I.O.S.

RRS DISCOVERY

CRUISE 163

26 OCTOBER – 19 NOVEMBER 1986

GEOPHYSICAL STUDIES OF THE MADEIRA ABYSSAL PLAIN AND CRUISER SEAMOUNT AREA, EASTERN NORTH ATLANTIC

CRUISE REPORT NO. 194

1987

NATURAL ENVIRONMENT RESEARCH COUNCIL

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Geophysical studies of the Madeira Abyssal Plain and Cruiser Seamount Area, eastern North Atlantic

Principal Scientist

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ABSTRACT

This Cruise Report describes Discovery Cruise 163, October - November 1986, to the Madeira Abyssal Plain and Great Meteor Seamount area. This was the last geology and geophysics cruise under the Department of the Environment Radioactive Waste Disposal research commission. It was also the first cruise on which the new deep-towed sonar TOBI was used successfully in deep water. Four TOBI tows were made at depths of 5 km over a total of 80 hours, covering over 100 miles of seafloor with sidescan swath 3 km wide. In addition to TOBI there was one WASP camera run, five deployments of PUPPIs, three box cores, one piston core and various seismic reflection profiles. The main objectives of the cruise were to use PUPPI to search for anomalous sediment pore pressures and TOBI to search for evidence of slumping and faulting: neither was found.

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S.D. Mayl	Master
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R. McCurry	Extra Chief Officer
S. Sykes	2nd Officer
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I.R. Bennett	Chief Engineer
P. Jago	2nd Engineer
C. Phillips	3rd Engineer
B. Entwhistle	Extra 3rd Engineer
W.D. Lutey	Electrician
C. Page	Radio Officer
F.S. Williams	Chief Petty Officer (Deck)
M. Drayton	Seaman
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L. Wright	IOS OE	Mechanical support
R. Phipps	RVS	Mechanical support
L. Wedlock	RVS	Computers
C. Woodley	RVS	Instrument support

ACKNOWLEDGEMENTS

This cruise was a considerable success, not only in proving TOBI but also for the smooth and effective running of most other operations. I am most happy to acknowledge the help of all who contributed to this success, but particularly those who worked hard at IOS prior to the cruise to prepare the equipment on time, to the shipboard scientific party, and to Captain Sam Mayl and his crew.

RCS

BACKGROUND AND OBJECTIVES

This cruise was the last in our DoE commissioned research programme on oceanic radioactive waste disposal. The new IOS deep-towed sidescan and profiler, TOBI, had been lost on our previous cruise to GME (Darwin 9B) when its glass buoyancy spheres imploded. Since January TOBI had been redesigned (with aluminium buoyancy spheres) and rebuilt, and cruise 163 was to be its first test at sea.

Another development since CD9B was the apparent discovery, using PUPPI, of a significant sediment pore-pressure gradient in an area just north of the "10 km box" that had been chosen for detailed study.

Our most important objectives were therefore to bring TOBI to a fully operational state; to use it to obtain data on outcrop patterns, sediment stability, and faulting in GME; and to continue the PUPPI programme, in particular trying to confirm and extend the observations of high pressure gradients near the 10 km box. Coring, seismic profiling and camera work was to be used to fill in between the TOBI and PUPPI operations, broadly continuing earlier lines of work. Finally, we were to recover a sediment trap (laid during CD9B) and Bathysnap seabed camera for the IOS biology group.

RESULTS

The TOBI programme was successful: after one initial failure the sidescan worked well, and we were able to obtain good data from a total of five stations covering 89 hours of towing and approximately 130 km of seafloor. Unfortunately there was insufficient time to get the TOBI profiler working.

Three precisely navigated PUPPI deployments were made near the site of the apparent pore pressure anomalies north of the DoE box. Although two of these also registered apparent pressure anomalies, the detailed behaviour of the instruments suggested that these and the earlier results were artefacts caused by hysteresis in the transducer.

The third notable result of the cruise was the success of the acoustic navigation system. We were able to use both sets of 10kHz transponders that had been left behind after Darwin cruise 9B; their performance was undiminished. Three 5kHz transponders were deployed (and recovered) during this cruise, and provided navigation for both the ship and various remote instruments (TOBI, WASP and corers). A comprehensive set of acoustic navigation programs was run on a BBC Master microcomputer, providing near-real-time fixes, maximum likelihood solutions for transponder network parameters, and post-processing of data.

Other successful stations included a faultless WASP run and two box cores.

Both the Bathysnap and the Sediment Traps were successfully recovered.

ITINERARY

26 October 1986	Departed Falmouth
19 November 1986	Arrived Gibraltar

NARRATIVE

See Figures 1-2 for track and station position charts, Table 1 for station list, and Table 2 for underway geophysical observations. All times in GMT.

In Falmouth the trawl warp had been removed and replaced by the new 18mm conducting tow cable, and the broken coring warp had been repaired by means of a short splice. These operations were difficult and lengthy, but they were eventually accomplished safely, and we sailed from Falmouth at 0830 on Sunday October 26th (day 299).

Day	Time	
299	0830	Departed Falmouth.
	1000	Main engine bearing damaged. Returned to Falmouth to put damaged part ashore.
	1100	Set course for GME, full speed on two engines.
300	1330	Deployed PES fish, 3.5 kHz fish and magnetometer.
	1430	Resumed course for GME, full speed on three engines.
	2100	Magnetometer record very noisy. Cured after two hours by cleaning connection between inboard and outboard cables. This problem recurred frequently during the next few days.
301	0400	3.5 kHz was giving no significant record, so was turned off. The failure was put down to the high speed of the ship (12 knots), but may have been an electronic failure, eventually discovered on day 305.
302	0122	First GPS fix obtained.
	1500	Recovered magnetometer and hove to while lifting 2-ton weight out of hold.
	1550	Underway again. Magnetometer streamed, then resumed full speed to GME.
303	0230	Hove to in 5650m water depth (East Azores Fracture Zone) for wire tests.

	0320-0942	Tested coring warp by paying out to 5520m with 2-ton weight on end. The new splice was successfully, but with some difficulty, passed out and back through the traction unit twice.
	1003-1342	PUPPI releases and loggers tested to 5360m on midships winch.
	1500-1950	Tested two TOBI aluminium spheres on coring warp to 5403 and 5463m.
	2010-2314	Second PUPPI wire test on midships winch.
304	0000-0348	Tested a further two TOBI spheres to 5203 and 5263m on coring warp.
	0348	Deployed magnetometer and resumed course for GME at full speed.
305	1745	Recovered magnetometer and deployed 5 kHz interrogator fish.
	1845	3.5 kHz switched on for first time since fast passage, but still not working. Extensive work carried out on its electronics over next 48 hours.
	1948	Laid PUPPI (station **11381**) just to north of 10 km box near site of previous (Cruise 160) positive pore pressure measurement.
	2019-2400	Wire test of 5 kHz transponders: two successful.
306	0051	Second PUPPI laid (**11382**) approximately 150m SE of 11381.
	0303-0520	Wire test of third PUPPI: unsuccessful.
	0525	Ran to start of SRP line 1 and deployed SRP.
306/	0855-307/0705	Ran SRP line 1 along Cruiser Fracture Zone between GME and Cruiser Seamount.
306	0922	Severe electrical noise appeared on PES, suspected result of changing electrical load from GLORIA generator to "Fred".
	1150	Deployed magnetometer.
	1323	Electrical load transferred from "Fred" to GLORIA generator cured noise problem.
307	0705	End of SRP line 1; recovered SRP gear and magnetometer steamed to crest of Cruiser Seamount.
	0907	Preparing for test deployment of TOBI.
	1203	TOBI deployed.
	1220	Tried repaired 3.5 kHz but still not working.
	1300	Unable to power up TOBI, decided to recover it.

	1330	TOBI on board. Moved to deeper water for wire tests.
	1534-1736	Wire test of third PUPPI: unsuccessful.
	1815	Recovered 3.5 kHz fish for repair; relaunched at 2119.
	1920-2152	Repeated PUPPI wire test: successful this time so set course for "Nod Hill" just NE of 10 km box for PUPPI deployment. 3.5 kHz still not working.
308	0934	PUPPI laid in manganese nodule field on Nod Hill (station **11383**).
	1000	Recovered 3.5 kHz fish again, then set course for IOS Biology sediment trap (Discovery station **11338**).
	1432-1830	Recovered sediment traps.
	1845	3.5 kHz fish deployed after repair of badly damaged bulkhead connector. The 3.5 kHz system worked well from now on. Then moved to small hill ("The Knoll") just SW of 10 km box for core.
309	0006-0730	Station **11384** : box core over The Knoll; successfully recovered pelagic sediment.
	0846	Moved to position of IOS Biology Bathysnap.
	1323-1530	Recovered Bathysnap.
	1542	Wire test of 5 kHz transponders: successful acoustically, but one release failed to fire.
	1845	Underway to 10 km box for deployment of acoustic navigation transponders.
310	0011	First 5 kHz transponder ("Red") released on GPS fix (station **11385**).
	0201	Second transponder ("Blue") released (**11386**), followed by baseline crossing measurements.
	0323-0642	Box survey over PUPPIs 11381 and 11382 to define their relative positions.
	0700	PUPPI D11381 released: on board at 0950.
	1105-1420	Final wire test for 5 kHz transponder: successful.
	1621	Third 5 kHz transponder laid ("Green"; **11387**).
	1820	Made crossings of remaining acoustic net baselines; then on passage to site of next PUPPI deployment in Cruiser Fracture Zone, running 3.5 kHz en route.

311	0208	PUPPI laid (station **11388**) at the most distal part of the Madeira Abyssal Plain, at the foot of a ridge damming sediments derived from Cruiser Seamount; then proceeding to the seamount for a second TOBI trial.
	0938-1658	Conducted second trial of TOBI over summit and flank of Cruiser Seamount, with complete success. This was the first successful TOBI run - spirits were high.
	1730	Began steaming full speed back to GME for first TOBI survey.
312	0026-0300	Conducted small 3.5 kHz survey around sediment dam near PUPPI 11388.
	0805	Began first TOBI deployment over GME, running from SE to NW across the southwestern end of Nod Hill, just NE of the 10 km box. TOBI provided spectacular views of rocks outcropping along lines of mid-ocean-ridge generated normal faults.
	1936	Began hauling TOBI in.
313	0051	TOBI recovered; set course to recover PUPPIs.
	0239-0530	Recovered PUPPI 11382. Instrument apparently showed significant upward pore-pressure gradient, though this was later believed to be an artefact introduced by friction in the pressure transducer of this particular PUPPI.
	0636	Attempted to release PUPPI 11383, without success. Conducted extensive visual and radio search, and repeated release signals, to no avail.
	1200	Abandoned PUPPI search and prepared to re-lay other PUPPI at site of D11382.
	1458	PUPPI deployed (station **11391**) over site of apparent pore pressure anomaly, just N of 10km box.
	1632	Commenced deploying TOBI for run over 10km box and edge of abyssal hills to its west (station **11392**).
314	1750	TOBI mis-triggering badly, decided to recover for examination and repairs.
	2246	TOBI on board. Proceeding to PUPPI site N of 10km box.
315	0037-0423	Conducted 3.5 kHz survey around area of apparent anomalous pressure gradients, searching for anomalous structures. No obvious anomalies found.

	0423-1035	Attempted box core of turbidites from abyssal plain near box; corer returned empty except for very small sample of apparently semi-indurated ooze (station **11393**).
	1135-2130	Attempted piston core (station **11394**) over site of apparent pore-pressure anomaly, using 1000m penant of trawl wire to avoid putting coring warp splice outboard. Piston corer returned empty with liners, cutter and catcher missing, but full pilot core was obtained.
315	2330-316/0605	Obtained box core of turbidites within 10km box (station **11395**). Sediment was extremely soupy.
316	0730-1835	WASP camera run over site of apparent anomalous pore pressure (station **11396**).
	2225	Began deploying TOBI for second run over 10km box (**11397**).
317	1912	TOBI mis-triggering and moderate swell building up: decided to recover.
318	0004	TOBI on board; proceeded to site of PUPPI 11388 for recovery.
	0751	PUPPI recovered: set course for 10km box to recover acoustic beacons, since heavy swell prevented TOBI deployment.
	1258-1909	Recovered all three 5 kHz transponders and the 5 kHz fish.
	1936	Still a heavy swell running, so hove to for 3.5 kHz interrogation of a PATSY (Penetrator Acoustic Telemetry SYstem) that had been deployed recently on penetrator number 54 by the Dutch ship MV Tyro. The PATSY replied to our interrogation, but we could not achieve synchronisation with its signal.
	2200	Proceeded to release the final PUPPI (11391).
319	0132	PUPPI recovered and on board. Result from this deployment cast doubt on earlier interpretations of positive pore pressure gradients. Swell diminishing so proceeded east to the "fault area" for a final TOBI run over a band of faults.
	0529	TOBI run began in moderate swell (station **11398**). Dynamic loading on the tow cable reached 3 tons peak-to-peak.
	1704	TOBI recovered after successful run: no signs of faults observed on the sidescan. Set course for final 3.5 kHz run at 8 knots out of GME <u>en route</u> to Gibraltar.
	1830	Deployed magnetometer.

320	0322	3.5 kHz survey complete; increased to full speed, en route to Gibraltar with 3.5 kHz, PES and magnetometer deployed.
322	c.1300	Magnetometer and 3.5 kHz recovered.
323	1633	Berthed at Gibraltar.

RCS.

INDIVIDUAL PROJECT AND EQUIPMENT REPORTS

TOBI

The tow cable was delivered directly to the ship at Falmouth and terminated while at sea. A quick check showed that the leakage current at 500 V applied DC is 10μA, and that the attenuation at frequencies up to 60 kHz is similar to, though slightly greater than, that predicted by the manufacturers. At present, the copper earth return is connected to the winch drive shaft:- this may not be the ideal arrangement.

Testing and setting up of the electronics continued after sailing. The main problem was that the profiler transmitter failed catastrophically and had to be rebuilt; it was never subsequently made to work in the water.

We intended to deploy and retrieve the system by the method used in 1984, which involves a line run from the auxiliary winch to a diverter sheave on the afterdeck, then up to a block on the end of the Schat Davit. This method failed with the new TOBI vehicle, weighing two tons, because the davit was unable to slew outwards against the pull from the auxilliary. On the second deployment, we lifted the vehicle into the water using the main tow cable, reattaching the cable to the weight after the vehicle had been deployed. Care is needed in swinging the vehicle over the stern, and time is wasted reattaching the swivel to the weight, but otherwise the method is workable.

TOBI was deployed six times: twice in shallow water over Cruiser Seamount, and four times in deep water in the GME area. The first trial failed because of a short on the power supply to the vehicle. This fault was eventually traced to a faulty bulkhead connector on the vehicle. At the second attempt (station **11389**), usable sidescan records were obtained, but the profiler failed to operate. Lack of time precluded any serious attempt to remedy the problem.

The first deep deployment (Station **11390**), over Nod Hill in 5400m water depth, produced complex and impressive sidescan records. The navigation interrogator and depth gauge operated satisfactorily, but it was painfully apparent that the tension limit of 5.5 tons makes this cable very marginal for use in 5400m depth: tension surges 1 ton above the prevailing average were frequently encountered.

The remaining three deployments were devoted to the DOE study box (**11392** and **11397**) and the "fault area" (**11398**) to its east. The sidescan records were remarkably featureless. However, during the fourth and fifth deployments (**11392** and **11397**) the electronics developed a strange fault after some 12-15 hours at depths greater than 4000m: the sidescan transmitter failed to transmit normally, but could be restored (though for only ten minutes at a time) by turning off the vehicle power supply. The fault was definitely pressure dependent, and, apparently time dependent as well, as it did not reccur on the last (short) run (**11398**).

Tests on the sidescan transducers between deployments showed that two had leaked due to connector faults, and one, number 4, had an incomplete circle diagram. It was subsequently disconnected.

The vehicle became progressively less buoyant as the deployments proceeded, and by the end we had added six segments of OBS foam totalling 108 kg extra buoyancy, with no additional ballast.

There were two outstanding conclusions: the sidescan can give geologically useful records, and the tension limit on the cable imposes severe operational limitations.

RJB

TOBI tape replays

TOBI signals were recorded direct onto an EPC graphic recorder which also provided the trigger signal at a repetition period of slightly less than 4s (causing problems on replay synchronisation). The direct signal was also recorded unfiltered on channel 1 of a Store-4D using Ampex 407 tapes running at 7.5 ips in FM mode; and the read-after-write monitor signal was recorded on a second EPC running at maximum paper feed rate. The 1800' tapes lasted approximately 50 minutes each. Initially both EPCs were set to record AC signals and ± print. This gave rather dark records. Later settings of DC +ve print were used. Channel 1 of the Store-4 was set after trial to ± 2V input window. Strong signals from abyssal hills were clipped at this setting however and occasionaly ± 5v was used instead. 30-minute time marks were recorded on channel 3 of the tape. At certain times a 5V to 0V inverted square pulse was recorded to act as a trigger. At other times the strong transmission (Tx) pulse in the data was used to trigger tape replays but there were problems with this when the data amplitude was high due to the short time interval between end of data and the next Tx pulse. Strong interference from the remote acoustic navigation interrogator degraded records and caused some mistriggering of replays. It was not possible to record the direct EPC trigger signal.

Tapes were replayed using an EPC, usually in AC -ve print mode. Although this is not an entirely appropriate mode for the data it had the advantage of suppressing stripiness caused by variations in DC signal level between different scans. Secondly, in areas of pronounced relief the graphic image appears more striking in this mode. On replay triggering was accomplished either by using the strong, rapidly rising edge of the Tx pulse or the 5V-0V-5V square pulse recorded on channel 2 of certain tapes. Either of these signals was fed to the variable-threshold EPC crystal delay unit and the output of this was used to trigger the EPC recorder. Tapes were replayed at double speed (15 ips) and the variable recorder sweep was set to just under 2 s (4s effective) to match the transmission interval. Replays made using DC +ve mode required external amplification of the Store-4 output signal (range ± 1V) of up to 40 dB. Major problems were encountered when attempting to use the Tx pulse as an EPC trigger on tape replays, causing degradation of replayed records.

SRJW

Pop-Up-Pore-Pressure-Instrument (PUPPI)

The primary objective of the PUPPI programme in the GME area is to investigate and quantify any pore water advection which may be significant to the radioactive waste disposal feasibility study. Pore water velocities greater than

1 mm/year are considered to be significant. Past data (primarily that collected on Discovery Cruise 153 and Charles Darwin Cruise 9B) has indicated that pore water movement is not a general feature within the area, although at one site (over a sub-bottom basement high) a significant reading was obtained showing a small amount of downward advection (about 3 mm/year). However, on Discovery Cruise 160 two deployments were made just outside the DoE box which indicated large excess pore pressures which would imply rapid upward pore water advection.

The specific objectives for this cruise were to:

1) Occupy additional sites north of the DoE box, close to the Cruise 160 sites that showed high excess pore pressures, and on the abyssal hill.
2) Use copper pipe instead of nylon to see what effect this has on the tidal pressure cycles recorded.
3) Test the new absolute pressure transducer and 4- channel logger.

Four wire tests were performed prior to deployment to ensure that all systems were fully operational. Initial problems were encountered with a lead in PUPPI logger IV, faulty acoustic command units, leaking pressure transducers and retractors.

Using three PUPPIs, five deployments were made during the cruise (stations D11381, D11382, D11383, D11388 and D11391) the positions of which are given in the station list (Table 1). The three deployments made close to each other N of the DoE box were accurately navigated using the 5kHz bottom transponders. All deployments were made using copper pipe for both ports with 1 Bar differential pressure transducers. The water used to fill the transducers and piping was GME bottom-water collected at station CD9B/2.

<u>D11381</u> (2039/305-0658/310)

PUPPI V was deployed N of the DoE box on the abyssal plain with a 4m lance close to PUPPI sites D11320 and D11329 which had shown significant excess residual pore pressures. Full penetration and no tilt were indicated by the acoustic telemetry. Recovery was uneventful after 4.5 days on the sea floor. The pre-release pipe cutter on the lower port failed to operate but all other systems worked well. The pressure record shows a normal insertion transient followed by the decay. Tidal cycles were recorded at both ports (peak to peak amplitudes were recorded of 135 and 45 Pa at the 4.24m and 2m ports respectively) until the cut, which showed no significant residual pore pressure.

D11382 (0142/306-0244/313)

PUPPI VI was deployed N of the DoE box on the abyssal plain with a 6m lance close to D11381. Full penetration and no tilt were indicated by the acoustic telemetry. Recovery was uneventful after 7 days on the sea-floor. The accelerometer failed to work and the absolute pressure transducer failed because of a leak in the tube. All the other systems apparently worked well. The pressure record shows that the insertion pressure was greater at the 4m port than at the 6.24m port. No significant tidal cycles were recorded and a large apparent pore pressure was evident from the pre-release cut. However, a further shift in the zero occurred after the release on both ports.

D11383 (1017/308-0910/313)

PUPPI III was deployed on what is known as Nod Hill in an area where large numbers of manganese nodules occur (about 100 metres about the abyssal plain). It was deployed with 4 lead weights, a 4m lance and a small 10 inch stray line sphere to increase the terminal velocity to 2.1 m/s. Full penetration and no tilt were indicated by the acoustic telemetry. On day 313 no trace of the PUPPI could be found using acoustic commands. There had either been a complete or partial failure of the command beacon (possibly preceeded by an implosion of the glass spheres) or the PUPPI had for some unknown reason released itself. The release procedure was followed and after no success a triangular search was conducted in the direction of the surface current (SSE) for about 10 miles (the radio beacon should have been detectable up to a further 5 miles). It is interesting to note that a short anomolous return (similar to that observed when the TOBI spheres imploded last year) was observed on the PES Mufax as the TOBI passed by PUPPI during a side scan sonar survey on the previous day. This may have been a sphere implosion but it is impossible to tell. It is also considered highly unlikely that the 30kHz pulses from TOBI could have initiated a failure; but there again all other scenarios seem highly unlikely!

D11388 (0252/311-0520/318)

PUPPI V was deployed with a 4m lance at the base of a dam which appears to run across the Cruiser Fracture Zone. It was located in what appears from the 3.5kHz records to be the most distal zone of the turbidites that dominate the GME area. Full penetration and no tilt were indicated by the acoustic telemetry. Recovery was uneventful after 7 days on the sea floor. Both of the pre-release cutters failed to work (probably because of a lack of firing current) but all other systems functioned well. Tidal cycles with a peak to peak amplitude of about 60 Pa were observed on both ports until the release which showed no significant residual pore pressure. The decay rate after insertion at the lower port was less rapid than usual indicating that the port was probably surrounded by less permeable sediment.

D11391 (1458/313-2302/318)

PUPPI VI was deployed N of the DoE box with a 4m lance close to D11382 which had shown an apparent excess pore pressure. Full penetration and no tilt were indicated by the acoustic telemetery. Recovery was uneventful after 5 days on the sea-floor. The accelerometer on this PUPPI failed to operate again. The absolute pressure transducer did not flood but did not register the pressure; all other systems worked well. The data showed no tidal cycles but high apparent residual pore pressures.

At face value, the data obtained from the small area N of the DoE box (Stations D11320, D11329, D11381, D11382 and D11391) indicates an area of significant excess pore pressure which would be accompanied by a rapid upward flow of pore water. However, there are a number of factors that make the data less than convincing:

a) One deployment in the area (D11381) showed no significant pore pressure.
b) The other 4 deployments that showed excess pore pressure all lacked tidal cycles.
c) The measured pore pressure gradient was very erractic.
d) All excess pore pressure results were obtained with the same pair of transducers.
e) A significant pressure shift occurred on release with some deployments.

f) There is no geological evidence to suggest that this site is in any way anomolous within the GME area.

There is one very simple theory which we currently feel almost certainly explains the observed data. The transducers that have recorded the anomolous data may have developed a hysteresis because of mechanical friction caused by small amounts of corrosion within the LVDT assembly. This would account for the positive residual pore pressure, the inconsistency in the data, the lack of tidal cycles and the extra pressure shift on release as the mechanical shock could overcome the friction. Unfortunately the theory could not be tested onboard because of the precision needed of the required measurements. However, it will be pursued in the laboratory at IOS.

The loss of the PUPPI on the hill is of some concern because it looks like an exact replica of the loss last year. It is probably coincidental that both deployments were made in pelagic sediments above the level of the abyssal plain.

The use of copper pipe instead of nylon may have increased the amplitude of the tidal cycles slightly. A detailed comparison with past records is needed before this can be confirmed. The experiment with the absolute pressure transducer did not work and needs further development. The 4- channel logger worked faultlessly.

In conclusion the results from this cruise confirm that there appears to be no significant vertical advection of pore water within the sediments on the abyssal plain within the GME area. However, GME has not been as extensively covered as is probably needed especially on the abyssal hills where only one measurement has been made on the flank.

PJS, SDMcP, & DEG

WASP

The Wide Area Survey Photography (WASP) camera system was deployed on one occassion with successful results. The system was identical to that used on Discovery Cruise 153 (IOS Cruise Report No. 172) except for the addition of a

3.5 kHz O.R.E. pinger which failed before the WASP reached the seafloor.

Station D11396 (0745 to 1835 Day 316)

The camera was loaded with 61m of 400 ASA black and white film. The camera aperture was set to F3.5-4 and data chamber to f5.6. The whole system was set to cycle at 16 second intervals.

The target for this run was a site on which three PUPPIs had been deployed (11381, 11382 and 11391). It was just to the north of the DOE box and within range of the 5kHz transponders which were used to navigate the station. The film was not developed on board; however it is estimated that approximately 1000 photographs were successfully obtained.

QH.

SRP and 3.5 kHz

1) SRP

The SRP system was used to shoot one line westwards from GME along a sediment-filled fracture zone towards the Cruiser Seamount. Deployment began at 0800 on day 306 with the ship hove to. The 40 cu. in. airgun with waveshape kit was towed from chains attached to a shackle mounted at the end of a warp fed through the Schat davit and suspended amidships above the stern, also being tied off on the stern rail. The ship was then brought up to 4 kts for deployment of the hydrophone streamer, a 2 channel Geomechanique type, consisting from aft forwards of: a tail rope and the following sequence of sections: active, passive, active, stretch, weight, stretch and lead-in. The streamer was deployed from a drum fitted on the capstan on the poop deck and fed through a fairlead in the stern gunwhale adjacent to the Schat davit. No attempt was made to adjust the tow depths of gun or streamer other than by speed changes.

The deck lead passed from the streamer connector to a panel in the plot room whence the 2 separate signals were fed into amplifiers on the RVS 19 inch SRP rack. The signals were then summed and the result was filtered at 15-250 Hz. The filtered signal was passed separately to channel 1 of the Racal Store-4 FM tape recorder and to a direct monitor EPC graphic recorder. The read-after write signal from the Store-4 was replayed on another EPC for monitoring. The gun was triggered by a free-running EPC crystal delay unit at an interval of 8s and later at 11s. The EPCs were set to sweep 4s scans after a delay of between 6.5s and 3s, depending on water depth and controlled by a second EPC delay unit. The trigger signal was recorded on channel 2 of the Store-4 and 10 minute time signals were recorded on channel 13 and also displayed on the EPCs. The Store-4 recording speed was set at 1.875 ips and Ampex 407 1800 ft tapes were used, each lasting about 192 minutes. Deployment was complete by 0855.

Initially data quality was poor owing to low compressor pressure, but after an hour very good quality data were obtained at 4 kts. Speed was increased to 6 kts but then reduced to 5 kts when noise levels became unacceptable. Plans to change over to the 160 cu. in. gun were shelved as the smaller gun gave adequate penetration to the shallow basement at less than 0.5s TWT subbottom. A few gaps in the data were caused by compressor cooling problems which were soon solved. A longer gap was caused by a necessary change in the warps by which the airgun was suspended. The line terminated as planned at 0705 on day 307.

Tapes were replayed at various filter settings: bands of 75 to 250 Hz and 100 to 200 Hz gave good results. A start was made at utilising the RVS digitising tablet and software with encouraging results but an insufficient quantity of SRP data was collected on this cruise to warrant extensive use. The use of an alarm clock is recommended for reminding watchkeepers of tape-change times.

2) 3.5 kHz Profiler

On setting up the system in the plot an excessive amount of noise was noticed on the record. This was eventually traced to a very noisy mains supply containing a lot of 2 kHz slot ripple as well as being clipped. Setting up the system in the forward rough lab and running it off a different mains feeder effected a cure.

The Plessey connector at the inboard end of the fish tow cable was found to be unreliable due to poor weather proofing for its position on the starboard shelter deck. Any moisture in the plug would produce conducting tracks between the pins and consequently produce a noisier record. Constant attention had to be given to this plug throughout the cruise. A combination of crimping and waterproof jointing has now hopefully remedied this.

The Raytheon line scan recorder was not advancing the paper at one stage of the cruise. A thorough servicing has now cured this.

3) Data Photography

During the cruise the Geophysics 35mm photographic system was used for copying 3.5 kHz data from both the present cruise and also from Discovery 144. As the RVS darkroom equipment was not available most equipment was supplied by IOS, including the permanently-installed enlarger. All the equipment worked well but the following useful items were unavailable: enlarger auto-timer, print masking board, timer with alarm. Flash operation was much improved over that on the previous cruise (Darwin 9b, 1985/6) by the use of a light-sensitive trigger on the slave flash unit. Some equipment and chemicals for developing were kindly provided by QJH from stocks for the continuous film processor. RM is thanked for doing much of the photography.

SRJW.

Satellite Navigation

The prime navigational aid for the cruise was the Transit satellite navigation system, which proved very reliable and precise. The dead reckoning positions produced by the shipboard computer were output to a printer every five or ten minutes; this was invaluable for plotting near-real-time tracks when manoeuvering or running stations. The positions were also output graphically to a "live track plot", but since no time annotations were available on this it was of limited use.

The new GPS receiver was run throughout the cruise. Without an atomic clock, we were only able to obtain 3-satellite fixes; these were available for about three hours each day, but since their accuracy was of the order of 50m or better throughout that period they provided a valuable supplement to the Transit system. One acoustic beacon and one PUPPI were laid on GPS fixes; several other stations were positioned largely by GPS; and our whole acoustic navigation net was ultimately linked to GPS positions. However, the acquistion of a suitable atomic clock would certainly enhance the system greatly, since 2-satellite fixes would then be possible: in our work area such fixes would have been available for about nine hours each day.

RCS.

Acoustic Navigation

The acoustic navigation systems worked extremely well. With the 5 kHz system we were able to fix the ship at all times within ranges of about 20 km, and sometimes up to 30 km, of the beacons. We were able to fix the remote interrogator reasonably consistently so long as it was more than 500m above the sea bottom and within about 15 km of the beacons. The 10 kHz transponders left behind after Darwin Cruise 9B were still working at full power and gave ranges up to 8 km.

After wire-testing, three 5 kHz transponders were laid in the box area, in a triangular network of side approximately 8 km. All transponders were moored 100m above the seabed. Throughout their nine day deployment, the transponders were used to navigate both the ship, TOBI, WASP and the piston corer. Although good navigation was obtained at ranges of up to 30 km, reliable and consistent navigation was only available up to ranges of about 16 km. The factors governing the reliability of the navigation were the weather and sea conditions, and the lie of the ship relative to these. Noise introduced acoustically by these factors resulted in a poorer signal to noise ratio at the receiver and hence this would limit the range of navigation.

The navigation of TOBI was implemented using a remote pinger on the TOBI vehicle. This was run synchronously from the tranceiver. It was however asynchronous to the TOBI transmissions and hence caused interference on the sidescan records. This could be cured in future by either synchronising all navigation transmit pulses with the sidescan of TOBI or making the TOBI vehicle a passive listening station for the 5 kHz navigation and sending the signals back up the wire to be decoded on board.

All transponders were deployed buoy first from the foredeck with approximately 50 kg anchors. All were recovered without damage, also from the foredeck.

Ranges from individual beacons were read either from the EPC recorder (for 5kHz beacons: Red, Green and Blue) or, less frequently, from the Mufax recorder (for 10 kHz beacons: Orange1, Black1, Orange2 and Black2 deployed on previous cruises). Ranges were written down in the acoustic navigation watchfile before being entered into the BBC Master computer on which the program NAVPLT was running. The BBC printed out true slant and horizontal ranges and either of these could be used for drawing intersecting arcs on a track chart; or, more often, the progam itself was used to calculate positions of the ship and any remote transponders in use. The processed data were stored in fix datafiles on a floppy disk. Intervals between fixes varied from 2 minutes when doing baseline crossings to 10 minutes when navigating slow-moving remote transponders.

The beacons were deployed and their positions approximated using GPS (for Red) or Transit (for Blue and Green). After the beacons were laid baseline crossings were made by the ship in order to determine lengths of baselines between transponders. From this an approximate set of beacon positions was determined as follows:

	Latitude	Longitude
RED:	31°16'.13N	25°23'.51W
GREEN:	31°17'. 3N	25°18'. 9W
BLUE:	31°20'. 5N	25°22'. 0W

Baseline lengths: RED-GREEN 7706 m, RED-BLUE 8819 m, GREEN-BLUE 7999 m.

Later, when ten fixes had been obtained using ranges from all three 5kHz beacons, the ranges and approximate beacon positions were written to a diskfile using the program "NAVVY". The same program was then used to calculate the following improved set of relative beacon positions (using the method described by Lowenstein for unconstrained ship and beacon positions):

	Latitude	Longitude	Error
RED:	31°16.10'N	25°23.50'W	36.4 m
GREEN:	31°17.40'N	25°18.85'W	6.4 m
BLUE:	31°20.70'N	25°22.16'W	10.8 m

(Error is the average error between the measured and calculated ranges of all ship positions, for each transponder). These positions were used throughout the survey for online navigation.

After acoustic navigation was completed the records of GPS navigation were scrutinized for times when both GPS fixes and good quality acnav data were available. Seventeen such fixes were aleady available but more could have been measured from the EPC records between time marks. The EPC records were then examined to check that correct readings had been calculated and then the ranges and corresponding positions were written, together with the estimated beacon positions, to the diskfile D163GP using "NAVVY". The same program was then used to select the best fit of beacon positions to the ship positions and ranges (using Lowenstein's method with non-varying ship positions). The resulting coordinates are the best approximation to the true geographical positions of the beacons:

	Latitude	Longitude	Error
RED:	31°16.00'N	25°23.46'W	30.5 m
GREEN:	31°17.37'N	25°18.82'W	29.6 m
BLUE:	31°20.62'N	25°22.15'W	16.2 m

Baseline lengths:	RED-GREEN 7757 m,	RED-BLUE 8796 m,	GREEN-BLUE 8006 m.
Predicted-Measured:	+51 m	-23 m	+7 m

(Note that these errors are larger than those derived using unconstrained ship positions, as would be expected. Similarly, the errors in individual fixes will tend to be larger using the geographically constrained net). The calculated baseline lengths are slightly different from those measured but not inordinately so. These positions are estimated to be accurate to within ± 50 m absolute. All calculations made during the cruise assumed a constant sonic velocity of 1517.6 m/s and a constant transponder delay time of 30 ms. Allowances for ray bending, velocity variations and signal-strength dependent transponder delay variations would probably increase accuracy.

Automatic reprocessing of acoustic navigation fixes utilising the final beacon positions was carried out on board using "NAVPLT".

SRJW, RCS

Coring

1) Box Coring

The I.O.S. Box corer (see I.O.S. Report No. 106, 1980) was used in order to obtain samples of surface sediments for an analysis of their physical properties. The two dominant sediment types of the GME area were to be sampled (Pelagic Oozes and Turbidites).

The box corer was triggered using a new release mechanism first used in Discovery Cruise 160. The system only releases the box corer doors on direct command from the ship once the operators are satisfied that the corer has penetrated satisfactorily.

A new wire pinger was also being used on the box corer. The pinger (mounted 30m above the corer) used a 30 kHz echo sounder to enable the correct amount of overrun to be calculated. It also used a pressure transducer so that the water depth at the core site could be calculated.

Station 11384 (0435, Day 309)

In order to avoid passing the splice on the coring warp outboard, a 1000m pennant from an auxilliary winch drum was used directly above the box corer.

The target for this core was a small abyssal hill (The Knoll) consisting of pelagic sediments. A good core was obtained from which pelagic sediment samples were taken.

Station 11393 (0740 Day 315)

This station was run over the 10 km box. Apart from using half the amount of ballast weight (in order to compensate for softer anticipated sediments), this core was rigged as for station 11384.

No core was obtained even though all the indications (acoustic and dynamometer) were that the corer had functioned correctly. Upon recovery the release mechanism was checked and found in good (fired) order and mud was found on the doors.

It is not known why this station failed.

Station 11395 (0303 day 316)

The corer was rigged as for station 11393.

The target was again the abyssal plain turbidite sediments found within the DOE box. A good core was obtained from which turbidite sediment samples were taken.

QH.

2) Piston Coring

Only one station was attempted (11394), near the PUPPI sites just north of the 10 km box. A standard setup with four barrels was employed. A moderate pull-out was obtained, but when recovered the piston corer was found to be empty; the core cutter, catcher, and liner tubes had all been pulled off. However, the pilot corer contained about 2 m of normal-looking sediment.

RCS.

Instrument Recoveries

1) Sediment traps

The sediment trap mooring had been deployed in GME on Discovery 160 (July 1986, Station 11338). The mooring consisted of an acoustic command unit, anchor chain, four traps at heights off the sea-bed of 10, 116, 1111, and 1143 metres, six 16" glass spheres, a 12 metre stray line and a 10" glass sphere.

The trap was released without difficulty, and surfaced one hour twenty minutes later. The top of the mooring was difficult to find because of the lack of a flag or flashing light to aid visibility.

The trap was recovered through the forward "A" frame, using the double barrelled capstan. This was a slow affair because of problems with the hydraulic pumps, causing the system to trip out.

Sediment samples were collected from each trap together with samples of water trapped in the tube connecting the trap valve and the sample cup.

Details for the four traps (top first) follow:

Mooring released:
1432 Day 308, 1986.
Ship position when mooring grappled: 31°33'.4N, 24°40'.1W.

First trap (trap #1), sample bottle #1.
On board 1658.
Valve closed.
Honeycomb baffle loose.

Second trap (trap #3), sample bottle #2.
On board 1713.
Valve 9/10 closed (because the valve was not fully closed, much water came through when the sample bottle was taken off. Hence the tube sample is suspect).

Third trap (trap #4), sample bottle #3.
On board 1813.
Valve closed.

Fourth trap (trap #2), sample bottle #4.
On board 1830.
Valve was open. The retractor had not fired and also the valve was jammed. The valve was closed manually before taking the samples.

2) Bathysnap Recovery

Bathysnap was recovered without difficulty through the forward "A" frame. Again, recovery would have been facilitated by a flag and a flashing light, which could have saved cruise time by allowing a night recovery.

Released 1323/309.
Surfaced 1457/309.
Recovery position 31°34.1'N 24°41.7'W

PATSY

Two PATSY telemetered penetrators had been deployed from the MV TYRO on a cruise immediately preceeding D163. It was communicated that one of these deployments had been successful and so an attempt was made to interrogate the PATSY.

PATSY responds to a 3.5 kHz interrogation pulse by transmitting a series of 3.5 kHz pulses representing several pulse-delay telemetry channels. It was understood that these channels included temperature, tilt in two axes. acceleration, differential and absolute pore pressure, and status information.

PATSY was set up to telemeter only during certain times on a four hour cycle and so interrogation was attempted during one of these periods. The PATSY was understood to telemeter on a 2 second repetition rate with a 1% gate every two seconds to reduce false triggering.

The chirped 3.5 kHz pulse was used to interrogate PATSY with 1 sec. repetition rate and TR gating (transmit every 2 seconds) on the RATHEON. The correlator on the 3.5 kHz system was by-passed to maximise the detection of the un-chirped return pulse.

Interrogation was started at 2030/318 and continued until 2130/318. Returns were obtained from the PATSY starting at 2050 and continued until after we had left the site at 2130. The replies, however, were uncorrelated with the transmission pulse. It seemed that the transponder could not lock onto the transmission. Various interrogation rates and gating sequences were tried without apparent success. The range to PATSY was less than 1 mile during this period.

It remains to be seen whether any useful data can be extracted from the records obtained, although the interrogation at least proved that the PATSY was still alive.

SDMcP.

Mechanical systems

The refit work carried out in Falmouth had included the repair of the damaged coring warp and the winding on of the new conducting cable.

Before any work could be carried out on the coring warp it had to be load tested and this was done by lowering a 2 ton weight to a depth sufficient to take the splice outboard. When passing the splice through the reeving carriage it was necessary to have maximum back tension (1800 psi) on the storage drum. When passing it through the traction winch noise and slip were noted but the splice passed through all stages of the traction winch successfully. On hauling in the first time it passed through with an increase in wire noise and slip and a second attempt at this produced further increase in noise and slip and full back tension was required to drive it through the traction winch. At this point the loading during surge was peaking at 8 tons.

It was then decided to whenever possible keep the splice on the wire drum, so in order to work to the depths required a 1000m wire pennant operated off the auxillary winch drum was used. At a later stage when piston coring, it was found that having such a capacity of wire at loads of the order of 1.5 tons caused the cheeks of the drum to spread.

The after system was used for TOBI deployments and coring alternately, which required the change over of the warps, an operation that was found to be difficult due to the problems of passing the TOBI termination through the traction winch; four people could complete a changeover in between two and three hours.

The first TOBI deployment involved a change in method when it was found that the davit was unable to slew outboard with the full load of TOBI taken on the outboard snatch block via the auxillary winch. On subsequent deployments the vehicle was lifted on the conducting cable connected by the swivel to the rope lifting strops and cutter. When the vehicle was in the water the swivel was swung back inboard and connected to the depressor weight. This method worked quite well, but there is a danger of the vehicle swinging against the davit and damaging the hydraulic hoses: these should be protected.

The forward hydraulic system was used throughout the cruise for wire testing on the midships winch and launch and recovery of equipment using the double barrel capstan. Initial use of the DBC revealed a problem of the pump cutting out due to low boost pressure. Further investigation suggested this was caused by air in the brakes and simultaneous use of the A frame.

The compressors were used for the air-gun survey, which lasted 24 hours; no problems occurred.

AG, LW, AW.

Shipboard instruments

1) DMW Clock

One recurring fault with the clock system has been a sudden gain of exactly one minute which occurs at random. In an effort to overcome this, a line transformer was connected to the output of the master clock to avoid D.C. coupling between the master and the slaves. However, after this was fitted, on three occasions the slave units froze while the master carried on as normal. The line transformer was disconnected to avoid this particular problem. Subsequently the master clock made one sudden gain of exactly two minutes and was re-aligned as soon as it was spotted. There were no further problems with the system.

2) Scintrex V-75 Magnetometer

Only one sensor was used throughout the trip and performed satisfactorily with no problems. However, early on a fault was discovered in the outboard connector of the inboard cable. On examination it was evident that corrosion had built up on the inside of the plug causing tracking and a noisy signal on the recorder. The cable was chopped, the connector cleaned and re-soldered and the fault disappeared. Later on another problem started to manifest itself: a very noisy record which came and went at random. Upon investigation the source of the fault was narrowed down to the electronics unit itself but the actual problem remains unsolved. Further action will be needed.

CW.

Table 1 Station List

Station Number	Equipment	Latitude N	Longitude W	Method	Water Depth corr m	Day/time Left Ship	Day/time On bottom	Day/time On board	Comments
11381	PUPPI	31°20'.87	25°25'.68	Acoustic	5440	305/1949	305/2039 to 310/0658	310/0950	N of 10km box
11382	PUPPI	31°20'.75 31°21'.02	25°25'.75 25°25'.60	GPS Acoustic	5440	306/0057	306/0142 to 313/0244	313/0520	N of 10km box
11383	PUPPI	31°24'.7	25°17'.6	Transit	5440	308/0934	308/1017		On nodule field: failed to respond to acoustic commands.
11338	Sediment trap	31°33'.4	24°40'.1	Transit	5440		308/1830 to 308/1432		Recovery
C9A403	Bathysnap	31°34'.1	24°41'.7	Transit	5440		Unknown to 309/1323	309/1530	Recovery
11384	Box Corer	31°12'.2	25°27'.2	Transit	5440	309/0006	309/0435	309/0730	Over The Knoll: laminated sediments.

11385	5 kHz transponder	31°15'.99	25°23'.44	Acoustic/ GPS	5440	310/0019		318/1830	"Red" transponder depth 5344m
11386	5 kHz transponder	31°20'.62	25°22'.15	Acoustic/ GPS	5440	310/0201		318/1258	"Blue" transponder depth 5344m
11387	5 kHz transponder	31°17'.34	25°18'.81	Acoustic/ GPS	5440	310/1621		318/1717	"Green" transponder depth 5344m
11388	PUPPI	31°27'.9	26°17'.8	Transit	5429	311/0208	311/0252 to 318/0520	318/0751	Cruiser Fracture Zone
11389	TOBI	32°09'.5 to 32°14'.2	27°27'.4 to 27°18'.9	Transit	1171 to 2367	311/1027		311/1658	First successful run, Cruiser Seamount
11390	TOBI	31°18'.2 to 31°25'.7 (TOBI positions)	25°10'.2 to 25°20'.0	Transit + Acoustic	5440 to 5330	312/0805		313/0047	Over Nod Hill
11391	PUPPI	31°20'.8 31°20'.91	25°25'.8 25°25'.82	Transit + Acoustic	5440	313/1410	313/1458 to 318/2302	319/0132	N of 10km box
11392	TOBI	31°09'.0 to 31°26'.2 (TOBI positions)	25°20'.3 to 25°31'.7	Transit + Acoustic	5440	313/1648		314/2246	Over 10km box and abyssal hills to W

11393	Box Corer	31°20'.26	25°26'.19	Acoustic	5440	315/0504	315/0740	315/1035	Over 10km box returned almost empty
11394	Piston Corer	31°21'.11 (Corer position)	25°25'.68	Acoustic	5440	315/1208	315/1703	315/2130	N of 10km box: pilot core, no piston core
11395	Box Corer	31°23'.98	25°18'.58	Acoustic	5440	316/0027	316/0303	316/0605	10km box: very soupy sediments.
11396	WASP	31°19'.6 to 31°21'.8 (Camera positions)	25°24'.2 to 25°26'.2	Acoustic	5440	316/0745	316/1112 to 315/1600	316/1835	N of 10km box over PUPPI sites
11397	TOBI	31°12'.9 to 31°25'.5 (TOBI postions)	25°10'.9 to 25°26'.3	Transit + Acoustic	5440	316/2311		318/0004	Over 10km box and SW end of Nod Hill
11398	TOBI	31°21'.5 to 31°29'.3 (TOBI positions)	24°49'.9 to 24°49'.7	Transit + Acoustic	5440	319/0529		319/1406	Over faults

Notes:

1. Positions refer to the ship except where stated otherwise.
2. Depths are water depth under ship.

Table 2: Underway geophysical observations

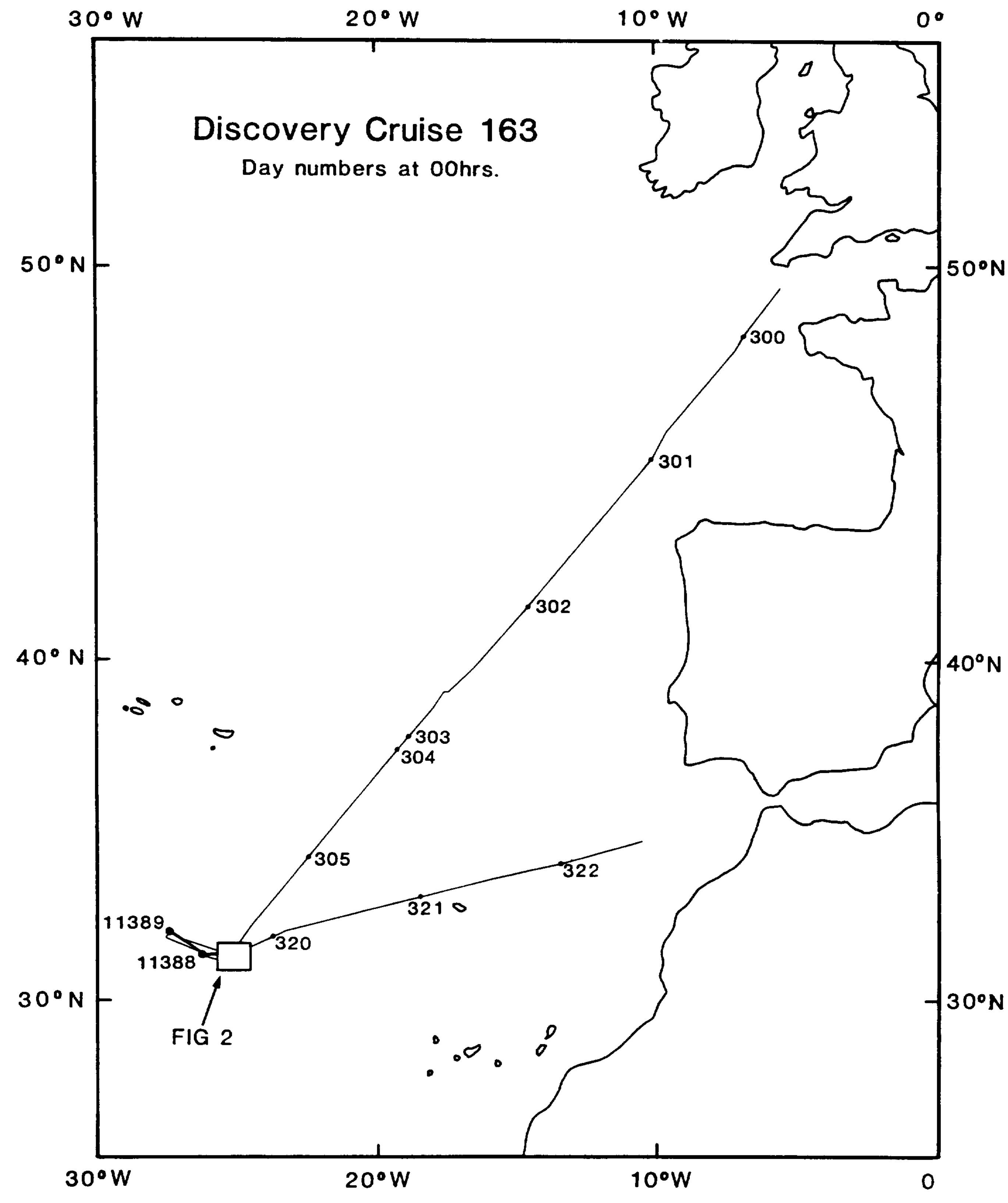
Observation	Start	Stop	Comment
Computer logging	299/1530	322/1434	
PES	300/1500	322/1300	Continuous except for some stations.
SRP	306/0900	317/0700	40 cu. in. gun with WSK.
Magnetometer	300/1500	303/0240	Reduced to IGRF
	304/1045	305/1743	
	306/1400	307/0700	
	319/1830	322/1300	
3.5 kHz	300/1430	300/2130	
	307/1130	313/1130	
	314/0130	316/0030	
	316/0830	317/0000	
	317/1130	319/1130	
	319/1600	322/1300	

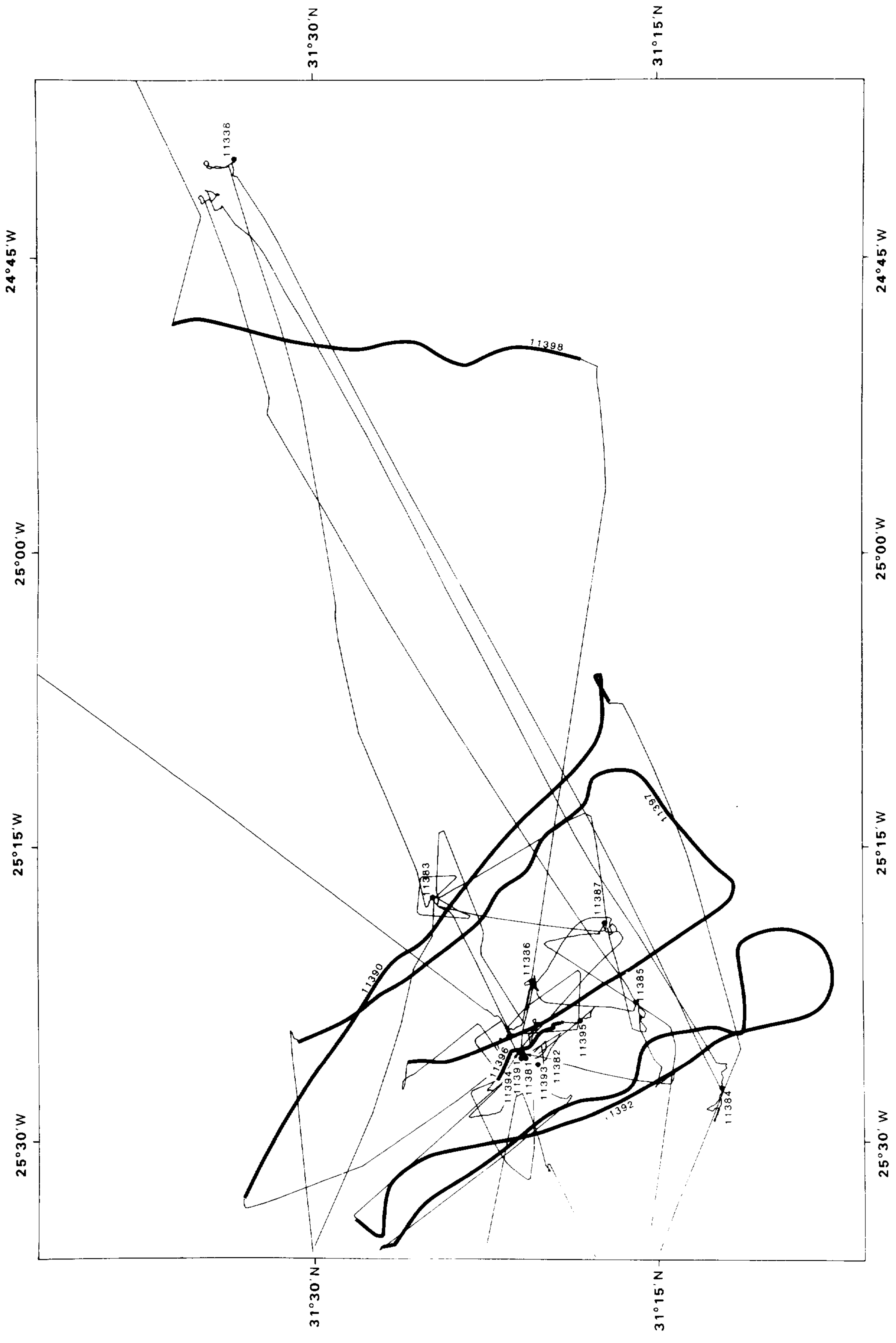
Table 3: 5 kHz Acoustic Beacon Positions

Beacon	Red	Green	Blue
Position of ship when beacon laid (Transit corrected)	31°16'.0N 25°23'.1W	31°17'.3N 25°18'.9W	31°20'.5N 25°22'.0W
Position of ship when laid (GPS)	31°16'.13N 25°23'.51W	-	-
Intermediate position used for shipboard plotting (after 1st relaxation of net with no external constraints).	31°16'.1N 25°23'.5W	31°17'.4N 25°18'.8W	31°20'.7N 25°22'.2W
Final position (after 2nd relaxation relative to GPS fixes)	31°15'.99N 25°23'.44W	31°17'.34N 25°18'.81W	31°20'.62N 25°22'.15W

Baselines:

Red-Green: 7757 ± 42m
Red-Blue: 8796 ± 34
Green-Blue: 8006 ± 34


30° W
20° W
10° W
0°
Discovery Cruise 163
Day numbers at 00hrs.
50° N
50°N
300
301
302
40° N
40°N
303
304
305
322
321
11389
320
11388
30° N
30°N
FIG 2
30°W
20°W
10°W
0


31°30'N
31°15'N
24°45'W
25°00'W
25°15'W
25°30'W
11336
11398
11383
11387
11390
11386
11385
11396
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11382
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