RRS 'Challenger'

Cruise 87

4 - 19 December 1991

Wave, current and sediment interaction study

Cruise Report No. 13

1992

NATURAL ENVIRONMENT RESEARCH COUNCIL

PROUDMAN OCEANOGRAPHIC LABORATORY

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WAVE, CURRENT AND SEDIMENT INTERACTION STUDY

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ABSTRACT

The Broad Fourteens study area, characterised by large tidal currents, moderate wave activity and regular, well developed sand waves in 30m water depth, is located approximately 40km off the Dutch coastline. The cruise strategy at this site was devised to study interactions between waves, currents and bottom sediments and to measure wave and current dissipation.

In total, 10 moorings were deployed for a period of approximately 7 days at two sites, (A and B), separated by 10km and aligned with the average tidal flow directions. Moorings at A included: Steel STABLE; ADCP; Waverider buoy; S4 (eta rig); and S4 and RCM U-mooring. At B moorings included: Pop-up STABLE; ADCP; Endeco wavetrack buoy; S4 (eta rig); and S4 and RCM U-mooring. In addition, red and blue fluorescent sand (Fesglo) were deployed at separate sites in the vicinity of A and B. During the cruise, the area was surveyed using sidescan sonar and echo sounding equipment and grab samples were obtained at locations around the fluorescent sand deployment sites. The experimental rig SEDRIG was deployed on three occasions and data from three 13 hour CTD (with transmissometer) stations were obtained. Data used to determine 2-D directional wave spectra and meteorological data were obtained hourly using RRS Challenger's secondary navigation radar and meteorological instruments respectively.

No difficulties were encountered during cruise operations and weather conditions were almost perfect for the scientific aims of the study. Data return from all the deployed instruments was approximately 80%.

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1.0 STAFF LIST

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2.0 CRUISE OBJECTIVES

2.1 The measurement of near-bed turbulence, vertical current structure, waves (especially directional spectra) and currents at two sites separated by 10 Km and aligned with the main tidal stream for a period of 10 days.

2.2 Determination of wave and current dissipation.

2.3 Measurement of suspended sediment flux using transmissometers, an acoustic backscatter probe and an array of drogue nets (SEDRIG).

2.4 The measurement of bedload transport rate and direction using STABLE and fluorescent sand tracers.

2.5 Determination of 3-D scale and structure of near-bed turbulent bursting events.

2.6 To observe the response of bedforms to bottom stress resulting from the combined action of waves and tidal currents.

2.7 Determination of drag partitioning, especially form drag imposed by local bedforms (sand waves).

The Broad Fourteens study area (figure 8.1.0) is located approximately 40 Km off the Dutch coastline. The site, characterised by large tidal currents, moderate wave activity and regular, well developed sand waves in 30 ± 3 m water depth, is well suited to meet the objectives of the study stated above.

3.0 NARRATIVE

RRS Challenger sailed from Troon at 10:36 on 4 December 1991 and reached the study site via the North Channel, Irish Sea, St. Georges Channel and the English Channel (in the vicinity of 52 31'N 03 32'E) at 21:38 GMT on 7 December 1991, (Figure 8.1.0). Weather conditions during passage to the working area were generally good. In order to establish the optimum locations for the two STABLE rigs, a PES echo sounding survey was carried out along a line from 52 31'N 03 32'E (site B) to 52 39'N 03 41'E (site A). The survey revealed the presence of well developed and regular sand waves over the general study area with wavelengths ranging between 100-200 m and amplitudes up to 5 m. In many cases the profiles indicated recent erosion on the crests. Two transmissometers, attached to the CTD cradle at the end of the echo sounding survey, were deployed for 20 minutes at site A for calibration purposes. Water bottle samples obtained during the CTD cast at mid-water (approximately 17 m) and close to the sea bed were filtered to determine the amount of suspended sediment present. This revealed the presence of only small amounts of fine material.

Faultless deployment of moorings at site A proceeded at first light on 8 December in the following order: Steel STABLE; Waverider buoy; ADCP; and an S4 near-surface current meter ETA rig. Routine hourly collection of meteorological and wave data (via a PC linked to the secondary navigation radar) commenced at 08:00 GMT.Challenger remained in the vicinity of A until slack water at approximately 13:00 when red and blue fluorescent sand tracers were released to the south west of the main instrument cluster. Following deployment of the sand, Challenger proceeded to B where the Endeco wavetrack buoy, an S4 ETA rig and an ADCP moorings were deployed successfully. At 20:00 GMT, hourly CTD casts commenced for a period of 12 hours close to the measurement site chosen for pop-up STABLE, (Appendix 7.3).

The following morning pop-up STABLE and a U-shape current meter rig were deployed. It was considered, however, that the stray line from the spar buoy of the U-shape current meter rig would present difficulties on recovery. Accordingly, the "Z" boat was launched to attach a second

stray line to the marker buoy. At slack water (approximately 13:30 GMT) red and blue fluorescent sand tracers were released at separate sites to the north of B. Challenger then proceeded to A to deploy the final U-shape current meter mooring. In the favorable weather conditions it was possible then to deploy the side scan sonar equipment for the purposes of calibration and testing prior to future survey work. Following this work, hourly CTD casts were undertaken at A for a 13 hour period, (Appendix 7.3).

Preparations of the sediment transport rig (SEDRIG) commenced at 08:30 GMT on 10 December. Following on deck testing, the rig was deployed to the south west of the blue tracer sand site at A for approximately one hour, (Appendix 7.5). On recovery it was found that the sediment traps had failed to open and that the rotary current meters had remained switched off. Possible causes of the malfunction were identified and rectified and a second deployment was attempted at 14:40 GMT at a site to the north east of the blue tracer sand, (Appendix 7.5). In this instance the rig functioned perfectly and obtained a small quantity of suspended sand in the lower nets. Examination of net samples and the rig under UV illumination revealed small quantities of fluorescent sand to be present.

At 17:00 GMT a detailed sidescan sonar and echo sounder study began along 9 closely spaced survey lines between A and B (not illustrated). The towed fish malfunctioned at 18:50 GMT due to a broken termination. Repairs were affected and the survey recommenced shortly after midnight on 11 December. The site survey then proceeded without incident until 12:57 GMT. Throughout the survey the chart was annotated using depth and navigation data.

Challenger then returned to site A at 13:00 GMT on 1 December to commence grab sampling of the sea bed in the vicinity of the fluorescent sand deployment sites. At first, samples were thought not to contain the tracer. Closer examination of slightly dry samples using a hand held UV source approximately 2 cm from the sand, however, revealed the presence of both red and blue grains in all samples. All grab samples obtained during the 12 hour sampling period were indexed and stored in sealed plastic containers for subsequent laboratory analysis (Appendix 7.4).

Low transmittance values from CTD casts on the 7 and 8 December indicated suitable conditions for photographing the sea bed using the POL bed-hopping camera. This was deployed successfully 120 times on 12 December and photographs were taken using monochrome and colour film,(Figure 8.4.0). Monochrome films processed on board showed clear details of the ripples present on the sea bed. Absence of the light table from the computer laboratory unfortunately halted further analysis of the negatives.

Challenger then returned to site B to begin a grab sample survey around the southern fluorescent sand deployment sites. In common with the previous survey, samples were obtained on an irregular grid, (Appendix 7.4). Sampling was suspended at midday to allow a third deployment of SEDRIG during the period of maximum tidal flow to the south west of the blue fluorescent sand site at B, (Appendix 7.5). Recovery operations began one hour after deployment. On the second attempt, in a strong cross tide, the recovery line became fouled under the hull and parted. Before commencing to grapple for SEDRIG, an experimental acoustic release mooring (anchor recovery spooler) was deployed at site B. The mooring consisted of 80 Kg of sub-surface buoyancy 10 m above the sea bed supporting a Benthos type 866A acoustic release and a Mors Environment rope canister type RC300. The mooring was anchored to the sea bed using a 0.25 tonne chain clump with a 50 m safety line to the surface.

After a number of unsuccessful passes over the SEDRIG deployment site using the Gifford grapnel, the rig was caught on the shackle joining the main warp by encircling it and slowly drawing in the wire. Remarkably, only minor damage to the current meters had occurred and one weighted foot was lost. During this work, the absence of the spar buoy from the U-shape current meter mooring was noted. Bottom grab sampling recommenced at 16:00 GMT and ended at 02:00 GMT on 13 December. All available containers and plastic bags had now been used to store the samples for subsequent analysis.

Challenger remained hove to until 10:00 GMT when the third 13 hour CTD study began at site B, (Appendix 7.3). In the period between casts at 14:00 GMT, the experimental acoustic release system was recovered

without incident. Whilst being generally successful, the exercise showed that the recovery technique could be refined further. The CTD station was completed at 22:00 GMT and watches were called off at 00:00 GMT on 14 December.

Recovery of moorings at site B commenced at 08:00 GMT on 14 December in the following order: ADCP; Endeco wavetrack buoy; ETA current meter rig; and pop-up STABLE. The work proceeded very smoothly owing to the relatively calm weather conditions (wind force 3-4). The Gifford grapnel was deployed at 12:30 GMT to hook the ground line of the U-shape current meter mooring. This was successful on the second pass and both the S4 and RCM instruments were recovered successfully. The whereabouts of the spar buoy could not be determined. With all moorings at B cleared, Challenger returned to A to begin recovery of the remaining equipment. The ADCP was fired at 15:00 GMT and recovered successfully. With little light remaining, Challenger moved away from the moorings to await first light.

Recovery of remaining moorings at A proceeded smoothly on 15 December in the following order: ETA current meter rig; U-shape current meter mooring; waverider buoy; and steel STABLE. Damage to STABLE was sustained on recovery due to unavoidable fouling with the ground line. This resulted in loss of the ABS probe and breakage of electromagnetic current meter heads and connecting cables. Data return was not thought to be compromised.

Following recovery, rig disassembly was necessary to provide sufficient deck space for sidescan sonar equipment. The tow fish was deployed to survey in the vicinity of A, (Figure 8.3.1). On completion of this survey, Challenger proceeded to B to undertake a final sidescan survey of the moorings site, (Figure 8.3.2). At 00:00 GMT on December 16 all scientific work was completed, and with the threat of severe weather to the west, Challenger began passage back to Barry and arrived at 13:00 GMT on 18 December 1991. Demobilisation was completed at 12:00 GMT on 19 December. On returning to POL, it was found that with the exception of the ABS logger on steel STABLE, data acquisition by all deployed instrumentation had been successful.

4.0 DIARY

DECEMBER 03

16:30 Remaining scientific party joined ship.

DECEMBER 04

10:36 Sailed from Troon.

DECEMBER 07

21:38 Arrived at site B (52 31.0'N 03 32.0'E). PES echo sounder towed from B to A.

23:53 CTD cast to calibrate two transmissometers at A.

DECEMBER 08

00:20 Optimum deployment sites for the STABLE tripods determined.

00:30 Hove to at A

08:31 Steel STABLE deployed at A.

08:53 Waverider buoy deployed at A.

09:28 ADCP deployed at A.

10:47 ETA current meter rig deployed at A.

12:52 Blue fluorescent sand deployed at A.

13:10 Red fluorescent sand deployed at A.

14:39 ENDECO wave buoy deployed at B.

15:43 ETA current meter rig deployed at B.

18:48 ADCP deployed at B.

20:00 Commence hourly CTD dips at B.

DECEMBER 09

08:00 End hourly CTD dips at B.

08:23 Pop-up STABLE deployed at B.

09:47 U-shape current meter mooring at B.

10:56 "Z" boat launched to attach additional stray line to the spar buoy of the mooring above.

11:15 "Z" boat recovered.

13:23 Red fluorescent sand deployed at B.

13:42 Blue fluorescent sand deployed at B.

15:10 U-shape current meter mooring deployed at A.

15:42 Commence side scan sonar setup run from A to B.

17:48 End side scan sonar test.

19:03 Commence hourly CTD dips at A.

DECEMBER 10

08:00 End CTD dips at A.

08:30 Preparation of sediment transport rig (SEDRIG).

10:41 SEDRIG deployed at A.

12:00 SEDRIG recovered. Traps failed to open and trigger current meters.

14:43 SEDRIG deployed.

15:15 Commenced recovery of SEDRIG.

15:53 SEDRIG recovered. Successful operation of equipment.

17:00 Sidescan sonar survey along lines between A and B commenced.

18:52 Towed fish termination broken.

22:55 Repairs affected.

DECEMBER 11

00:37 Survey restarted.

12:37 End of sidescan survey.

13:32 Commenced bottom grabs in the vicinity of the fluorescent sand deployment sites at A.

20:13 First fluorescent grains identified.

DECEMBER 12

04:00 End bottom grabs at A. Many useful samples obtained.

04:41 Commence bottom photography. Film 1.

05:17 Film 2.

06:38 Film 3.

07:09 Film 4.

07:47 Proceed to B for grab sampling in the vicinity of the fluorescent sand sites.

08:56 Start grab sample survey at B.

11:07 Grab sample survey suspended for deployment of SEDRIG to the south west of the blue fluorescent sand site.

11:29 SEDRIG deployed.

12:00 Spar buoy on the U-shape current meter mooring at B missing.

12:41 SEDRIG grappled and lost.

12:52 SEDRIG grappled. Stray line severed beneath the hull. Rig lost.

13:38 Deployment of test mooring (Harrison).

14:28 Commenced grappling for SEDRIG.

15:28 SEDRIG recovered with superficial damage.

16:22 Recommenced bottom grabbing at B.

DECEMBER 13

01:53 End grab sample survey. Hove to.

10:02 Start 13 hour CTD station at B.

14:55 Experimental acoustic release rig recovered.

21:58 End CTD station at B.

DECEMBER 14

00:00 Watches called off.

08:00 Commence mooring recovery operations at B.

08:44 ADCP on the surface.

08:48 ADCP recovered.

09:12 Alongside the Endeco buoy.

09:19 Endeco grappled.

09:25 Endeco recovered.

09:58 ETA rig grappled.

10:01 ETA rig recovered.

10:15 Pop-up STABLE on the surface.

10:41 Pop-up STABLE grappled.

10:45 Pop-up STABLE recovered, no damage incurred.

11:00 Hove to. Pop-up STABLE disassembled.

12:00 Approach to U-shape mooring using Gifford grapple.

13:29 Ground line grappled.

13:36 S4 and RCM instruments recovered successfully.

14:00 Sail to A.

15:07 ADCP fired.

15:22 ADCP grappled.

15:24 ADCP recovered successfully.

15:30 Hove to close to A.

DECEMBER 15

08:25 ETA recovered.

09:20 U-shape mooring recovered.

10:29 Waverider buoy recovered.

11:10 Steel STABLE recovered.

12:30 Disassembly of STABLE to give deck space for sidescan equipment.

14:27 Begin sidescan survey at A.

16:50 End sidescan survey at A.

19:10 Begin sidescan survey at B.

23:30 End sidescan survey at B.

DECEMBER 16

00:00 Commence passage to Barry.

DECEMBER 17

Passage to Barry.

DECEMBER 18

Passage to Barry.

13:00 Arrival at Barry.

DECEMBER 19

12:00 Demobilisation completed. Scientific party returned to POL.

5.0 PROJECT REPORTS

5.1 Moorings

Moorings deployed at sites A and B during Challenger 87 are listed in Appendix 7.1 and illustrated in Figure 8.2.0. In addition, three deployments of the SEDRIG were made in the vicinity of the fluorescent sand release sites, (Figure 8.2.0). All mooring components were prepared prior to departure from POL and were arranged as kits of parts. Prior to deployment, each instrument mooring was assembled on deck. With the aid of the Challenger crew, no difficulties were encountered during these operations.

Damage to the U-shape current meter mooring at B was thought to have occurred around 13 December. On recovery, using the Gifford grapnel to snag the ground line, the mooring was found to be approximately 300m to the west of the deployment location. The missing spar buoy was not located. Steel STABLE suffered damage on recovery that resulted principally from fouling with the ground line. This consisted of damage to one EM current meter head, loss of the ABS probe and damage to the main signal cable. On the third deployment of SEDRIG, recovery operations were unsuccessful and the rope parted beneath the hull. Miraculously, however, the rig was grappled successfully and suffered only minor damage. All the other moorings were deployed and recovered without incident. Given the amount of shipping and fishing activity in the study area, it was fortunate that only one of the moorings was damaged.

5.2 Sediments

Four 500 Kg loads of red and blue fluorescent sand (Fesglo resin coated sand) were deployed at separate sites in the vicinity of A and B, (Figure 8.2.0) simply by tipping the material off the stern at slack water. In the clear water conditions at the time of deployment the sand was observed to sink very rapidly with little dispersion. Grab samples obtained more than 48 hours after recovery contained small quantities of the tracer at locations up to 500m from the deployment site, (Appendix 7.4). The small hand held UV lamp used to reveal the presence of fluorescent materials was found to perform poorly when samples were wet.

By holding the source close to the samples, however, it was possible to see single fluorescent grains clearly. All samples were indexed and stored for future analysis.

Detailed sidescan sonar and echo sounding surveys of the study area revealed the presence of well developed and regular sand waves with their crests aligned normal to the current direction and showing recent evidence of erosion on the crests. With maximum tidal velocities exceeding 1.0 m/s and moderate wave activity (significant wave height = 2 m; period 6 seconds), bottom sediments were thought to mobilise readily. This was confirmed by the rapid and extensive dispersal of the fluorescent sand tracers in the vicinity of the deployment sites.

5.3 Waves

During the cruise, images of waves were captured from the ship's secondary radar using MIROS software running on an OPUS PC. This digitised and stored the image directly to enable the determination of 2-D directional wave spectra. Before leaving Troon, software in the MIROS system was updated and the impedance matching to the secondary radar was checked by the MIROS engineer. Although no adjustments to the system were considered to be necessary, attempts to select auto-capture mode during the cruise were not successful. In order to obtain hourly wave data, it was necessary, therefore, to capture data manually. In general, the MIROS system worked well throughout the cruise. In total, 137 hourly sets of data were captured between 08:00 on 8 December to 00:00 on 14 December. Data captured during some watches, however, requires checking for usefulness.

The wavetrack buoy at B, on loan from ENDECO/YSI INC. in the USA, performed extremely well throughout the cruise. Although the operational range was limited significantly in moderate sea conditions, the buoy memory worked well and data could be recovered via the radio link when Challenger was within the local receiving range. The real time acquisition and processing of wave data achieved by this system was both useful and impressive with only one hour of data lost during the deployment. Both processed and raw data were backed-up on diskettes and a hard copy of quick look reports of directional wave spectra were produced. The POL waverider buoy functioned correctly during the

experimental period and gave a full data set.

5.4 Underway monitoring and CTD

With the exception of the broken sidescan fish termination, both the PES echo sounder and sidescan sonar equipment worked well during the cruise and a considerable quantity of data was collected for the purpose of preparing a topographic map of the study area. No problems were encountered with either the ADCP or the CTD equipment and the thermosalinograph performed well. Use of the Shipek grab sampler on many occasions presented no difficulties.

5.5 Data processing

The computer system on Challenger 87 consisted of the RVS 'ABC' system. Data were logged from various instruments including: em log; gyro compass; Decca navigator; GPS; MX1107 satellite navigator; Simrad echosounder; thermosalinograph; ADCP; and CTD. Plots of cruise and sidescan tracks, mooring, CTD, SEDRIG, bed hopping camera and grab sample locations were produced when requested. Some concern was expressed regarding the quality of the hard copy plot output. HPGL plot files were produced for reproduction on a better quality plotter. In general, the computer system worked well throughout the duration of the cruise.

6.0 RECOMMENDATIONS

6.1 Light Table

Installation of a light table, preferably in the computer laboratory.

6.2 Tension indicator

It was noted that the absence of a tension indicator on the main warp handicapped severely dragging operations. Given that the recovery of damaged moorings frequently requires dragging techniques, the installation of a tension meter as soon as possible is strongly recommended.

APPENDIX 7.1 Moorings, site A

No.	Description	Position	Deployed	Recovered
A1	Steel STABLE	52 39.1' N 03 39.4' E	08/12 08:26	15/12 11:10
A2	ADCP	52 39.2' N 03 39.1' E	08/12 08:31	14/12 15:24
A3	Waverider	52 38.9' N 03 39.1' E	08/12 08:53	15/12 10:28
A4	S4 (ETA-rig) near surface	52 39.1' N 03 38.9' E	08/12 10:47	15/12 08:25
A5	S4 & RCM (U-rig) (near-bottom)	52 38.7' N 03 38.9' E	09/12 15:10	15/12 09:12
B1	Pop-up STABLE	52 31.2' N 03 32.3' E	08/12 08:23	14/12 10:45
B2	ADCP	52 31.2' N 03 31.7' E	08/12 18:46	14/12 08:48
B3	ENDECO buoy	52 31.6' N 03 31.9' E	08/12 14:39	14/12 09:25
B4	S4 (ETA rig) near-surface	52 30.9' N 03 33.0' E	08/12 15.43	14/12 10:01
B5	S4 & RCM (U-rig) (Mooring dragged)	52 31.5' N 03 32.6' E 52 31.5' N 03 31.7' E	09/12 10:20	 14/12 13:36

APPENDIX 7.2 Sand tracer deployments

Site No.	Description	Position	Deployed
A1SB	Blue sand	52 38.0' N 03 38.0' E	08/12/91 12:52
A2SR	Red sand	52 38.1' N 03 38.8' E	08/12/91 13:10
B1SR	Red sand	52 32.1' N 03 33.8' E	09/12/91 13:23
B2SB	Blue sand	52 32.5' N 03 31.9' E	09/12/91 13:42

APPENDIX 7.3 CTD Stations

Site	Start time	Latitude	Longitude	Depth	Comments
1A	07/12/91 23:19	52 38.7'	03 39.3'	26 m	Transmissometer calibration dip
2B	08/12/91 20:00	52 31.7'	03 31.2	27 m	
3B	08/12/91 21:00	52 31.0'	03 31.0'	27 m	
4B	08/12/91 22:05	52 31.2'	03 31.6'	27 m	
5B	08/12/91 23:05	52 32.1'	03 32.3'	27 m	
6B	09/12/91 00:05	52 33.5'	03 32.9'	27 m	
7B	09/12/91 01:00	52 31.6'	03 32.8'	27 m	
8B	09/12/91 02:06	52 31.3'	03 32.2'	26 m	
9B	09/12/91 03:02	52 30.7'	03 31.8'	26 m	
10B	09/12/91 04:03	52 31.3'	03 32.8'	27 m	
11B	09/12/91 05:05	52 30.8'	03 32.7'	26 m	Water sample
12B	09/12/91 06:02	52 30.6'	03 32.4'	25 m	
13B	09/12/91 07:03	52 31.2'	03 32.7'	27 m	
14B	09/12/91 08:00	52 31.3'	03 32.2'	27 m	
15A	09/12/91 19:03	52 38.8'	03 40.1'	25 m	
16A	09/12/91 20:00	52 38.7'	03 39.7'	24 m	
17A	09/12/91 21:00	52 38.9'	03 39.8'	23 m	
18A	09/12/91 22:00	52 39.0'	03 39.9'	24 m	
19A	09/12/91 23:00	52 39.1'	03 39.8'	23 m	
20A	10/12/91 00:00	52 39.5'	03 40.5'	23 m	
21A	10/12/91 01:00	52 39.1'	03 39.8'	25 m	
22A	10/12/91 02:00	52 39.6'	03 40.4'	24 m	
23A	10/12/91 03:01	52 38.9'	03 41.1'	24 m	
24A	10/12/91 04:10	52 38.6'	03 39.6'	24 m	
25A	10/12/91 05:04	52 38.4'	03 40.1'	24 m	
26A	10/12/91 06:04	52 37.2'	03 40.3'	24 m	
27A	10/12/91 07:05	52 37.7'	03 39.8'	24 m	
28A	10/12/91 08:00	52 38.3'	03 39.1'	25 m	
29B	13/12/91 10:02	52 31.7'	03 33.8'	32 m	
30B	13/12/91 10:57	52 31.4'	03 33.9'	34 m	
31B	13/12/91 11:57	52 31.5'	03 33.3'	33 m	

32B	13/12/91 13:04	52 31.3'	03 33.4'	31 m	
33B	13/12/91 14:00	52 31.2'	03 33.2'	33 m	
34B	13/12/91 15:18	52 31.5'	03 33.5'	31 m	
35B	13/12/91 16:00	52 31.4'	03 33.4'	33 m	
36B	13/12/91 17:00	52 31.7'	03 32.9'	29 m	
37B	13/12/91 18:00	52 31.3'	03 32.3'	33 m	
38B	13/12/91 19:06	52 31.6'	03 32.1'	31 m	
39B	13/12/91 20:02	52 31.2'	03 33.5'	33 m	
40B	13/12/91 20:59	52 30.5'	03 31.3'	32 m	
41B	13/12/91 21:58	52 30.9'	03 32.5'	34 m	

APPENDIX 7.4 Grab sample positions

Site A (X = sample not retained)

NOTE: All samples at A indexed with A (eg.A1.3)

Start 15:31 11/12/91 - End 03:59 12/12/91

Latitude	Logitude	No.	Day	Time
52.63510	3.632131	X	345	15:36
52.63372	3.631044	X	345	15:54
52.63523	3.638746	X	345	16:15
52.63542	3.640960	X	345	16:21
52.63527	3.643971	X	345	16:26
52.63459	3.644295	X	345	16:28
52.63508	3.646239	X	345	16:30
52.63493	3.647466	X	345	16:33
52.63476	3.649162	X	345	16:36
52.63440	3.650510	X	345	16:38
52.63410	3.653196	X	345	16:42
52.63396	3.654294	X	345	16:44
52.63364	3.655886	X	345	16:47
52.63353	3.657953	X	345	16:50
52.63517	3.622695	X	345	17:11
52.63463	3.624405	X	345	17:15
52.63514	3.626190	X	345	17:18
52.63470	3.627164	X	345	17:21
52.63505	3.628072	X	345	17:23
52.63561	3.629942	X	345	17:28
52.63569	3.630793	X	345	17:31
52.63572	3.632053	X	345	17:36
52.63505	3.633938	X	345	17:41
52.63440	3.637030	X	345	17:45
52.63448	3.638768	X	345	17:50
52.63468	3.639459	X	345	17:52
52.63392	3.626091	X	345	18:15
52.63409	3.627971	X	345	18:19
52.63495	3.627373	X	345	18:22
52.63407	3.627080	X	345	18:30

52.63427	3.629213	X	345	18:37
52.63361	3.627945	X	345	18:40
52.63315	3.628197	X	345	18:43
52.63332	3.630613	X	345	18:47
52.63354	3.631470	X	345	18:49
52.63259	3.638300	Grab 1-1	345	19:00
52.63491	3.640179	Grab 2-1	345	19:05
52.63453	3.642249	Grab 3-1	345	19:08
52.63167	3.642394	Grab 3-2	345	19:18
52.63294	3.641819	Grab 3-3	345	19:22
52.63342	3.641557	Grab 3-4	345	19:24
52.63367	3.641249	Grab 3-5	345	19:27
52.63286	3.642735	Grab 4-1	345	19:31
52.63185	3.644293	Grab 4-2	345	19:34
52.63121	3.645571	Grab 4-3	345	19:36
52.63087	3.648038	Grab 4-4	345	19:39
52.63152	3.650047	Grab 4-5	345	19:42
52.63220	3.651197	Grab 5-1	345	19:44
52.63249	3.652562	Grab 5-2	345	19:46
52.63239	3.655743	Grab 5-3	345	19:50
52.63326	3.656473	Grab 5-4	345	19:55
52.63396	3.655607	Grab 5-5	345	19:58
52.63352	3.654356	Grab 6-1	345	20:01
52.63229	3.653127	Grab 6-2	345	20:06
52.63398	3.653158	Grab 6-3	345	20:13
52.63426	3.650966	Grab 6-4	345	20:20
52.63347	3.651196	Grab 6-5	345	20:24
52.63239	3.650580	Grab 7-1	345	20:28
52.63253	3.649470	Grab 7-2	345	20:32
52.63347	3.646482	Grab 7-3	345	21:02
52.63463	3.646258	Grab 7-4	345	21:05
52.63584	3.645106	Grab 7-5	345	21:09
52.63499	3.642853	Grab 8-1	345	21:13
52.63317	3.640250	Grab 8-2	345	21:20
52.63410	3.634280	Grab 8-3	345	21:32
52.63442	3.633355	Grab 8-4	345	21:35
52.63431	3.630506	Grab 8-5	345	21:41
52.63436	3.628934	Grab 9-1	345	21:45

52.63437	3.628430	Grab 9-2	345	21:50
52.63419	3.627075	Grab 9-3	345	21:54
52.63353	3.625524	Grab 9-4	345	22:04
52.63284	3.623836	Grab 9-5	345	23:01
52.63760	3.649487	Grab 10-1	345	23:04
52.63681	3.649278	Grab 10-2	345	23:06
52.63610	3.648492	Grab 10-3	345	23:09
52.63553	3.648390	Grab 10-4	345	23:13
52.63560	3.648793	Grab 10-5	345	23:16
52.63550	3.647998	Grab 11-1	345	23:19
52.63513	3.647817	Grab 11-2	345	23:24
52.63495	3.647689	Grab 11-3	345	23:26
52.63490	3.646544	Grab 11-4	345	23:30
52.63445	3.646229	Grab 11-5	345	23:34
52.63441	3.645915	Grab 12-1	345	23:36
52.63437	3.644365	Grab 12-2	345	23:39
52.63405	3.642693	Grab 12-3	345	23:44
52.63375	3.642331	Grab 12-4	345	23:48
52.63202	3.642478	Grab 12-5	345	23:56
52.63096	3.643542	Grab 13-1	346	00:04
52.62781	3.645008	Grab 13-2	346	00:27
52.62734	3.645702	Grab 13_3	346	00:35
52.62775	3.646892	Grab 13_4	346	00:41
52.62759	3.649735	Grab 13-5	346	00:48
52.62894	3.647247	Grab 14-1	346	00:52
52.62862	3.641923	Grab 14-2	346	01:13
52.62851	3.639794	Grab 14-3	346	01:17
52.62719	3.640290	Grab 14-4	346	01:21
52.62779	3.641145	Grab 14-5	346	01:30
52.63218	3.645816	Grab 15-1	346	01:45
52.63127	3.647040	Grab 15-2	346	01:49
52.63000	3.650696	Grab 15-3	346	01:53
52.62910	3.651023	Grab 15-4	346	01:57
52.63026	3.646327	Grab 15-5	346	02:03
52.63041	3.632423	Grab 16-1	346	02:34
52.62992	3.635013	Grab 16-2	346	02:38
52.62976	3.635863	Grab 16-3	346	02:42
52.62988	3.637920	Grab 16-4	346	02:45

52.63115	3.639332	Grab 16-5	346	02:50
52.62808	3.635393	Grab 17-1	346	03:11
52.62761	3.634571	Grab 17-2	346	03:14
52.62726	3.636577	Grab 17-3	346	03:19
52.62772	3.638332	Grab 17-4	346	03:23
52.62824	3.639510	Grab 17-5	346	03:28
52.62632	3.631706	Grab 18-1	346	03:41
52.62690	3.631373	Grab 18-2	346	03:45
52.62691	3.635757	Grab 18-3	346	03:49
52.62674	3.634940	Grab 18-3	346	03:52
52.62607	3.637457	Grab 18-4	346	03:56
52.62489	3.640033	Grab 18-5	346	03:59

Site B(X =sample not obtained due to misfire)

NOTE: All samples at B indexed with B (eg.B1.3)

Start 08:56 12/12/91 - End 01:50 13/12/91

Latitude	Longitude	No.	Day	Time
52.53719	3.564276	Grab 1-1	346	08:56
52.53725	3.563379	Grab 1-2	346	09:00
52.53762	3.562573	Grab 1-3	346	09:04
52.53821	3.561927	Grab 1-4	346	09:09
52.53809	3.561792	Grab 1-5	346	09:12
52.53789	3.561305	Grab 2-1	346	09:14
52.53792	3.560800	Grab 2-2	346	09:17
52.53787	3.560327	Grab 2-3	346	09:20
52.53861	3.560156	Grab 2-4	346	09:22
52.53913	3.559400	Grab 2-5	346	09:25
52.53865	3.557740	Grab 3-1	346	09:28
52.53822	3.556711	Grab 3-2	346	09:30
52.53818	3.557574	Grab 3-3	346	09:32
52.53885	3.557201	Grab 3-4	346	09:36
52.53894	3.557222	Grab 3-5	346	09:38
52.53967	3.556273	Grab 4-1	346	09:41
52.54035	3.554969	Grab 4-2	346	09:44
52.54089	3.554578	Grab 4-3	346	09:47
52.54070	3.554593	Grab 4-4	346	09:49

52.54062	3.553910	Grab 4-5	346	09:52
52.54088	3.553683	Grab 5-1	346	09:55
52.54065	3.552343	Grab 5-2	346	09:57
52.54072	3.551490	Grab 5-3	346	10:00
52.54064	3.551080	Grab 5-4	346	10:03
52.53996	3.549084	Grab 5-5	346	10:06
52.54138	3.548247	Grab 6-1	346	10:30
52.54063	3.546951	Grab 6-2	346	10:33
52.54031	3.545470	Grab 6-3	346	10:36
52.54089	3.545715	Grab 6-4	346	10:38
52.54148	3.545938	Grab 6-5	346	10:40
52.54182	3.545905	Grab 7-1	346	10:42
52.54186	3.544955	Grab 7-2	346	10:45
52.54197	3.544461	Grab 7-3	346	10:47
52.54168	3.542569	Grab 7-4	346	10:50
52.54181	3.542093	Grab 7-5	346	10:52
52.54197	3.541448	Grab 8-1	346	10:54
52.54201	3.540153	Grab 8-2	346	10:57
52.54209	3.539890	Grab 8-3	346	10:59
52.54201	3.538724	Grab 8-4	346	11:02
52.54204	3.537672	Grab 8-5	346	11:04
52.54225	3.537959	Grab 9-1	346	11:07
52.54120	3.538763	Grab 9-2	346	16:22
52.54109	3.538591	Grab 9-3	346	16:25
52.54106	3.538604	Grab 9-4	346	16:27
52.54141	3.538088	Grab 9-5	346	16:32
52.54195	3.538003	Grab 10-1	346	16:34
52.54291	3.537332	Grab 10-2	346	16:38
52.54290	3.537965	Grab 10-3	346	16:40
52.54207	3.539240	Grab 10-4	346	16:43
52.54198	3.540151	Grab 10-5	346	16:45
52.54357	3.527885	Grab 11-1	346	16:57
52.54508	3.528053	Grab 11-2	346	17:00
52.54645	3.529153	Grab 11-3	346	17:03
52.54792	3.529609	Grab 11-4	346	17:06
52.54860	3.529572	Grab 11-5	346	17:08
52.54868	3.531282	Grab 12-1	346	17:11
52.54821	3.532263	Grab 12-2	346	17:13

52.54798	3.533098	Grab 12-3	346	17:15
52.54596	3.533448	Grab 12-4	346	17:20
52.54599	3.533400	Grab 12-5	346	17:22
52.54566	3.533578	Grab 13-1	346	17:24
52.54562	3.533897	Grab 13-2	346	17:26
52.54563	3.534392	Grab 13-3	346	17:29
52.54557	3.534265	Grab 13-4	346	17:31
52.54552	3.533534	Grab 13-5	346	17:34
52.54563	3.532426	Grab 14-1	346	17:37
52.54526	3.533087	Grab 14-2	346	17:39
52.54470	3.534918	Grab 14-3	346	17:43
52.54439	3.535249	Grab 14-4	346	17:45
52.54341	3.535279	Grab 14-5	346	17:48
52.54333	3.535743	Grab 15-1	346	17:50
52.54305	3.536953	Grab 15-2	346	17:53
52.54466	3.535591	Grab 15-3	346	18:41
52.54473	3.535910	Grab 15-4	346	18:43
52.54486	3.535526	Grab 15-5	346	18:45
52.54378	3.535674	Grab 16-1	346	18:48
52.54214	3.536692	Grab 16-2	346	18:51
52.54101	3.537543	Grab 16-3	346	18:54
52.54043	3.537982	Grab 16-4	346	18:56
52.54049	3.539275	Grab 16-5	346	18:58
52.54114	3.540953	Grab 17-1	346	19:01
52.54203	3.542140	Grab 17-2	346	19:03
52.54247	3.544165	Grab 17-3	346	19:06
52.54238	3.545101	Grab 17-4	346	19:08
52.54205	3.545662	Grab 17-5	346	19:11
52.54235	3.545082	Grab 18-1	346	19:15
52.54241	3.544472	Grab 18-2	346	19:17
52.54279	3.543649	Grab 18-3	346	19:19
52.54280	3.543131	Grab 18-4	346	19:21
52.54270	3.542580	Grab 18-5	346	19:23
52.54238	3.541595	Grab 19-1	346	19:26
52.54223	3.540801	Grab 19-2	346	19:28
52.54167	3.540430	Grab 19-3	346	19:30
52.54205	3.539747	Grab 19-4	346	19:32
52.54175	3.538272	Grab 19-5	346	19:35

52.54190	3.537552	Grab 20-1	346	19:37
52.54181	3.536772	Grab 20-2	346	19:40
52.54176	3.535942	Grab 20-3	346	19:42
52.54148	3.535211	Grab 20-4	346	19:44
52.54171	3.533905	Grab 20-5	346	19:47
52.54196	3.533083	Grab 21-1	346	19:49
52.54226	3.532391	Grab 21-2	346	19:51
52.54302	3.531064	Grab 21-3	346	19:54
52.54335	3.530512	Grab 21-4	346	19:56
52.53435	3.559040	Grab 21-5	346	20:05
52.53468	3.558439	Grab 22-1	346	20:41
52.53456	3.557118	Grab 22-2	346	20:44
52.53426	3.556395	Grab 22-3	346	20:46
52.53484	3.556206	Grab 22-4	346	20:49
52.53493	3.555917	Grab 22-5	346	20:51
52.53572	3.555434	Grab 23-1	346	20:54
52.53640	3.555117	Grab 23-2	346	20:56
52.53684	3.555077	Grab 23-4	346	20:58
52.53652	3.555045	Grab 23-4	346	21:00
52.53601	3.554942	Grab 23-5	346	21:02
52.53602	3.554630	Grab 24-1	346	21:03
52.53609	3.553361	Grab 24-2	346	21:06
52.53603	3.552557	Grab 24-3	346	21:08
52.53615	3.551461	Grab 24-4	346	21:10
52.53645	3.550635	Grab 24-5	346	21:12
52.53695	3.549581	Grab 25-1	346	21:15
52.53734	3.549071	Grab 25-2	346	21:17
52.53809	3.548483	Grab 25-3	346	21:19
52.53792	3.547622	Grab 25-4	346	21:21
52.53720	3.546496	Grab 25-5	346	21:23
52.53679	3.544955	Grab 26-1	346	21:26
52.53732	3.533778	Grab 26-2	346	22:00
52.53829	3.532459	Grab 26-3	346	22:02
52.53897	3.531944	Grab 26-4	346	22:04
52.53991	3.531297	Grab 26-5	346	22:07
52.54044	3.531002	Grab 27-1	346	22:09
52.53958	3.560587	Grab 27-2	346	22:59
52.53943	3.561572	Grab 27-3	346	23:01

52.53906	3.561878	Grab 27-4	346	23:03
52.53874	3.562308	Grab 27-5	346	23:05
52.53846	3.562796	Grab 28-1	346	23:07
52.53764	3.563219	Grab 28-2	346	23:09
52.53635	3.563905	Grab 28-3	346	23:12
52.53538	3.564449	Grab 28-4	346	23:14
52.53418	3.564650	Grab 28-5	346	23:17
52.53330	3.564969	Grab 29-1	346	23:19
52.53284	3.564955	Grab 29-2	346	23:21
52.53282	3.564375	Grab 29-3	346	23:23
52.53304	3.563722	Grab 29-4	346	23:25
52.53292	3.562150	Grab 29-5	346	23:28
52.53281	3.560511	Grab 30-1	346	23:31
52.53277	3.559990	Grab 30-2	346	23:33
52.53303	3.558523	Grab 30-3	346	23:35
52.53326	3.557305	Grab 30-4	346	23:38
52.53348	3.557135	Grab 30-5	346	23:40
52.53383	3.556625	Grab 31-1	346	23:42
52 32.22	03 33.22'	Grab 31-2	346	23:46
52 32.19	03 33.20'	Grab 31-3	346	23:50
52 32.21	03 33.07'	Grab 31-4	346	23:55
52.53874	3.550685	Grab 32-1	347	00:35
52 32.32	03 33.04'	Grab 32-2	347	00:38
52 32.31	03 33.08'	Grab 32-3	347	00:45
52 32.33	03 32.97'	Grab 32-4	347	00:51
52.53956	3.546359	Grab 33-1	347	01:13
52 32.35	03 32.66'	Grab 33-2	347	01:16
52 32.30	03 32.53'	Grab 33-3	347	01:20
52 32.24	03 32.45'	Grab 33-4	347	01:25
52.53780	3.538790	Grab 34-1	347	01:35
52 32.32	03 32.03'	Grab 34-2	347	01:37
52 32.37	03 32.11'	Grab 34-3	347	01:50

APPENDIX 7.5 SEDRIG deployments

No.	Description	Position	Deployed	Recovered
A1	Test	52 38.0N 03 38.4E	10:41 10/12	12:00 10/12
A2	Site A	52 38.1N 03 38.7E	14:43 10/12	15:53 10/12
B1	Site B	52 32.5N 03 31.8E	11:29 11/12	15:28 11/12

APPENDIX 7.6 Bed hopping camera photograph sites

(Location and time of every 5th photograph only shown)

Latitude	Longitude	No.	Day	Time
52.58778	3.603738	Touch A1	346	04:45
52.58756	3.604582	Touch A5	346	04:48
52.58850	3.605541	Touch A10	346	04:58
52.58933	3.606899	Touch A15	346	05:03
52.59022	3.608179	Touch A20	346	05:07
52.59101	3.609559	Touch A25	346	05:11
52.59172	3.610658	Touch A30	346	05:15
52.59326	3.614751	Touch B1	346	05:48
52.59349	3.615233	Touch B5	346	05:51
52.59413	3.615777	Touch B10	346	05:55
52.59442	3.616175	Touch B15	346	05:59
52.59486	3.616518	Touch B20	346	06:03
52.59617	3.618087	Touch B25	346	06:07
52.59607	3.617800	Touch B30	346	06:12
52.59946	3.622397	Touch C1	346	06:39
52.60003	3.623084	Touch C5	346	06:43
52.60021	3.624223	Touch C10	346	06:48
52.60081	3.625205	Touch C15	346	06:54
52.60105	3.625664	Touch C20	346	06:58
52.60107	3.624742	Touch C25	346	07:03
52.60053	3.624621	Touch C30	346	07:07
52.59767	3.621715	Touch D1	346	07:27
52.59807	3.622490	Touch D5	346	07:30
52.59902	3.624248	Touch D10	346	07:34
52.59889	3.625680	Touch D15	346	07:38
52.59962	3.626345	Touch D20	346	07:41
52.59990	3.626385	Touch D25	346	07:44
52.59881	3.625447	Touch D30	346	07:47

APPENDIX 7.7 Notice to mariners

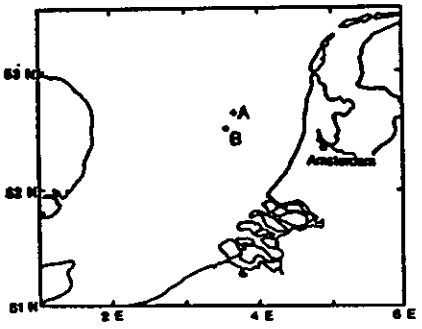
NOTICE TO MARINERS

Southern North Sea
4 - 20 December 1991

A hazard to shipping and fishing will be presented by an array of moorings at two sites in the vicinity of 52° 35'N 3° 40'E (The Broad Fourteens).

Sea bed frame, sub-surface buoyed and surface buoyed moorings will be deployed. The yellow surface buoys (either 2m diameter toroids or 5m spar buoys) conform to IMCO recommendations and contain a radar reflector and a yellow light which flashes rapidly for 5 seconds every 20 seconds. The Laboratory's name is painted on the buoys.

To avoid fouling the moorings the Laboratory would be grateful if ships and fishing boats would keep at least 5 cables clear of the moorings.

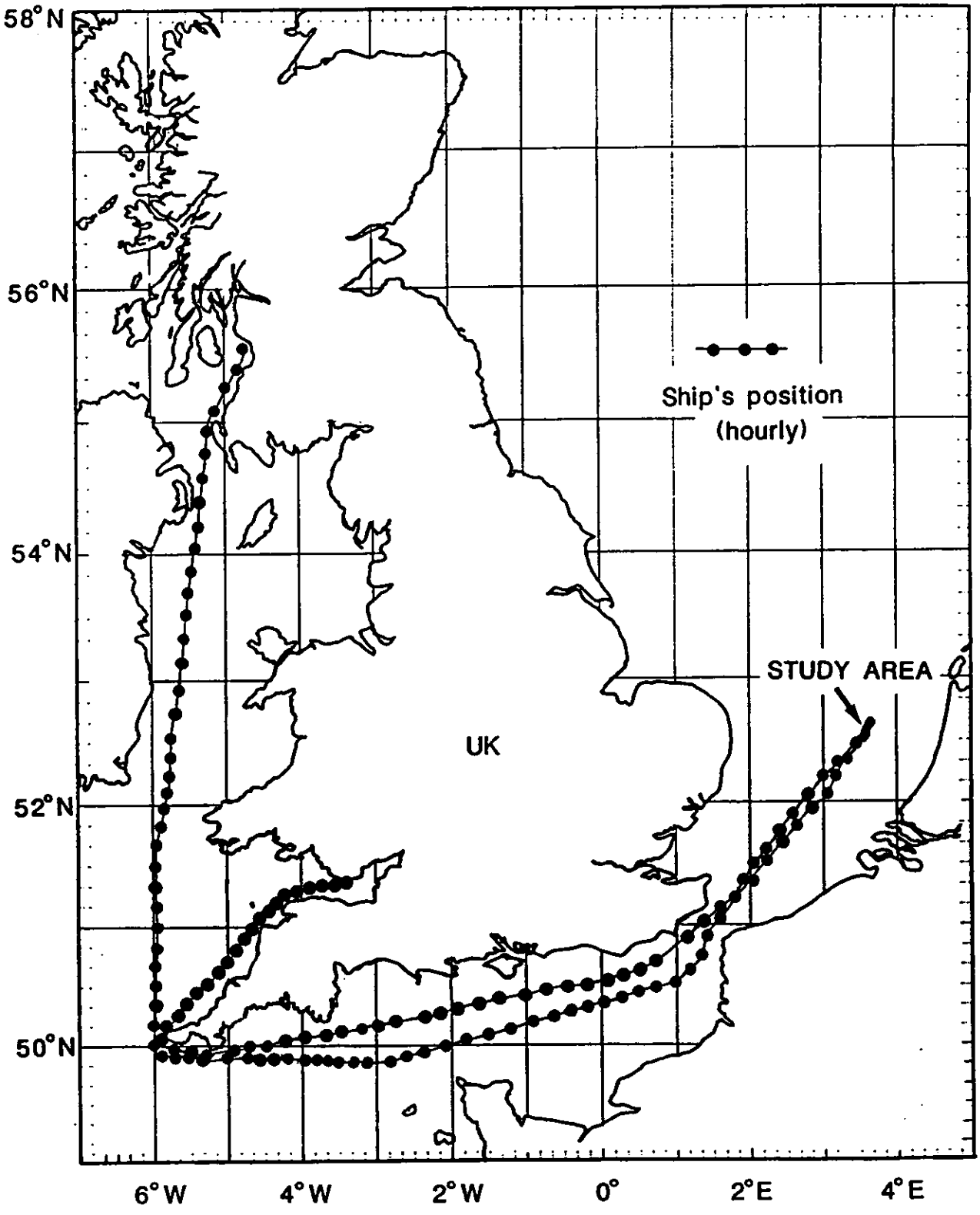


	Position			
	Lat	Long	Decca(OE)	
	(N)	(E)	Green	Purple
A	52°39'	3°41'	D38.7	B9.3
B	52°31'	3°32'	D46.1	H15.8

Proudman Oceanographic Laboratory,
Bidston Observatory,
Birkenhead L43 7RA,
United Kingdom

Tel 051-653 8633 / Telex 628591 OCEANB G / Fax 051-653 6269

Figure 8.1.0 Ships track and location of the study area



Mercator Projection Scale 1: 4266483 (natural scale at Lat. 55°N)

Figure 8.2.0 Moorings, SEDRIG and fluorescent sand deployment sites at A and B.

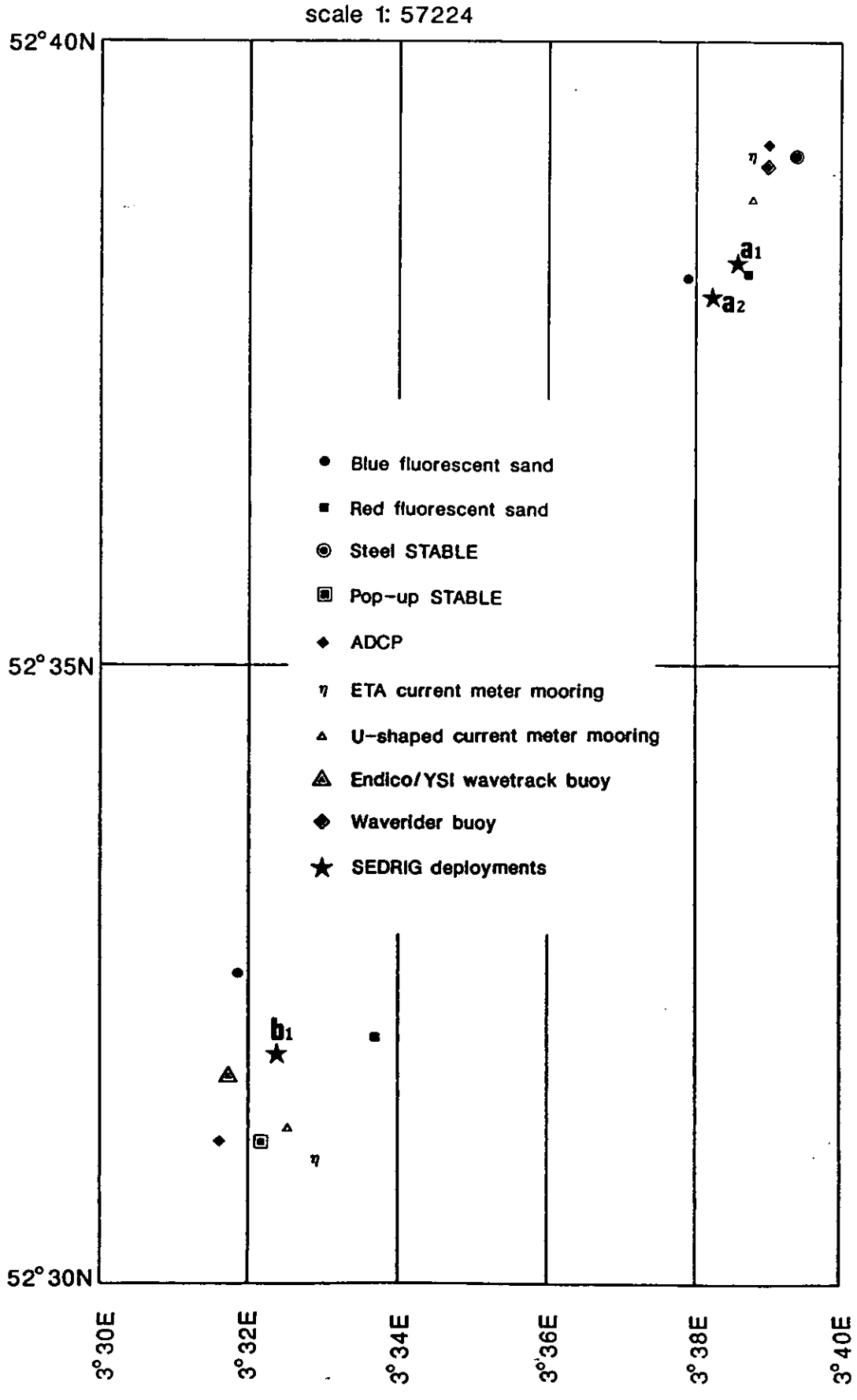


Figure 8.3.1 Sidescan sonar survey track at A.

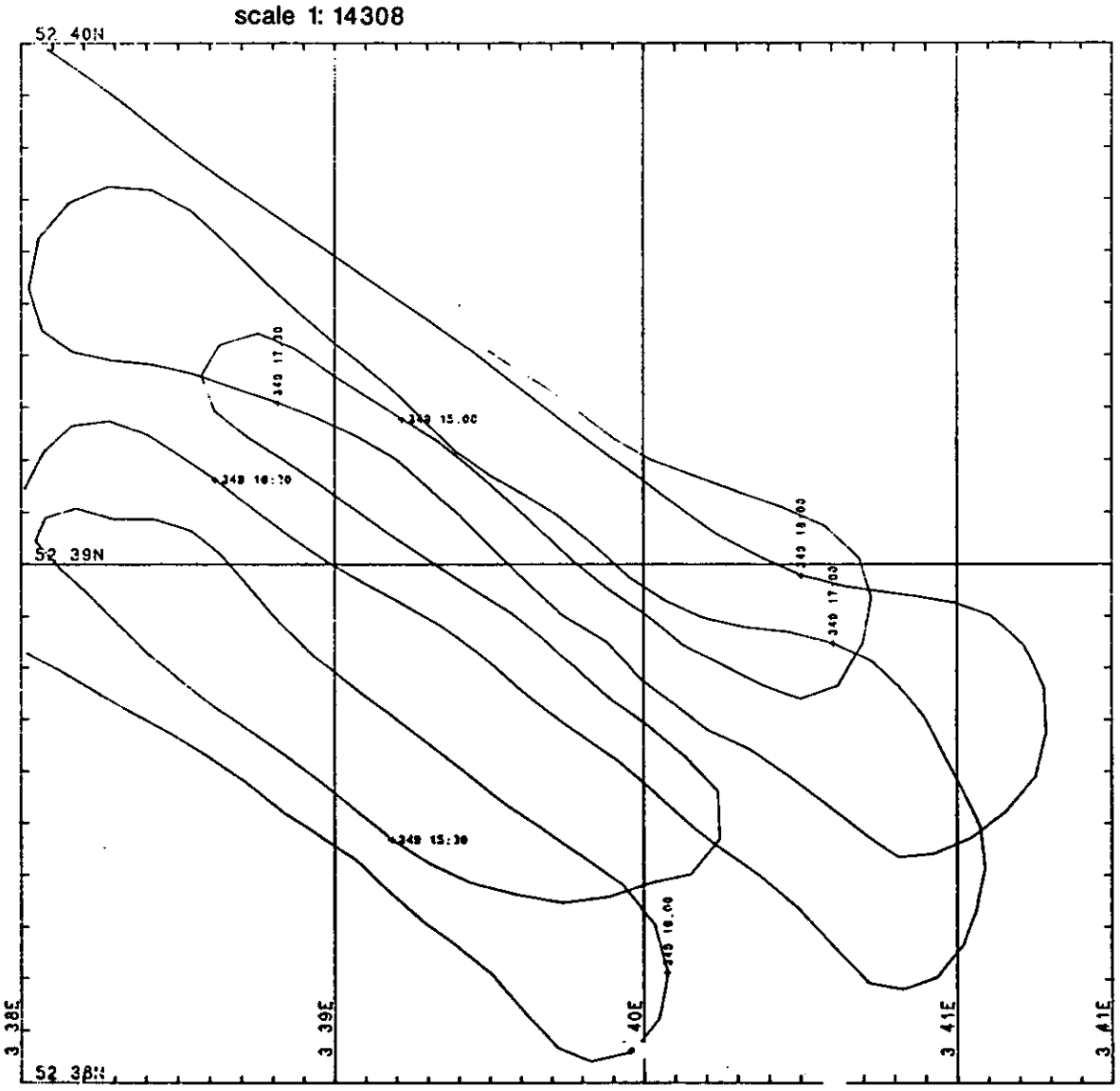
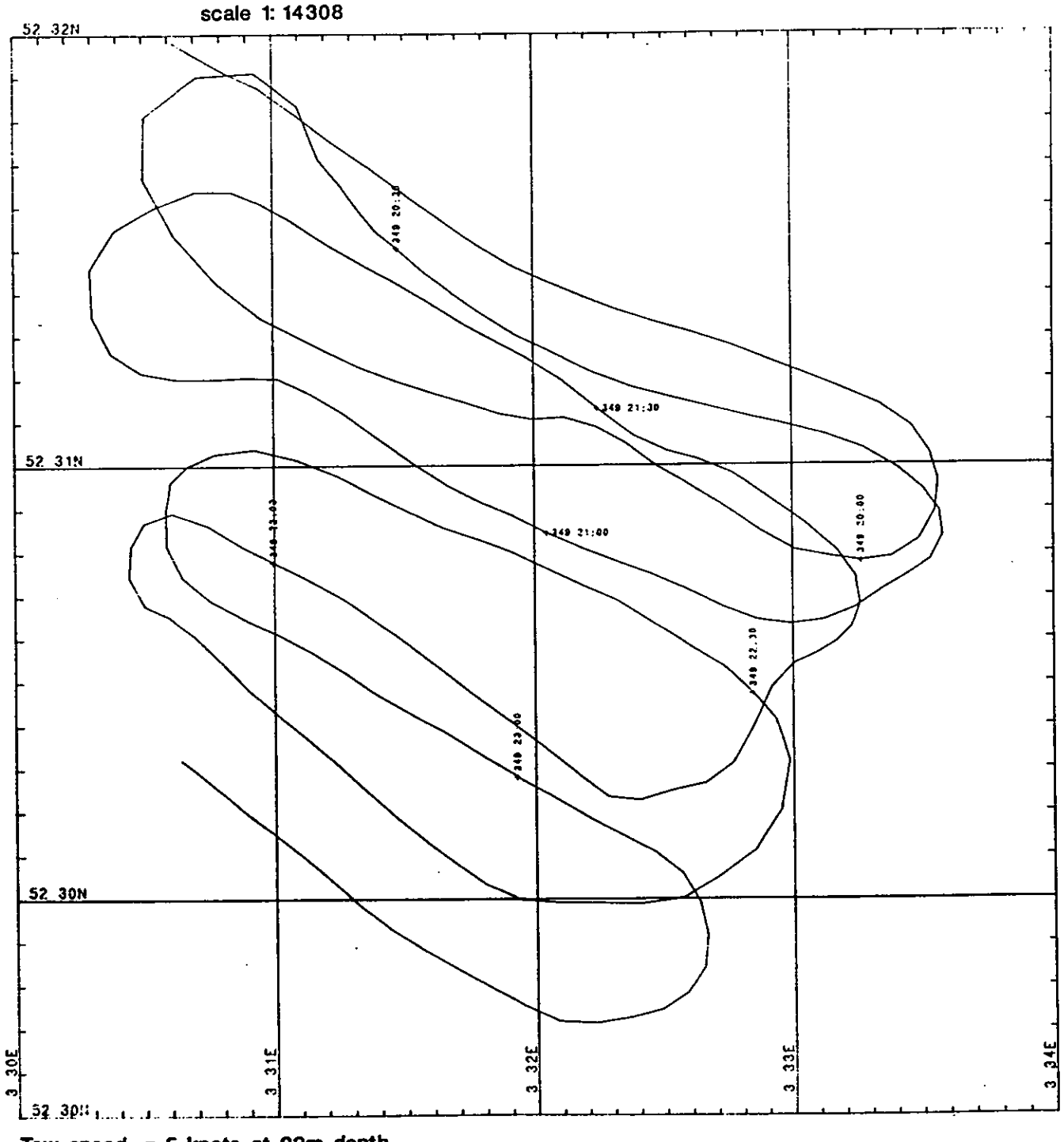


Figure 8.3.2 Sidescan sonar survey track at B.



Tow speed = 5 knots at 22m depth

Figure 8.4.0 Bed hopping camera photograph sites.