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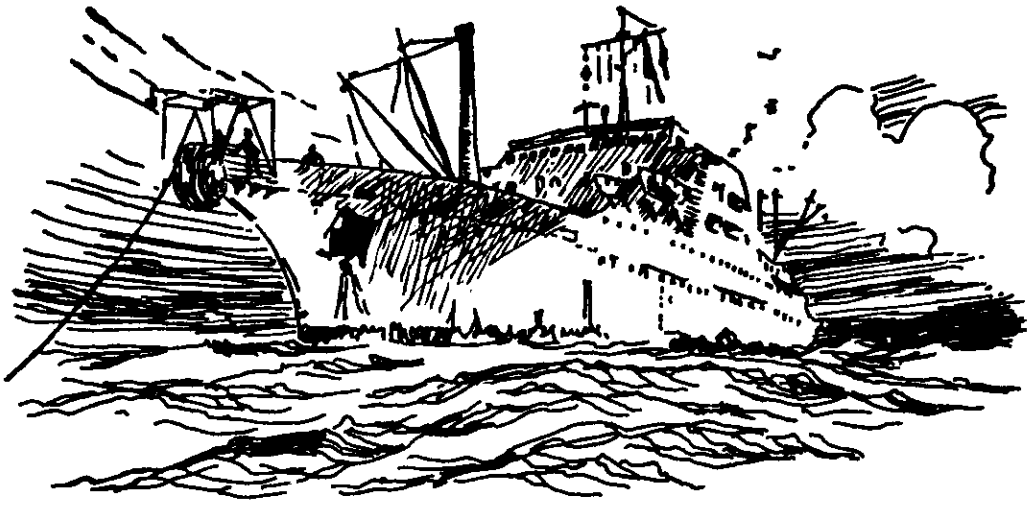

N.C. MARCEL BAYARD

CANTAT II OCEAN SURVEY CRUISE

June - August - September 1971

BATHYMETRIC AND MAGNETIC TRANSVERSES ACROSS
THE NORTH ATLANTIC

N. I. O. CRUISE REPORT No. 44
(Issued December 1971)

N. I. O. CRUISE REPORTS

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R. R. S. "DISCOVERY"		
1, 2, 3	International Indian Ocean Expedition	Published and distributed by the Royal Society
4	February – March 1965	4
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PREFACE

The CANTAT II OCEAN SURVEY CRUISE was undertaken by the British Post Office in the summer of 1971 in order to select and survey a suitable route for the trans-Atlantic cable 'Cantat II' to be laid in 1973 between Widemouth, U. K. and Beaver Harbour, Nova Scotia. The French cable ship N. C. Marcel Bayard (built 1961; Length 400 ft; Breadth 51 ft; Displacement 7080 tons) was chartered for the survey which was aimed primarily at providing a bathymetric and bottom temperature profile along the selected cable route. Two scientists from the National Institute of Oceanography were invited to participate in the cruise and they would like to record their grateful appreciation to:-

The Submarine Superintendent of the BPO, Capt. I. R. Finlayson for his kind invitation, and for giving permission to tow a marine magnetometer during the survey.

The Project Controller, Mr. D. P. F. Chisholm and the members of his survey team for their generous co-operation and,

The Masters, Officers and crew of the N. C. Marcel Bayard for their generous hospitality and assistance in all matters.

CONTENTS

DATES

Leg 1	Leave Falmouth, England	12th June	Day 163
	Arrive Falmouth, England	29th June	Day 180
	Total Distance Covered:		4200 n. miles
Leg 2	Leave Falmouth, England	23rd August	Day 235
	Arrive Halifax, Nova Scotia	5th September	Day 248
	Total Distance Covered:		3200 n. miles
Leg 3	Leave Halifax, Nova Scotia	8th September	Day 251
	Arrive Falmouth, England	18th September	Day 261
	Total Distance Covered:		2800 n. miles

PERSONNEL

SURVEY PERSONNEL

	Leg 1	Legs 2 & 3
British Post Office		
Mr. D. P. F. Chisholm (Project Controller)	X	X
Mr. R. Aitken		X
Mr. C. Blake		X
Mr. A. Chalmers	X	X
Mr. J. Lofts	X	
Mr. L. Street	X	
Mr. J. Wright	X	X
Decca Navigator Company		
Mr. E. Prince		X
Mr. R. Reid	X	

SCIENTIFIC PERSONNEL

National Institute of Oceanography		
Dr. M. T. Jones (Principal Scientist)	X	X
Mr. J. Haigh	X	X

SENIOR SHIPS OFFICERS

N. C. Marcel Bayard

Master Leg 1	Commandant	Gallas
Master Legs 2 and 3	Commandant	Duret
Chief Officer Legs 1, 2 and 3	2nd Officer	A. Girard

SUMMARY OF CRUISE INTENTIONS

The cruise was undertaken to collect bathymetric and bottom temperature data for use in the design and laying of the Cantat II cable system. A provisional route had been selected prior to the cruise on the basis of existing charts. Because of the risk of cable breakdowns due to trawling on the Grand Banks the route was not chosen to lie on a great circle line between its shore ends. It was taken instead on a great circle line from Widemouth, U.K. to a point south of the Grand Banks at approximately 40°N, 50°W and then, after a slight deviation westwards, on a great circle line to Beaver Harbour N.S. The basic intention of the cruise was to check the suitability of this provisional route and where necessary to survey alternative route sections. From a bathymetric standpoint the suitability criteria were based on providing a route that (a) avoided slopes in excess of about 1 in 3, (b) avoided large local variations in depth, and (c) lay as deep as possible. However, due to the high cost per mile of a submarine cable these factors had to be optimised in such a manner as to provide as short a route distance as possible. Route selection was further restricted to areas at least 10 n. miles from existing cable routes although, where necessary, other cables could be crossed providing the crossing was made (a) half way between the repeaters of existing cables, and (b) with as great an angle as possible between the cables. These restrictions were particularly relevant in the region of the mid-Atlantic Ridge crossed by TAT 2 cables 1 and 2 between 48°30' and 49°30'N. The shallow water parts of the route (i.e. depths less than 1000 fms) had been surveyed earlier in the year by the C.S. 'J. Cabot'. On the basis of this work a final route had been selected across the continental shelves of both Nova Scotia and the United Kingdom out to roughly the 200 fm contour line i.e. to 43°26'N, 60°05'W and 50°12'N, 11°05'W, respectively. The cruise was thus intended to fill in the route between these two positions paying particular attention to the mid-Atlantic Ridge region between 25° - 31°W at 49°N and to the continental shelf edges between depths of 200 and 1000 fms. Bottom temperatures were to be taken at regular depth intervals down the continental slopes but only a few sample values were required in the deep ocean.

As mentioned the prime purpose of the cruise was to survey for the Cantat II cable route. However, as it provided an excellent opportunity for obtaining a cross section across a geophysically interesting part of the Atlantic Ocean, a magnetometer was installed on board and towed on all possible occasions. Furthermore, as the cruise schedule necessitated sailing between the U.K. and the mid-Atlantic Ridge on four

occasions, it was decided that, once the cable route had been covered by two of these tracks, the other two were to be made 10 miles to the north and south respectively of the cable route in order to provide a suitable section for the correlation and identification of geomagnetic anomalies. It was hoped that such a section would make a valuable contribution to our understanding of the nature and timing of the drift of North America from Europe especially in the region between the Azores-Gibraltar High plate boundary and the Charlie Gibbs Fracture Zone at 52°N..

NARRATIVE

Leg 1

N. C. Marcel Bayard sailed from Carrick Roads, Falmouth, on the evening of 12th June (163), in calm clear weather enroute westwards to a continental shelf edge position in the Porcupine Sea Bight at 50°17'N, 09°57'W. On arriving at this position on the morning of the 13th June (164) bathymetric surveying commenced westwards to familiarize staff with the equipment. The 300 fm. line was reached at 1300 hrs. G. M. T. and a bottom temperature station was occupied before commencing on the survey proper along the proposed cable route. Further bottom temperature measurements were made at 550, 1060, 1560 and 2200 fms - the last station being completed at 0900 hrs. on 14th June (165) by which time the wind had freshened to force 7. The magnetometer was streamed and the survey was continued westwards in deteriorating sea conditions. Several reductions in speed were made so as to minimize aeration. However, by midday on 15th June (166) the weather had moderated considerably and we stopped for four hours for an unsuccessful bottom temperature station at 49°45'N, 23°26'W. On arriving at 25°00'W in the early hours of 16th June (167) the first run across the mid-Atlantic Ridge was commenced along the originally proposed cable route with brief stops at 49°26'N, 25°40'W and 48°59'N, 27°28'W for bottom temperature stations. By 17th June (168), the weather had deteriorated again with S. Westerly force 5/6 winds and continuous rain. The first Ridge crossing was terminated at a position 47°39'N, 32°00'W where a further bottom temperature station was occupied. A second traverse was started at 1600 hrs on 17th June (168) and from then on until 0930 hrs. on 23rd June (174) a variety of traverses were made between 25° and 30°15'W, to examine possible alternative routes across the central region of the mid-Atlantic Ridge (Fig. 2). The poor weather prevailed until midday on 19th June (170), but the last four days of the Ridge Survey were conducted in calm seas with light breezes and clear skies. Particular attention was paid to a possible route through the central ridge region

10 miles north and south of latitude 49°N. An alternative route was also examined 40 miles further north and a series of tracks were taken between 28°30' - 30°W to examine the possibility of joining this route with the original proposed cable route position at approximately 49°N, 30°W. The tracks covered during the Ridge Survey were, however, considerably restricted by the position of the TAT 2 cable route and its repeater locations. Bathymetric and magnetic data were continuously recorded during this 6 day survey period except for a brief break between 0055 and 0140 hours on 19th June (170) for engine repairs. The Ridge Survey was terminated at 48°51'N, 30°14'W and an unsuccessful attempt was made to obtain a bottom temperature reading. After a quick assessment of the available data, an optimum cable route was selected through the median valley and the fractured zones of the ridge crest, and in deteriorating weather this route was followed eastwards to 25°W so as to check its suitability. On completion of this final run through the ridge an unsuccessful bottom temperature station was occupied at midday on 24th June (175) before we started on the return track to the U. K. continental shelf along a line approximately 10 miles south of the track taken on the way out. By midday on 25th June (176) the wind had strengthened to gale force. Rough seas and a heavy swell were encountered throughout the return journey and the subsequent surveying on the continental slope. The shelf survey area was reached at 0600 on 26th June (177) and the magnetometer was finally recovered three hours later. The next two days were spent on a detailed bathymetric survey between the 200 and 1200 fm contours of the shelf edge between 50°00' and 50°20'N. On completion of the survey at 0930 hrs. on 28th June (179) the echosounding and navigation watches were stopped before we finally set off on passage back to Falmouth.

Leg 2

The survey party boarded the N. C. Marcel Bayard on 23rd August (235), and set sail that evening in calm, foggy conditions from Carrick Roads, Falmouth enroute for a position at 50°16'N, 10°03'W over the continental slope in the Porcupine Sea Bight. This position was reached on the morning of 24th August (236) and a sounding run was made westwards between the 100 and 400 fm. contours to familiarize the new personnel with the navigation system. During this period two bottom temperature stations were occupied, at depths of 100 and 200 fms. respectively. The survey proper commenced in the evening with a detailed bathymetric survey between the 200 and 600 fm. lines within a range of 3 miles of the proposed cable route. Due to apparent discrepancies between the Satellite Navigator and Loran C readings, a Dan Buoy was used for navigation and the detailed survey was completed by 0800 hrs. on 25th August (237). Following

a successful recovery of the Dan Buoy we proceeded westwards, stopping at 460 and 1000 fms. for further bottom temperature measures, before streaming the magnetometer at 1500 hrs. During the day several adjustments were made to the Loran C aerials to improve signal reception and by midday on 26th August (238) the Loran C navigation was back to normal. The westward traverse to the mid-Atlantic Ridge was made along the outward track of Leg 1 in order to check the repeatability of the bathymetric and navigation data. This run was completed by midnight on 27th August (239) by which time the wind had freshened considerably and the sea was rough with a moderate to heavy swell. The westward run through the mid-Atlantic Ridge was then made with only slight deviation from the optimum route selected on Leg 1. We then proceeded on a great circle route across the Newfoundland Basin to a point just SE of the Newfoundland Rise before commencing on a westerly run across the southern continental rise of the Grand Banks, and finally on a north westerly traverse across the northern end of the Nova Scotia Basin to a point on the Nova Scotian shelf edge just south of Sable Island. Because of rough seas and a heavy swell, most of this traverse from the mid-Atlantic Ridge was run at a reduced speed to minimize aeration and pounding. The Nova Scotian shelf edge survey region was reached just before midnight on 3rd September (246) when the magnetometer was finally recovered. A Dan Buoy was then anchored for navigation purposes in about 400 fms. of water and a detailed bathymetric survey was made over the shelf edge between the 100 and 1200 fms. lines. The bad weather prevailed until the detailed survey was completed at 0300 hrs. on 5th September (248). Three hours later, after having recovered the Dan Buoy, we set off on passage to Halifax, N. S., arriving at 2000 hrs. on the same day.

Leg 3

Sailing from Halifax, N. S., was delayed by thick fog but we finally got underway at 1800 hrs. on 8th September (251) and proceeded to the 100 fm. line position at 43°28'N, 60°10'W on the continental shelf edge. From 1100 hrs. to 1900 hrs. on 9th September (252) a series of bottom temperature measurements were taken down the continental slope on the selected cable route - at depths of 100, 300, 500 and 1000 fms. respectively. On completing these stations the magnetometer was streamed and the sounding run was commenced in a south easterly direction into the Nova Scotia Basin. We deviated eastwards at 52°W and finally crossed over the Newfoundland Rise during the afternoon of 11th September (254). The track up to this point was taken within 1 to 4 n. miles of that taken on Leg 2

and the winds during this period were strong with rough seas and a moderate swell. On passing the Newfoundland Rise we deviated northwards by between 10 and 15 n. miles from our outward route in the hope of by passing a 1500 fm. peak observed at 44°15'N, 39°15'W on the outward run some 45 n. miles NW of Milne Sea Mount. By now a WNW gale was blowing and the ship was rolling heavily. The Milne Sea Mount region was reached during the night of 12th September (255) and, on finding that we were again crossing a peak in this area, we decided to conduct a detailed survey to ascertain the extent of what now appeared to be a ridge. However, as the rough seas and strong winds persisted and Hurricane Ginger was imminent in our area, this survey had to be abandoned before it was started and we were forced to continue at full speed on our homeward run. We proceeded on a route 10 n. miles north of our outward run until 31°N, and then commenced on a final attempt at improving our route through the mid-Atlantic Ridge. This final traverse was started during the morning of 14th September (257) and was interupted at 1700 hrs. for a bottom temperature station on the ridge crest (49°07'N, 28°44'W) just west of the median valley. By now the sea and weather had moderated slightly although conditions were far from ideal. On completing the ridge traverse at 0900 hrs. on 15th September (258) we set off for 50°00'N, 24°00'W and then proceeded eastwards to the U. K. shelf keeping to a line 10 to 15 n. miles north of the proposed cable route. This track was intended mainly to supplement the magnetics taken on the earlier tracks. The weather deteriorated again with strong to gale force SSE winds during the 15th and 16th September. Several speed alterations were required to reduce aeration and rough seas and a heavy swell prevailed until the U. K. continental shelf edge survey region was reached at 0100 hrs. on 17th September (260). The magnetometer was finally recovered at this time and, following a series of four bottom temperature stations between 500 and 100 fms., we stopped logging depths at 1200 hrs. before setting off on our return passage to Falmouth. We arrived in Carrick Roads on the morning of 18th September (261) and disembarked at 0830 hrs.

DETAILED SURVEYS

Detailed bathymetric surveys were conducted over the continental shelf slopes at both ends of the proposed cable route. The transition between the heavier armoured cable to be laid on the continental shelf and the lightweight cable to be laid on the floor of the deep ocean would be made in these areas. It was important therefore, to survey the areas in some detail as such information would be essential to the cable laying ship. Particular attention was paid to the areas between 200 fms. and 600 fms. as it was planned to splice the shelf cable into a transition cable at the 300 fm. contour before

finally connecting up with the lightweight deep ocean cable at 500 fms.

U. K. Continental Shelf Edge (Fig. 3).

It was proposed that the cable route should cross the U. K. shelf edge in a WSW direction in the area of the Porcupine Sea Bight between 50°00'N and 50°15'N. This area was surveyed in two phases. A preliminary bathymetric survey was made at the end of Leg 1 (0800 hrs. on 26th June (177) to 1000 hrs. on 28th June (179)) between the 200 and 1200 fms. contours, i. e. 11-12°W. Five East-West lines were run between 50°08'N and 50°16'N followed by 20 North-South lines between 50°00'N and 50°10'N. The mean line spacing on both sets of lines was 2 to 3 n. miles. The navigation was controlled by quarter-hourly Loran C fixes but the survey was only conducted while the Loran C fixes agreed to within 0. 2 n. miles of those obtained with the Satellite Navigator. As soon as the night time drift of the Loran C started the survey was suspended until the Loran regained stability. On this basis the survey was suspended on two occasions, the first between 2105 hrs. on 26th June (177) and 0500 hrs. on 27th June (178) and the second between 0100 hrs. and 0445 hrs. on 28th June (179). The contoured bathymetric data from this preliminary survey revealed a 100 fm. deep canyon, with its head at 50°00'N, 11°12'W, cutting through the shelf edge for some 20 to 30 n. miles in a NW direction. A more detailed bathymetric survey was conducted at the beginning of Leg 2 between the 200 and 700 fm. lines to the north of the canyon (1915 hrs. on 24th August (236) to 0815 hrs. on 25th August (237).). Nine East-West runs were made at a line spacing of between $\frac{1}{2}$ and 1 n. mile. As some trouble was experienced with the Loran C navigation at this time, it was decided to drop a Mark Buoy on the 400 fm. line for navigation purposes. The position of the Buoy was fixed as 50°12. 3'N, 11°14. 3'W using some five Satellite Navigator fixes taken in conjunction with simultaneous ranges and bearings on the Buoy.

Nova Scotian Continental Shelf Edge (Fig. 4).

The Nova Scotian shelf edge was surveyed in detail at the end of Leg 2 (between 2200 hrs. on 3rd September (246) and 0330 hrs. on 5th September (248)). The survey was conducted roughly at right angles to the shelf edge between 200 fms. and 1200 fms. contours in a region contained within the limits 43°12'N and 43°30'N; 59°41'W and 60°10'W. A box some 8 n. miles wide and 20 n. miles long, orientated in a NW/SE direction, was surveyed by NW/SE lines at a mean track spacing of 1 n. mile. The survey was conducted in two phases during the 4th

September (247) - the first between 0125 hrs. and 1200 hrs. was conducted between the 200 and 700 fm. contours with navigation on a Mark Buoy anchored in 350 fms. The Mark Buoy was fixed, using the Satellite Navigator in conjunction with simultaneous range and bearing readings, at a position 43°25.4'N, 60°03.2'W. Between 1200 hrs. and 2245 hrs. suveying was concentrated between the 700 and 1200 fm. lines using Decca Navigation controlled by occasional Satellite Navigator fixes.

NAVIGATION

The following navigational aids were used:-

(a) Omega.

(b) Decca Chains on Canadian and U.K. Shelves.

(c) Loran 'C' using both airborne and marine versions of the Decca Loran ADL21 receiver.

(d) Satellite Navigation System using an I.T.T. receiver linked with a PDP8 computer. This system was out of action from 1600 hrs. on 14th September (257) until the end of Leg 3, i.e. last 3 days of cruise.

(e) Anchored Dan Buoys.

Great importance was attached to the accuracy of the navigation due to the need to reoccupy the selected route during the actual laying of the cable in 1973. Except during the last 3 days of Leg 3 when the computing system developed a fault, the Satellite navigation system behaved extremely well and was used as the prime navaid. During Leg 1 an average of 16 good Satellite fixes/day was obtained with 12 fixes on the worst day. For Leg 2 the average was 21 good fixes/day with a minimum of 18/day while during the first half of Leg 3 an average of 21/day with a minimum of 19/day was achieved. Interpolation between these fixes was usually made using Loran 'C' fixes taken at quarter-hourly intervals with, whenever possible, 3 Loran chains. During Leg 1 Loran chains SL7W, X and Z were used and, except during the middle of the night when the Loran was noted to drift by the order of $\frac{1}{2}$ to 1 n. mile without losing lock, the Loran readings were usually within 0.3 n. miles of the Satellite points. The Loran behaved equally well during Legs 2 and 3 east of about 40°W, especially during daylight hours. However, at night it was often necessary to use the Satellite Navigator, or Dead Reckoning from the ship's log and gyro, for lane identification. West of 40°W Omega was used as the secondary navaid until the ship was within range of the SS7X and Y chains. The Decca chains were used for secondary navigation on both the Nova Scotia and U.K. continental shelves. Thus, by using the Satellite Navigator in conjunction with the appropriate secondary navaid and the readings of the ship's log and gyro,

a high order of navigational accuracy was obtained. It is estimated to be good to within $\frac{1}{4}$ n. mile except during the last 3 days of the cruise when it was probably reduced to the order of 1 n. mile.

The navigation was digitised from smoothed tracks drawn on $\frac{1}{4}$ million plotting sheets. Navigation points were selected at all course and speed changes and at any other locations necessary so as to provide linearly interpolateable positions at all times lying within $\frac{1}{4}$ n. mile of those on the smoothed $\frac{1}{4}$ million plotting sheet tracks.

BATHYMETRIC MEASUREMENTS

Bathymetric data was collected using a hull mounted ELAC model RGN8BK transducer with an ELAC model LAZ17DD echo-sounder. This system was not a precision depth recorder and daily checks were made to control its accuracy. The rotating band of the recorder was timed daily (with an accuracy of the order of 0.1%) in order to obtain some control on temporal variations in relative accuracy. Such measures revealed that the system speeded up in an almost linear fashion over a range of some 2% during the cruise. Control on absolute accuracy was provided by comparing cross overs in flat areas with tracks obtained by other cruises that had used P.D.R. in conjunction with a good navigation system. Due to the sparsity of such information in the areas of the Cantat II route, this control relied heavily on crossings in the area of the box survey undertaken by Cambridge University in August 1971 using the 'John Murray' between 49-51°N; 18-22°W. A calibration curve was thus constructed for correcting all the depths measured with the ELAC system. At the beginning of Leg 1 this correction produced a 3.4% increase in depth falling to an increase of 1.4% at the end of Leg 3. An indication of the accuracy of the depths so obtained is given below:-

Depth Range (fms)	Reading Accuracy (fms)	Estimated Absolute Accuracy After Calibration (fms)
0-385	$\pm$ 1	$\pm$ (1-2)
385-770	$\pm$ 2	$\pm$ (1-2)
770-1540	$\pm$ 3	$\pm$ (2-5)
1540-3080	$\pm$ 5	$\pm$ (5-10)

Depth was logged continuously during the cruise except during passage between Falmouth and the U.K. shelf edge survey area, and between Halifax and

the Nova Scotia shelf edge survey area. Readings were taken every 5 minutes and also at significant peaks and troughs. The readings were based on an assumed velocity of sound in sea water of 1500 m/sec.

MAGNETIC MEASUREMENTS

Except during temperature stations, shelf edge surveys and passage tracks on the continental shelves, the earth's magnetic field was logged continuously using a Varian Associates proton magnetometer towed some 200 metres astern of the ship. Some 630 hours of magnetic recordings were obtained during the cruise covering a total distance of 7,600 n. miles. The records were digitised every 5 minutes and also at significant peaks and troughs. No corrections were made for either daily variation or the effect of ship's heading.

BOTTOM TEMPERATURE STATIONS

During the three legs of the cruise a total of some 25 bottom temperature stations were attempted using either a single protected reversing thermometer or, in depths of less than 500 fms, a resistance thermometer. Unfortunately, due to the methods and instrumentation used these measurements are considered to be unreliable. In the case of the reversing thermometer measures, an unprotected reversing thermometer should have been lowered as well for calculating the depth at which reversal took place, as should have been a second protected reversing thermometer for checking the repeatability of the bottom temperature reading. The resistance thermometer measures are also suspect due to the long time constant produced by the insulating effect of an excessive cover of epoxy resin over the sensor.

DATA REDUCTION AND STORAGE

The digitised magnetic, bathymetric and navigation data have been punched into card decks in the standard Lamont format (Talwani (1969)) for exchange purposes, and for use in the N. I. O. software package. So as to be compatible with this package the depth card deck has been converted after calibration from an assumed sound velocity of 1500 m/sec. to one of 800 fm/sec. The magnetic, bathymetric and navigation time series have been merged to produce a reduced data file with listings. The International Geomagnetic Reference Field (Mead (1970)) has been removed from the total magnetic field values to produce magnetic anomaly values. All depths have been corrected according to the appropriate Matthews Area Table (Matthews (1939)).

The reduced data files have been used for plotting profiles of magnetic anomaly in gammas, corrected depth in fathoms, together with the ship's speed and course made

good, against distance on the standard Admiralty 1:1,000,000 scales. Numerical values have also been plotted out on 1:1,000,000 charts. Some time in 1972 these and other data will be published in an N. I. O. Geophysics Data Report. The bathymetry produced by the box surveys on the Nova Scotia and U. K. continental shelves has not been digitised and will be produced as contoured plots.

REFERENCES

D. J. Matthews (1939) 'Tables of velocity of sound in pure water and seawater' published by the Hydrographic Department, Admiralty.

G. D. Mead (1970) International Geomagnetic Reference Field 1965. 0 in dipole co-ordinates; Journal of Geophys. Research, Vo. 75 No. 22.

M. Talwani (1969) A computer system for the reduction, storage and display of underway data acquired at sea; Lamont-Doherty Geological Observatory Technical Report No. 1.

TABLE I: DAILY POSITIONS AT 00.00 HRS AND 12.00 HRS G. M. T.

Leg 1

Date	Day No.	00.00 hrs G. M. T.			12.00 hrs G. M. T.		
		Lat(N)	Long(W)	Depth(C. fms)	Lat(N)	Long(W)	Depth(C. fms)
13. 6. 71	164	Passage from Falmouth and Bottom Temperature Stations					
14. 6. 71	165	49°56. 0'	13°20. 6'	1554	49°49. 5'	14°56. 6'	2438
15. 6. 71	166	49°39. 7'	18°02. 4'	2586	49°45. 2'	21°29. 5'	2240
16. 6. 71	167	49°43. 7'	23°57. 8'	2221	49°04. 4'	26°37. 2'	1919
17. 6. 71	168	48°47. 8'	29°17. 8'	1844	47°38. 6'	31°58. 7'	2084
18. 6. 71	169	48°50. 0'	30°13. 0'	1934	49°03. 1'	26°35. 0'	1934
19. 6. 71	170	48°56. 3'	29°09. 8'	1716	49°49. 4'	29°01. 3'	1400
20. 6. 71	171	49°43. 2'	25°41. 1'	2189	49°07. 4'	27°35. 3'	1625
21. 6. 71	172	48°51. 9'	28°38. 8'	1083	49°22. 9'	25°52. 1'	2052
22. 6. 71	173	49°14. 5'	28°58. 6'	1399	49°33. 7'	29°00. 9'	1636
23. 6. 71	174	49°50. 9'	28°46. 5'	1977	48°54. 2'	30°04. 5'	1880
24. 6. 71	175	49°03. 2'	26°27. 0'	1930	49°33. 4'	23°13. 1'	2199
25. 6. 71	176	49°29. 5'	19°48. 2'	2163	49°33. 7'	16°09. 1'	2654
26. 6. 71	177	49°55. 2'	13°24. 3'	1661	50°11. 6'	11°31. 8'	867
27. 6. 71	178	50°16. 0'	11°51. 0'	1100	50°01. 8'	11°28. 5'	551
28. 6. 71	179	50°08. 0'	11°25. 3'	644	Passage back to Falmouth		

Leg 2

Date	Day No.	00.00 hrs G. M. T.			12.00 hrs G. M. T.		
		Lat(N)	Long(W)	Depth(C. fms)	Lat(N)	Long(W)	Depth(C. fms)
24. 8. 71	236	On passage from Falmouth					
25. 8. 71	237	50°14. 1'	11°13. 2'	369	50°11. 1'	11°29. 2'	918
26. 8. 71	238	49°51. 0'	14°23. 1'	2291	49°42. 2'	17°39. 2'	2661
27. 8. 71	239	49°40. 8'	19°55. 2'	2058	49°47. 2'	22°44. 3'	2352
28. 8. 71	240	49°33. 2'	25°12. 9'	2244	48°56. 8'	27°44. 7'	1519
29. 8. 71	241	48°52. 6'	30°12. 1'	1904	47°31. 7'	32°32. 5'	2217
30. 8. 71	242	46°14. 4'	35°12. 1'	2261	45°05. 5'	37°38. 5'	2340
31. 8. 71	243	43°53. 3'	40°04. 9'	2605	42°39. 7'	42°37. 7'	2648
1. 9. 71	244	41°34. 1'	44°54. 7'	2672	40°36. 2'	46°57. 6'	1971
2. 9. 71	245	39°52. 5'	49°40. 3'	2960	39°58. 7'	52°22. 7'	2886
3. 9. 71	246	40°56. 4'	54°52. 4'	2750	42°08. 2'	57°22. 6'	2577
4. 9. 71	247	43°25. 4'	60°03. 2'	380	43°19. 6'	60°01. 4'	797
5. 9. 71	248	43°28. 7'	60°04. 2'	158	Passage to Halifax		

TABLE I: cont.

Leg 3

Date	Day No.	00.00 hrs G. M. T.			12.00 hrs G. M. T.		
		Lat(N)	Long(W)	Depth (C. fms)	Lat(N)	Long(W)	Depth (C. fms)
9.9.71	252	Passage from Halifax and Bottom Temperature Stations					
10.9.71	253	42°46.0'	58°44.1'	2214	41°16.4'	55°39.8'	2685
11.9.71	254	40°00.7'	52°25.3'	2877	39°59.8'	48°49.8'	2452
12.9.71	255	41°10.4'	45°40.1'	2597	42°40.7'	42°56.1'	2691
13.9.71	256	44°11.6'	39°54.9'	2537	45°41.5'	36°50.1'	2548
14.9.71	257	47°06.5'	33°46.2'	2227	48°45.7'	30°22.1'	1877
15.9.71	258	48°57.2'	27°18.4'	1700	49°57.5'	24°07.0'	2136
16.9.71	259	49°58.5'	20°58.5'	1929	49°59.2'	16°24.1'	2624
17.9.71	260	50°02.7'	12°21.3'	1172			
18.9.71	261	Passage to Falmouth and Bottom Temperature Stations					

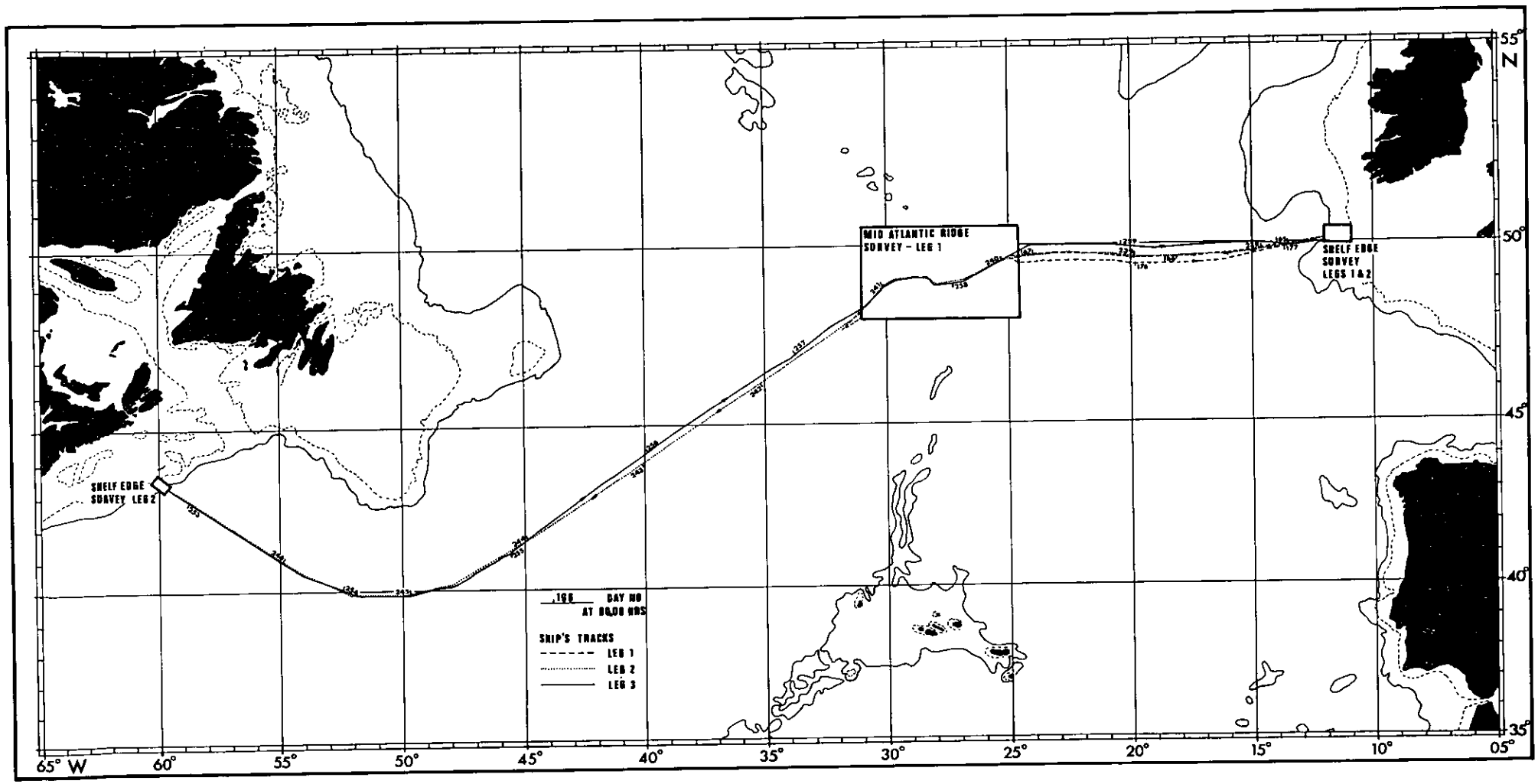

Fig. 1

CANTAT II OCEAN SURVEY CRUISE 1971

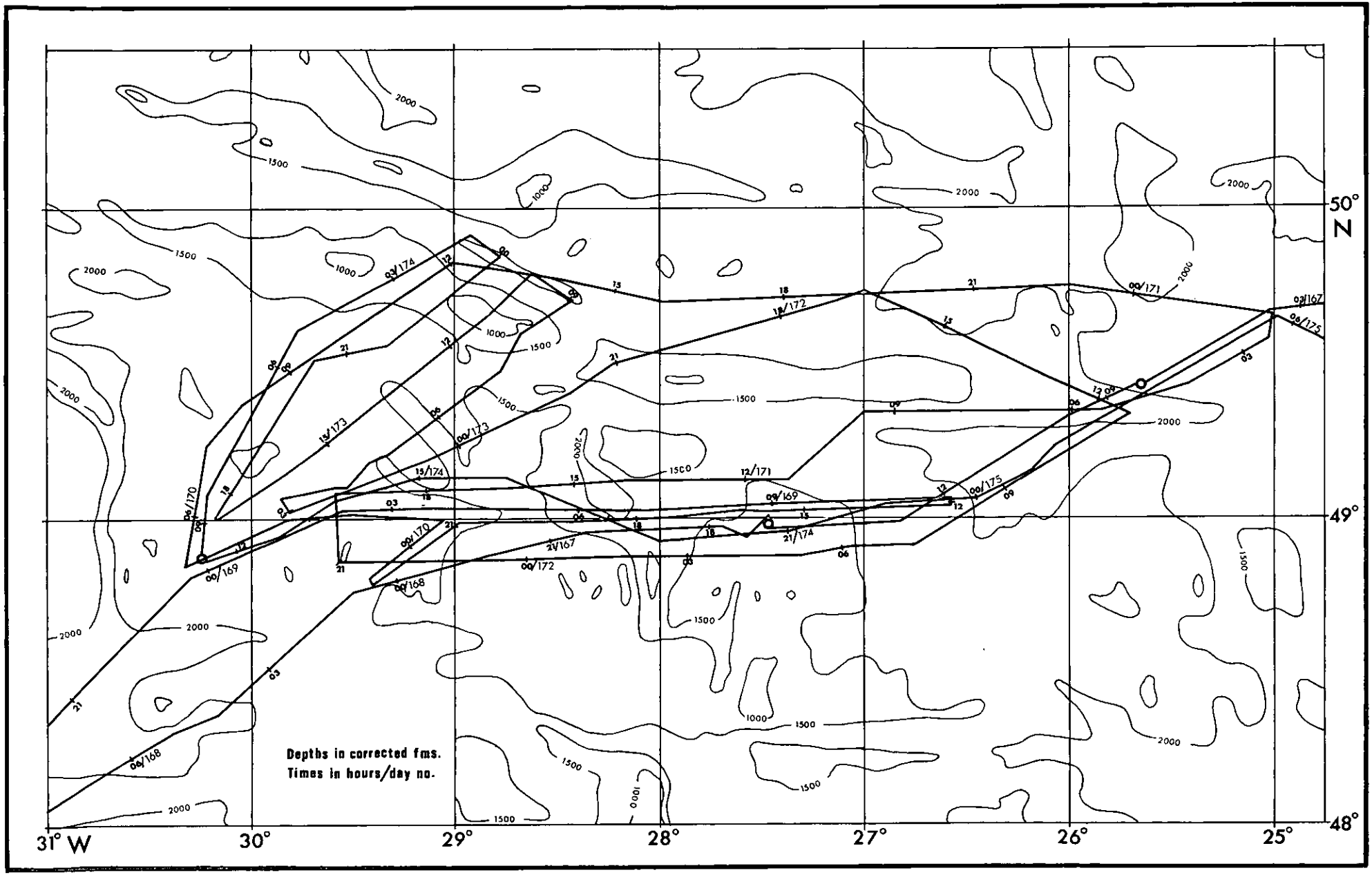

Fig. 2 LEG 1: MID-ATLANTIC RIDGE SURVEY

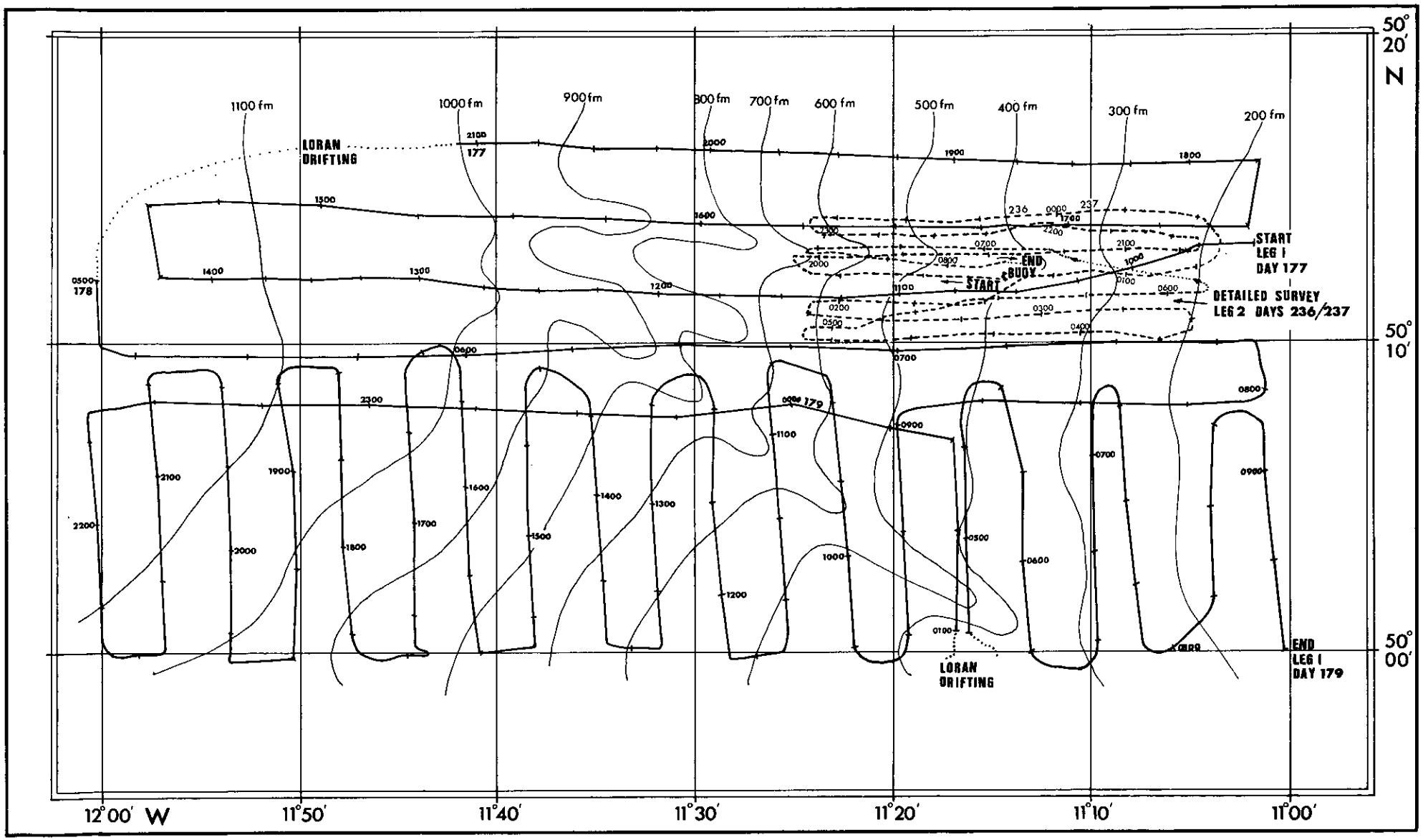

Fig.3 LEGS 1& 2; UK SHELF EDGE SURVEYS

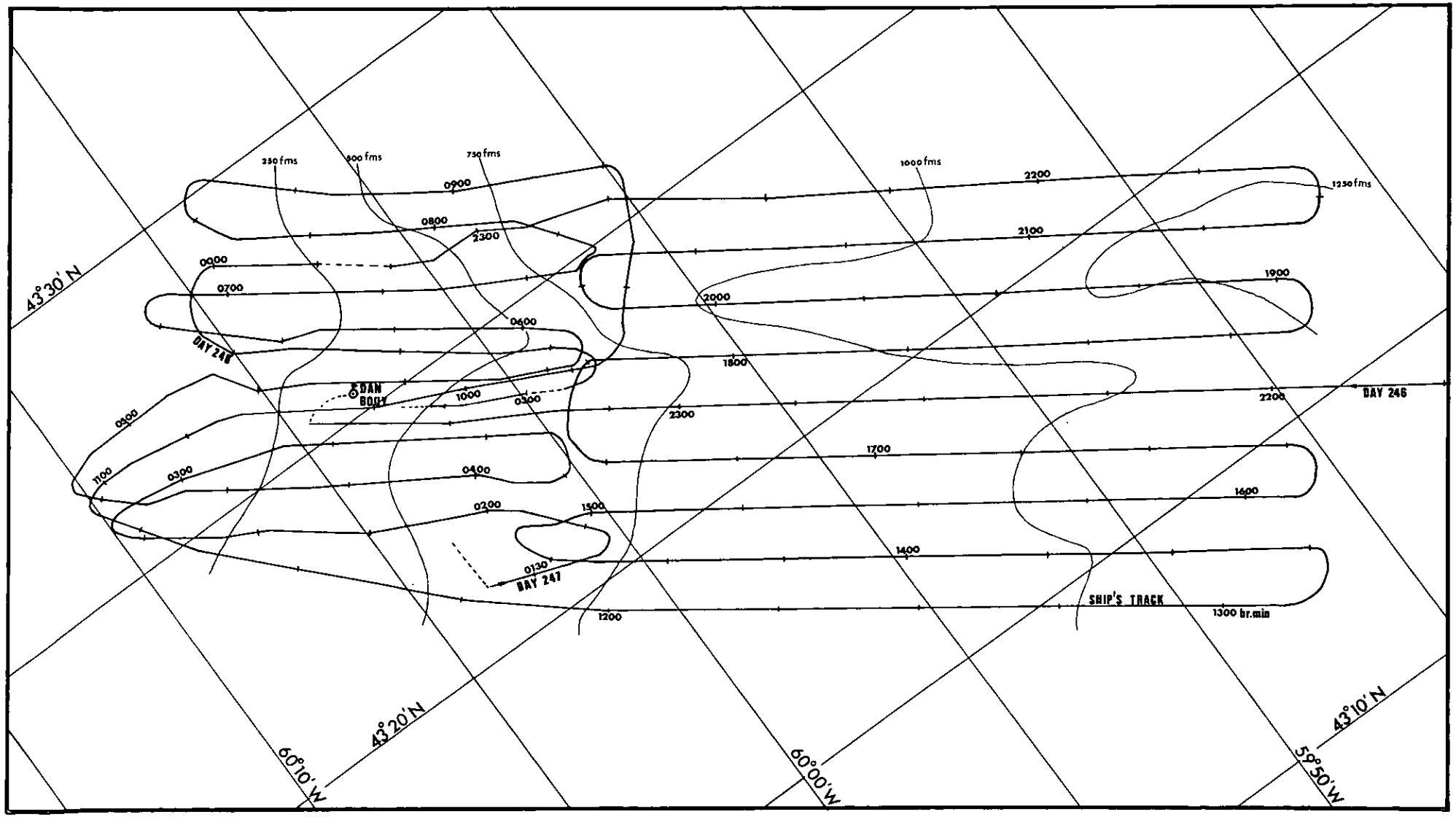

Fig.4 LEG 2: NOVA SCOTIA SHELF EDGE SURVEY