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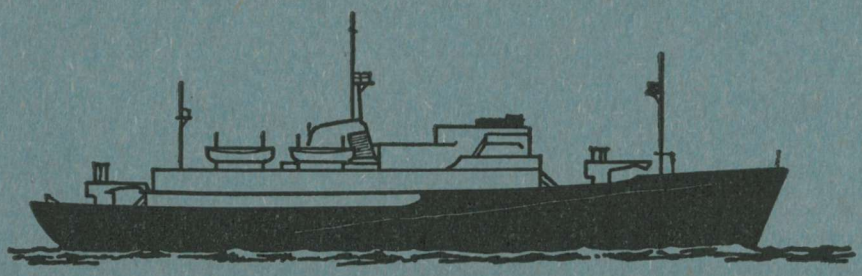

R.R.S. DISCOVERY

CRUISE 41

9th August — 19th September 1971

PHYSICAL OCEANOGRAPHY

N.I.O. CRUISE REPORT No. 45
(Issued December 1971)

N. I. O. CRUISE REPORTS

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R.R.S. DISCOVERY
CRUISE 41 REPORT

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PHYSICAL OCEANOGRAPHY

N.I.O. CRUISE REPORT NO. 45

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DISCOVERY CRUISE 41

Duration Leg 1: 9-8-71 (Barry) to 19-8-71 (Lerwick)
21-8-71 (Lerwick) to 10-9-71 (Stornoway)
11-9-71 (Stornoway) to 18-9-71 (Stornoway)

Scientific Staff (all from N.I.O.)

Legs 1 and 3

J. Berry (computer technician)
K. Birch
D.E. Cartwright (senior scientist)
P.G. Collar
R. Dobson
D. Grohmann
T. Gwilliam
R. Kirk
R. Spencer
M. Wimbush (Leg 1 only)

A. Fisher, R. Clements and R. Bonner also sailed from Barry to Stornoway (arr. 11-8-71), to deal with 'GLORIA' transfer.

Leg 2.

J. Berry (computer technician)
K. Birch
A. Braithwaite
G. Bryan
R.M. Carson
C.H. Clayson
J. Crease
R. Dobson
Mrs. P. Edwards
J.A. Ewing
B.H. Hart
E.G. Pitt
A.G.D. Watson (senior scientist)
A.L. Watson
S. White

tidal current between Position 6 and the Shetland mainland, and also as a record of the velocity profile. N.I.O. had been maintaining a tide recorder at Foula Island during the summer months). The three anchor stations were:

Station no.	Position no.	Latitude	Longitude	Average depth
7730	6A	60°12'.5N	1°47'.5W	83 m.
7731	6B	60°10'.0N	1°56'.5W	74 m.
7742	6C	60°06'.7N	2°14'.7W	102 m.

Bathy thermograph dips were made at 6A (17 Aug) and 6C (17 Sep); also near Position 3 (13 Aug).

3. A tide gauge sphere, empty except for a pressure switch, was lowered to implosion, which occurred at the healthy depth of 990 m. This was the first time such a test had been carried out on these spheres.

4. A radio transmitter with ground plane circle was mounted on an empty tide gauge sphere with framework, and tested for range of reception. Reception was still good at 14 miles, when the ship returned to retrieve the assembly. The same aerial was also tested without the ground plane circle, and gave weak reception at 10 miles.

Narrative - leg 1.

'Discovery' left Barry at noon 9 August, and headed at full speed for Stornoway, reached by early morning of the 11th. On the way, we stopped for about 3 hours on the morning of the 10th, for preliminary tests on the acoustics for the first moorings.

The unloading of G.L.O.R.I.A. was speedily completed, and we left Stornoway at 1500 h 11 August, steaming slowly to reach Position 2 by first light. (Daylight was necessary for all mooring and recovery, in order to ensure good Decca and Loran fixes).

Soon after leaving Stornoway, an accident occurred with the after deck crane, which could easily have been more serious. Our first tide-gauge sphere, tested and fully loaded with expensive equipment, was being lifted from the main deck to the after deck, when the cable slipped a sheave and dropped the sphere 15 feet on to the deck. Luckily, the scientist underneath saw it dropping in time to step aside, and although the sphere was rendered unusable, (value about £200), the equipment inside was not seriously damaged. But

it was clear that some defect in the crane's design (which has been known to fail similarly before), should be quickly remedied. The crane was restored to normal condition the same evening by the efforts of Captain Justin, the Chief Engineer and the Bosun.

Owing to good weather conditions, efficiency of deck operations, and only minor trouble from our acoustic equipment, all moorings at Position nos. 2,3,4 and 5 were completed and tested by 0930, 14 August. 'Discovery' then steamed for the nearest position of depth greater than 1000 m (Station 7729, 61°10'N, 3°40'W) for the sphere implosion test. Before this test, another sphere was leak-tested for an hour at 90 m, and found to let in a few drops of water. If this sphere had not leaked (or if first sphere had not been damaged by the crane), we should have laid a fifth tide-gauge. All tests were completed by 2000, 14 August.

Anchor station 6A was occupied from 15 to 17 August and 6B from 17 to 19 August. At both stations, D.R.C.M. measurements proceeded without serious incident in moderate sea conditions (winds less than 25 knots) with the anchor holding well. During this period, considerable quantities of haddock and mackerel were caught by the seamen, making a welcome addition to the diet.

On completion of 6B, 'Discovery' sailed directly to Lerwick, and after anchoring in Bressay Sound, was allowed in to the pier early morning of 20 August.

Narrative - leg 3

'Discovery' left Stornoway at 0900, 11 September, and proceeded to recover the moorings in the order in which they were laid. Navigations were done entirely by Decca, since the Loran receiver, though apparently balanced, gave noisy and inconsistent readings throughout. The Decca itself broke down during the 13th, but was made operational again by cleaning the generator slip-rings.

Satellite fixes were coming in regularly at roughly hourly intervals during this leg and, after a difficult starting period, during leg 1, but they were not particularly

useful in this good Decca region. In fact, apart from filling up disks with meteorological data (whose value was totally incomprehensible to the senior scientist at least), the computer could well have been switched off during legs 1 and 3. It was however, useful during the wave buoy operations of leg 2.

There was some doubt as to whether some of the current-meter moorings would have survived the gales of early September or the frequent trawlers near the Shetlands, but finally all moorings were recovered as near to their original positions as could be judged, (say within $\frac{1}{4}$ mile). Both moorings in the shallowest position (no. 5) gave trouble in switching on their 'command pingers', and several hours were spent on the evening of the 12th 'hunting' within a mile of the tide gauge position. However, the pinger was located early the next morning, and the capsule was then soon released. The current meter mooring at Position 2 failed to release on our first visit, although its 'command pinger' behaved normally. We returned to it on the 14th, after recovering all the other moorings, and succeeded in releasing it during the morning. The only casualty in the whole of these highly successful operations, (all recording tapes were found with full complement of data, except one pressure tape which failed after ten days), was a hand-held hydrophone which accidentally fouled the main propellor and sheared off its cable.

The radio buoy experiments were carried out in an area to the north of Position 2, during the afternoon of the 14th, and were continued the next day in a more easterly position, the ship having steamed overnight towards anchor position 6C. This anchor station was kept from 15 to 17 September, again without incident. On its completion, 'Discovery' steamed towards deeper water to pay out some unwanted **trawl**-warp, and finally returned to Stornoway, arriving 1400, 18 September.

D.E. CARTWRIGHT
(senior scientist, legs 1 and 3)

Report on Leg 2 by A.G.D. Watson (senior scientist).

1. The main purposes of this leg were to make (a) wind profile measurements with a spar-buoy, (b) measurements of waves with a pitch-and-roll buoy at a position north of Rockall, (c) measurements of ship motion in relation to sea and swell and (d) measurements of currents with neutrally buoyant floats in areas of the shelf and continental slope. In addition, tests were made of a disposable wave buoy, of modifications to the tail of a P.E.S. fish and of a new design of Pisa current meter and improvements were made in the operation of the ship's computer and of the new hydrographic winch.

2. The ship left Lerwick at 0900h on 22 August, later than planned since some scientists had been delayed by fog. On passage to Sumburgh Head, the ship's log was calibrated by steaming at speeds of 5 and 10 knots on courses fixed visually and by radar on two shore points, Perie Bord and Helli Ness Beacon. The day was sunny and clear. The first position on the shelf, at which current measurements were sought, was reached at 0500h on 23 August and hydrographic station 7732 was carried out there, followed by a first test of the Pisa current meter, ship's runs for comparisons of log and revolution counter and the first launch of the spar buoy for tests of mechanical behaviour and handling. The first neutrally buoyant float was launched shortly before midnight and this was located at intervals during the succeeding day. Tests of the first experimental P.E.S. fish tail wave also made on 24 August and an unsuccessful attempt was made to line up the compass of the wave buoy, using a dinghy to tow it away from the influence of the ship. At 2320 on 24th, when it appeared that the neutrally buoyant float was probably fouled, course was set for the north Rockall area. At 0920 on 25th an echo-sounding watch was set, as the ship was crossing an area with few sounding lines. During this passage strong southerly winds, veering to westerly, were met with, reaching 50 knots at midnight of 25th. The ship arrived on station (58° 06'N, 15° 30'W) at 1730 on 27th August. A second test of the Pisa current meter was then carried out, followed by hydrographic station 7734. The wave buoy programme was begun at 0900 on 28th and continued for three days. At 1000 on 29th, a second neutrally buoyant

float was launched and was tracked at intervals during the succeeding two days. At 1500 on 30th, hydrographic station 7736 was carried out and later the same day tests of the disposable wave buoy and of the Pisa current meter.

At 1000 on 31st August the wave-buoy programme was concluded and the ship moved off towards Barra Head in view of the imminence of severe gales. An echo-sounding watch was again set on this passage. Wind and sea increased rapidly during the day and at 0130 on the 1st September, the vessel shipped a sea on the starboard quarter that did some damage aft and flooded some cabins and other spaces below. The vessel passed Barra Head at 1430 and entered Loch Boisdale at 1730 to take refuge from the storm. She remained at anchor during the next day, while the wave-buoy accelerometers were calibrated and its compass lined up and the spar-buoy was prepared for launching with instruments and electronics complete. On 3rd September the vessel left Loch Boisdale but remained in the Sea of the Hebrides where another configuration for the P.E.S. tail was tested and then at 1430 the spar-buoy was launched at a point about 10 n. miles distant from any point of land. The spar was found to be detectable with difficulty on the ship's radar at distances between 2 and 11 cables. It was recovered at 1730 and a successful test of the disposable wave-buoy was then carried out. During this day the wind averaged about 18 knots from 230, rising to 23 knots at midnight; however, it then slackened somewhat and the vessel thereupon left the Sea of the Hebrides on 4th September and made for the second area of the continental slope and shelf, west of St. Kilda, at which current measurements were to be made. She arrived on station at 2330 and the first neutrally buoyant float (the third of the cruise) was dropped. This was tracked during the night and at 0940 on 5th September a fourth float was launched. At 1400 on this day the spar buoy was launched for the third time and recovered at 1630 and at 2000 a fifth neutrally buoyant float was dropped. During this day the wind remained southerly at about 20 knots, decreasing slightly later. The neutrally buoyant floats were tracked through the night and during the next day (6th September) when hydrographic stations 7730, 7739 and 7740 were carried out, at 1200, 1330 and 1600 respectively.

Tests of the hydrographic winch and tracking of the neutrally buoyant floats occupied the next day morning and early afternoon. At 1600 a further test of the disposable wave buoy was carried out, but at 1710 work in this area was broken off and course was set for the Butt of Lewis on account of forecasts of further severe gales. However, this particular depression made off to the northwest and on the morning of 8th September, the vessel found herself in the North Minch with the wind dropping and the weather improving. A fourth spar buoy launch was carried out here between 0900 and 1200 when the vessel again made out to the west for trials of ship motions. This work occupied the remainder of 8th and 9th September, interrupted only by a last trial of a P.E.S. configuration at 1830 on 8th and tests of the hydrographic winch. At 1800 on 9th the vessel passed the Flannen Islands and made back to Stornoway arriving off Chicken Rock at 0500 h on 10th September.

3. Spar Buoy (A.G.D. Watson, R. Dobson, Mrs. P. Edwards, E.G. Pitt, A.L. Watson, B. Hart, G. Bryan).

The purpose of the work was to test the operation and instrumentation of the new Spar Buoy under sea conditions, and if possible to make some meteorological observations near the air/sea interface.

The buoy was designed to be launched from the Schatt davits in the horizontal position, and then brought upright by flooding the lower tank. After some hours of data collection, it was to be lowered by blowing the ballast tank with compressed air, and a system of recovery lines and snubbing blocks was used in conjunction with the Schatt davits to hoist the buoy on board again.

All the control and switching operations were effected via 100 yds of neutrally buoyant cable. However, in contrast with its immediate, (and late lamented) predecessor, the data were recorded on magnetic tape by an on-buoy 11 Channel data logger (Rapco type 12).

The recorder interfacing electronics had been completed only just before departure, so that the first 7 days of the cruise were spent in fault finding and testing this equipment.

However, a "dry run" was made at 1530 h, 23rd August to test the flooding/blowing system and rehearse the launching

and recovery procedures. Ballast was carried in place of the recorders etc.

The launch was made to the WSW of the Hebrides, and there was a light SE wind, with poor visibility, occasional drizzle and a moderate swell.

The control system worked well, as it did on all launches, but the buoy was not cast adrift, because of the poor visibility.

As it was blown (de-ballasted) the spar-buoy always fell away from the wind, and this resulted in its upper and lower ends being in positions reversed from those required for recovery, and so the spar had to be turned round. As a result of this trial a better way of turning the spar round was suggested.

By 3rd September, the buoy electronics were working satisfactorily and were used for the remaining 3 launches.

The data recorded were as follows:-

(a) 5 analogue channels for measuring the motions of the spar-buoy. (this is essentially the same system as that used in the pitch/roll buoy.)

(b) 4 digital channels. These were the F.M. outputs of 2 cup anemometers at heights of approximately 1.5 and 6 m above mean water line, and one platinum resistance thermometer at about 5 m AMWL. The fourth channel was used to monitor the accelerometer-drive oscillator.

2 digital channels were left unused. All channels were recorded at one second intervals, the digital data being the accumulated count for the preceding second. The second launch was carried out in the Sea of the Hebrides at 1445 h 3rd September. It was sunny, with a slight sea and a 20 Knot SW wind.

The buoy floated at its design water line and the wind vane worked well. Recording commenced at 1455 and finished at 1733.

Launching and recovery were without mishap, although the instruments were submerged from time to time. The modified recovery system worked well and was retained for the remaining launches.

On recovery the upper anemometer was not working properly and one of the horizontal accelerometers was damaged. The anemometer resumed working on being dried out, and the accelerometer was replaced.

The thermometer and its radiation shield withstood the swamping and appeared to work well on this and subsequent launchings.

Launch 3 was carried out on the edge of the continental shelf, W. of the Hebrides at 1400 h, 5th September. There was a Southerly wind of about 18 knots, a 5 foot sea, and during the run a cold front crossed the area.

The rendering system on the Schatt davits was used during this launch, but the buoy was not heavy enough (just over 1 ton) to operate the system effectively. The instruments were again submerged, both during launch and recovery, and the upper anemometer was not functioning properly after recovery.

Recording was started at 1415 h and finished at 1625 h.

The fourth and final launch was made in the north Minch in conditions of sunshine, light ESE wind, and slight sea. The instruments were kept dry during both launch and recovery, but the lower anemometer was observed to be sticking from time to time. Recording was from 0231 h to 1'27 h.

SBWR records were taken (two or three during each launch). The data were logged by the computer, and spectra computed and plotted using the programs written by J. Ewing. Visual inspection of a sample print-out from the tapes suggests that the data are of adequate quality. Meteorological observations were taken at hourly intervals during the launches and consisted of:-

(a) Dry and Wet bulb temperatures measured with an Assman psychrometer.

(b) Sea temperatures measured by the limpet thermometer, sometimes supplemented with Crawford bucket temperatures.

(c) Apparent wind and ships course and speed.

(d) Visual observations of sea and swell, and of cloud and weather.

4. Measurements with the pitch-roll buoy (J. Ewing C. Clayson, A. Braithwaite, K. Birch).

Nineteen measurements of the directional wave spectrum were obtained using the pitch-roll buoy in the vicinity of 57.1°N, 15.5°W. The measurements were made about every four hours throughout the period 0900, 28 August to 1000, 31 August. Each record consisted of 5 channels (acceleration, pitch, roll and 2-components of buoy orientation) sampled simultaneously at 0.25 sec; the total record length was about 45 min.

The records were taken using the telemetry and tape recording system developed by Clayson. This recorder was also interfaced directly with the IBM 1800 computer so that the data was available for analysis on disk at the end of the measurement.

The buoy system differed from that used in previous experiments in two respects. First, a buoyant cable was used as a replacement of the previous system consisting of cable, supports and floats. Second, the original capacitance compass was replaced by a 2-component fluxgate magnetometer. The buoyant cable proved very successful and can be recommended for future wave buoy work. The fluxgate compass was difficult to calibrate at sea and it is still uncertain whether this transducer provides a useful technique for measuring buoy orientation.

The wave measurements will be used as verification data for a numerical wave forecasting model of the North Atlantic Ocean.

Some results were analysed on the ship to test the recording method and buoy system. The Fast Fourier Transform was used in the computation of the directional wave spectrum. A general program was written by Birch to display on the plotter a specified number of channels with data recorded at the standard rate of 64 words/record. Throughout the wave buoy measurements the wave spectrum from the shipborne wave recorder was monitored using a program written by Ewing.

5. Ship motions measurements (J. Ewing, C. Clayson, A. Braithwaite, K. Birch).

The ship motions of surge, sway, heave, roll and pitch were measured using the transducers in the pitch-roll buoy but modified to include 2 additional accelerometers on the gyroscope for the measurement of surge and sway. The central buoy compartment was taken to the gravimeter room (near the centre of gravity of the ship) for the measurements.

The aim of the work is to investigate the bispectra of surge/pitch in relation to speed loss in head waves. Calm water runs were made on two occasions to establish the RPM versus ship speed characteristics of the ship. RPM and ship speed (from the e.m. log) were recorded at 1 sec. interval on the computer.

Ten records each of 45 min. duration were taken of ship motions in waves on convenient occasions between other work. The ship motions data being recorded on magnetic tape at 0.25 sec. interval simultaneously with 1 sec. sampling of RPM, ship speed and wave height (with the shipborne wave recorder) on the computer.

6. Disposable wave buoy (K. Birch, A. Braithwaite, C. Clayson, J. Crease, J. Ewing, S. White)

A number of trial launches were made to test the radio telemetry system. Finally, a 20 minute wave record was made at 4 samples/second using a spare analogue input on the ship's computer. The spectrum obtained from this record agreed very well with that obtained using the shipborne wave recorder just prior to the DWB record.

Owing to restrictions on the ship's manoeuvres, since the DWB was usually launched during spar buoy recordings, the maximum radio range was never reached, but good reception was achieved at 2 miles range.

7. Float Tracking and Hydrographic Stations (J. Crease P. Edwards, R. Dobson).

Five neutrally buoyant floats were tracked.

(1) One float fitted with external load on end of 20 m. nylon line was released on the shelf midway between

Cartwright's current meter moorings at 130 m depth.

(2) The float was very close to the bottom and showed little or no movement suggesting that it had become snagged on foul ground. No conclusions can be drawn from the results except probably that the technique of placing N.B.F. close to the bottom, although exploitable in deeper water, will not be satisfactory on the continental shelves in areas of rough bottom.

During the pitch-roll/buoy runs one float set to a depth of 500 m. was tracked for 2 days. A pair of hydrographic stations was worked across the track of the float which moved in a northerly direction at approximately 2 ml/day.

(3) On the slope at 57°30'N, 9°30'W, 3 floats were tracked for 3 days. Two were close to the bottom, using external loading on nylon lines as stabilisers, at depths of 400 m and 900 m on the slope. The third was at 400 m above the 900 m float. The two at 400 m had a strong northerly drift of about $\frac{1}{2}$ knot with a superimposed tidal oscillation, that at 900 m was considerably less, of the order of a mile a day.

Hydrographic stations were worked across the track of the floats. Two water bottles were lost when the wire parted on the new for'd electric winch due to slack turns on the drum below deck.

8. Towed Body Trials (Carson)

A standard Mk 11 PES body was towed at speeds ranging from 2 knots to 10 knots. The pitch and roll angles of the body were measured, along with the heave acceleration. Five different tail configurations were tried, which gave a variation of the hydrodynamic pitching moment, while leaving the yawing moment unaltered. The aim of the trials was to discover a configuration giving minimum pitch response to the heave induced by the ship motion; this condition is required for the

success of the proposed narrow-beam echo-sounder. The results obtained suggest that the tail tube of the PES body contributes a major part of the pitching movement and that alterations to the tail alone are not sufficient to bring the body pitch to acceptable values.

The data obtained should enable an improved body to be designed.

9. Pisa Current Meter (P. Edwards, J. Crease, R. Dobson).

A new design of Dr. Carruthers' current meter as a free fall instrument was tested on a number of occasions down to a maximum depth of 1130 m. Although it triggered successfully on several occasions the wire guides on the frame were severely damaged when they hit the plummet at the end of the fall, but this can easily be remedied by re-designing the wire guides. At 50°06'N, 15°36'W a current of about 0.3 knots towards the west was measured; interpretation of the angle of set of the jelly/oil interface was difficult because the interface was confused and the jelly murky.

10. Computer (J. Crease, J. Berry)

The normal on-line system was in use for only part of the cruise. The new facilities of being able to store to disk file selected one-second data from our instruments was of value, as was the ability to take instruments off line at will.

Extensive use was made of a special system for logging pitch-roll/buoy and ship motion data at 1 second intervals in 45 minute runs. The original intention was to simultaneously log Loran/Decca and 8 channels of the standard system (wind speed, EM log, Gyro, SBWR, Engine revs). In the event the system was not able to maintain this sampling rate and for the ship motion studies, we reverted to logging the ship motion data direct to Clayson's recording system, only logging on line the standard channels mentioned above. In this way we were able to satisfactorily collect all the data we set out to except the Loran/Decca observations. Several significant points arise from these experiments.

a) that although practicable the logging of data at this frequency to disk without available back-up magnetic tape is highly inefficient. The necessity for the creation of large data files precludes the use of our standard on-line system, it would be highly desirable to develop facilities to cope with the increasing demand for the high sampling rates with our standard system.

b) There was as a result of these experiments, the need by those concerned for a considerable amount of off-line time for reduction of data. It is a pleasure to note that the system is in this respect now beginning to meet one of the remaining objectives we set ourselves when purchasing it, making possible extensive analysis of the data while still at sea.

c) The interaction of the computer and the magnetic tape logging system was of particular significance. It turned out that the particular recording led to a significant reduction in the hardware error rate over the first few runs of the system.

11. Hydrographic Station List (For Leg 2 only).

Station	Position	
7732	59°52'.8N	08°47'.5W
7734	58°04'N	15°32'.0W
7736	58°05'.3N	15°19'.7W
7738	57°47'.3N	09°26'.0W
7739	57°47'.4N	09°31'.9W
7740	57°47'.2N	09°37'W

12. Echo-sounding runs

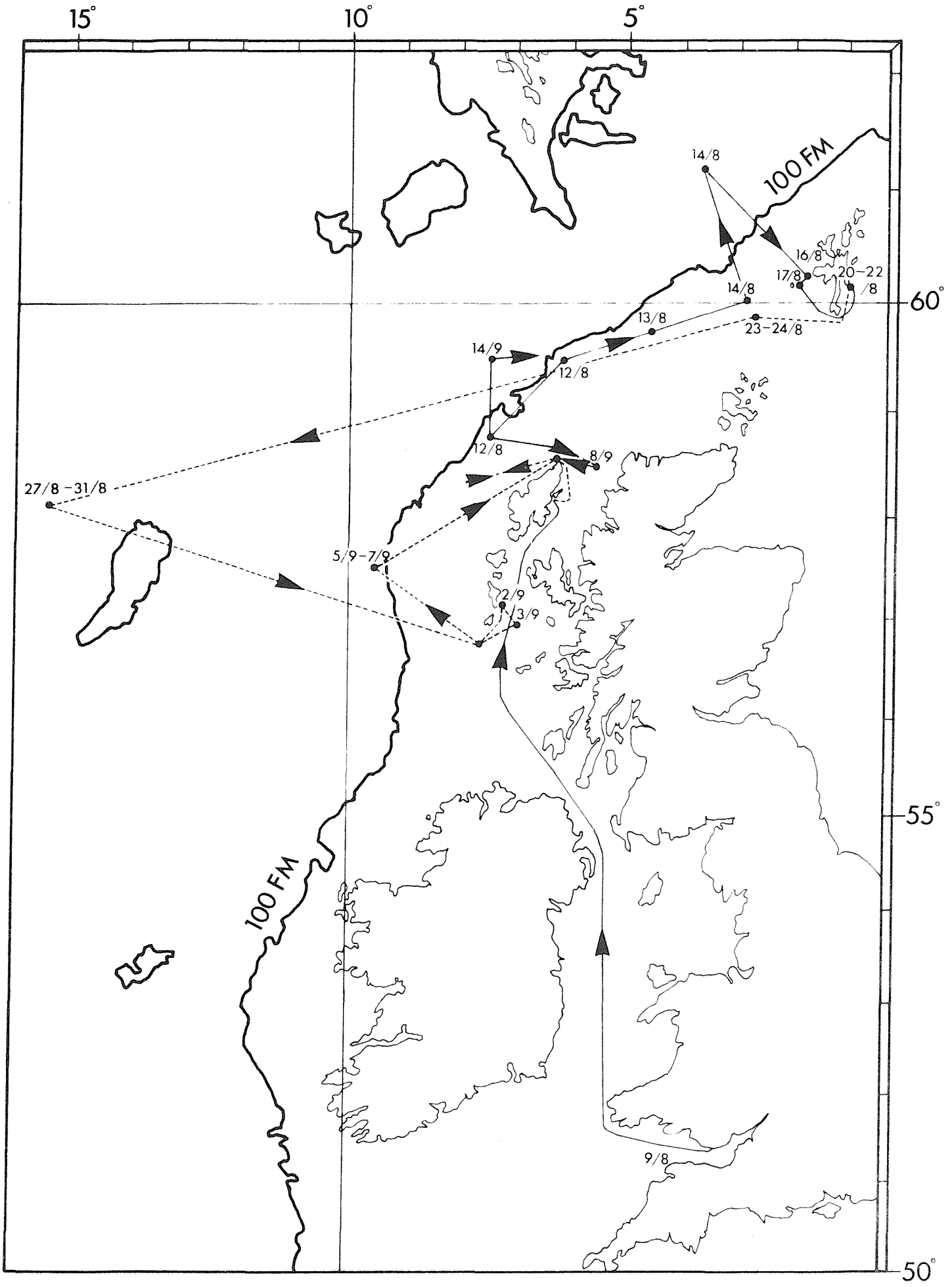
Precision echo-sounding runs were carried out on passage as follows:

From	To
59°25'.2N, 06°22'.0W	58° 0'6 N. 15°30'W
58°8'.6W, 15°15'.1W	57°10'.3N, 09°13'.3W

(There were no echo-sounding runs during legs 1 and 3, since they were conducted entirely in shallow water or well documented sea areas).

Track Chart

A rough track chart for the whole cruise is reproduced on the next page. It is self-explanatory.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