P.O.L.

RRS 'Challenger'

Cruise 74B

1-10 February 1991

Wave and current dissipation and sand transport in the Bristol Channel

Cruise Report No. 11

1991

NATURAL ENVIRONMENT RESEARCH COUNCIL
PROUDMAN OCEANOGRAPHIC LABORATORY

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Wave and Current Dissipation and Sand Transport in the Bristol Channel

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ABSTRACT

This cruise was designed to study wave and current dissipation and sediment transport in a high energy regime. The study took place off Camarthen Bay in the Bristol Channel in February, which is an area of strong tidal currents, frequently experiencing large waves including long-period swell from the Atlantic.

11 moorings were deployed at the beginning of the cruise and recovered at the end, at two stations separated by about 10 nautical miles. The instruments deployed consisted of two STABLE rigs to measure the bottom boundary layer structure, two ADCP rigs with pressure recorders, two near-surface and two near-bottom S4 current meters, a WAVEC buoy, a Waverider buoy and a meteorological buoy. In the intervening period of about a week between deployment and recovery the area around the two stations was surveyed using sidescan sonar, echosounder, grab and core samples and CTD (with transmissometer) dips. An experimental suspended sediment profile rig was deployed. The ship's radar was also used to obtain wave spectra.

The cruise operations were generally successful, with almost ideal weather, being calm for deployment and recovery, with a gale during the middle part providing interesting conditions for the study. However, one S4 current meter was not recovered, and a Shipek grab was lost. The S4 current meter was picked up by a trawler two weeks later. On recovery, the STABLE rigs and the met. buoy were found to have failed to record any data, and limited data were obtained from the ADCP and S4 instruments.

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CRUISE REPORT CHALLENGER 74B 1-10 FEBRUARY 1991

Wave and Current Dissipation and Sand Transport in the Bristol Channel

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1. CRUISE OBJECTIVES

The aims of this cruise were:

(i) To measure waves, currents, near-bed turbulence and vertical current structure at two stations A and B, separated by about 10 nautical miles, aligned with the main tidal stream and the prevailing swell direction.

(ii) To measure the bedforms and suspended sediment concentrations at the two stations and over the surrounding area.

The area chosen for this study was just offshore of Camarthen Bay in the Bristol Channel. This area is characterised by large tidal currents and frequently large waves, including long period swell from the Atlantic. Station A was in deeper water (approximately 35m relative to chart datum), further offshore than station B which was in about 25m depth.

11 moorings were to be deployed at the beginning of the cruise and recovered at the end. The equipment to be deployed included two STABLE rigs (STABLE I and STABLE II) to measure turbulent pressure and velocity components, current direction and rig attitude. STABLE I, to be deployed at site B, was in addition set up to measure suspended sediment using an acoustic backscatter (ABS) device and record bedforms using a camera and shadow bar, and had a transmissometer mounted on the frame. An ADCP current meter and water level recorder was to be deployed at each site to give mean currents through the water column and water depth. Also near-surface and near-bottom S4 current meters were to be deployed at each station to give turbulent velocities in burst mode. A WAVEC buoy was to be deployed at station A and a waverider at station B to give wave spectra. Finally, a meteorological buoy was to be deployed near the offshore station to give wind-speed and direction, air and sea temperature. In the intervening period of about a week between deployment and recovery the area around the two stations was to be surveyed.

During the survey, an experimental suspended sediment profile rig was to be deployed, at various locations, to take suspended sediment samples and record the flow at various depths. CTD plus transmissometer profiles were to be taken, over a few tidal cycles at each station, and the area was to be surveyed by echo-sounder and sidescan sonar. Grab samples of bottom sediment were to be taken. Wave spectra were to be measured from the ship using a PC to digitise and capture the signal from the ship's radar, and also by using a photographic technique. A continuous record of surface temperature, salinity and transmittance was to be obtained on the ship. Echosounder depths were also to be recorded continuously, plus vertical profiles of velocity every 10 minutes from the ship-borne ADCP.

2. NARRATIVE

The ship left Barry on Friday 1st February (0600) and proceeded to station B (51°34'N 04°30'W). The line B to A was echosounded and a grab sample taken at station A (51°30'N 4°45'W), to determine the best position for STABLE II. The Met. buoy, WAVEC, a near-surface (ETA-rig) S4 current meter mooring and an ADCP were deployed in the vicinity. The weather was good and the sea slight with a low long-period westerly swell. Following a test deployment of the sidescan sonar the ship returned to Barry, being constrained to arrive before the last lock at 2100.

On Saturday morning the remaining large items of equipment were loaded including both STABLE rigs, the sediment profile rig and two toroid buoys. The imported optical backscatter (OBS) probes for STABLE I were unfortunately delayed in Customs. The Racal/Decca engineer was called out to transfer the link to the PC from the main to the secondary navigation radar (as originally requested - having discovered the previous day that it would cause some disruption to the ship's officers on watch otherwise). The ship sailed at 1000 and arrived at station B by 1450. The weather was again good and the sea calm. After taking a grab sample and a CTD dip to calibrate the transmissometer for STABLE I, the latter was deployed, followed by a near-bottom (U-shape) S4 mooring and an ADCP. It was then too dark to deploy further moorings.

Overnight a sidescan sonar survey of the area between B and A was carried out, concentrating on the area around A where sand-waves were observed. At 0830 STABLE II was deployed at A. There was some delay when it was dicovered that 2 anchor clumps had been left behind, but this problem was overcome by using odd pieces of scrap chain. A further problem was in deploying the near-bottom (U-shape) S4 mooring at A, when the water depth at the selected location was deeper than planned for (50m instead of 45m). This problem was circumvented by attaching the surface buoy higher up the strop. The remaining 2 moorings at station B (S4 eta-rig and waverider) were deployed by 1320 at which time we anchored at station B to do CTD and sediment rig deployments through the tidal cycle.

The first sediment rig deployment at anchor was not totally successful. It was difficult to keep the ship from swinging to get a straight pull when recovering the rig, and a bight of wire pulled off the top flowmeter on recovery. However the damage was repaired and successive free deployments were done with some surface floats to buoy the wire. The planned hourly sediment rig deployments were cancelled and we instead performed half-hourly CTD dips through the tidal cycle until 0700 the following morning. After a second trial deployment of the sediment rig, we proceeded to station A where we carried out 13 hours of hourly CTD dips until 0200 Tuesday 5th. A further sidescan survey around station A was performed, extending further west than before, finishing at 0742. At 0830 the moorings at station A were checked and all accounted for, and a grab sample survey of line A to B was begun. The wind had increased to Easterly 4/5. At 1855, with wind against tide, the hydrographic wire parted and the grab was lost. The grab had gone under the ship, with the A-frame not fully out, and had been pulled up too quickly. It was decided to return to RVS Barry to collect a spare grab, and also a corer to collect samples from the patch of muddy sand which had been observed midway between A and B, during the grab survey. The remainder of the evening was taken up with a survey around A carrying out wave data capture from the ship's radar.

By 0700 on the 6th we were off Barry, waiting for the equipment to be ferried out on the pilot boat. This was completed by 1140 and we were back on station by 1720. The sea was now too rough for overside work, being moderate to rough with winds up to force 8 from the east. Further radar wave data capture was carried out, until the weather moderated. This involved steaming on a steady heading around a rectangular box near A keeping a steady speed of about 5 knots. We recommenced the grab sample survey at 1240 on 7th with wind and tide in the same direction giving optimum conditions. The survey was suspended for a further sediment rig deployment at B. The last of the daylight was used to recover the two S4 moorings at B. The ETA-rig had dragged about half a mile off the deployment location.

The grab survey line was then completed, followed by a deployment of the underwater camera at A. After developing the film, the bottom visibility was found to be too poor to give useful pictures and no further deployments were attempted. Hourly CTD dips through the ebb tide at A were carried out through the night. At first light recovery of the moorings at A was begun. The U-shaped S4 mooring, ADCP and pop-up STABLE were successfully recovered, but the S4 ETA-rig was not found. The ship then returned to B for further mooring recovery, taking a core sample from the mud-patch on the way. The ADCP and steel STABLE were recovered at B. STABLE had received some damage, thought to be sustained during recovery although the procedure appeared to go smoothly with winds of about force 4.

The remaining 3 moorings: met. buoy, WAVEC and waverider were left to be recovered on the following day and we started a systematic search for the S4 ETA-rig, assuming the surface line had been cut and the surface buoy was drifting downwind. We used a numerical model of the Bristol Channel, set up by Roger Proctor, to predict the likely movement of the rig with wind and tide over a period of up to 3 days, since its last positive sighting. This suggested it could have moved SW or W and possibly (though unlikely) as far as 50 miles. We stopped at selected points about 7 km apart and operated the overside transducer to search for the rig, up to 30 miles from the original position, but without success. STABLE I was dismantled and stowed, to allow us to cancel our scheduled port call in Barry on the 9th. On the Saturday morning the ship returned to station A, obtained some cores between A and B, and recovered the last 3 moorings.

The sidescan sonar survey around A was repeated, followed by a tidal cycle of CTD dips at B plus some acoustics tests. The work was finished at 1000 on Sunday 10th at which time the ship returned to Barry.

3. DIARY

JANUARY 31

1700 Main scientific party joined ship.

FEBRUARY 1

0600 Sailed from Barry.
0900 Scientists briefing.
1120 **Station B.** Echo-sounding B to A.
1220 **Station A.** Grab sample. Deployed met. buoy, WAVEC, ADCP, and S4 (near-surface) mooring. Sidescan test deployment.
1534 Return to Barry.

FEBRUARY 2

0830 Loaded 2 STABLE rigs, sediment rig plus toroid buoys.
1000 Sailed from Barry.
1450 **Station B.** Grab sample. CTD calibration dip. Deployed STABLE I, S4 (near-bottom) and ADCP.
2045 Start sidescan sonar survey, run 1, between B and A.

FEBRUARY 3

0748 Sidescan sonar survey ended.
0830 **Station A.** Deployed STABLE II and S4 (near-bottom).
1135 **Station B.** Deployed S4 (near-surface) mooring.
1310 Waverider deployed at B.
1320 Anchored at B. Grab sample. CTD dip.
1429 First trial deployment of experimental sediment profile rig. Damaged on recovery, but repairable.
1530 Commenced half-hourly CTD dips at B, plus hourly data capture of wave images from the ship's radar, through a tidal cycle.

FEBRUARY 4

0700 Completed CTD station. Weighed anchor.
1010 Second trial deployment of sediment rig, free.
1046 Rig recovered. Grab sample.
1222 **Station A.** Anchored at A. Grab sample.
1300 Commenced hourly CTD dips at A, plus hourly radar wave data capture.

FEBRUARY 5

0200 Ended CTD station. Weighed anchor.
0300 Commenced sidescan sonar survey, run 2, near A.

0742	Sidescan sonar survey completed.
0830	Checked moorings at A.
1009	Commenced grab sample survey, from A towards B.
1500	Grab survey suspended.
1544	**Station B.** Third trial deployment of sediment rig.
1635	Sediment rig recovered. Checked moorings at B.
1815	Resumed grab survey.
1855	Hydrographic wire parted, grab lost.
2000	Radar wave data capture survey around A.

FEBRUARY 6

0035	Set course for Barry, to replace grab and pick up a corer.
0715	Hove to off Barry.
1141	Pilot boat alongside, transfer of scientific equipment.
1600	Back on station but weather too rough for overside work.
1749	Commenced radar wave survey of rectangular area enclosing A and B. Also echosounding.

FEBRUARY 7

1241	Recommenced grab survey.
1353	Grab survey suspended.
1441	**Station B.** Fourth trial deployment of sediment rig.
1524	Sediment rig recovered. Recovered S4 (near-bottom) and S4 (near-surface) moorings at B.
1808	Recommenced grab survey.
2100	Grab survey completed.
2246	**Station A.** Deployed underwater camera.
2330	Recovered camera.

FEBRUARY 8

0000	Commenced CTD dips at A through ebb tide.
0718	CTD dips completed. Recovered S4 (near-bottom), ADCP and STABLE II moorings at A. S4 (near-surface) missing.
1113	Core sample between A and B.
1229	**Station B.** Recovered ADCP and STABLE I moorings.
1500	**Station A.** Commenced search for S4 (near-surface) mooring.

FEBRUARY 9

0912	Search pattern completed. Nothing found.
0954	Core samples between A and B.
1156	**Station B.** Recovered Waverider.
1323	**Station A.** Recovered WAVEC and Met. buoy.
1516	Commencing sidescan sonar survey.
2053	Sidescan sonar survey completed.

2210 **Station B.** Commenced CTD dips at B through a tidal cycle plus acoustics tests.

FEBRUARY 10

1000 CTD station completed. Returned to Barry.

4. PROJECT REPORTS

4.1 MOORINGS (J.Humphery, S.Moores, D.Flatt, G.Ballard, A.Harrison)

Instruments and moorings were deployed during Challenger 74B, at sites A and B as listed in Appendix A and shown in Figs 2 and 3. In addition, several deployments of the suspended sediment trap were made at different locations, near station B.

All mooring components were prepared prior to departure from POL, and were arranged as kits of parts. Each mooring/instrument package was assembled on deck, and then deployed. Some difficulty was experienced because water-depth, particularly at site A, was greater than expected.

The ETA rig at site A was lost: there was no indication of the reason for the failure. One electromagnetic current meter on pop-up STABLE was cracked during recovery: it protruded beyond the frame, and rubbed up against the transom while being lifted out of the water. Damage to STEEL STABLE during recovery was more extensive: the groundline, (which forms the recovery line), caught under the electromagnetic current meter spar, and all the sensors were broken by the weight of the rig. (It was fortunate that new optical backscatter sensors were delivered too late for deployment, otherwise thay would have been lost, too.) Damage to the suspended sediment rig was caused in a similar way: a current sensor was torn off, and part of the frame was bent.

4.2 WAVES AND CURRENTS (J.Wolf, R.Proctor, X. Wu)

During the cruise a new technique of capturing images of waves from the ship's radar was assessed, using an OPUS PC to digitise and store the data directly, as well as a photographic method which had been used successfully before. Various problems were encountered but a reasonable quantity of data was acquired.

On the first day it was discovered that the connection box installed by Racal/Decca to take the synch pulse, header marker and raw video signal from the radar had been connected to the main navigation radar rather than the secondary radar. Since it was necessary to adjust the controls before capturing the image (to select short pulse length and 1.5 miles range), this caused some interference with the ship operation and was felt to be undesirable. The opportunity was taken during the port call in Barry on Saturday 2nd to get Racal/Decca to transfer the connection to the secondary radar.

The data capture proceeded smoothly for about 24 hours, capturing data every hour, then the system began to fail. A considerable amount of time was spent, after consultation with MIROS who supplied the data capture and digitisation system, in checking where the problem lay. The signal was getting from the radar to the PC correctly and suspicion focussed on the PC or the data capture board. During the problem period the photographic method was used to acquire wave data directly from the radar PPI. After moving the data capture board to another slot in the PC, the system started to work again and continued for another 30 hours before failing again. Out of a possible 192 hours of data, 73 were achieved, including the main period of interest from 6th to 7th when there was an easterly gale.

The WAVEC system which was hired from Hydraulics Research worked well throughout the cruise, telemetering data to the ship every hour (except when the ship was not in range, which only occurred during return to Barry). However, due to a misunderstanding, it only became apparent on 6th that the data was not being logged and that the only record was the paper printout. At this point a logger was connected to the RS232 port on the HP85B receiving system and the raw data and co- and quad-spectra were logged from this time on.

4.3 SEDIMENTS (J.Williams, K.Taylor, A.Hannay)

4.3.1 Side scan sonar survey, (EG&G model 290)

Following trial deployments of the side scan sonar fish to determine the optimum tow speed and depth, (determined to be 5kts and 37m respectively), survey commenced at 2045 on 2nd February following a rectangular coarse between station B and A and covering an area approximately 300m either side of the tow line. Differences in sediment density, as indicated by acoustic reflection, were noted during the survey together with a range of bedforms which included sand waves, mega ripples and dunes, sand ribbons and streaks and ripple fields. Some images showed bottom features in remarkable detail. As the area adjacent to station A was identified as having the best developed bedforms, subsequent surveys on 5th February (before the storm), and 9th February (following the storm), concentrated on this area. Changes in bedform assemblages and position during the period between the surveys were noted. During all the surveys, (see figure 4), continuous echo sounder depths were also recorded and in many instances showed large scale, low amplitude bedforms well. In all cases, performance of the equipment was satisfactory and no data were lost.

4.3.2 Sediment grab samples

Surface grab samples of the sediments were obtained using a Shipek sampler deployed off the hydrographic wire. In the first instance, in conjunction with echo sounder data, these were used to determine the optimum location for the STABLE rigs. A detailed survey of bottom sediments between stations A and B was then conducted on 5th and 7th February, (see sample location map, figure 5), when 42 samples were taken. A grab sampler was lost on 5th February but was replaced allowing the sample survey to be completed. All samples were transferred to 500ml plastic jars and treated with 10% formalin solution. Significant differences in grain size and mineralogy were noted along the transect.

4.3.3 Sediment core samples

Midway between stations A and B, sediments obtained by the grab had a high percentage of mud in them. It also appeared that coarser sand covered this material. In order to ascertain the depth of this cover and to determine whether or not the material resembled sands found upstream and downstream of the muddy site, 3 sediment cores were obtained successfully using the trigger from a piston corer. Differences between cores obtained at successive sites were not sufficient to warrant further samples. Cores were logged visually and samples from representative depths were taken.

4.4.4 Suspended sediments

Using a vertical array of sediment streamer traps, designed to collect suspended material > 100μm in diameter, samples were obtained at 5 heights above the seabed on four occasions. Unfortunately, the current meters on this prototype rig failed to operate correctly and thus no concurrent flow data were obtained. The deployments did, however, give vital evidence of resuspension/turbulent mixing processes during peak ebb and flood tides and provided, for the first time, samples of suspended particles. The data resulting from analysis of these samples will aid considerably in the interpretation of both ABS and transmissometer data. All samples were treated with formalin to prevent blooming.

Continuous surface measurements of optical transmission were made during side scan and grab sample survey legs using a deck-mounted transmissometer (PSW water jacket) linked to the ships non-toxic water supply. Vertical profiles of suspended sediments were taken at the following CTD stations: Station B, 3rd-4th February; station A, 4th-5th February; station A, 8th February; and station B, 9th-10th February. Significant changes in the suspended solids profile resulted from resuspension processes during the storm period 6th-7th February. In total, 10 water bottle samples (middle and bottom) were taken during CTD dips to determine the suspended load for use in calibration of transmissometers on the CTD and on STABLE I. To restrict biological activity likely to increase sample biomass following the increase in water temperature during storage aboard the ship, formalin was added to all samples to make a 10% solution.

4.4 UNDERWAY MONITORING AND CTD SYSTEM (R.Powell)

The precision echo-sounder (PES) in the main lab was used in general, with the hull transducer. The PES in the plot was used only once. Results were satisfactory.

The sidescan sonar worked well throughout the cruise. The metering block stops when the traveller is at the right hand side of the winch, which meant it was difficult at times to know accurately how much wire was out.

The ADCP worked well throughout the cruise.

The CTD system (CTD 1117) worked satifactorily, logging on the BBC and Viglen micros as well as the RVS 'ABC' system. It was frequently used in yo-yo mode so the bottles were removed during these periods. A digital reversing thermometer (T256) just back from manufacturer's calibration, flooded on the first deployment in 35m. Another (T261) failed to operate correctly after a few deployments. The other two (T208 and T213) were satisfactory. There was an intermittent fault on the winch monitoring system when the counting did not work.

The thermosalinograph and deck transmissometer were both used successfully during the cruise.

The shipek grab worked well, until the first one was lost. A replacement was picked up from Barry to complete the work. The pilot corer which was also picked up worked all right, although the catchers were slightly too large for the plastic liners.

4.5 DATA PROCESSING (Kay Batten)

The computer system aboard Challenger for this cruise consisted of the RVS 'ABC' system.

Data were logged from various instruments: em log, gyro compass, Decca navigator, GPS, MX1107 satellite navigator, Simrad echosounder, thermosalinograph and transmissometer (from 3 Feb), ship ADCP and CTD (except for 6 dips which were not recorded).

At the end of the cruise various plots were produced: cruise track, mooring and CTD stations, sidescan sonar survey tracks and grab and core stations.

The computer system worked well throughout the cruise.

Appendix A: MOORINGS

Site no.	Description	Position	Deployed	Recovered
A1	STABLE II	51°30.12'N 4°45.13'W	3/2/91 0830	8/2/91 1005
A2	WAVEC	51°29.76'N 4°45.10'W	1/2/91 1255	9/2/91 1323
A3	ADCP	51°29.85'N 4°44.55'W	1/2/91 1334	8/2/91 0910
A4	S4 (ETA-rig) near-surface	51°29.98'N 4°45.09'W	1/2/91 1430	-
A5	S4 (U-shape) near-bottom	51°30.02'N 4°45.35'W	3/2/91 0936	8/2/91 0810
A6	Met. buoy	51°29.60'N 4°45.50'W	1/2/91 1430	9/2/91 1421
B1	STABLE I	51°34.00'N 4°30.00'W	2/2/91 1628	8/2/91 1300
B2	Waverider	51°33.59'N 4°29.62'W	3/2/91 1312	9/2/91 1155
B3	ADCP	51°34.20'N 4°30.00'W	2/2/91 1839	8/2/91 1229
B4	S4 (ETA-rig)	51°33.80'N 4°30.50'W	3/2/91 1130	7/2/91 1659
B5	S4 (U-shape) near-bottom	51°34.10'N 4°30.30'W	2/2/91 1712	7/2/91 1602

Appendix B: CTD STATIONS

NO.	START TIME	LATITUDE	LONGITUDE	DEPTH	COMMENTS
01	2/2/91 1526	51°34.2'N	04°29.6'W	30	Calibration of STABLE transmissometer
02	3/2/91 1355	51°33.2'N	04°29.4'W	27	Start tidal cycle at B
03	3/2/91 1537	51°33.4'N	04°29.6'W	27	
04	3/2/91 1600	51°33.4'N	04°29.6'W	24	
05	3/2/91 1632	51°33.4'N	04°29.5'W	24	
06	3/2/91 1701	51°33.4'N	04°29.5'W	25	
07	3/2/91 1730	51°33.4'N	04°29.4'W	25	
08	3/2/91 1759	51°33.4'N	04°29.4'W	27	
09	3/2/91 1831	51°33.4'N	04°29.4'W	29	
10	3/2/91 1900	51°33.3'N	04°29.4'W	30	
11	3/2/91 1930	51°33.4'N	04°29.4'W	31	
12	3/2/91 1959	51°33.3'N	04°29.4'W	30	
13	3/2/91 2030	51°33.4'N	04°29.6'W	31	
14	3/2/91 2101	51°33.4'N	04°29.6'W	31	
15	3/2/91 2130	51°33.3'N	04°29.6'W	31	
16	3/2/91 2200	51°33.3'N	04°29.6'W	31	
17	3/2/91 2231	51°33.3'N	04°29.6'W	31	
18	3/2/91 2300	51°33.3'N	04°29.5'W	30	
19	3/2/91 2330	51°33.4'N	04°29.6'W	28	
20	4/2/91 0000	51°33.4'N	04°29.6'W	29	
21	4/2/91 0030	51°33.4'N	04°29.6'W	28	
22	4/2/91 0101	51°33.4'N	04°29.6'W	25	
23	4/2/91 0129	51°33.4'N	04°29.6'W	26	
24	4/2/91 0200	51°33.4'N	04°29.6'W	25	
25	4/2/91 0230	51°33.4'N	04°29.6'W	25	
26	4/2/91 0259	51°33.4'N	04°29.6'W	24	

CTD STATIONS

NO.	START TIME	LATITUDE	LONGITUDE	DEPTH	COMMENTS
27	4/2/91 0329	51°33.4'N	04°29.6'W	24	
28	4/2/91 0358	51°33.4'N	04°29.6'W	24	
29	4/2/91 0430	51°33.4'N	04°29.6'W	25	
30	4/2/91 0458	51°33.4'N	04°29.6'W	25	
31	4/2/91 0528	51°33.4'N	04°29.5'W	26	
32	4/2/91 0559	51°33.4'N	04°29.4'W	27	
33	4/2/91 0629	51°33.4'N	04°29.4'W	27	
34	4/2/91 0659	51°33.4'N	04°29.5'W	29	
35	4/2/91 1256	51°29.0'N	04°45.2'W	55	Start tidal cycle at A
36	4/2/91 1400	51°29.0'N	04°45.2'W	52	
37	4/2/91 1458	51°29.0'N	04°45.2'W	51	
38	4/2/91 1600	51°29.0'N	04°45.2'W	50	
39	4/2/91 1700	51°29.0'N	04°45.2'W	52	
40	4/2/91 1800	51°29.0'N	04°45.1'W	53	
41	4/2/91 1859	51°28.9'N	04°44.9'W	55	
42	4/2/91 1959	51°28.9'N	04°44.9'W	56	
43	4/2/91 2059	51°29.0'N	04°45.0'W	57	
44	4/2/91 2200	51°29.0'N	04°45.1'W	57	
45	4/2/91 2259	51°29.0'N	04°45.3'W	57	
46	5/2/91 0001	51°29.1'N	04°45.3'W	55	
47	5/2/91 0100	51°29.0'N	04°45.3'W	54	
48	5/2/91 0159	51°28.9'N	04°45.1'W	52	
49	8/2/91 0006	51°29.4'N	04°44.6'W	55	Start ebb tide at A
50	8/2/91 0100	51°29.3'N	04°44.4'W	52	Decca unreliable
51	8/2/91 0159	51°29.1'N	04°44.7'W	48	Using GPS
52	8/2/91 0300	51°29.2'N	04°44.3'W	52	GPS

CTD STATIONS

NO.	START TIME	LATITUDE	LONGITUDE	DEPTH	COMMENTS
53	8/2/91 0400	51°29.6'N	04°45.2'W	49	GPS
54	8/2/91 0606	51°29.2'N	04°44.3'W	46	GPS problems
55	8/2/91 0704	51°29.3'N	04°44.2'W	49	GPS
56	9/2/91 2212	51°34.0'N	04°30.0'W	33	Start tidal cycle at B
57	9/2/91 2300	51°34.0'N	04°30.0'W	32	
58	10/2/91 0000	51°34.0'N	04°30.0'W	33	
59	10/2/91 0101	51°34.0'N	04°30.0'W	34	
60	10/2/91 0201	51°33.9'N	04°29.9'W	33	
61	10/2/91 0307	51°33.5'N	04°30.3'W	32	
62	10/2/91 0402	51°33.9'N	04°30.0'W	34	
63	10/2/91 0500	51°33.9'N	04°29.9'W	34	
64	10/2/91 0601	51°34.0'N	04°30.0'W	33	
65	10/2/91 0700	51°34.0'N	04°29.9'W	33	
66	10/2/91 0800	51°34.0'N	04°30.2'W	32	
67	10/2/91 0859	51°33.9'N	04°30.0'W	30	
68	10/2/91 0956	51°33.9'N	04°30.0'W	30	

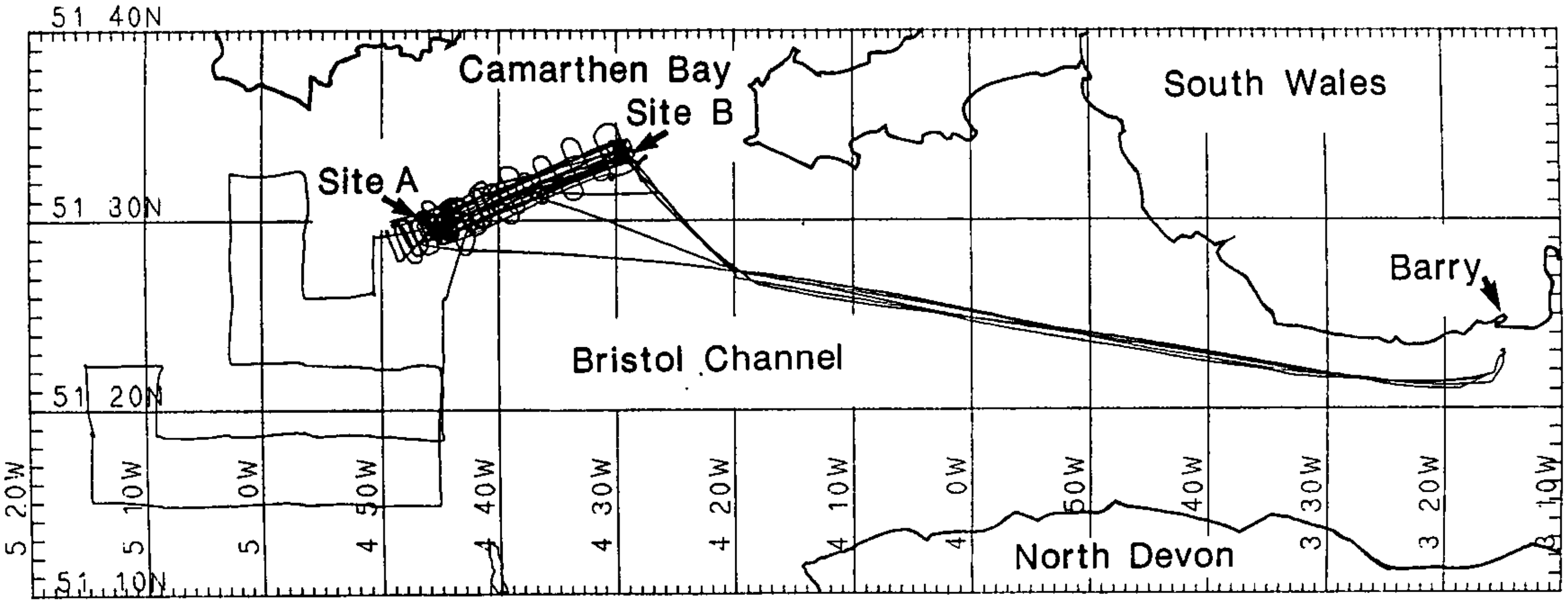
Appendix C: GRAB SAMPLES

NO.	TIME		LATITUDE	LONGITUDE	DEPTH	COMMENTS
X1	1/2/91	1226	51°29.8'N	04°45.3'W	-	Sample site A
X2	2/2/91	1520	51°34.2'N	04°30.0'W	-	Sample site B
X3	3/2/91	1348	51°33.4'N	04°29.6'W	-	Start tidal cycle at B
X4	4/2/91	1102	51°32.7'N	04°30.4'W	-	Sed. rig deployment at B
X5	4/2/91	1243	51°29.0'N	04°45.2'W	-	Start tidal cycle at A
01	5/2/91	1009	51°30.3'N	04°44.8'W	52	Start grab sample survey
02	5/2/91	1024	51°30.3'N	04°44.3'W	52	
03	5/2/91	1041	51°30.4'N	04°44.0'W	51	
04	5/2/91	1057	51°30.4'N	04°43.4'W	45	
05	5/2/91	1112	51°30.5'N	04°43.1'W	51	
06	5/2/91	1127	51°30.6'N	04°42.7'W	49	
07	5/2/91	1142	51°30.7'N	04°42.4'W	45	
08	5/2/91	1156	51°30.8'N	04°42.0'W	46	
09	5/2/91	1211	51°30.9'N	04°41.8'W	45	
10	5/2/91	1226	51°31.0'N	04°41.4'W	44	
11	5/2/91	1240	51°31.0'N	04°41.0'W	43	
12	5/2/91	1256	51°31.0'N	04°40.5'W	42	
13	5/2/91	1316	51°31.1'N	04°40.2'W	41	
14	5/2/91	1325	51°31.3'N	04°39.9'W	42	
15	5/2/91	1341	51°31.5'N	04°39.6'W	42	
16	5/2/91	1355	51°31.6'N	04°39.2'W	41	
17	5/2/91	1410	51°31.7'N	04°38.9'W	40	
18	5/2/91	1425	51°31.8'N	04°38.5'W	39	
19	5/2/91	1440	51°31.9'N	04°38.2'W	39	
20	5/2/91	1455	51°31.9'N	04°37.8'W	38	
21	5/2/91	1815	51°32.0'N	04°37.4'W	38	

GRAB SAMPLES

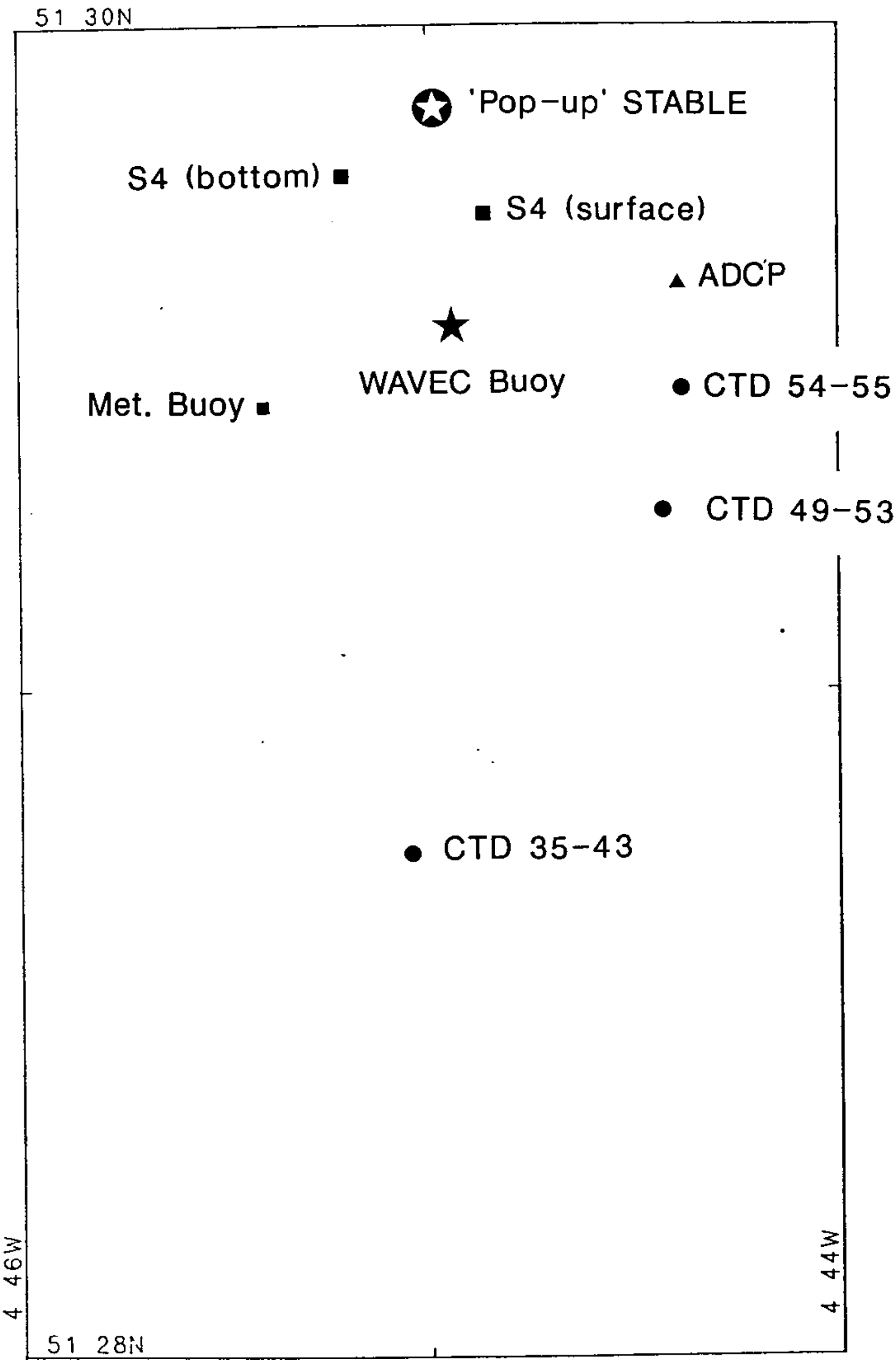
NO.	TIME	LATITUDE	LONGITUDE	DEPTH	COMMENTS
22	5/2/91 1855	51°31.9'N	04°37.0'W	40	Wire parted. Grab lost.
23	7/2/91 1241	51°32.4'N	04°36.9'W	41	
24	7/2/91 1257	51°32.3'N	04°36.6'W	41	
25	7/2/91 1310	51°32.4'N	04°36.1'W	40	
26	7/2/91 1325	51°32.5'N	04°35.8'W	39	
27	7/2/91 1338	51°32.5'N	04°35.5'W	39	
28	7/2/91 1351	51°32.6'N	04°35.3'W	38	
29	7/2/91 1808	51°32.7'N	04°35.0'W	37	
30	7/2/91 1820	51°32.8'N	04°34.6'W	34	
31	7/2/91 1831	51°32.9'N	04°34.4'W	36	
32	7/2/91 1843	51°33.0'N	04°34.0'W	36	
33	7/2/91 1854	51°33.1'N	04°33.7'W	36	
34	7/2/91 1905	51°33.1'N	04°33.4'W	36	
35	7/2/91 1919	51°33.2'N	04°33.0'W	35	
36	7/2/91 1931	51°33.4'N	04°32.7'W	35	
37	7/2/91 1942	51°33.5'N	04°32.5'W	35	
38	7/2/91 1955	51°33.6'N	04°32.0'W	34	
39	7/2/91 2006	51°33.7'N	04°31.6'W	34	
40	7/2/91 2016	51°33.7'N	04°31.3'W	33	
41	7/2/91 2026	51°33.6'N	04°30.9'W	33	
42	7/2/91 2037	51°33.8'N	04°30.4'W	33	
43	7/2/91 2101	51°34.0'N	04°29.4'W	33	

Figure 1



RRS Challenger 74b Cruise Track

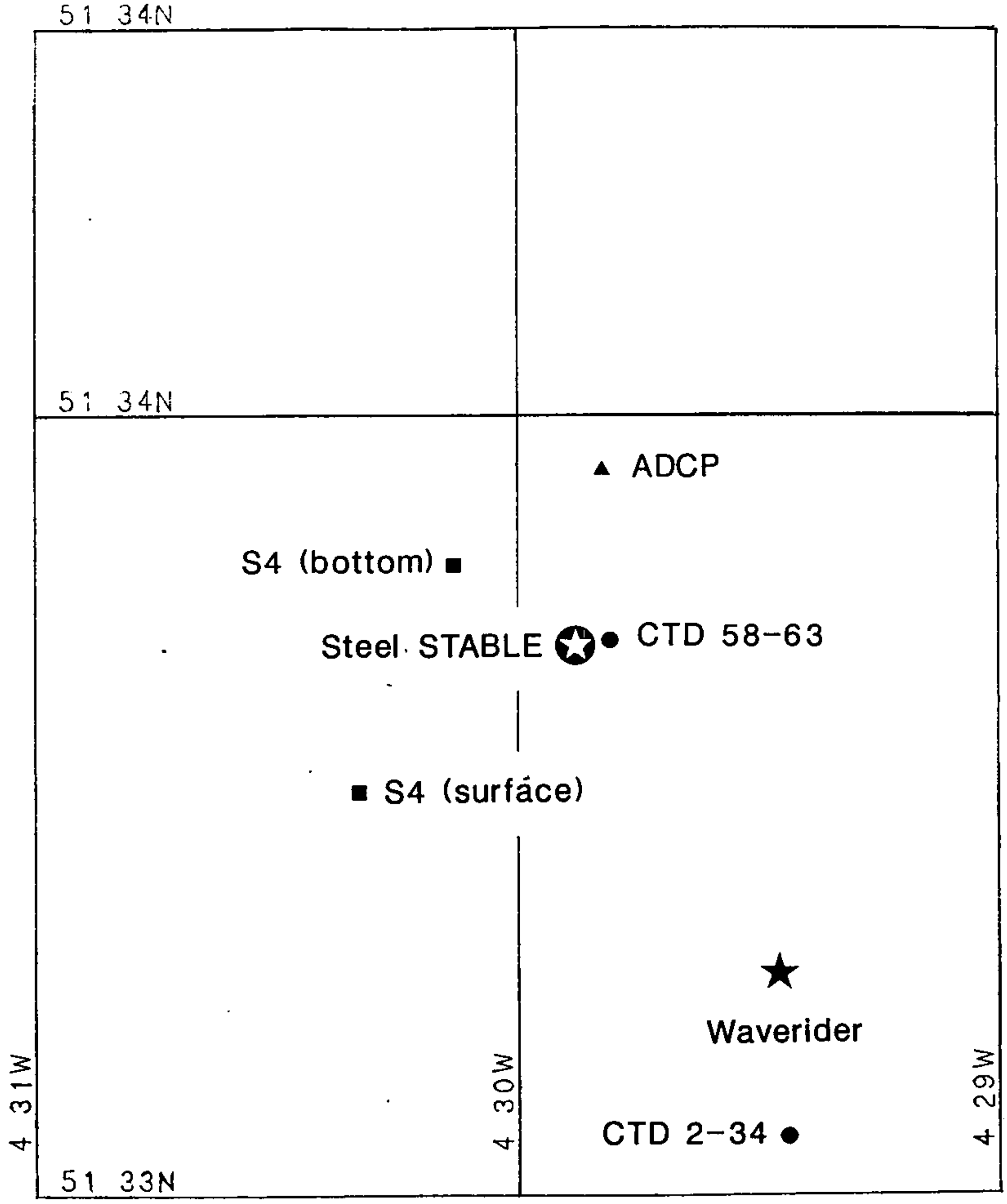
Scale 1:100000



RRS Challenger 74b Instruments Deployed at Site A, (d=50m)

Scale 1:25000

Figure 2

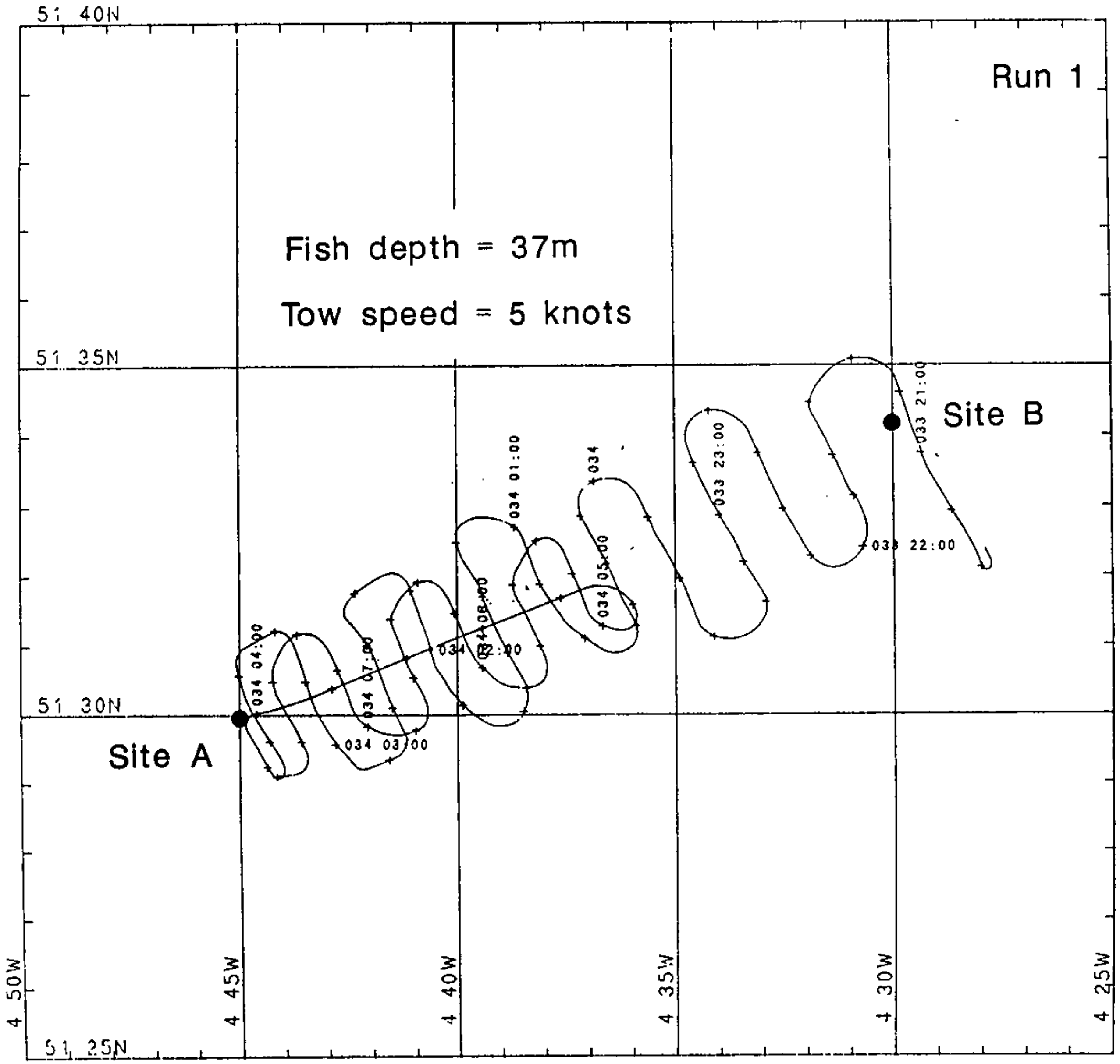


RRS Challenger 74b Instruments Deployed at Site B, (d=30m)

Scale 1:25000

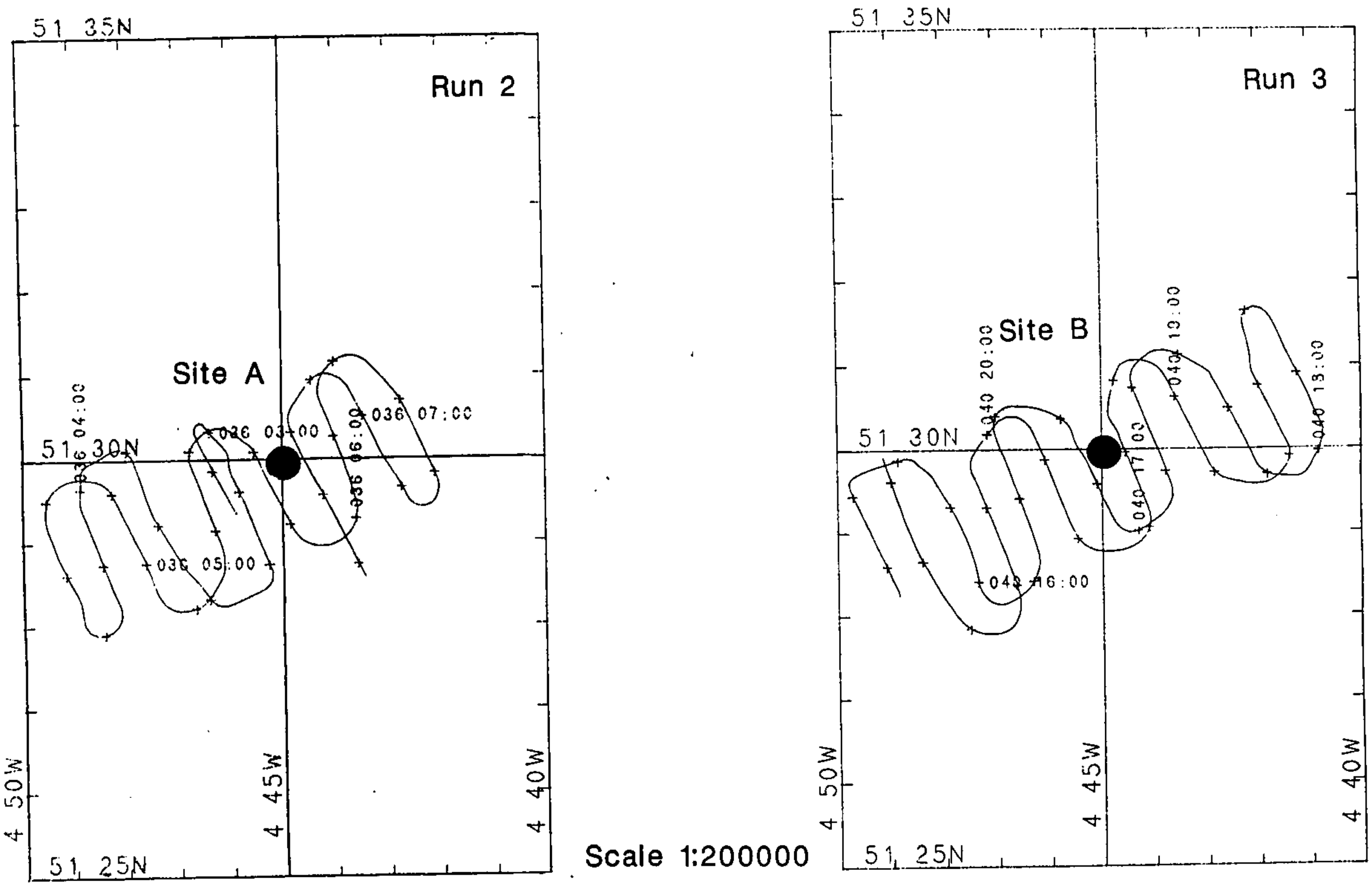
Figure 3

Figure 4a



RRS Challenger 74b Sidescan Sonar Survey 1, (2-3, February 1991)
scale 1:200000

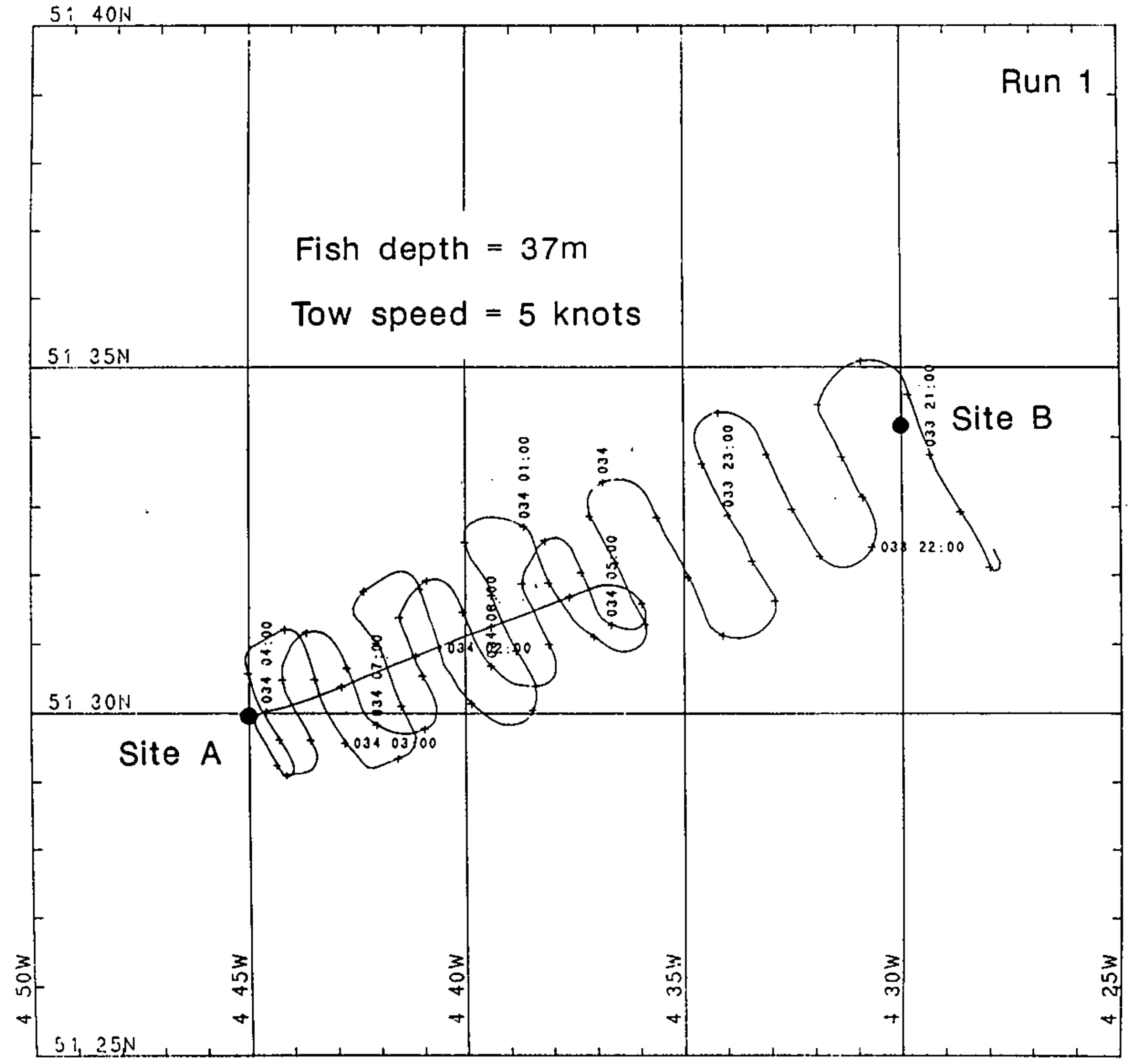
Tow speed = 5 knots Fish depth = 37m



RRS Challenger 74b Sidescan Sonar Surveys 2 and 3, (5 and 9 February 1991)

Figure 4b

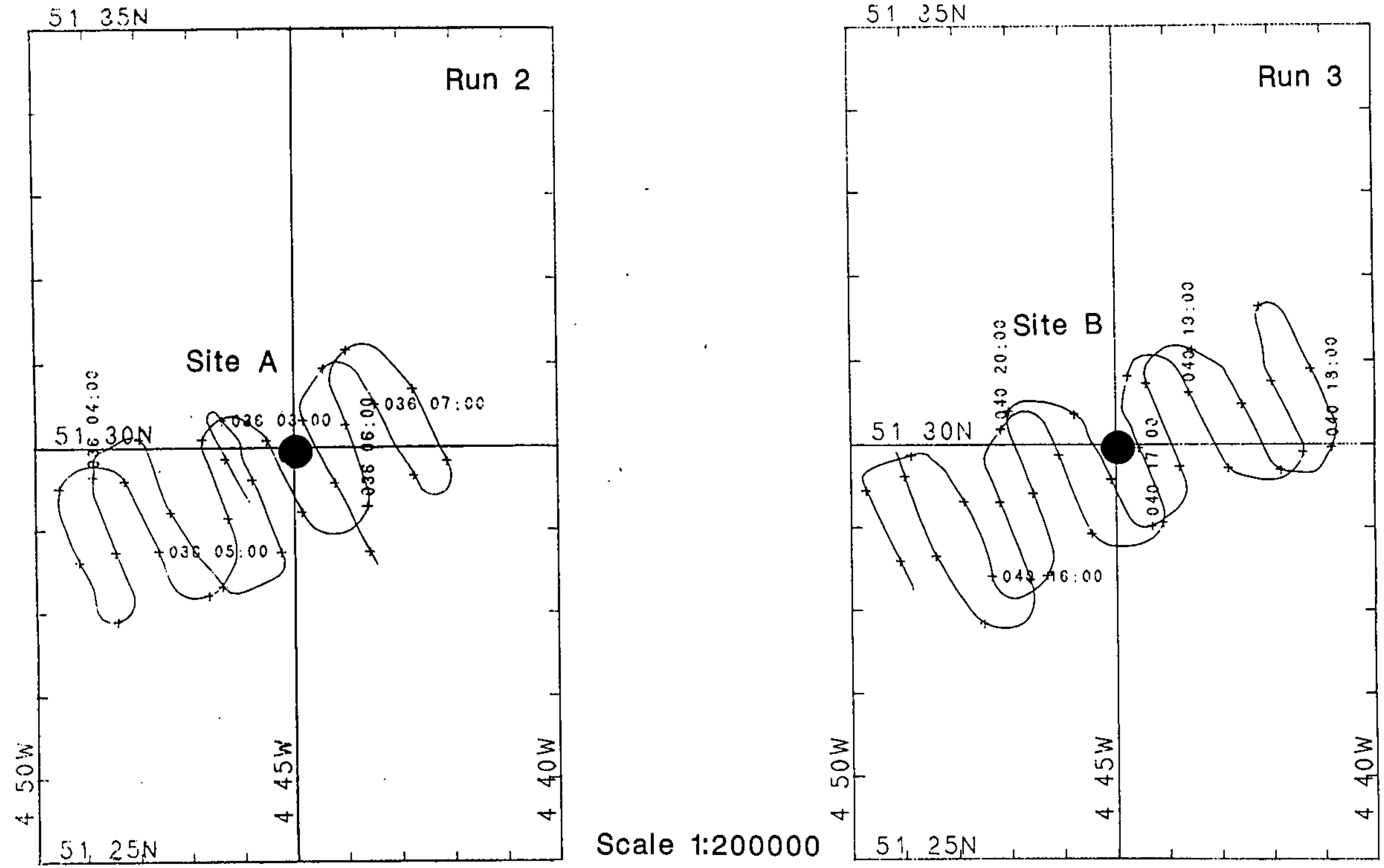
Figure 4a



RRS Challenger 74b Sidescan Sonar Survey 1, (2-3, February 1991)
scale 1:200000

Tow speed = 5 knots

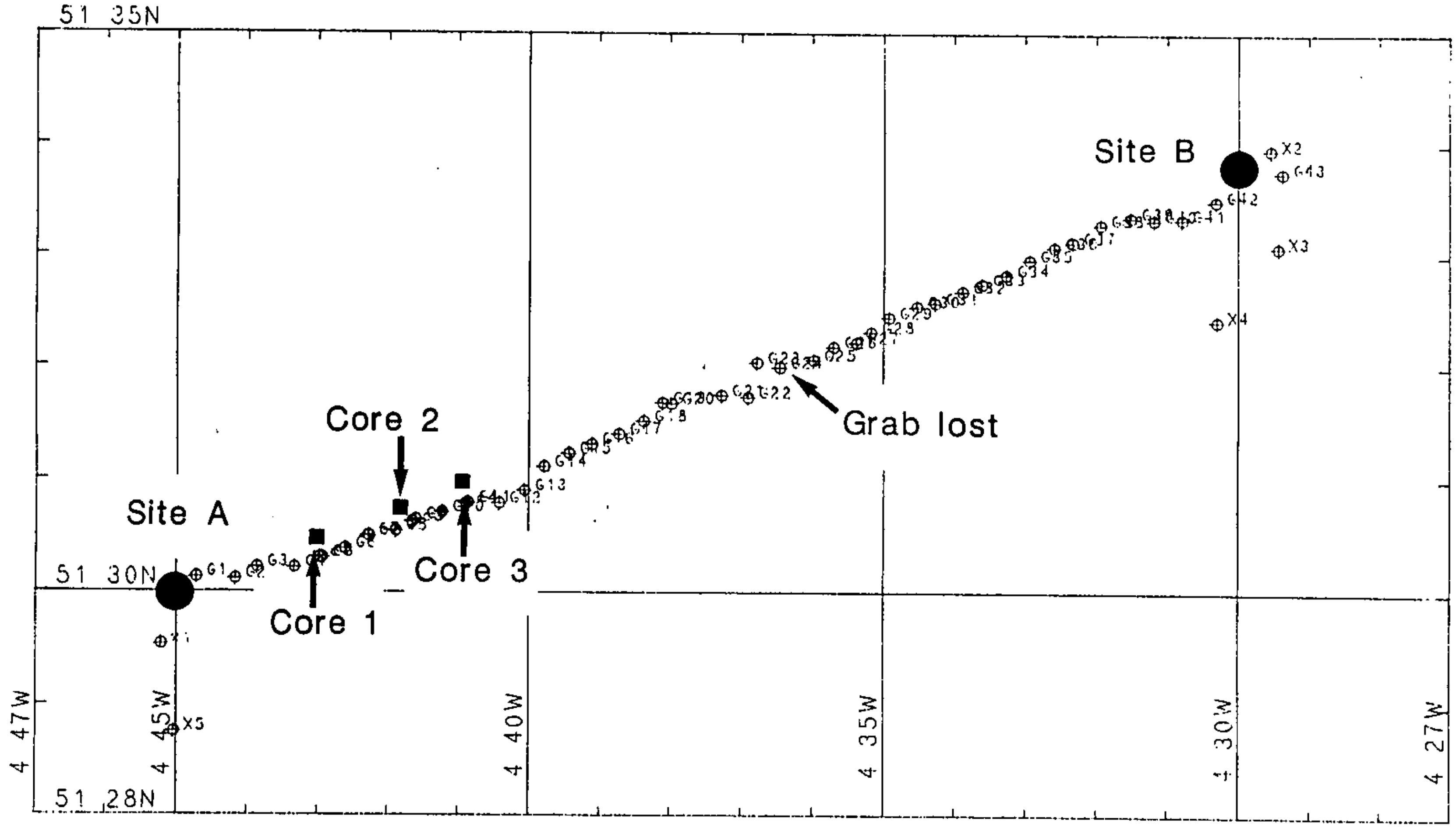
Fish depth = 37m



RRS Challenger 74b Sidescan Sonar Surveys 2 and 3, (5 and 9 February 1991)

Figure 4b

Figure 5



RRS Challenger 72b Grab Sample Survey, Line A to B

scale 1:150000