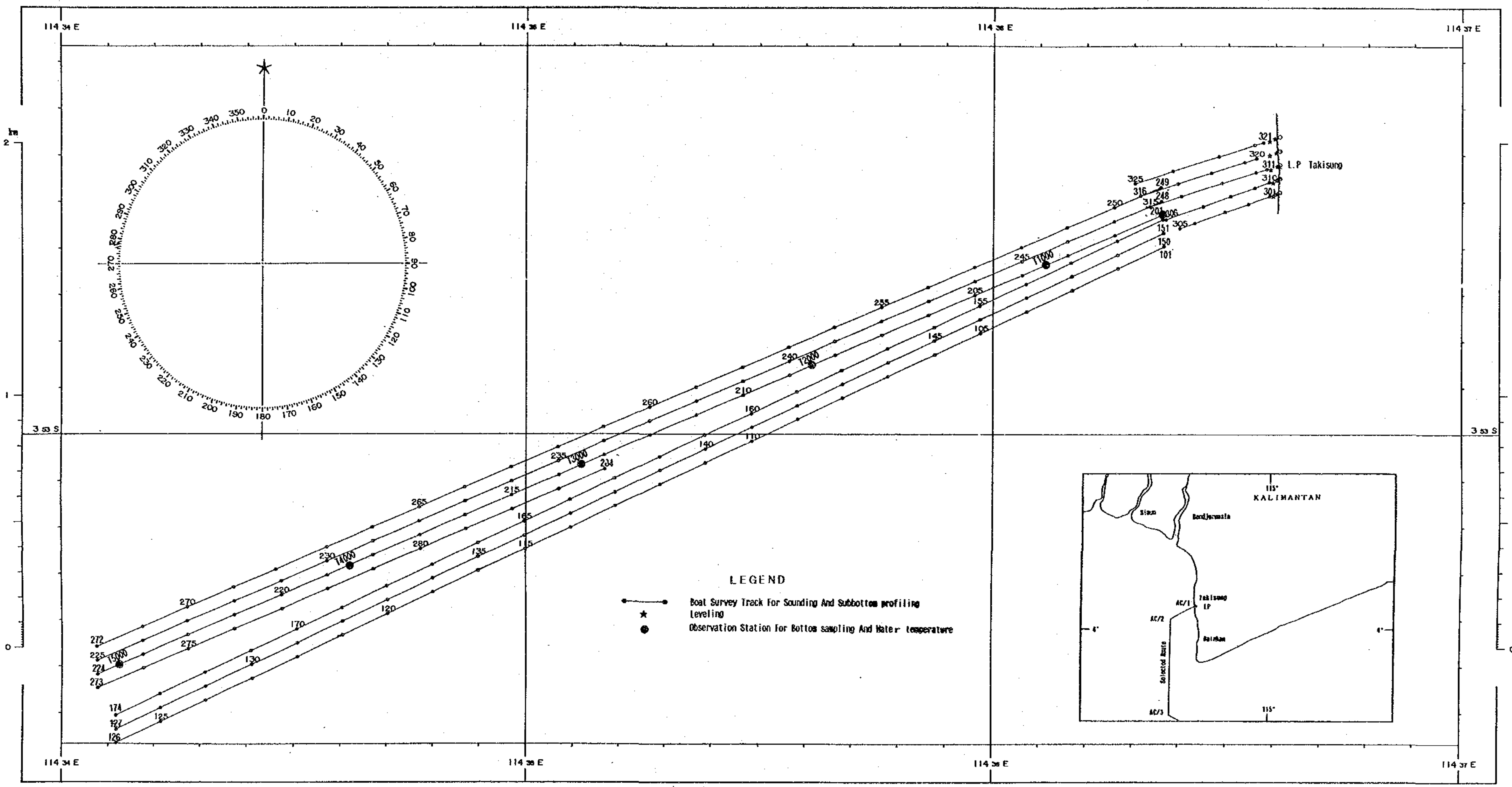
# APPENDIX 8

## COASTAL SURVEY TRACKS

## (TAKISUNG, BONTO MARANNU)

Appendix 8

(Lat. 5'S WGS-72 )

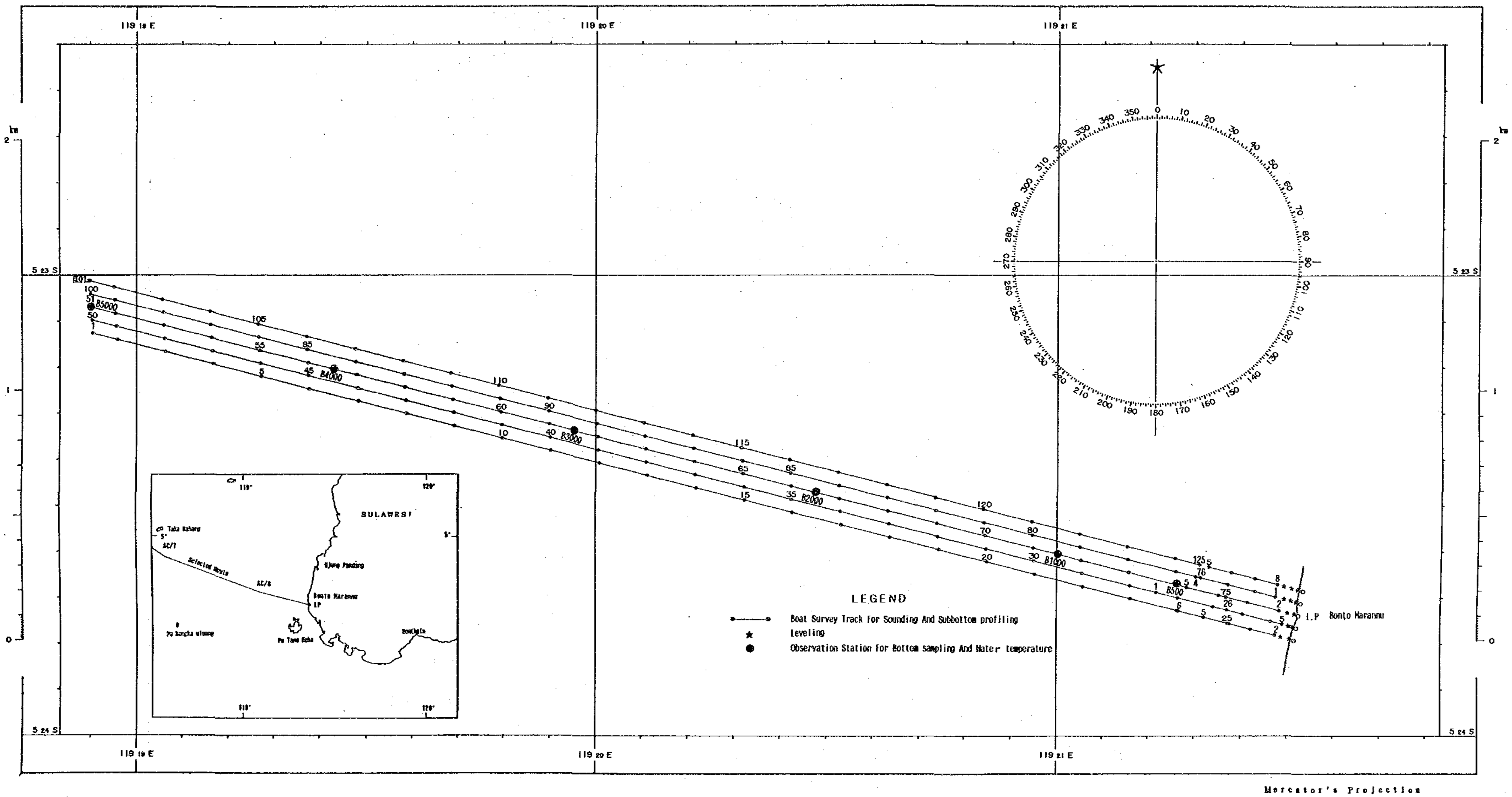



Coastal Survey Tracks (Takisung)

Mercator's Projection

Appendix 8

(Lat. 5°S WGS-72 )



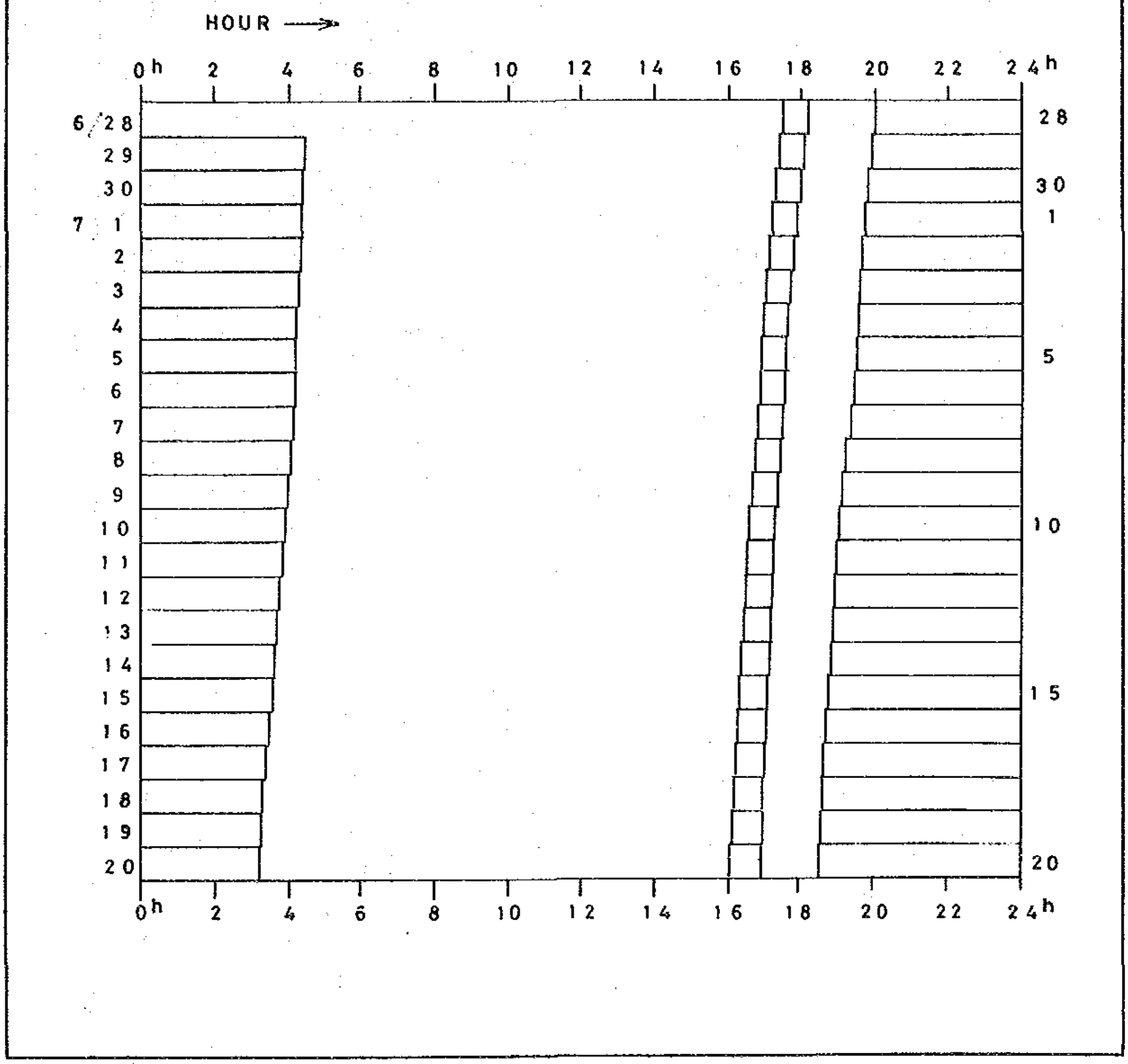

Coastal Survey Tracks (Bonto Marannu)

# APPENDIX 9

## SATELLITE PASS FREQUENCY (GPS, NNSS)

Appendix 9

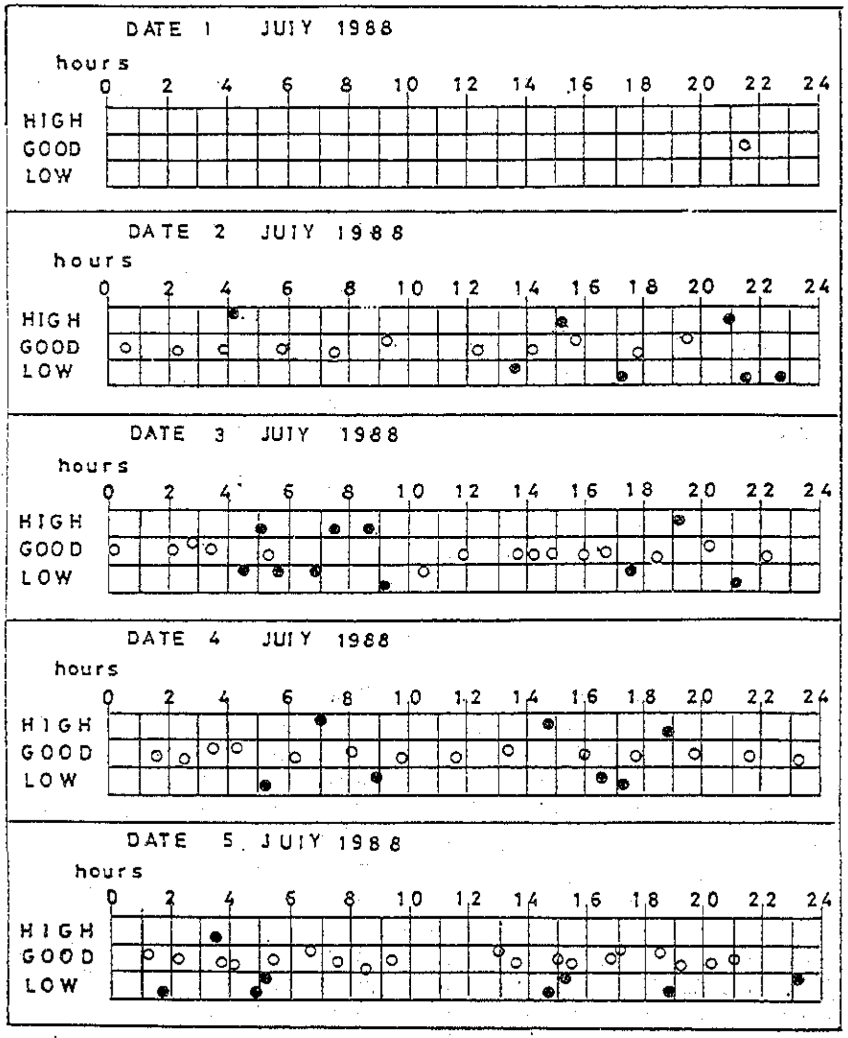
Satellite Pass Frequency(G.P.S)



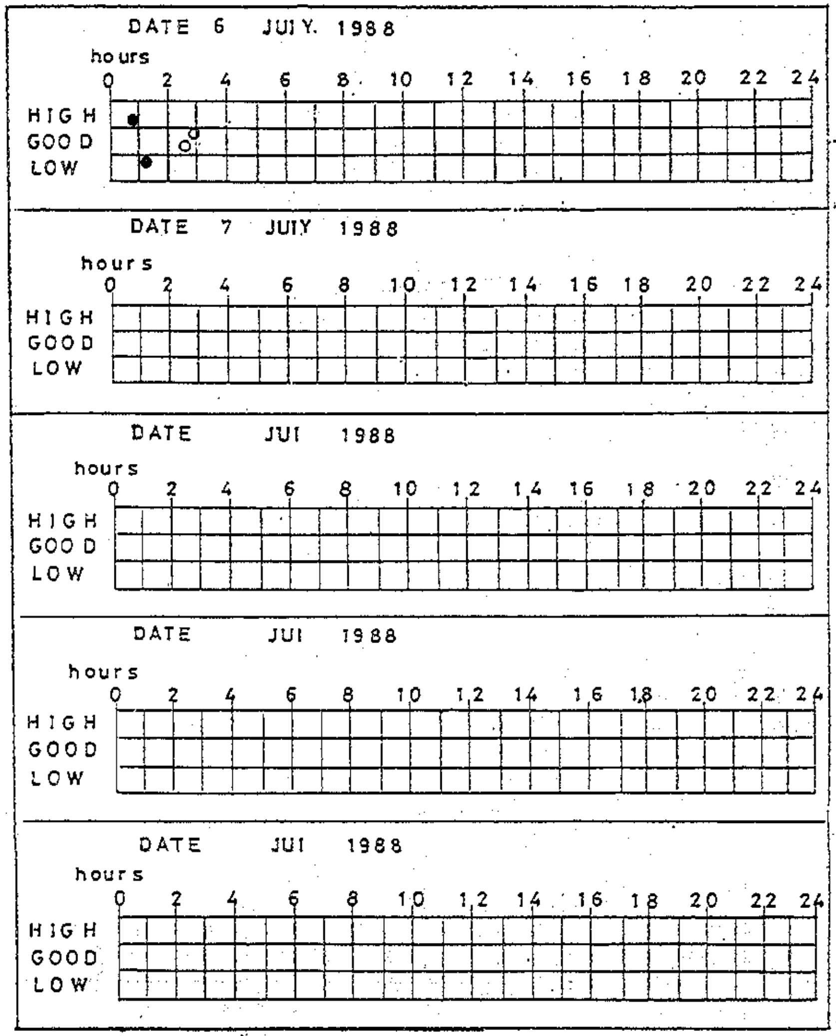

Available Time Period for Positioning by G.P.S
Satellite Signals During the Ocean Survey

Appendix 9

Satellite Pass Frequency(NNSS)




Satellite Pass Frequency(NNSS)

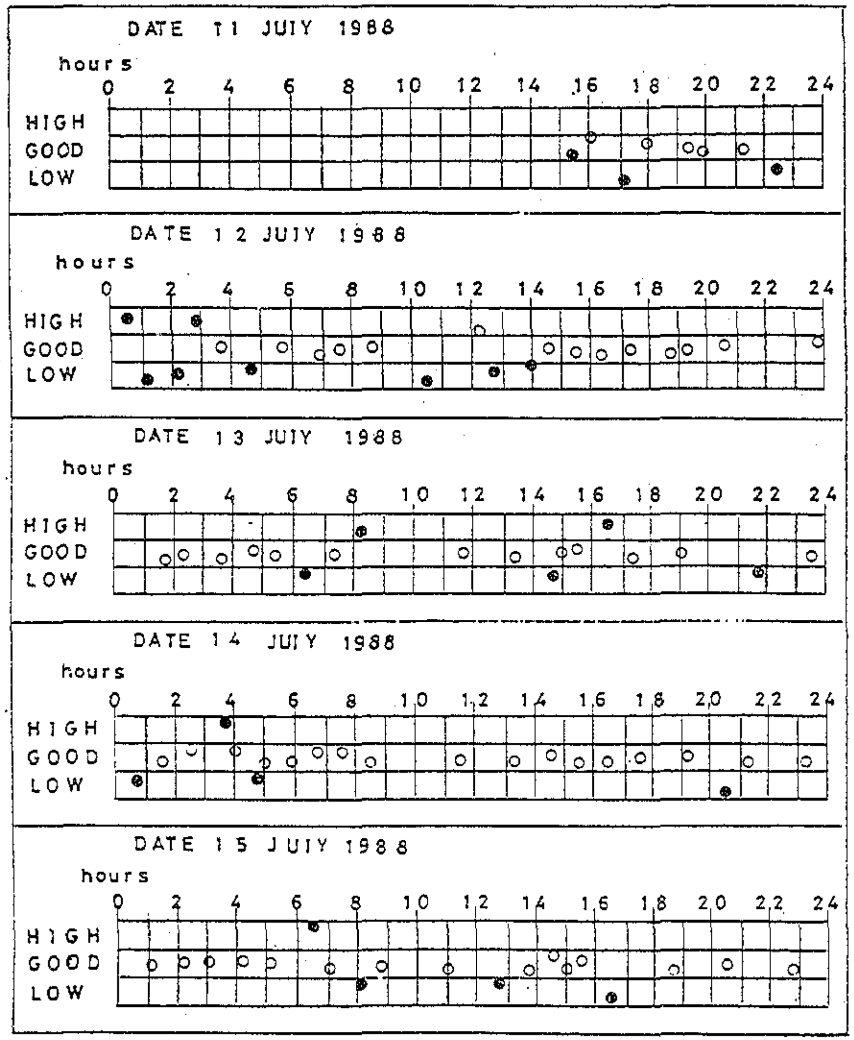



HIGH : passes Above 70° Alt
GOOD : 〃 10° ～ 70° 〃
LOW : 〃 Less Than 10° Alt
Hours : Indonesia Standard Time

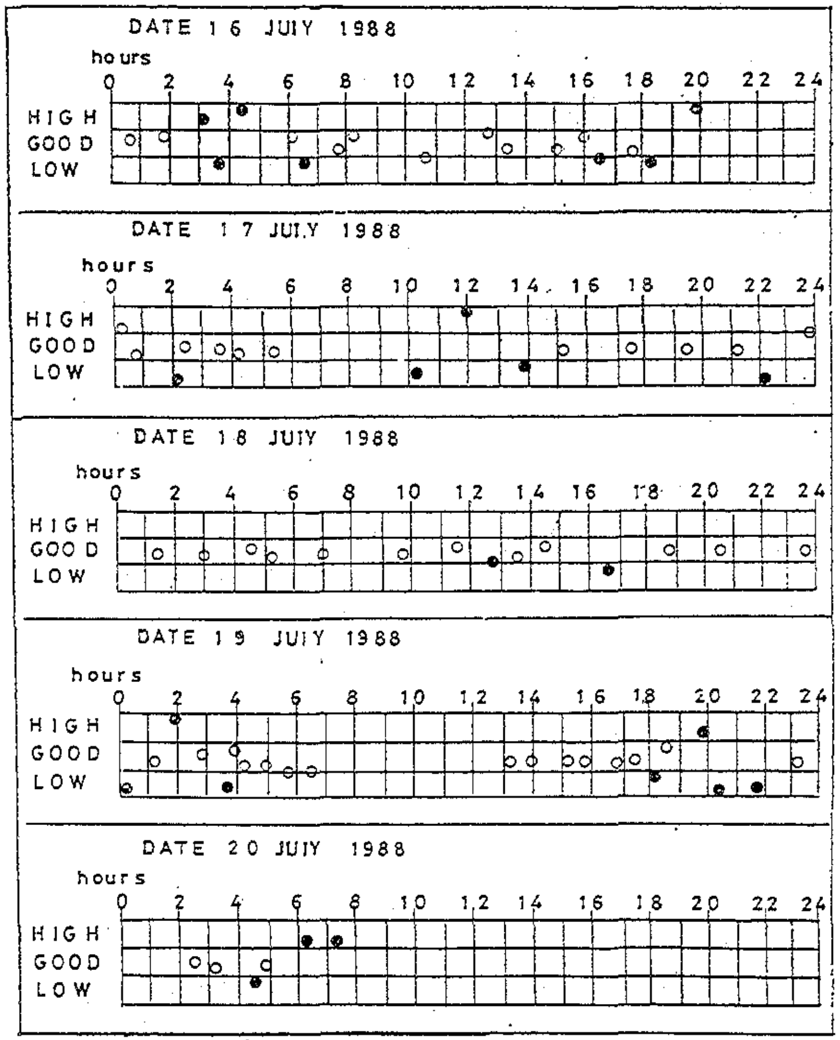
○ : O.K
● : N.G

Appendix 9

Satellite Pass Frequency(NNSS)



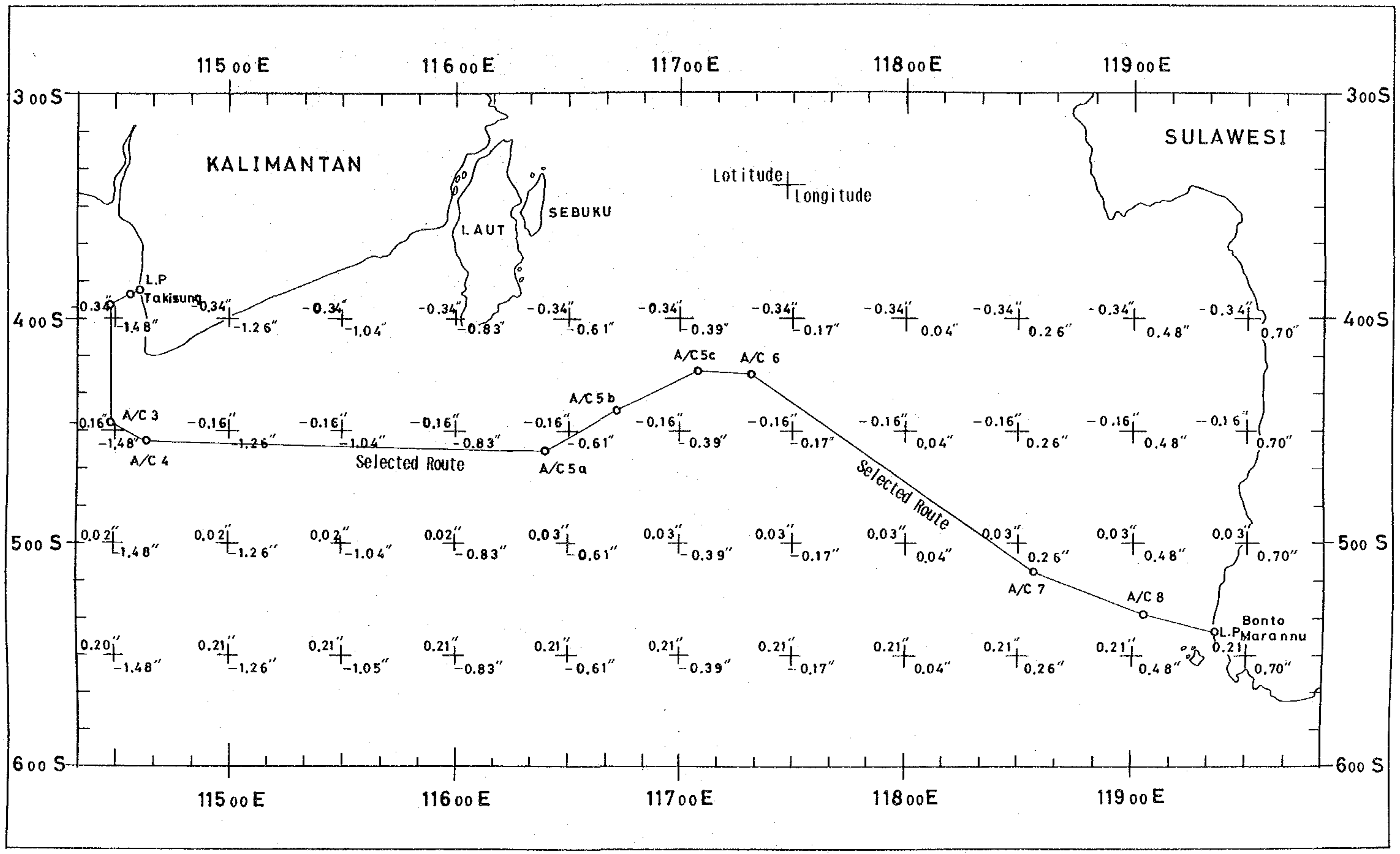

Satellite Pass Frequency(NNSS)




HIGH : passes Above 70° Alt
GOOD : 〃 10° ～ 70° 〃
LOW : 〃 Less Than 10° Alt
Hours : Indonesia Standard Time

○ : O.K
● : N.G

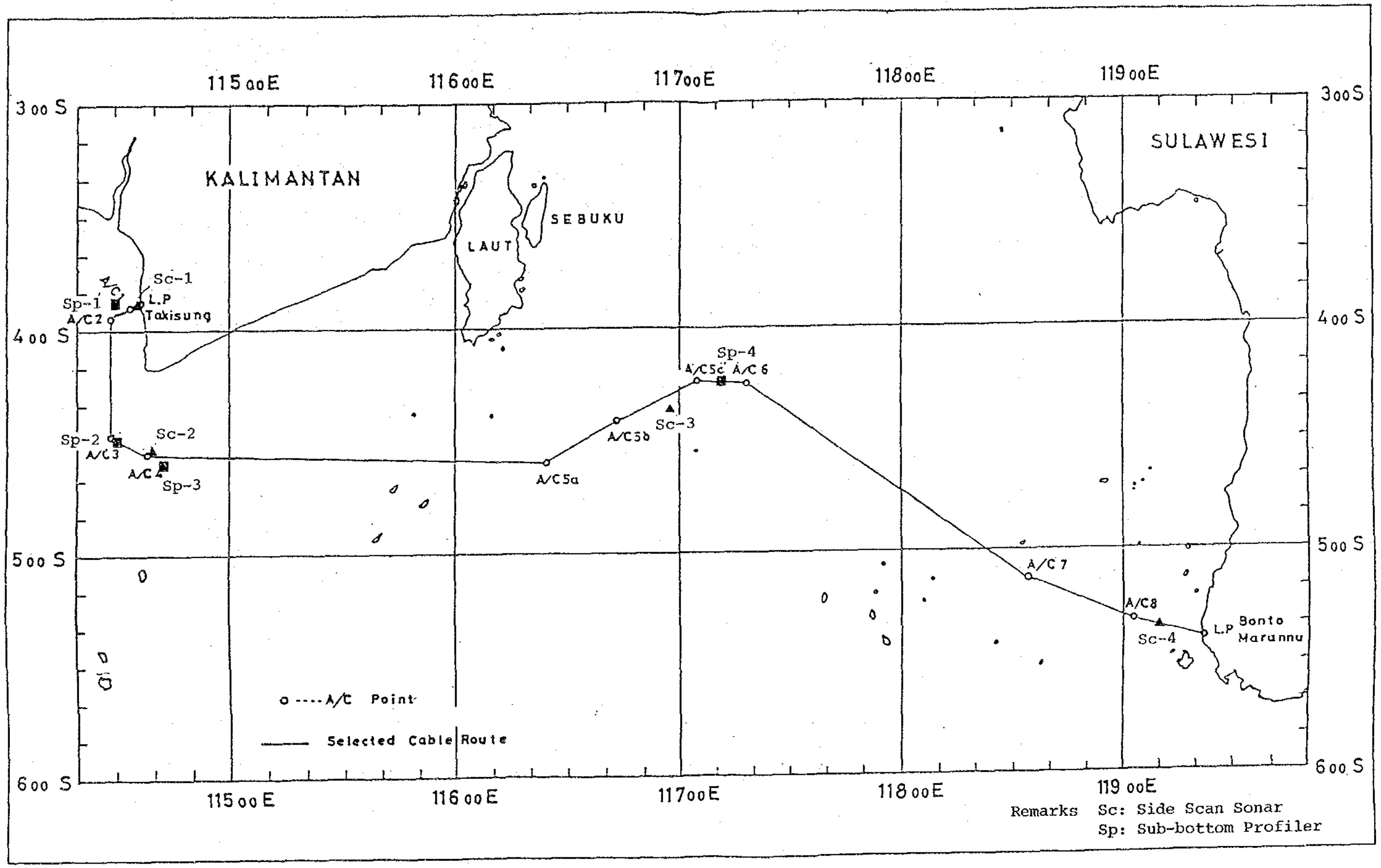
Appendix 10



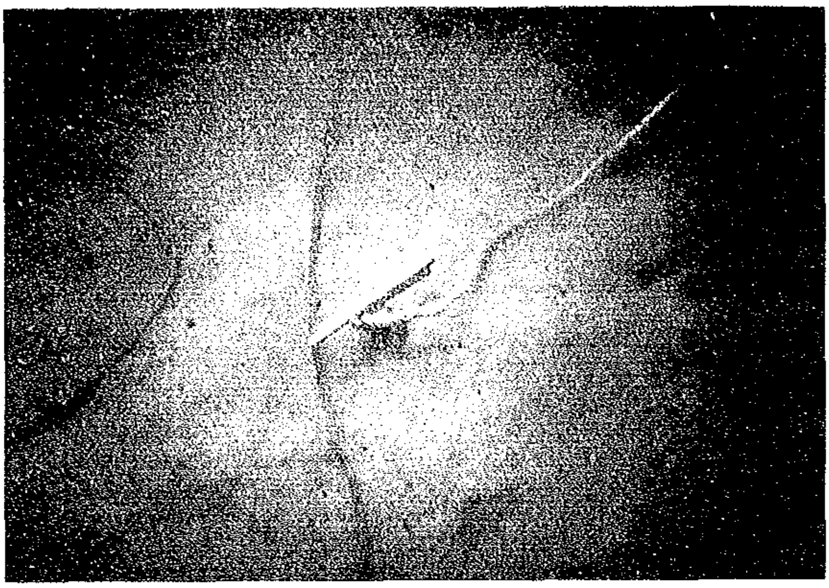

Coordinate Conversion Diagram from WGS-72
to Indonesia Geodetic System (Jakarta)

# APPENDIX 10

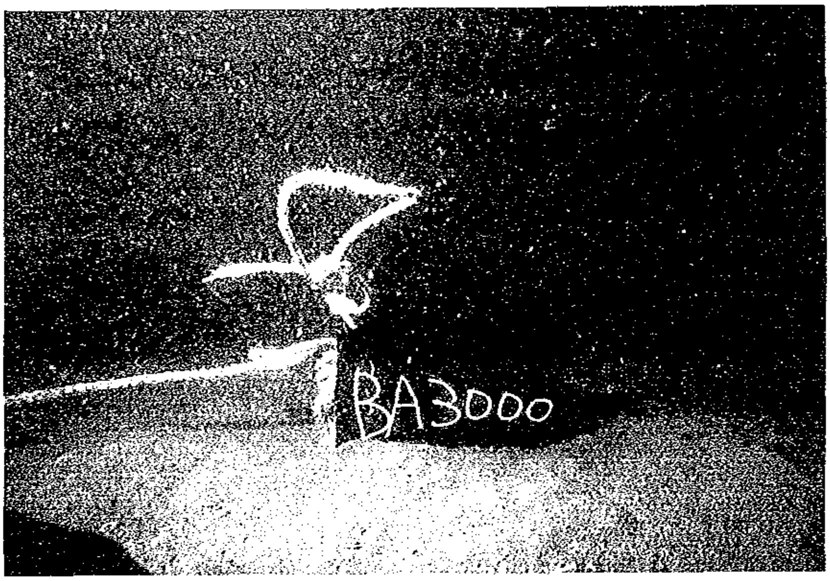
## COORDINATE CONVERSION DIAGRAM FROM WGS-72 TO INDONESIA GEODETIC SYSTEM (JAKARTA)




Positions of Records by Sub-bottom Profiling Side Scanning



Takisung Inshore 5km from T.LP Mud




Bonto Marannu Inshore 3km from B.LP Coral Sand

# APPENDIX 11

# RECORDS OF SIDE SCAN SONAR, SONOPROBE AND SEABED PHOTOGRAPHS

Photo P-3
Sandy Mud

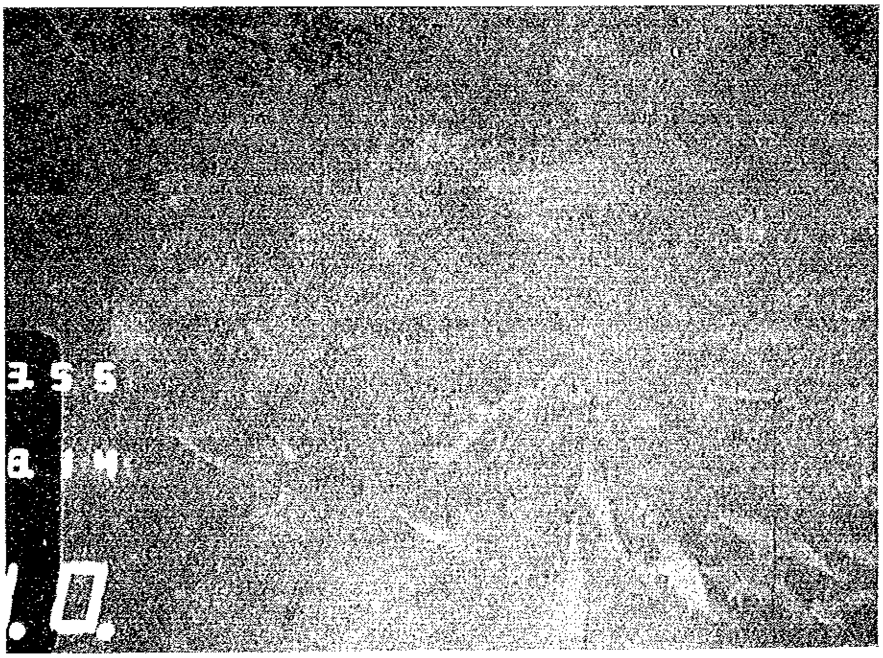


Photo P-10
Coral Reef

Seabed Photographs