NATIONAL INSTITUTE OF OCEANOGRAPHY

Wormley, Godalming, Surrey.

R.R.S. DISCOVERY

Cruise 44

4 - 13 December 1971

Acoustic Range Tests and other Instrument Trials and Moored Current Meters and Hydrographic Work on the Continental Slope

N.I.O. Cruise Report No. 46

(Issued January 1972)

CONTENTS

AIMS

(1) To recover two current meter moorings laid by 'Surveyor' in September. These were

No. 104: 47° 32'·6N 8° 21'·6W
No. 106: 47° 45'·6N 7° 58'·4W

(2) To lay a near-bottom mooring in 2000m depth near the position of mooring 104, with a single current meter in it, for recovery in May 1972.

(3) To measure the signal strength at various ranges from a 5 kHz sound source, intended for use in long-range floats for the "Minimode" experiment.

(4) To test an acoustic release system suitable for use with recoverable neutrally buoyant floats.

(5) To make STD and water sampling observations in relation to the current measurements from the moorings, and to test new STD sensors and improvements in processing STD data.

(6) To measure ship flexure when pitching, by observing deflections of a laser beam running most of the length of the ship.

All these aims were achieved, except that mooring 106 was picked up adrift instead of being released normally, and the weather was too calm for much ship flexure to be observed. All the work was done in the neighbourhood of the mooring site and in the adjacent deep water at the foot of the continental slope.

NARRATIVE:

Left Southampton	1000/4th Dec.
Arr. continental slope area	1300/5
Left " " "	1700/11
Arr. Barry roads	0400/13

Using 3 engines, a quick passage was made from Southampton to the mooring area. An attempt was made first to interrogate mooring 106, but no reply was obtained from its command pinger. Going on southwestwards, mooring 104 was successfully located before the Decca became too uncertain. The satellite navigation receiver which had just been repaired before sailing was still not working. Overnight, three STD stations were occupied around the position of mooring 104, with a velocimeter dip at the first one to allow ray paths to be calculated for the acoustic range tests.

Faults on the echo-sounding system were repaired, and a command pinger was tested by lowering on a wire, which also checked the working of the 10 kHz interrogation system. Next morning (the 6th) a further search for mooring 106 was made, again unsuccessful. Leaving that after 2 hours, a temporary mooring (No. 107) was laid carrying a 5·1 kHz pinger and a 6·4 kHz transponder (triggered by the pinger). A dan buoy with radar reflector was attached to the mooring which had its main buoyancy below the surface. Listening stations were then occupied at ranges from 1 to 30 mls from the buoy. At each station a hydrophone was lowered to various depths from 100 to 3500m and recordings of signal strength were taken. At one station the sound velocity profile was determined, by velocimeter and water sampling. These observations went on until a.m. 8th December. Then, whilst the radar buoy was still in place, a pattern of various courses and speeds was run within radar range for calibration of the 2 component E.M.log. With favourable weather, the long-term mooring 104 was then recovered, followed by the temporary mooring 107. Two more STD stations were then occupied, completing the pattern relative to mooring 104, and a further STD station was worked in deep water 20 mls to the southwest. An acoustic release was tested, to be ready for laying the new long-term mooring. Returning then towards mooring 106 position for another search, an orange 4ft sphere was seen at the surface, which on recovery proved to be mooring 106 drifting some 13½ miles SW of its laid position. The release bolt had not fired, evidently the anchor strop below the release had failed by corrosion of the Talurit ferrules. Having recovered that mooring unexpectedly quickly, the rest of that day (9th) was spent in dragging unsuccessfully for the lost mooring 75. That mooring had been in the water since February, and the release pinger still switched on and off readily and gave a good signal. After giving up dragging late in the evening of the 9th, work in deeper water was resumed. More STD work was followed by a test of the 6·4 kHz transponder, which seemed insensitive. Returning in daylight (and reliable Decca) to the 2000m mooring site, the new long-term mooring (No. 108) was laid in the afternoon of the 10th. Both STD sea units were calibrated for depth using a bottom-finding pinger, and on returning to deep water further tests were made with the transponder which had been improved. This time it worked well down to 4000m, and in the morning of the 11th it was put down on a wire below a surface float. It could be triggered from 5 miles range but not from 10 or 15 miles. The transponder buoy was recovered p.m. 11th, and course was set for Barry.

The weather was exceptionally good throughout the cruise, with only a few hours of force 6 winds during the 7th.

LIST OF SCIENTIFIC PARTICIPANTS:

Mr. B.J. Barrow	N.I.O.	
Mr. J.W. Cherriman	"	
Mr. E. Darlington	"	
Mr. J.T. Dickson	U. of Wales, Cardiff	
Dr. M. Fasham	N.I.O.	
Dr. N. Hogg	W.H.O.I. - M.I.T. - N.I.O.	
Mr. G. Mardell	N.I.O.	
Dr. B.S. McCartney	"	
Mr. N. Millard	"	
Mr. G.K. Morrison	"	
Mr. T. Sankey	"	
Mrs. J. Sherwood	"	
Dr. J.C. Swallow	"	Principal Scientist
Mr. D.C. Webb	W.H.O.I. - N.I.O.	
Mr. W.B. Wright	N.I.O.	

Notes on Equipment and Observations:

1. Current meter moorings (Cherriman, Darlington, Swallow)

As indicated in the narrative, two long-term moorings were recovered and a new one laid during the cruise. Mooring 104, laid on 25th September by the 'Surveyor', was interrogated from 1½ mls range at the first attempt on 5th December, and released at the first attempt on 8th December. The acoustic release pinger was not detected, and the first sign of release of the mooring was the appearance of the 4ft sphere at the surface. The release pinger was however working when recovered. Both current meters in the mooring, at 311m and 1981m depths, appeared to have worked satisfactorily.

Mooring 106 was found adrift on 9th December and recovered. The bolt of the release was still in place, but all that remained of the 8mm double strop connecting the release to the sinker were the two thimbles from the hard eyes. Each eye had been made with two Talurit ferrules, which must have corroded sufficiently to release the wire. This is the first positive evidence of serious corrosion of Talurit ferrules that we have had on these 2 month moorings. The one current meter in mooring 106 appeared to have worked satisfactorily. It should be possible to determine the time that the mooring went adrift, from the change in temperature recorded.

The new long-term mooring, No. 108, was laid at 47° 32'·3N, 8° 23'·4W (Decca Red F6·10, Green F31·00) in 2048m depth, on 10th December. It was a near-bottom mooring, with a single current meter 20m off the bottom, the buoyancy being provided by a 28" sphere 5m above the current meter. This mooring will be left out until May 1972, and besides producing a current meter record it is intended to serve as a corrosion test on the 28" sphere and on the new deep pressure case for the Bergen current meter.

2. <u>Acoustic experiments</u> (Barrow, McCartney, Millard, Webb)

At the present time the system which is intended to be used to track neutrally buoyant floats during the 1973 Mode I experiment is based upon transponders interrogated from the ship, and recoverable on command by the release of a weight. During the present cruise three experiments were undertaken to check on the predictability of the acoustic paths and range, on the command recovery and on the transponder operation.

<u>Acoustic Ranging Experiment</u>

A mooring (N.I.O. No.107) was laid with a pinger on the wire at 1,700 metres depth and a transponder at 1,000 metres depth. The pinger transmitted a 100 ms pulse at the interrogation frequency 5·1 kHz once every 4 secs, and the transponder operated at 6·45 kHz near the middle of the working band. The transponder was inhibited for 5 secs after a reply, so that generally it transmitted only every other pulse.

The listening system on the ship consisted of a hydrophone array with battery operated pre-amplifier feeding the armoured conducting cable on the midships winch; the signal was heterodyned down in frequency and filtered in the laboratory before display on a 4 sec sweep Mufax Brüel and Kjaer Level Recorder and audio output. Tape recordings were made prior to the heterodyne operation so that both pinger and transponder could be recorded. The listening channel was selected by altering the local oscillator frequency. The receiving system was checked for linearity, bandwidth and noise, and calibrated to provide absolute acoustic pressure levels.

Records were taken at various depths, generally at 100 metres, 500 metres and then at 500 metre intervals as the water depth allowed at each station. Running away from the buoy, stations were made at nominal ranges of 1,5,10,20 and 30 miles and on the return run up to the buoy at 25,15,7 and 2·5 miles. Throughout the operation the weather was good and sea state never exceeded 3. Out to 20 miles the signal-to-noise ratios were good and the results generally fitted the expected spreading, absorption and refraction losses. However before the 30 mile station the hydrophone pre-amplifier output lead was damaged and had to be repaired. The signal levels at this station were then low but still detectable at 5·1 kHz, though not at 6·4 kHz. At the time this was attributed to the extreme range, but subsequent stations at 25,15,7 and 2·5 miles suggested a signal loss of some 20 to 30 dB.

It was suspected also that the noise level was lower than might be expected and eventually it was found that the repaired output lead had been wired incorrectly. When this fault was remedied the 2·5 mile station was repeated, increasing the signal levels around 25 dB up to the same propagation curve as for the outward stations.

Before the experiment a velocimeter profile was taken and ray traces computed and plotted for sources at the pinger and hydrophone depths. The variation of signal level with depth at a fixed range was observed to be in general agreement with what the ray plots predicted, though detailed numerical comparisons have yet to be made. A velocimeter profile was also taken toward the end of the experiment with comparable form to the first. Water bottle measurements of temperature and salinity on the same wire subsequently revealed that the Plessey sound velocimeter is reading 2·7 metres per second low; this could be accounted for by a 4 thou error in path length.

The results of this experiment were encouraging after allowance is made for the faulty lead, though it must be admitted that the weather was surprisingly good and much higher noise levels could occur. It was possible to see the effect of a lower absorption coefficient at 5·1 kHz relative to 6·45 kHz. At any range, variations in signal level with depth could reach 25 dB, though at a fixed range and depth, levels generally were within ± 5 dB. Occasionally at short range the signals were detectable as the hydrophone was lowered at about 1 m/s, but more frequently the flow noise marked them by up to 60 dB.

Before recovering the buoy, underway listening with the echo-sounder fish out to 3 miles and with the towed hydrophones out to 7·3 miles were successful.

Acoustic Release Experiments

Attempts to command the release circuitry at the end of ranging run were unsuccessful and were subsequently thought due to low battery supply voltages. The transponder was lowered to various depths down to 4000 metres on the hydrographic wire and the pinger to 100 metres on the conducting cable. Using the echo-sounder transducer to listen with, it was found that the transponder failed to operate beyond 540m, and the pyro release did not work until 500m was reached before the return to the surface. The transponder converted to a 10 kHz pinger after the release operated satisfactorily. After some circuit modifications the transponder without pyro release was lowered on the wire to 4000m, at which depth the command system operated first time and converted to 10 kHz pinger. The transponder unit was then lowered to 4000 metres a third time with a pyro release connected. Using full power but adjacent release frequencies the release was not operated, but it did operate immediately after 1 minute at its correct frequency and full power. The weight released operated a water bottle, confirming depth of operation.

Transponder Tests

During the ranging experiment the transponder consistently operated when 700 metres above the interrogating pinger. However, during the first release test on the hydro wire, very poor transponder performance was attributed to the random operation on noise, presumably spiky noise caused by knocking the transducer on its rope mounting. After taking all precautions with shackles, ropes and messenger for the second command test on the wire, the performance was better, working down to 2000 metres. On the third lowering the pinger was turned to make its transducer axis horizontal to gain the benefit of its directivity and reliable triggering was achieved to 4000 metres depth.

Since the only two pyro releases had been used up it was not possible to place the transponder unit in the sea as a neutrally buoyant float, so that for the final transponder ranging experiment, it was necessary to suspend the transponder from a surface float with dan buoy. The transponder was at 820 metres depth.

The pinger interrogator was positioned below the listening hydrophone. At 5 miles the transponder was received clearly with the pinger/hydrophone as shallow as 10 metres. Because time was short, range was then increased to 15 miles, but the transponder replies, though clearly audible, were not coherent and must have been triggered by noise. Similarly at 10 miles the transponder was heard but at incoherent intervals. At 5 miles on the return the transponder was again coherent with the interrogator at 10 metres. At the 5 mile ranges the radar and acoustic ranges did not agree. The acoustic range was 0·25 mile and 0·16 mile greater in the two cases. Comparison with charted distances on the way in to Barry suggested that the radar was reading approximately 0·1 ml low at ranges of 4 to 5 mls. The remaining discrepancy could possibly be due to wire angle on the floating mooring, since only a 60 lb weight was added below the transponder.

3. STD and water sampling (Mardell, Morrison, Sankey, Mrs. Sherwood Wright)

To provide temperature and salinity observations that could be related to the current meter data, a set of 4 STD station positions was occupied around the position of mooring 104. To this end stations 7758, 7759, 7760, 7771 (repeat 7760), 7772 were worked using casts of 8 calibration water bottles and a 10 metre bottle on each station with the 9006/NS STD. (NS = new salinity sensor).

Hardware: In the deep water south of the mooring site an STD cast (station 7773) to 3000m was conducted, both to further the calibration of the STD used for the above stations and to obtain sound velocity data below 2000m, to aid the acoustic ray diagram plots.

Of the remaining STD stations 7774 consisted of two casts, the first using the STD used on the previous stations with the General Oceanics Multisampler - providing a compatibility test and further salinity calibration data. For the second cast the recently repaired 9040 STD was tested and although the multisampler was not used, the instrument was switched off and on at 200m intervals to 3000m where a water bottle calibration was taken. The switching experiment demonstrated that this instrument would be compatible with the multisampler, and the 3000m and 10m water bottles provided two calibration points for the salinity and temperature sensors. In order to calibrate the 9006/NS and 9040 depth gauges and two unprotected thermometers station 7776 was conducted, one STD per cast in 2000m of water. The bottom separations measured using a type 'D' precision pinger, were tabulated against the depth periods of these instruments.

The test of the 9006/HT/ND for compatibility with the multisampler was conducted at station 7777; the instrument successfully switched off and on down to 500m. However when the instrument was switched off at 3000m, the salinity sensor failed to restart until it had been raised to 900m - this could be either a depth or temperature effect, and requires attention before the old 9006 salinity unit can be used in conjunction with the multisampler.

Software: A revised suite of STD software was used to handle the data on the shipborne computer. The programs were more efficient and a new feature was an index file used to store all the station details e.g. date, time, calibration used, location of the data on disk. Once minor faults had been eliminated the system worked well, although further development is still required to cope with noisy data.

Water bottle stations: The water bottles used in conjunction with the STD's were also used on a sound velocimeter dip to 2000m to form the shallow cast of a deep station to 4200m (station 7768). Two deep thermometer test casts (stations 7773, 7777) with a few water bottles closely spaced, were conducted using the forward winch.

Duplicate salinity samples were drawn from each water bottle. One sample was analysed on the ship using a modified Cox thermostat salinometer. The duplicates have been returned to the laboratory for analysis on a standard Cox thermostat salinometer.

As well as providing calibrations for the STD, the water bottle thermometer readings are being used to check the calibrations of the thermometers themselves. Water bottle salinities are being used to provide a comparison between the standard Cox thermostat salinometer and the modified version installed on the ship, in which the oil in the thermostat bath was circulated continuously. A total of about 120 samples was analysed on the cruise.

STD composite signal logging: The STD sea unit signals at stations 7758, 7759, 7771, 7772 and 7773 were recorded on magnetic tape. Although spikes on the records were introduced, a replay of station 7773 compared very well with the original computer output. Spike suppression software is now under consideration, and the above tapes will provide adequate test pieces for their development.

4. Ship Flexure Measurements (Hogg)

There is some interest in using the 'Discovery' to measure cloud heights by taking stereo photographs using cameras mounted on the bow and stern of the ship. In order to make meaningful measurements from the photographs the cameras must be parallel but small deviations from parallel, produced mainly by ship bending, can be corrected for if this divergence is known. For this reason an attempt was made to measure the amount of ship bending forced by waves for a range of sea state.

The experimental set-up, devised by Mr. N.D. Smith, was as follows. A laser projector, mounted on the after end of the upper deck, port side, was directed forward on to a target (about two feet square) mounted just forward of the bridge (total separation distance ~ 147ft.). With an unfortunately large beam divergence of 1 milliradian the laser produced a spot approximately 2 inches in diameter on the target. The movement of this spot was recorded with a Bolex ciné camera set to operate at 24 frames per second.

Unfortunately, at least for the aims of this experiment, the weather encountered during the cruise was unusually fine and the sea never reached a state sufficient to give useful results. On one attempt in the morning of December 7th, when the ship was steaming at 7-8 kts, a 4-5 ft. sea (typical period ~ 7-8 sec.) was incident at 30° on the starboard bow. There was a barely discernible vertical deflection of the spot (less than 0·5 cm) and a larger (about 1 cm) horizontal movement. This horizontal deflection might have been due to torsional strain forced by the obliquely incident waves but, more likely, was caused by a lateral bending of the laser support. Outside of this short period the sea was never sufficiently developed to give useful data. If the experiment is repeated I suggest that a laser with smaller beam divergence be obtained and that more lateral strength be added to the laser support.

5. Meteorological Observations (from notes compiled by Mrs. Edwards)

The Meteorological diary was kept by W.B. Wright, who serviced the instruments and took visual readings at least once daily.

Air temperatures: Dry and wet bulb readings from resistance element thermometers in screens on Monkey Island were data-logged by computer and monitored by Assmann readings; these indicated that the port side elements are either faulty or have changed calibration, readings for both dry and wet bulb being 2-3°C high; these were put off line late on December 5th. The starboard readings were apparently O.K.

Sea Surface Temperatures: These were measured by

Met. Office limpet (R.A.S.T.U.S.)
G.K. Morrison's Wien Bridge Oscillator limpet (data-logged)
Crawford bucket
T/S profiler (up to late on 6 Dec. only)
Water bottles at 10m.

There was generally agreement to within 0·3°C between all these sensors, with the W.B.O. about 0·1°C higher, and the Crawford bucket 0·1°C lower, than the mean.

A test was done by W.B. Wright to determine the effect on the limpets of heating the air in the hold in which they are located, and this is reported on separately. It was necessary because it was noticed that on Cruise 43 when G.L.O.R.I.A. was off, the R.A.S.T.U.S. and W.B.O. limpet readings were approx. 0·2°C and 0·7°C higher than those of the Crawford bucket, but when the G.L.O.R.I.A. generator and alternator were switched on readings were higher by approx. 1·2°C and 0·9°C respectively, suggesting that the air was warmed and heating the limpets by approx. 1·0°C (R.A.S.T.U.S.) and 0·2°C (W.B.O.).

Solarimeter: Values were data-logged. They were apparently O.K. apart from two large negative readings during daylight hours; the softwear still produces strange-looking pseudo zero readings at night. Intermittent faults may be due to faulty contacts in the potential divider electronics (which are due to be replaced by a new recording system as soon as this is ready) or to interference such as that due to radio transmissions, which are known to create noise in the data-logging system.

N.I.O. two-component anemometer: Readings seemed satisfactory when spot-checked with M.O. anemometer; detailed analysis of winds logged during manoeuvres for E.M. log calibration should give more information on the performance of the anemometer.

Determination of effect of change in surrounding air temperature on hull mounted Meteorological Office limpet (R.A.S.T.U.S.) (Note by W.B. Wright):

On GLORIA cruise 43, R.A.S.T.U.S. readings had been in the order of 1°C higher than those of the Crawford bucket when the GLORIA generator had been switched on.

To confirm that this higher temperature was due to air heating, an experiment was conducted using a hot air blower slung from the 'deckhead', 2 metres from and blowing directly on to both the R.A.S.T.U.S. and the Wien bridge limpet.

On heating, it was seen that R.A.S.T.U.S. temperature increased as the surrounding air temperature increased, whereas the Wien bridge limpet showed only a slight temperature increase under the same conditions.

When R.A.S.T.U.S. was then insulated with a thick covering of fibreglass blanket encased in a polystyrene box, the same heating conditions showed no effect on the R.A.S.T.U.S. temperature readings.

		TEMPERATURES °C		
TIME	AIR AT HULL	R.A.S.T.U.S.	WIEN BRIDGE	CRAWFORD
1100	12·3	11·7	11·7	11·7
1200	25	16·5	11·8	
1230	25	16·5	11·8	11·7
R.A.S.T.U.S. Insulated				
1430	25	11·7	11·8	11·7

6. <u>Computer System:</u> (Fasham, Mrs. Sherwood)

Apart from the satellite navigator which broke down on the first day, the computer system was fully operational throughout the whole cruise. A new addition to the system was a set of programs enabling the on-line DECCA and LORAN equipment to be sampled and fixes to be calculated from the data as frequently as every two minutes.

Whilst within radar range of an anchored buoy on 8th Dec., manoeuvres were made at various courses and speeds to provide the means of calibrating the computer dead-reckoning system.

TABLE I

CRUISE 44 STATION LIST

Stn. No.	Date	Time (GMT)	Lat.N.	Long.W.	Gear Used
7758	5	1802 2338	47°25'·8	8°22'·8	Vel, STD, WB
7759	6	0034 0235	47°32'·6	8°12'·3	STD, WB
7760	6	0335 0515	47°39'·1	8°23'·8	STD, WB
7761	6	1400 1512	47°28'·9	8°30'·6	Mooring 107 laid
7762	6	1549 1733	47°27'·7	8°30'·6	ART
7763	6	1807 1944	47°24'·0	8°30'·8	ART
7764	6	2025 2225	47°19'·0	8°31'·0	ART
7765	6	2336	47°08'·9	8°31'·5	ART
	7	0219			
7766	7	0335 0851	46°58'·8	8°32'·0	ART
7767	7	0939 1308	47°04'·1	8°32'·5	ART
7768	7	1410 2203	47°13'·0	8°33'·1	ART, Vel, WB
7769	7	2310	47°21'·6	8°33'·6	ART
	8	0112			
7770	8	0209 0700	47°26'·2	8°30'·1	ART
7771	8	1826 2004	47°40'·7	8°21'·7	STD, WB
7772	8	2109 2305	47°33'·5	8°32'·3	STD, WB
7773	9	0116 0645	47°21'·3	8°51'·6	STD, WB
7774	10	0140 1005	47°19'·2	8°54'·2	STD, Multisampler
7775	10	1245 1328	47°32'·3	8°23'·4	Mooring 108 laid
7776	10	1356 1835	47°33'·4	8°21'·8	STD, WB (2 dips)
7777	10	2117	47°19'·7	8°53'·0	Transponder test
	11	0848			STD, WB
					Transponder buoy laid
7778	11	0937 0947	47°14'·7	8°53'·0	ART
7779	11	1053 1253	47°06'·5	8°50'·0	ART
7780	11	1330 1458	47°10'·4	8°51'·9	ART
7781	11	1545 1555	47°16'·0	8°51'·0	ART

Abbreviations:
- Vel: velocimeter
- STD: temperature-salinity-depth recorder
- WB: water bottles
- ART: acoustic range test

TABLE II

CRUISE 44 CURRENT METER MOORINGS

N.I.O. Mooring No.	Discovery Sta. No.	Position	Water Depth (m)	Time (GMT) and Date Set	Time (GMT) and Date Recovered	Current Meter No.	Depth (m)	Remarks
104	-	47°32'.6N 8°21'.6W	2003	1835/25.9.	1328/8.12.	222 223	311 1981	data apparently good " " "
106	-	47°45'.6N 7°58'.4W	742	1812/27.9.	0935/9.12.	281	344	" " " (mooring found adrift near 47°38'.5N 8°15'.8W
107	7761	47°28'.8N 8°30'.5W	2156	1512/6.12.	1530/8.12	-	-	(5.1 kHz pinger at 1696m (Transponder at 986m
108	7775	47°32'.3N 8°23'.4W	2048	1328/10.12.	-	73	2026	left out for recovery in May 1972

Fig.1 DISCOVERY CRUISE 44 Noon Positions

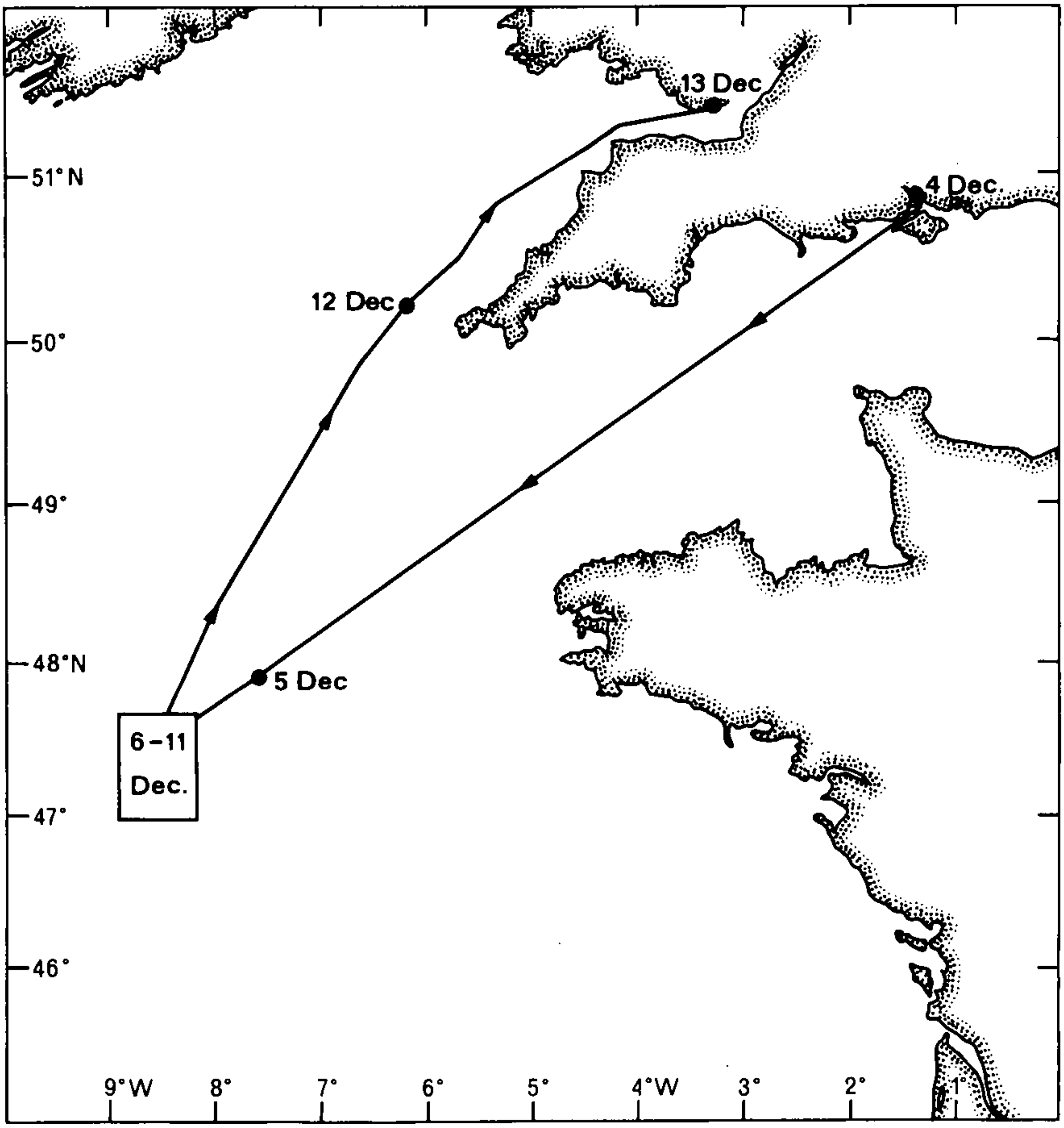

Fig.2 **DISCOVERY CRUISE 44 Station Positions**