P.O.L.

*RRS CHARLES DARWIN*
CRUISE 91

LEG A: BARRY TO FAIRLIE

2 MARCH 1995
-
22 MARCH 1995

DR. B.S. McCARTNEY

LEG B: FAIRLIE TO FAIRLIE

22 MARCH 1995
-
2 APRIL 1995

Dr. J.M. HUTHNANCE

LOIS SHELF EDGE STUDY

CRUISE REPORT NO. 20

1995

Natural Environment Research Council

PROUDMAN OCEANOGRAPHIC LABORATORY

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*Natural Environment Research Council*

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# RRS CHARLES DARWIN CRUISE 91

## LOIS SHELF EDGE STUDY

Leg A: Barry to Fairlie

2nd March to 22nd March 1995

Principal Scientist: Dr. B.S. McCartney

Leg B: Fairlie to Fairlie

22nd March to 2nd April 1995

Principal Scientist: Dr. J.M. Huthnance

# DOCUMENT DATA SHEET

AUTHOR
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ABSTRACT

On RRS *Charles Darwin* cruise 91A weather severely constrained scientific work. A high resolution Bathymetric Survey of the Hebridean Shelf Edge from 56°N to 57°N and from 150m down to 1000m was largely completed and charts at 1:50,000 were produced. The extension of this area to North and South or deeper water was largely prevented by weather and time constraints. Some 85 hours of side-scan-sonar data using the IOSDL TOBI was obtained within the same area as the bathymetry. The sonar mosaic records details of slumps, slides, channels, levees, ridges, wavy bedforms and changing facies. These features will help to guide coring and geochemical sampling in later Shelf Edge cruises of LOIS. Seismic Profiling was unavailable due to weather and equipment limitations.

On RRS *Charles Darwin* cruise 91B (for the UK Land-Ocean Interaction Study - LOIS - Shelf-Edge Study):
a) an initial "skeleton" mooring array, comprising current meters, bottom pressure recorders, thermistors, transmissometers, a sediment trap, nutrient analysers, a meteorological buoy and other surface buoys, was deployed nearly as planned, excepting sediment traps and any thermistor chains near the surface;
b) CTD and water sampling were carried out at locations of moorings, with analyses for salinity, nutrients and preservation for later analysis of DON, particulates and plankton;
c) coring (Kasten, gravity and one box-core) and sea-bed photography (with a "bed-hop" camera) were carried out near mooring locations, but few good cores were obtained;
d) swath bathymetry filled in a few joins and covered the shelf between the shallowest moorings, to complement the extensive Hebrides slope coverage on CD91A;
e) intended recovery of OMEX moorings off NW Ireland was not carried out;
f) there is useful data from the ship-borne ADCP current profiler, run throughout.
Experience of value to following SES cruises was obtained.

**ACKNOWLEDGEMENT.** The scientific party extends warm thanks to the Master, R.C. Plumley, Officers and crew of RRS *Charles Darwin* for their help and co-operation during the cruise, and to RVS, Barry, for its support, all willingly given and making the scientific work possible.
Experience of value to following SES cruises was obtained.

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KEYWORDS

| | | |
|---|---|---|
| HEBRIDES SEA | NWEURHEB | LOIS |
| LAND-OCEAN | INTERACTION STUDY | CONTINENTAL SHELVES |
| TOBI | SIDE SCAN SONAR | BATHYMETRIC SURVEYS |

CONTRACT

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**The Library, Proudman Oceanographic Laboratory.**

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FIGURE CAPTIONS

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FIGURE CAPTIONS

## A1. OBJECTIVES

LOIS Shelf Edge (SES) Objectives are:-

(a) to identify the time and space scales of ocean-shelf momentum transmission and to quantify the contributions to ocean-shelf water exchange by physical processes;
(b) to estimate fluxes of water, heat and certain dissolved and suspended constituents across a section of the shelf edge with special emphasis on net organic carbon export from, and nutrient import to, the shelf;
(c) to relate sediment properties and fluxes to the physical context;
(d) to quantify organic carbon cycling in shelf-edge sediments;
(e) to incorporate process understanding into models which will be tested by comparison with observations and provide a basis for estimation of fluxes integrated over time and the length of the shelf edge.

These SES objectives are being pursued by measurements at the shelf edge west of Scotland, and by the development of numerical models representing physical processes and microbiology. The overall plan for measurements includes an initial sea-bed survey, maintenance of moorings from spring 1995 to summer 1996, seasonal measurements of distributions, coring, tracking of drogued buoys and remote sensing. RRS *Charles Darwin* cruise 91 is the first of a sequence of seven planned SES cruises at intervals ~ 3 months.

Specific Objectives for Leg A of Cruise 91 are:

1.1 to obtain a detailed high resolution bathymetric map, principally along the slope between 55°N and 60°N, for use in numerical models, and as a basic guide for all the other SES work.

1.2 to obtain high resolution seismic profiles of surface sedimentary layers, for interpretation for site stability, and to complement and extrapolate from cores.

1.3 to obtain a wide area view of the sea-bed surface roughness and bed features, as a guide to the placement of moorings and the choice of sites for cores and other sampling in later SES cruise, including Darwin CR 91 leg B following immediately. Evidence for sedimentary forms that can be interpreted as responses to hydrodynamic forcing will be sought.

The principal equipment in use to meet these objectives are the Simrad EM12 Swath Bathymetric mapping system, permanently installed for 1.1, the BGS Boomer hired for 1.2, and the IOSDL TOBI side-scan sonar hired for 1.3. In addition the TOBI system includes a high resolution sub-bottom profiler to contribute to objective 1.2. Also the Simrad EM12 has a narrow swath backscatter display which gives side-scan data close to and under the track, usefully filling in the region which the TOBI side scan does not cover.

Because of the overall need for high spatial resolution, a Trimble Differential GPS link (DGPS) was hired from Racal, enabling navigational errors less than 5 metres rms. Separate data loggers were used for each instrument, but all logger time-bases were referenced to the DGPS clock. The shipboard computer logger maintained accurate time/position navigation files.

## A2. SUMMARY OF LEG A

This cruise was very seriously affected by adverse weather. A succession of depressions tracked east across the Atlantic and we received gale after gale force winds. Even in the short periods between the depressions there was no respite from the swell, and the vessel pitched and rolled most uncomfortably at times. The working starboard and aft decks were frequently awash (Fig A1). Despite these limitation the cruise did achieve some of its objectives and much data was obtained.

Principally data was from the Swath Bathymetry system permanently fitted in Darwin. Data quality clearly suffered in these heavy sea conditions, but because it was the only tool in use for most of the time, we were able to devote time to covering areas more than once, thereby improving the data statistically. Thus the principal objective 1.1 was partially achieved in the box 56N to 57N and 8 30W to 10W. Complete coverage with Swath soundings was not achieved, mainly because weather prevented steering suitable courses for much of the time and time was also lost for ship repairs and running for shelter. Although we had poor control over the course, we knew rather precisely were we had been, thanks to the differential GPS. A thorough bathymetric survey of the shelf edge (150 metres down to over 1,000 metres) from 56N to 57N has been compiled and plotted.

The topography of the shelf edge and slope has been measured at a resolution better than anything before, but only within the limited latitudes around the moorings area. We were not able to survey significant areas to the North or South to determine the regional context or to assess the representativeness of the knowledge. A digital bathymetric data set has been assembled which modellers will be able to use with confidence as a high resolution representation of the outer shelf, upper shelf edge and most of the slope down to about 1500 meters depth. The 60 miles of edge so covered contains much variety, with different steepnesses, and topographic features.

From crossover tracks with swath bathymetry, one can assess the combined accuracies of the soundings and the navigation. It would seem that good correlation at these cross-overs in moderate sea conditions indicates that both work well and to specification. When sea conditions were really bad the quality of the Swath Bathymetry data clearly suffered, but there was no evidence that the DGPS was affected.

The second achievement has been to obtain fascinating side-scan data with TOBI that highlights the complexity of this slope's sedimentary features. We were only able to deploy and recover TOBI twice, for 53 hours and for 30 hours, taking great care in choosing the opportunities. However once deployed TOBI could gather data in rather worse conditions than in which it could be recovered; this is due to its two-body design, which is very effective at decoupling ship motions from the TOBI vehicle itself. The wide (6Km) swath covered by TOBI made up to some extent for the slow (<3 knots) speed at which it could be safely towed. A sonar mosaic of the slope from 56N to 57N shows fascinating detail, with slumps, slides, channels, levees, ledges, ridges, wavy bedforms, and changing facies. This should prove a valuable guide for the SES coring and geochemical sampling programme in this area, as required by Objective 1.3. The combination of TOBI side-scan and the swath bathymetry will be a powerful baseline for the LOIS SES community.

We failed to gain any sub-bottom profiling data from the BGS Boomer. This was a consequence of a seized towing block, and partly the result of being unable to use a single heavy body tow in the sort of heavy weather experienced. Some shallow sedimentary layers were delineated by the high frequency profiler on TOBI, contributing towards Objective 1.2, which otherwise was not fulfilled.

The geological data obtained could in principal be obtained in any season, or year of SES for that matter. Yet it was programmed for March, traditionally a windy month in these latitudes. It really does demonstrate a rigidity within the NERC system for running its ships. The reluctant delay to SES by the LOIS Steering Committee under pressure from HQ is one factor. The crewing policy of RVS is another. There are periods in the Summer months in 1993, 1994 and 1995 when the Darwin was not programmed, when it would have been far more preferable to have undertaken the tasks that were so constrained by weather. See Fig. A2 for time allocation to activity during leg A and Fig. A1 for the observed wind and swell conditions experienced. Passage and periods hove-to or at anchor accounted for 34% of the time. Swath Bathymetry was in use for 65% of the time and TOBI for 18% (simultaneous with 18% of Swath Bathymetry time). Of course one cannot ever expect perfect weather all the time, but on this cruise we did not get any decent spell at all. Efficiency was bound to be affected, and it was. Only about half of our total objectives were met.

## A3. PERSONNEL ON BOARD

*Scientists*

| | |
|---|---|
| J. M. Huthnance (PS) | POL |
| R. Holmes | BGS |
| J. D. Armishaw | SUDO |
| C. P. Brett | BGS |
| J. M. Hodgins | BGS |
| N. W. Millard | IOSDL |
| I. Rouse | IOSDL |
| P. Weatherall | BODC |
| C. Day | RVS |
| J. E. Scott | RVS |
| G. C. Knight | RVS |
| H. C. Anderson | RVS |
| A. M. Fern | RVS |
| D. G. Booth | RVS |

*Officers and crew*

| | |
|---|---|
| R. C. Plumley | Master |
| C. M. Leather | C/O |
| P. D. Gauld | 2/O |
| J. C. Holmes | 3/O |
| D. Stewart | R/O |
| I. G. McGill | C/E |
| S. F. Dean | 2/E |
| A. F. James | 3/E |
| W. D. Lutey | E/E |
| M. Trevaskis | CPO(D) |
| C. Vrettos | SG1A |
| P. R. Bennett | SG1A |
| P. H. Dean | SG1A |
| R. Dickinson | SG1A |
| A. MacLean | SG1A |
| A. Healy | MM1A |
| E. Staite | SCM |
| C. K. Perry | Chef |
| C. J. Kenny | M/Steward |
| W. J. Link | Steward |
| S. Shields | Steward |

## A4. NARRATIVE

(Note all times GMT). See Figs. A3, A4, A5 for Cruise tracks and general area map.

**2/3/95** The ship sailed from Barry at 06.30 and after swinging the compass in poor visibility set course down the Bristol Channel in choppy conditions. The DGPS system worked from the start. Sea conditions improved during the passage up through the Irish sea, despite some snow in the afternoon.

**3/3/95** Passage continued through the Irish Sea. At 08.30 the Simrad EM12 Swath Bathymetry (SB) was switched on to gain experience of working it in depths as shallow as 100-150 metres, the lowest values expected in the working area. During the morning the weather, though cold, was bright, enabling preparatory work on deck. SB data was acquired through the deeper parts of the North Channel, but the EM12 system does not work well if depths are less than 100m, so coverage over the Hebridean shelf towards the working area was patchy. The working area was reached at 22.00 and a westerly course was set overnight; good SB data was obtained. XBT1 was launched at 23.30 to 750m. The water was isothermal at 9.2°C to 500m, then cooler to the sea bed as to be expected.

4/3/95 At 01.30 Heaved-to for Sound Velocimeter Station 1, using starboard (CTD) winch to lower Applied Microsystems self logging probe. Slight delay due to lighting on A frame, then successful station, completed by 03.00, with data to 1,500m in 1,600 metres of water.

As wind was less than 20kts at this time it was decided to turn SE towards a start line for TOBI, with a projected launch time 08.00. However in the meantime the wind backed to S and increased to 30+ knots, with the latest forecast indicating Westerly gale force 9, due soon. Decided against deploying TOBI, but was able to carry on with SB lines to NE then W.

The gale was on us by midday, pitching causing a speed reduction to 5 knots. Afternoon bright but W wind still strong and increasing the swell.

5/3/95 Overnight continued West against wind and swell making less than 4kts. By 06.00 the vessel reached 12° 10'W and turned to go North for ten miles, but the swell was too severe for that course, so headed ENE until on the parallel track East 10 miles North. Later the weather moderated slightly with winds from NW at 30kts, so we were able to make 9+ kts whilst taking SB data. Made a zig-zag towards NE then ESE in order to pass over the foot of the Peach slide, then down the line of the Northerly moorings array. Good SB obtained. Turned NW then for a systematic SB survey of the shelf break.

6/3/95 Started with a Southerly course down the 160 metre contour, completed by about 07.15, but in deteriorating weather, causing gear on deck and inside to break free. Hove-to for 2 hours whilst lashing down. Swell very large, limiting course options. Forecast unclear, but not very hopeful. The next Northerly run began at 10.15. with 30 knots wind on port beam and swell continuing to build. Thus vessel rolled heavily, making 7.5 knots, and the SB signal was frequently quenched, so the record was patchy. However SB data was being gathered, centred approximately over the 500 metre contour. This was completed at about 20.30, with a slow turn to prevent the EM12 gyro system losing control, onto the next Southward line over the 350 metre contour approximately.

7/3/95 At 03.00 the gale forced the ship to slow and lose course, until 07.00 when conditions allowed track to be resumed. Pitching causing loss of some data. This line was completed by 08.30 but further northward lines prevented again by increased winds, this time from first SE then veering to SW. The vessel remained head to wind with just enough steerage way, so moved some way East, in shallow depths, from the start of the next run. Conditions did not improve until 17.00 and it took another 7 hours to reach the start of the next line. This had been a frustrating day.

8/3/95 Northerly run began at 00.30, at slowish speed into wind and swell, completing at 15.35. Weather slightly improved allowing 8 knots for the Southerly run one mile to the West, giving a small (1/4 mile) overlap of the swath bathymetry with the previous line. This run ended at 23.30, after which two short lines N then S were run to fill in between earlier lines and to bring the vessel onto position to deploy TOBI.

9/3/95 TOBI deployment began at 08.10 and it was working at a vehicle depth of 50 metres and a speed of 1.5 knots by 08.55. Speed was increased gradually to 3 knots and cable was paid out to give a vehicle depth of 93 metres, obtaining data out to 2 to 3 Km each side. Course was set over 350-400 metre contour, preferring a straight track rather than meandering with the contours. Over half the line was completed when increasing wind to gale 9 forced a course deviation downwind to the NW. On this course overnight, taking vessel outside main survey box, but good interesting data in any case.

10/3/95 At 07.00 the weather eased enough to turn ship to head back into wind towards North end of uncompleted line. This was reached at 14.10, when course was altered to a southerly track just West of the shelf break. A depression centre moved north through our position.

11/3/95 After cyclonic wind directions for a while the winds veered, just conveniently for our run to the West along 56° 24min N latitude by 04.30. There were several fishing vessels around in this (moorings) area. At 08.30 the Master informed that a sea valve was leaking into the accommodation, and that the ship would need to anchor in sheltered water whilst the engineers fix it. At 09.30 we altered course to East along 56° 26'N still gathering TOBI data. We were looking for a calmer spell to recover the TOBI system prior to steaming to an anchorage. TOBI was recovered successfully by 15.30, though in the process the Boomer cable was squashed in the A frame. On inspection no armour wires were broken and electrical continuity remained.

12/3/95 Poor visibility delayed the anchoring East of Uist, but eventually a suitable place was found. Repairs to the sea valve were made by 13.30. In order to test the insulation of the Boomer cable in sea water the Boomer fish was deployed over the stern whilst at anchor. Though this electrical test proved positive, unfortunately on recovering the fish the cable caught between the rubber insert and the wheel of the towing block, damaging the armour wires to the point of requiring a new termination. The boomer fish was recovered inboard using a stopper and another winch wire to take the load of the boomer cable whilst it was cleared. The cause of the jam was clearly the failure of the block to swivel under side loading. The Bosun supplied a 5T swivel to place between block and support shackle on the A frame. As this manoeuvre required a man aloft in a Bosun's chair it could only be done in sheltered conditions, so we finally left the anchorage at 17.00.

13/3/95 Overnight we steamed to the working area and at 03.00 switched on the Swath Bathymetry again to fill in gaps of earlier coverage. The Boomer cable was reterminated by 02.30. Weather conditions were still very poor with 30-35 knot winds and a heavy swell from the SW. Nevertheless useful swath bathymetry was obtained.

14/3/95 This continued until, at 11.00, increased swell prevented the vessel from maintaining heading and so we hove-to, awaiting an improvement. In fact weather became worse, so prospects of useful work this day were zero.

15/3/95 Winds over 40 knots maintained the swell and we went further NW away from the working area at 1 to 2 knots, just sufficient speed to steer ship head to wind safely. At 08.55 ship was turned to go down wind, making 11 knots back towards working area, but swell unlikely to allow courses of choice. This continued until midnight.

16/3/95 Winds abated slightly allowing an XBT at 03.00 and further Swath lines were possible until about 10.00, when again we had to heave-to for a blow, hoping to remain as close to our working area as possible. At 14.00 after another gloomy forecast the Captain decided to head for shelter behind Barra Head in the Minch, reached by about 22.00.

17/3/95 Sheltered behind Barra Hd. Emergency, Fire and Boat drills began at 10.30. Course was set at 14.24 to return to the working area against a large swell and snow showers. Had to heave-to at 20.18 for four and a half hours.

18/3/95 Swath Bathymetry restarted, and by 07.00 the wind had dropped below 15 knots for the first time. At 11.35 despite a marginal swell running an attempt to deploy the Boomer was made; however, as it had at the anchorage, the tow cable came up off centre and fell between the rubber insert and the wheel of the towing block. It was apparent that the block was not responding to the lightly loaded cable direction, but to its own weight swinging under the A frame because of the pitching. Also the rubber insert had clearly split from the sheave. We returned to Swath Bathymetry.

19/3/95 Moderate winds encouraged consideration of lowering down the Boomer block from the aft A frame, to effect repair or modification, but there was too much swell to put a man up in the Bosun's chair, and that idea was abandoned. However TOBI was deployed, data beginning to be collected at 10.30. We set a northerly course west of the previous TOBI run, with about 1Km of overlap. Despite a considerable swell running good side-scan data was obtained and swath bathymetry.

20/3/95 Continued the TOBI and SB run northwards, and more good data was obtained. Swell seemed to have gone down a little overnight, but vessel still pitching and rolling. Best weather all cruise experienced during the daylight, but forecasts of strong winds from the South advised recovery of TOBI during low swell conditions, and this was concluded by 16.50. Good side scan data complementing the earlier runs was obtained; the high frequency profiler also showed useful penetration in places. We continued with the swath bathymetry until 20.30 for Sound Velocimeter station no 2, completed by 21.45. The sound velocity and the temperature record obtained showed that the depth of the mixed layer had increased since the first station from 500m to 750 metres, from a temperature of 9.2 to 8.8. Possibly the storms were responsible for this deepening, but note that the two stations were in different positions.

21/3/95 Swath bathymetry of remaining gaps then continued overnight, the return of heavy winds and swell as predicted. Some coverage South of 56N was possible, until at 1300 the vessel had to set course eastwards for Fairlie. The Simrad EM12 Swath Bathymeter system was finally switched off at 13.30. Overall during the cruise it had performed very well, in appalling weather at times. Processing and plotting the data carried on. The TOBI and Boomer teams packed equipment and prepared for disembarkation on 22nd.

22/3/95 Vessel tied up at Fairlie, and demobilisation began. Handover to scientific party for leg B.

## A5. GEOLOGY REPORT (Leg A, 2nd - 22nd March 1995) (R. Holmes)

### *A5.1 Introduction*

A detailed desk survey (Holmes,1994) maps the framework topography for the SES area, describes the geological processes at the shelf edge and provided a basis for planning the topographic, sonar reflectivity and sub-bottom seismic reflection surveys that were completed during this cruise. The findings of the detailed desk survey are not repeated for this cruise report.

The survey results from this cruise confirm the findings of the desk survey site investigations for the mooring arrays. The topography of cross-slope arrays separated by a distance of approximately 37 km (20 nautical miles) are illustrated (Figs. A6, A7).

### *A5.2 EM12 (12KHz) Swathe seabed topography*

The seabed topography compiled for interpretation principally covers the area from 56°N to 57°N. 8°50'W to 9°45'W and was output for planning and interpretation purposes during the cruise at 1:50,000 plan scale and to a vertical resolution of 10m.

The indications from the seabed topography and sonar reflectivity over the north and south scarps of the Peach Slide are that slide translation is now inactive, so that the main body of the slide with relatively rough seabed topography, comprises a stable seabed for the northern mooring array. The southern mooring array is outside the boundary of the Peach Slide in an area of relatively smooth seabed, and no threat to the choice of the southern array site is identified.

8 smaller-scale slides and slumps, only one of which also incises into the modern shelfbreak, occur in areas south of the Peach Slide between 56°14'N and 55°00'N. These have very sharp sonar reflectivity boundaries in areas of very soft cohesive sediments, so that a modern or recent historical origin is likely. At least 18 channels are incised into seabed on an average slope gradient of approximately 10° and branch upslope into dendritic feeder systems, some of which incise into the modern shelfbreak. These channels extend north of the Peach Slide to approximately 58° 10'N. The fresh appearance of the sonar textures adjacent to the shelfbreak indicate that the tops of the dendritic feeder systems are now capturing sediment from the shelf and transporting it downslope.

Considerable effort was expended to retrospectively fill gaps in the swathe programme that were generated in median water depths ranging from approximately 150m to 500m, of which some were generated during marginal-weather survey conditions. Recommendations for future operations in shallow water (and poor weather) are for the capacity for the scientists and ships bridge to have display of current and historical swathe coverage to avoid the need for re-runs.

*A5.3 EM12 (12KHz) Sonar*

This was principally output at 1:25,000 scale. An attempt early on during the cruise for output at 1:50,000 scale resulted in systems overload. The sonar data was not systematically compiled for interpretation during the cruise because of the potential difficulties in handling a large amount of map paperwork shipboard. The EM12 sonar would form a worthwhile dataset for comparison with the TOBI 30 KHz sonar, and would improve geological interpretation where TOBI swathe coverage is not available.

*A5.4 TOBI (30KHz) sonar*

Excellent quality 6km-width 30 KHz sonar records were obtained and integrated with seabed topography at 1:50,000 scale along the shelf margin. The sharpness of the sonar reflectivity boundaries indicate that historically recent-to-modern mass-wasting occurs on seabed gradients of up to approximately 8° at the shelfbreak on the northern moorings array, but the precise timing of this mass-wasting is uncertain. When integrated with interpretation from the seabed topography the sonar records provide new insights into processes of gravity-driven down-slope sediment flux, and indicate areas where strong bottom-currents are driving along-slope (contouritic streaks) and oblique-slope (megaripples) sand movement.

*A5.5 TOBI (7.5KHz) sub-bottom profiler*

The distribution of sands and gravelly sands restricts interpretation of the profiler records to topography-only quality control on sonar interpretation for a sampling strategy above approximately 400m water depth. The sonar, seabed topography and sub-seabed information below approximately 400m water depth were interpreted shipboard to provide a shipboard strategy for the sampling cruise leg 22 March to 2 April.

**Reference:**

Holmes, R. 1994. Seabed topography and other geotechnical information for the Shelf Edge Study 55°N-60°N NW of Britain. *British Geological Survey Technical Report*, WB/94/15 (30 pages, 7 maps, appendices)

# A6. EQUIPMENT PERFORMANCE REPORTS

## A6.1 Simrad EM12 Multibeam Swath Bathymetry Systems (G.C. Knight, D.G. Booth, A.M. Fern)

The system worked very well during the cruise. The main problems experienced tended to be caused by the weather.

The number of "PING FAILURES" was higher than normal due to the pitching causing aeration under the transducers.

When surveying with TOBI in shallow water (less than 450m) the EM12 & TOBI interfered with each other. The EM12 had to run on reduced power.

### *A6.1.1 Swath System Configuration and Management* (see Fig. A12 and A13)

The EM12s-120 system on board RRS *Charles Darwin* is a multibeam echosounder generating 81 stabilized beams, providing + and - 60 degrees athwart coverage in water depths of 100 to 11,000 metres. Acoustic frequencies used are 12.66, 13.0, and 13.33 KHz. Transmission transducers are installed in 24 modules each containing 16 elements mounted alongships, slightly to starboard and flush with the keel. Receiving transducers are installed in 14 modules each containing 15 elements mounted athwartships just forward of the transmitting array. The system is continually provided with surface sound velocity, clock, gyro and (D)GPS navigation data. A vertical referencing unit mounted close to the centre of the ship provides roll, pitch and heave information. The system detects the range to the sea bed on each of the 81 beams for every pulse and calculates the depth and off track distance, with corrections for sound refraction. The signal levels of the backscatter on the beams are logged and presented on a side scan sonar display.

Installed in the Scientific Plot is a console for the operator with across and along track depth displays, a console for sonar imagery and bathymetry display, and a quality assurance display unit. Control of system parameters, operation, acoustic response, etc. is gained through the Bottom Detector Unit.

The system provides an ETHERNET link which is connected to the ships network for forwarding data to the Sun SPARCstation logging and processing systems. The multibeam data logging and processing system in the Plot consists of:

- Sun SPARCstation IPX with 1.3 Gbyte data disk and high density Exabyte tape drive - running Simrad Mermaid data logging software.
- Sun SPARCstation 10 with 2.5 Gbyte data disk and high density Exabyte tape drive - running the Simrad Neptune 2 data processing and IRAP 6.2 software.
- Sun SPARCstation IPX with 2.5 Gbyte data disk, CDROM drive and optical disk drive - used as utility/backup machine. Both Neptune and Mermaid packages have been installed on this system so that it can take over either task in the event of a failure.
- AST 486/33 PC configured for sound velocity profile collection, calibration processing and transfer. Other applications such as AutoCAD and word-processing software have also been installed for ancillary tasks.
- Hewlett Packard DraftMaster RX-PLUS HPGL-2 A0 Drum Plotter.
- Hewlett Packard PaintJet XL300 PostScript colour printer.
- Hewlett Packard LaserJet 4 laser printer.

All three workstations have Solaris 2.3 operating systems. 'Neptune' and 'utility' have full installations and 'mermaid' has an 'end-user' set up. All three workstations have had SUN Motif 1.2.2 for Solaris installed.

*A6.1.2 Swath Data Logging* (See Fig. A12 and A13)

The Mermaid data logging system handles the reception of raw data telegrams via the Ethernet interface from the EM12. Communication with the sounder is based on block exchange though UDP (User Datagram Protocol - which is a member of the TCP/IP protocol suite). The Mermaid application reads all telegrams that are sent to a given port number and IP address. Telegrams are stored contiguously as a raw stream on the data disk using file names of the type:

lineno_date_time_raw.all

The Mermaid application allows the user to start and stop logging, set up survey and sub-survey names (which are used to construct directory names), and to enable or disable parsing of raw datagrams into Simrad Survey Format files. Line changes made on the EM12 Operator Unit are reflected by the Mermaid system closing previous and starting new files. A continuous status display is maintained in a workstation window.

For cruise 91 it was decided that data should not be parsed into Survey Format on the logging system. This task was performed 'down stream' on the Neptune 2 processing system. Data accumulating on the Mermaid system was routinely copied across the network to the Utility machines data area as an online backup.

Once safely copied to the Utility machine, raw files could then be dumped to tape, copied to optical disk and passed on to the Neptune 2 processing systems.

Neptune 2 processing is largely based on sets of indexed Survey Format files. These files were simply generated by running a remote process on the Utility system that read the *_raw.all files and parsed them locally into depth, position, sidescan, etc files. A further step in preparing data for processing was to transfer smoothed navigation data from the ships ABC computer system and build Survey Format position files to replace the raw (D)GPS navigation.

*A6.1.3 Swath Data Manipulation* (See Fig. A12, A13)

Data was transferred from the data logging system Mermaid to the data processing system Neptune by means of network file copying.

The data processing system was configured with a Solaris 2.3 unix operating system. The editing and data transfer software Neptune2 were supplied by Simrad and the contouring and griding software, IRAP 6.2, supplied by Geomatic.

Survey data lines were read into the data editing tool 'binstat'. The total survey area was divided for the purposes of data processing into eight more manageable subareas. These areas were processed individually.

When invoking data editing it is necessary to divide the subsurvey area into an appropriate number of blocks, the actual number used dependent on the density of data and the size of the area. The density of data is largely determined by the water depth in the survey area. The blocksize chosen for most blocks during CD91 was 7.5 minutes latitude by 15 minutes longitude; however in the shallower water close to the slope the areas were divided into 3.75 minutes latitude by 15 minutes longitude. Having set the areas and blocks the editing process requires each block to be edited in turn. When invoking the editor the data contained within the block from each of the survey lines is converted into xyz coordinates. As many of the editing features make use of statistical analysis of the data it is necessary to further subdivide the block into a series of cells each of which can then form a sample for this analysis. During CD91 a cell size of 100m * 100m was used.

Each block was read into the editor where two basic editing processes were performed. Firstly a best fit plane through the data cells was calculated and each beam return compared to it. Returns which exceed the standard deviation by greater than 1.9 times the standard deviation were marked as rejected. Further editing then concentrated on obvious spikes in the data where a cell showed an average depth clearly very different from neighbouring cells. These cells were then edited using the correlation plotting feature of the data editor which allows manual editing of the data on an individual beam return basis.

Due to the exceptionally poor weather experienced on CD91 it is anticipated that further substantial editing of this data will need to be done. It is suggested that by examination of the data over the total swath width and by comparison of successive swaths significant improvements can be made particularly with respect to the returns from the outer beams.

Once the initial editing had taken place the xyz data was written to both ascii and binary files. The ascii files purely to provide transportability of the xyz format, the binary to be used in the IRAP griding and contouring package present on the Neptune processing system.

Each subarea was gridded individually to a 50m grid. The resulting grids were contoured and plotted at a scale of 1 to 50,000 with a contour interval of 10m. No smoothing or filtering was applied to this data or to the standard grids produced. The final grids were output in binary and ascii form. Due to the difficulties of following the desired survey lines in extreme weather conditions the survey was constructed by revisiting the subareas a number of times during the cruise. This resulted in the editing and griding process being repeated three times prior to a final cycle at the end of data gathering. Figures A8 and A11 indicate from an A4 pen plotter the bathymetric chart produced, but do not do justice to the quality of the final 1:50,000 prints.

### A6.2 XBTs (D.G. Booth)

Two XBTs were carried out.

XBT 1 56°25.4N 09°14.7W 062/2330

XBT 2 56°50.0N 09°07.0W 075/0309

### A6.3 Sound Velocity Profile (D.G. Booth)

At the start of the cruise the sound velocity was manually entered using the surface sound velocity as a start value and a fixed gradient of 1.8m/s per 100m.

Two sound velocity profiles were obtained to 1500m depth. Prior to the cruise the probe (Applied Microsystems SVP16) had been returned to the manufactures for modification and calibration. The probe can now operate to 5000m (Previously 2000m).

On trying to transfer the data from the probe after the first deployment problems occurred. A dual header had been written which prevented the data being read by the transfer software. The SVP software needs the calibration files updating to allow for the change in depth range.

The data was manually read from the probe and then the dual header edited. The data could then be read using the transfer program, break points selected and then transferred to the EM12.

On entering deeper water (>1500m) problems were noticed with the outer beams. This was cured by adding additional sound velocity points below 1500m.

The second sound velocity profile was obtained at the end of the cruise. The data correlated well with the first profile. (The software had been modified and therefore no transfer problems were encountered). The EM12 was not updated with the second sound velocity data.

| | | | |
|---|---|---|---|
| SVP 1 | 56°24.3N | 09°46.6W | 063/0200 |
| SVP 2 | 56°49.7N | 09°27.3W | 079/2045 |

A6.4 The Surface Sound Velocity (OTS) Probe (D.G. Booth)

The OTS probe failed when pitching caused air to enter the tank. Bleeding the tank only solved the problem for a short time before more air entered the tank. Fixed values were used based on the last readings before the failure. At this time of year and with the heavy wave-mixing, sea surface temperatures remained similar throughout.

A6.5 Differential GPS (G.C. Knight)

A DGPS system was hired from Racal Surveys for the cruise. This replaced the normal Trimble GPS system. Although the output message was the same the frequency of the message caused position datagram errors and time errors on the EM12. These errors caused the EM12 clock to drift which needed manual updating from time to time. When the receiver failed to update, the last output message was repeated until a good update was obtained.

The data was lost for about 1 hour 45 minutes when the Goonhilly West satellite dish failed. The system was re-established using the East satellite.

A6.6 Chernikeeff EM Log (D.G. Booth)

On sailing it was discovered that the bridge equipment was not receiving data from the log. It was eventually found that the interface on the bridge needs pulses not a contact closure.
The relay was removed and a link fitted to provide the required signal.

6.7 TOBI (N.W. Millard and I. Rouse)

*A6.7.1 Background*

For this cruise it was hoped to use the Deep-Scan 60 sidescan system recently developed through a collaborative programme between IOS and Ultra Electronics. This system should be better suited to shelf edge surveys than TOBI which was designed for slow deep-towed operations. The deep scan system operates at 60 KHz rather than TOBI's 30 KHz and is a smaller streamlined, heavy, single towed fish compared to the TOBI's bulky neutrally buoyant fish towed 200 metres horizontally behind a heavy depressor weight. In the event Deep-Scan 60 was not sufficiently proven and TOBI was mobilised for the survey.

*A6.7.2 <u>TOBI run 1</u>*

TOBI was launched in moderate wind and sea conditions at about 0800 on day 068 (09/03/95) and recovered at about 1500 on day 070 (11/03/95) again in moderate conditions. Both operations went smoothly. Conditions during the survey worsened considerably but, although it was not always possible to keep to the required course, the system performed well. The vehicle was in the water for 55 hours and was towed for 157 nm. at an average speed of 2.85 knts.

Interference from the swath bathymetry was at first apparent but was removed by reducing the swath transmit power by 10db without loss in performance. Sea noise and surface backscatter were noticeably higher than for a deep water survey but did not significantly reduce the quality of the data. As the survey moved over the shelf edge into deeper water there was evidence of refraction effects caused by the thermocline indicated at about 700 metres by the TOBI temperature sensor. The profiler gave a degree of penetration, mostly in the deeper water and, more interestingly revealed small scale topography related to changes of backscatter shown on the sidescan.

The recently installed emergency recovery system meant that the rigging of the recovery lines and the launch technique had to be modified but no problems resulted, in fact launching with a simple no-load release made the operation easier than before.

*A6.7.3 <u>TOBI run 2</u>*

Another short break in the bad weather allowed TOBI to be launched again on day 078 (19/03/95) in conditions made difficult by a large swell. Data logging started at about 1000. The wind again increased throughout the day but had reduced again by the morning of day 079 and a relatively easy recovery was made at about 1630, providing another 30 hours of good data.

Worries about how TOBI would behave in such shallow water proved unfounded and the two-body towing proved to be a very stable arrangement in the rough conditions encountered.

**A6.8 <u>Boomer</u>** (C.P. Brett)

The boomer system was mobilised on *Charles Darwin* between 27 Feb and 1 Mar and tested successfully in the harbour, at full power, before sailing. On 11 March the boomer tow cable was damaged by being caught in the A-frame when recovering TOBI, prior to heading to anchor to carry out ship repairs. At anchor on 12 Mar, the boomer was deployed for test purposes and functioned correctly. However, during this exercise the block did not swivel correctly and on recovery the cable ran up the side of the sheave and jammed between the rubber lining and the steel edge of the sheave. This damaged the cable further, necessitating a retermination. The block was modified by inserting additional spacers intended to prevent this recurring and was re-hung using a separate swivel. This had the additional effect of making the block very lively in any ships motion. After an extended period of very poor weather deployment of the boomer was attempted on 18 Mar in a very large, 6m swell. During this attempt, with considerable heave on the stern and movement of the block, the cable again became jammed between the rubber insert and the steel edge of the sheave. The boomer was recovered and any further deployment in the current situation suspended until the block could be lowered and further modified to prevent this recurring. The weather remained too poor to lower the block and no further attempts at deployment were made.

A6.9 <u>Shipboard Computer</u> (H.C. Anderson)

*A6.9.1 Level A:*

Data was logged from the following level A's:

| | | |
|---|---|---|
| GPS_TRIM | - | Trimble 4000DL GPS satellite receiver coupled with a Racal Survey Differential GPS interface and decoder. (This instrument was supplied especially for this cruise and was used in place of the Trimble 4000AX). |
| DECMK53G | - | Bridge Mk53g Decca Navigator in GPS mode. |
| LOG_CHF | - | Chernikeeff Instruments 2 axis speed log. |
| BIN_GYRO | - | Heading information from the onboard gyroscope. |
| MX1107 | - | Magnavox Transit satellite receiver. |
| EA500D1 | - | Simrad EA500 echo sounder. |

The data from the EA500 was found to be of little use, without a towed fish as the instrument would not lock onto the seabed. This instrument was therefore disabled for the majority of the cruise and bathymetry data should be taken from the EM-12 Swath Bathymetry system.

Centre beam data from the Simrad EM-12 swath bathometry system was logged on Neptune and transferred to the Level C system. Meterological data logged by the Bridge were input into the Level C via the 'metin' program.

*A6.9.2 Level B:*

The Level B Data logger has logged all Level A sourced data without any problems during this cruise.

*A6.9.3 Level C:*

The Level C system was used to log and process the data provided by the Level B. It crashed once during the cruise on 95 070 150600 approximately 10 minutes of data was lost.

Navigation logged from the Racal Differential GPS system was initially stored in the file gps_trim. This data has a sub-second sampling frequency, so it was sub-sampled into one record per second data and stored in file gps_fix. This file was used as an input to the bestnav program which produced the final navigation file called bestnav, with a frequency of 10 seconds per record. The navigation from this file was plotted against the gps_fix and Decca GPS navigation sources, on a daily basis to ensure accuracy of the data. On day number 072 The Differential GPS signal to the decoder was lost between 14:36:58 and 17:10:00. This was not immediately identified as no alarm was sounded by the Racal equipment. The data sent on into the Level B and C during this period consisted of an identical time-stamp and position. Since the data logging is time signal based, no alarm was signalled by these systems. To produce reasonable navigation though this period, six fixes were selected from the Decca GPS receiver, and fed into the bestnav program along with relative navigation derived from the gyro and speed log. When plotted this produced a smooth line of fit around the 180 degree turn we had been making, without the GPS jitter and stepping associated with the raw Decca GPS signal. The following fixes were used:

| Time | latitude | longitude |
| --- | --- | --- |
| 95 072 15:03:20 | 5.607300e+01 50 | -9.157167e+00 50 |
| 95 072 15:20:00 | 5.605100e+01 50 | -9.160667e+00 50 |
| 95 072 15:36:34 | 5.602633e+01 50 | -9.168667e+00 50 |
| 95 072 15:53:42 | 5.600250e+01 50 | -9.174667e+00 50 |
| 95 072 16:10:00 | 5.599267e+01 50 | -9.196333e+00 50 |
| 95 072 16:26:26 | 5.602633e+01 50 | -9.191667e+00 50 |

Bathymetry from the EM-12 was imported into the Level C using the cbeam program and placed in the file: rswath. It was then processed to remove duplicate, backwards and other erroneous time-stamps and placed in the file: depth. This data does not require processing by prodep as the use of the sound velocity probe with the EM-12 during the cruise negates the need for Carter area correction.

Daily plots of entire working area track were produced, in addition to an hourly record of the ships position, both of which were produced from bestnav. Other track plots of various types were also produced, including 1:50,000 plots for TOBI track lines. Plots were mostly produced in UTM at zone 29, so that they could be overlaid on swath and BGS plots.

Raw and processed data were backed up daily, initially to 150mb tape and later in the cruise to optical disk, which was an easier and quicker method, with a higher storage capability.

The system has a new Artecon re-writable optical drive attached to it which has performed well for backups of the Level C system. The drive is unable to read TOBI image discs as they appear to use incompatible formats. However, the drives were not purchased with this application in mind. It was not possible to remotely mount optical discs onto Workstation 'Darwin2'.

The Hamcom 2.8 Gigabyte disc attached to Workstation 'Darwin 2' has been moved up to the Neptune swath processing system, to provide sufficient data space to store the entire survey area during the next leg of the cruise. Since space shortages have occurred before on this system, provision of additional disk should be examined for future cruises.

*A6.9.4 Translation PC*

A new Viglen Genie PCI - IBM Compatible computer was installed in the Computer Room at the start of this cruise. It has not performed as well as expected, requiring extensive re-configuration. Several configuration faults still appear to be present in this machine, which though not serious, make the system awkward to use. Its physical location in the corner of computer room will be reviewed on return to Barry.

**A6.10 <u>Shipboard Mechanical Handling Equipment</u>** (C. Day)

The scientific operations requiring input from the RVS engineering division on cruise CD91 leg 1 were as follows:

1. Supervision/operation of mechanical handling equipment relevant to use of the IOS TOBI system.

2. Supervision/operation of ships fixed equipment required for the BGS BOOMER vehicle deployments.

3. Execution of sound velocity probe deployments for swath bathymetry calibration.

4. Technical support for institute and university personnel.

Due to persistent inclement weather overside operations were significantly reduced severely restricting the scientific programme. For operations that were carried out, no problems were encountered with any of the RVS ship's fixed or deck mounted mechanical equipment. The *Charles Darwin's* new CTD winch and wire functioned well with no teething problems, as did the main ships winch system which was utilised for TOBI operations.

Table A1

RRS CHARLES DARWIN EM12 MULTIBEAM OPERATIONS SUMMARY LOG
CRUISE: 91 FROM: 062/0740 TO: 063/0515 SHEET NO: 1

| DAY/TIME | FAULT | ACTION | COMMENTS |
|---|---|---|---|
| 062/0740 | | SET UP SV PROFILE MANUALLY | Used surface value with a 1.8 m/s gradient per 100m |
| 062/0830 | | START OF DATA COLLECTION | |
| 062/0840 | Locked on 2nd Multiple | Use manual depth setting to force to correct depth (149m) | Changed line number once correct (Line 2) |
| 062/1407 | Time drift against ship's clock | Manually set time | Unable to read clock due to ping rate and navigation data being too frequent |
| 062/1416 | | Even beams turned off | To reduce work load |
| 062/1440 | | All beams back in | |
| 062/1506 | Lost Bottom Lock | Manual Reset of Depth | only 67m |
| 062/1511 | | Retry to get bottom Lock | |
| 062/1535 | | SYSTEM SWITCHED OFF | To shallow to continue |
| 062/1952 | | SYSTEM BACK ON-LINE | |
| 062/2330 | | XBT 1 | 56° 25.4N 09°14.7W depth 780m |
| 063/0200 | | SVP PROFILE | 56°24.3N 09°46.6W depth 1500m |

Table A1 (continued)

RRS CHARLES DARWIN EM12 MULTIBEAM OPERATIONS SUMMARY LOG
CRUISE: 91 FROM: 063/0200 TO: 068/1534 SHEET NO: 2

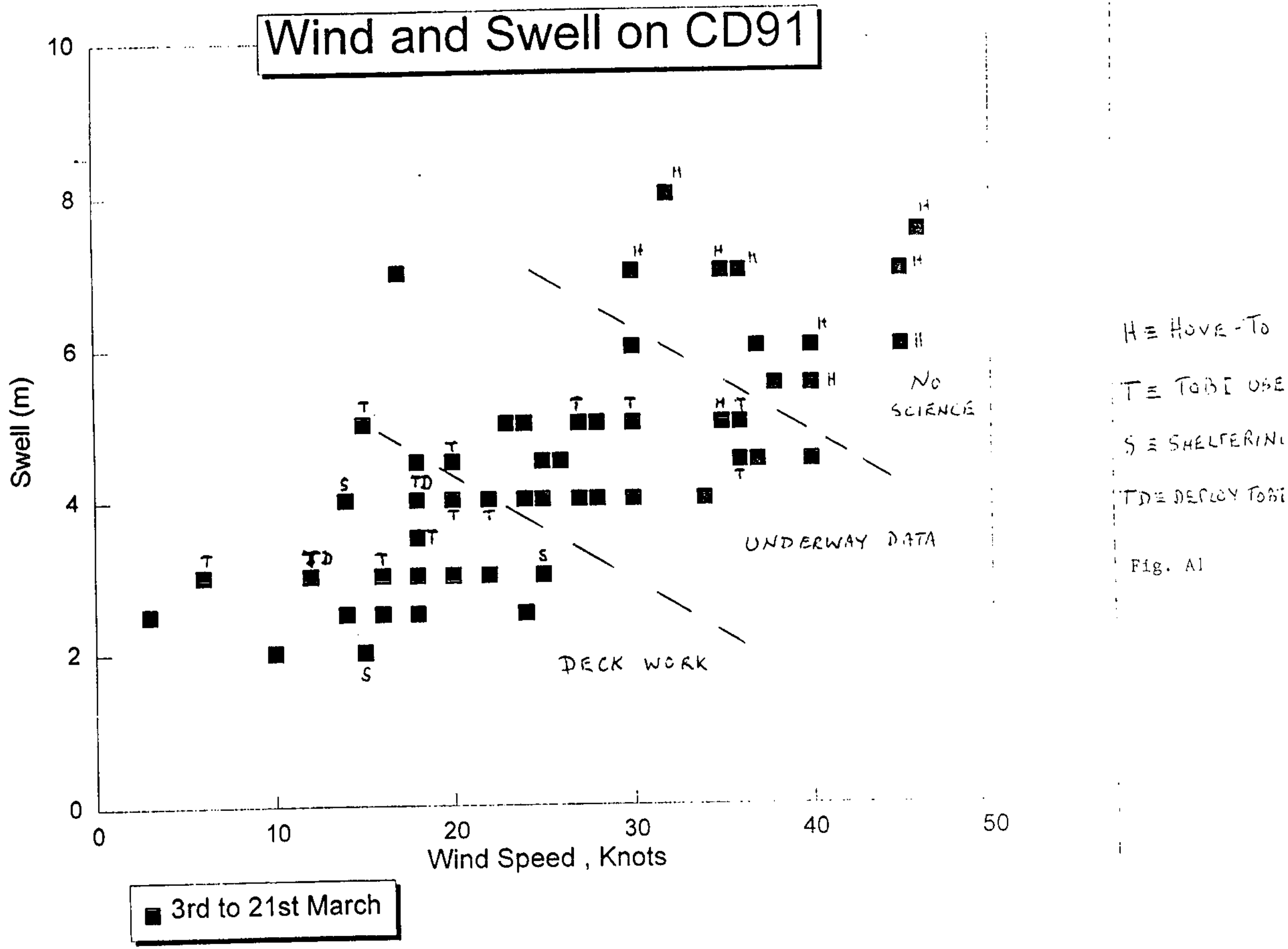
| DAY/TIME | FAULT | ACTION | COMMENTS |
|---|---|---|---|
| 063/0515 | | SVP TRANSFERRED TO EM12 | Problems with reading probe data. Needed Manual Editing |
| 063/0800 | | | Data poor due to weather |
| 063/0834 | Ethernet Locked Up | Reset OPU Lan | This occurred frequently during the cruise. This affects the operation control but does not affect the data collection |
| 063/2200 | OTS S/V Probe Fail | Manually set sv to 1488 m/s | Air in tank due to pitching |
| 064/0045 | | POWER INCREASED TO -10dB | Previously -20dB |
| 064/1200 | | | Start of EM12 Line 50 |
| 064/1403 | Curve Errors in outer beams | Extend s/v profile down below working depth | |
| 066/1700 | | | Start of EM12 Line 100 |
| 067/1320 | | OTS Tank Serviced & Back On-Line | |
| 068/0900 | | | TOBI deployment |
| 068/1030 | Interaction between TOBI & EM12 | Reduced Power to -20dB | TOBI caused outer beam errors and beam drop outs while in shallow water (<450m) |

Table A1 (continued)

| RRS CHARLES DARWIN EM12 MULTIBEAM OPERATIONS SUMMARY LOG<br>CRUISE: 91 FROM: 068/1030 TO: 072/1515 | | | SHEET No: 3 |
|---|---|---|---|
| DAY/TIME | FAULT | ACTION | COMMENTS |
| 068/1534 | | Power increased to -10dB | Too much drop out |
| 068/1800 | | | DATA VERY POOR FOR PROCESSING |
| 068/2004 | | | Start of EM12 Line 150 |
| 068/2032 | OTS Probe - Air in Tank | Manual SV of 1488 m/s | |
| 068/2106 | | Power to msx 0dB | |
| 068/2345 | | S/v changed to 1487 m/s | Same as last probe reading |
| 069/0015 | | Filters cleaned and replaced in Plot equipment | |
| 069/1106 | | Power reduced to -10dB | Request from TOBI watchkeeper |
| 070/1435 | | | TOBI recovery |
| 070/2150 | | TURNED TO STAND-BY | Depth too shallow - sheltering for repairs |
| 072/0028 | | SYSTEM BACK ON-LINE | Running for tests etc. |
| 072/0129 | | Logging restarted | Start of EM12 Line 200 |

Table A1 (continued)

| RRS CHARLES DARWIN EM12 MULTIBEAM OPERATIONS SUMMARY LOG<br>CRUISE: 91 FROM: 072/0129 TO: 078/1020 | | | SHEET NO: 4 |
|---|---|---|---|
| DAY/TIME | FAULT | ACTION | COMMENTS |
| 072/1515<br>072/1552 | QA display not being updated | Lots<br>Transferred to Decca 53G GPS | Found to have no navigation<br>Lost DGPS - Satellite Down |
| 072/1770 | | Transferred back to DGPS | Using different satellite |
| 073 pm | | | Bad weather upto Force 11 |
| 074/1224 | | SYSTEM TO STAND-BY | Too shallow to operate |
| 074/1920 | | BACK ON-LINE | |
| 075/0248 | QA Unit LAN Fail | Reset QA Computer | |
| 075/0309 | | XBT 2 | 56 50.0N 09 07.0W depth 760m |
| 075/1700 | | LOGGING OFF | |
| 075/1705 | | SYSTEM TO STAND-BY | To shallow - Running to Barra to shelter |
| 076/1900 | OTS PROBE FAILED | SYSTEM RESTARTED<br>Manual Value 1487m/s | Tank had been serviced while at shelter |
| 077/1145 | | | Aborted Boomer Deployment<br>Problems with Block |
| 077/2100 | | | Start of EM12 Line 300 |
| 080/1330 | | SWITCHED OFF | End of Survey |



Wind and Swell on CD91
Swell (m)
Wind Speed , Knots
3rd to 21st March
NO SCIENCE
UNDERWAY DATA
DECK WORK
H ≡ HOVE-TO
T ≡ TOBI USE
S ≡ SHELTERING
TD ≡ DEPLOY TOBI


Fig. A1

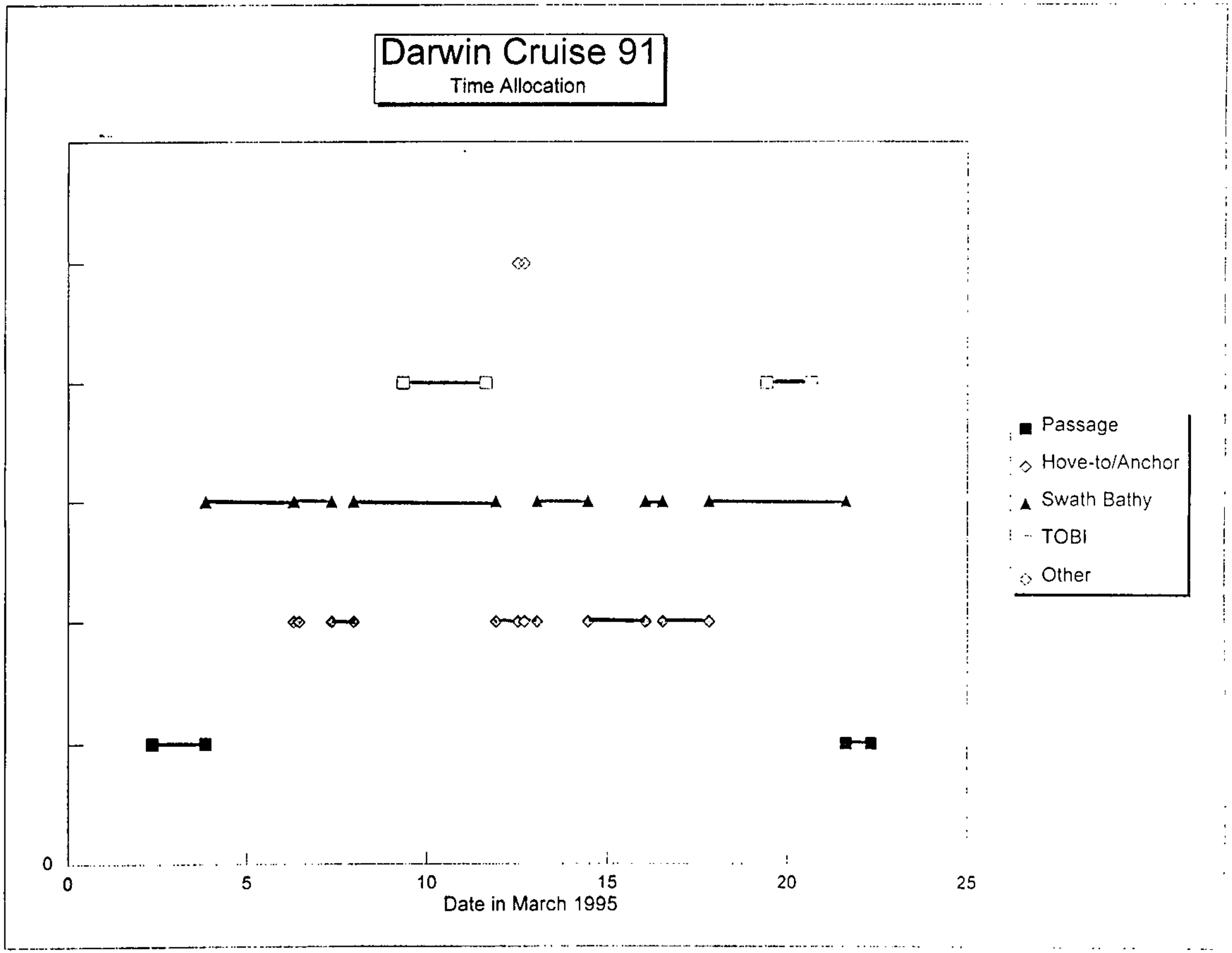
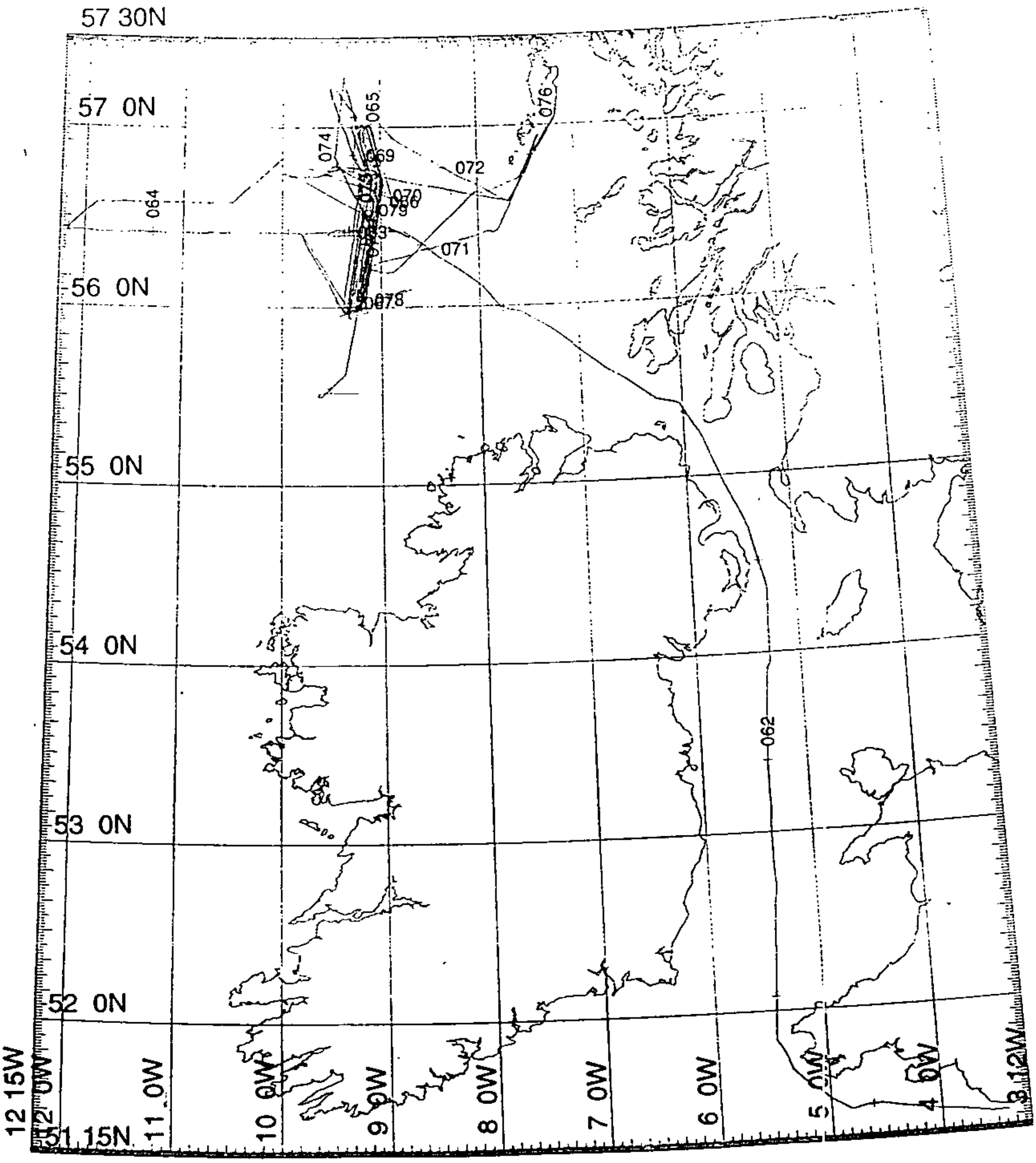

Darwin Cruise 91
Time Allocation
Passage
Hove-to/Anchor
Swath Bathy
TOBI
Other
0
0
5
10
15
20
25
Date in March 1995

Fig. A2




U.T.M. PROJECTION

GRID NO. 1

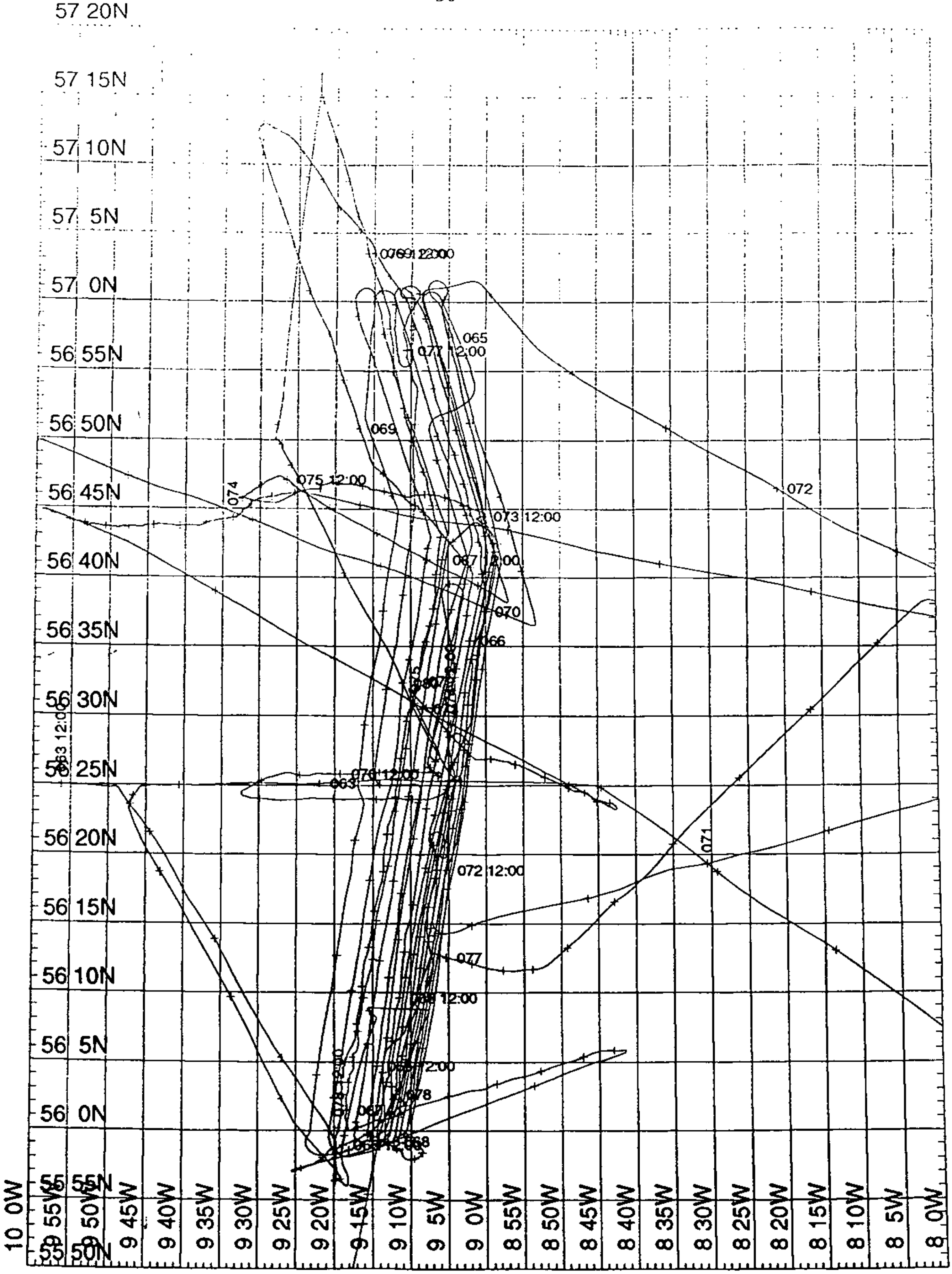
SCALE 1 TO 4000000 (.9996 NATURAL SCALE AT C.M.)

C.M. 9W International Spheroid

U.T.M. Zone 29

CD 91 Navigation

Fig. A3




U.T.M. PROJECTION

GRID NO. 1

SCALE 1 TO 740000 (.9996 NATURAL SCALE AT C.M.)

C.M. 9W International Spheroid

U.T.M. Zone 29

CD 91 Navigation

Fig. A4

## NERC Land Ocean Interaction Study (LOIS)
## The Location of the Shelf Edge Study Area

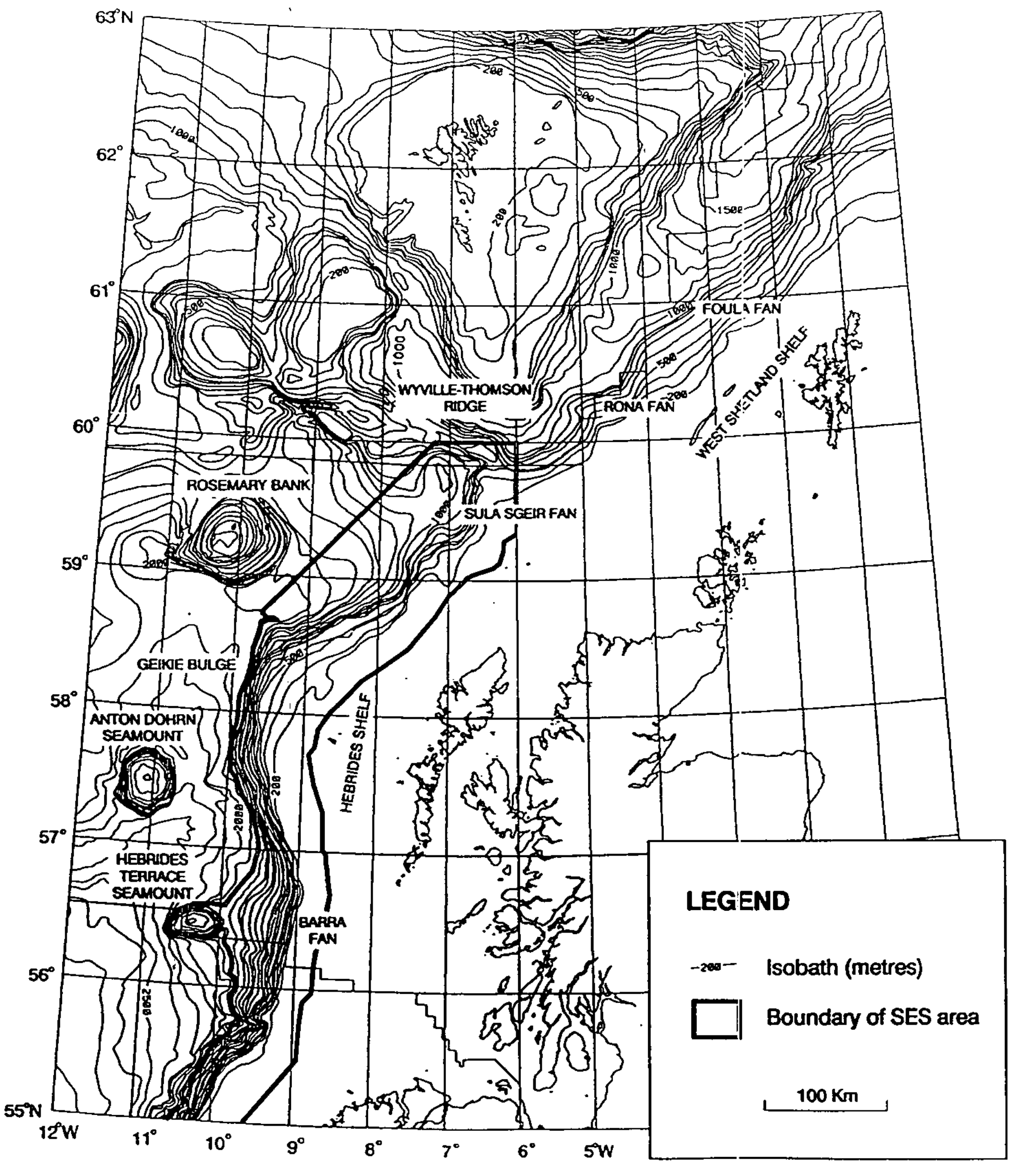



Fig. A5

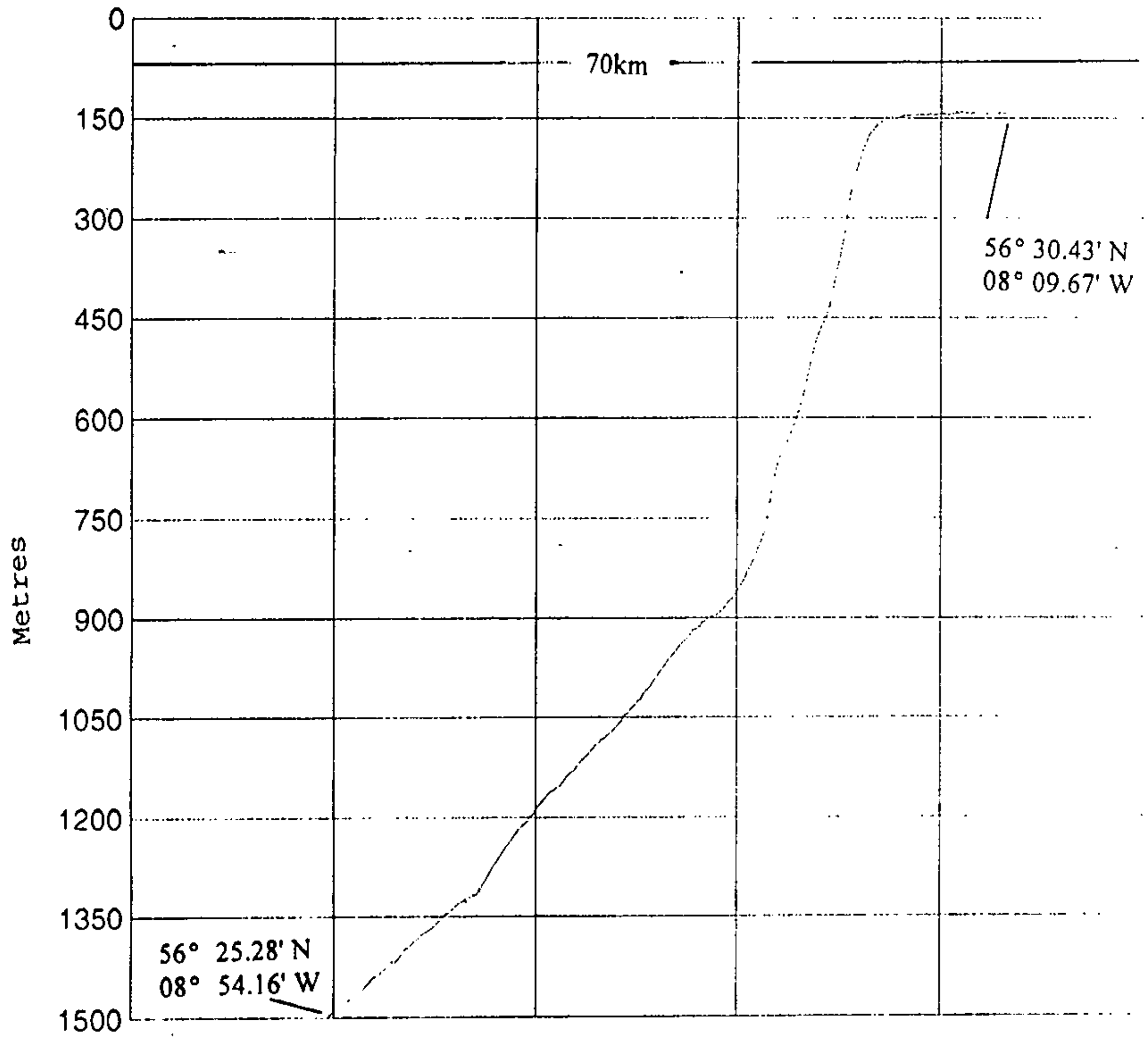



Fig. A6

**Generalised section across the shelf edge in the southern array zone**

Situated to the south of the Peach Slide, the section illustrated is across another buried slide or slump zone. If the section is shifted approximately 5km to the north, the large-scale topography will be preserved but the macroscale topography will be relatively smooth compared to the northern array zone. In this way the section will more closely fit the site requirements for a relatively smooth seabed compared to the northern section, these requirements being specified by the SES science community in April 1994.

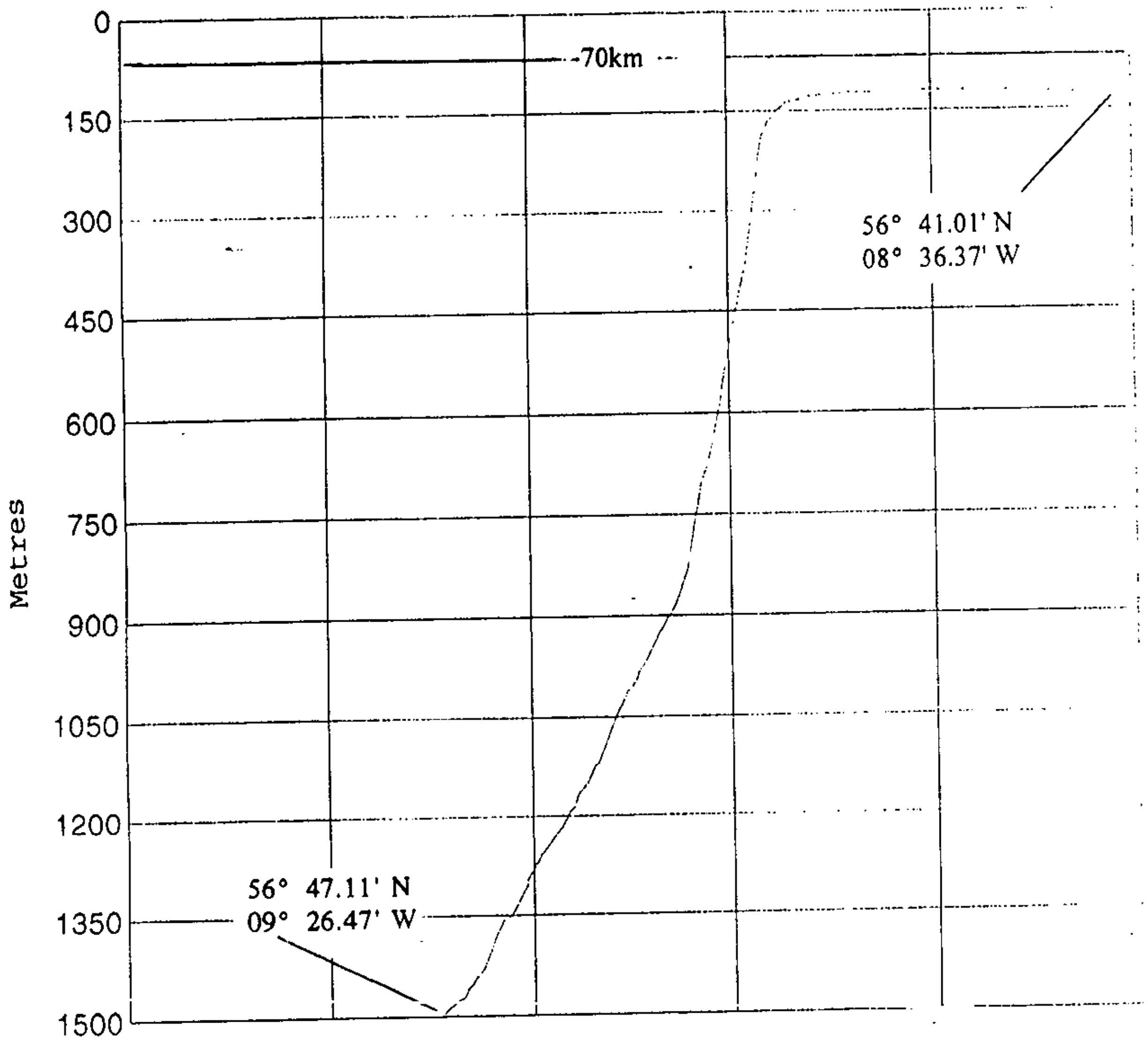



Fig. A7

**Generalised section across the shelfedge in the northern array zone**

The section illustrated is across part of the Peach Slide (Holmes, 1994).

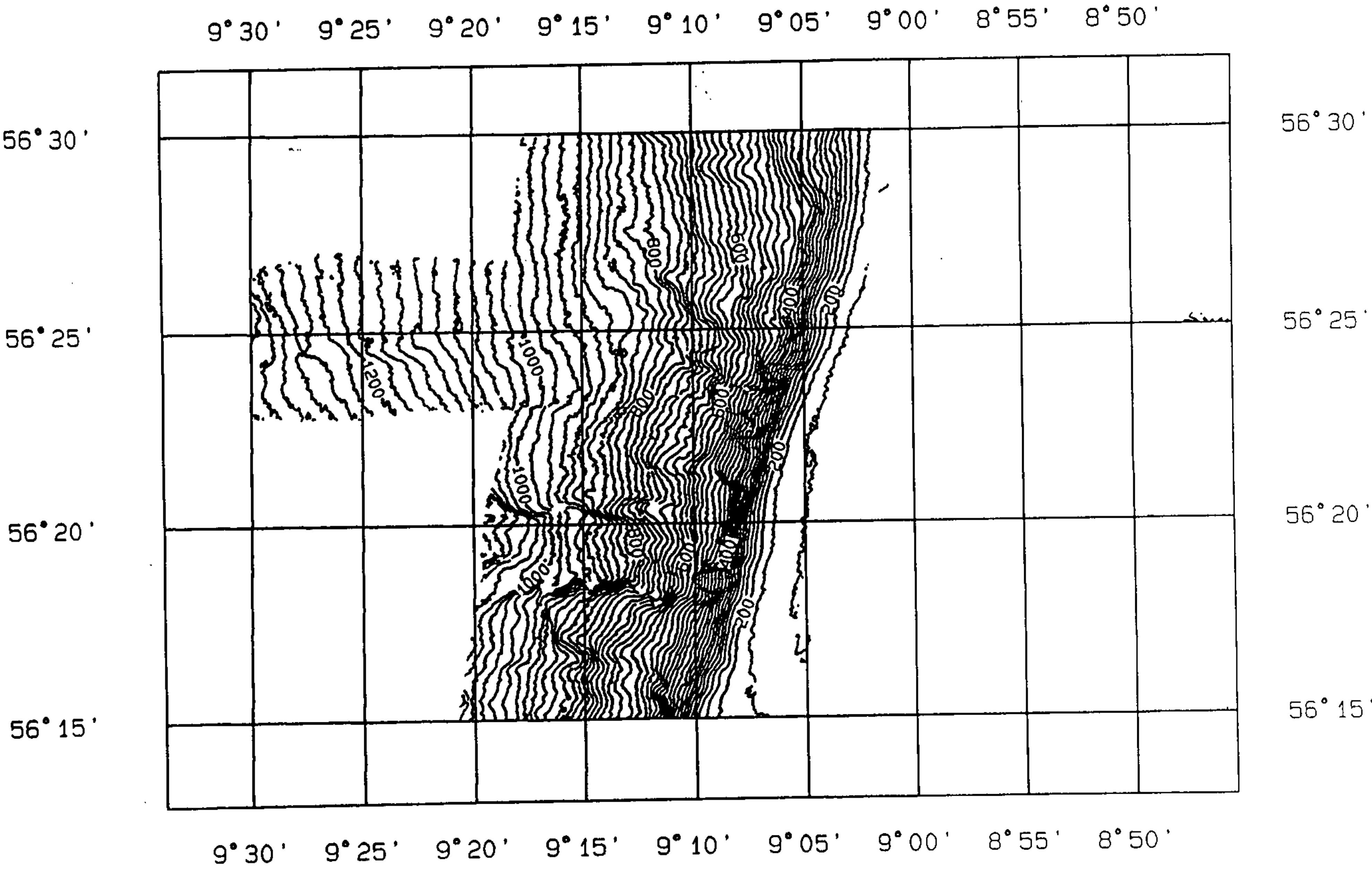

9° 30'
9° 25'
9° 20'
9° 15'
9° 10'
9° 05'
9° 00'
8° 55'
8° 50'
56° 30'
56° 25'
56° 20'
56° 15'
200
400
600
800
1000
1200

Fig. A9

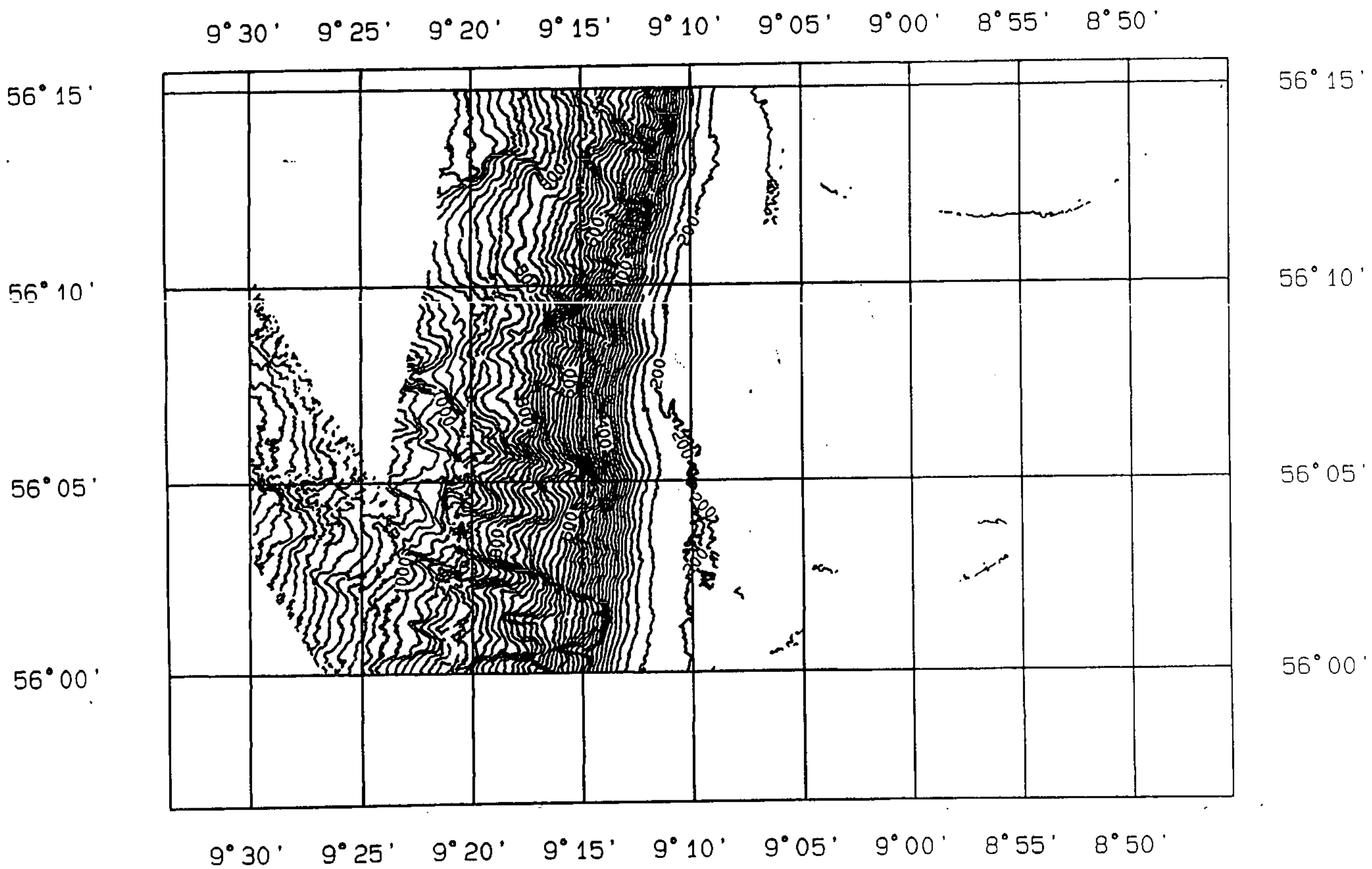
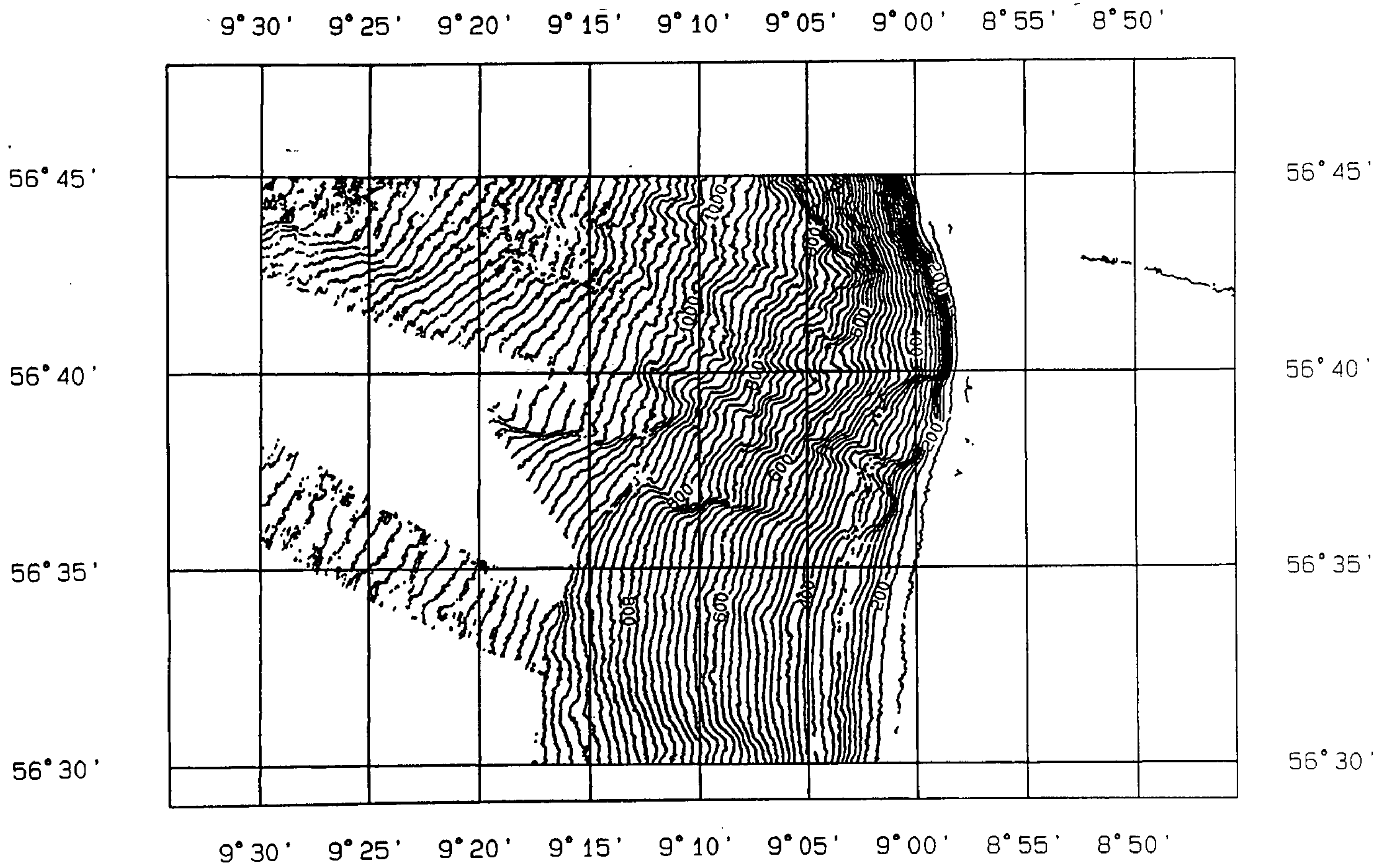



Fig. A8



9°30'
9°25'
9°20'
9°15'
9°10'
9°05'
9°00'
8°55'
8°50'
56°45'
56°40'
56°35'
56°30'
200
400
600
800
1000


Fig. A10

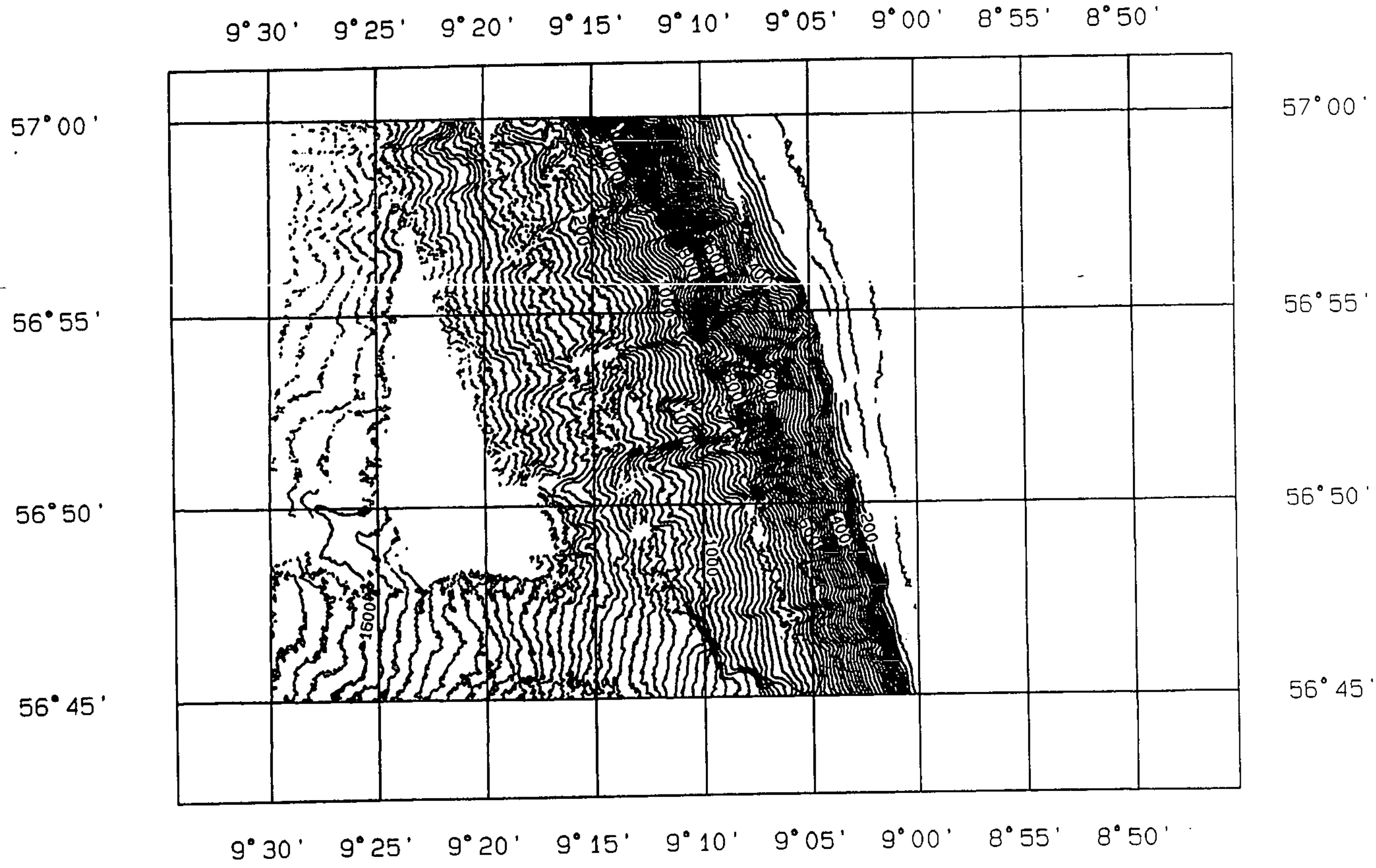

9°30'
9°25'
9°20'
9°15'
9°10'
9°05'
9°00'
8°55'
8°50'
57°00'
56°55'
56°50'
56°45'
200
400
1000
1600

Fig. A11

# SIMRAD EM12S 120
# RRS Charles Darwin

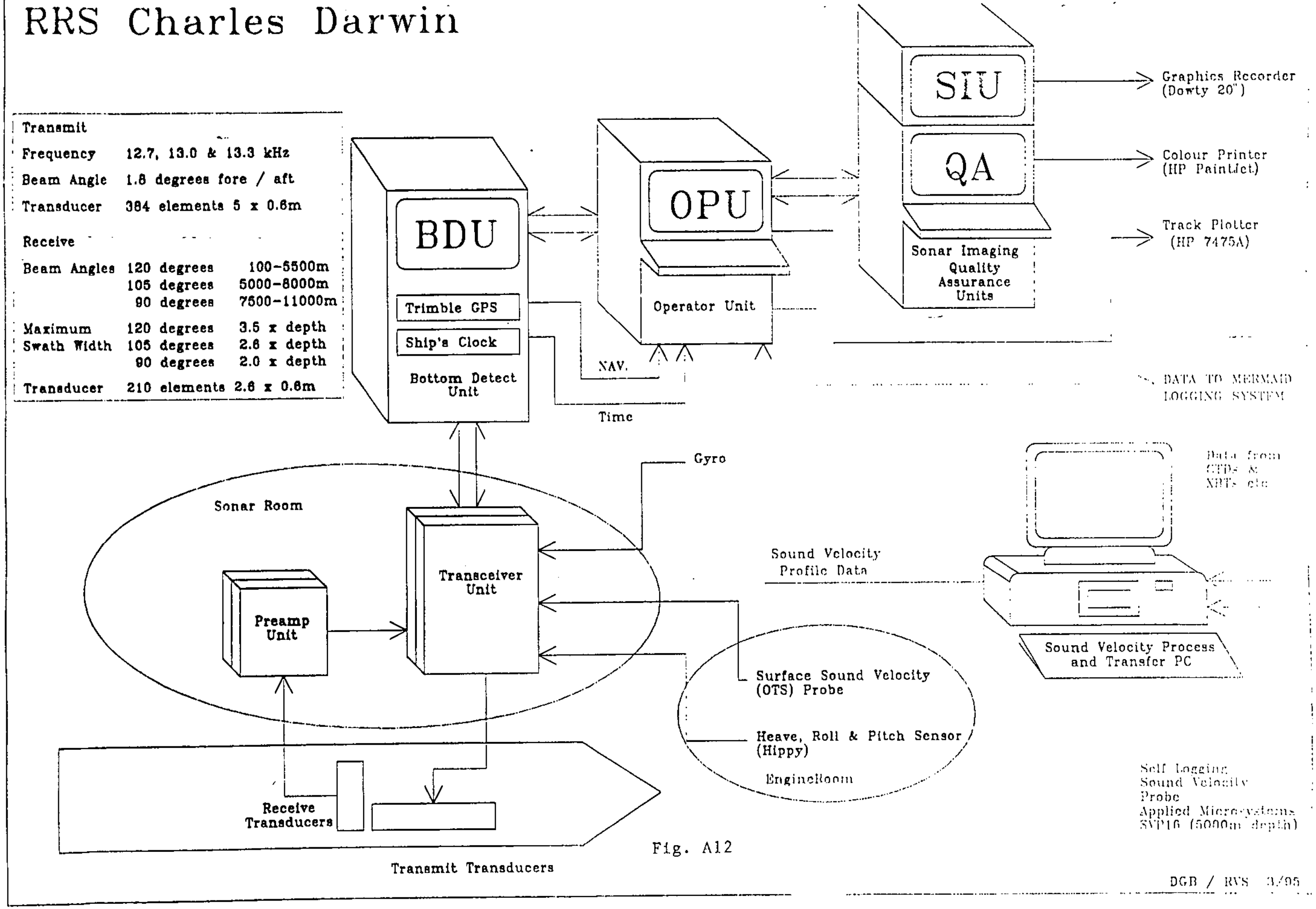



Fig. A12

# Simrad EM12S - 120 Data Processing

A guide to processing multibeam surveys

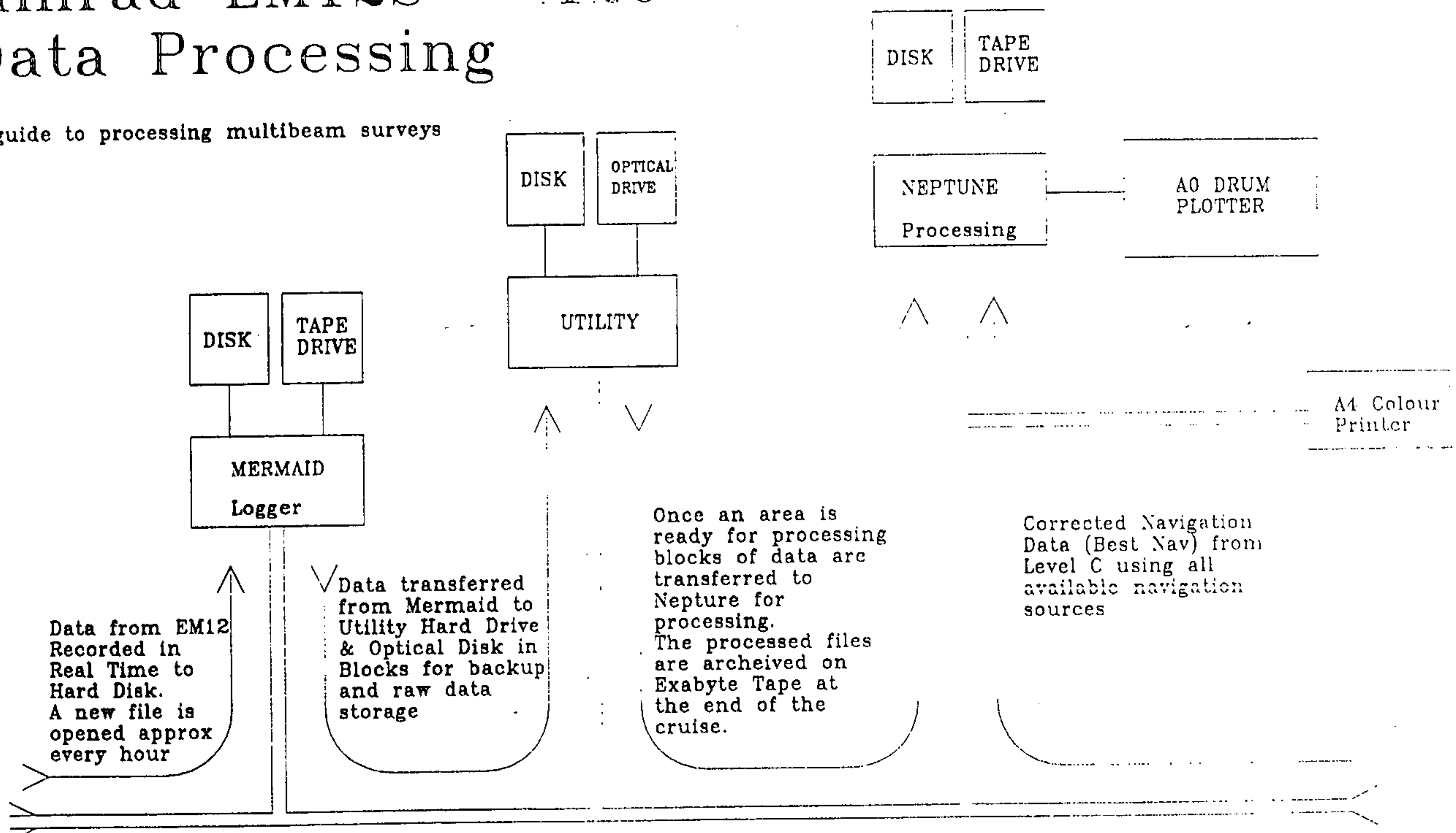



Fig. A13

## B1. OBJECTIVES

LOIS-Shelf Edge Study (SES) Objectives are:-

(a) to identify the time and space scales of ocean-shelf momentum transmission and to quantify the contributions to ocean-shelf water exchange by physical processes;

(b) to estimate fluxes of water, heat and certain dissolved and suspended constituents across a section of the shelf edge with special emphasis on net organic carbon export from, and nutrient import to, the shelf;

(c) to relate sediment properties and fluxes to the physical context;

(d) to quantify organic carbon cycling in shelf-edge sediments;

(e) to incorporate process understanding into models which will be tested by comparison with observations and provide a basis for estimation of fluxes integrated over time and the length of the shelf edge.

These SES objectives are being pursued by measurements at the shelf edge west of Scotland, and by the development of numerical models representing physical processes and microbiology. The overall plan for measurements includes an initial sea-bed survey, maintenance of moorings from spring 1995 to summer 1996, seasonal measurements of distributions, coring, tracking of drogued buoys and remote sensing. RRS *Charles Darwin* cruise 91 is the first of a sequence of seven planned SES cruises at intervals ~ 3 months.

Specific Objectives for Leg B of Cruise 91 were:

B1.1 Deployment of initial "skeleton" mooring array

| *Latitude N* | *Long./depth* | *Configuration* | *Instruments* |
|---|---|---|---|
| 56°25′ | 1500 | BP | |
| 56°25′ | 700 | pop-up + 1-strand | 3 × RCM, Tc, Tr + surface & Tc |
| 56°24′ | 300 | pop-up + 1-strand | 3 × RCM, Tr + spar buoy only |
| 56°24′ | 200 | "U" | 3 × RCM, 3 × Tc, Tr, Nu, surface |
| 56°24′ | 150 | "U" + 2 × 1-strand + BP | 2 × RCM + Met buoy + waves |
| 56°43′ | 1500 | 1-strand | RCM, Tr, 2 × ST |
| 56°39′ | 700 | 1-strand | ___ (spar buoy only) |
| 56°38′ | 300 | 1-strand | ___ (spar buoy only) |
| 56°38′ | 200 | 1-strand | ___ (spar buoy only) |
| 56°37′ | 130 | 1-strand | ___ (spar buoy only) |

(Tc = thermistor chain, Tr = transmissometer, Nu = nitrate analyser, surface = surface sensor package on toroid).

B1.2 CTD and water sampling at locations of mooring deployments. CTD records of C, T, DO, transmittance, fluorescence, irradiance. Analysis of samples for SPM, nutrients (autoanalyser), freezing for subsequent analysis of DON, filtering for subsequent analyses of particulates and plankton.

B1.3 Coring (piston, Kasten and box type) for vertical structure and as a back-up to multi-coring on later cruises for profiles of total organic carbon, C:N ratios, "labile" organic components and trace-metals.

B1.4 Sea-bed photography (bed-hopping camera).

B1.5 Recovery of OMEX moorings at
54°04.88'N, 11°55.65'W
54°33.20'N, 10°58.65'W
55°02.16'N, 10°12.40'W

## B.2 SUMMARY OF LEG B

B2.1 The initial "skeleton" mooring array was deployed as conditions allowed. Constraints were imposed by waves, swell and winds (often adverse but probably no more than to be expected for the area and season), by restricted use of the bow thruster and by the one slow winch. Nevertheless, a deployment was made at each intended location. Overall, the array comprised current meters, bottom pressure recorders, thermistors, transmissometers, a sediment trap, nutrient analysers, a meteorological buoy and other surface buoys. The deployed array was nearly as planned except for sediment traps and the absence of any thermistor chains near the surface.

B2.2 CTD and water sampling were carried out at locations of moorings (10 stations altogether) with analyses for salinity, nutrients and preservation for subsequent analysis of dissolved organic nitrogen, particulates and plankton. At some stations, sample-bottle "firing" was erratic and water sample depths are uncertain.

B2.3 Coring (Kasten cores; gravity cores; one box core before loss of the box-corer spade) was carried out, mostly near mooring locations. Some good cores were obtained, but disappointingly few. Sand and some gravel armoured the upper slope, with soft mud below.

B2.4 Sea-bed photography (with a "bed-hopping" camera) was carried out at six coring sites.

All these activities were also constrained by restricted use of the bow thruster and by the conditions, especially because the corer bucket location implied extra manoeuvring to deploy other equipment over the side.

B2.5 Intended recovery of OMEX moorings in 660 m water off NW Ireland was not carried out, all suitable periods being taken up with the SES array.

B2.6 In addition, swath bathymetry was carried out through periods unsuitable for over-side work, filling in a few poor joins and covering the shelf between the shallowest moorings to complement the extensive Hebrides slope coverage on CD91A.

The ship-borne ADCP current profiler was run throughout the cruise, including several runs along the shelf between the shallowest moorings and evidence of wind-driven structure in the upper water column.

Experience of value to following SES cruises was obtained, especially with regard to the mooring deployments

## B3. PERSONNEL ON BOARD

| *Scientists* | | *Officers and crew* | |
|---|---|---|---|
| J. M. Huthnance (PS) | POL | R. C. Plumley | Master |
| A. J. Harrison | POL | C. M. Leather | C/O |
| J. D. Humphery | POL | P. D. Gauld | 2/O |
| A. D.Banaszek | POL | J. C. Holmes | 3/O |
| N. G.Ballard | POL | D. Stewart | R/O |
| R. Holmes | BGS | I. G. McGill | C/E |
| Z. Loncar | BODC | S. F. Dean | 2/E |
| B. E. Grantham | DML | A. F. James | 3/E |
| I. A. Ezzi | DML | W. D. Lutey | E/E |
| F. Perez-Castillo | UWB | M. Trevaskis | CPO(D) |
| J. Foster | Edinburgh | C. Vrettos | SG1A |
| M. G.White | Galway | P. R. Bennett | SG1A |
| P. G. Taylor | RVS | P. H. Dean | SG1A |
| C. Day | RVS | R. Dickinson | SG1A |
| J. E. Scott | RVS | A. MacLean | SG1A |
| G. C. Knight | RVS | A. Healy | MM1A |
| H. C. Anderson | RVS | E. Staite | SCM |
| D. G.Booth | RVS | C. K. Perry | Chef |
| | | C. J. Kenny | M/Steward |
| | | W. J. Link | Steward |
| | | S. Shields | Steward |

## B4. NARRATIVE

(Note all times GMT). See Figs. B1, B2, B3 for general area map and cruise tracks.

22/3/95 RRS *Charles Darwin* sailed from NMSD Fairlie (the NATO pier) at 2005 after a full day unloading and loading equipment between legs A and B of cruise CD91. Some time was taken to continue fastening down equipment, before proceeding out of sheltered waters.

23/3/95 Course was made for the first mooring position, S140, where the POL meteorological buoy was to be deployed. A cruise planning discussion and emergency drill took place *en route*. Conditions did not permit winding the mooring on the winch in advance; this was carried out on arrival at 1400; the meteorological buoy mooring was then deployed buoy first at 56°27.14'N, 8°58.27'W, being completed at 1637.

RRS *Charles Darwin* remained hove to while the next mooring (N140, a single-strand spar-buoy mooring) was wound onto the winch.

From 1900, three lines of swath bathymetry were carried out, approximately parallel to the 200 m depth contour, between 56°26'N and 56°37'N, to cover the area around the deployed meteorological buoy, checking suitability for the other S140 rigs, likewise for N140, and to assess any along-shelf variations in between that could encourage cascading of dense winter water off the shelf edge. This work was planned to cease at 2400, by which time the increasing winds were posing a problem for keeping the intended track, and the increasing sea state degraded accuracy (both these factors are more stringent in shallow water, here 130-150 m).

24/3/95 A cycle of successive Kasten coring, CTD and bed-hop camera stations had been planned for 0000-0800. The corer was prepared, but increasing winds and concerns over the likely wire angle in a shallow deployment with ship's drift caused the exercise to be ended. By the time the CTD was ready, worsening conditions caused all overside deployments to be abandoned (0300).
Thereafter, RRS *Charles Darwin* was hove to in confused seas and winds reaching 45 knots around mid-day, decreasing to 30 knots through the afternoon. No overside deployments were possible, but at 1900 the ship's position and conditions suggested that deeper-water bathymetry was the best option. Course was made to begin a westward run from 56°29'N, 9°17'W, but after half and hour it became apparent that seas were too high for good data collection. RRS *Charles Darwin* hove to overnight.

25/3/95 As conditions eased around 0600, course was again made for mooring position N140, and better swath bathymetric data were obtained. The approximate N140 position was reached at 0920, work began on deck, and at 1010 the mooring was completed (again - anchor last) without complications. The position was then 56°36.44'N, 8°56.13'W.

Chain and cable winding onto the winch began for N200. A CTD cast was also carried out successfully at N140 (1110-1205) although the corer bucket location meant extra manoeuvring to deploy and recover the CTD over the side, and there were some uncertainties in firing the bottles.

Position N200 was reached at about 1300 but conditions deteriorated as a squall passed: at 1330 the attempt to deploy N200 was abandoned. As there was little prospect of conditions improving that day (and the 1400 forecast subsequently predicted force 8 for the whole area) it was decided to seek shelter east of Barra so that mooring buoys (4 spar, 2 sub-surface) loaded on the upper deck at Barry (before leg A, 2nd March) could be brought down to the after deck. This was done off Sandray (2000-2130) and RRS *Charles Darwin* headed back towards N140.

26/3/95 The area of N140 was reached at about 0600 but seas were too high for coring. The bed-hop camera was deployed, one photograph was taken, but intermittent receipt of the pinger signal caused it to be hauled in (0700-0730).

Position on N200 was gained; this spar buoy mooring was deployed buoy first in 199 m at 56°37.24'N, 9°0.32'W (0835-0905) and a CTD station carried out (0920-1000). Meanwhile, mooring N300 was wound onto the winch.

Then RRS *Charles Darwin* moved into position to begin N300. Operations began at 1045 but while the cable was being paid out the ship drifted into water that was too deep (a 0.5 m/s current was flowing to the north). In worsening conditions it was decided to haul in the mooring (rather than tow it around two loops) which was completed at 1120. Worsening weather and seas prevented an immediate re-attempt, and RRS *Charles Darwin* hove to until moderating winds allowed a second attempt. This was successfully completed (1700-1755) with a buoy-first deployment of N300 at 56°37.39'N, 9°1.43'W in 302m (at the time of anchor release) by means of a distant start to the deployment and slow tow to position, depth and DGPS position being monitored on the swath-bathymetry repeater in the main laboratory.

Near N300, a CTD station was carried out (1835-1915) and cable for mooring N700 was wound. Kasten coring was about to commence when the bow thruster cut out and all station operations had to be abandoned. The set of along-shelf swath bathymetry lines (begun on 23/3/95) was resumed.

27/3/95 Four lines were completed by 0800. The ship turned south (with the wind) to allow the engineers to take out the cooling fans (for the bow thruster) to be inspected. This fifth line was completed at about 1015, and subsequently a sixth line in passage to N700. Conditions improved steadily.

N700 (another spar buoy mooring) was successfully deployed buoy first (1310-1350) and RRS *Charles Darwin* proceeded to S300 while this spar buoy mooring was prepared. S300 was also deployed successfully, buoy first (1535-1630). This completed the set of un-instrumented moorings.

Conditions remained favourable and the surface toroid mooring for S700 was prepared while RRS *Charles Darwin* headed for the site. This mooring comprised a temperature-conductivity-transmissometer fixed under the toroid, below which a thermistor chain and logger were mounted along the mooring line. It was successfully deployed buoy first (1810-1910). The technique of a distant start to the deployment and slow tow to position, depth and DGPS position being monitored on the swath-bathymetry repeater in the main laboratory, was successfully used on all the day's deployments.

Meanwhile, tests were carried out on the bow thruster temperature, cooled by means of a spare small fan (only), both installed fans proving to have burned out. The bow thruster could be run at the lowest setting for perhaps an hour before time would be needed for cooling down; any higher setting would result in rapid heating. Thus station keeping would be limited to moderate conditions (force 4-5, say).

A CTD station and acoustic release tests were carried out near the S700 position (1940-2130). A bottom pressure recorder was prepared before steaming for position S140, and an XBT was fired once under way. The S140 bottom pressure recorder was deployed in 146m of water at 2235. Kasten coring was started but increasing winds (and limited bow thruster capability) caused the exercise to be halted before the corer reached the bed.

28/3/95 Swath lines were completed during the night (0030-0730) along 56°29'N out to 9°45'W and back from 9°45'W along 56°27½'N to cover the strip along the south line. A leak in the main fuel line caused a short delay in passage to S300 for which the sub-surface mooring was prepared (0830-1400).

Meanwhile the gravity corer was prepared and deployed in 237 m and 232 m near the south line (1050 and 1150). The first time, it appeared that the corer "bounced"; only a minimal sample was recovered (sand and gravel). The second time, the wire tension record looked good although the block "snatched" when the corer landed; the contents were again minimal - pebbles. It was inferred that a bed of pebbles shielded sand.

For the S300 mooring, the CTD had transmissometers attached and was lowered to 20 m for intercalibration with the CTD transmissometer and bottle samples (1300-1325). Position 0.8 miles SW of the intended mooring location was then taken and anchor-first deployment commenced (1415). The top current meter was finally in the water at 1526 and the mooring cut away at 1531 in 302 m water depth. The acoustics were tested satisfactorily. During deployment, plastic coating was repeatedly pulled off this mooring cable while winding off the winch, and several times the cable had to be negotiated around shackles. It was decided to prepare S700 for buoy-first deployment on the next day.

Meanwhile a CTD station was carried out near S300 (1630-1710) and the ship moved to the deeper side of S300 for coring.

Gravity (sediment barrel) cores were taken:
- at 374 m (1820); 0.33 m of mud was retrieved, the sand being washed out
- at 378 m (2005); nearly 1 m of sand over 1 m of mud were retrieved.

The bed-hopping camera was deployed (2100-2305) while the corer barrel was changed for a Kasten core.

29/3/95 The Kasten corer hit the bed in 320 m (0010) and a 2.1 m core was retrieved. Then the box corer was deployed, reaching the bed (258 m) at 0145 and recovering 0.19 m sand. The orientation device did not work.

With S300 sampling completed, RRS *Charles Darwin* steamed to S700, and the box corer was deployed without the orientation device, reaching the bed in 644 m at 0435. It was recovered without a sample, the spade being missing. There could be no box coring for the remainder of the cruise.

Way points 56°40'N, 9°10.25'W and 56°30'N, 9°4.75'W were covered to fill in swath bathymetry from the first leg, *en route* to S700.

The S700 sub-surface-buoyed single-point mooring was deployed buoy first (0935-1040) in fine conditions, followed by a CTD near this site (1200-1300). Then RRS *Charles Darwin* steamed to N1500, arriving 1500. A CTD cast to full depth was carried out (1540-1640) including a test of the N1500 acoustic release and calibration of two transmissometers with the CTD and bottle samples.

The N1500 sediment-trap single-strand sub-surface mooring deployment began at 1820, anchor first. One supporting rope to the anchor was released prematurely, resulting in a bent current meter mounting, which was replaced (1825-1845). The release, bottom current meter / transmissometer, buoyancy, bottom sediment trap and two further buoyancy units had been put in line and were in the water when the line tension was lost (about 1930, in 1534 m at 56°43.97'N, 9°25.15'W).

On winding in, a cable termination proved to have parted, at the top of the buoyancy unit 20 m above the sediment trap. A buoyancy unit was seen floating on the surface (the uppermost one would have been expected to; the fate of the next one was not known). Acoustics showed the release falling to the bottom and subsequently upright at a range corresponding approximately to the bottom depth. The deployed part of the rig could be upright to the buoyancy unit above the sediment trap, or an inverted V shape with both anchor and trap on the bed, if that buoyancy were missing. In the latter case, the rig might not float if released.

Conditions during deployment had been moderate. Debate about starting the deployment had focused on speed of the ship relative to the water (in order to maintain position on the ground) causing the paid-out mooring to stream out, but in the event this and the overall ship's drift were well controlled. Heave appeared to increase somewhat after the deployment began, so that the deployed line was going slack periodically prior to the failure, but not to any extent unusual during such deployments. The winch had been stopped immediately prior to the failure, and therefore made no unusual contribution to line tension.

As it was dark, nothing useful could be done about the mooring that day. After a pause, RRS *Charles Darwin proceeded* to N700 for intended coring. The situation was assessed, winds being 30 knots, and the bed-hopping camera was deployed (2325-0105) while a short (1.0 m) Kasten corer was prepared.

30/3/95 The Kasten corer was deployed (0155-0315) but "bounced" at the bottom (693 m) and returned empty. A second attempt with the 1 m barrel (0335-0445) also returned no sample (the dynamometer record showed no good pull out). The long (2 m) Kasten corer was then used and a satisfactory 1.25 m core was obtained (0510-0620) in 720 m (at N700).

At N300, the corer was deployed with a 1 m barrel (0800-0845) but no sample recovered. The bed-hopping camera was also used (on the bottom 0930-1020). Then RRS *Charles Darwin* steamed to N200 where the camera was used again. The Kasten corer was also deployed at N200 (1400-1445) without success. Throughout the day, the wind had maintained 30 knots and conditions were slowly deteriorating; with the lack of success, coring was abandoned and RRS *Charles Darwin* undertook in-fill swath bathymetry with way points 56°41'N, 9°01'W; 56°18.8'N, 9°08.5'W; 56°18.6'N, 9°25'W. However, with continued prospects of poor weather, the last of these points was dropped in favour of 56°02.5'N, 9°21'W and 56°23.5'N, 9°15'W.

31/3/95 These swath lines were completed at 0800, and with the ship hove to in improved but marginal conditions it was decided to proceed to S1500 to deploy the bottom pressure recorder (for which conditions were less critical). This deployment was completed at 0945 and the rig was heard through its descent to the bottom (1007). RRS *Charles Darwin* then steamed to S140 as the waves continued to decrease slowly.

The "U"-shaped mooring at S140 was deployed successfully (sub-surface buoy first, spar buoy last) in an east-to-west line (1255-1325). After moving the ship to cool the bow thruster, a CTD station was carried out (1425-1500) before moving to S200.

A 2m Kasten core at S200 returned empty, probably due to gravel.

The complex "U"-shaped mooring at S200 was deployed (sub-surface buoyancy first, toroid last) in line approximately NE-to-SW, but well-positioned across the 200 m depth contour. The duration of deployment (1920-2020) implied that the nitrate analyser on the toroid sampled air and might not record good data. Although waves had declined, a heavy swell persisted throughout the day.

There followed a pause to investigate why some CTD bottles had not been firing correctly; at the same time a fault in the ship's engine cooling system was repaired. The CTD problem was diagnosed but not rectified. Thus a camera drop was carried out (2220-2335). The ship proceeded to N300.

1/4/95 At N300, a full Kasten core was obtained (0120-0220) but possibly after a double hit; surface sands were missing but a layer between two mud layers was obtained.

The deck was cleared for swath bathymetry to 57°N and back to N1500. Two passes close over the sediment trap position using the PES gave no convincing evidence of the mooring. No further action was taken.

Argos reported the S700 toroid off position, and RRS *Charles Darwin* proceeded towards the latest reported fix, thence NE in the expected drift direction. The toroid was found near 56°34.6'N, 8°58.1'W around 1140; the ship was brought alongside at 1158 and the buoy was inboard at 1203. The line had broken within the talurit copper-swaged fitting at the top end of the 40m thermistor chain fitting. Thus the chain (and logger) were absent; the toroid retained the temperature/conductivity/transmissometer recorder.

RRS *Charles Darwin* proceeded to S200 for the final CTD station (1340-1420), the firing of bottles having been improved. After bottle samples had been taken (1450), RRS *Charles Darwin* returned to Fairlie *via* S300 (this spar buoy was not seen, although it had been the previous night; it has the same type of copper-swaged fitting as S700) and S200 (the toroid was sighted).

2/4/95 The ship tied up at Fairlie (0930) and demobilisation began.

## B5. TECHNICAL REPORTS

### B5.1 <u>Moorings</u> (A.J. Harrison, P.G. Taylor, I. Ezzi)

Moorings were deployed along the north and south sections of the SES mooring array at each of the sites N140 to N1500 and S140 to S1500, at corresponding depths. See mooring diagrams (Fig. B7 *et seq.*) for details.

*Free-fall pop-up* bottom pressure recorders were deployed at S140 and S1500 from one of the cranes. A ballast recovery spooler was fitted to the S140 instrument.

*Single-point surface* marker-buoy moorings were laid buoy first at N140, N200, N300, N700 and S300, with no instrumentation attached and using fibre mooring lines. A meteorological buoy was deployed on a single point wire/chain mooring at S140. A single-point surface toroid was laid at S700 buoy first on a fibre line with a 25cm-path-length transmissometer and 40 m thermistor string attached. This was subsequently reported drifting on 1/4/95 by the ARGOS MBM monitoring service, and tracked down and recovered that day, but with the loss of the mooring and the thermistor string.

*U-shaped moorings* were deployed at S140 and S200 with spar and toroid marker buoys respectively, plus RCMs, thermistor string, nitrate analyser, fluorometer and 25 cm transmissometer as detailed in the mooring diagrams. It had been intended to fit a 40 m thermistor string below the toroid buoy on the S200 mooring but this was omitted to ease the deployment in the prevailing weather conditions (with hindsight the thermistor chain might have been deployed also).

The timing requirements of the nitrate analyser place considerable constraints on the deployment, which must be completed within the sampling period of the instrument, giving a window of 45 minutes. Two possible solutions are: 1) make the surface buoy accessible up until it is deployed in order to give it a "drink" should the sampling time be reached before it is in the water; 2) re-programme the instrument in order that it will not start sampling until it is in the water. The latter option will be pursued with the manufacturers. The experience gained from this first deployment and the data which will be obtained will be invaluable for the future.

Argos beacons were fitted to the surface and sub-surface buoys at each end of the S200 mooring, together with an acoustic release to give maximum recovery potential.

*Single-point sub-surface* pop-up moorings were deployed at S300 and S700 with RCMs, thermistor string and transmissometer (25 cm path) together with part of the sediment trap mooring at site N1500. The mooring line parted in the latter.

The S300 mooring was deployed anchor first from the RVS 3T single drum winch as a taut-line deployment. However, this proved to be unsatisfactory from the single drum winch when the load forced the outer turns into lower layers, causing extra load, judder, and badly damaging the polypropylene covering. However, the mooring was successfully deployed and subsequently tracked to the sea floor using the Oceano RT661 release transponder. The verticality of the mooring was confirmed before leaving the site.

To avoid the problems encountered deploying S300, S700 was modified to allow buoy-first deployment. The mooring was successfully deployed, as the ship moved into position for the anchor release, and again tracked to the sea floor using the acoustic release. Once on the sea bed, the verticality of the mooring was confirmed.

In spite of the difficulties with the single drum winch, it was felt important to deploy the sediment trap mooring at N1500 anchor first, because of the sediment traps at 100m and 400m above the sea bed. Deployment was temporarily halted after the anchor suddenly dropped, causing damage to a current meter vane assembly. This was substituted for, and proceedings resumed. Although extra tension had been applied when winding the wires onto the winch, the same problems occurred as with S300. Coupled with surges in wire tension caused by the ship heave, this caused one of the swaged wire terminations to fail, on a 3m strop connecting two buoyancy packages G6600-3/4 and G6600-3/3 above the 100m sediment trap. The failure was at a deployed depth of about 80 m at the time. As a result, the lower sediment trap, RCM transmissometer, release, 120 m wire and one or two buoyancy units fell to the sea bed. This fall was tracked; a descent rate of about 2m/s was observed. Once on the sea bed the verticality of the release was confirmed.

Recovery of the top part of the mooring revealed that a swaged steel termination just above G6600-3/4 had pulled out. The subsequent release of energy had caused the steel bar of G6600-3/3 to shed its floatation packages, one of which was spotted drifting astern. The immediate concern was that the same shedding may have occurred with buoyancy package G6600-3/4, leaving the deployed part of the mooring negatively buoyant.

Deteriorating weather conditions and lack of suitable 'backup' dragging equipment prevented a recovery attempt.

*Wire inspection* The polypropylene jacketing on the 8mm galvanised wire supplied was extremely brittle. Several wire jackets were damaged during routine handling.

During the 'winding on' of S700 a line parted. Inspection revealed that the termination had not been swaged and was only held on by its protective heat shrink covering. Close inspection of all wires revealed another unswaged termination.

Table B1 lists the moorings and instruments deployed.

B5.2 <u>Coring</u> (C. Day, R. Holmes & J. Scott)

The coring operations were to include piston, box and gravity coring. It was noted on leg A that the sea-bed conditions and operating depths were not generally conducive to box coring; the box corer is essentially a deep-sea soft-sediment coring system. The sea-bed conditions were shown generally to be sand, gravel and firm sediments. In particular, the gravelly areas around 200m depth and shallower provide a problem for sampling: percussion-type core devices will not function well with gravel and rock sea beds; the gravity corer provides the best tool of those used for retention of sand, but the Kasten corer has the best chance of penetration and the box corer is unsuitable. It was decided on leg A to procure the RVS Kasten corer.

The loss of the box-corer spade early on in the project stopped the main thrust of the science based on sea-bed sampling. Non-function of the orientation device added to the problems with the core objectives for examination of surface sands: the orientation device would not be ready for a second sampling cruise beginning 6 April.

The Kasten corer provided good samples of clays but was heavy and difficult to handle, and impossible to turn around in less than two hours, 12 hours being nearer the norm if proper attention is paid to core splits and archival.

Considerable care needs to be taken with all coring devices in marginal weather: the ship's heave added to the likelihood that double sampling would occur, but the bed-hopping camera was not so sensitive to poor sea conditions. Due to bad weather conditions, core operations were intermittent with the initial operations being gravity coring. During good weather periods the Kasten corer and box corer could be utilised.

Tables B2 to B4 summarise the coring locations and samples obtained.

B5.3 Bed-hopping camera (J.D. Humphery)

The POL bed-hopping camera was used at six sites during the cruise (see table B5). It performed fairly well.

The camera itself was reliable, but the film broke or was torn on four occasions. However, a significant proportion of only one film was lost due to this fault. Modifications to the film transport mechanism are being considered. The flashgun performed faultlessly.

The pressure-switch on the new pinger failed during the first deployment; thereafter, it was screwed down manually before use and gave clear traces of bottom-approach on the Simrad echo-sounder system. A faster ping-rate gave a good indication of bottom-contact, although PES fish beam-steering and beam-shaping were necessary to maintain contact with the signals when the ship was rolling heavily.

No film-processing was carried out on board because the darkroom sink-drains were blocked; attempts to clear them were unsuccessful.

The cruise programme called for three types of corer, CTD and camera work. All these activities took place from the starboard gantry: the working area was very crowded. In particular, the camera, CTD and box-corer all had to be lifted up over the Kasten corer rotation-fixture. Marginal weather conditions and considerable ship-motion made handling these heavy pieces of equipment hazardous in the confined space.

**B5.4 DGPS**

This system worked well through the cruise and gave especially valuable input to mooring deployments and the swath bathymetry (*qv.*).

B5.5 Swath Bathymetry (G.C. Knight & D.G. Booth)

The *EM12S 120 Multibeam System* was used for two main purposes during cruise 91B: 1) normal surveying and 2) to obtain the depth profile during rig deployment and coring. It had to be turned off during camera stations to allow the pinger to be easily heard on the audio output on the echo sounder.

Following the completion of CD91A it was agreed that further *swath survey* work could be beneficial. During leg B additional survey lines were run, both to improve upon the data collected during leg A and to extend the coverage. This required the re-editing and re-gridding of the leg A data set and the subsequent exporting of all data into ASCII format at the end of leg B.

The further survey during leg B included a detailed survey of an area of shelf leading up to the shelf edge. As the water depth was on average about 135 m, this necessitated running lines between two and three cables apart in a north-south orientation; the lines were 12′ latitude in length. These data needed to be collected with good overlap of swath lines and in relatively good weather conditions to be of any value. It was necessary to edit the data in much smaller blocks than the main survey, as the data density was considerably higher. Editing was also carried out to a nearer-final conclusion, so that contouring of the shelf could be made at 5 m resolution. A slope of 15 m from north to south could clearly be seen.

It was apparent that along-track errors of about three to four metres were present, shown as a thin band running with the swath-to-swath interface. This produced closed contours on the contour plot of the area. However, when a colour-fill contour was examined, it was obvious that these errors were present. It may well be possible for this offset from the plane to be processed out during post-cruise work.

This very detailed survey was only made possible because of the presence of the DGPS receiver on board. This could be clearly demonstrated by the presence of ice-scarring running from west to east and often crossing six survey lines. This scarring was typically around 5 m deep and 50 m wide. The line-to-line registration of these features was excellent.

The survey data manipulation procedures are described in the cruise report on leg A.

The BDU (Bottom Detect Unit) computer locked up twice, each time with the same error codes but in completely different depths. No survey data was lost as station work transits were being carried out at the time.

During the shallow (>160m) surveys it was noticed that the outer beams were showing a curl. An XBT was carried out but this showed no change in sound velocity (at 700m). On examining the sound velocity data from the CTDs carried out it was noted that a variation did occur, especially in those carried out in shallow water. This may account for some of the curling effect.

A summary of EM12 operations is shown in Tables B6 to B8.

B5.6 Ship-borne ADCP (P.G. Taylor)

The 150KHz VM system gave no major problems. It was used in bottom-tracking and water-tracking modes. Depending on conditions, bottom tracking was achieved down to 450 m.

The Bridge remote display (remdis) was not working for a large part of the cruise; this was traced to a faulty connector on the PC serial interface and faulty wiring/set-up in the remdis unit. This was remedied to correct working at the end of the cruise.

B5.7 CTD (P.G. Taylor)

The CTD/sampling system consisted of a Neil Brown Mk3b CTD fitted with a Chelsea Instruments Mk2 *Aquatracka* fluorometer, Sea Tech 25cm transmissometer, PML 2pi PAR light meters and a Beckmann polargraphic dissolved oxygen sensor with Seabird pumped supply. The water sampling system comprised a General Oceanics 1015 rosette (12 x 10 l Niskins) fitted with a 1.6 KHz tone-fire system.

The CTD and associated instruments gave no problems with the exception of the oxygen sensor. The $O_2$ temperature record showed a lag which disappeared when the pumped water chamber was removed. Poor flushing or improper operation of the pump is suspected.

The General Oceanics tone-fire rosette system failed to operate properly both on the deck and in the sea, giving numerous misfires. The spare underwater unit behaved in a similar manner. Both worked well with no bottle lanyards connected. Lanyard tensions and/or motor alignment are suspected of preventing the ramp shaft from completing its duty cycle. The outcome was uncertainty on occasion, as to the depths at which the bottles were fired. Salinity samples were taken from each bottle to help calibrate firing depths. This information will be passed on to users by BODC.

CTD stations are listed in Table B9.

**B5.8** Nutrients and chlorophyll (I.A. Ezzi & B.E. Grantham)

*Water Sampling.* Water samples were taken for analysis of nutrients (ammonium, silicate, nitrate, phosphate) at eight CTD stations. Samples were taken for chlorophyll on the southern line (full profile) and northern line (CTD fluorometer calibration only), water was filtered and frozen for later analysis of dissolved organic nutrients. Because of a malfunction in the rosette sampler, there was uncertainty as to exact depths. Salinity samples were taken in such cases, later analysis of which will help to determine depths. Samples for nutrients and chlorophyll were also taken from the ship's non-toxic water supply.

*In-Situ Instrumentation.* Calibrations of one fluorometer and two nitrate analysers were carried out prior to deployment at S200. Due to sampling frequency, on-board chemistry and deployment time, one of the nitrate analysers, on the surface toroid with other instruments, took its first sample in air. This may lead to a drastic reduction in the efficiency of the reducing agent. A third nitrate analyser was brought for surface mapping, but this was not carried out due to a malfunction.

*Water Column Nutrients.* Measurements were carried out for ammonium, phosphate, silicate and nitrate plus nitrite. A new method and flow injection auto-analyser, the Lachat Quickchem 8000, was tried at sea for the first time. Sufficient time was available to sort out minor teething troubles and gain experience in using the instrument at sea. The instrument worked well and a full set of results was obtained.

**B5.9** Suspended sediment (F. Perez-Castillo)

*Sediment Traps.* Two Parflux mark 7G-21 sediment traps were planned for deployment on one mooring at N1500, to be serviced on the SES-3 Cruise in August 1995.

In order to prepare the traps for deployment, the standard procedure was carried out. Bottles were engraved and marked; then, washed with Decon-90 detergent and rinsed with distilled water. Preservative, consisting of 5% formaldehyde, NaCl and Borax was prepared on March 27, three days before trap deployment.

On March 28, one day before deployment, the cone and the baffle were washed with Dacon-90 and rinsed with tap water, then fitted in the trap's frame and covered with a plastic bag to keep the cone and the baffle free of dust. Bottles were filled with the preservative and fitted in each trap. The traps were then programmed for 22 events at seven-day intervals starting on April 2, at mid-day and ending on August 28, 1995.

On March 29, the N1500 sediment-trap single-strand sub-surface mooring was deployed in moderate conditions. However (see *Narrative*) during deployment the line parted. The deployed part of the rig could be upright to the buoyancy unit above the sediment trap, or an inverted V shape with both anchor and trap on the bed, if that buoyancy were missing. In the latter case, the rig might not float if released. It was decided that trap recovery should be on Cruise SES-2 in May.

*Water Column* (Suspended Particulate Matter: SPM). In order to calibrate the transmissometers, two sea-water samples from different depths were taken in each CTD cast (Table B10) and filtered through GF/C pre-weighted filters. Four litres of seawater were filtered in each sample and rinsed with 50 ml distilled water. For CTD 7 only (the cast being used to calibrate the transmissometer) 6 litres of sea-water were filtered.

*Particulate Organic Carbon* (POC). To complement the sediment trap experiment from which a *sinking rate* will be determined, sea-water samples were taken at several depths in each CTD cast (Table B11) and 200 ml were filtered in duplicate in pre-combusted GF/F filters.

**B5.10** General Equipment (D.G. Booth)

With the exceptions mentioned below, no problems were encountered with the general instrumentation.

The surveillance camera on the aft winch cab had a fault at the beginning of the cruise which was traced to a damaged connector at the control unit under the bridge console.

The EA500 was used solely as a monitor for pingers. The only problem occurred with the bed-hopping camera when the wire streamed out too far to get a good return. This problem was cured using the Beam steering unit.

No pinger was provided for the coring. Initially the spare CTD pinger was used with clamps manufactured on board. This soon failed with a broken ferrite core. For the rest of the coring, the pinger from the CTD was transferred as required. This however developed a fault (dry joint on the output capacitor) which was quickly repaired on board.

**B5.11** Mechanical Equipment (C. Day, J. Scott)

Utilisation included: handling equipment relevant to mooring deployments; operation of ship's fixed equipment and sea-bed coring equipment for coring operations; execution of sound-velocity probe and CTD deployments.

Due to periodic inclement weather, overside operations were reduced, restricting the scientific programmes. For operations that were carried out, no problems were encountered with the ship's fixed or deck-mounted mechanical equipment. However, there was some concern about the low speed of the mooring deployment winch. The RRS *Charles Darwin*'s new CTD winch and wire functioned well with no teething problems, as did the main ship's winch system which was utilised for coring operations.

**B5.12** Computing (H.C. Anderson)

*Level A.* Data was logged from the following level A's:

GPS_TRIM - Trimble 4000DL GPS satellite receiver coupled with a Racal Survey Differential GPS interface and decoder. (This instrument was supplied especially for this cruise and was used in place of the Trimble 4000AX).

DECMK53G - Bridge Mk53g Decca Navigator in GPS mode.

LOG_CHF - Chernikeeff Instruments 2 axis speed log.

BIN_GYRO - Heading information from the onboard gyroscope.

MX1107 - Magnavox Transit satellite receiver.

EA500D1 - Simrad EA500 echo sounder.

RVS_CTDF - CTD data from the EG&G CTD deck unit.

BOTTLES - Bottle firing times and status.

Data from the EA500 is subject to gaps due to loss of bottom lock, and false readings during pinger work. Bathymetry data should be taken from the EM-12 swath bathymetry system.

Centre beam data from the Simrad EM-12 swath bathymetry system was logged on Neptune and transferred to the Level C system. Meteorological data logged by the Bridge were input into the Level C *via* the METIN program.

The BOTTLES level A was only used during the first 3 dips, as its RS232 link to the tone-firing unit was suspected of causing misfires.

*Level B.* Logging commenced on March 22 at 19:40:00. The Level B Data logger logged all Level A sourced data. It crashed once during the cruise (March 23 at 01:02:20; restarted at 08:23:33 on March 23).

*Level C.* The Level C system was used to log and process the data provided by the Level B. It also directly logged data from the ADCP. It had no problems during this cruise leg.

Navigation logged from the Racal Differential GPS system was initially stored in the file *gps_trim*. These data were sub-sampled with an interval of one second into a file called *gps_fix*, to remove any duplicate time stamps caused by data gaps. This file was used as an input to the BESTNAV program which produced the final navigation file called *bestnav*; one record per 10 seconds. The navigation from this file was plotted against the *gps_fix* and Decca GPS navigation sources, on a daily basis to ensure accuracy of the data.

Bathymetry from the EM-12 was imported into the Level C using the CBEAM program and placed in the file *rswath*. It was then processed to remove duplicate, backwards and other erroneous time-stamps and placed in the file *depth*. These data do not require processing by *prodep* as the use of the sound velocity probe with the EM-12 during the cruise negates the need for Carter area correction.

An hourly record of the ship's positions was produced from BESTNAV. Ten CTDs were performed and plots produced. The data from CTD dip number eight, though present in its entirety in the main raw and processed files *rawctd* and *proctd*, cannot be split off into a separate dip file. Hence no *ctdp008* or *ctdr008* will be present on the data tape.

The Data on the Level C system were backed up daily onto optical disk.

*Translation PC* A new Viglen Genie PCI - IBM Compatible computer was installed in the Computer Room at the start of the cruise. It did not perform as well as expected, requiring extensive re-configuration. Several configuration faults still appear to be present in this machine; though not serious, the faults make the system awkward to use. Its physical location in the corner of computer room will be reviewed on the ship's return to Barry. A virus was detected by Dr Solomon's anti-virus toolkit during this leg. It was reported as the Ripper virus. However, an investigation found no evidence of this virus. It appears that corruption present on the disk caused the virus scanner to misinterpret the contents of the disk. The disk was destroyed as a precaution.

**B6. CONCLUSIONS** for future SES moorings (A.J. Harrison, P.G.Taylor)

1. The swath bathymetry provided valuable data for mooring site selection and position-fixing, greatly aiding the mooring deployments; the ship could tow the mooring to pre-selected positions.

2. Off-deck space for mooring equipment storage and preparation was ample, with two good cranes

and "A"-frame, albeit rather slow. Water sloshing around the aft deck was a problem, preventing deck work and access when under way in other than calm conditions.

3. The RVS-supplied deck winch was the only means available for mooring deployments. It proved satisfactory for single-point moorings. However, it posed problems for the other moorings, with slack spooling and very slow line speed when the drum is nearly empty. The use of only one winch requires that all the different mooring elements (wire, chain, rope) are spooled on the same drum, making for complication and possible damage. It also limits preparation to one specific mooring and thereby lacks flexibility for opportune deployment. Extra and different winches are required for subsequent SES deployments. Anchor-first deployments using jacketed wire rope, especially, require the double-barrelled capstan winch for RRS *Charles Darwin*. If deck space becomes an issue then mooring design may have to be reviewed.

4. The complexity of the S200 "U"-shaped mooring design proved to be too restrictive in the prevailing conditions. As a result, the surface buoy thermistor chain was omitted. Even so, the deployment took over one hour, mainly due to the slowness of the winch. Some time could also be saved by attaching instruments into the line with clips and rings.

5. Weather conditions were a limiting factor for mooring deployments, preventing activities on two days and only allowing the simpler moorings to be deployed on others. Mooring designs with simpler configuration have a better chance of being deployed or recovered. The surface toroid buoy part of the S200 "U" mooring would be better if replaced by a spar buoy and the toroid made a single-point mooring.

6. The polypropylene jacketing on sub-surface moorings was too brittle and totally unsuited to the SES application.

7. Quality control on the supplied wires must be improved as a matter of urgency; it was very lucky that the unswaged terminations were spotted. The use of steel swaged terminations may need reviewing although there is no guarantee that a standard tallurit fitting would prove stronger. Consideration may have to be given to the individual testing of terminations if this is not already the case.

8. N1500 was deployed in conditions which became marginal as the deployment proceeded. Greater caution will need to be exercised when deploying 'draggy' moorings containing sediment traps.

Table B1

# Cruise CD91 Leg B

## MOORING SITES AND INSTRUMENTS DEPLOYED

| DATE/TIME | SITE | LAT (°) | LAT (') | LON (°) | LON (') | DEPTH | TYPE | DEPTH |
|---|---|---|---|---|---|---|---|---|
| 23/03/95 16:37 | S140 | 56 | 27.14 | 8 | 58.27 | 145 | MET-BUOY | SURFACE |
| 25/03/95 10:08 | N140 | 56 | 36.44 | 8 | 56.13 | 134 | SPAR MARKING BUOY | SURFACE |
| 26/03/95 09:03 | N200 | 56 | 37.24 | 9 | 0.32 | 199 | SPAR MARKING BUOY | SURFACE |
| 26/03/95 17:53 | N300 | 56 | 37.39 | 9 | 1.43 | 302 | SPAR MARKING BUOY | SURFACE |
| 27/03/95 13:50 | N700 | 56 | 38.83 | 9 | 6.75 | 702 | SPAR MARKING BUOY | SURFACE |
| 27/03/95 16:27 | S300 | 56 | 27.27 | 9 | 3.95 | 302 | SPAR MARKING BUOY | SURFACE |
| 27/03/95 19:10 | S700 | 56 | 27.06 | 9 | 9.60 | 712 | THERMISTOR STRING | 43 |
| 27/03/95 19:10 | S700 | 56 | 27.06 | 9 | 9.60 | 712 | TRANSMISSOMETER-TOROID BUOY | SURFACE |
| 27/03/95 22:35 | S140 | 56 | 27.52 | 8 | 58.47 | 146 | BOTTOM PRESSURE RECORDER | 146 |
| 28/03/95 15:30 | S300 | 56 | 27.30 | 9 | 4.63 | 296 | RECORDING CURRENT METER & TRANSMISSOMETER | 289 |
| 28/03/95 15:30 | S300 | 56 | 27.30 | 9 | 4.63 | 296 | RECORDING CURRENT METER | 150 |
| 28/03/95 15:30 | S300 | 56 | 27.30 | 9 | 4.63 | 296 | RECORDING CURRENT METER | 50 |
| 29/03/95 10:40 | S700 | 56 | 27.73 | 9 | 9.68 | 695 | RECORDING CURRENT METER | 50 |
| 29/03/95 10:40 | S700 | 56 | 27.73 | 9 | 9.68 | 695 | THERMISTOR STRING | 50 |
| 29/03/95 10:40 | S700 | 56 | 27.73 | 9 | 9.68 | 695 | RECORDING CURRENT METER | 201 |
| 29/03/95 10:40 | S700 | 56 | 27.73 | 9 | 9.68 | 695 | RECORDING CURRENT METER & TRANSMISSOMETER | 688 |
| 29/03/95 19:33 | N1500 | 56 | 43.97 | 9 | 25.15 | 1534 | RECORDING CURRENT METER & TRANSMISSOMETER | 1490 |
| 29/03/95 19:33 | N1500 | 56 | 43.97 | 9 | 25.15 | 1534 | SEDIMENT TRAP | 1400 |
| 31/03/95 10:08 | S1500 | 56 | 27.08 | 9 | 38.48 | 1500 | BOTTOM PRESSURE RECORDER | 1500 |
| 31/03/95 13:22 | S140 | 56 | 28.07 | 8 | 57.67 | 145 | RECORDING CURRENT METER | 50 |
| 31/03/95 13:22 | S140 | 56 | 28.07 | 8 | 57.67 | 145 | RECORDING CURRENT METER | 140 |
| 31/03/95 20:19 | S200 | 56 | 27.18 | 9 | 2.77 | 194 | RECORDING CURRENT METER | 50 |
| 31/03/95 20:19 | S200 | 56 | 27.18 | 9 | 2.77 | 194 | THERMISTOR STRING | 50 |
| 31/03/95 20:19 | S200 | 56 | 27.18 | 9 | 2.77 | 194 | RECORDING CURRENT METER | 100 |
| 31/03/95 20:19 | S200 | 56 | 27.18 | 9 | 2.77 | 194 | THERMISTOR STRING | 100 |
| 31/03/95 20:19 | S200 | 56 | 27.18 | 9 | 2.77 | 194 | RECORDING CURRENT METER & TRANSMISSOMETER | 190 |
| 31/03/95 20:19 | S200 | 56 | 27.18 | 9 | 2.77 | 194 | NITRATE ANALYSER SYSTEM ON TOROID BUOY | 192 |
| 31/03/95 20:19 | S200 | 56 | 27.18 | 9 | 2.77 | 194 | NITRATE ANALYSER SYSTEM ON TOROID BUOY | SURFACE |
| 31/03/95 20:19 | S200 | 56 | 27.18 | 9 | 2.77 | 194 | TRANSMISSOMETER ON TOROID BUOY | SURFACE |
| 31/03/95 20:19 | S200 | 56 | 27.18 | 9 | 2.77 | 194 | FLUOROMETER ON TOROID BUOY | SURFACE |

**Table B2** Seabed sample list

Key: Camera= POL bed-hop camera; s = start position, e = end position

| REGISTRATION NUMBER | DATE | DEPTH (m) | LAT. yy°yy.yy'N | LONG. xx°xx.xx'W | SAMPLE TYPE | SUMMARY DESCRIPTION |
|---|---|---|---|---|---|---|
| +56-09/363 | 26/3/95 | 140 | 56 37.38 | 08 57.72 | Camera | Film 1. 1 shot. Not processed shipboard |
| +56-10/165 | 28/3/95 | 374 | 56 29.15 | 09 04.83 | Gravity core | No recovery of surface sediment, 033m mud, very soft, highly plastic, with sulphide blebs retained. |
| +56-10/166 | 28/3.95 | 378 | 56 29.07 | 09 04.90 | Gravity core | 20cm slightly gravelly medium-coarse dominantly quartz-lithic sand on soft, highly plastic mud, with sulhide blebs and colour banding |
| +56-10/167 | 28/3/95 | 350 | 56 29.32 s<br>56 29.65 e | 09 04.62 s<br>09 04.66 e | Camera | Film 2. 25 shots. Not processed shipboard. |
| +56-10/168 | 29/3/95 | 320 | 56 29.20 | 09 04.85 | Kasten core | 2cm medium-coarse carbonate sand on very soft mud with occasional fine colour banding |
| +56-10/169 | 29/3/95 | 258 | 56 29.44 | 09 03.28 | Box core | 19cm medium-coarse carbonate sand |
| +56-10/170 | 29/3/95 | 667 | 56 38.37 s<br>56 38.15 e | 09 06.35 s<br>09 06.21 e | Camera | Film 3. 25 shots. Not processed shipboard. |
| +56-10/171 | 30/3/95 | 720 | 56 38.49 | 09 07.13 | Kasten | 5cms fine muddy quartz-clastic sand on very soft highly plastic and strongly bioturbated mud |
| +56-10/172 | 30/3/95 | 345 | 56 37.20 s<br>56 37.59 e | 09 01.79 s<br>09 01.79 e | Camera | Film 4. 25 shots. Film broken estimated 1/4 to 1/3 way through. Not processed shipboard. |
| +56-10/173 | 30/3/95 | 199 | 56 37.49 s<br>56 37.94 e | 09 00.00 s<br>09 00.16 e | Camera | Film 5. 25 shots. Not processed shipboard. |
| +56-10/174 | 31/3/95 | 157 | 56 26.08 s<br>56.27.05 e | 09 01.73 s<br>09.02.56 e | Camera | Film 6. 25 shots. Film broke towards the end. Not processed shipboard. |
| +56-10/175 | 01/4/95 | 331 | 56 37.59 | 09 01.69 | Kasten | 13cms gravelly quatrz-lithic sand on very soft , highly plastic mud, with occasional very thin sand layers and sediment lamination disturbed from 1.65 to 2.13 m below seabed. |

**Refer to tables B3 and B4 for a summary of seabed photograph sites and seabed and subseabed sample sites related to the designated southern and northern mooring sites.**

**Table B3** Summary of seabed photograph sites and seabed and subseabed sample sites related to the designated southern mooring sites

| MOORING SITE | BED-HOP CAMERA | BOX CORER | GRAVITY CORER | KASTEN CORER |
|---|---|---|---|---|
| S140 | Film 1: 1 shot only<br>+56-09/363: film not developed shipboard | | | |
| S200 | Film 6: 25 shots<br>56-10/174 start 157m, film not developed shipboard | | 2 attempts: no sample retained, probably due to gravel at 237m and 232m depth, small samples of which were in the core catcher | 1 attempt with 2m barrel, descent 40m/min, no sample probably due to gravel at 187m depth. |
| S300 | Film 2: 25 shots<br>+56-10/167 start 350m, film not developed shipboard | +56-10/169 258m, no orientation data. 19cms thick medium to coarse, dominantly biogenic carbonate sand, approximately 10% quartz- lithic sand with rare lithic gravel to 4cms maximum size. | +56-10/165 374m, surface sand washed out,<br>+56-10/166 378m, 20cms fine to medium dominantly quartz-lithic sand with approximately 20% biogenic carbonate sand, on very soft plastic mud | +56-10/168 320m with 2m barrel, 2cms medium to coarse dominantly biogenic carbonate sand on very soft highly plastic mud |
| S700 | | Lost spade, no sample | | |
| S1500 | | | | |

KEY TO TABLE

1. Codes in the style +56-09/363 ...etc.refer to the BGS system of sample archival adopted with BODC approval for this cruise
2. Because of the differing sample techniques and weather-dependant acquisition, thickness values for surface layers appear to vary considerably at one site. The Kasten corer appears to be more prone to surface-sand washout but because of its wider internal aperture ,15cm x 15cm, it has a greater chance of penetrating surface gravel than the gravity corer that has an internal diameter of 7cms
3. See Table B2 for more details of the sample station data.

**Table B4** Summary of seabed photograph sites and seabed and subseabed sample sites related to the designated northern mooring sites

| MOORING SITE | BED-HOP CAMERA | BOX CORER | GRAVITY CORER | KASTEN CORER |
|---|---|---|---|---|
| N140 | | | | |
| N200 | Film 5: 25 shots<br>+56-10/173 start 199m, film not developed shipboard | | | 2m barrel, 40m/min descent, good pull-out/penetration data, but no sample, probably due to gravel caught in the catcher. |
| N300 | Film 4: 25 shots<br>+56-10/172 start 345m, film not developed shipboard | | | +56-10/175, 2m barrel with 40m/min descent rate, sand washout at top but surface sediments preserved at the base of the core due to a double hit, 13 cms gravelly dominantly quartz-lithic sand, with approximately 20% biogenic carbonate sand, on very soft plastic mud. |
| N700 | Film 3: 25 shots<br>+56-10/170 start 667m, film not developed shipboard | | | 2 first attempts with 1m barrel and 25m/min descent rate failed, probably due to low rates of descent.<br>+56-10/171 720m, from 40m/min descent rate with 2m barrel, 5cms fine muddy quartz-lithic sand on very soft highly plastic mud |
| N1500 | | | | |

KEY TO TABLE

1. Codes in the style +56-09/363 ...etc.refer to the BGS system of sample archival adopted with BODC approval for this cruise
2. Because of the differing sample techniques and weather-dependant acquisition, thickness values for surface layers appear to vary considerably at one site. The Kasten corer appears to be more prone to surface-sand washout but because of its wider internal aperture .15cm x 15cm, it has a greater chance of penetrating surface gravel than the gravity corer that has an internal diameter of 7cms
3. See Table B2 for more details of the sample station data.

**Table B5** Bed-hopping camera deployments

| FILM | SITE | POSITION | DATE/TIME on bottom | COMMENT |
|---|---|---|---|---|
| 1 | N140 | 56°37.38'N 8°57.72'W | 26/3/95 0722 GMT | Only one frame was taken on the bottom at this site because the pinger failed after the first touch. |
| 2 | S300 | 56°29.32'N 9°04.62'W | 28/3/95 2209GMT | 25 nominal touches, 348 m |
| 3 | S700 | 56°38.37'N 9°06.31'W | 29/3/95 2348GMT | 25 nominal touches, 686 m |
| 4 | N300 | 56°37.20'N 9°01.79'W | 30/3/95 0926GMT | 25 nominal touches. This film broke in the camera approx. 1/4 - 1/3 through. |
| 5 | N200 | 56°37.69'N 8°59.99'W | 30/3/95 1139GMT | 25 nominal touches. |
| 6 | S200 | 56°26.89'N 9°01.73'W | 31/3/95 2245GMT | 25 nominal touches. This film broke close to the end, but there should be enough good frames for site-analysis purposes. |

Table B6

RRS CHARLES DARWIN EM12 MULTIBEAM OPERATIONS SUMMARY LOG

CRUISE: 91 leg B FROM: 082/1200 TO: 085/0900 SHEET NO: 1

| DAY/TIME | FAULT | ACTION | COMMENTS |
|---|---|---|---|
| 082/1200 | | System Up & Running | Clock Set |
| 082/1218 | | LOGGING ON | Start of EM12 Line 365 |
| 083/0830 | OTS Probe failed | LOGGING OFF<br>Fixed surface sv | EOL 384<br>sv = 1487 |
| 083/1126 | | Transmitter OFF | |
| 083/2030 | | BACK ON LOGGING ON | |
| 083/2338 | BDU LOCKED UP | RESET BDU COMPUTER | CODES 13,66,4,27,5,5,5 57 Beams<br>Clock Stopped Depth 1193 |
| 084/0050 | | Restarted | (On station- No watchkeeping) |
| 084/0900 | Interference | | Bridge Echo Souder In Use |
| 084/1204 | DGPS Drop Outs | Recovered itself | |
| 084/1440 | | System to standby | |
| 085/0335 | | System Back ON with LOGGING OFF | |
| 085/0438 | | LOGGING ON | Start of EM12 Line 400 |
| 085/0614 | | LOGGING OFF / TRANSMIT OFF | Camera Station |
| 085/0737 | | TRANSMIT ON / LOGGING ON | |

Table B7

RRS CHARLES DARWIN EM12 MULTIBEAM OPERATIONS SUMMARY LOG

CRUISE: 91 LEG B FROM: 085/0737 TO: 88/1445 SHEET NO: 2

| DAY/TIME | FAULT | ACTION | COMMENTS |
|---|---|---|---|
| 085/0900 | Interferrence | | Bridge Echo sounder On |
| 085/1241 | BDU LOCKED UP | Reset BDU Computer | Codes 13,66,4,2,5,5,5<br>Clocked Stopped Depth 373m |
| 085/1330 | | LOGGING OFF | |
| 085/1504 | | System Back ON + LOGGING ON | (On station - No watchkeeping) |
| 085/1716 | | LOGGING OFF | |
| 085/2044 | | LOGGING ON | |
| 086/2127 | | XBT | 56° 27.8N 09° 09.9W depth 661m |
| 087/1000 | | LOGGING OFF | |
| 087/2158 | | TRANSMIT OFF | Camera Station |
| 087/2309 | | TRANSMIT ON - NOT LOGGING | |
| 088/0545 | | LOGGING ON | |
| 088/0851 | | | START OF EM12 LINE 450 |
| 088/0913 | | LOGGING OFF | Station Work |
| 088/1312 | | LOGGING ON | |

Table B8

RRS CHARLES DARWIN EM12 MULTIBEAM OPERATIONS SUMMARY LOG

CRUISE: 91 FROM: 088/1312 TO: 091/1430 SHEET NO: 3

| DAY/TIME | FAULT | ACTION | COMMENTS |
|---|---|---|---|
| 089/1455 | | LOGGING OFF | |
| 088/2345 | | Transmit OFF | Camera Station |
| 089/0054 | | Transmit On - Not Logging | |
| 089/0905 | | Transmit OFF | Camera Stations (2) |
| 089/1500 | | Transmit ON & Logging ON | |
| 089/2256 | | LOGGING OFF | |
| 090/0428 | | LOGGING ON | |
| 090/0803 | | LOGGING OFF | |
| 090/2330 | | Transmit off | Camera Station |
| | | | |

Table B9

# Cruise CD91 Leg B

CTD CASTS

| Cast id | Start Date/Time | End Date/Time | Fixed Station | Lat | Lon | Wdepth | Comments |
|---|---|---|---|---|---|---|---|
| CTD1 | 25/03/95 11:30 | 25/03/95 12:05 | N140 | 56.62133 | -8.93050 | 133 | |
| CTD2 | 26/03/95 09:20 | 26/03/95 09:52 | N200 | 56.62650 | -9.00500 | 255 | |
| CTD3 | 26/03/95 18:35 | 26/03/95 19:15 | N300 | 56.63667 | -9.01633 | 719? | |
| CTD4 | 27/03/95 19:45 | 27/03/95 20:40 | S700 | 56.44833 | -9.16883 | 735 | |
| CTD5 | 28/03/95 13:00 | 28/03/95 13:10 | S300 | 56.48900 | -9.01100 | 157 | Trans-cal (555, 558), 20m cast |
| CTD6 | 28/03/95 16:30 | 28/03/95 17:10 | S300 | 56.48983 | -9.04883 | 573? | |
| CTD7 | 29/03/95 12:00 | 29/03/95 13:00 | S700 | 56.47233 | -9.15267 | 454? | |
| CTD8 | 29/03/95 15:42 | 29/03/95 17:32 | N1500 | 56.74767 | -9.42883 | 1565 | Trans-cal (556, 557) |
| CTD9 | 31/03/95 14:29 | 31/03/95 14:56 | S140 | 56.48817 | -8.97200 | 145 | |
| CTD10 | 01/04/95 13:48 | 01/04/95 14:15 | S200 | 56.45150 | -9.05300 | 249 | |

**Table B10** Suspended Particulate Matter: water column samples

| DATE | POSITION | TIME | CTD | DEPTH |
|---|---|---|---|---|
| DD-MM | STN. No. | HH:MM | No. | METRES |
| 26-03 | N200 | 10:25 | 2 | 5 |
| | | | | 242 |
| | N300 | 19:28 | 3 | 5 |
| | | | | 250 |
| 27-03 | S700 | 19:45 | 4 | 15 |
| | | | | 500 |
| 28-03 | S300 | 13:30 | 5 | 20 |
| | | | | 20 |
| | | 17:23 | 6 | 15 |
| | | | | 180 |
| 29-03 | S700 | 12:45 | 7 | 200* |
| | | | | 620* |
| | N1500 | 17:00 | 8 | 200* |
| | | | | 200* |
| | | | | 1400* |
| | | | | 1400* |
| 31-03 | S140 | 14:50 | 9 | 5* |
| | | | | 100* |
| 01-04 | S200 | 14:00 | 10 | bottle 7 |
| | | | | bottle 5 |

*** uncertain depths due to problems in CTD System**

**Table B11** Particulate Organic Carbon: water column samples

| DATE | CTD | POSITION | SAMPLE DEPTH |
|---|---|---|---|
| DD-MM | No. | STN. No. | METRES |
| 25-03 | 1 | N140 | 54 |
| | | | 94 |
| | | | 124 |
| 26-03 | 2 | N200 | 5 |
| | | | 100 |
| | | | 242 |
| | 3 | M300 | 5 |
| | | | 30 |
| | | | 60 |
| 27-03 | 4 | S700 | 15 |
| | | | 100 |
| | | | 650 |
| 28-03 | 6 | S300 | 5 |
| | | | 60 |
| | | | 200 |
| 29-03 | 7 | S700 | bottle 3* |
| | | | bottle 6* |
| | | | bottle 8* |
| 29-03 | 8 | N1500 | 600 |
| | | | 800 |
| | | | 1400 |
| 31-03 | 9 | S140 | bottle 5* |
| | | | bottle 9* |
| | | | bottle 12* |
| 01-04 | 10 | S200 | bottle 12* |
| | | | bottle 9* |
| | | | bottle 7* |

*uncertain depths due to problems in CTD system.

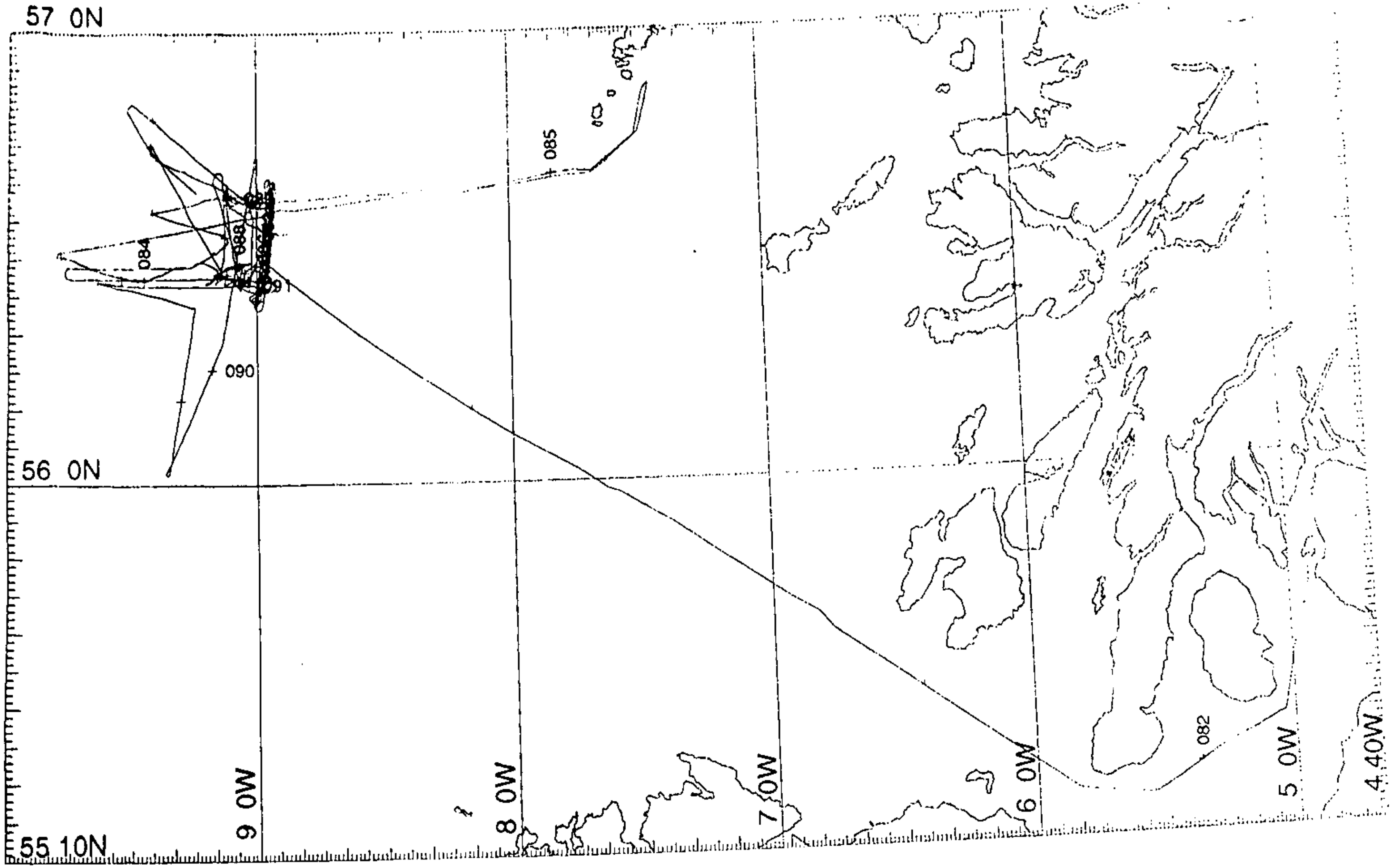



Fig. B1

U.T.M. PROJECTION

SCALE 1 TO 1600000 (.9996 NATURAL SCALE AT C.M.)

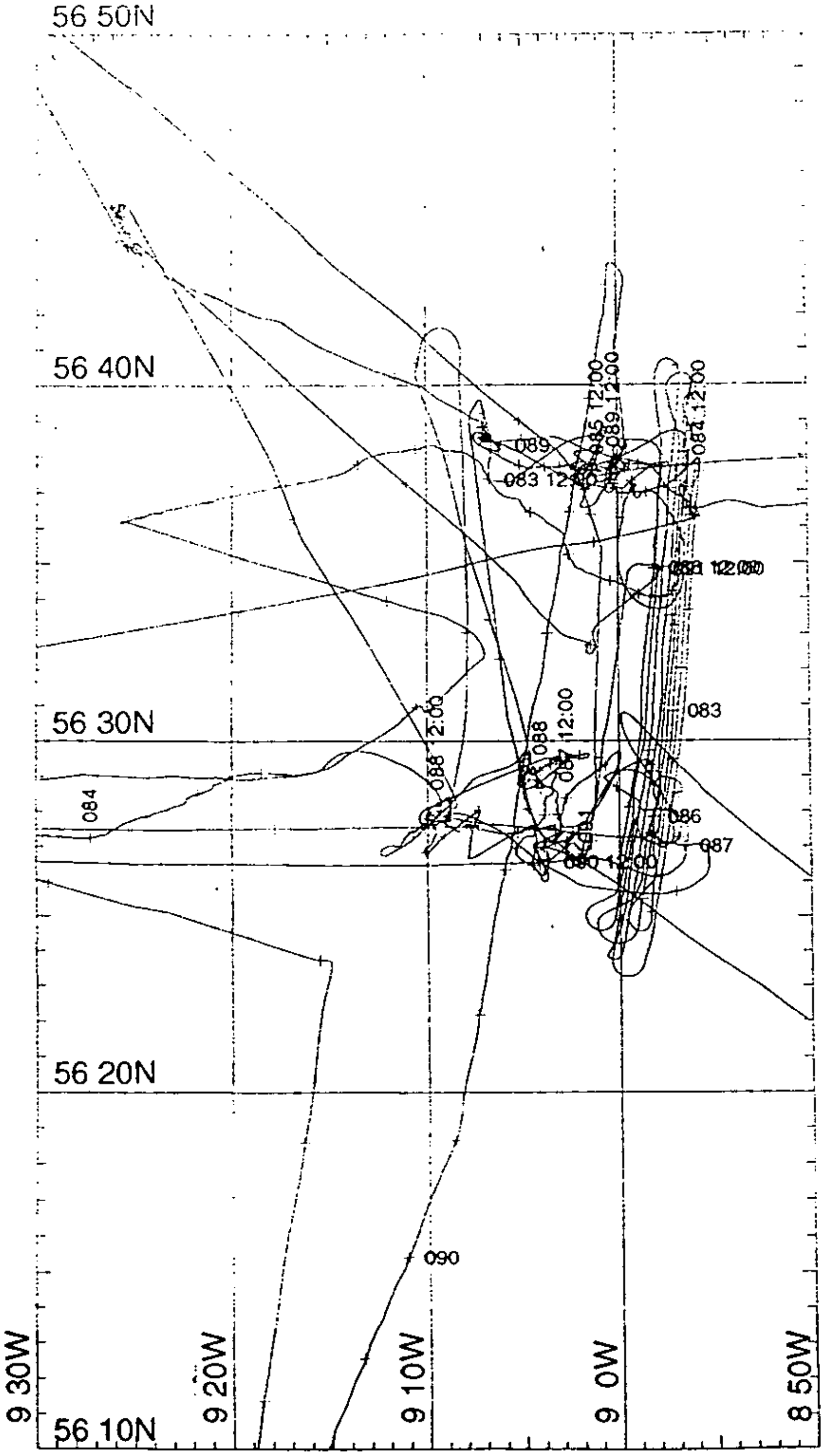
C.M. 9W International Spheroid

U.T.M. Zone 29

CD 91B Navigation

GRID NO. 1

Track plotted from bestnav




U.T.M. PROJECTION

GRID NO. 1

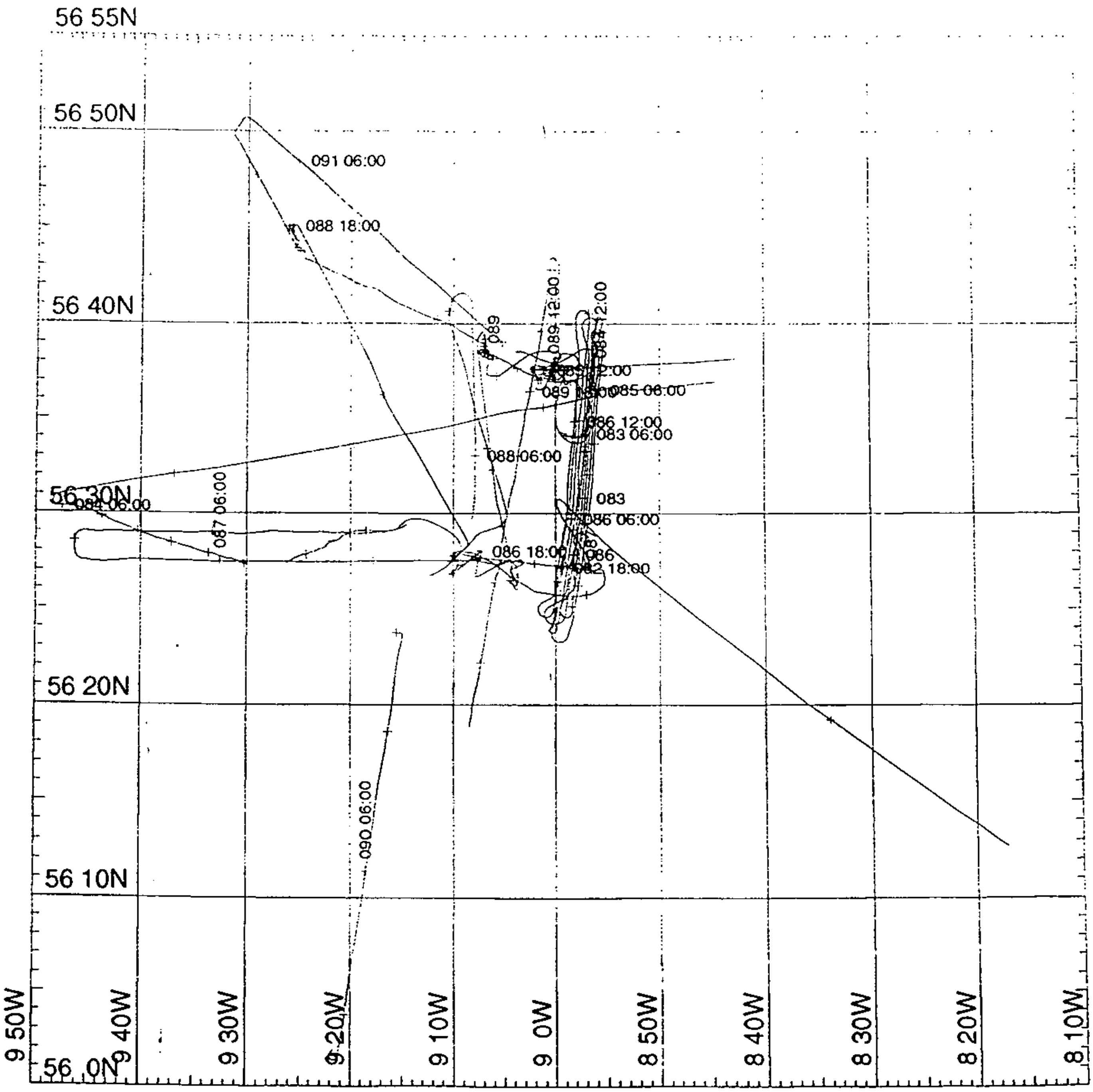
SCALE 1 TO 400000 (.9996 NATURAL SCALE AT C.M.)

C.M. 9W International Spheroid

U.T.M. Zone 29

CD 91 Navigation

Fig. B2




U.T.M. PROJECTION

GRID NO. 1

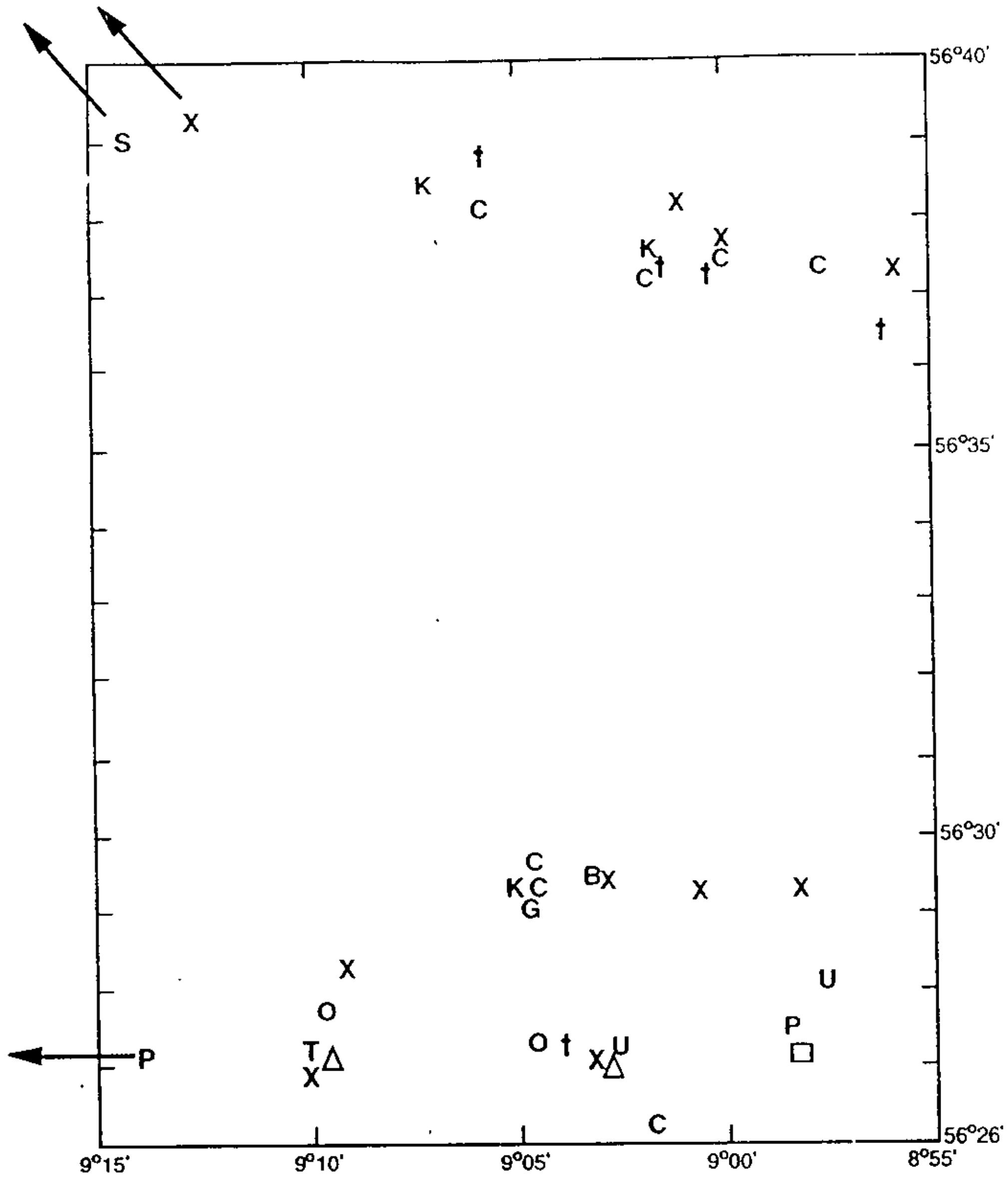
SCALE 1 TO 600000 (.9996 NATURAL SCALE AT C.M.)

C.M. 9W International Spheroid

U.T.M. Zone 29

CD 91 Navigation Swath Tracklines

Fig. B3




Codes:
- □ meteorological buoy
- ↑ uninstrumented spar buoy
- Δ instrumented toroid
- P bottom pressure
- O sub-surface mooring
- S sediment trap mooring
- U U-shaped mooring
- X CTD station with bottle samples
- B box core
- C camera station
- G gravity core
- K Kasten core
- T XBT cast

Fig. B4

# DARWIN CRUISE SES 1

South Section

Deployment from 22 March to mid May 1995

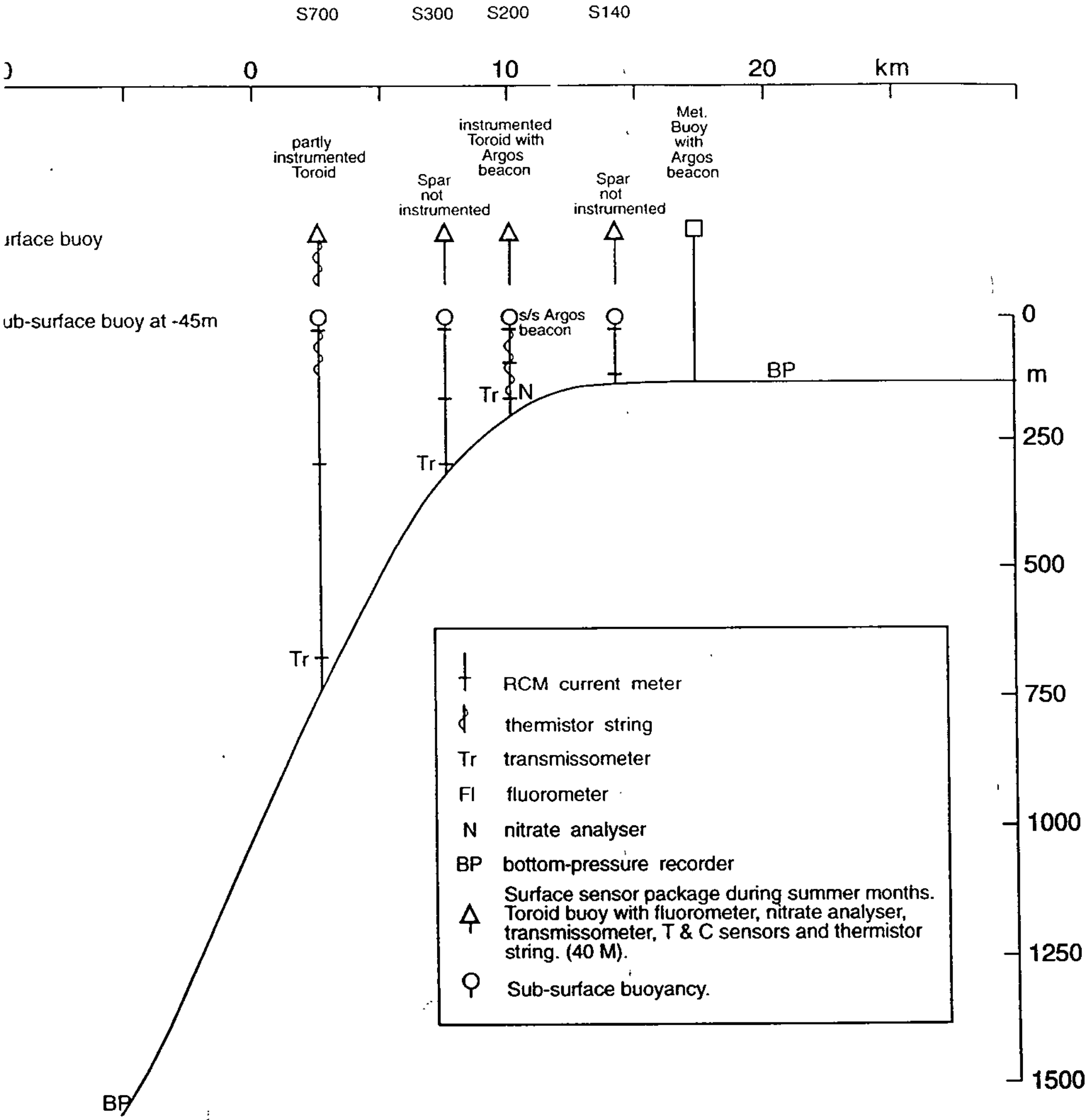



Fig. B5

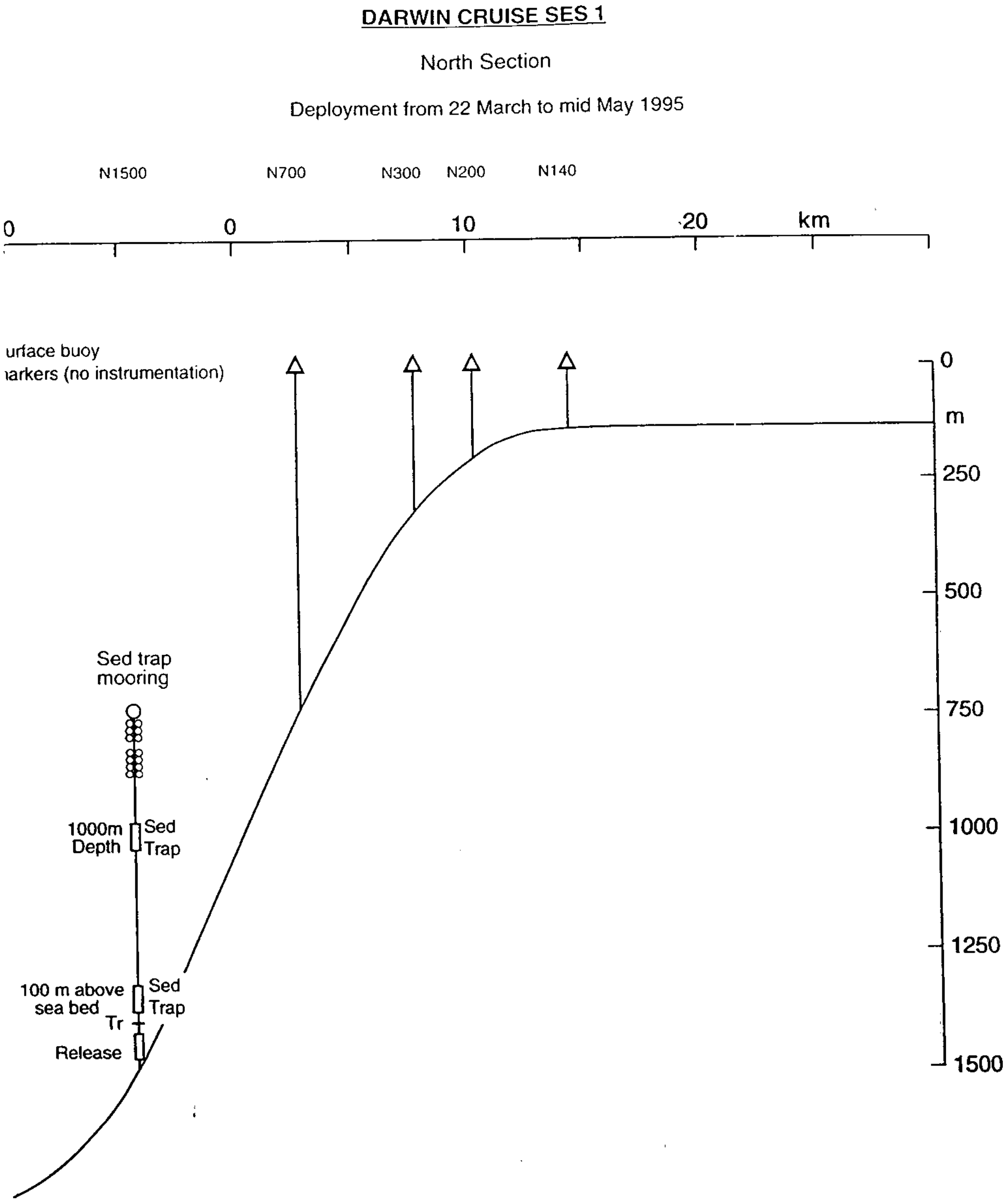

DARWIN CRUISE SES 1
North Section
Deployment from 22 March to mid May 1995
N1500
N700
N300
N200
N140
0
0
10
20
km
urface buoy
arkers (no instrumentation)
0
m
250
500
750
1000
1250
1500
Sed trap
mooring
1000m
Depth
Sed
Trap
100 m above
sea bed
Sed
Trap
Tr
Release

Fig. B6

# DARWIN CRUISE SES1

## S 140 South section mooring

## Deployment from 22 March to mid May '95

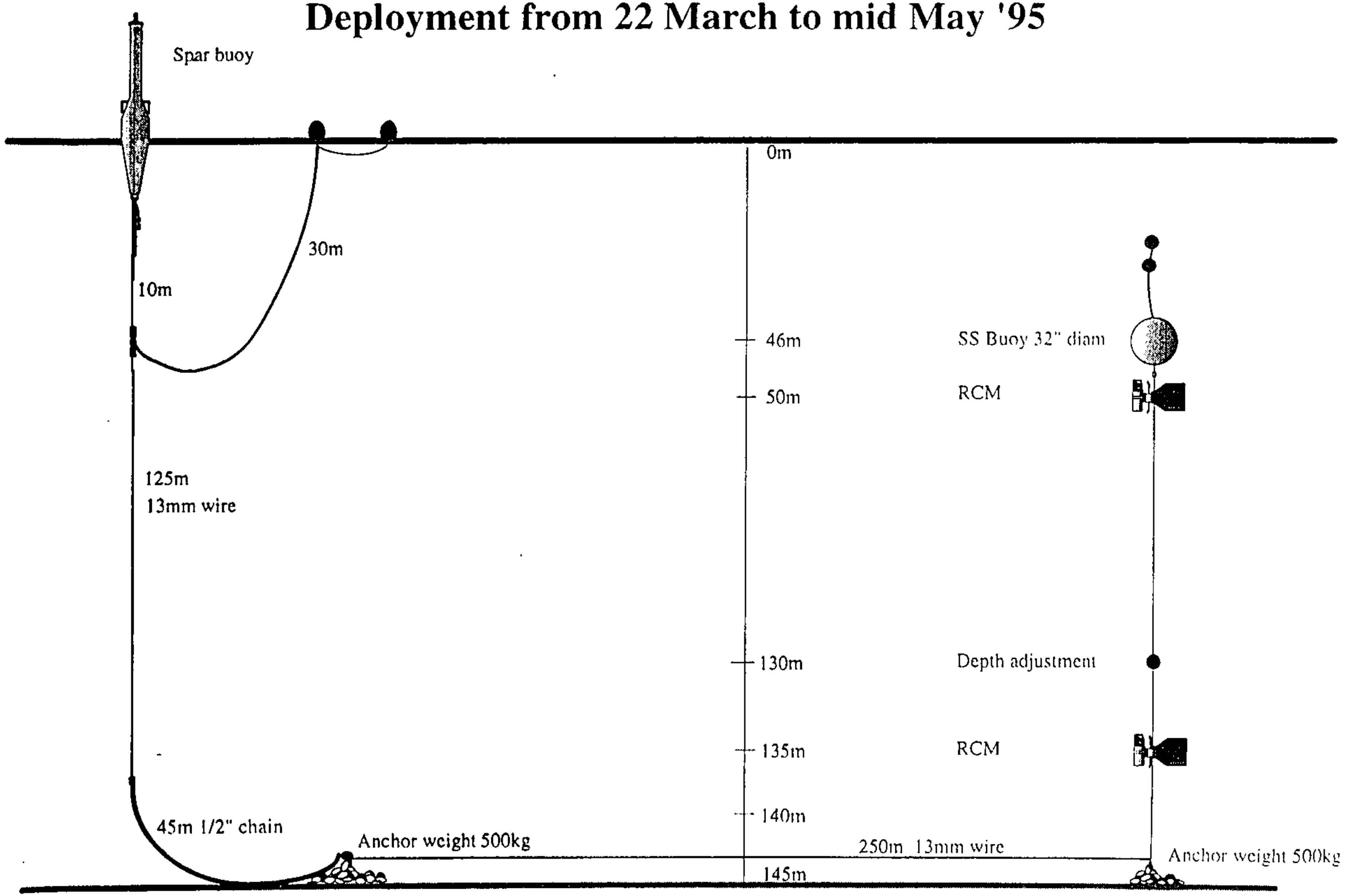



Fig. B7

# DARWIN CRUISE SES1

## S 200 South section mooring
## Deployment from 22 March to mid May '95

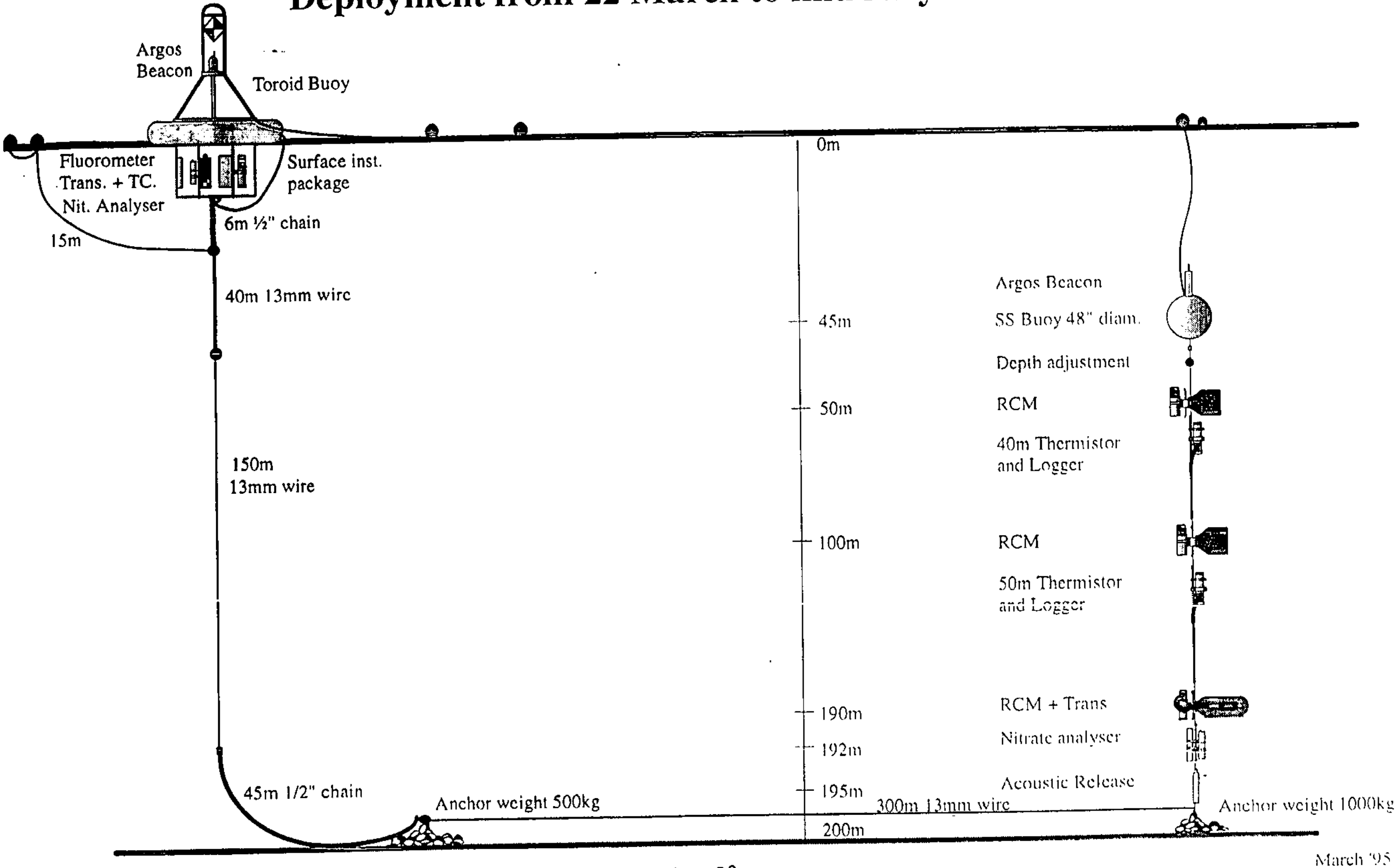
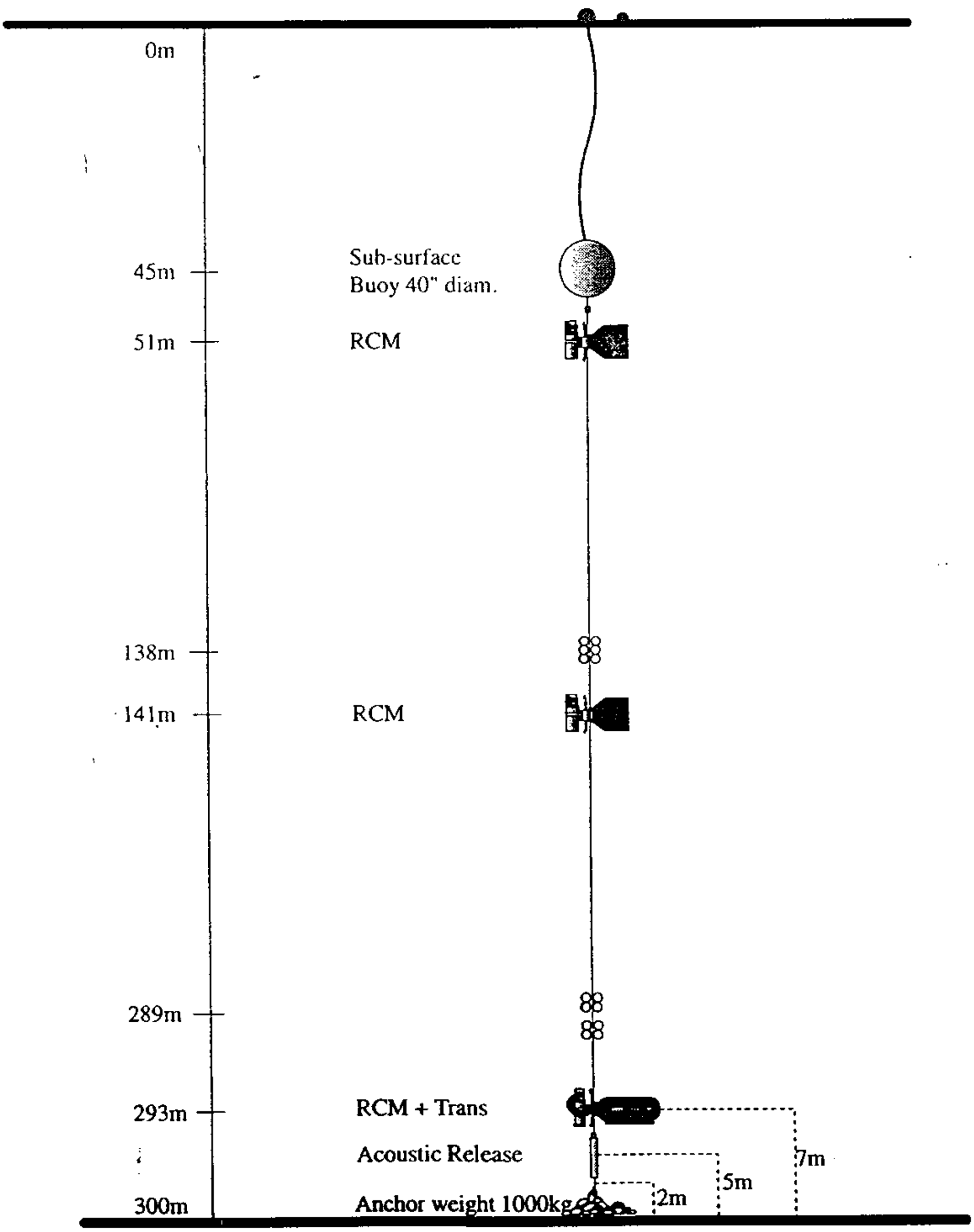



Fig. B8

# DARWIN CRUISE SES1

## S 300 South section. (Sub-surface mooring)
## Deployment from 22 March to mid May '95

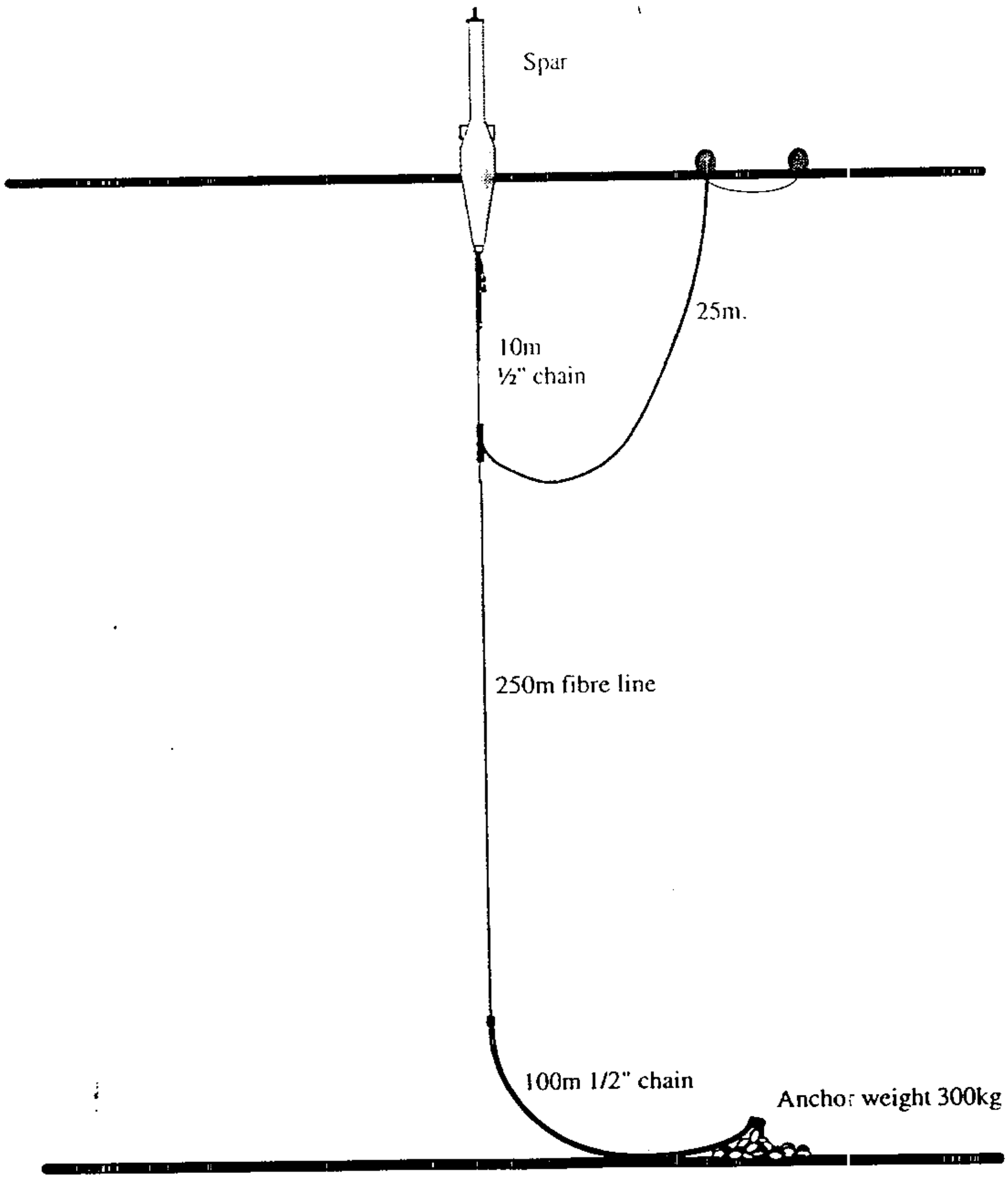



March '95

Fig. B9

# DARWIN CRUISE SES1

## S 300 South section. Surface marker buoy mooring.
## Deployment from 22 March to mid May '95




March '95

Fig. B10

# DARWIN CRUISE SES1

## S 700 South section. (Sub-surface mooring)
## Deployment from 22 March to mid May '95

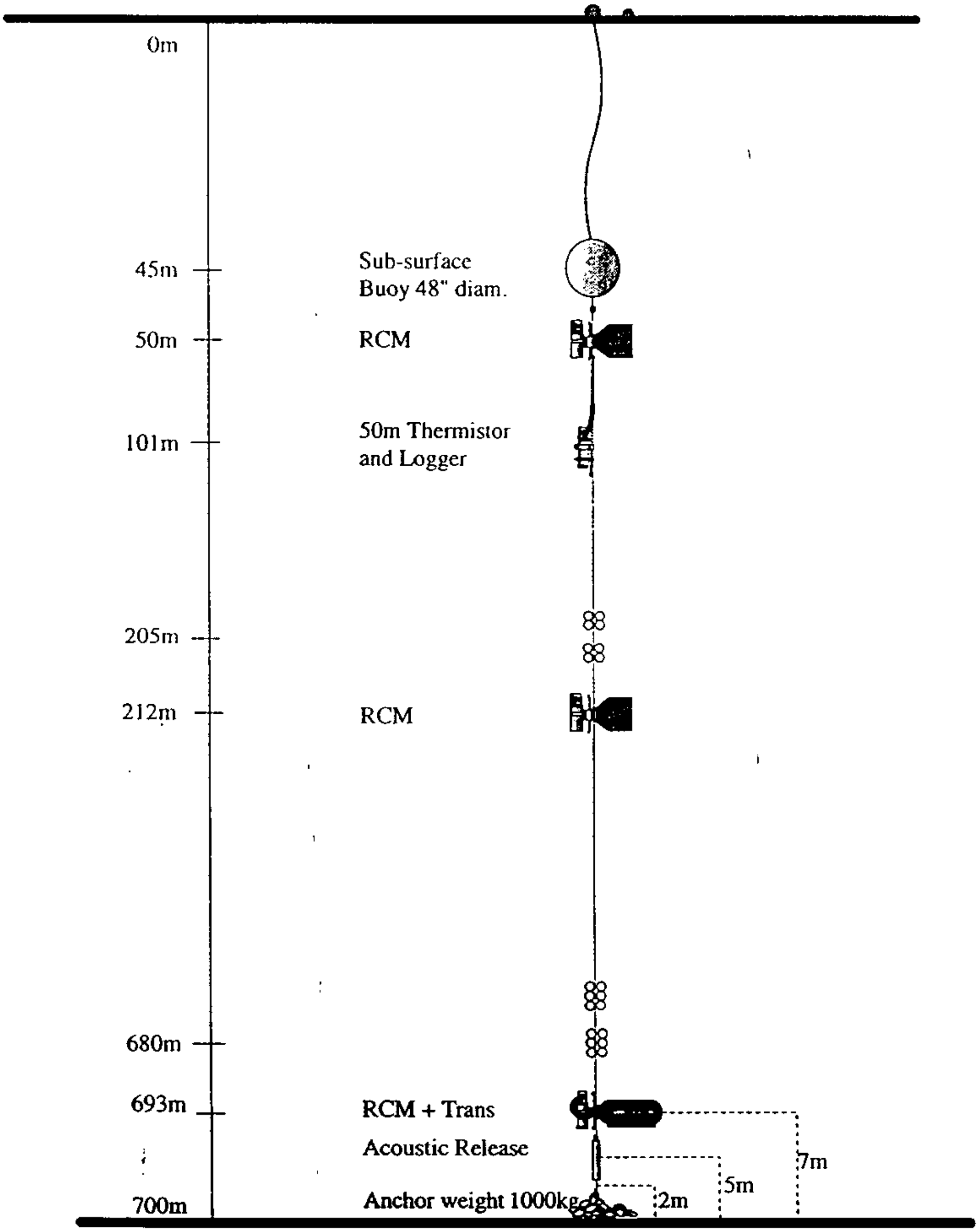
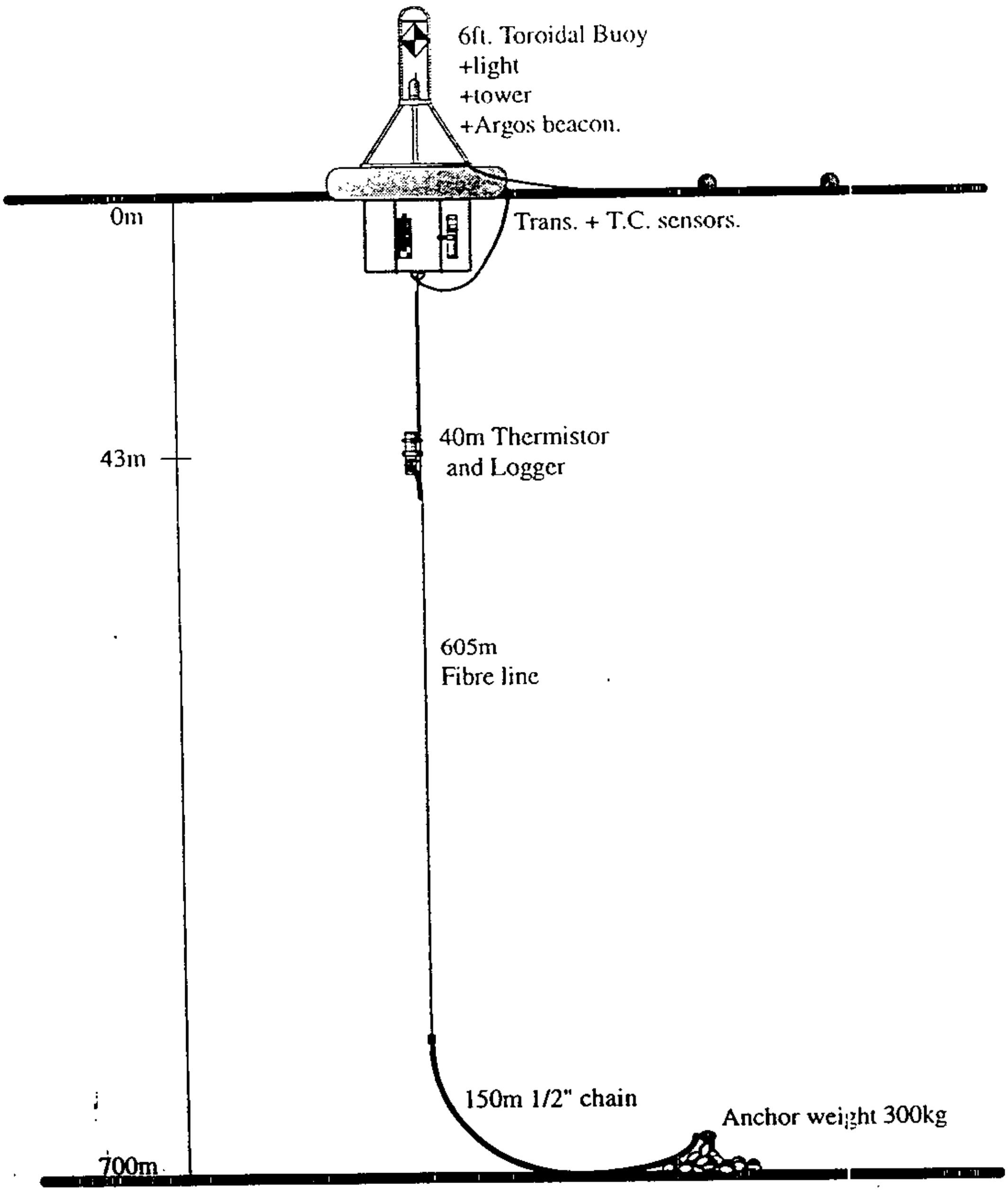



Fig. B11

March '95

# DARWIN CRUISE SES1

## S 700 South section. (Surface buoy mooring) Deployment from 22 March to mid May '95



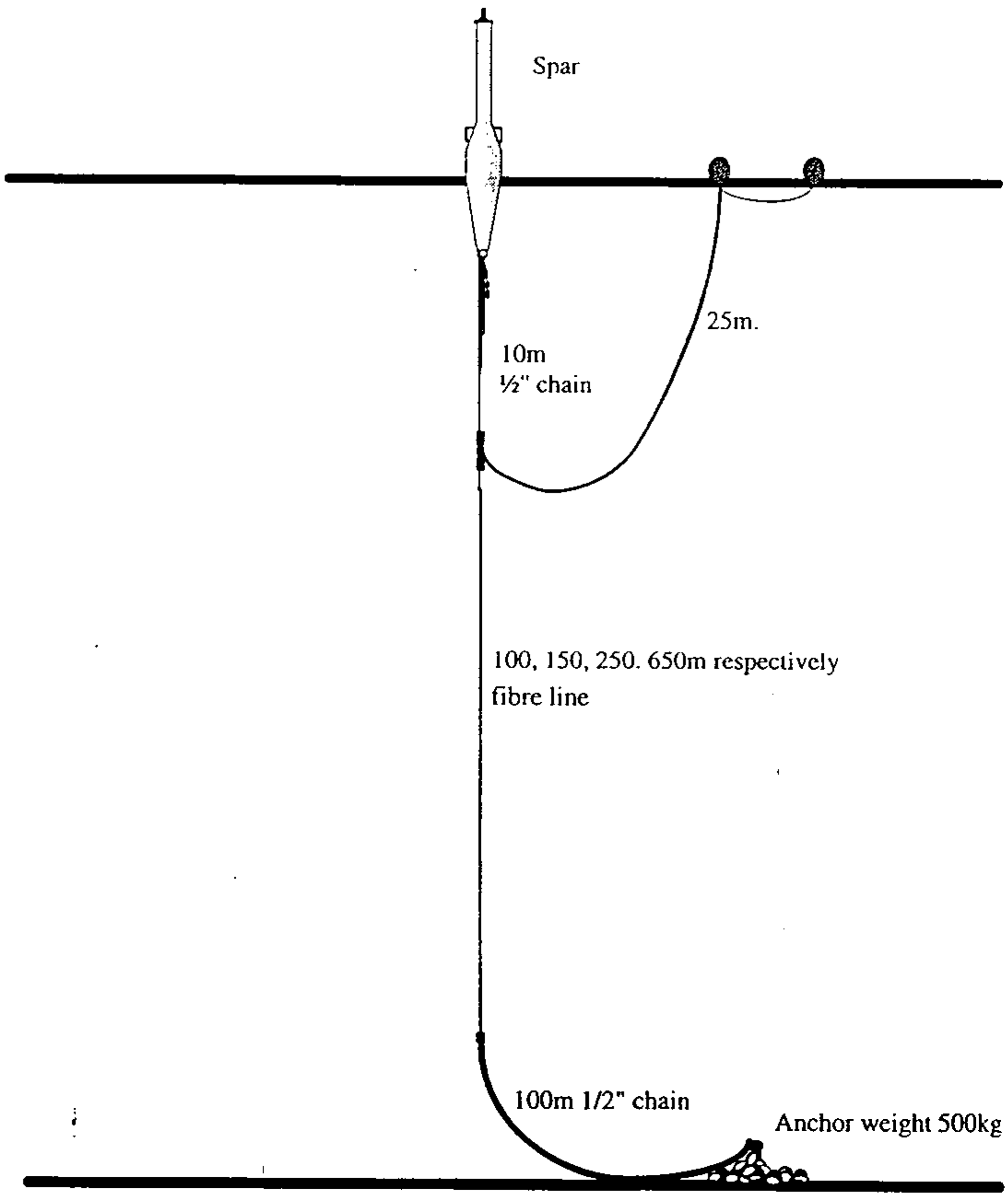

March '95

Fig. B12

# DARWIN CRUISE SES1

## N 140, 200, 300, and 700 North section. Surface marker buoy mooring.

## Deployment from 22 March to mid May '95

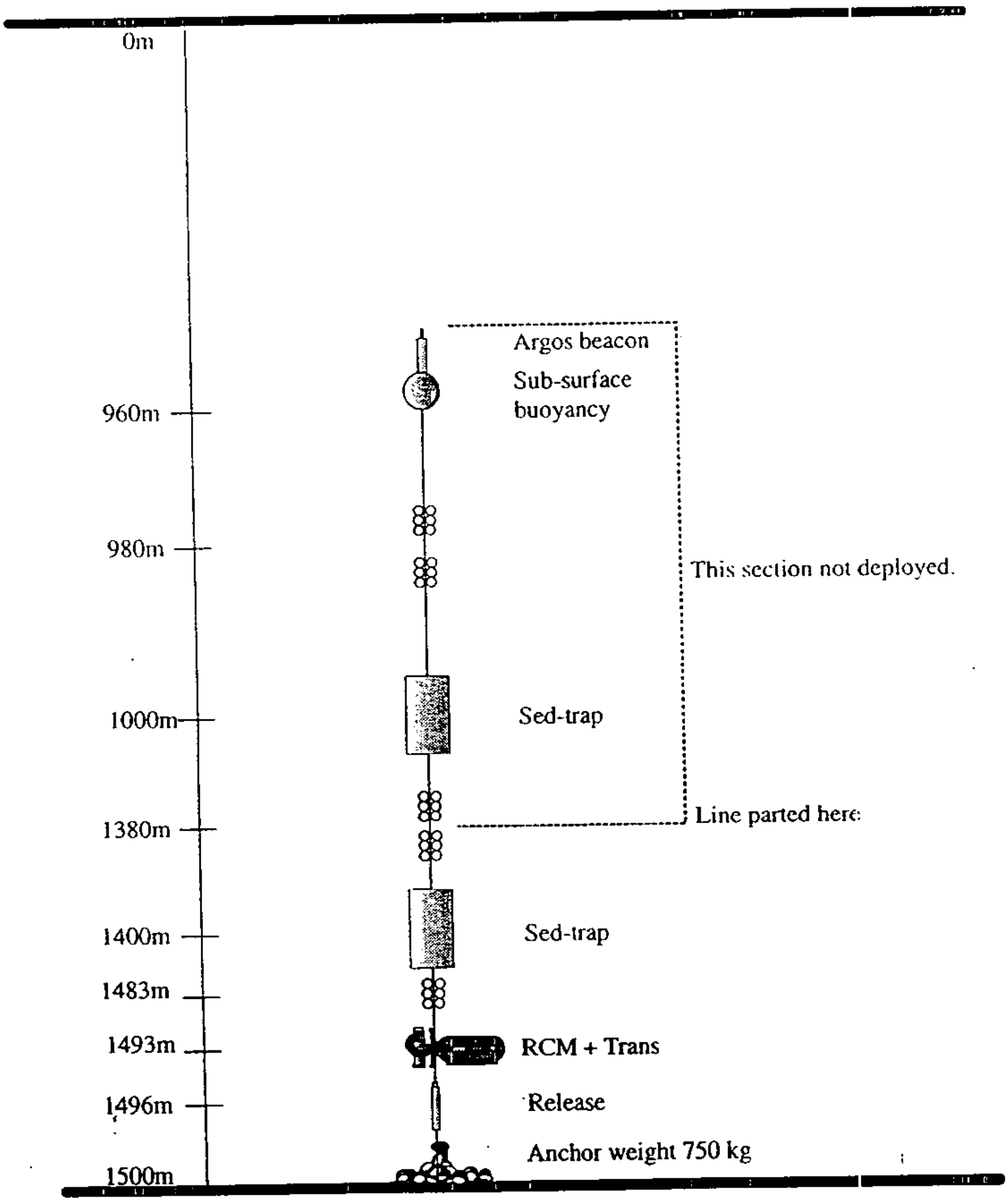



March '95

Fig. B13

# DARWIN CRUISE SES1

## N 1500 North section. (Sub-surface Sed-trap mooring)
## Deployment from 22 March to mid May '95




March '95

Fig. B14