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# A GEOLOGICAL AND GEOPHYSICAL INVESTIGATION OF THE WESTERN SOLOMON SEA, TROBRIAND BASIN, AND ADJACENT AREAS - CRUISE REPORT OF THE R/V NATSUSHIMA

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## INTRODUCTION

In December 1983 and January 1984, the Japanese Government, in co-operation with the governments of Australia and Papua New Guinea, and the United Nations sponsored organization CCOP/SOPAC, initiated a survey of the western Solomon Sea between new Britain Island and the Trobriand Platform. Although geological information has been obtained by occasional research vessels traversing this area, few major surveys have been made. Consequently the area is little known in detail, and large areas are uncharted. This report indicates what work was accomplished in this internationally sponsored survey, and provides a preliminary discussion of some of the results.

This cruise designated by the code name 'NA T -83', supports the following elements of the CCOP/SOPAC work programme: CCSP/PN.6 (An Investigation into the Hydrocarbon Potential of the Cape Vogel Basin); CCSP/PN.ll (Bathymetric Mapping of the Sea Floor of Papua New Guinea); CCSP/REG.2 (Study of the Bismarck, Solomon, and Woodlark Basins); and CCSP/REG.16 (Study of Energy Release and Seismicity in the Southwest Pacific). It is the first of three cruises in the western Pacific proposed by Japan, and conducted by the governments of Japan, Australia and New Zealand, in co-operation with CCOP/SOPAC, in three different areas under the program entitled "Indian-Pacific Plate Boundary Area Study" (IPPBAS). The program is proposed to acquire basic scientific information for marine mineral and hydrocarbon exploration in the host countries, to aid the study of volcanism and earthquakes, and for geo-scientific research of international interest in the island arc-trench system along the interface between the Pacific and Indo-Australian plates.

The research vessel Natsushima, a submersible tender in Japan, was chartered by the Geological Survey of Japan and the Japan National Research Centre for Disaster Prevention for the 35 day survey. The vessel is 67m overall, 1530 gross tonnes, and carries a crew of 30 and accommodation for up to 25 scientists. It is owned and operated by the Japan Marine Science and Technology Centre.

## BACKGROUND

The Solomon Sea Basin is bounded to the northeast and northwest by an active arc-trench subduction system. The New Britain Trench, reaching more than 8.5km in depth, marks the site of consumption of the Solomon Sea crust under New Britain, south New Ireland and Bougainville islands. The trench makes a sharp bend south of New Ireland where the rate of intense seismicity is among the highest in the world. On the south side, the Trobriand Trough is up to 5.3km deep, and separates the Solomon Sea Basin, normally 3 to 5 km deep, from the wide and shallow water of the Trobriand Platform adjacent to the northern coast of the Papua Peninsula.

The southeast side is bounded by the Woodlark Rise, a broad elevated area of ocean floor less than lkm in depth, extending northeast from Woodlark Island and separating the Solomon Sea Basin from an area of newly generated crust in the Woodlark Basin, a spreading centre. In the west, the Solomon Sea Basin is terminated east of the Huon Gulf and adjacent Huon Peninsula, by the 1490 Embaymment, an area where the Trobriand Trough and New Britain Trench meet (Figure 1).

The Solomon Sea is in a area of complex and little known tectonics related to subduction and collision of small plates existing in the boundary zone of the two major plates, the Pacific plate and the Indo-Australian plate. Present day seismicity clearly indicates the relative movement of the Solomon Sea plate under New Britain, dipping into the New Britain Trench where large magnitude earthquakes are common-place. The rate of convergence is estimated to be 9.2 to 12.5 cm/yr in a direction of approximately NNW. In contrast, seismicity along the Trobriand Trough is almost non-existent, and rate of convergence of the Solomon Sea plate with the Papuan coast to the south is unknown, if it exists at all at this time. The age of the Solomon Sea lithosphere is also unknown.

The Trobriand Platform, a shallow-water, reef- studded area between the north coast of the Papua Peninsula and the Trobriand Trough, is underlain by up to 5km of Miocene and younger sediments. Petroleum exploration has been conducted over some parts of the area, called in general, the Cape Vogel Basin, but sub-divided into several smaller sub-basins. Two exploratory holes were drilled in 1973 north of the D'Entrecasteaux Islands, reaching about 2840m and 2370m in depth. The wells penetrated Middle Miocene and younger sediments of mainly marine, shallow water marine and fluvial/deltaic environments before bottoming out in volcanics. However, these tests did not evaluate all of the Tertiary sediments of the Cape Vogel basin and further exploration is needed.

## CRUISE OBJECTIVES

Cruise objectives were proposed at a pre-cruise meeting in Port Moresby, March 1983, and later revised due to time constraints and other factors, to those listed here. The cruise plan was designed to meet these objectives.

1. To obtain multichannel and single channel seismic reflection surveys of the New Britain Trench and Trobriand Trough, and of part of the Trobriand Platform (to link with earlier Amoco surveys and thus tie into the two exploratory wells).

2. To make OBS surveys of a) the triple plate junction near the bend of the New Britain Trench south of St. Georges Channel; b) the proposed spreading centre in the Manus Basin, northeast Bismarck Sea.

3. To establish heat flow, particularly on the Trobriand Platform.

4. To obtain bottom samples of sediment and rock from the slopes of the New Britain and Trobriand Trenches and from the Solomon Sea Basin.

5. To obtain bathymetric and magnetic data of the Western Solomon Sea.

## PERSONNEL

The shipboard scientific staff was composed of nineteen professional participants; nine from Japan, three from Papua New Guinea, one from CCOP/SOPAC (Fiji), and six from Australia. The participants are listed in Appendix 1. The ship was under the able direction of Captain Imura.

## EQUIPMENT AND FACILITIES

R/V Natsushima

| | | |
|---|---|---|
| Gross tonnage | : | 1530 tonnes |
| Overall length | : | 67 m. |
| Beam | : | 13 m. |
| Draught | : | 3.75m, flat bottom |
| Cruise Speed | : | 10-12 kts |

Twin screw, variable pitch propellors, plus bow thrusters
Large hydraulic A-frame at stern
Shock-mounted engines for low acoustic noise level

| | | |
|---|---|---|
| Endurance | : | 8,400 nautical miles |

Natsushima, designed as a submersible support ship, required dockyard modifications to prepare her for the geological research operations performed on this cruise. In particular a deep-sea winch, air-compressor and multi-channel cable reel were installed and modifications made to the hydraulically movable A-frame to enable bottom sampling. Additional facilities were added to deploy and retrieve the seismic equipment. All equipment was provided and installed by Japan. The ship performed adequately and its rapid maneuverability proved very useful. The ship's crew assisted with all launching and recovery operations and performed efficiently once a routine was established for the various operations.

## Geophysical Systems

1. Single channel seismic reflection system using one Bolt Model 1900 airgun. Airchambers used were 120, 150 and 450 cubic inches.

2. Multi-channel seismic system consisting of:
   (a) A 12-channel streamer with 50m active sections containing 64 hydrophone elements each.

   Three pre-adjusted depressors were used to maintain the desired depth, which was monitored by three transducers in the streamer. Depth readout was in the seismic lab on board ship.

   (b) A recording system built by Nippon Electric Company with outputs to digital tape decks, visigraph recorder, teletype, graphic recorders and POP 11 mini-computer.

   (c) Sound source consisting of one 450 cubic inch Bolt air gun driven by one 60 SCFM air compressor. The airgun, firing at 23.1 second intervals, was maintained at approximately 1400 psi and towed at 7-10m depth.

3. Geometrics proton precession marine Magnetometer System.

4. Ocean Bottom Seismometers capable of operating to 6000m depth, with two-component velocity type geophones, recording in the range of 1-15 Hz over a duration of 30 days. The OBS's are equipped with strobe lights and radio and acoustic transponders to ensure retrieval on the surface.

5. Bathymetric Recording system at a frequency of 12 KHz, 2 kwatt output level, with a transducer beam width of 15° at 3 db points.

6. Integrated navigation system using satellites, doppler sonar and Omega inputs.

7. A sonobuoy system consisting of: a Vagi-type antenna directed astern from the after mast; a receiving unit; and Type OC-O 1 sonobuoys made by OKI Electric Company in Japan. The system operates in the 169 MHz frequency range.

8. Expendable Bathythermograph System

Bottom Sampling Equipment

| | |
|---|---|
| Piston corer | : 450 kg weight stand, 4 or 8m barrel. |
| Rock corer | : 2m barrel |
| Gravity corer | : 4m (adapted piston corer) |
| Dredges | : 40cm pipe dredge with chain bag |
| | 16cm sediment pipe dredge |
| | 60cm large pipe dredge with wire mesh bag |

Free-fall grabs with cameras (made by Preussag)
Winch, 100h.p. 6 tonne capacity with 6000m of t" wire.
(Sampling was therefore restricted to water depths less than 5500m. )

Bullard-type heat flow probe (Nichiyu Giken Co.)
Utilizing three thermisters on a 2 metre long probe, spaced evenly at 0.8m. A bridge network measures thermistor resistance and readings are maintained in internal microcomputer memory. Up to three measurements can be recorded in one lowering, however, only one recording was made per site during this survey. The readings are recovered through an external connection through which the batteries are also recharged without dismantling the watertight container.

## WORK ACCOMPLISHED

The work programme was carried out in three main areas, and can be considered in three parts:

1. Ocean bottom siesmometer studies were made in the Bismarck Sea and Solomon Sea;

2. Underway magnetics, bathymetry, seismic profiling, (both single channel and multi-channel reflection seismic) heat flow measurements and bottom sampling were carried out in the western Solomon Sea, and

3. The same methods were used on the Trobriand Platform. Most of the survey time was spent in the western Solomon Sea (Figure 2).

The survey took place in two legs, with a two-day break between in the port of LAE, Papua New Guinea, for Christmas. Prior to the first leg while en route to Rabau1, the ship laid eight pop-up type OBS's in the Bismarck Sea in the area of the proposed spreading centre of Manus Basin. Water depths ranged from 1300m to 2400m. Each OBS position was located by satellite fixes adjusted relative to the ship by acoustic distance ranging and direction measuring. The OBS's were in position for 27 days before being successfully retrieved during leg 2.

Two more OBS's were deployed in the Solomon Sea south of St. Georges Channel after leaving Rabaul, in water depths of 2800m and 3320m (Figure 2). Refraction lines were shot, using a 450 cubic inch air gun, along a line between OBS 9 and OBS 5 in the Bismarck Sea, and between OBS stations 1 and 2 in the Solomon Sea.

Following deployment of the OBS's, seismic profiling commenced from St. Georges Channel with lines in a general north-south direction, working from east to west across the Solomon Sea to Huon Gulf (Figure 2). A total of 2754kms of single channel seismic data was collected over the Solomon Sea basin and Huon Gulf during Leg 1, and 792 km of multi-channel seismic (Figure 2). In addition 2900km of magnetic data were obtained and 4800 km. of bathymetry. Six dredge stations were occupied, four cores were taken, one heat flow measurement made, and ten free fall cores were dropped while stations were occupied.

During Leg 1, a survey of the Trobriand Platform area east of the Trobriand D'Entrecasteaux Islands was made. In this area 166km of single channel seismic data was recorded, and 278 Km of multi-channel. One dredge haul, three heat flow measurements, and three core stations were taken and 3 free fall grabs were recovered. The station data is listed in Table 1. On completion of Leg 1, the ship entered the port of Lae for Christmas.

An official reception was held on the ship in Lae on December 24 for invited guests representing the PNG Government, local provincial officials and staff from the PNG University of Technology.

Leg 2 began after the two day stop in LAE. The ship proceeded out of Huon Gulf, around Huon Peninsula and through Vitiaz Strait (Figure 3) to the Bismarck Sea where the eight OBS's laid previously were all successfully recovered (Figure 4). During the time of their deployment a magnitude 6.8 earthquake was recorded with epicentre in the New Britain area. One dredge station was attempted near the Bismarck Sea spreading centre, but no volcanic material was recovered, although some sedimentary material was returned. A free fall core was also dropped. Only bathymetric data were collected while underway in the Bismarck Sea. During this time the air compressor was repaired by the Chief Engineer and his staff. Spare parts ordered from Japan had not arrived in Lae before the ship's departure and it is due entirely to the skill and perseverence of the ship's Chief Engineer that the compressor operated during Leg 2, allowing seismic work to continue.

With the eight OBS's recovered, the ship steamed for St. Georges Channel, where two more OBS's were also retrieved. Single channel seismic profiling then continued in the Solomon Sea with collection of 1190km more data, mostly at night and between sample stations, and a similar amount of magnetics data. About 3300km of additional bathymetry were also recorded. Sampling and heat flow measurements were given priority. Station data includes 4 dredge hauls, 3 cores, 3 heat flow measurements and 9 free fall grabs.

During both legs of the survey sea water temperature profiles were made to 1800m water depth using XBT's at twelve stations, ten in the Solomon Sea and two in the Bismarck Sea. These were mainly taken near the OBS stations to aid in determination of acoustic ray paths to the OBS's.

The final port stop at the end of the survey was changed from Rabaul to Lae due to concern regarding the Stage 2 volcanic alert in Rabaul. The ship arrived in Lae on the morning of January 5, 1984.

Table 2 lists all of the data obtained during both legs of the cruise. Excellent weather and a calm sea state throughout the cruise permitted efficiency to remain high and made sampling and data collecting easier, however, some data and time were lost due to compressor, airgun, hydrophone streamer and magnetometer failures. Lack of sufficient lifting power of the winch caused mionr delays when on several occasions, the corer could not be extracted from the sea floor. The A-frame was used to provide extra lift by alternately lowering and raising it. The only equipment lost during the cruise were two free-fall grabs with cameras which failed to surface.

## DATA COLLECTION

### A. Navigation

Primary navigation for the survey was obtained from the Navy Navigation Satellite System but since the survey was mainly between 3 and 8 degrees latitude south of the equator, passes were widely separated in time compared to higher latitudes, and gaps of up to 8 hours sometimes occurred.

Dead-reckoning was maintained by a dedicated navigation computer with automatic input from the doppler speed log and gyro compass, but sometimes strong and unknown currents were operative, especially in parts of the Solomon Sea such as the Trobriand Platform area, which caused errors in the DR positions.

The computer updated the DR every two, seconds and this was recorded with other navigational data once every 15 or 30 minutes as required. Fixes were recorded as received. An X- Y plotter on the bridge plotted positions and the ships track at selected intervals, usually every 5 or 15 minutes, at any pre-selected scale, complete with grid lines, latitude and longitude scales, and a compass rose. A notation of satellite fixes, half-hourly positions, depth, magnetic, speed and course was maintained in the underway scientific navigation log, as well as speed and course alterations when they occurred.

The daily plot of the ship's track was kept manually on a bathymetric map at a scale of 1:1,000,000. Computer plots of ship's track at various other scales were also prepared. The ship's track will be reconstructed from satellite and radar fixes with consideration of other data including course, speed, and DR positions, to arrive at a "best fit" track line. Over most of the survey, fixes should be accurate to within much less than a kilometer whereas, DR positions along the tracks between fixes maybe in error by as much as three kilometres when fixes are widely spaced. However, in most areas, errors in corrected DR positions should be small. The base map is to be replotted at a scale of 1:500,000 after the cruise.

## B. Bathymetry

Seafloor configuration beneath the ship was recorded continuously by the precision depth recorder. All depths are in uncorrected meters, assuming a velocity of sound in seawater of 1500 m/sec.

As well as being automatically printed at 5-minute intervals, depths were also manually logged at 30-minute intervals in the Underway Log. New bathymetric contours at 500m intervals were constructed by hand at 1: 1 million scales as time permitted. In particular, the new bathymetry was continuously updated during Leg 1 operations over the Markham Canyon. Bathymetric data were collected in a number of areas where no previous information existed.

After completion of the survey all bathymetric records were taken to the Bureau of Mineral Resources, Canberra, to be used in the preparation of a final bathymetric map at 1:500,000 scale.

## C. Single-channel Seismic Reflection

Data quality on some early lines was poor, probably due to a combination of factors: gain set too high, ship's speed too fast (l0knts), and deep water. Difficulty in initial communications between Japanese and English speaking scientists may have contributed. Subsequent lines with gain reduced, and ship's speed about 8 knts, resulted in much better quality record.

The 150 cu. in. airgun used was normally fired at 12 second intervals, and at this rate the 60 cfm compressor could only maintain a gun pressure of about 110 kg/cm3 (1550p.s.i.), somewhat low for best results. The gun was towed 15m behind the ship at a depth of about 8m. Data were not digitized or tape recorded and are available only on the graphic chart recordings.

## D. Multi-Channel Seismic Reflection

With the long 12-channel streamer, towing speed was limited to less than 5 knots to reduce strain on the cable. For Common Depth Point (CDP) shooting, a ship's speed of 4.26 knots was required to give 50 meter spacing between shots when fired at 23.1 seconds interval. This would provide a 6-fold CDP coverage. However, at this firing rate, the compressor could not maintain a gun pressure greater than 1400-1500 psi. in the 450 cu. in. air gun. Any longer firing interval would require slower ship's speed, so attempts were made to maintain a constant speed over the bottom at 4.26 knots. However, wind and currents, and the navigational control on the bridge rather than in the lab, often thwarted those efforts. Consequently, proper CDP coverage may not always be possible.

Digital MCS data were recorded on 41 magnetic field tapes. One data channel was displayed on a graphic recorder to provide an immediate record and to monitor data quality. Six-fold CDP processing of the taped data will be carried out both at Geological Survey of Japan and Bureau of Mineral Resources in Australia. Migration and application of high resolution techniques should remove diffractions, multiples and other extraneous effects, and should improve the quality of the multi-channel profiles.

Other than a few minor electronic problems with the Raytheon recorders, the MCS electronic equipment appears to have worked reliably despite occasional high heat levels in the recording lab.

One section of the MCS streamer had to be replaced after oil escaped from the section creating a noise problem. Shark bites were suspected to be the cause of the leaks. Other channels may be noisy for the same reason.

The single new air compressor developed trouble after two days of operation and eventually had to be serviced. Fortunately, the ship's Chief Engineer undertook to maintain it and stripped and repaired the troublesome cylinder almost every time the compressor was stopped. Due to his mechanical knowledge and capability the survey was able to proceed with seismic work. A second compressor had been highly recommended prior to the cruise, and the validity of that recommendation is reinforced by the events of this survey.

## E. Sonobuoys

Three attempts were made at recording seismic refraction data from sonobuoys during Leg 1 and one during Leg 2, with poor results. Considerable radio noise was present, and some interference to the sonobuoy record emanated from the multichannel recording system. It was finally determined that the Vagi antenna on the mast was found to have lost the lower half of the main receiving element which seriously degraded the received signal. This could not be repaired at sea. Also bottom topography and acoustic basement are generally rough in the survey area, thus limiting favourable areas for refraction measurements. The use of the sonobuoy system was, therefore, discontinued.

## F. Magnetics

Because of the multichannel seismic streamer towed astern, the magnetometer sensor was kept on a short cable only about 100m behind the ship during some parts of Leg 1. At that distance the ship's magnetic field is strong enough to make absolute magnetic readings unreliable, and on some large course changes, shifts in the magnetic level of up to 100 gammas occurred. However, when on one course, the shape at least, of the magnetic field should be approximately as recorded and the configuration of anomalies will be apparent, even if the values of the anomalies may be in error.

Problems occurred with the magnetometer on Line 4 and again on Line 24 resulting in Lines 5 to 7 and 25 to 30 not being recorded while the system underwent repair. Magnetics were not recorded in the Bismarck Sea. The magnetics show a strong increase in the magnetic field from north to south. The field is generally low and flat along the New Britain coast with a few small anomalies apparent at Crater Point near Wide Bay in the northeast.

The values increase smoothly southward from New Britain, becoming slightly flatter in gradient over the New Britain Trench but climbing gently and smoothly again, toward the mid-part of the Solomon Sea Plate. Some slight magnetic expression is found near the mid-plate ridges in the east, but in general, the magnetic field ignores topography. The field continues to increase toward and over the Trobriand Trough, with some anomalies occurring near or over small ridges just north of the trough. The upward gradient continues over the slope south of the trough, reaching a culmination on Line 11 just east of Kiriwina Island (Trobriand Platform) where a sharp drop of 600 gammas occurs. Elsewhere on the Trobriand Platform, our data show anomalies occur east of the Trobriand Islands, and northwest of Egun A toll but most other areas of the Trobriand Platform covered by this survey have little magnetic relief.

## G. Ocean Bottom Seismometry

All ten OBS's were recovered successfully from BOOm to 2400m in the Bismarck Sea, and from 2800 to 3320m in the Solomon Sea. Before deployment, a master clock in each OBS was calibrated by a standard time clock synchronized with radio standard time signals (JJY), making correction for the path delay time of the radio waves, or by a high precision Rubidium clock (stability better than 10-10 /month) on board ship. The internal clocks will be checked again after opening the OBSls in controlled conditions in Japan. OBS refraction lines along a line between Stations 1 and 2 in the Solomon Sea were shot using a 40 cu. in. airgun.

Earthquake data from Port Moresby Geophysical Observatory's land-based seismograph stations recorded during the cruise period will support the OBS data. Two additional temporary land stations were established especially for the duration of the cruise. The data will be analysed jointly by Japanese and PNG scientists.

## H Sedimentology

Rocks and/or sediments from 23 sampling stations were recovered by 9 dredge hauls, 9 cores (6 gravity and 3 piston), and 13 free-fall grabs. All station data together with sample quantity and brief description are listed in Table 1. Station locations are shown on Figures 2, 3 and 4.

Of the nine dredge hauls recovered during the cruise, four come from the Solomon Sea basin in water depths of 2500-4-800m, three from the Trobriand Platform in water depths of 694--3020m, one from the central rift scarp on the Trobriand Platform at the Western end of the Woodlark Basin (24-00-24-4-6m), and one from the central part of the Bismarck Sea in water depths of 1780-2050m. Of the nine cores recovered, four come from the central part of the Solomon Sea Basin in water depths of 5020-5l90m. (Including one from Finsch Deep) three from the Trobriand Platform (4-26-l709m), and two were recovered from the Trobriand Trough on the south margin of the Solomon Sea basin (5266-5300m). Of the thirteen successful free-fall grabs, eleven were recovered from the Solomon Sea basin, one from the Trobriand Platform and one from the central part of the Bismarck Sea.

All the cores were described after splitting on-board, and logs of visible structures, colors and sediment types were prepared. Samples were taken at least every 25cm for smear-slide and binocular examination. Material collected in free-fall grabs and dredge hauls was also examined on board and preliminary descriptions prepared. Generally core quality was good with little disruption to internal structure whereas dredge hauls are of disturbed surface sediment and exposed rocks.

## I. On-board Paleontology

Paleontology studies were only made on Leg 1 as no paleontologist was on board during Leg 2. Further studies will be completed in PNG.

Surface sediment from core and dredge sites was stained in Rose Bengal and washed. Sediment fractions greater than 63 pm were retained for detailed micropaleontological analysis. Initial picking of residues was made.

Sedimentary rock analysis gave the following preliminary results:

| Station and Sample No. Site | Water Depth (m) | Rock Type | Age | Palaeobathymetry |
|---|---|---|---|---|
| 11D5 | 2040 | Sandy mudstone | N21 (late Pliocene) | Bathyal |
| 12D6-4 | 2520-2720 | Foram mudstone | P6 or 7 (earliest Eocene) | Upper Bathyal |
| 12D6-5 | " | Muddy sandstone | N12 (middle Miocene) | Upper Bathyal |
| 12D6-7 | " | Limestone | Upper Te | Neretic |
| 12D6-8 | " | Limestone | Upper Te | Neretic |

Some core sections were sub sampled on baord, but due to risk of contamination and lack of proper laboratory facilities, the samples were not processed at sea. Analysis of core catcher samples from the base of each core gave an age of late Pleistocene/Holocene.

## 3. Igneous Petrology

Dredging and sampling for basalt rocks was not always successful. Table I list the sample stations attempted and the degree of success. Free fall grabs sometimes returned small rock samples (i.e. Station Nos. 3, 22 and 23). One dredges station (No. 25) in Manus Basin (Bismarck Sea); was added when time became available while the OBS array was being recovered there. Apart from pumice, the only igneous rocks obtained from eleven dredge attempts throughout the cruise were some small fragments of basaltic glass (Station Nos. 12, 25), the largest pieces of which are 2 cm in diameter, and one dredge full of basalt and sediments (Station 29). This rock dredge sample from the Solomon Sea contained approximately 30 kg of basaltic rock fragments, sediments, and breccias. The breccias are relatively rare (total of about 500g) and appear to be hyaloclastite breccias associated with the basalts. Much of the basaltic material is fragmF'nts of pillows and, although generally altered, smooth margins which were originally glassy can be recognized. All of the basaltic material shows some degree of alteration with glassy margins being altered to palagonite. Some fresh glass is also present: ThF' freshest glass occurs in some of the hyaloclastite breccia. Many of the pillow fragments are encrusted with manganese oxides, some up to 7 mm thick. Two basaltic types are present: a massive, weakly plagioclase-phyric variety and a weakly vesicular aphyric variety. Some fresh olivine is present in one rock sample. The basalts at Station 29 appear to be typical oceanic basalts.

The igneous rocks obtained in the free fall grab sample from Station 3 are a mixture of slightly differing finely porphyritic, partly glassy (or palagonitic) basalt, with clinopyroxene and plagioclase laths to 1 mm. Most of the ten rock fragments obtained show fine jointing (1 em scale) and have the appearance of having been stressed in or near a shear zone. All show some degree of alteration concentrically arranged from the outer rim of each fragment.

Igneous rocks collected from the floor of Kanapu Canyon at Station 12 (Trobriand Trough inner slope) have a rounded form and appear to be river pebbles which could possibly have been redeposited from alluvial or neritic environments. All are either submarine basalt or glassy (palagonitic) basalt. Some show zeolite veining and, in one instance later alteration of pyroxene to prismatic amphibole has occurred.

## K. Heat Flow

Seven heat flow stations were made, as shown on Figures 2 and 3. Anomalous readings were noted at Stations 9 and 30, indicating possible malfunction of the heat flow equipment. On a number of stations, the probe was returned badly bent. Heat flow values obtained are in the range of 1.98 - 2.4-1 HFU except at station 9 where a reading of 5.60 was obtained. The reason for such a high value is unknown.

## L. Sea-floor Photographs

During the cruise 17 black and white photographs were taken by the free-fall grabs in depths ranging from 670 to 5268m.

The sea-floor photographs show gross surface features including sediment textures and structure, and evidence of benthic organisms (e.g. feeding trails).

## M. Water Temperature Profiles (XBT)

Sea water temperature profiles down to l300m were obtained by Expendable Bathythermographs (XBT) at 12 stations during the cruise. These were obtained primarily to calculate the acoustic ray path between the transponder near the sea surface and ocean bottom seismometers, but also provide basic oceanographic information on near surface water temperatures (thermocline), mixing, and current regimes in the areas visited.

## PRELIMINARY RESULTS AND OBSERVATIONS

Pillow basalt with altered glass margins are exposed on ridges in the central Solomon Sea. Lithified hyaloclastite and Mn/Fe crusts are present. A central ridge further to the west (also on oceanic crust) has sheared lithified mudstone exposed. Dating these sediments will help to define the age of the crust and tectonic movements in this area.

Bathymetric trends on the oceanic plate are controlled by basement faulting and sedimentation. The grain of the bathymetry trends NI05°E although the height of the relief varies along strike. Major east-west valleys contain thick sediment disconformably overlying older strata. Some faults may be old (transforms?) and some are obviously young because they break through the surface sediment.

Our data confirm that the Trobriand Trough is a subduction system and deformation in the surface sediments suggests recent tectonic activity. An abrupt deformation front in the turbidites marks the base of the trench slope. The oceanic basement crust under the sediments of the Trobriand Trough is at a depth comparable to that in the New Britain Trench. Accretionary ridges of deformed sediment compose structural highs on the trench inner wall forming perched basins filled with slump deposits, pebbly mudstone and turbidites (showing tectonic tilt of the deeper strata).

Where the Trobriand and New Britain trenches come together in the west the relief is more subdued by thicker sediment cover but the underlying crust is arched with many faults. The New Britain Trench axis passes along the southern margin of the Huon Peninsula and its eastward submarine extension.

There is a general increase in sediment thickness to the west, both on the oceanic crust and in basins on the trench slopes. The Trobriand Trough is filled with over 2 km of sediment whereas in contrast the New Britain Trench lacks much sediment except at its western end.

There is a thick sedimentary sequence under the eastern Trobriand Platform in relatively shallow water. The sequence is characterised by a major unconformity with underlying (Miocene?) strata containing fold structures.

Submarine canyons are prominent and important features on the slope leading from the Trobriand Platform into the Trobriand Trough. These canyons are major suppliers of sediment to the trench-slope basins and trenches. Turbidity currents and slumps have transported gravel, sand, mud and wood into abyssal depths of the 1490 Embayment over 100 km from the present shoreline. Initial canyon development may be fault controlled.

Sediment cores from water depths greater than 5 km show a basin-wide near-surface hiatus in the Solomon Sea. Oxidised hemipelagic calcareous brown mud overlies a thin Mn/Fe-rich layer and greymuds. Microfossils may enable the dating of this significant change in oceanic and sedimentary conditions. A history of volcanic activity is represented by several ash layers.

The generalised magnetic pattern on the oceanic crust is smooth with a constant dip to the north.

Seismic reflection and morphology suggest active rifting (spreading?) is occurring in the eastern Trobriand Basin, probably relating to the propagation westward of the Woodlark Rift.

## CONCLUSIONS

Data has been distributed to agencies and cruise participants in Japan, PNG, Australia and Fiji for analysis and interpretation. Because of this widespread scattering of the data, communication between scientists is very important in keeping abreast of progress, findings and evolving theories that can be significant to all those working on the project. It is an expressed desire of the cruise participants that manuscripts resulting from this data collection should be published together in a special issue of an international journal in about 18-24 months time.

TABLE 1: BOTTOM STATION SUMMARY

| Station No. | Sample No. | Position | | Depth | Area | Remarks |
|---|---|---|---|---|---|---|
| | | Lat. (S) | Long. (E) | (m) | | |
| 1 | OBS1 | 4°48.4' | 152°34.1' | 3320 | St. Georges Chan | Lay OBS |
| 2 | OBS2 | 5°17.4' | 152°19.1' | 2800 | " | Lay OBS |
| 3 | D1 | 7°12.9' | 152°11.2' | 3700 | Ridge in Solomon Basin | No recovery |
| | | 7°13.5' | 152°11.8' | 3900 | " | |
| | FC1 | 7°12.8' | 152°11.0' | 3258 | " | Basaltic rocks (10 pieces) |
| 4 | D2 | 7°13.5' | 152°15.7' | 3737 | " | No recovery |
| | | 7°14.0' | 152°16.3' | 3565 | " | |
| | FC2 | 7°16.1' | 152°17.4' | 4548 | " | Trace of brown mud |
| 5 | RC1 | 8°42.7' | 151°17.5' | 417 | E. of Trobriand Is. | 4cm core plus core catcher: 1 kg sand |
| | HF1 | " | " | | | |
| 6 | RC2 | 9°15.6' | 151°24.5' | 1495 | " | 197cm core |
| | HF2 | " | " | | | |
| | FC3 | 9°17.6' | 151°24.2' | 1520 | | No recovery |
| 7 | GC1 | 9°19.7' | 151°36.4' | 1709 | " | 295cm core |
| | HF3 | " | " | | | |
| | FC4 | 9°19.2' | 151°36.3' | 1700 | | |
| 8 | D3 | 9°39.0' | 151°17.0' | 2446 | W extension of Woodlark Rift | Calcareous mud |
| | | | | 2400 | | |
| | FC5 | 9°38.5' | 151°16.5' | 2560 | | |
| 9 | GC2 | 7°43.8' | 151°15.5' | 5250 | Trobriand Trough | 400cm core: 100cm brown clay overlying 300cm semiconsolidated sediments |
| | HF4 | " | " | | | |
| | FC6 | 7°44.3' | 151°15.5' | 5255 | | |

| Station No. | Sample No. | Position | | Depth | Area | Remarks |
|---|---|---|---|---|---|---|
| | | Lat. (S) | Long. (E) | (m) | | |
| 10 | D4 | 8°15.2' | 150°48.0' | 675 | S slope of Trobriand | Brown Mud |
| | | 8°15.7' | 150°49.1 | 694 | Trough | |
| | FC7 | 8°15.4' | 150°48.3' | 1709 | | No recovery |
| 11 | D5 | 8°08.1' | 150°49.7' | 2040 | " | Dredge full of mud with 1 kg calcareous sed. rocks. Foraminifera N21 |
| | | 8°08.5' | 150°50.0' | 1800 | " | |
| | FC8 | 8°08.1' | 150°49.7' | 1900 | | No recovery |
| 12 | D6 | 8°12.9' | 149°57.9' | 2720 | W wall of canyon in up. slope of Trobriand Trough | Dredge full of mud, silt store, gravels, corals |
| | | 8°14.0' | 149°58.6' | 2520 | " | |
| | FC9 | 8°12.9' | 149°57.9' | 2667 | " | |
| 13 | PC1 | 6°33.7' | 148°33.0' | 5170 | | 470cm core: layered turbidites |
| | FC10 | 6°32.1' | 148°32.0' | 5205 | | |
| 14 | GC3 | 7°17.5' | 148°27.9' | 5020 | Canyon axis in Huon Gulf | 120cm core: coarse sand, mud, turbidites and slumped layers. |
| | FC11 | 7°17.4' | 148°28.1' | 5011 | | |
| 15 | GC4 | 7°19.2' | 148°00.3' | 4066 | " | Black volcanic pebbles, rounded up to 5mm diameter |
| | FC12 | 7°18.4' | 148°00.3' | 4072 | " | |
| | FC12' | 7°18.4' | 148.00.3' | 4072 | " | |
| 16 | D7 | 7°14.5' | 147°43.2' | 3316 | " | Mud balls, woods and a few pebbles in muddy sand |
| | | 7°14.3' | 147°42.8' | 3300 | " | |
| | FC13 | 7°14.1' | 147°43.3' | 3310 | | |
| | FC13' | 7°14.1' | 147°43.4' | 3310 | | |

| Station No. | Sample No. | Position | | Depth | Area | Remarks |
|---|---|---|---|---|---|---|
| | | Lat. (S) | Long. (E) | (m) | | |
| 17 | OBS3 | 3°29.6' | 148°43.3' | 1840 | Bismarck Sea | Recovery of OBS (4) |
| 18 | OBS4 | 3°18.6' | 148°51.4' | 1800 | " | Recovery of OBS (1) |
| 19 | OBS5 | 3°38.0' | 148'59.7' | 1960 | " | Recovery of OBS (5) |
| 20 | OBS6 | 3°52.6' | 149°00.9' | 1580 | " | Recovery of OBS (6) |
| 21 | OBS7 | 3°52.0' | 149°24.1' | 1920 | " | Recovery of OBS (9) |
| 22 | OBS8 | 3°32.9' | 149°14.4' | 1990 | " | Recovery of OBS (7) |
| | FC14 | 3°32.5' | 149°14.2' | 2220 | " | |
| 23 | OBS9 | 3°26.0' | 149°30.7' | 2400 | " | Recovery of OBS (11) |
| | FC15 | 3°25.9' | 149°31.0' | 2410 | " | |
| 24 | OBS10 | 3°39.2' | 149°39.5' | 2400 | " | Recovery of OBS (10) |
| 25 | D8 | 3°52.8' | 149°43.0' | 2200<br>2080 | " | Some older sediments & bag full of mud (100kg) |
| | FC16 | 3°53.0' | 149°43.0' | 2660 | | |
| 26 | OBS1 | 4°48.3' | 151°35.1' | 3320 | St. Georges Chan | Recovery of OBS1 |
| 27 | OBS2 | 5°18.4' | 152°21.8' | 2800 | " | Recovery of OBS2 |
| 28 | D9 | 5°39.9' | 152°00.7' | 2800 | " | 1 kg of small rocks and mud |
| | | 5°39.4' | 151°59.4' | 2500 | " | |
| | FC17 | 5°38.8' | 152°02.6' | 1719 | | |
| 29 | D10 | 7°13.4' | 152°04.2' | 3582 | Central Solomon Sea | ½ bag full basalt. Mn crust and firm sediments. Surface seds in sed. bucket |
| | | 7°11.5' | 152°03.0' | 3315 | | |
| | FC18 | 7°13.1' | 152°04.0' | | | |
| 30 | GC5 | 7°48.0' | 151°30.9' | 5266 | Trobriand Trough | 315cm core. 5cm surface mud, 10cm cc brown hemipelagic mud on grey/green turbidites |
| | HF5 | | | | | |
| | FC19 | 7°47.0' | 151°30.4' | 5268 | | |

| Station No. | Sample No. | Position | | Depth | Area | Remarks |
|---|---|---|---|---|---|---|
| | | Lat. (S) | Long. (E) | (m) | | |
| 31 | PC2 | 7°37.4' | 151°14.5' | 5062 | Outer Trobriand Trough | 30cm core: 15cm brown mud over 15cm green sandy mud intercalated by thin Mn crust |
| | FC20 | 7°37.5' | 151°15.0' | 5050 | | |
| 32 | D11 | 7°26.9' | 151°23.7' | 4800 | Central Solomon Sea | 20kg of sedimentary rocks and mud |
| | | 7°27.6' | 151°25.1' | 4600 | | Sed. rocks are sheared. |
| | FC21 | 7°26.8' | 151°23.7' | 5000 | | |
| 33 | PC3 | 7°15.8' | 151°03.7' | 5023 | Central Solomon Sea | 730cm core: brown mud on grey/green mud |
| | FC22 | 7°15.1' | 151°04.0' | 5045 | | |

## TABLE 2
## LIST OF DATA OBTAINED

| | | |
|---|---|---|
| Single Channel Seismic | - | 62 line profiles: Lines 1-62 |
| Multi-Channel Seismic | - | 12 lines: 7-10, 12-15, 24,32,44-45 |
| Ocean Bottom Seismometry | - | 10 stations: 8 in Manus Basin Bismarck Sea; 2 south of St. George's Channel, N.B. island |
| Bathymetry | - | Collected over all ship's tracks. |
| Sonobuoy Reflection Seismic | - | No good results |
| Magnetics | - | Recorded over all seismic lines except 5-7 and 25-30. Not recorded in Bismarck Sea. |
| Gravity Cores | - | Five stations: Sta. 7,9,14,15,30. No core at Sta. 15. |
| Piston Cores | - | Three stations: Sta. 13, 31, 33 |
| Rock Cores | - | Two Stns: Sta. 5, 6 |
| Dredge Stations | - | Eleven Stns: Sta. 8, 10-12, 16, 25, 28, 29, 32. No samples were recovered at St. 3, 4 |
| Free Fall Grab Stations | - | Twenty three stns., thirteen successful |
| Bottom Photographs | - | At free fall grab stations |
| Heat Flow Stations | - | Sta. 5-7, 9, 30. |

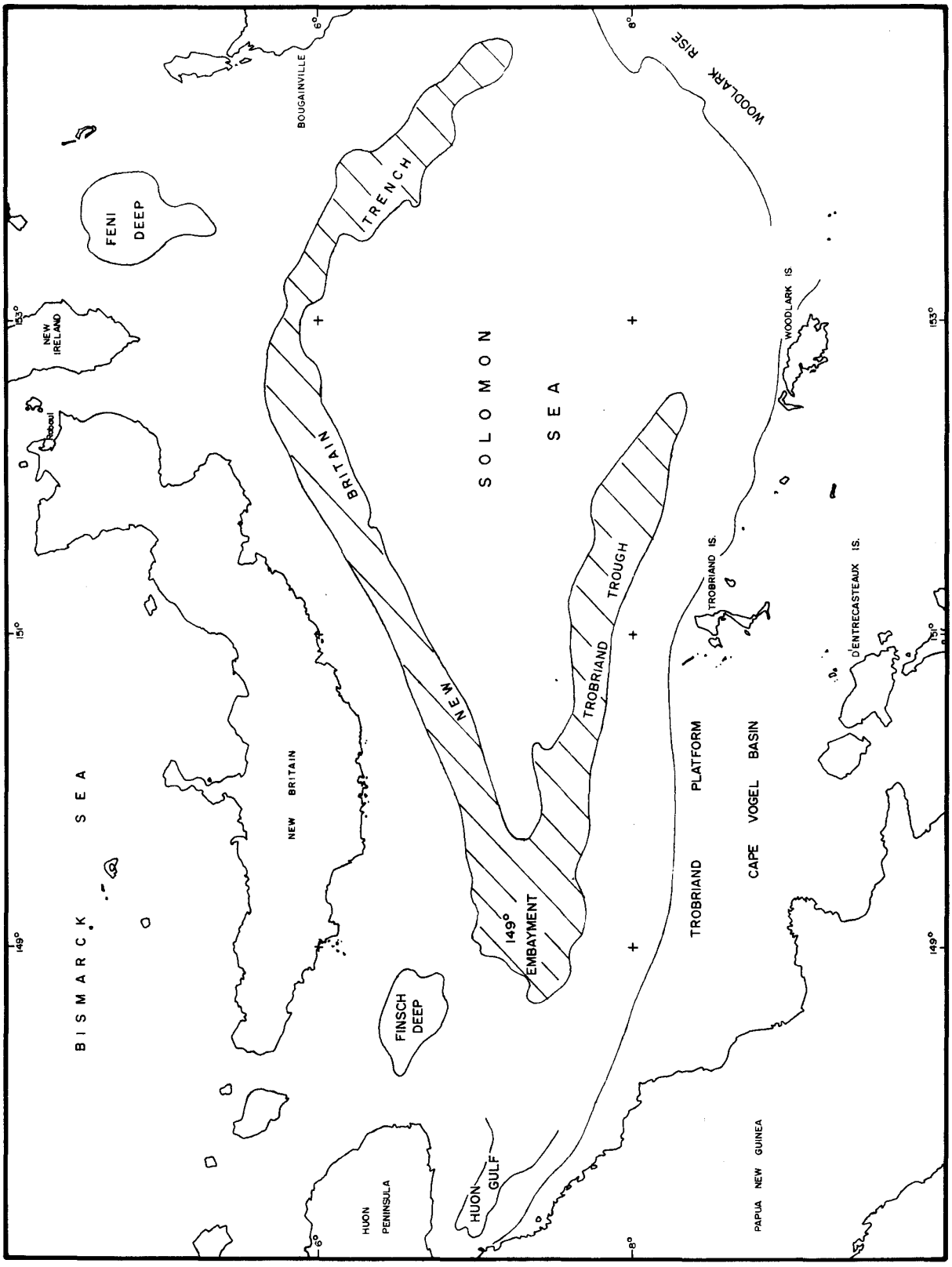



FIGURE 1

The Solomon Sea and surrounding areas of Papua New Guinea showing platforms, basins, deeps and trenches.

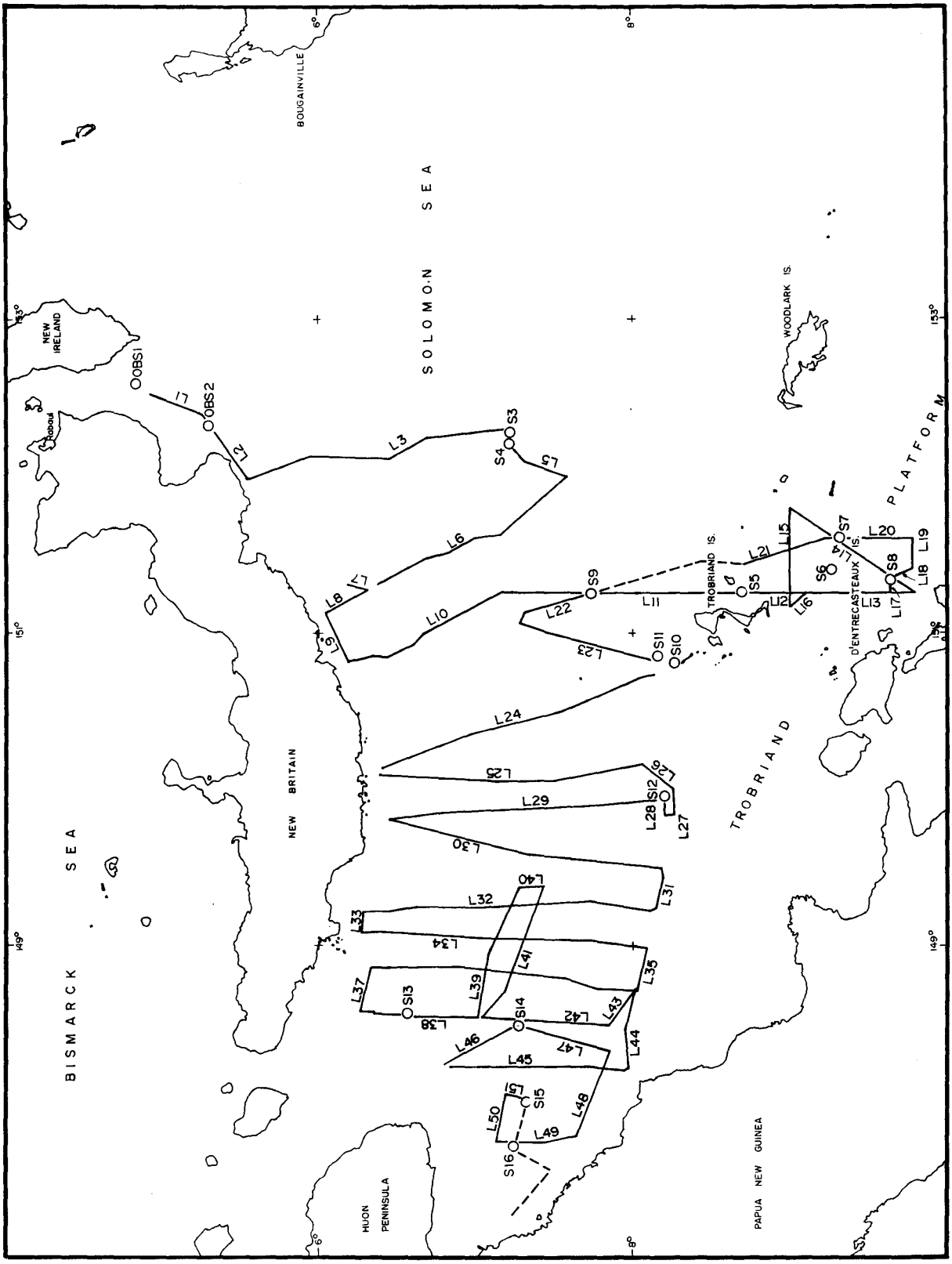



FIGURE 2

Seismic tracklines and bottom station sites (circles) in Western Solomon Sea and Trobriand Platform made by R/V Natsushima during Leg 1. Dashed lines are transit lines (bathymetry only).

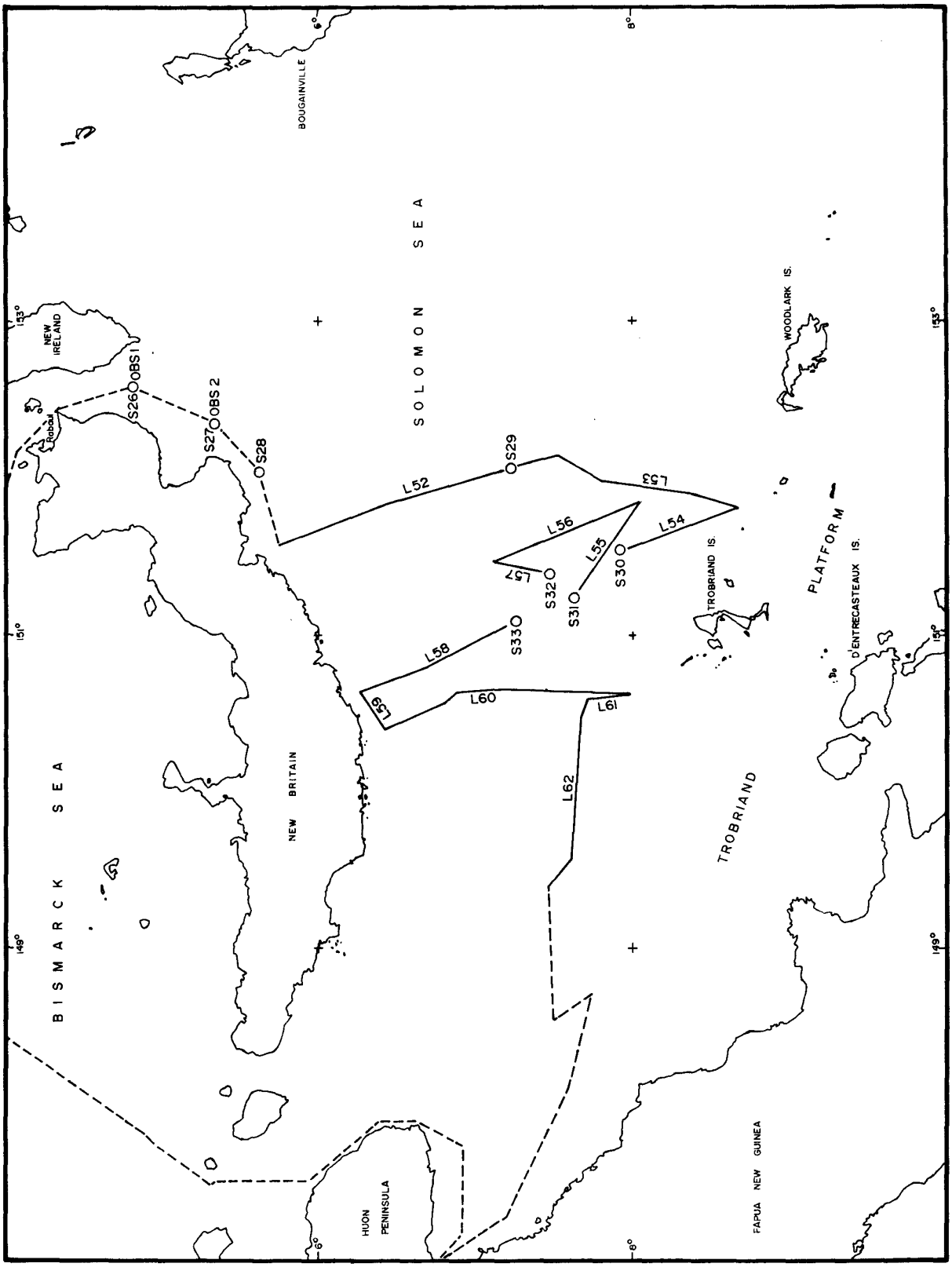



FIGURE 3

Seismic lines and bottom stations made during Leg 2. After leaving the port of Lae, Huon Gulf, the ship proceeded to the Bismarck Sea (see Figure 4) to retrieve ocean bottom seismometers there.

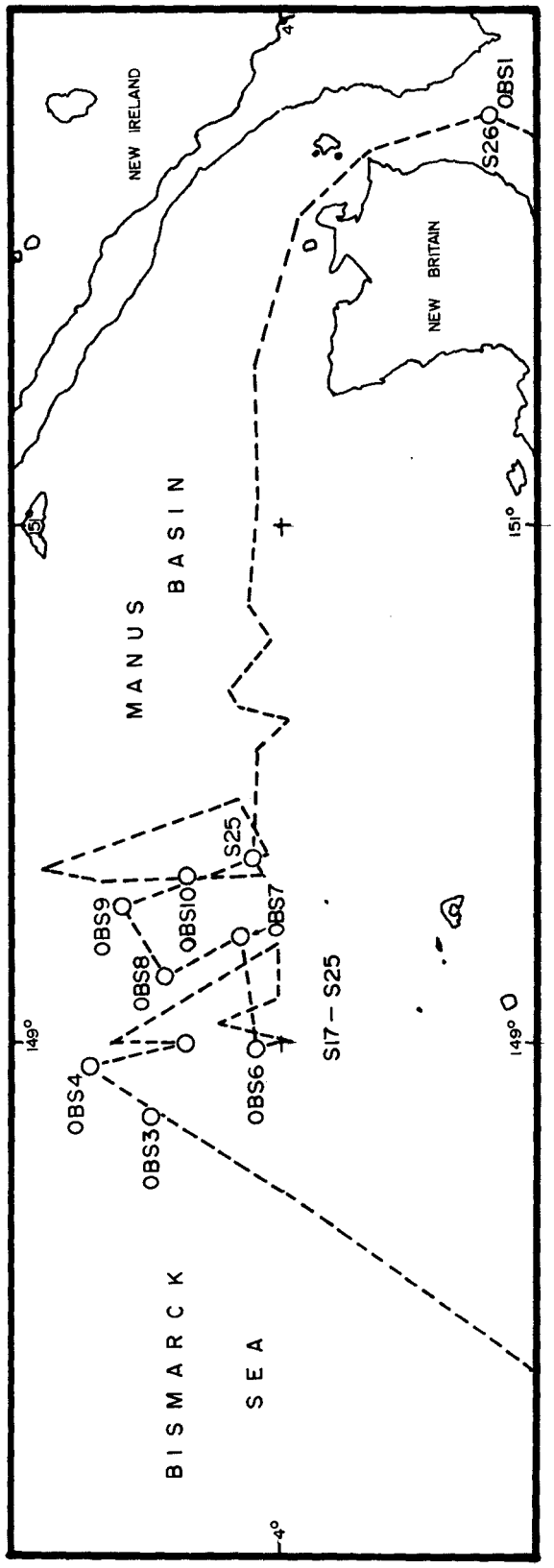



FIGURE 4

Locations of ocean bottom seismometers and sample sites in Manus Basin, Bismarck Sea. The OBS sites numbered 3 to 10 also are sample sites numbered S17 to S24.

## APPENDIX

## LIST OF ONBOARD PARTICIPANTS

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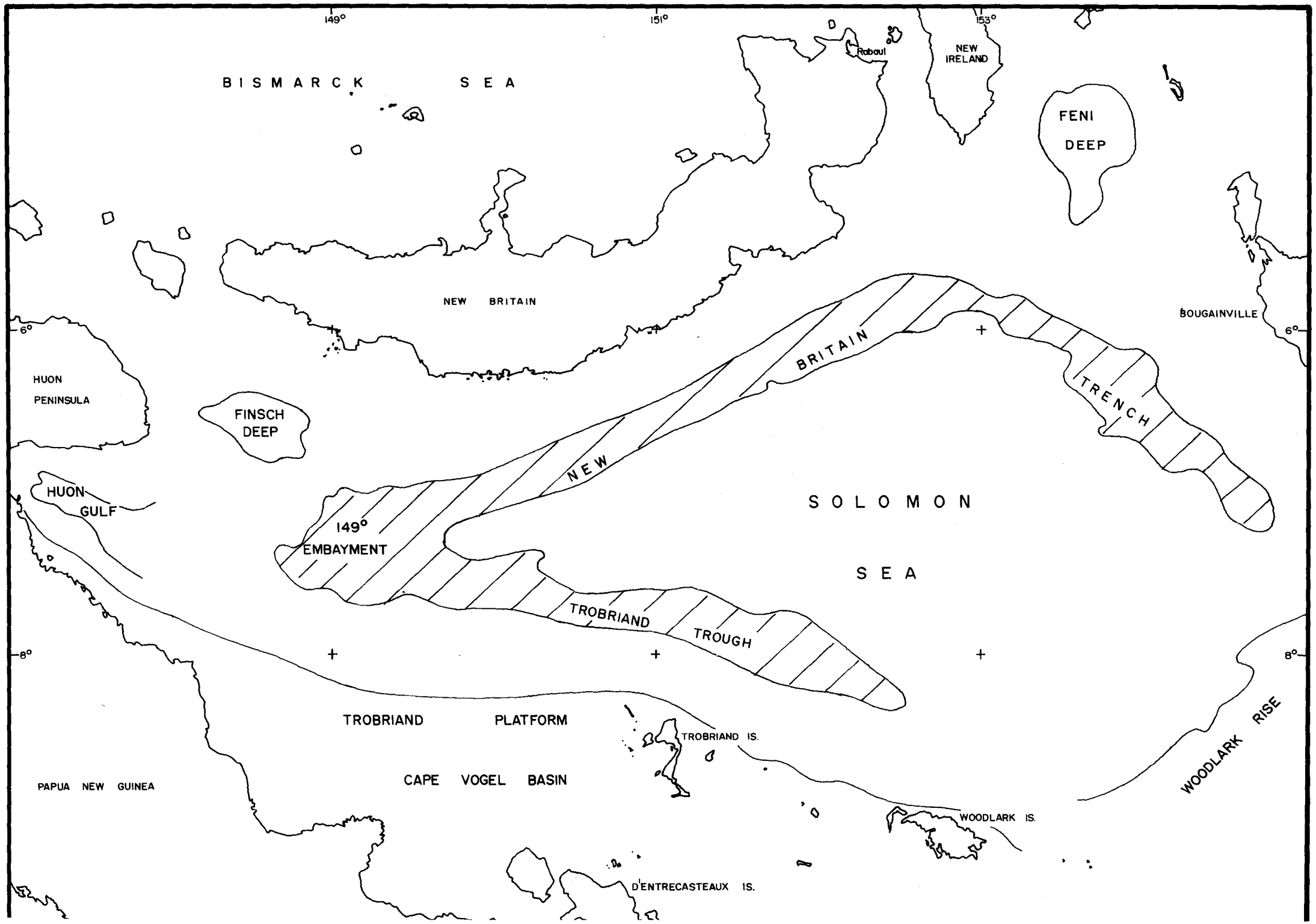
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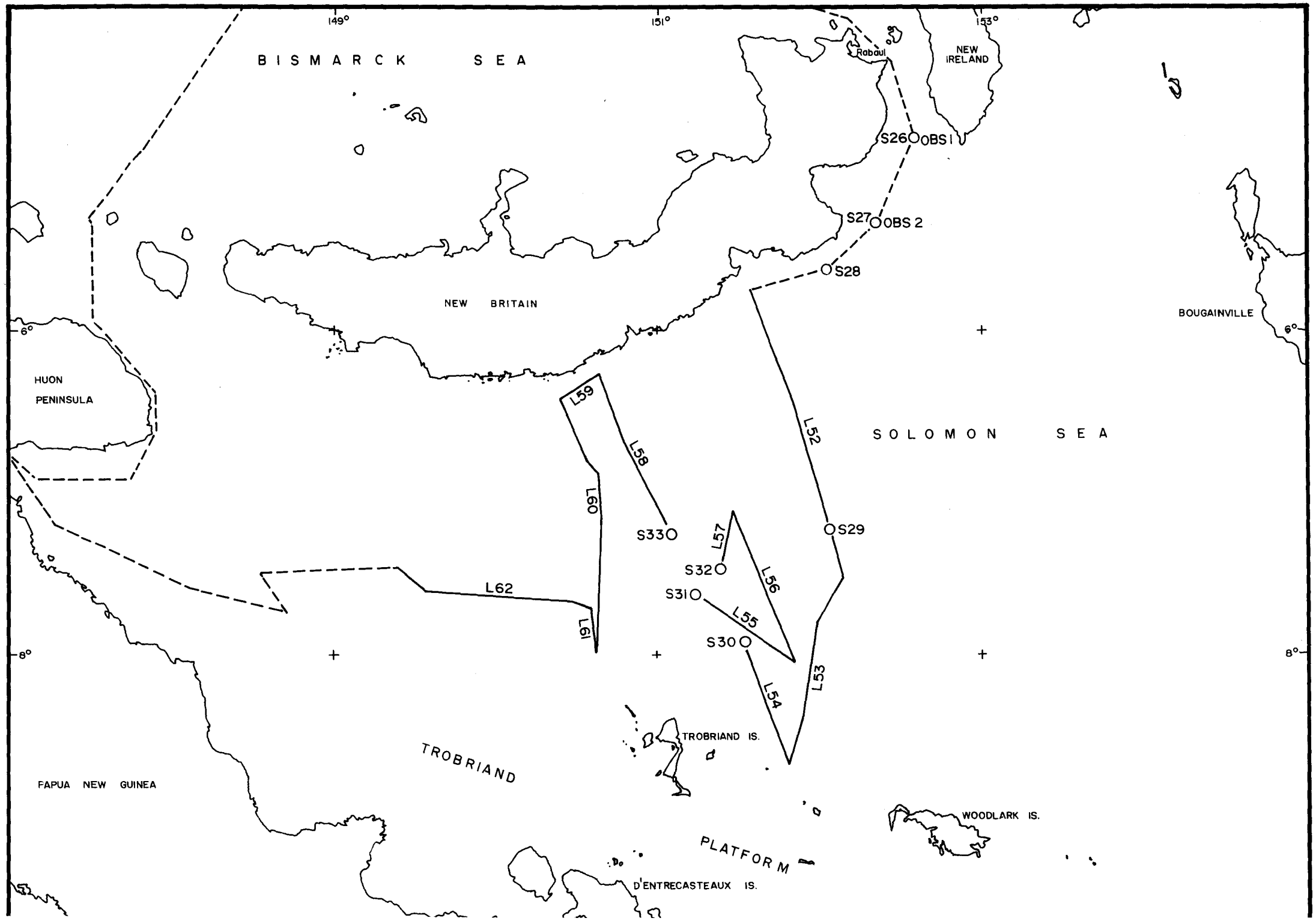
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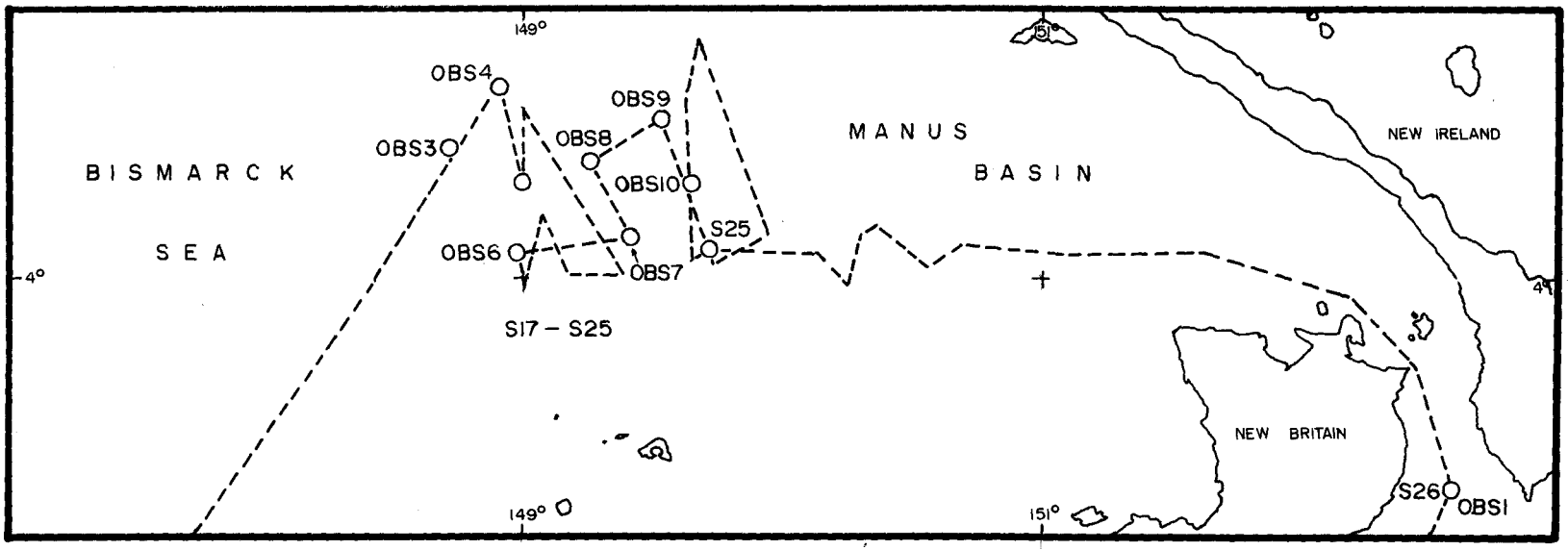
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149°
151°
153°
BISMARCK SEA
Rabaul
NEW IRELAND
FENI DEEP
NEW BRITAIN
BOUGAINVILLE
6°
HUON PENINSULA
FINSCH DEEP
BRITAIN
TRENCH
NEW
HUON GULF
149° EMBAYMENT
SOLOMON SEA
TROBRIAND TROUGH
8°
TROBRIAND PLATFORM
TROBRIAND IS.
WOODLARK RISE
PAPUA NEW GUINEA
CAPE VOGEL BASIN
WOODLARK IS.
D'ENTRECASTEAUX IS.


149°
151°
153°
BISMARCK SEA
Rabaul
NEW IRELAND
S26
OBS 1
S27
OBS 2
S28
NEW BRITAIN
BOUGAINVILLE
6°
HUON PENINSULA
L59
L58
L60
L52
SOLOMON SEA
S33
S29
L57
L56
S32
S31
L55
L62
L61
S30
L53
L54
8°
TROBRIAND IS.
TROBRIAND
FAPUA NEW GUINEA
WOODLARK IS.
PLATFORM
D'ENTRECASTEAUX IS.


149°
151°
OBS4
OBS9
OBS3
OBS8
OBS10
OBS6
OBS7
S25
S17 – S25
BISMARCK
SEA
MANUS
BASIN
NEW IRELAND
NEW BRITAIN
S26
OBS1
4°
149°
151°