Confidential Report to
Leg 33A
The New Zealand Oceanographic Institute
Department of Scientific and Industrial Research
and
Leg 33B
Defence Scientific Establishment
Ministry of Defence, New Zealand

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GLORIA SURVEYS IN THE BAY OF PLENTY

AND THE HAVRE TROUGH

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SCIENTIFIC PERSONNEL

HALL, Lindsay	DSE	New Zealand	Cruise 33A + B
FALCONER, Robin	GeoResearch Assoc.	New Zealand	Cruise 33A + B
CARTER, Lionel	NZOI	New Zealand	Cruise 33A
WRIGHT, Ian	NZOI	New Zealand	Cruise 33A
LEWIS, Keith	NZOI	New Zealand	Cruise 33A
PICKRILL, Richard	NZOI	New Zealand	Cruise 33A
HANDLEY, Jane	GeoResearch Assoc.	New Zealand	Cruise 33B
KENNY, Jill	GeoResearch Assoc.	New Zealand	Cruise 33B
GREGORY, Murray	Auckland Univ.	New Zealand	Cruise 33B
POPE, John	DSE	New Zealand	Cruise 33B
CARESS, David	SIO	U.S.A.	Cruise 33B
JACOBS, Colin	IOS	U.K.	Cruise 33A + B
DARLINGTON, Eric	IOS	U.K.	Cruise 33A + B
GRIFFITHS, Andrew	Marconi	U.K.	Cruise 33A + B
CLARKE, James	Marconi	U.K.	Cruise 33A + B
MILSOM, Neill	Marconi	U.K.	Cruise 33A + B
JONES, Stephen	RVS	U.K.	Cruise 33A + B
PAULSON, Christopher	RVS	U.K.	Cruise 33A + B
POTTER, Kay	RVS	U.K.	Cruise 33A + B
DAVIES, John	RVS	U.K.	Cruise 33A + B
DAVIES, David (Rob)	RVS	U.K.	Cruise 33A + B

IOS - Institute of Oceanographic Sciences Deacon Laboratory
RVS - Research Vessel Services
NZOI - New Zealand Oceanographic Institute
DSE - Defence Scientific Establishment
SIO - Scripps Institution of Oceanography

SHIP'S PERSONNEL

MAYL, Samuel	Master
HARRIES, Gordon	Chief Officer
SYKES, Sidney	Second Officer
PROCTOR, Graeme	Third Officer
BAKER, Jeffrey	Radio Officer
BATTEN, George	Chief Engineer
GIMBER, Geoffrey	Second Engineer
LOVELL, Vincent	Third Engineer
PARKER, Philip	Electrical Officer

OBJECTIVES

The main objectives of these surveys were to provide a) an overlapping Gloria sonograph mosaic of the Bay of Plenty as commissioned by the N.Z. Oceanographic Institute, Department of Scientific and Industrial Research and b) to provide Gloria sonograph data over those areas of the Havre Trough designated by the representative of the Defence Scientific Establishment, New Zealand Ministry of Defence.

EQUIPMENT

A full suite of geophysical equipment was deployed for most of the surveys, including the IOS Gloria Mk.2 long-range sidescan sonar, two-channel airgun seismic reflection profiling system, proton precision magnetometer, La Coste & Romberg gravitymeter, IOS 10 kHz and 3.5kHz fish-mounted, high resolution acoustic profilers. Additional data were collected in the form of approximately twice-daily XBT drops (see Appendix I). Navigation, depth, magnetics (field and anomaly), and gravity FAA were logged by the RVS standard ABC shipborne data aquisition system.

The Gloria data were recorded in digital form onto data cartridges which every 4 days were downloaded onto standard ½ inch 9-track computer tape. As an on-line guide to data quality and range, the data were also displayed in real-time on an electrostatic dry-paper record. A ship-board mosaic was produced by combining the raw Gloria data with navigation and depth information to remove both along-track, and slant-range scale distortions. The Corrected data was then played through a purpose-built laser writer onto high-resolution, professional quality, black and white 35mm film. On-board processing of the films enabled photographic images of the sonographs to be printed at the required scales.

The airgun seismic reflection profiles were recorded onto four-track analogue tapes, and displayed in real-time on two electrostatic dry-paper recorders enabling two frequencies and/or record lengths to be monitored. The 3.5kHz profiles were also displayed on dry paper records, whereas the 10kHz profiles utilized a wet-paper recording system. Both gravity and magnetics data were logged directly onto the ABC data aquisition system as well as onto analogue chart recorders built into the instruments. Tapes of both Gloria and navigation were made available at the end of the survey.

NARRATIVE

Cruise 33A Auckland - Tauranga

All personnel had joined the vessel by 0000hrs (N.B. all times in GMT) on Sunday 19 June 1988 (Julian Day 171), and the vessel sailed for the start of the DSIR survey at 0600. The Survey equipment was launched at 2015, beginning with the 3.5kHz and 10kHz fishes. We attempted to launch Gloria at 1950 and logging was begun at 1953, however TX was not begun until 2115, after problems in trying to move the 'A' frame clear of the launching gantry. The magnetometer and gravitymeter came on line soon afterward. The hydraulic motor on the new airgun winch blew up so we began the survey at 8 kts without seismics. At 2214 we decided to take what advantage we could of the seismic down-time by surveying at 10 kts in an effort to increase the area of Gloria coverage. The airgun and hydrophone were streamed at 0312 on 20 June (Day 172) and were logging by 0400. The survey continued without incident until the airgun was recovered at 0900 on the 22 June (Day 174) after failure at 0820. A new gun was running and logging recommenced by 1000. At 0825 on 23 June (Day 175) it was decided to retrieve the airgun and increase speed to 10 kts to obtain a final line landward of the main survey area (Fig. 1). Logging of Gloria data ceased at 1647, and the vehicle, along with the other survey equipment was recovered prior to a personnel change off Tauranga.

Cruise 33B Tauranga - Nuku'alofa

Personnel were embarked and the vessel sailed for the begining of the DSE survey at 2230 on the 23 June (Day 175). The survey equipment was redeployed and on line by 0940 on the 24 June (Day 176). The survey began very well, with excellent sonograph images over the Rumble seamounts until 1945 when the airgun failed. Several problems with the 300 cu. inch airgun were encountered, mainly it was believed, due to problems in sealing the guns with their waveshape kits. By 0207 on the 25 June (Day 177) it was decided to continue the seismic profiles with a 160 cu. inch gun without a waveshape kit. At 0649, we began to record the Gloria data on analogue tape for use in detailed acoustic reflectivity bottom studies.

At 1425 we altered course due east (Fig.2) to begin the double-swath survey across the width of the Havre Trough over an area previously mapped using Seabeam. During this eastward leg, the weather deteriorated producing 3-5m seas and 30kt winds. It was decided to try again with a 300 cu. inch airgun with a waveshape kit, and this was running successfully by 0050 on 26 June (Day 178). At 0344 we altered course to 270° onto the westward leg of the Havre Trough study area. The central Havre Trough survey was completed by 1717, and we recovered the airgun and hydrophone enabling us to increase Gloria survey speed to 10 kts along the western flank of Colville Ridge. At 0311 on 27 June (Day 179) we altered course to 065° to run a final transect across the Havre Trough. The seismic reflection profiling system was redeployed to obtain records across the centre of the Trough. The seismic system was back on-line at 0500 and surveying continued at 8kts. By 2000, both the sea and the wind had moderated considerably giving a substantial improvement in record quality. At 2130 we began a small survey (Fig.2) on the fore-arc wall, upslope of an anomalously high backscattering target identified on Gloria data obtained by Dr. L. Parson during RRS Charles Darwin cruise 33. At 0500 on 28 June (Day 180) the airgun developed another fault and was recovered by 0520, however, it was decided to continue steaming at 8kts and to redeploy the airgun after it had been fixed so that we could retain the benefit of the waveshape kit. The repaired gun was redeployed by 0920. Once again the airgun began giving problems, it was seen to be mis-triggering at 1540, and the system was switched off at 1600. The survey at the upper slope continued until 1830, when we slowed to recover Gloria, the hydrophone, and airgun. After the above were recovered, we steamed at full speed (approximately 12 kts) until 1206 on 29 June (Day 181), when all the survey equipment was once again streamed to carry out the final part of the survey over part of Louisville Ridge including the eastern flank of Osbourn Seamount. The equipment was streamed without incident and on-line by 1320. The survey continued until 1048 on 30 June (Day 182) when the airgun and 3.5kHz systems were closed down.

Between 1048 and 1204 various experiments for DSE were carried out using the Gloria sonar. The standard Gloria coverage resumed at 1204, without the airgun and 3.5kHz profiler systems until 0100 on 1 July (Day 183), when further DSE experiments were carried out. Gloria was eventually recovered after these experiments at 0145, and speed was increased to 12 kts, heading for Tonga. The magnetometer and the 10kHz fish were recovered and data logging ceased at 0400.

PROJECT REPORTS

i) Bay of Plenty Gloria Data

Over three and three-quarter days were spent on the DSIR Bay of Plenty survey, using Gloria, two-channel airgun, and 3.5kHz seismic reflection profilers, a 10 kHz precision echo-sounder, a magnetometer and gravitymeter. In all an area of over 23000km^2 were insonified, with (in the shallower water) up to 50% overlap. One of the more striking components of the data in this region is the linearity of many of the features. The survey area, located at the junction of the southern extremity of the Havre Trough and the Bay of Plenty, was expected to show evidence of transform features linking the active volcanic regions in the Havre Trough with the Taupo - White Island Volcanic Zone.

In the northwestern region, the southern extremity of the Colville Ridge is imaged, and appears as a disjointed set of highly reflective targets. There are a series of concentric, arcuate features lying just to the south of Mercury Knoll, that from their appearance, suggest downslope movement along discrete planes (earthquake-related faults?). Alderman Trough is an area of uniform acoustic backscattering, apart from three small (ca. $2km^2$) circular features. These discrete features show acoustic shadows that imply they are relief features. The sonographs also reveal that the Ngatoro Basin is flanked to the south by a heavily gullied slope, and to the north by a topographic high, characterised on the sonographs by a subparallel series of sinuous acoustic reflectors. The Ngatoro Ridge (especially the northern part) is also characterised by a similar series of reflectors (scarps ?). In both areas, the features display the same overall orientation of NE-SW.

The Raukamara Plain displays a higher background level of acoustic reflectivity than the Ngatoro Basin, suggesting greater seabed roughness, or coarser-grained sediments. The northwest quadrant of the Raukamara Plain shows the southern limit of the Rumble Seamount - Kermadec Ridge complex, and again these features appear to have a superimposed (tectonic) grain of NE-SW.

The White Island Trench area has an extremely high level of 'background' reflectivity, presumably due mainly to the sediment facies. Oblique crossings of the Trench itself ensure that it is well-imaged, although the intensity of the backscattering dictates (on the pre-processed mosaic) that we do not see many fine structures. The orientation of the White Island Trench is approximately N-S, and appears to cut across NE-SW structures on the White Island Ridge.

Although existing bathymetry over much of this area is of good quality, with a high density of track lines, the lineations identified from the Gloria sonographs are not always well-expressed.

ii) Havre Trough Gloria Data

The Gloria data in the Havre Trough began at the northwestern edge of the Bay of Plenty survey with a single transect of the Rumble seamount area. The images, especially of Rumble II and Rumble III, show the seamounts to be generally circular-subcircular in shape, with radial gully systems and extensive talus aprons. On the eastern edge of the sonographs in this area, the back-arc slope of the Kermadec Ridge is seen to be composed of a series of step-like scarps. However, the interpretation of these are hindered by (up to 4) multiples, probably produced by water-column stratification.

The 'double-swath' survey across the centre of the Havre Trough was located approximately on latitude 33°30'S, as this region had previously been surveyed with a Seabeam swath bathymetry system, and offered a degree of 'ground truth' to the Gloria data. Here the Gloria data reveal a series of NE-trending acoustic basement ridges and troughs. On the eastern side of the Trough, Gloria reveals a large (ca. 1200km^2) area of high backscattering that, although appearing to follow the overall NE trend, has in detail a disjointed, en-echelon character. The intensity of acoustic backscattering over this region (along with the information from the airgun records) suggests that there is little, or no sediment cover on the acoustic basement here, thus we may be imaging an active volcanic (spreading) centre.

iii) Fore-arc slope Gloria data

Approximately 21 hours were spent on obtaining two 40+ mile lines upslope of an anomalously bright (acoustically reflective) area identified from data collected by Dr. L. Parson during RRS Charles Darwin cruise 33. No trace of this acoustic anomaly was found on the data collected during this survey. Initial impressions of the data collected on this leg suggest either sediment waves, or folds on the upper reaches of the fore-arc slope. Noise on the shipboard mosaic has degraded some of the data on the mid- and lower slope, but this will hopefully be rectified during post-cruise processing.

iv) Louisville Ridge Gloria data

This final section of the survey began by running up the wall of the Kermadec Trench onto the Pacific plate, then across the eastern flanks of some of the seamounts (including Osbourn Seamount) at the northern end of the Louisville Ridge, before returning back to the fore-arc slope just to the north of the collision zone, and ending with a final short transect along the face of the slope. The run up the wall of the Kermadec Trench revealed the characteristic pattern of fault scarps associated with the bending of the oceanic crust as it is subducted down the trench. The eastern flanks of the seamounts are heavily gullied, whilst in some areas the aprons are highly reflective. The high reflectivity and morphology of the aprons suggests either recent gravity-flow activity, or more likely, a volcanic (flow) origin (by analogy with other areas, notably Hawaii).

v) DSE Sonar Experiments

Gloria was used as a 'sonar of opportunity' to collect data for further experiments into Synthetic Aperture Sonar.

To this end a number of recordings were made of Port and Starboard post-correlation data from the standard full array, and also from transmission to reception of a single array section in order to later examine data collected from a much wider beam angle.

FIGURE CAPTIONS

Figure 1. Schematic track-chart of RRS Charles Darwin cruise 33A for the New Zealand Oceanographic Institute DSIR, in the Bay of Plenty. The shaded area represents the area of sonograph coverage (22.5km to either side of the track line). Solid track-lines indicate when all geophysical equipment was running, dashed line indicates that no airgun data were being collected. Small ticks and numbers refer to the Julian Day No. at 0000 GMT.

Figure 2. Schematic track-chart of RRS Charles Darwin cruise 33B for the Defence Scientific Establishment, New Zealand. Major physiographic features are labelled, the crosses representing ridges. The approximate area of Gloria coverage is encompassed by the thin rectilinear box around the tracklines. Dotted trackline are areas where airgun data were not collected.

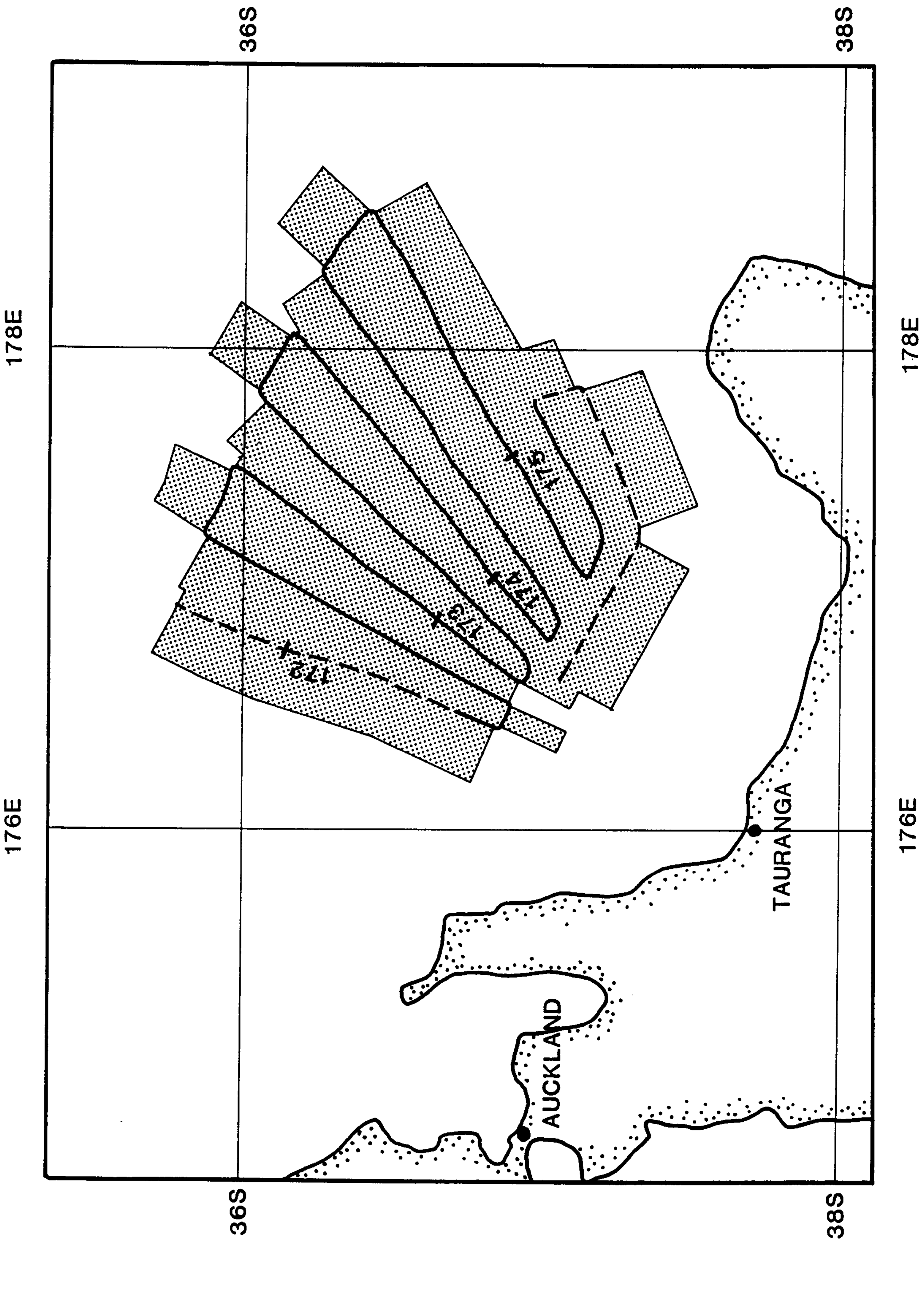

FIG.1

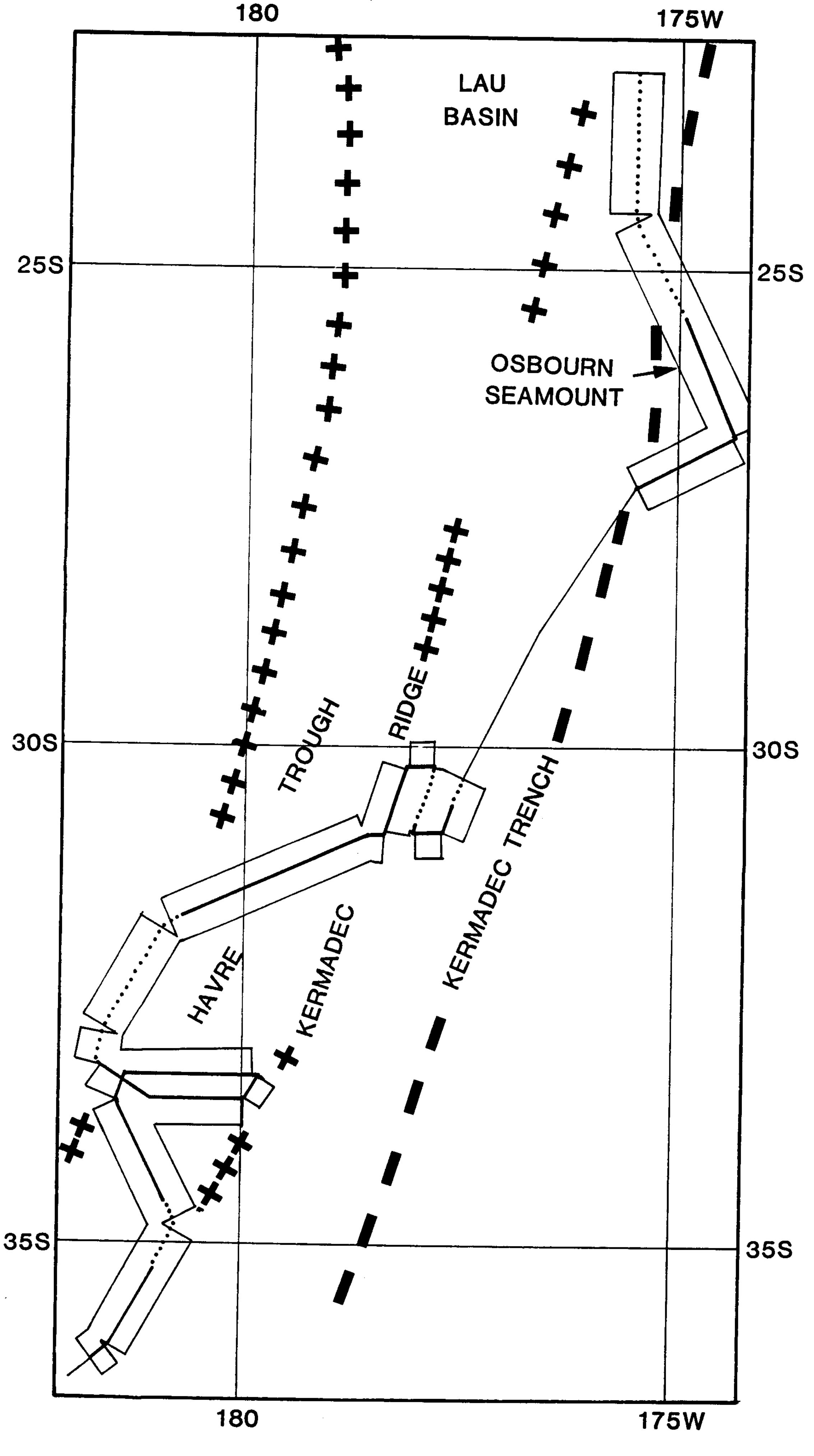
180
175W
LAU
BASIN
25S
25S
OSBOURN
SEAMOUNT
TROUGH
RIDGE
30S
30S
KERMADEC TRENCH
HAVRE
KERMADEC
35S
35S
180
175W

FIG.2

XBT STATIONS RRS CHARLES DARWIN CRUISE 33A and 33B

* = Not to full depth (ca. 550m) or corrupted data

Leg 1

Sta.No.	Day/Time	Latitude	Longitude	
1	172/2002	36°14.5'S	177°15.5'E	
2	173/0259	36°55.1'S	176°45.0'E	
3	173/0650	36°39.1'S	177° 5.6'E	
4	173/1124	36°13.3'S	177°34.4'E	
5	173/2021	36°32.9'S	177°30.3'E	
6	174/0550	36°50.9'S	177°17.1'E	
7	175/0030	36°55.3'S	177°29.4'E	

Leg 2

1	177/0323	36°30.7'S	179° 2.7'E	*
2	177/0329	36°30.7'S	179° 2.7'E	*
3	177/0337	36°30.7'S	179° 2.7'E	
4	177/1446	33°19.3'S	178°39.7'E	
5	178/0917	33°34.9'S	179°13.9'E	
6	179/0100	32° 7.2'S	178°51.2'E	
7	179/0726	31°35.5'S	179°37.6'E	
8	179/1324	31°16.4'S	179°31.3'W	
9	179/2307	30°40.6'S	178°16.4'E	
10	180/0304	30°12.3'S	178° 1.6'W	
11	180/2318	29°31.5'S	176°58.9'W	*
12	180/2358	29°24.4'S	176°54.4'W	
13	181/0738	28° 9.5'S	176° 7.6'W	
14	181/1849	27° 3.4'S	174°54.6'W	
15	182/0103	26°39.2'S	174°23.3'W	
16	182/1805	24°26.5'S	175°30.4'W	
17	183/0017	23°23.1'S	175°29.6'W	