P.O.L.

RRS CHALLENGER

CRUISE 10/87 and 12/87

27 January - 7 February 1987

11 March - 21 March 1987

CURRENT PROFILES

CELTIC SEA

CRUISE REPORT NO.6

1989

NATURAL ENVIRONMENT RESEARCH COUNCIL

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RRS CHALLENGER

Cruise 10/87 : 27 January - 7 February 1987

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Current Profiles
Celtic Sea

Principal Scientists

M.J. Howarth

A.J. Harrison

1989

DOCUMENT DATA SHEET

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ABSTRACT

RRS "Challenger" 10/87 and 12/87 formed a pair of cruises, the first for the deployment and the second for the recovery of moored instruments, with the objective of measuring the vertical variation of currents with depth in an area of weak tidal currents during well-mixed conditions. The cruises followed on from RRS "Frederick Russell" 7/85 and 9/85 (in August and October 1985), when stratified conditions were studied. The plans for both the 1985 and 1987 experiments were similar in conception - a main site where the majority of moorings were concentrated (eleven in 1987), with several (three in 1987) satellite sites to measure horizontal gradients. As well as measuring currents and current profiles, particularly near the sea surface, the instruments measured sea bed pressures, winds and waves. Both in 1985 and 1987 shore-based HF radar systems were deployed to measure surface currents, in 1987 the University of Birmingham's system with transmitters/receivers near Milford Haven and Hartland Point. The longer range of this system enabled the main site to be further offshore, in the centre of the Celtic Sea. Thirteen moorings were left in the sea at the end of RRS "Challenger" 10/87, all of which were recovered during RRS "Challenger" 12/87, giving six week record durations. Since the techniques for measuring current profiles are still being developed (particularly recording acoustic doppler current profilers, ADCPs), there was also an element of instrument testing which involved several shorter period trial deployments during each cruise. An innovation for the 1987 experiment was the use and evaluation of a ship-mounted ADCP system. During both cruises CTD surveys were carried out to determine the structure of the temperature, salinity and density field.

Since the ship was in the area, the opportunity was taken on both cruises to service offshore pressure recorders at three sites at the mouth of the Bristol Channel, part of a separate experiment studying surges there.

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CHALLENGER/RRS-CRUISE(1987)(10)
CHALLENGER/RRS-CRUISE(1987)(12)

CONTRACT

PROJECT LS-21-2

PRICE

SCIENTIFIC PERSONNEL

10/87	M.J.	Howarth	(Principal Scientist)
	G.	Ballard	
	D.	Flatt	
	J.S.	Galloway	(Wimpol)
	A.J.	Harrison	
	A.G.	Kerr	
	P.J.	Knight	
	D.L.	Leighton	
	R.I.R.	Palin	
	J.	Perrett	(IOS Wormley)
	R.W.	Powell	(RVS)

12/87	A.J.	Harrison	(Principal Scientist)
	G.	Ballard	
	A.D.	Banaszek	
	D.	Flatt	
	K.P.	Hubbert	
	C.A.	Hunter	(IOS Wormley)
	A.G.	Kerr	
	D.L.	Leighton	

SHIP'S OFFICERS

	10/87	12/87
Master	S. Mayl	P. Maw
Chief Officer	B. Richardson	B. Richardson
Second Officer	P. Oldfield	R. Chamberlain
Third Officer	G. Proctor	C. Leather
Chief Engineer	D. Rowlands	D. Anderson
Second Engineer	G. Gimber	G. Robertson
Third Engineer	A. Greenwood	R. Perrian
Electrical Engineer	P. Edgell	B. Smith
Bosun	R. Sullivan	R. MacDonald

ACKNOWLEDGEMENTS

It is a pleasure to thank the master, officers and crew of RRS Challenger for their willing assistance and cooperation, which contributed greatly to the success of the experiment.

OBJECTIVES - OVERALL

To obtain measurements of the vertical variation of current with depth in an area of weak tidal currents during well mixed conditions.

To obtain the necessary supporting measurements (winds, waves, density field, gradients of currents and pressures) to interpret these current profile measurements.

Rigs will be deployed during RRS Challenger 10/87 and recovered during RRS Challenger 12/87. This experiment complements similar measurements obtained in August - October 1985 when stratified conditions were being studied (Howarth & Harrison, 1989).

OBJECTIVES - 10/87

1) To deploy 17 moorings at sites A, B, C and D, Table 1; 11 of the moorings being concentrated at site A. The instruments measure currents and current profiles, with some emphasis on measurements near the sea surface; sea bed pressures; winds and waves. An element of the experiment involves test deployments of new instruments, mainly self-contained Acoustic Doppler Current Profilers (ADCPs), including one on loan from RDI; see also 2 below. To recover three moorings (3, 4 and 6).

2) To evaluate the recently fitted ship mounted ADCP.

3) To measure the temperature and salinity (and hence density) field in the vicinity of the moorings. Both surface monitoring and CTD profiles to be recorded. The CTD profiles to be widely spaced unless unexpected stratification is encountered.

4) To recover two and deploy three pressure recorders in the Bristol Channel at sites E, F and G (part of a separate study).

5) Related to the NURWEC2 experiment (Van Heteren, 1988) to recover a waverider buoy at site H and redeploy it at site A, to deploy a WAVEC directional wave buoy at site H and to search for a lost current meter rig at 51 21.30N 6 12.06E. This experiment involves the University of Birmingham's HF radar wave and surface current measuring system, which will be concentrated on site A during 10/87 (Venn et al., 1988).

NARRATIVE - 10/87

RRS Challenger left Birkenhead docks at 09.00 27 January 1987 for site A, see Fig.2a for the track chart. On the way she stopped twice, firstly at 15.40, off Anglesey, to deploy both the surface monitoring pump and the PES fish and secondly, from 21.00 to 21.35, for wire testing of acoustic releases. The surface monitoring pump fits into a shoe on the side of the ship and pumps water into a bath on the deck in which the

CTD sits. On arrival at site A at 11.30 28 January the ship mounted ADCP was switched on and rig deployment started, interrupted at intervals by acoustic release wire tests. A complete account of each rig follows the narratives, whilst a brief description is given in Table 1. During 28 January five rigs were deployed - the met. buoy (rig 10, 12.13-12.28); the POL 250 kHz ADCP in a sea bed frame (Flatt et al., 1988, rig 5, 14.55-15.00); a satellite buoy which measured currents 2 m below the surface (Collar et al., 1988, rig 1, 15.35-15.51); a loaned RD Instruments 300 kHz ADCP in a modified MkIV pressure recorder sea bed frame (rig 4, 18.05-18.11); another satellite buoy, with its sensor 1 m below the surface (rig 2, 19.11-20.06). As no more rig deployment could take place that night Challenger set course eastward in the hope of contacting a Belgian trawler, the 'Philadelphia', which had reported picking up one of the Bristol Channel pressure recorders off Hartland Point (presumably from site E). However at 23.20 the Hartland coastguard was contacted and reported that the 'Philadelphia' had now left the fishing grounds to return to Belgium. Challenger, therefore, returned to site A for more rig deployments the next day.

During 29 January another five rigs were deployed - a 1 MHz ADCP mounted about 20 m below the surface on a sub-surface mooring (10.52-10.59, rig 3, Griffiths & Flatt, 1987); an ETA rig with three vector-averaging current meters suspended beneath a tethered toroidal surface buoy (rig 6, 13.00-14.02); a pop-up current meter rig with three near surface vector-averaging current meters (rig 7, 15.21-15.32); a pop-up Aanderaa current meter rig (rig 8, 17.09-17.17); and finally a combined pressure recorder and current meter in a bottom frame with a U-shaped mooring (rig 9, 19.40-20.20).

On completion of the mooring deployments at site A the first CTD profile was recorded at 20.30, and the second at 23.00 during the westward journey to site B. A complete list of CTD profiles is given in Table 2 and their positions are shown in Figure 2. On arrival at site B a U-shaped Aanderaa current meter mooring was deployed (rig 12, 12.08-12.43 30 January) followed by a pop-up pressure recorder (rig 13, 13.43-13.53). The third CTD profile was recorded at 14.15, succeeded by acoustic wire tests. The sea-bed ADCP was not deployed since it was not ready and since another visit to the site was planned later in the cruise. Because there was sufficient time to be at site C by daybreak the next day the westward course was continued to 51N 10W, where CTD number four was recorded at 20.05, before setting course for site C.

When this was reached, at 08.00 31 January, a U-shaped Aanderaa current meter mooring was deployed (rig 14, 09.20-09.47) followed by a

pop-up pressure recorder (rig 15, 10.35-10.42) and CTD profile 5 (11.00). The next destination was St. Ives Bay for daybreak the following day to pick up the pressure recorder recovered by the 'Philadelphia' and unloaded in Penzance. Since again there was sufficient time, a southwesterly course was first set for 50N 8 40W to record CTD profile 6 at 15.00 before turning eastward. The transfer of the pressure recorder from a small boat in St. Ives Bay was completed by 07.25 1 February.

At site D a U-shaped Aanderaa current meter mooring was deployed (rig 16, 10.00-10.27), completing the majority of deployments at sites A, B, C and D, and followed by CTD profile 7 at 10.35. A dog-leg course was set for site F in order to search for a missing Rijkswaterstaat mooring at 51 21.30N 6 12.06W. The visual search took place in rain and rough seas from 16.45 to 19.15, both in daylight and after dark (looking for the surface buoy light), but was not rewarded. CTD profile 8 was recorded there at 18.10. The course for site F was recommenced, with Challenger steaming eastward in a beam sea generated by 30 knot winds from the south, when the pipe bringing water up to the deck for the surface monitoring system broke. Challenger hove to at 21.30 in order to recover the pump, now secured only by its stays, and steaming was resumed at 22.00 when everything had been safely brought in board.

Site F was reached at 03.00 2 February, the bottom pressure recorder's acoustics were switched on at 03.17 and the instrument recovered in daylight at 08.03. An excursion to site H and back now took place during which the pressure recorder was prepared for redeployment. At site H, off Milford Haven, a WAVEC directional wave recorder was deployed, 12.50-12.57, and a recording waverider recovered. The waverider was located at 11.00 but was not recovered until slack water, when the Zodiac was launched in order to uncouple the buoy from its mooring and tow it to the ship, 13.34. The rest of the mooring was recovered through Challenger's A frame by 14.03. The WAVEC provided in situ directional wave measurements to compare with estimates from the University of Birmingham's HF radar system. Surface monitoring of temperature and salinity recommenced at 14.13 when the CTD bath was connected to the non-toxic supply. Site F was revisited (see Fig.1b for the continued cruise track) and the pressure recorder redeployed at 17.21.

Challenger now returned to site A to check the moorings and to obtain a tidal cycle (12 1/2 hours) of ship ADCP data to compare with the moored current meter measurements. The site was reached at 04.50 on 3 February and all the surface buoys checked. The recording waverider was deployed

at 09.12, as rig 20. The time during the tidal cycle was spent in executing a depth survey of the site (14.00 - 16.30) and in searching for the buoyant line and pellet floats marking the bottom current meter / pressure recorder frame, which were not visible. The line was not found despite a search with the Zodiac and at slack water - the danger being that it might get wrapped round the frame and impede the rotors. CTD profile 9 was recorded from 11.30-12.00. During the night, starting at 19.00, an excursion was executed - north to 51 30N 7W, west to 51 30N 8W and back to A - to sample the temperature, salinity (through the surface sampling system) and the velocity fields (ship ADCP) to the north of A, towards the Irish coast.

The excursion finished back at site A at 07.00 4 February for a day of rig recoveries and deployments. The plan before sailing had been to recover four rigs (3, 4, 6 and 7) and to redeploy one (7) with fewer instruments. However since we were now informed by telex from Wormley that one of the satellite buoys, rig 2, was not transmitting it too had to be recovered. The recoveries went in quick succession from 07.50 to 12.29, in rig order 6, 7, 4, 3, with no problems. CTD profile 10 was recorded at 13.05 and rig 7 redeployed with only one current meter by 13.53. Rig 2 was now recovered with the aid of the Zodiac to attach a stray line to the satellite buoy, by 15.18. The buoy was checked and redeployed by 20.54. The RDI self-contained ADCP on loan from the manufacturer (rig 4) had unfortunately not recorded any data. Although it later transpired that a malfunction with the data logger in the instrument was responsible, after some effort (there had been little time to gain familiarity with the instrument prior to sailing and the handbook was not over informative to the unitiated) the instrument was persuaded to record data on the ship. A second deployment was therefore attempted even though only a few days were left in which to obtain data. After the bottom frame had been deployed, at 21.43, a course was set for site B.

There rig 12's surface buoy was checked and the sea bed ADCP (rig 11), which was now ready, was deployed at 11.06 5 February. The next two days (until 08.00 on 7 February, back at site A) were spent firstly in deeper water trials of the ship-borne ADCP system, and secondly in establishing the temperature and salinity (and also the velocity) gradients to the southwest of Ireland. So far the ship-mounted ADCP system appeared to have worked well, recording the absolute velocity profile since in continental shelf seas the instrument also measures the ship's speed over the ground from the doppler shift in a bottom return. As the water depth increases crossing the shelf break the bottom return

becomes too weak and then relative profiles only can be recorded - the ship's navigation, based on mainchain Decca, Transit Satnav, Omega or Loran, is not precise enough for the necessary calculation of the ship's speed. Hence to gain experience of deeper water measurements and to determine the range of the instrument and the water depth at which the bottom lock was lost a westward course was taken toward the shelf edge. On the way CTD profiles 11 and 12 were recorded. The shelf break was crossed in the early hours of 6 February, at which time the wind was blowing strongly from the west, up to 35 knots. An upper limit on the instrument range appeared to be of order 400 m and on the depth where bottom lock was lost to be of order 500 m - values which are frequency dependent; this instrument transmitted on 150 kHz. The trial continued until 02.45 when the course was changed to northeastward. At 51 40N 10 30W, at 08.12, the course was altered to southeastward to zig-zag round southwest Ireland. CTD profile 13 was recorded at 11.10. Site C was visited at 23.27 and the surface buoy sighted.

Two moorings were due for recovery at site A - the satellite buoy, rig 2, since its transmitter was still not working and the ADCP on loan from RDI, rig 4. After this had been accomplished without problems (07.50 - 09.28 7 February) the other surface buoys were checked and CTD profile 14 recorded (10.20). The RDI ADCP was checked and this time found to have recorded some data, although it later transpired not without regular gaps. A course was now set for the Dutch current meter site, which was reached at 14.15 when 5 1/2 hours were spent fruitlessly dragging with the gifford grapnel. The pressure recorder at site E was deployed at 08.00 8 February whence a course was followed up the Bristol Channel to site G. On arrival, at 14.10, the site was surveyed until slack water when the pressure recorder was deployed (15.38), CTD profile 15 recorded (15.45) and the PES fish brought in board. Surface sampling was stopped. A course was set for Barry, the ADCP was stopped at 19.25 and Challenger docked at 01.10 9 February.

The cruise was very successful, with all five objectives attained. In part this can be ascribed to the suitability of Challenger for this kind of work and the competence of the people on board but also to the fact that conditions were good for winter so that no time was lost through bad weather. During the cruise 33 rigs were deployed or recovered and 15 CTD profiles recorded. The ship mounted ADCP system showed great promise and represents an improvement to the scientific facilities on board Challenger. The sensor head had been newly fitted, whilst the controlling electronics were borrowed from ARE, Portland, whose cooperation is gratefully acknowledged. The system was used for the

first time on the previous cruise (RRS Challenger 9/87), whilst for the present cruise the transfer of information from the ship's gyro was incorporated into the system so that currents orientated relative to the Earth were displayed and recorded.

OBJECTIVES - 12/87

1) To recover 13 moorings left in the sea after 10/87 at site A, B, C, and D.

2) To deploy and recover moorings for instrument trials (five).

3) To measure the temperature and salinity fields in the vicinity of the mooring sites and at the same time to operate the ship's ADCP.

4) To redeploy a pressure recorder at site E, in the Bristol Channel, and to check the acoustics of the pressure recorders at sites F and G there.

NARRATIVE - 12/87

RRS Challenger sailed from Barry at 14.09 Wednesday 11 March (Fig. 3a) and by 16.50 site G (BCS1) was occupied and the position of the bottom pressure recorder verified by activating its acoustic pinger but recovery was not attempted at this time. The surface water sampling system was set into operation at 17.10 using the ship's non-toxic pump. Then the ship set a course for site A and arrived at 07.00 the following morning, 12 March. Recovery of the first mooring, rig 9, the bottom mounted current meter / pressure recorder started at 08.02 and was successfully completed by 08.57. This was followed by rigs 8 and 7, two pop-up current meter moorings, which were inboard by 10.06 and 10.43 respectively. CTD profile 16 was recorded at 11.20 and the pop-up ADCP system (no. 1, rig 5) recovered by 12.08. Deployment of rig 3, the 1 MHz moored ADCP, rig 6, the surface current meter mooring and rig 2, the satellite buoy, were all successfully carried out by 15.03, 18.39 and 19.22 respectively. This completed the day's work at site A and after checking operation of the satellite buoy the ship left at 21.00 to carry out CTD casts nos. 17, 18 and 19 on route to site B, see Fig. 4 for a map of the CTD positions.

At 08.05, Friday 13 March recovery of rig 12 at site B started and continued until 08.58 when the 'U' current meter mooring was completed. Successful recovery of the no. 2 ADCP system, rig 11, and the pop-up pressure recorder no. 7, rig 13, followed at 09.18 and 09.51 respectively, completing the work at this site. The ship headed to site C and on arrival CTD profile 20 was recorded at 15.15. The second bottom pressure recorder, no. 8 - rig 15, was recovered by 15.30, followed by the 'U' current meter mooring, rig 14, at 16.19. This concluded the work at site C and so the CTD section along the southern boundary was carried out with profiles 21 to 26 en route to site D.

On arrival there was no sign of the surface buoy marking the 'U' current meter mooring, rig 16, so attempts were made to drag for the

ground line with the aid of the pinger which showed that the rig was half a mile out of position. Dragging continued until slack water when the pellet floats marking the sub-surface buoy were sighted on the surface. A line was attached by the ship's Zodiac and the mooring eventually recovered at 13.13 when the free end of the buoy line was brought aboard and showed that it had been cut by a blow torch.

CTD profile 27 was recorded on the way to site E and on arrival profile 28, at 17.53. The pressure recorder, rig 17 (BCS2), was located on position and recovered at 18.32 then after re-furbishment was re-laid at the same position at 21.44. CTD profile 29 was recorded in passage to site F (BCS3) and profile 30 on this site at 03.04, Sunday 15 March. The position of the pressure recorder was verified by activating its pinger but the recorder was not recovered. The CTD section continued to the west along the northern boundary with profiles 31 to 37, then southeast to site A with profiles 38 to 41.

All the moorings previously set at site A were inspected and found to be in good order. ADCP no. 2 was prepared for re-deployment as rig 5A and eventually set on the sea bed at 13.22, Monday 16 March. A 13 hour fixed current profiling station using the ship's ADCP system started at 14.17 and continued until 03.30, Tuesday 17 March, with CTD profile 42 at 03.00. The CTD section to the west of site A was continued, with profiles 43 to 48, see Fig. 3b for the continued cruise track. However, engine failures in the face of a westerly gale forced Challenger to seek shelter off the Irish coast at Courtmacsherry Bay throughout Wednesday 18 and Thursday 19 March.

With improvement in the weather site A was re-occupied for the final time at 07.00, Friday 20 March when recovery of all seven moorings at the location started at 08.00 and was successfully completed at 15.40, in the order rig 6, surface current mooring; rig 5A, no.2 ADCP; rig 3, 1 MHz ADCP mooring; rig 20, waverider; rig 1, satellite buoy; rig 2 satellite buoy; rig 10 met. buoy. CTD profile 49 concluded the work at site A and the ship left at 16.15 on a heading of 242 degrees to continue with the CTD sections. However, after CTD profile 50 at 19.40, the problems with the main engines recurred and the captain decided to end the cruise and head for Barry, the ship eventually docking at 13.40, Saturday 21 March.

This, too, was a highly successful cruise, with all four objectives achieved despite losing two days through bad weather and having the cruise curtailed by four days (it was due to finish on 25 March) because of problems with the main engines. During the cruise 25 rigs were deployed or recovered, with all 13 of the rigs left in the sea at the

end of Challenger 10/87 recovered, giving record durations of 6 weeks. Problems were encountered with only one rig (at site D), which was half a mile off station. The lack of losses contrasted with the 1985 experiment - a plausible explanation being the presumption that fishing activity was less both because it was winter and because no rigs were deployed close to the coast. The effect of the lost time was to reduce the extent of the CTD and ADCP survey although even so 35 CTD profiles were recorded, giving an acceptable coverage in the vicinity of the mooring sites.

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RIG REPORTS

Rig 1 - Site A

Instrument	:	Satellite buoy with electro-magnetic current sensor 2m below the sea surface.
Mooring	:	Single-point with sub-surface buoy.
Deployment	:	15.35 - 15.51 28 January 1987; surface buoy first.
Meter in water	:	15.37
Water depth (m)	:	98
Position/Decca 1B	:	51 00.3N 7 01.2W : -, D41.40, F67.80
Recovery	:	11.30 - 11.54 20 March 1987
Buoy grappled	:	11.33
Meter out of water	:	11.47
Position/Decca 1B	:	51 00.3N 7 01.3W : -, D41.59, F67.68

Rig 2 - Site A

Instrument	:	Satellite buoy with electro-magnetic current sensor 1m below the sea surface.
Mooring	:	Single point with sub-surface buoy.
Deployment	:	19.11 - 20.06 28 January 1987; surface buoy first.
Meter in water	:	19.22
Water depth	:	98
Position/Decca 1B	:	51 00.1N 7 01.9W : -, D42.10, F67.35
Comments	:	Buoy towed for 25 minutes at 3 knots whilst
	:	returning to station.
Recovery	:	14.33 - 15.18 4 February 1987
Meter out of water	:	15.03
Position/Decca 1B	:	50 59.9N 7 02.0W : -, D42.06, F67.30
Comments	:	Transmitter not working. For recovery Zodiac
	:	deployed to attach line to buoy.
Deployment	:	20.40 - 20.54 4 February 1987; surface buoy first.
Meter in water	:	20.45
Water depth (m)	:	98
Position/Decca 1B	:	51 00.0N 7 02.0W : -, D42.21, F67.16
Recovery	:	08.53 - 09.28 7 February 1987
Meter out of water	:	09.18
Position/Decca 1B	:	51 00.1N 7 02.0W : -, D42.04, F67.62
Comments	:	Transmitter not working. For recovery Zodiac
	:	deployed to attach line to buoy.
Deployment	:	19.14 - 19.22 12 March 1987; surface buoy first.
Meter in water	:	19.16
Water depth (m)	:	96
Position/Decca 1B	:	50 59.6N 7 00.1W : -, D41.65, F67.00
Recovery	:	13.35 - 14.09 20 March 1987
Buoy grappled	:	13.58
Meter out of water	:	14.03
Position/Decca 1B	:	50 59.5N 6 59.9W : -, D41.54, F66.70

Rig 3 - Site A

Instruments	:	1 MHz acoustic doppler current profiler at 70m
	:	above the sea floor, pointing upward.
	:	Aanderaa temperature and pressure recorder at
	:	65m above the sea floor.
Mooring	:	Pop-up. Polo floats (5 and 6).
Deployment	:	10.52 - 10.59 29 January 1987; meter first.
Meter in water	:	10.55
Water depth (m)	:	96
Position/Decca 1B	:	51 00.0N 7 01.7W : -, D42.08, F67.32
Recovery	:	11.45 - 12.29 4 February 1987
Release fired	:	12.08
Meter out of water	:	12.29
Position/Decca 1B	:	: -, D42.0 , F67.3
Comments	:	No data were recorded by doppler;
		fault with the tape.
Deployment	:	14.58 - 15.03 12 March 1987; meter first.
Meter in water	:	14.58
Water depth (m)	:	98
Position/Decca 1B	:	51 00.1N 7 00.7W : -, D41.41, F67.45
Recovery	:	09.14 - 09.44 20 March 1987
Release fired	:	09.29
Meter out of water	:	09.43
Position/Decca 1B	:	51 00.1N 7 00.7W : -, D41.40, F67.46

Rig 4 - Site A

Instrument	:	300 kHz acoustic doppler current profiler
	:	on loan from the manufacturers, RD Instruments.
Mooring	:	Pop-up sea bed frame - converted from MkIV
	:	pressure recorder frame.
Deployment	:	18.05 - 18.11 28 January 1987
Meter in water	:	18.07
Water depth (m)	:	96
Position/Decca 1B	:	51 00.6N 6 59.9W : -, D39.96, F67.52
Recovery	:	10.25 - 11.12 4 February 1987
Release fired	:	10.59
Meter out of water	:	11.12
Position/Decca 1B	:	: -, D41.04, F67.42
Comments	:	No data were recorded; logger malfunction.
Deployment	:	21.39 - 21.43 4 February 1987
Meter in water	:	21.43
Water depth (m)	:	98
Position/Decca 1B	:	51 00.2N 6 59.8W : -,D40.80, F68.20
Recovery	:	07.50 - 08.14 7 February 1987
Release fired	:	08.00
Meter out of water	:	08.14
Position/Decca 1B	:	50 59.4N 7 00.0W :

Rig 5 - Site A

Instrument	:	250 kHz acoustic doppler current profiler, no. 1.
Mooring	:	Pop-up sea bed frame. Acoustic release 2470c.
Deployment	:	14.55 - 15.00 28 January 1987
Meter in water	:	14.57
Water depth (m)	:	98
Position/Decca 1B	:	51 00.3N 7 00.8W : -, D41.23, F67.74
Recovery	:	11.35 - 12.08 12 March 1987
Release fired	:	11.54
Meter out of water	:	12.08
Position/Decca 1B	:	51 00.3N 7 00.7W : -, D41.30, F67.78
Instrument	:	250 kHz acoustic doppler current profiler, no. 2.
Mooring	:	Pop-up sea bed frame, no. 15;
	:	acoustic release 2471bc
Deployment	:	13.16 - 13.22 16 March 1987
Meter in water	:	13.18
Water depth (m)	:	94
Position/Decca 1B	:	51 00.2N 7 00.6W : -, D41.28, F67.65
Recovery	:	08.43 - 09.13 20 March 1987
Release fired	:	09.03
Meter out of water	:	09.13
Position/Decca 1B	:	51 00.1N 700.4W : -, D41.24, F67.55

Rig 6 - Site A

Instruments	:	Three vector averaging current meters :-
	:	S4 no. 04020639 (Wimpol), VAECM no. 1 (Wormley),
	:	VAECM no. 10 (Wormley) at 5, 9, 17m below the
	:	sea surface.
Mooring	:	Eta rig. Meters suspended beneath a tethered
	:	surface toroidal buoy, no. 4. Spherical command
	:	pinger S17; 32" sub-surface buoy no. 28;
	:	acoustic release no. 2421.
Deployment	:	13.00 - 14.02 29 January 1987; meters and
	:	surface buoy first.
Meters in water	:	13.16, 13.23, 13.28 (bottom to top)
Water depth (m)	:	96m
Position/Decca 1B	:	50 59.8N 7 00.4W : -, D41.50, F67.26
Recovery	:	07.50 - 09.04 4 February 1987
Release fired	:	08.25
Meters out of water	:	08.54, 08.57, 09.00 (top to bottom)
Position/Decca 1B	:	: -, D41.55, F67.49
Instruments	:	Three VAECMs, no.s 1 (Wormley), 2 (Wormley),
	:	BD2 (Bidston) at 5, 10, 18m below the sea surface.
Mooring	:	Eta rig. Meters suspended beneath a tethered
	:	toroidal surface buoy, no.4. Spherical command
	:	pinger no. S21; 32" sub-surface buoy no. 15;
	:	acoustic release no. 2164.
Deployment	:	17.54 - 18.39 12 March 1987; meters and surface
	:	buoy first.
Meters in water	:	18.05, 18.10, 18.16 (bottom to top)
Water depth (m)	:	96
Position/Decca 1B	:	51 00.2N 6 59.9W : -, D40.91, F67.58
Recovery	:	07.50 - 08.42 20 March 1987
Release fired	:	08.08
Meters out of water	:	08.32, 08.35, 08.38 (top to bottom)
Position/Decca 1B	:	51 00.1N 6 59.7W : -, D40.86, F67.66

Rig 7 - Site A

Instruments	:	Three vector averaging current meters :-
	:	VAECM no. 2 (Wormley), S4 no. 04590852 (Wimpol),
	:	VAECM no. BD2 (Bidston) at 61, 67, 73m above
	:	the sea floor.
Mooring	:	Pop-up. 32" sub-surface buoy no. 15;
	:	back-up buoyancy; acoustic release no. 2473.
Deployment	:	15.21 - 15.32 29 January 1987; buoy first.
Meters in water	:	15.27 - 15.28 (top to bottom)
Water depth (m)	:	97
Position/Decca 1B	:	50 59.7N 6 59.8W : -, D41.30, F67.33
Recovery	:	09.05 - 10.23 4 February 1987
Release fired	:	09.18
Meters out of water	:	10.22
Comments	:	Since the mooring came to the surface too close to
	:	another rig (9) for the ship to manoeuvre there was
	:	an hour's wait whilst the mooring drifted clear.
Instrument	:	VAECM BD2 (Bidston) at 72m above the sea floor.
Deployment	:	13.47 - 13.53 4 February 1987; buoy first.
Meter in water	:	13.50
Water depth (m)	:	95
Position/Decca 1B	:	51 00.0N 7 00.9W : -, D41.62, F67.32
Recovery	:	10.06 - 10.43 12 March 1987
Release fired	:	10.26
Meter out of water	:	10.42
Position/Decca 1B	:	51 00.0N 7 01.4W : -, D41.86, F67.35

Rig 8 - Site A

Instruments	:	Four Aanderaa current meters, nos. 1139, 4388,
	:	7389, 1509 at 14, 29, 46, 56m above the sea floor.
Mooring	:	Pop-up. 32" sub-surface buoy no.1; back-up
	:	buoyancy; acoustic release no. 2164.
Deployment	:	17.09 - 17.17 29 January 1987; buoy first.
Meters in water	:	17.11, 17.12, 17.13, 17.13 (top to bottom)
Water depth (m)	:	99
Position/Decca 1B	:	51 00.0N 7 00.2W : -, D41.20, F67.23
Recovery	:	09.20 - 10.06 12 March 1987
Release fired	:	09.34
Meters out of water	:	10.04, 10.05, 10.06, 10.06 (top to bottom)
Position/Decca 1B	:	50 59.9N 7 00.4W : -, D41.48, F67.15

Rig 9 - Site A

Instrument	:	Current meter / pressure recorder no. 7 in sea
	:	bed frame.
Mooring	:	U-shaped. 6m spar buoy no. 4;
	:	command pinger no S21.
Deployment	:	19.40 - 20.20 29 January 1987; surface buoy first.
Meter in water	:	20.17
Water depth (m)	:	97
Position/Decca 1B	:	50 59.8N 6 59.7W : -, D41.12, F67.03
Comments	:	No pellet floats were attached to the buoyant line
	:	line from the frame because the line was too short.
	:	An unsuccessful attempt was made to find the line
	:	on 3 February.
Recovery	:	08.02 - 08.57 12 March 1987.
Meter out of water	:	08.55
Position/Decca 1B	:	50 59.9N 6 59.6W : -, D41.06, F67.46

Rig 10 - Site A

Instrument	:	Aanderaa meteorological station.
Mooring	:	Single point, 1/2" chain links.
	:	8ft diameter toroid.
Deployment	:	12.13 - 12.28 28 January 1987; anchor first.
Buoy in water	:	12.25
Water depth (m)	:	95
Position/Decca 1B	:	51 00.2N 7 00.2W : -, D41.08, F67.60
Recovery	:	15.10 - 15.40 20 March 1987.
Buoy out of water	:	15.27
Position/Decca 1B	:	51 00.1N 7 00.2W : -, D41.10, F67.56
Comments	:	No data were recorded because of a tape / logger
	:	problem.

Rig 11 - Site B

Instrument	:	250 kHz acoustic doppler current meter no. 2.
Mooring	:	Pop-up sea bed frame no. 15;
	:	acoustic release no. 2471c.
Deployment	:	11.00 - 11.06 5 February 1987.
Meter in water	:	11.03
Water depth (m)	:	116
Position/Decca 7D	:	50 59.8N 9 00.2W : B4.80, - , D60.75
Recovery	:	09.00 - 09.18 13 March 1987.
Release fired	:	09.08
Meter out of water	:	09.18
Position/Decca 7D	:	50 59.6N 9 00.3W : B5.00, - , D60.76

Rig 12 - Site B

Instruments	:	Four Aanderaa current meters, nos. 3277, 4387,
	:	4968, 6440 at 14, 34, 55, 76m above the sea floor.
Mooring	:	U-shaped. 6m spar buoy no.6; 40" sub -surface buoy
	:	no. 18; command pinger no. S07.
Deployment	:	12.08 - 12.43 30 January 1987; meters first.
Meters in water	:	12.26, 12.27, 12.28, 12.28 (top to bottom)
Water depth (m)	:	111
Position/Decca 7D	:	50 59.7N 9 00.1W : B4.82, - , D60.90
Recovery	:	08.05 - 08.58 13 March 1987.
Meters out of water:		08.51, 08.53, 08.54, 08.55 (bottom to top)
Position/Decca 7D	:	50 59.7N 9 00.1W : B4.84, - , D60.86

Rig 13 - Site B

Instrument	:	Pressure recorder; strain gauge no. 284.
Mooring	:	Teleost pop-up sea bed frame no. 7;
	:	acoustic release no. 236.
Deployment	:	13.43 - 13.53 30 January 1987.
Meter in water	:	13.50
Water depth (m)	:	114
Position/Decca 7D	:	50 59.8N 8 59.9W : B4.63, - , D61.07
Recovery	:	09.20 - 09.51 13 March 1987.
Release fired	:	09.40
Meter out of water	:	09.51
Position/Decca 7D	:	50 59.8N 9 00.0W : B4.70, - , D60.96

Rig 14 - Site C

Instruments	:	Four Aanderaa current meters, nos. 6443, 7570,
	:	5521, 5522 at 14, 34, 60, 86m above the sea floor.
Mooring	:	U-shaped. 6m spar buoy no. 2; 40" sub-surface buoy
	:	no. 17; command pinger S14.
Deployment	:	09.20 - 09.47 31 January 1987; meters first.
Meters in water	:	09.33, 09.34, 09.34, 09.35 (top to bottom)
Water depth (m)	:	126
Position/Decca 7D	:	50 24.3N 7 59.9W : A3.38, - , F54.57
Recovery	:	15.36 - 16.19 13 March 1987.
Meters out of water	:	16.07, 16.13, 16.15, 16.17 (bottom to top)
Position/Decca 7D	:	50 24.6N 7 59.8W : A3.34, - , F54.38
Comments	:	On recovery the bottom meter was tangled with the
	:	anchor and the next meter was missing its rotor.

Rig 15 - Site C

Instrument	:	Pressure recorder; digiquartz no. 289.
Mooring	:	Teleost pop-up sea bed frame no.8;
	:	acoustic release no. 2166.
Deployment	:	10.35 - 10.42 31 January 1987.
Meter in water	:	10.40
Water depth (m)	:	124
Position/Decca 7D	:	50 24.7N 8 00.2W : A3.35, - , F54.45
Recovery	:	14.57 - 15.30 13 March 1987.
Release fired	:	15.24
Meter out of water	:	15.30
Position/Decca 7D	:	50 24.7N 8 00.0W : A3.32, - , F54.45

Rig 16 - Site D

Instruments	:	Three Aanderaa current meters, nos. 2672, 6720,
	:	5526 at 14, 29, 45m above the sea floor.
Mooring	:	U-shaped. 6m spar buoy no. 1; 40" sub-surface buoy
	:	no. 10; command pinger no. S15
Deployment	:	10.00 - 10.27 1 February 1987; meters first.
Meters in water	:	10.07, 10.08, 10.08 (top to bottom)
Water depth (m)	:	82
Position/Decca 1B	:	50 25.1N 6 00.3W : -, C47.82, D67.60
Recovery	:	07.00 - 13.13 14 March 1987.
Meters out of water	:	12.45, 12.50, 12.55 (top to bottom)
Position/Decca 1B	:	50 26.0N 5 59.8W : -, C46.32, D69.01
Comments	:	The surface buoy was missing, but the pinger was
	:	soon switched on (07.24). The rig was dragged for
	:	with a gifford grapnel from 08.00 - 12.00 without
	:	success, although several times the tensiometer
	:	showed a temporary load. At 12.00 (slack water)
	:	the pellet floats marking the sub-surface buoy
	:	were spotted and the Zodiac launched to attach a
	:	line to the pellet line to effect the recovery.
	:	The middle meter was recovered tangled with the
	:	meter wire and the bottom meter was damaged, both
	:	could have occurred during dragging. The buoy line
	:	had been cut with a blow torch. The rig was about
	:	half a mile from its laid position.

Rig 17 - Site E

Instrument : Pressure recorder.

Mooring : Teleost pop-up sea bed frame no. 14.

Deployment : 07.56 - 08.01 8 February 1987.
- Frame in water : 07.58
- Water depth (m) : 59
- Position/Decca 1B : 50 51.7N 4 58.9W : -, G45.89, F62.11

Recovery : 17.37 - 18.32 14 March 1987.
- Release fired : 18.21
- Meter out of water : 18.32
- Position/Decca 1B : 50 51.7N 4 58.8W : -, G45.87, F62.30

Instrument : Aanderaa WLR no. 1038; teleost frame no. 11;
: acoustic release 2472bc..

Deployment : 21.42 - 21.44 14 March 1987.
- Frame in water : 21.42
- Water depth (m) : 57
- Position/Decca 1B : 50 51.7N 4 58.9W : -, G46.10, F61.96

Rig 18 - Site F

Instrument : Pressure recorder.

Mooring : Teleost pop-up sea bed frame.

Recovery : 07.40 - 08.03 2 February 1987.
- Frame grappled : 07.52
- Position/Decca 1B : 51 30.9N 4 40.8W : -, F44.5, J62.0

Deployment : 17.15 - 17.21 2 February 1987.
- Frame in water : 17.17
- Water depth (m) : 42
- Position/Decca 1B : 51 30.7N 4 41.2W : -, F44.85, J61.26
- Comments : Acoustics checked at 02.30 15 March 1987.

Rig 19 - Site G

Instrument	:	Pressure recorder.
Mooring	:	Teleost pop-up sea bed frame.
Deployment	:	15.34 - 15.38 8 February 1987.
Frame in water	:	15.36
Water depth (m)	:	43
Position/Decca 1B	:	51 18.5N 3 38.8W : -, C42.52, A79.88
Comments	:	Acoustics checked at 16.50 11 March 1987.

Rig 20 - Site A

Instrument	:	Recording waverider (Wimpol).
Deployment	:	09.02 - 09.12 3 February 1987.
Buoy in water	:	09.06
Water depth (m)	:	98
Position/Decca 1B	:	50 59.9N 7 01.5W : -, D41.94, F67.09
Recovery	:	10.04 - 10.30 20 March 1987.
Buoy out of water	:	10.30
Position/Decca 1B	:	51 00.0N 7 01.3W : -, D41.97, F67.15
Comments	:	Zodiac launched to detach buoy from mooring and
	:	recover separately.

Rig 21 - Site H

Instrument	:	WAVEC directional wave buoy.
Deployment	:	12.50 - 12.57 2 February 1987; anchor first.
Buoy in water	:	12.57
Water depth (m)	:	62
Position/Decca 1B	:	51 34.6N 5 30.9W : -, I36.84, I60.64
Comments	:	The buoy was checked at 07.00 15 March 1987 and
	:	recovered later by Wimpol.

Table 1. Rig summary. Water depths are below chart datum.

Site	Position Latitude N	Position Longitude W	Water Depth	Rig	Mooring	Instruments
A	51 00	7 00	90	1	Single point	Satellite buoy, sensor 2m below sea surface
				2	Single point	Satellite bouy, sensor 1m below sea surface
				3	Pop-up	1 MHz ADCP on a mooring 20m below sea surface
				4	Sea bed frame	300 kHz RDI ADCP
				5	Sea bed frame	250 kHz ADCP
				6	Eta	Vector averaging current meters at 5, 9, 17m below sea surface
				7	Pop-up	Vector averaging current meters at 61, 67, 73m above sea floor
				8	Pop-up	Aanderaa current meters at 14, 29, 46, 56m above sea floor
				9	U-shaped	Current meter / pressure recorder in bottom frame
				10	Single point	Meteorological buoy
				20	Single point	Recording waverider
B	51 00	9 00	110	11	Sea bed frame	250 kHz ADCP
				12	U-shaped	Aanderaa current meters at 14, 34, 55, 76m above sea floor
				13	Sea bed frame	Teleost pressure recorder
C	50 25	8 00	120	14	U-shaped	Aanderaa current meters at 14, 34, 60, 86m above sea floor
				15	Sea bed frame	Teleost pressure recorder
D	50 25	6 00	80	16	U-shaped	Aanderaa current meters at 14, 29, 45m above sea floor
E	50 51.6	4 59	55	17	Sea bed frame	Teleost pressure recorder; Bristol Channel site BCS2
F	51 30.6	4 41	40	18	Sea bed frame	Teleost pressure recorder; Bristol Channel site BCS3
G	51 17.2	3 35	40	19	Sea bed frame	Teleost pressure recorder; Bristol Channel site BCS1
H	51 35	5 30	60	21	Single point	Wavec directional wave buoy

Table 2. Position of CTD Profiles

Profile Number	Date	Time Started	Position Latitude N	Position Longitude W	Water Depth (m)	Site
1	29/1/87	20.30	50 59.5	7 00.0	97	A
2	29/1	23.00	50 58.5	7 24.2	98	
3	30/1	14.06	50 59.6	8 59.6	109	B
4	30/1	20.05	50 59.9	10 00.1	121	
5	31/1	11.00	50 24.1	8 00.4	124	C
6	31/1	15.00	50 00.0	8 40.0	124	
7	1/2	10.35	50 24.8	6 01.1	84	D
8	1/2	18.10	51 19.8	6 10.6	110	
9	1/2	11.20	51 00.1	6 58.9	97	A
10	4/2	13.05	50 59.8	7 02.0	95	A
11	5/2	16.05	50 59.5	10 00.2	120	
12	5/2	22.07	51 02.5	10 57.8	120	
13	6/2	11.10	51 19.5	9 58.8	110	
14	7/2	10.20	51 00.2	6 59.0	100	A
15	8/2	15.45	51 18.5	3 39.1	40	G
16	12/3/87	11.20	51 00.3	7 00.9	95	A
17	12/3	23.40	51 00.5	7 39.5	90	
18	13/3	02.29	51 00.1	8 20.0	109	
19	13/3	05.50	50 59.0	8 59.6	115	B
20	13/3	15.02	50 24.7	7 59.8	123	C
21	13/3	17.48	50 10.2	8 00.3	108	
22	13/3	20.05	50 09.4	7 31.9	110	
23	13/3	22.45	50 10.2	7 00.0	106	
24	14/3	01.10	50 10.2	6 27.4	94	
25	14/3	03.50	50 10.1	5 45.0	55	
26	14/3	06.03	50 24.3	5 59.8	80	D
27	14/3	15.21	50 39.0	5 28.6	72	
28	14/3	17.41	50 51.7	4 59.8	62	E
29	15/3	00.29	50 10.9	4 49.8	58	
30	15/3	02.54	51 31.1	4 40.3	41	F
31	15/3	05.10	51 29.7	5 05.9	54	
32	15/3	07.00	51 34.7	5 30.3	68	H
33	15/3	09.44	51 34.5	6 09.0	116	
34	15/3	12.15	51 34.3	6 47.3	65	
35	15/3	14.39	51 34.5	7 25.9	79	
36	15/3	17.08	51 34.5	8 02.8	87	
37	15/3	19.40	51 34.5	8 37.2	42	
38	15/3	21.39	51 24.7	8 14.6	89	
39	15/3	23.49	51 15.0	7 49.5	93	
40	16/3	02.53	51 08.2	7 24.9	98	
41	16/3	07.04	51 00.8	7 01.4	97	A
42	17/3	03.00	50 59.5	6 57.7	96	A
43	17/3	06.35	50 59.9	7 34.0	105	
44	17/3	09.22	50 59.6	8 08.1	102	
45	17/3	11.56	50 59.7	8 41.1	109	
46	17/3	14.26	51 00.1	9 14.5	119	
47	17/3	17.40	51 00.3	9 49.7	123	
48	17/3	21.43	51 00.0	10 21.2	138	
49	20/3	15.59	51 00.1	7 00.4	96	A
50	20/3	19.40	50 45.1	7 43.7	111	

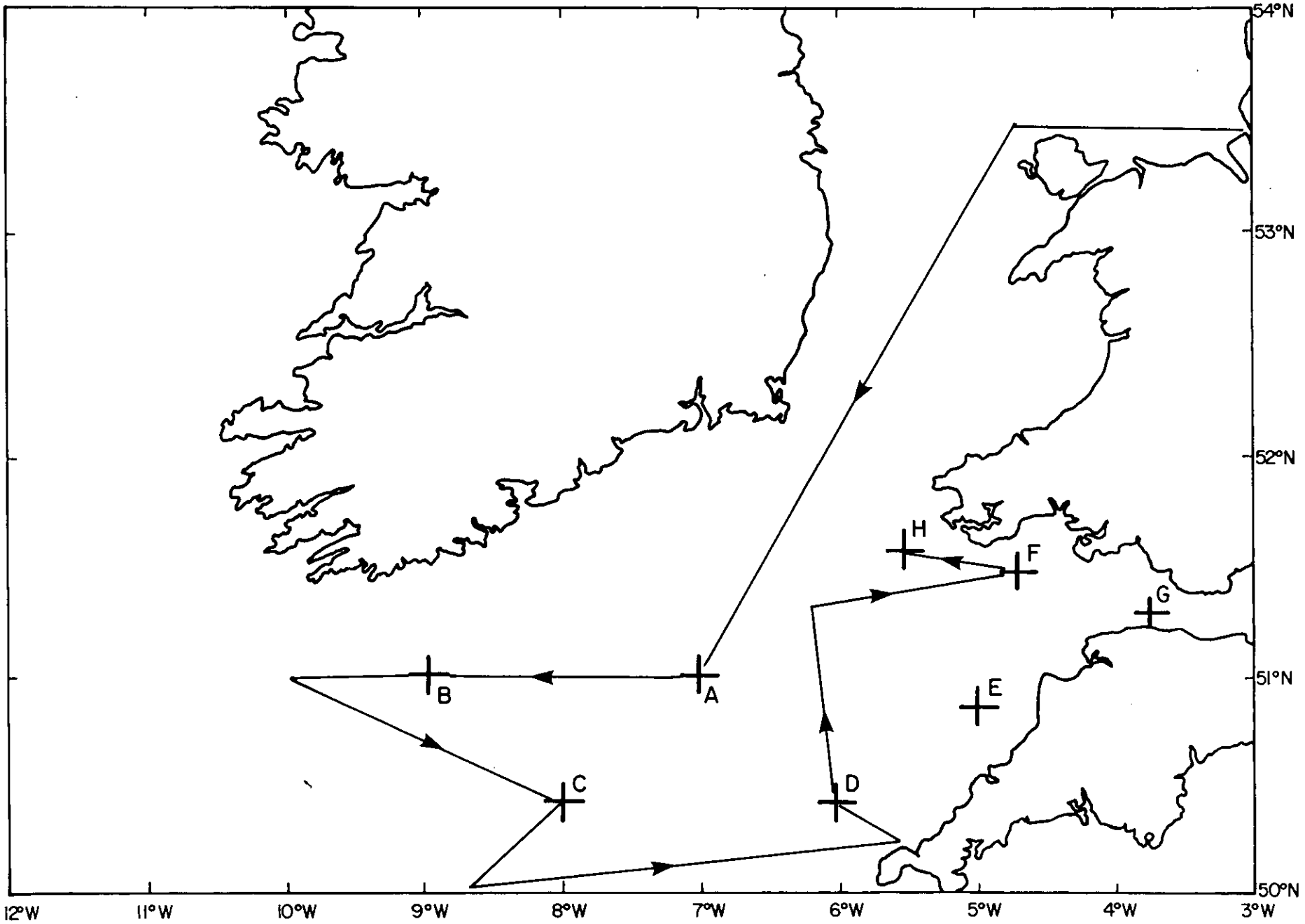

Figure 1a RRS Challenger 10/87 cruise track and mooring locations, 27 January – 2 February 1987.

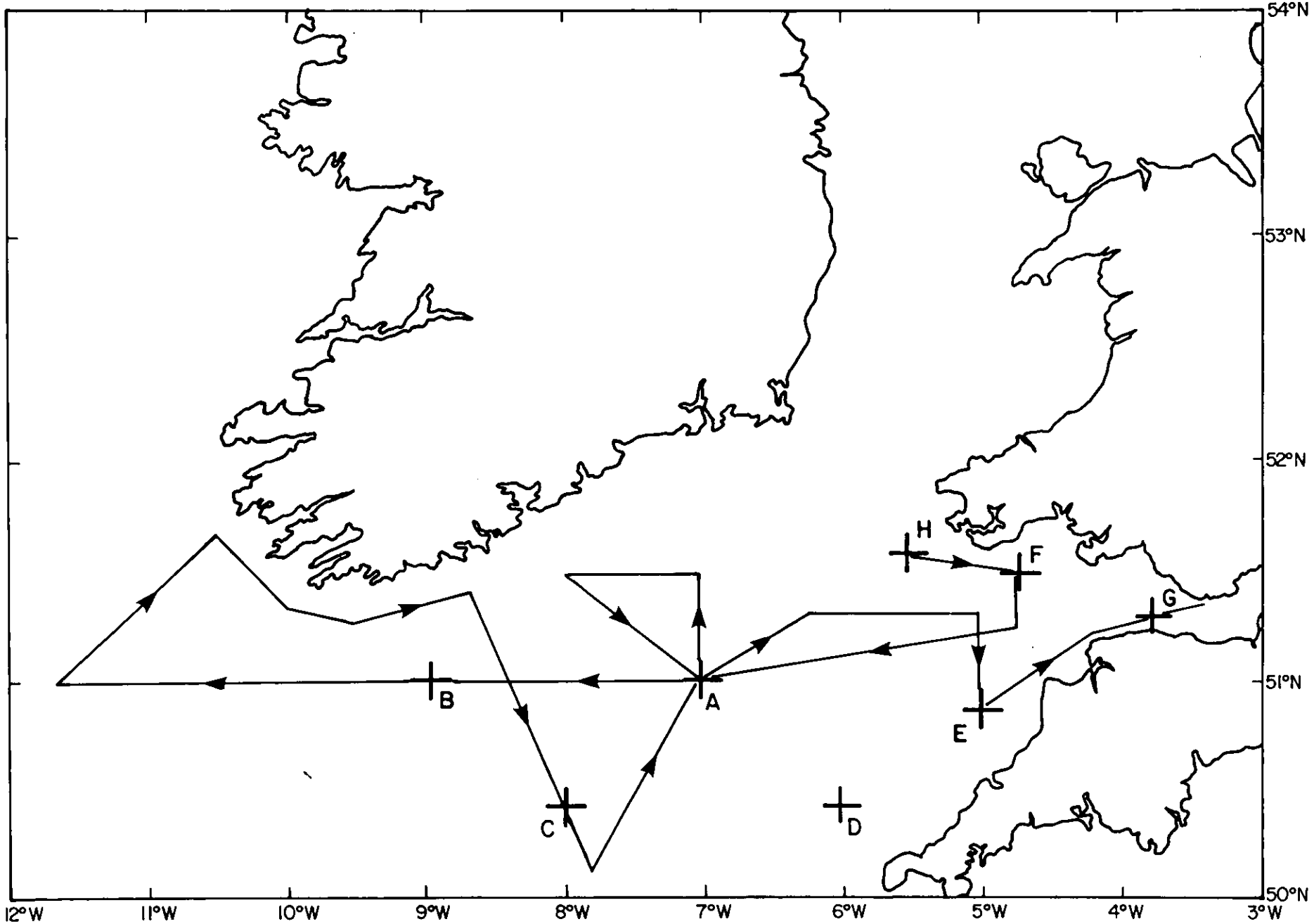

Figure 1b RRS Challenger 10/87 cruise track and mooring locations 2 – 7 February 1987.

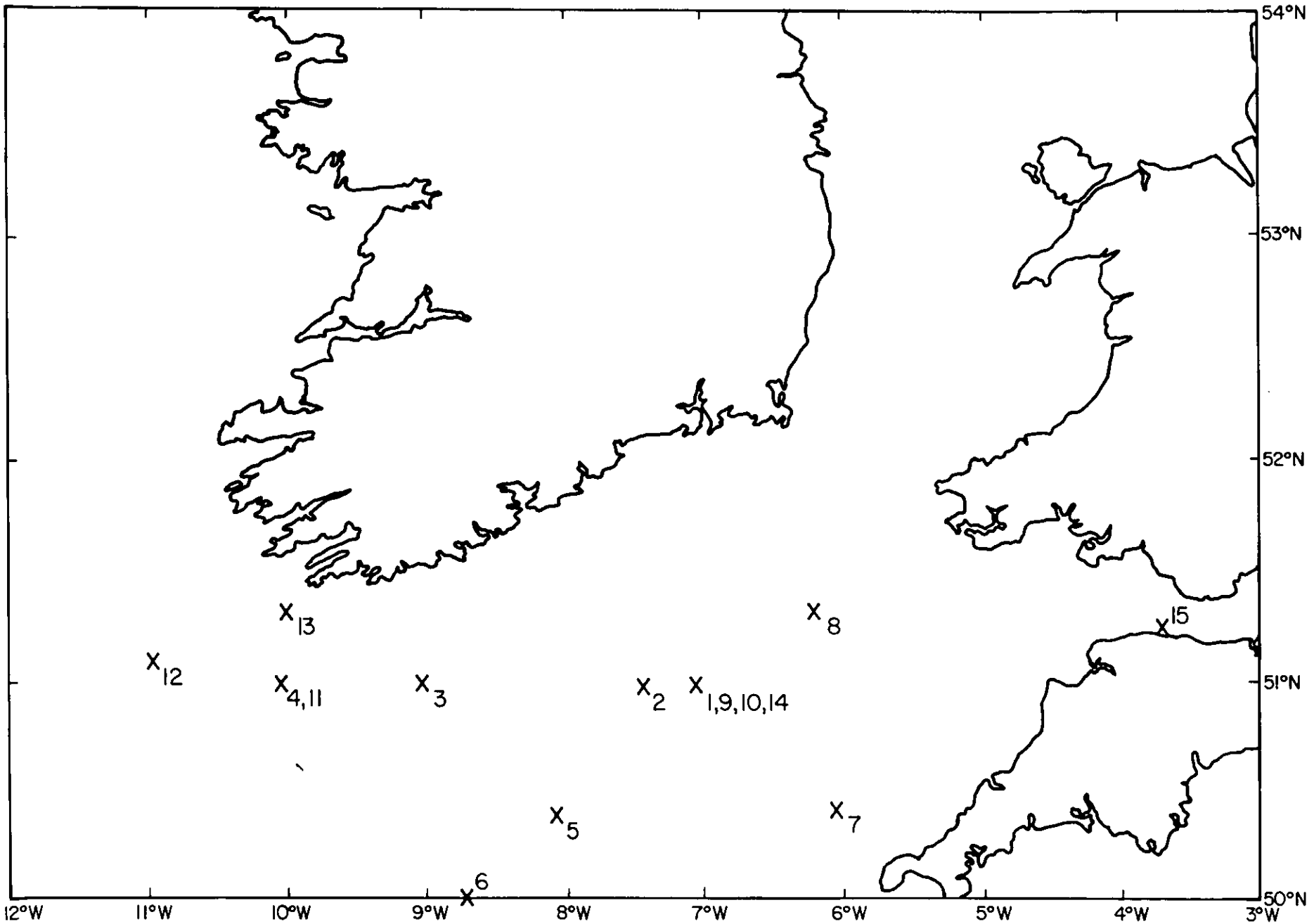

Figure 2 RRS Challenger 10/87 CTD positions

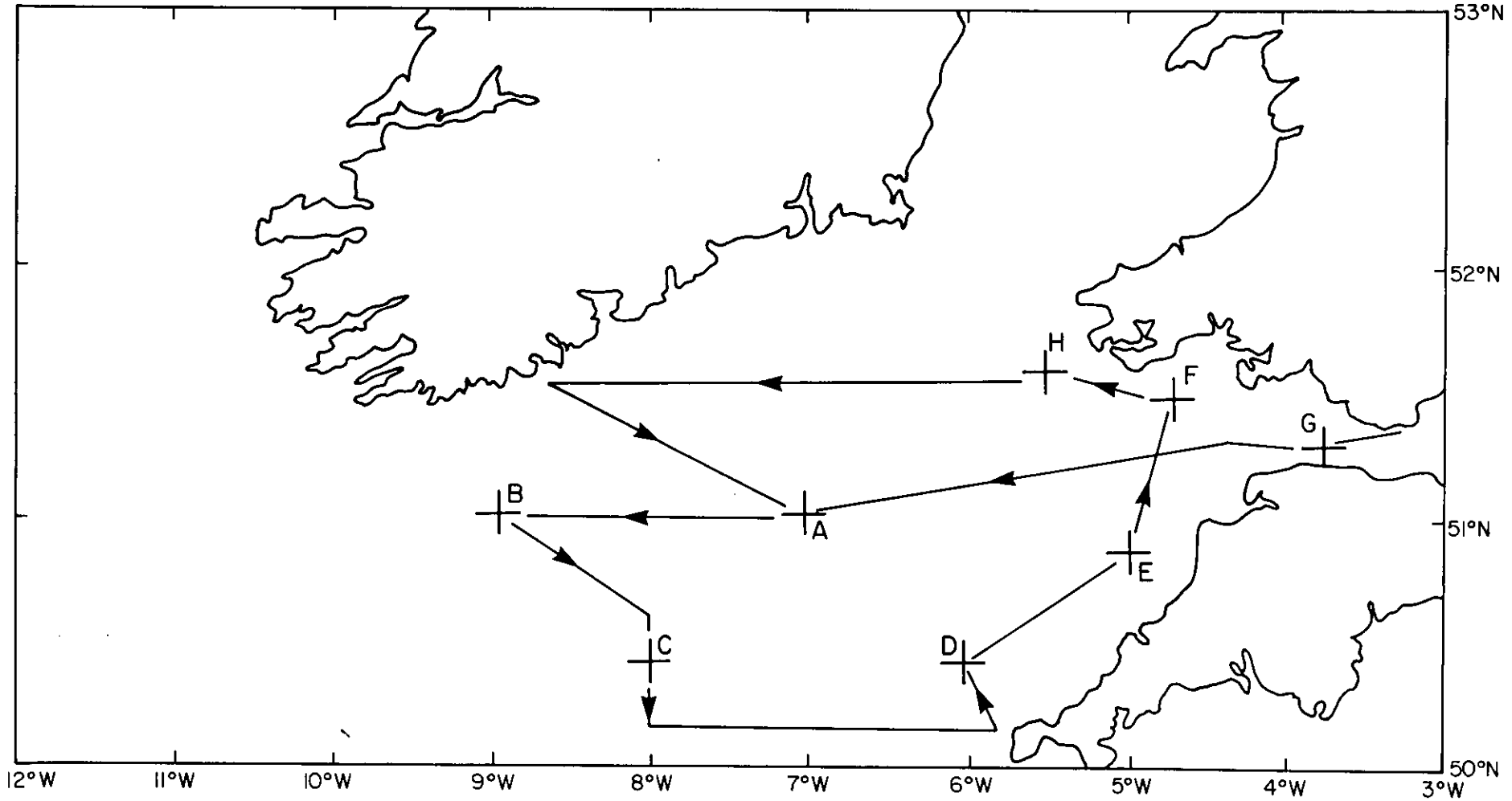

Figure 3a RRS Challenger 12/87 cruise track and mooring locations, 11 – 16 March 1987.

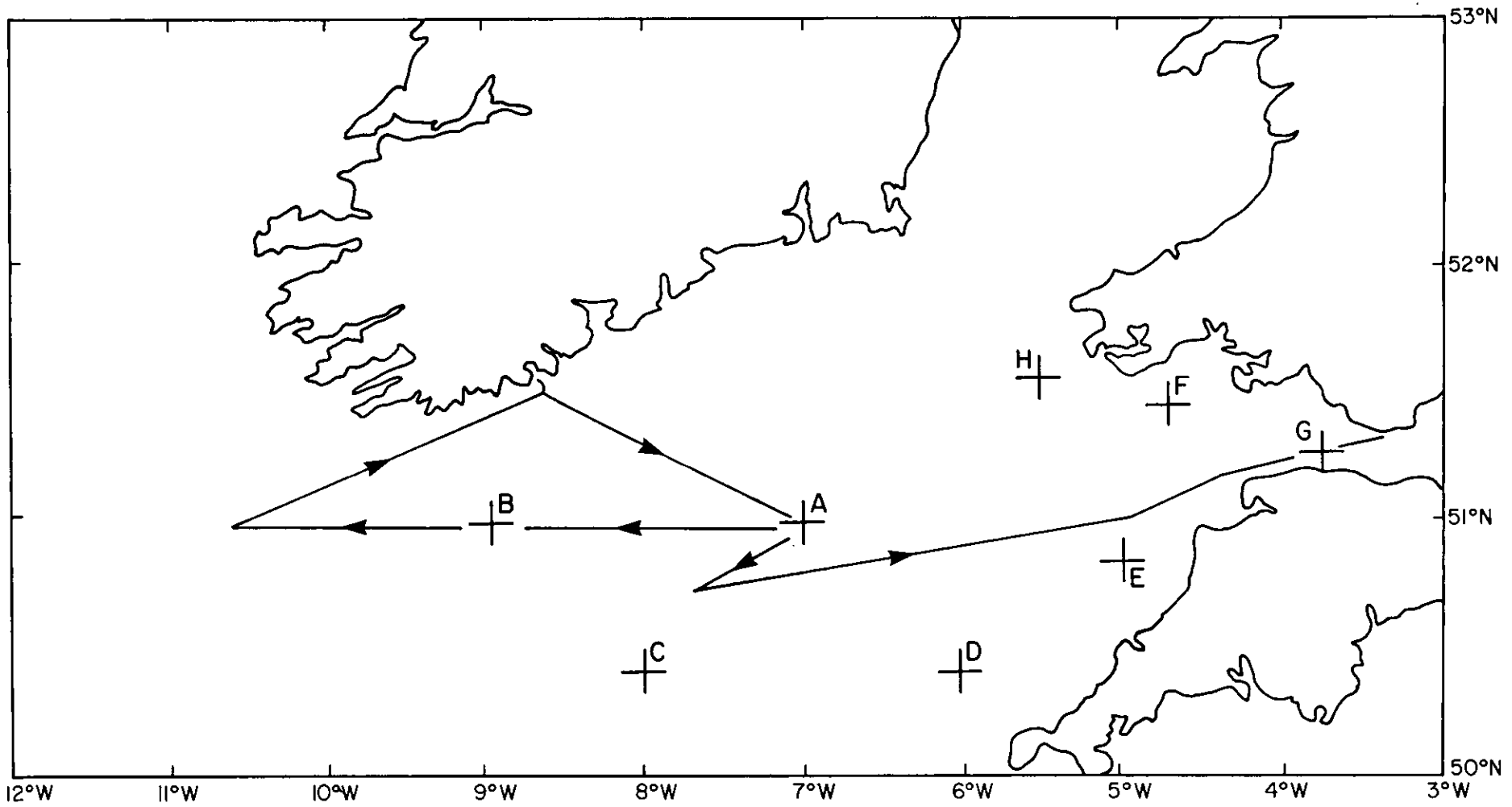

Figure 3b RRS Challenger 12/87 cruise track and mooring locations, 17 – 21 March 1987.

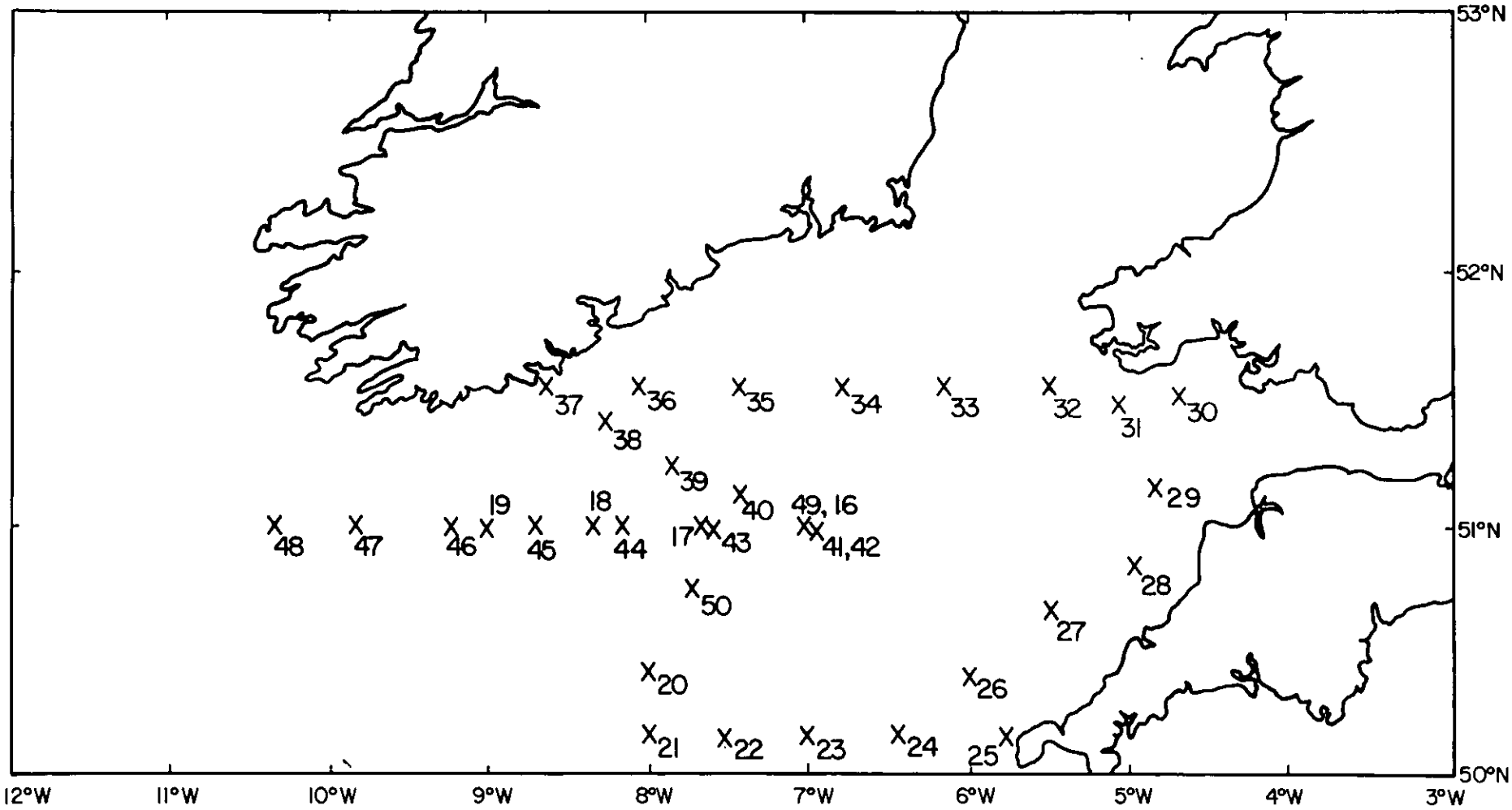

Figure 4 RRS Challenger 12/87 CTD positions.