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DEACON LABORATORY

RRS DISCOVERY CRUISE 181

1 APRIL – 1 MAY 1989

CIRCULATION AND STRUCTURE OF THE BAY OF BISCAY AND NORTH EAST ATLANTIC OUT TO 20°W and 41°N

CRUISE REPORT NO. 210

1989

Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY

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Circulation and structure of the Bay of Biscay and north east Atlantic out to 20°W and 41°N

Principal Scientist

R.T. Pollard

1989

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ABSTRACT

RRS Discovery Cruise 181 in April 1989 was the first of two cruises to examine the interannual variability of the ventilating North Atlantic Mode Water north east of the Azores. The second cruise, *RRS Discovery* Cruise 189, is scheduled a year later, in March 1990. After a series of trials, the SeaSoar was operated on four 500 km sections between 17°W and into the Bay of Biscay, revealing major spatial and temporal changes in the upper ocean structure and the development of the spring bloom in late April. A section was also run from 51°30'N to 54°N at 20°W earlier in the bloom development, but crossing two oceanic fronts.

CTD sections to 3500 m were worked along 42°N and 20°W to examine decadel changes compared with previous IOSDL cruises in 1983, 1977, and others. Moorings and drifters were deployed in the Bay of Biscay and along 20°W for R Pingree (PML) and the BOFS programme.

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WARNER, R.	3rd Officer
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DEAN, S	3rd Engineer
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ELLIOTT, C.	Steward
ROBINSON, P.	Steward
SMITH, D.	2nd Steward

SCIENTIFIC OBJECTIVES

The scientific objectives are stated as given in the sailing orders:

1. Quantify the circulation of the Biscay region northeast of 41°N, 20°W with a box of full depth CTD casts at about 75km intervals along the sections. Sampling will include nutrients (nitrates, phosphates and silicates), chlorophyll 'A' and bacterial counts. Vertical net samples will also be taken during selected CTDs for BOFS. (Biogeochemical Ocean Flux Study - to be run during *RRS Discovery* cruises 182, 183 and 184).

2. Conduct SeaSoar trials to test various modifications to the fairing, fish and depressor, designed to improve its performance and increase its maximum depth and duration of tow; also to test improved editing and display software.

3. Run SeaSoar sections within the CTD survey box to quantify variations of the T/S characteristics of newly ventilated winter Mode water.

4. Run a SeaSoar section from 47°N to 60°N along the BOFS line at 20°W to examine the latitudinal variation of mixed layer depth, the horizontal statistics of eddy and frontal activity, and the variability of upper ocean properties (temperature, salinity, oxygen and Chlorophyll 'A')

5. Continuously sample surface parameters to examine the spatial (and temporal) variability of temperature, salinity and fluorescence.

6. Deploy and recover a short term mooring (4 weeks) to observe internal tidal wave propagation off the Celtic shelf.

7. Deploy a two year trial mooring close to 6.

8. Recover two moorings from the shelf edge off the north coast of Spain (deployed in July 1988 to observe the shelf edge current and its variations).

9. Deploy sediment traps at 47°N, 20°W for BOFS.

All these objectives were achieved, except that the SeaSoar section (4) was run from 44-52°N along 17°W rather than the BOFS 20°W line, and one of the two moorings (8) could not be found. An additional objective, to lay a second sediment trap mooring at 60°N, 20°W could not be accomplished because of non-delivery of mooring components.

NARRATIVE

RRS Discovery sailed from Barry, South Wales at 1500/1 after a short delay because of a problem with the bow propeller (all times are GMT and the date is the day of April, i.e. 1st April, 1989. Day numbers are shown on the Track Plot, Figure 1. !st April is day 91. 1st May is day 121). Computer logging of all navigation, GPS, MX1107 satellite navigator and Decca to the newly installed three Sun 3/60 computers was begun immediately, as was relative navigation using the EM log as soon as it was deployed. Logging of the Acoustic Doppler Current Profiler was also started, the data being recorded onto the logging PC's hard disk until transfer of data to the Sun system could be arranged (see ADCP report).

At 0800/2 the Precision Echo Sounder fish was deployed, and at 1000-1100/2 a shallow CTD cast (station 11795) on the shelf was done to check out the system. Several problems with multisampler bottles were found (see CTD report). During over 5 hours of good GPS reception, a series of zigzags with 90° turns every 20 minutes was undertaken (1320-1920/2) to provide calibration data for both the EM log and ADCP (bottom and water track modes). An XBT was launched and the 50-123 kHz echosounder fish borrowed from the Admiralty Research Laboratory was deployed before continuing passage at 2040/2 .

CTDs and wire tests (11796-7) near the shelf edge were carried out from 0127-0700/3 near the site of the first mooring (47°17'N, 6°40'W) but a third CTD and wire test of a new release was necessary (11798, 0830-1128/3) before the mooring could be deployed. The deployment took from 1315-1640/3, and was followed by a survey until 1800/3 to establish that the anchor had fallen nearly vertically after the buoy first, anchor last deployment. By the time the second mooring position was reached at 2150/3, the weather had deteriorated and 35-40 knot winds prevented further work until 0600/4.

The XBT launcher was repaired after the lead from the deck unit had been crushed and broken in severe weather. After being hove-to overnight the vessel steamed back to the mooring position, and a full depth (4640m) CTD and wire test (11799) was done. Despite continuing 30 knot winds, the Master said deployment of the second mooring was possible. The vessel was in position, hove to 4.1 miles downwind of the mooring site at 1358/4, and after laying out all gear on the after deck, deployment buoy first began at 1539/4. The anchor was ready to deploy at 2203/4, but a further three hours of very slow manoeuvering was necessary to find the right depth of water to within 100m. The anchor was finally deployed at 0054/5, after a marathon 11 hour deployment and a final survey of the mooring position was completed at 0156/5.

A CTD section running south along 7°W was then begun. The position of CTD 11800 was chosen to be where the internal tidal ray from the shelf edge should reach the surface after reflecting off the bottom. The multisampler was still misfiring, particularly at depths below 3000m, so CTD 11801 was the last full depth cast. Thereafter, casts were to 3000m (except in shallower water), and later to 3500m. This saved time, but was deep enough to calibrate salinity using the Saunders deep theta/S relation (SAUNDERS, 1986) that holds for potential temperatures less than 3.5°C.

After cast 11802, the SeaSoar was deployed for a short systems trial from 2137/5-0018/6. Conditions were reasonably calm, but several problems were found (see SeaSoar report) with the entirely novel (for *RRS Discovery)* deck arrangement using a small 'A' frame mounted on a flatbed, and a horizontal axis faired cable winch mounted on the extension of the forecastle deck above the after working area. However the winch, borrowed from the Institut fur Meereskunde at Kiel, worked excellently, and was a great improvement over previous systems.

During the SeaSoar run, the weather had worsened with westerly winds gusting to 40 knots, and several hours (0216-0542/6) were spent hove to before CTD 11803. The last few stations of the section were deferred in order to attempt recovery of two shelf edge moorings during daylight. Mooring 118/477 was approached at 1032/6, sighted at 1129/6, grappled and recovered from 1140-1226/6. Master and mooring team deserve commendation for an extremely professional recovery in very difficult (force 7) conditions. Release, sighting, grappling and buoy recovery were rapidly and safely accomplished, which was fortunate as the bow propeller cut out shortly after the buoy was inboard, and personnel on the foredeck were drenched by spray. There was no acoustic sign of the second mooring, despite a three-hour search along the 500m contour, and attempts to fire the release. At 1535/6 the search was abandoned, and *RRS Discovery* steamed north, offshelf and back again until 1800/6 to obtain a section of shelfedge currents while GPS fixes were available. Shallow CTDs 11804-6 in 284m, 1100m and 3700m across the shelf edge to 44°15'N completed the 7°W section.

At 0000/7, course was set to run round Cape Finisterre, completing two CTD casts (11807-8) in deep (over 3000m) water just off the shelf edge at about 40°30'N, 9°W and 43°05'N, 10°W before running into Vigo. The intention was to use these casts, together with deep casts on the 7°W and 42°N section, to calculate the geostrophic offshelf transport round the Cape.

Director IOSDL disembarked at Vigo 0900/8, timed to allow a section to be run across the shelf edge west of Vigo while GPS fixes were available that afternoon. CTDs 11809-11 were made in 174m, 460m and 910m depth, before *RRS Discovery* ran a reciprocal course east from 1535/8 - 1702/8 then west again until 1931/8 to collect ADCP data on the shelf currents.

After this it was at last possible to establish a routine as a CTD section was worked out to 41°30'N, 20°W with casts to 3500m or the bottom at 40n.m. (75km) intervals. The section was a repeat of the section worked on *RRS Discovery* cruises 81 and 132. This section, casts 11812-24, took until 1427/13. Progress was slow, because of persistent 30-40 knot westerlies which slowed the westward passage and caused 27 hours to be lost, hove to in unworkable conditions. However, two trial runs with the SeaSoar (Runs 2 and 3) were possible on 9th and 10th April, on passage between CTD casts 11814-15 and 11818-19. They went smoothly, and yielded very useful test results.

Attempts to calibrate the oxygen sensor on the deep CTD showed that it had aged so much as to be nearly useless, so it was replaced after CTD cast 11820.

The section running westwards was followed by a CTD section running approximately northwards along 20°W the exact line being chosen to duplicate the section worked on Cruise 132 in 1983, so that changes in properties over the five year interval could be quantified. This was also the BOFs section, on which a number of shallow net casts were to be made. A test was accordingly carried out on the electric winch, and it was decided that the nets could not safely be deployed during CTD casts from the midships winch because the drag of the net made fouling on the CTD wire an unacceptable risk.

The section from 41°30'N, 20°W to the BOFs mooring site at 47°58'N, 19°33'W took from 1211/13 to 0945/17, CTD casts 11824-11834. Nets were cast after CTD stations 11825, 27, 29, 31 and 34. Further SeaSoar trials were carried out between stations 11824-25, 11827-28 and 11831-32 (SeaSoar runs 4-6), XBTs were launched underway between most CTD casts, but it was found that XBT deployment during a SeaSoar tow was likely to result in strands of XBT wire wound tightly many times round the SeaSoar cable. This could have caused the fairing to seize on the cable with serious consequences, so the XBT deployments were stopped. During this section severe weather was again encountered, and a further 16 hours were lost.

Work at the BOFS site got off to a bad start when it was found that CTD 11834 (0731-0945/17) had not been logged to the level B and Sun 3/60 computers. However, weather conditions were not quite as bad as forecast, and deployment of the BOFS sediment trap mooring was possible. Preparations took from 0945-1328/17 and the deployment was completed by 1730/17. A 500m CTD cast 11835 followed with samples at 50m intervals, but an attempt to deploy the WP2 net was abandoned after the cod end was lost in the wind. An Argos buoy was deployed from 1911-1929/17 and the deep CTD (11836) was repeated while bathysnap was made ready. Eventually the bathysnap deployment was abandoned because of repeated failure of the flash unit, and passage was set due north to continue the

CTD section at 2355/17. Despite force 7 winds, most of the day's work was accomplished successfully thanks to the competence of all hands.

The CTD section northwards along 19°35'W was continued up to 54°N, where CTD 11845 ended at 0552/21. During this section, XBTs continued to be deployed midway between the CTD casts, which were 40n.m. apart. Argos buoys were deployed after CTD stations 11839, 42 and 44. WP2 and Apstein nets were cast after CTD 11842 and before CTD 11845. It was clear during cast 11842 at 52°N that we were close to or in a front which was of such interest that the SeaSoar was deployed for Run 7 after the cast, and *RRS Discovery* ran back southwards (200°) from 2105-2356/19, before coming round to recross the front and continue on to 54°40'N for CTD 11843. The SeaSoar was redeployed after casts 11843 and 11844 to give continuous coverage from 52-54°N, Runs 7-9. The IOSDL Chelsea Instruments fluorometer was mounted on the SeaSoar for these runs, and showed that productivity was picking up in the surface layers.

The CTD box had to be completed by a section back to Porcupine Bank. Unfortunately, permission to work within 200n.m of Ireland could not be obtained, and the planned section was modified to patch onto a section across the shelf edge that had been worked by Mr D Ellett in early February 1989 on *RRS Discovery* Cruise 180 along 52°N. Casts 11846-48 were made at 40n.m. intervals (from 54°N,19°35'W) along a track 107° , and then CTDs 11849-50 on course 172° ending at 52°N, 16°W.

It was planned to work two final casts westward along 52°N back towards CTD 11842, where the front had been found, thus boxing in the circulation into the Rockall Trough. However, the pump driving the forward ring main that supplies the midships CTD winch failed with 2700m wire out during hauling of cast 11851. It took from 2015/22-0455/23 to determine that no easy solution was possible, make emergency connections to the foredeck Coles crane hydraulics, and recover the CTD. It was not possible to complete the last CTD cast. The fault was traced some days later to an O-ring seal in the pump that was breaking up.

The major CTD survey having been completed, it remained to conduct as extensive a SeaSoar survey as time permitted within the CTD box to examine the spatial variability of the upper ocean T/S relations. The SeaSoar was therefore deployed at 0500/23, but was almost immediately recovered (0527/23), when it was found that the fluorometer had flooded. It was removed, and the SeaSoar redeployed 0638-0701/23 for Run 10. After three hours, the temperature sensor began to drift wildly, and the SeaSoar was recovered again, 1020-1057/23. The platinum resistance thermometer appeared to be in poor shape, so the old shallow CTD was substituted while *RRS Discovery* remained hove to, so as not to break the run south along 17°W. During this time three Apstein net casts were made. The SeaSoar was redeployed 1448-1512/23 and towed south (Run 11) until 2125/23 when the temperature sensor on that CTD failed also. After recovery, passage south at full speed had to be resumed during repair.

After four hours, the new shallow CTD was ready for redeployment with a new, hence uncalibrated, platinum resistance thermometer, and Run 12 began after redeployment from 0200-0227/24, but still without a fluorometer. However, a new Turner Designs fluorometer was on board at the request of PML, so could be fitted after correspondence with RVS to establish the correct connections. SeaSoar recovery commenced at 2050/24, and *RRS Discovery* ran north while the fluorometer was installed, so that Run 13 began without a gap in the section once deployment was completed at 2245/24.

There followed an unbroken run for 3 days 17 hours. Three tracks between 44°N and 47°30'N were run, first south along 17°W until 0013/26 at 44°N, 17°W, then 035° until 0937/27 then 160° until 1540/28 when response became sluggish. On recovery, water was found in the hydraulics and the balance weight was loose. During repairs, the vessel ran a short reciprocal course, so as not to break the section, and hove to from 1717-1800/28, during which time Apstein nets were cast. Passage on the 160° course had to be resumed, and the SeaSoar was redeployed three hours later at 2117/28. The final turn was made at 0009/29 at 43°04'N, 11°W just north of Galicia Bank, and course 036° was set towards the mooring recovery site on the north side of the Bay of Biscay.

On arrival near the northern mooring site at 1421/30, the SeaSoar was recovered, and the mooring was released and retrieved without incident, the operation being completed by 1754/30. A full depth 3290m CTD cast (11854) was done at the mooring site, before passage to the other mooring site, where a 3500m CTD (11855) was done prior to mooring recovery at first light. Shortly after the search for the mooring was begun at 0518/1 May, the buoy was spotted on the surface. It was released and retrieved, with all gear inboard by 1015/1. Examination of the mooring components showed that the mooring line had stretched past its elastic limit, attributable to the long tow in severe weather during the deployment. After passage back to the shallow site, a long-term trial mooring was deployed 1456-1739/1 May.

It was intended to deploy the SeaSoar for a final run near the shelf edge, but there was no conductivity reading when it was deployed at 1820/1, so it was immediately brought inboard again. After a long and delicate operation to repair a carbonfilled lead, the conductivity cell was found to be operable again, against the odds, though the calibration had changed, and the final SeaSoar run began, after deployment, at 0005/2 May. *RRS Discovery* ran west until full control had been established, then turned north to run onto the shelf as far as the 200m contour before turning at 5°/minutes to the southwest to run into deep water again. The vessel then ran west and north as time allowed until the shelf edge was reached and the SeaSoar recovered at 0904/2 May.

The PES fish was recovered at the same time, and passage set towards Barry. When GPS was up, a second series of 20 minute zig zags was run from 1220-1700/2 May to calibrate the EM log and ADCP. *RRS Discovery* docked at Barry on the afternoon tide the following day, Wednesday 3 May, after a scientifically very successful cruise, despite the extended run of severe weather encountered during the first fortnight.

INDIVIDUAL PROJECT REPORTS

CTD Casts

The IOS "new" deep CTD deck unit, and 24 bottle multisampler were used for 57 casts on cruise 181 (Table 1 and Fig 2). This equipment is now about 12 years old and well past its useful working life, it has been accepted for some time that its performance is unreliable, however it continues to do sterling work.

The first deployment brought to light a loose wire inside the underwater unit, an indication of old age, but once this was repaired the CTD underwater unit worked well throughout the remainder of the cruise.

Due to lack of sensitivity, the oxygen sensor was replaced for station 11821. Calibration of the oxygen sensor using water bottle samples still remains a problem as the sensor characteristics are continually changing. It would appear that the oxygen sensors we use are in need of improvement in order to provide the stability required.

With symptoms indicating potential losses in data, the midships cable was remade twice and at the same time the 2 pin Brantner lead between the junction tube and CTD underwater unit was also replaced.

The usual problems arose with the water bottles; broken taps, bad seals, rubbers perished and nylon cords damaged, however, with the spares available it was always possible to have 12 bottles available.

A persistent problem with the multisampler bottle firing indicator signal re-occurred throughout the cruise. On casts deeper than 3000 metres there was sufficient evidence to show a pressure effect on the multisampler return pulse. A possible cause could be pressure distortion on the solenoid mechanism. Bottle firing indication in depths less than 3000 metres caused no problems and the system worked well. Once it had been concluded that indications of a misfire by the deck unit were wrong, 'misfires' were ignored but great care had to be taken with all the samples to determine from what depth they were taken. It is recommended that the unit be returned to the IOS workshop for overhaul and further tests in the pressure vessel.

On station 11851 the winch was accidently tripped, by the operation of the emergency switch on the console, and failed to restart on reset. This left the CTD suspended at 2726 metres until it was later recovered using the Coles crane hydraulic unit. The winch hydraulic system was repaired.

Three sets of water bottles were taken on the cruise: twelve 1.1 litre Niskin bottles, twelve 1.7 litre Niskin bottles and six 2.5 litre Go-Flow bottles. The 1.1 litre bottles were only used twice for test purposes as the volume was too small for the amount of water required for samples. Also they do not have the necessary supports for thermometer housings. Despite their age they worked well as they have been relatively little used and are in good condition. The 1.7 litre Niskin bottles are the standard Marine Physics sampling bottles, during the first few casts various alterations and repairs had to be made because of poor seals, broken thermometer supports, broken lanyards, & etc. It was noticed that all the rubber seals and strops had perished badly and need replacing. The 2.5 litre Go-Flow bottles were donated to IOS by Southampton University Department of Oceanography, but had no taps. New taps were made and fitted at the beginning of the cruise. The bottles were used for several BOFS CTD casts along the line 20°W for the large volume of water required for biological sampling. The bottles only fitted in certain locations around the rosette because of the supporting framework so had to be interspersed with 1.7 litre bottles. Some difficulty was encountered during the first week of the cruise as none of these bottles had been used on the 24 bottle rosette. This caused a variety of 'hang-ups' until the correct method of rigging the lanyards was established.

Two RVS digital reversing thermometers were used for temperature calibration (Model RTM4002, manufactured by SIS, serial nos 213 and 219).

No. 213 worked well throughout the cruise and was much easier to use than the traditional mercury reversing thermometers. However no. 219 gave problems after the first few days as it failed to display the 'HOLD' message and part of the last digit. After a week it was showing only one decimal place instead of three and flashing '1' intermittently. At first it was thought that the batteries might be drained but swapping the batteries for those of no. 213 made no difference, while no. 213 continued to work correctly. Eventually (9 April) the thermometer was replaced by IOS mercury thermometers. The location of thermometers on the 24 bottle rosette was restricted by the supporting framework.

The bottles were sampled for oxygen, nutrients and chlorophyll 'A' and for salinity. Water was also drawn from selected casts along 20°W for POC (particulate organic carbon), PON (particulate organic nitrogen), phytoplankton (lugol) and zooplankton (formalin) samples.

Salinity samples were drawn from the CTD bottles and from the thermosalinograph non-toxic supply. Over 700 samples were analysed using the Guildline Autosal salinometer. This worked well after some initial problems when one of the pumps and the pump switch had to be replaced. The results were used to calibrate the deep CTD, and the shallow (SeaSoar) CTD salinity data.

Samples were drawn from the CTD bottles for analysis of the dissolved oxygen content. They were titrated using equipment provided by UCNW Bangor. Duplicate samples were drawn on eight casts for analysis on the Marine Physics unit to compare the two systems.

TJPG, JFR, RH

SeaSoar

Due to problems with the IOS SeaSoar vertical drum winch an alternative unit was found by RVS for this cruise. The replacement was loaned by The Institut fur Meereskunde at the University of Kiel. The winch had a horizontal drum with an auto-spooling mechanism and fairing guide assembly. Electrically powered and incorporating a hydraulic speed control system it had many features that should be used on any future IOS replacement.

The winch was mounted on a container bed on the port side of the chemistry lab deck with the cable leading directly to the new IOS block on the 'A' frame. The 'A' frame, ex RRS Shackleton, was mounted on a container bed situated on the port side of the ship's stern. The block could be raised and lowered by a hydraulically activated winch mounted on the inboard end of the container bed.

With the combination of winch and 'A' frame the deployment and recovery operations went smoothly and were a great improvement over the labour intensive procedures using the IOS winch.

The SeaSoar operations (Table 2, Fig 3) were divided into two phases. The first, covering the initial six deployments, was used to collect data on the hydrodynamic qualities of the SeaSoar underwater system when performing various manoeuvres. The primary object in collecting this data is to find ways in which the vehicle performance can be improved to increase the depth capability. In order to assess the vehicle characteristics, small modifications had to be made to incorporate the sensors, electronic sampling and RS423 transmission unit. Vehicle parameters measured were pitch/roll/wing angle, bridle angle/propeller revolutions and vehicle strain on the cable. The sensor outputs were multiplexed and sampled at 50 frames per second and transmitted up the cable at 4800 baud. The shipboard equipment consisted of a demultiplexer and an IBM PS/2 with a data analogue voltage acquisition card/hard disc and tape streamer. As well as the underwater signals; pressure, command and cable strain data from the shipboard equipment were also collected and logged. The first deployment of the SeaSoar, Run 1, mainly used to reveal 'bugs' in the system, again highlighted the age of the deck unit. The digital-to-analogue convertor failed to produce a pressure signal required to operate the vehicle servo system. The sensor and telemetry system worked without failure for all deployments. Early assessments of the data have provided interesting insights of the vehicle's 'flight' characteristics that were previously unknown and also indicate that the 400m depth capability can be achieved.

The second phase, Runs 7 to 15 inclusive, was primarily for the collection of CTD and fluorometer data for the physical oceanographers. Because of the inclusion of the fluorometer, the sensors and telemetry equipment had to be removed precluding any further collection of SeaSoar vehicle dynamic data.

During Runs 7, 8 and 9, the IOS fluorometer was installed and provided satisfactory data. However on deployment for Run 10 problems arose with the signal and on recovery the unit was found to be flooded. A backup PML/RVS unit was then deployed which gave a far stronger signal, with less scatter, than the IOS unit had produced on previous runs. On Run 10 problems with the temperature data arose and on inspection the platinium resistance thermometer (PRT) was found to be corroded. The second CTD unit was then deployed but the temperature data were again corrupted. On recovery the CTD was replaced with the original unit and a new PRT.

Run 13 was terminated after losing 'flying' control of the vehicle. Initially this was thought to be a hydraulic unit problem but workshop checks proved this unit as satisfactory. However, the ballast weight underneath the vehicle had partially come away from its mountings and this could very well have been the reason for the observed instability.

Run 14 was another successful run and was terminated for the recovery of the mooring near the shelf edge.

Run 15 ran into problems from the start when during deployment it was found that the conductivity cell was not working. The problem was found to be an open circuit in one of the leads of the conductivity cell connector. Unfortunately this was found to be a carbon filled conductor. With the vital assistance of an expert lace maker, a little instant glue and araldite the lead was repaired and Run 15 was completed.

TJPG, DG, HL

XBT Casts

The IOSDL XBT system was used successfully on this cruise once a faulty connection had been repaired. In all, there were 35 XBT launches using T7 probes supplied by the Hydrographic Office, MOD, and these provided temperature information over, typically, the top 700m of the water column (for the T7 probes) in between the CTD stations, thus improving the horizontal resolution of the various physical structures. The salient features of the profiles obtained (ie the turning points of temperature viewed as a function of depth, or "breakpoints") were entered into the SUN computer system and contoured to supplement the CTD transects.

An attempt was made to deploy XBT's during SeaSoar tows, but it was found that the XBT wire frequently fouled the SeaSoar cable, taking many tight turns around it. This formed a knot which could have prevented the fairing from turning freely, with possibly serious consequences.

The Marine Physics hand held XBT launcher is on its last legs, and after damage during the cruise, ended up more araldite than plaster. A new unit is urgently needed.

Twice daily, XBT messages were relayed (by telex) both to the Meteorological Office at Bracknell and to the Fleet Weather and Oceanographic Centre at Northwood. The messages consisted of the temperatures and depths of the breakpoints, in coded form, together with other supplementary information (eg positional and meteorological).

IW, ALN, JBN

Moorings

Two thermistor chain/current meter moorings were deployed on *RRS Discovery* Cruise 181 to examine the generation and propagation of internal tidal energy from the continental shelf-break of the Celtic and Armorican shelf. Profiles of Brunt Vaisala frequency (stations CTD11796, CTD11797) showed that even under conditions of winter mixing the bottom slope matched the internal tidal characteristic on the upper slope at a critical depth of about 380m where a minimum occurred in stability frequency. This minimum value of Brunt Vaisala frequency of about 1cph was widespread throughout the cruise survey area and occurred on the sigmat = 27.17 isopycnal and represents the local mode water. Large internal tides are expected at the critical depth resulting in ray-like propagation of internal tidal energy into the ocean interior. Mooring 120/483 was positioned about 20km from the critical slope and the instrumentation on the mooring was designed to span the main beam of internal tidal energy emanating from the upper slopes at a depth of about 1200m. Mooring 121/484 was positioned about 95km from the critical slope where the beam is predicted to be again at about 1200m after its first reflection from the sea floor. These depths were chosen so that the thermistors on the moorings would be in a region of maximum temperature gradients and below the generally isothermal region of the Mediterranean water.

Mooring 122/486 was a longterm test rig and deployed on the Armorican slopes to investigate seasonality in the slope currents and internal tides.

Moorings 118/477 and 119/478 had been deployed on Challenger Cruise 31/88. These longterm moorings were designed to examine the slope current along the northern Spanish slopes and extend the slope current measurements already made along the Armorican and Celtic slopes.

Mooring deck preparations were carried out using ships fitted equipment and RVS fitted SeaSoar handling gear. Deployments were carried out aft, buoy first, recoveries from the foredeck. Handling all the hardware was straight forward and all systems performed well.

Mooring details are summarized in Table 4.

Comments on mooring operations are in chronological order;

Deployment of mooring 120 PML, 483 IOSDL

This mooring was deployed as part of a continuing investigation of internal tides and ray propagation. The mooring was designed to a specification from Dr R Pingree and utilized the subsurface "pop up" buoy technique.

Deployment was buoy first from the aft deck using the ship's capstan to pay out the mooring line over a wide throat sheave fitted to the SeaSoar handling 'A' frame via a diverter sheave to obtain a good lead. Instrumentation was inserted into the line by stopping off at shackle joints using a 13mm chain across the 'A' frame with Boss hooks to clip on. Thermistor strings were attached to the line by plastic cable ties at approximately 5m intervals. Anchor deployment was free fall from 2m beneath the surface by slip rope.

Deployment of mooring 121 PML, 484 IOSDL

This mooring was deployed as 120 above. Instrumentation was connected with Boss snap type stainless hooks to reduce connecting time. This proved very successful and is to be introduced into all "short term" moorings where applicable. Glass sphere buoyancy was inserted into the line to improve mooring stiffness and to help reduce loads during deployment.

Recovery of mooring 118 PML, 477 IOSDL

This mooring had been deployed from RRS Challenger Cruise 31/88, 06/07/88. (Pingree, Waddington.)

Recovery was initiated by acoustic command to release the anchor. The subsurface buoys were observed at the sea surface and the ship manoeuvered alongside to permit grappling by thrown line. The mooring was recovered by double barrel capstan and 'A' frame onto the fore deck. The line was measured using the metre sheave. Mooring components were in good condition, however the current meter stainless steel spindles were exhibiting signs of crevice corrosion at the fork ends.

Attempted recovery of mooring 119 PML, 478 IOSDL

This mooring had been deployed as 118 above but could not be relocated acoustically. A search pattern was initiated with no contact. The site was abandoned after attempting acoustic release.

Deployment of mooring BOFS 1, 485 IOSDL

This mooring was designed to BOFS specification and was deployed buoy first from the aft system. The deployment went very well with the Parflux traps being easily handled under the 'A' frame.

The mooring line used in this design was of Paraline, a parallel fibre polyester within a braided polyester outer jacket. End terminations were spliced on steel eyes and coated with a urethane finish to cover the eye and splice. These lines were stiff to handle but could be freely paid out around the ships capstan. Glass sphere buoyancy was inserted in the mooring line to provide buoyancy should the steel sphere fail and positioned as an aid to deployment. The Parflux traps specification indicated a water weight of 55kg but when handled on deck this appeared excessive. To check this a trap was floated off the stern buoyed up by a series of 8kg buoyancy floats and observed. Three floats sank indicating a water weight of 24kg. The mooring buoyancy was reduced to compensate for this. The anchor was free fall from a slip rope over the stern and was fitted with a Carew parachute to reduce descent speed.

Mooring recovery 120 PML, 483 IOSDL

Deployed as above. The mooring was relocated acoustically and released from the anchor. It was recovered using the fore deck system. Mooring lines measured using the metre sheave indicated more stretch than calculated in the newly purchased lines and also in prestretched line. This could be attributed to towing the mooring during deployment causing excess stretch loading of the line. All mooring hardware was in excellent condition.

Mooring recovery 121 PML, 484 IOSDL

Deployed as above. The mooring was relocated acoustically and by eye as the steel sphere was on the surface. The anchor was released and the mooring recovered on the fore deck system. All mooring lines were measured on the metre sheave to determine the line length. This indicated stretch on a majority of the line lengths greater than calculated stretch. This could be as 120 PML above, further investigation at IOSDL is to be carried out.

Mooring deployment 486 IOSDL

This mooring is the prototype for two year duration moorings and incorporates much of the one year mooring technology supplemented with improved components at points of possible weakness, such as crevice corrosion, abrasion. The deployment was buoy first aft using the Auxiliary winch for the jacketted steel wire with the capstan for the fibre line. The anchor was free fall over the stern using a slip line. A small Carew parachute was fitted to reduce descent rate.

Acknowledgements for assistance to Martin Harrison CPOD, "Lofty" Walker POD, Jim Carew and all other crew members who assisted with the successful deck operations.

Mooring Instrumentation

Aanderaa current meter and temperature profiler records were all decoded to diskette using the P3059 program onboard. All instrumentation appears to have run full data as shown in Table 5.

RDP, IW, KMG

Argos Drifting Buoys

Four METOCEAN Argos satellite tracked drifting buoys were deployed on behalf of BOFS on the BOFS 20°W meridian. All buoys were equipped with platform sensors measuring atmospheric pressure, wind speed, sea surface temperature, air temperature and battery voltage. These buoys were air freighted to RVS Barry and uncrated and assembled one day prior to the start of *RRS Discovery* Cruise 181. The buoys had an overall length of 3.5m and weighed 95kg.

The drogues consisted of trawl netting which was coiled and sewn. These were 16m long and weighed about 100kg, but were neutrally buoyant in sea water. A Balmoral polo with buoyancy of 8.5 kg was inserted into the tip of each drogue to compensate for the progressive increase in weight due to prolonged immersion. Although the drogues were slack and loose when on deck they extended into a tubular column when deployed. The net pulldown on the Argos buoy at the tether lug was 50kg and this was provided by 6m of $^5/_8$" chain below the buoy, the bridles for the drogue and 3m of $^1/_2$" chain and a Bruce anchor below the drogue. The drogues were set at 70m and details of each deployment and measured values for the calibration of the sensors at the time of release are listed in table 6.

Buoy 3907 was deployed after station CTD11835 on the sigmat = 27.14 surface isopycnal in the BOFS BIOTRANS region and moved in a clockwise sense with a period of about 12 days and speed of about 15cm/s.

Buoy 3909 was deployed after station CTD11839 on the sigmat = 27.17 isopycnal, the local mode water. After moving northeast at a speed of 30 cm/s for 5 days the buoy moved in an anticlockwise sense with a period of about 5 days and mean speed of about 15cm/s.

Buoy 3906 was deployed after station CTD11842 at the start of the polar front where the sigmat value was 27.22. The buoy moved 25km eastnortheast in just over 8 days (about 30cm/s).

Buoy 3908 was deployed at the northern end of the '20W' line on the southern flank of Lorien Bank, after station CTD11844. The buoy moved slowly (<10cm/s) westnorthwest.

RDP, IW

Hydrography and Plankton Sampling

Continuous measurements of temperature, salinity (STD), chlorophyll fluorescence (Turner Designs Fluorometer), light transmission (Sea Tech 660nm), surface irradiance (PAR sensor) and inorganic nutrients (phosphate, silicate, nitrate and nitrite : Technicon AA II System) were maintained along the cruise track, using the ships non toxic water supply (intake depth 3-4m). Calibration of the STD was effected by comparison with surface salinity samples and surface CTD data. Additional data were obtained from SeaSoar tows.

About 700 fluorometric determinations of chlorophyll 'A' were made during the cruise together with more than 200 samples for particulate organic carbon and nitrogen. Samples for phytoplankton species identification counts were preserved in both lugols iodine and neutralized formalin at regular surface intervals and also at CTD stations. Zooplankton samples were obtained by vertical hauls of a single WP2 net (200μm mesh) from 100m to the surface. Due to the prevailing weather conditions during the first half of the cruise, only seven stations were sampled (Table 7). At station 11835 (47°58'N, 19°32'W) 12 samples for microplankton were taken at depths from 5m - 35m.

At about 50 CTD stations, from 12 standard depths (in conjunction with BOFS sampling programme) samples were either taken or analyses made for chlorophyll, inorganic nutrients, transmittance (Sea Tech 1m transmissometer), particulate organic carbon and nitrogen and preserved samples for species counts in both lugols iodine and neutralized formalin. Vertical oxygen distribution was investigated using the CTD system equipped with a Beckman polarographic dissolved oxygen sensor. The electrode was calibrated by analysis of water samples from 12 depths using the CTD rosette system (either 1.7l Niskins or 2.5l Goflos). Water samples were routinely collected at the oxygen minimum and at depths to 3500m. Near surface samples were analysed for chlorophyll 'A', particulate organic carbon and nitrogen, salinity and for preserved phytoplankton on each cast (nontoxic seawater system).

Surface chlorophyll values were generally low, 0.5mg/m^3 or less except for the return legs from 12°W where chlorophyll values increased to levels of greater than 3.5mg/m^3 on approaching the shelf together with a reduction in nitrate levels to less than 0.5μm. In the same area a subsurface maximum of fluorescence was observed during the day on SeaSoar runs. This feature was greatly exaggerated due to strong inhibition by light of phytoplankton fluorescence in the surface water.

All surface measurements were logged on chart records, the MBA 749 data logging system and the level A of the ship's computing system. Owing to the large number of samples taken, much of the data still has to be worked up. Most of the analyses of samples and data should be completed within 3 - 4 months with the longest delays likely to be with the phytoplankton counts.

Notes on equipment:

1. Autoanalyser System - Problems were encountered with the chart recorder when the drive pinion failed. Thanks are due to the RVS personnel for effecting a temporary repair which lasted until the end of the cruise. Three of the stream dividers in the

analytical system failed due to corrosion because of the extended use of the system. This necessitated finishing the cruise with only two of the four channels functional.

2. The nontoxic seawater system - This supply was used for both the surface measurements and for washing down of nets. The flow was considered to be inadequate producing a flow of less than 1 litre/minute through the fluorometer. When nets were washed, enhanced fluorescence was observed on the Turner Designs fluorometer probably due to air being introduced into the system.

RH, RDP

Notes on BOFS work

BOFS Particle flux measurements

The intention was to deploy two moorings of sediment traps during the cruise along the 20°N BOFS transect. One was to be at approximately 48°N and the other at approximately 59°30'N. Each mooring was to carry three Parflux traps and one IOS trap. However, the mooring line was not delivered to RVS in time for the cruise, and the backup line failed a strain test. It was therefore only possible to set the southern mooring, and consequently *RRS Discovery* only worked the 20°W section up to 54°N. Due to poor weather at the southern site, only Parflux traps could be used, an additional Parflux replacing the IOS trap. It is intended that the northern mooring will be deployed on cruise 182 and that both will be recovered and redeployed on cruise 184.

The protocol adopted for these traps was within the framework of the JGOFS recommendations. Parflux traps have 13 sampling cups and these were set to sample for 7 days each, moving to the next cup at 1200h on Sundays. The preservative in each cup was prepared using previously collected deep water. A saline concentrate was added to this water to provide a solution of salinity 2ppt above ambient and formalin at about 4% (to be determined accurately later).

A number of problems were encountered using these traps, this being their first deployment by a UK ship.

1. Software would not "wake up" on command and no McLane menu could be obtained on interrogation of unit 520. Solution: Open up pressure case, remove both main and 9v batteries, wait for one minute and then reconnect main battery followed by 9v battery.

2. Carousel of unit 525 would not move for bottle filling. The unit worked well during test movements on 3/4/89 but after checking out on 17/4/89 the carousel would not turn for bottle filling. The problem has not so far been diagnosed.

3. Leakage of trap cup solution. In spite of hand tightening sample cups onto the carousel before topping up, most leaked beside the cup threads so that some had large air bubbles in them as they were deployed. Three possible solutions are to use a strap wrench to tighten them further, to wrap the threads in PTFE tape before tightening, or to use polypropylene (PP) bottles instead of high density polyethylene (HDPE).

4. Most of the traps were supplied with PP trap cups as opposed to HDPE as requested. Sufficient spare HDPE cups were fortunately available for the deployment. A complete set of spare cups should in future be taken at 15 per trap.

5. Sharp edges on Ti angle of trap frame were a hazard during handling. These should be filed down prior to cruise.

6. Bolts loose. Most of those holding the carousel were loose on arrival. Before deployment threads should be treated with locking compound (eg Hylo-medium strength).

7. Due to the pressure on ship time and the absence of large volume rosette bottles on the CTD, water from the trap depths was accumulated over the few days prior to the deployment. However, due to CTD problems it was discovered only retrospectively that the actual depths of the samples were often considerably below the stated depth. There was insufficient time to take alternative samples when the error was made known.

BOFS Bathysnap

Two bathysnap modules were prepared for deployment at the BOFS sites. The northern site could not be reached due to weather and gear problems early in the cruise. It was also not possible to make a deployment at the southern site. In spite of satisfactory performance in the laboratory, electronic problems developed on deck preventing deployment in the allocated time. Both camera and flash units were found to contain faults. It is hoped that both bathysnaps will be deployed on cruise 182 after overhaul during the port call.

BOFS Microplankton Net Sampling

Strong winds and severe weather prevented the collection of fine net samples at the 48°N BOFS site using the Apstein net (20µm mesh). Samples were however collected at four other stations using horizons of 600-200m, 200-100m, 100-50m and 50-0m. These will be analysed particularly with respect to the types of material found in the sediment trap samples.

BOFS Microbiology

Water was collected from all the rosette samples at the southern BOFS site for study of the suspended bacterial flora. 50ml samples were fixed in 2% gluteraldehyde or 2% formalin and the former samples were then stained with DAPI. A 5ml subsample was then filtered (0.2µm) and the filters frozen in the dark. These will be examined microscopically using fluorescent techniques.

RSL

Acoustic Doppler Current Profiler

Two main configurations were set up and used for this cruise: alnshelf, having 64 x 8 m bins and bottom tracking for work in shallow water (ie less than about 600 m deep), giving typically 60 pings per ensemble; and alnocean, having 64 x 8 m bins and no bottom tracking, for deeper water, giving 120 pings per ensemble on average. The ADCP software was version 2.34.

Data were transferred to the RVS system by writing to floppy discs on the IBM PC, reading these into hard disk on a PS2 PC, and then transferring to the RVS SUN workstation acting as a "level C" computer. The data were processed on the user's SUN with the PEXEC system. Due to problems with decoding the data output by the ADCP software, real variables, such as the ship's heading and surface temperature, could not be transferred. All velocity information, however, was successfully decoded and could be quickly processed and contoured using macro commands on the SUN. Merging of all navigational data was also performed on the SUN computers.

The ship's heading was input directly into the ADCP from the master Sperry gyro in the gravimeter room, and tests (averages over 2 minute periods) showed an agreement to within ±0.5°. Also, the ADCP time was reset daily (ADCP clock typically 20-30 seconds slow after 24 h) by using the 'time' command from dos.

Two calibrations of the ADCP were performed, at the beginning and the end of the cruise, in periods of GPS on the shelf. These gave mean scaling factors of 1.06 and 1.04 respectively, and mean misalignment angles of -1.1° and +0.6°.

A minor problem was encountered with occasional crashing of the system: the programme was always able to be restarted by switching the IBM off, and then on. Also, the "low transmitter current" message was in evidence between 2-10% of the time in water temperatures above about 10°C, but occurred 40-80% of the time in water less than 9.5°C. This was thought to be a "phantom" problem which would not cause any velocity errors to be recorded.

The main problem encountered on this cruise with the ADCP, however, was the appearance of a spurious shear in the direction of the ship's motion (and slightly to starboard). This seemed to be particularly bad when the ship was pitching into swell and was characterised by horizontal surface currents of up to 1 m/s (relative to the depth mean), decreasing sharply (reminiscent of exponential decay) over the top 40-80 m before reaching the (supposed) true velocities at depth, which were nearly constant in the vertical. (Also, a large vertical velocity downwards, 10-20cm/s, was usually apparent near the surface when this phenomenon occurred.) This major problem contaminated about half the near surface data with at least a 20 cm/s error near the surface and should be thoroughly investigated. Initial examinations (by G Griffiths) support the theory that the problem is due to the trapping of bubbles beneath the ship's hull (a well-known occurrence on *RRS Discovery*), possibly made worse by the Asdic pod being directly astern of the bow propeller. This conclusion is supported by the observation that the AGC (acoustic gain control) decreased to only 50 at depth (rather than the more normal 20) during periods of bad data, since the presence of bubbles would produce a continuous "background" noise or backscatter, which would show up at all depths as an increased AGC, but most noticeably in those bins for which the AGC is normally low (ie the deepest). It is possible that this background bubble noise causes the tracking filter to pick up an incorrect frequency shift (and velocity) in the first bin, then recovering slowly to the true value at deeper bins under the action of various algorithms in the ADCP software (RDI are being consulted). The occurrence of the spurious shear did not seem to correlate with any particular percentage of good data (ie occurring sometimes with 20% good data and sometimes 80%), but the onset of bad data (ie when leaving station and beginning to steam) was always accompanied by a decrease in this parameter, especially at depth.

On board ship the ADCP firmware was downgraded from version 16.26 to version 15.7 and three-beam solutions were utilized (after receiving suggestions from G Griffiths) in attempts to remedy this problem, but without success. Throughout the cruise, however, the ADCP was run with the pod retracted and stayed (but note that the hydraulic ram was seen to be distinctly oscillating, perhaps by a degree or so, in rough weather), and it is strongly recommended that tests should be carried out with the pod extended to see whether this has any effect on the above problem.

ALN

Navigation

Transit satellite fixes interpolated with EM log DR data were as usual the prime navaid. However, GPS was available for an hour or so each morning and for up to four hours from about 1400Z. This was used to good advantage for velocity surveys across the shelf edge and for on-shelf calibration runs at the start and end of the cruise, as well as for mooring operations when possible. At the start of the cruise, Decca data were logged on the MNS2000D, but quickly abandoned when it put us on the wrong side of the Scillies.

Zig-zag calibration runs on the shelf were used to calibrate the ADCP and EM log. The former is discussed elsewhere. The EM log calibration at the start of the cruise gave a clockwise misalignment angle of 1.6± 0.19°, and scaling factor of 0.972 ±003. These were applied to the EM log, and apparently sensible residual currents between sat fixes were derived (fig 9).

AB, RTP, HL, ALN, JFR

By integrating the absolute (ie relative to the ground) athwartships component of the current derived from satellite navigational data and either the EM log or the ADCP it was possible to calculate a streamfunction for these two instruments. For the circuit starting from and returning to the mooring site at 47° 17' N, 6° 40' W a difference in the streamfunction for the EM log of 42 km•m/s was obtained, and 480 km•m/s for the ADCP. For the path length of 6200 km this corresponds to a mean athwartships component of about 0.7 cm/s for the EM log and 7.7 cm/s for the ADCP. These represent errors of 0.26% and 2.9% of the ship's mean speed of 2.6 m/s respectively, or misalignment angles of 0.15° and 1.7°. Whereas the values for the EM log are within the calibration error, those for the ADCP are not, indicating an unresolved source of error in the signal (but see the cruise report on the ADCP).

The absolute athwartships currents calculated from the EM log compared well with geostrophic currents calculated from the mass field obtained from the CTD data.

It is encouraging that both the stream function calculation and the geostrophic comparison support the calibration derived for the EM log. However, data from the calibration run at the end of the cruise, worked up in haste, gave different answers, so further examination will be necessary.

HL

Meteorological data

The usual suite of meteorological sensors was logged routinely, and checked daily at noon. Relative winds were converted to absolute winds using EM log and gyro information, and hourly averaged wind vectors are shown in fig 10. Winds over 10m/s were encountered for 47% of the entire voyage, winds over 15m/s for 11%. For the voyage prior to 20 April, these percentages increase to 65% and 18%.

When wicks were put onto the wet bulbs, it was found that wet and dry bulbs were wrongly wired! It was convenient to fix this problem with a software solution.

The main problem found with the metpac level A revolved around the barometer which stopped giving any sensible reading at a few points in the cruise. Due to the fact that the reading on the new met box in the plot does not give a reasonable value for atmospheric pressure it was not noticed for about a week. Attempts to solve the problem were hindered by a lack of documentation on both the barometer and the interface box.

The only problem with the PAR irradiance meter (Fig. 11) was the minor detail that the cover was left on for the first five days.

HL, AB, JFR

Deck Equipment

Midships Winch

This was used for CTD casts powered by the forward hydraulic ring main. The winch performed as was required, paying-out and hauling-in at up to 1m/sec. to all depths cast. The ring main tripped-out once during a cast and continually failed to make full pressure. The cast was eventually completed after connecting to the forward crane's hydraulic power system to power the winch.

The failure of the ring main was traced to an 'O' ring in the main relief valve breaking up, and small pieces blocking the relief valve orifice. The 'O' ring was changed.

Double Barrel Capstan Mooring Winch

This was used for retrieving two moorings laid at the beginning of the cruise; from the stern 'A' frame and capstan. The winch performed as required and without trouble.

Electrical Hydrographic Winch

This was used to deploy small nets to depths down to 200 metres using wire of 6.35mm diameter at first, then 4mm diameter for the remainder of the cruise. Both winch drums operated satisfactorily. Winch speeds were kept to 30m/min when in "veer", owing to the light wire loads, although weights were attached to the nets.

SeaSoar Winch (ex. Kiel University)

This was mounted on the forecastle deck above the main after deck with the faired cable running down to the sheave hanging from the 'A' frame and platform assembly installed alongside the coring davit. The winch performed well and was easy to operate and control. The cable fairing had to be manipulated by hand to ensure it did not foul the guide roller when hauling-in, but this did not prove troublesome. The addition of a deflector or manipulator before the guide rollers would be an advantage.

Stern 'A' frame Assembly

This was installed portside aft to enable easy deployment of SeaSoar and moorings. The 'A' frame was mounted on a 20ft long IOS flat bed adapted platform which was in turn deck mounted. A small Rexroth winch was mounted on the platform, and its wire rope cable fed over diverter sheaves and used to hang a sheave block which could be raised and lowered as required. A vertical diverter sheave was also mounted on the platform. The winch and 'A' frame were controlled hydraulically from the forward corner of the platform. The system worked well for all deployments allowing good access and visibility to all involved in the operations taking place, and providing a good flat area upon which to work.

Non Toxic Sea Water

This ran continuously throughout the cruise supplying the equipment in the Biology and Hydrographic Laboratories.

Pumped Sea Water

This was taken from the seismic compressor cooling water system and fed to the Thermosalinometer and CTD/Transmissometer systems installed at different positions about the upper deck. Two pumps ran continuously to feed both systems. The discharge pipe to the CTD/Transmissometer had to be positioned such that the syphoning effect of the discharge balanced the system, which consisted of a long run of PVC tubing for both feed and discharge. The system operated adequately and without problem.

RG, GAL

Computing

This was the first *RRS Discovery* cruise with three Sun 3/60s as level C computers (Cook, Ross and Scott). One of these (Ross) was devoted to PSTAR work. Plotting was done with a Zeta 8 drum plotter, an HP 7221 flatbed plotter, and a Tektronix 4693 colour plotter. Printing was done almost exclusively on an A4 laser printer.

Level A's

The CTD level A performed well throughout the cruise, the only problems related to the new switch box, which although being a very good idea needs some refinements -

1. The wiring mounted in the switch box needed to be more secure i.e. built onto some vero board or the like.
2. The choice of connector for the Level A front panel left a little to be desired, as it was very easy for the pins to be bent.

Level B

1. The level B performed quite well throughout the cruise with only 6 crashes. Most of these appeared to be caused by the CTD level A hanging the v24 line that it was plugged into. Once the Level A CTD was plugged into the Cambridge ring this problem disappeared.
2. Throughout most of the cruise, the level B was logging in excess of 12 level A's at an average data rate of one message every 8 seconds, the fifo cycled approximately

3. The level B was plugged into the back of Cook for the length of the cruise and apart from a few zs0 silo overflow messages, and some syntax errors, probably caused by a buffer overflow there were no significant problems. However, it was probable that this cruise was very near the limit for serially transferred data.

4. Towards the end of the cruise, the 8800 tape deck on the Level B refused to load tapes. It was not possible to swap to the 8900 because the cables could not be found. After much playing, it was discovered that the tape could be loaded manually by spooling it until the BOT sensor was aligned with the BOT marker. When the cables were eventually found and tried, the 8900 again failed., Eventually, it was found that it was necessary to remove the SCSI adapter card from the card cage to use the drive in its original mode.

Level C

The system configuration that was chosen for this cruise worked quite well although some mistakes showed up.

The most obvious of these was that three discs was the minimum possible configuration, split 2 on Scott,1 on Ross, with a cartridge drive on each machine. The reason for this was that the load on the network when archiving from Ross was so great that the parser ground to a halt. To solve this, the arrow 300 Mbyte winchester should be replaced with a disc pack with cartridge before the next cruise. This should be configured with a minimum configuration kernel and all of the PSTAR suite and data space.

Archiving to tapes on the SCSI bus was very difficult due to the inability to write over tapes. The only package that could write over tapes was dump, which required a quiescent system, i.e. dismounted which was not feasible.

The lack of swap space on Scott meant that ALV manipulation could not be performed on that machine, also there was a limit to the number of windows that could be opened. This problem will have to be solved in the near future.

Because of the nature of a distributed computer system, it was important that people remembered which machines they started programs on. There did not seem to be a network-wide version of ps, so it was very easy to have two copies of the same program running on the same datafile causing havoc.

At the start of the cruise, it was hoped to run the parser with DALIVE set (sync after write) so that data files were forced to disc after each write operation. This system had been used on previous cruises as it allows immediate access to the data files and avoids the problems of synchronization which would otherwise occur on a system which uses one processor to write data files and another to read them concurrently. It soon became apparent that the overheads of using DALIVE were unacceptable as the speed of parsing was being greatly reduced due to the amount of disc access required. The fact that the data files were being written to a remote disc across an Ethernet link only made the problem worse. It was therefore decided to switch DALIVE off as no ill effects of this change were anticipated. The change certainly had the desired effect of speeding up the parser, however it had the side effect of making unusable all programs which attempted to read newly parsed data from the data files. It became clear over the following days that there were a number of problems with the system, each of which appeared as its predecessor was removed. All the problems were a direct result of using a system designed (consciously or not) as a single processor system on a multiple processor network.

The first assumption which had to be removed from the data access routines was that the streamstates file was correct. In particular the routines read the size of the data file from streamstates and attempted to read the final record, returning a fatal error if unsuccessful. This would work on a single processor system since, even if the final record in the data file had not been written to disc, it would be waiting in a buffer on the same machine, and the read could find this buffer and succeed. On a multi-processor system, each processor only has access to data physically present on the disc so that buffered data cannot be assumed to be available. If the streamstates file has been written to disc more recently than the data file it describes, it may describe a file larger than that available on the disc, leading to a fatal error when the data access routines attempt to read the final record. Since this situation can only occur when a file is being simultaneously written by one process and read by another, the reading program can distinguish it from a true read error by checking the 'file open for write' flag in the streamstates file. If an error is obtained while reading the last record of the file, the program compromises by reading the last record it has access to and modifying its internal copy of the streamstates record to match the file available.

This change removed the problems from most data access programs, but the CTD processing program, proctd, still had occasional difficulties in reading the input data file. The input file in question was probably the fastest growing on the system, as it recorded data once a second for nine variables. Each record in the file comprised 58 bytes, larger than most other raw data files. Because of this large record size, it was particularly likely that each buffer written to the disc file would end with an incomplete record. Such incomplete records caused the data access routines to fail because they assumed that a read was either completely successful or completely unsuccessful. In fact, it appeared that the C read function may read part of its requested input and then fail, leaving the file's read pointer in an unexpected position. The next read assumes that this pointer is at the start of a data record and so reads the file incorrectly. This error was corrected by checking for such partially successful reads and resetting the pointer to its correct position at the start of the record after the read had failed.

After correcting these problems, the data access system was intensively used for two and a half weeks with no further bugs being detected. It is therefore reasonable to hope that the problems associated with distributed processing have been eliminated from this part of the shipborne system at least.

AB, AC, RTP

Plotter

The Zeta 8 Plotter caused much concern at the start of the cruise due to buffer overflow problems, and, when this was finally fixed, the old problems of the paper being thrown all over the place, and pen selection failing due to the ship rolling, reappeared. A new problem also occurred. When two commands, both writing to the nicolet via the micom, were separated by a semicolon, as is the norm, the second command failed with a connection refused message. The only way around this appeared to be by inserting a sleep between the two commands which was long enough to wait for the first plot to finish before sending the second plot.

PSTAR

A new version of all PSTAR software was installed and debugged on the cruise. The main changes that had been made were:

1. a new header, more compatible with RVS and GF3 requirements, and with a large comment field.
2. data storage in RVS packed 6-byte format, giving 5-byte instead of 4-byte precision to all real numbers.
3. all programmes re-examined, and often streamlined or improved.

Thanks to much preliminary work by Dr Steven Alderson, very few bugs were found, and the system was a significant improvement. An extremely fast conversion programme, DATAPUP, had been written by RVS to convert RVS to PSTAR format. This speeded up the transfer of data considerably. It meant, for example, that all navigation corrections were done on the level C in RVS files, and the entire file for the cruise could be transferred to PSTAR for archiving and transfer to land.

SPI to DIPF conversion routines were used for all PSTAR plotting, allowing the RVS DIPF plotter drives to be used. This made plotting much easier, with a single plot file that could be examined in Sun View before taking hard copy.

Contour plotting could still be done with PCONTR, but in parallel RVS developed programs were used to create colour fill contour plots. These proved a substantial aid to data interpretation and on one occasion, a section was contoured before the end of the last CTD cast, enabling a decision to be made on the next section to be run based on the best possible data. Thus, expensive facilities can easily pay for themselves in improved utilization of shiptime.

REFERENCES

SAUNDERS, P.M. 1986 The accuracy of measurement of salinity, oxygen and temperature in the deep ocean.
Journal of Physical Oceanography **16**,189-195.

ACKNOWLEDGEMENTS

Cruise 181 was hampered by severe weather for much of the first three weeks. Despite this, morale was high and the scientific programme was completed, thanks to the cooperation and expertise of all hands. I would particularly like to thank the mooring team and the Master for their skill in hazardous conditions.

TABLE 1

CTD Station List

Cast	April Date	Start Time	Down Time	End Time	Max Press (dbar)	Water Depth (m)	Latitude (N)	Longitude (W)
11795	2	1021	1030	1100			49°11.6'	6°14.6'
11796	3	0128	0148	0220	563		47°27.8'	6°37.2'
11797	3	0404	0506	0657	2591		47°17.1'	6°39.8'
11798	3	0830	0924	1129	2496		47°17.3'	6°40.3'
11799	4	0906	1040	1307	4643		46°42.3'	6°58.2'
11800	5	0532	0632	0813	4627	4755	46°17.5'	7°01.8'
11801	5	1245	1353	1526	4520	4840	45°33.3'	7°00.2'
11802	5	1857	1943	2100	3002	4861	45°04.1'	7°00.4'
11803	6	0543	0632	0721	2999	4860	44°29.3'	7°01.9'
11804	6	1905	1916	1921	293	305	44°00.6'	6°57.8'
11805	6	1944	2005	2023	1067	1032	44°01.9'	6°58.3'
11806	6	2212	2302	2353	3072	3713	44°13.7'	6°59.0'
11807	7	1053	1140	1230	3088	4901	44°29.5'	9°00.0'
11808	7	2128	2252	2344	3027	3108	43°05.3'	9°59.8'
11809	8	1210	1215	1222	174	160	42°15.8'	9°13.5'
11810	8	1413	1422	1429	459	247	42°15.5'	9°27.0'
11811	8	1459	1516	1530	928	919	42°15.2'	9°29.7'
11812	8	2050	2128	2208	2153	2128	42°13.2'	9°41.0'
11813	9	0144	0228	0343	2795	2770	42°09.2'	10°19.9'
11814	9	0819	0857	0954	2475	2440	42°05.8'	11°13.6'
11815	9	1528	1628	1741	2961	4025	42°02.0'	12°07.7'
11816	9	2159	2244	0009	3436	5328	41°57.7'	12°59.9'
11817	10	0540	0633	0755	3538	5340	41°54.4'	13°55.5'
11818	10	1210	1303	1424	3498	5330	41°51.0'	14°47.1'
11819	10	2009	2103	2226	3459	5270	41°47.5'	15°40.5'
11820	11	0424	0524	0654	3478	5054	41°43.6'	16°33.7'
11821	11	1348	1450	1615	3482	5550	41°40.2'	17°27.7'
11822	12	1141	1310	1440	3378	5066	41°40.2'	18°24.3'
11823	13	0337	0430	0557	3478	4590	41°34.4'	19°14.0'
11824	13	1216	1310	1450	3491	3735	41°32.3'	20°19.2'

Continued..

TABLE 1

CTD Station List

Cast	April Date	Start Time	Down Time	End Time	Max press (dbar)	Water depth (m)	Latitude (N)	Longitude (W)
11825	13	2106	2158	2331	3500	4133	42°10.2'	20°17.5'
11826	14	0348	0457	0625	3468	5339	42°48.4'	20°13.8'
11827	14	1054	1151	1310	3484	3932	43°26.5'	20°08.9'
11828	14	2024	2115	2238	3498	3790	44°04.0'	20°02.8'
11829	15	1550	1643	1806	3494	4077	44°43.2'	19°59.4'
11830	16	0009	0115	0317	3948	4321	45°19.6'	19°57.0'
11831	16	0826	0923	1050	3428	4322	45°58.5'	19°53.0'
11832	16	1712	1804	1924	3498	4833	46°35.7'	19°46.7'
11833	16	2325	0017	0206	3229	4551	47°14.0'	19°42.0'
11835	17	1803	1815	1845	493	4559	47°58.0'	19°32.6'
11836	17	2109	2211	2342	3457	4563	48°02.6'	19°33.6'
11837	18	0648	0742	0907	3474		48°39.4'	19°31.5'
11838	18	1331	1424	1543	3361		49°20.1'	19°32.3'
11839	18	2049	2147	2314	3508		50°01.13'	19°35.0'
11840	19	0320	0414	0532	3502		50°40.8'	19°37.1'
11841	19	0934	1032	1150	3451		51°20.0'	19°33.7'
11842	19	1556	1649	1805	3448		51°59.4'	19°33.3'
11843	20	0931	1012	1118	2648		52°39.2'	19°36.0'
11844	20	1842	1920	2024	2494	2484	53°20.0'	19°34.4'
11845	21	0436	0501	0545	1445	1475	54°00.1'	19°36.0'
11846	21	1024	1101	1201	2431	2414	53°48.7'	18°30.5'
11847	21	1637	1713	1805	2345	2340	53°36.4'	17°25.4'
11848	21	2219	2303	0013	2981	2968	53°25.0'	16°21.6'
11849	22	0501	0556	0712	3475	3442	52°42.5'	16°09.7'
11850	22	1157	1245	1404	3399	3360	52°00.1'	16°01.2'
11851	22	1830	1921	0454	3483	4353	52°00.7'	17°11.3'
11854	30	1818	1910	2022	3336		47°16.9'	6°39.9'
	May							
11855	1	0132	0225	0354	3506	4490	46°43.3'	6°48.5'

TABLE 2

SeaSoar Deployments

Run No.	Start Date April	Start Time	Stop Date April	Stop Time	Duration	Comments
1	5	2138	5	2321	1h 43m	CTD deck unit fault
2	9	1018	9	1517	5h	good run
3	10	1441	10	1926	4h 45m	
4	13	1450	13	2040	5h 50m	
5	14	1406	14	1941	5h 35m	
6	16	1143	16	1633	4h 50m	
7	19	2101	20	0811	11h 10m	telemetry off, fluorimeter on
8	20	1135	20	1748	6h 13m	
9	20	2115	21	0311	7h 56m	
10	23	0654	23	1018	3h 24m	no fluorimeter
11	23	1450	23	2110	6h 20m	PRT problems
12	24	1441	24	2050	6h 09m	
13	24	2221	28	1612	89h 51m	RVS/PML fluorimeter
14	28	2120	30	1440	41h 20m	
	May		May			
15	1	2343	2	0930	9h 47m	conductivity lead problems

Total duration 8d 17h 53m

TABLE 3

XBT Casts

XBT No.	April Date	Time	Latitude (N)	Longitude (W)	Comments
1	2	2028	48°07.99'	6°25.93'	
2	4	0733	46°43.31'	6°58.77'	
3	7	0558	44°22.46'	7°59.22'	
4	12	2059	41°43.82'	18°51.81'	
5	12	2306	41°47.89'	18°57.48'	
6	13	0108	41°37.80'	19°03.65'	
7	13	0513	41°34.60'	19°14.20'	
8	13	0717	41°33.95'	19°26.86'	
9	13	1753	41°51.75'	20°18.82'	
10	14	0158	42°30.39'	20°14.68'	
11	14	0858	43°08.78'	20°11.95'	
12	no data				
13	14	1709	43°47.44'	20°07.05'	only down to 150m
14	14	1716	43°48.44'	20°06.64'	200m
15	14	1722	43°49.30'	20°06.28'	300m
16	15	1234	44°26.24'	20°08.97'	
17	15	2130	45°01.48'	19°59.87'	
18	16	0554	45°39.86'	19°59.31'	
19	no data				
20	no data				
21	16	0615	45°42.73'	19°59.47'	
22	16	1045	45°58.12'	19°52.65'	
23	16	2137	46°57.42'	19°48.86'	
24	17	0508	47°37.32'	19°40.49'	
25	18	0136	48°20.73'	19°33.13'	
26	18	1137	49°03.19'	19°32.22'	
27	18	1818	49°44.59'	19°32.44'	

Continued....

Table 3

XBT Casts

XBT No.	April Date	Time	Latitude (N)	Longitude (W)	Comments
28	no data				
29	19	0721	50°58.81'	19°38.65'	
30	19	1347	51°39.90'	19°32.46'	
31	21	0804	53°54.07'	19°04.33'	
32	21	1420	53°43.07'	16°51.72'	
33	21	2017	53°30.17'	16°51.72'	
34	22	0234	52°02.81'	16°17.02'	
35	22	0949	52°18.50'	16°04.85'	

TABLE 4

Moorings

Mooring number		Position		deployed		recovered		Water depth
IOSDL	PML	Latitude(N)	Longitude(W)	Date	Time	Date	Time	(m)
477	118	44°02.1'	06°58.7'	6/7/88	2122	6/4/89	1220	975
478	119	44°01.0'	06°57.2'	6/7/88	2241	not found		505
483	120	47°17.3'	06°40.5'	3/4/89	1640	30/4/89	1520	2690
484	121	46°42.6'	06°56.8'	5/4/89	0054	1/5/89	0902	4546
485		47°58.4'	19°33.0'	17/4/89	1730			4566
486	(122)	47°23.4'	06°40.1'	1/5/89	1727			1470

TABLE 5

Records from moored instruments

Mooring	Instrument	Record Interval mins	Number of Records
PML 119/	ACM 5908*	60	6651
IOSDL 477	ACM 7945	60	6651
	ACM 3624	60	6651
PML 120/	ACM 9656	10	4216
IOSDL 483	ACM 7947	10	4120
	ACM 9609*	10	4360
	ACM 9578*	10	4216
	TL 879	20	2165
	ACM 9575*	10	4360
	TL 925*	20	2117
	ACM 9582*	10	4352
	ACM 9649	10	4216
PML 121/	ACM 7401	15	3201
IOSDL 484	TL 772	20	2433
	VO 666	15	Not decoded
	ACM 7643	15	3245
	ACM 421	15	3245
	ACM 7765	15	3245
	ACM 7517	15	3245
	ACM 7948	15	3245
	ACM 7946	15	3245
	ACM 6867	15	3245
	ACM 3622	15	3245
	ACM 2109	15	3245
	ACM 4738	15	3245
	TL 806	20	2434
	VO 627	15	Not decoded

* RVS instrumentation. All other instrumentation IOSDL.

VO627, VO666 EG & G 610C current meters

ACM Aanderaa current meters

TL Aanderaa temperature profile recorders

TABLE 6

Argos Buoy Deployments

Buoy	Date April	Time	Position of Release Latitude(N)	Longitude(W)	Atmospheric Pressure (mb)	Wind Speed (knots)	Direction (True)	Sea Temp (°C)	Air Temp (°C)
3907	17	1927	47°58'	19°32'	1007.3	25-30	160	11.39	12.10
3909	18	2332	50°01'	19°35'	1006.2	30	140	10.93	10.90
3906	19	1929	51°59'	19°31'	1014.0	12	130	10.15	10.80
3908	20	2048	53°20'	19°34'	1019.2	18	115	09.95	10.40

TABLE 7

Zooplankton Stations (single WP2 net)

Sample No.	Station No.	Date	Latitude(N)	Longitude(W)	Sampling Depth
001	11824	13/4	41°33'	20°19'	100-0m
002	11825	13/4	42°10'	20°18'	100-0m
003	11827	14/4	43°27'	20°09'	100-0m
004	11829	15/4	44°43'	19°59'	100-0m
005	11831	16/4	45°59'	19°53'	100-0m
006	11842	19/4	51°59'	19°31'	100-0m
007	11844	20/4	53°20'	19°34'	100-0m

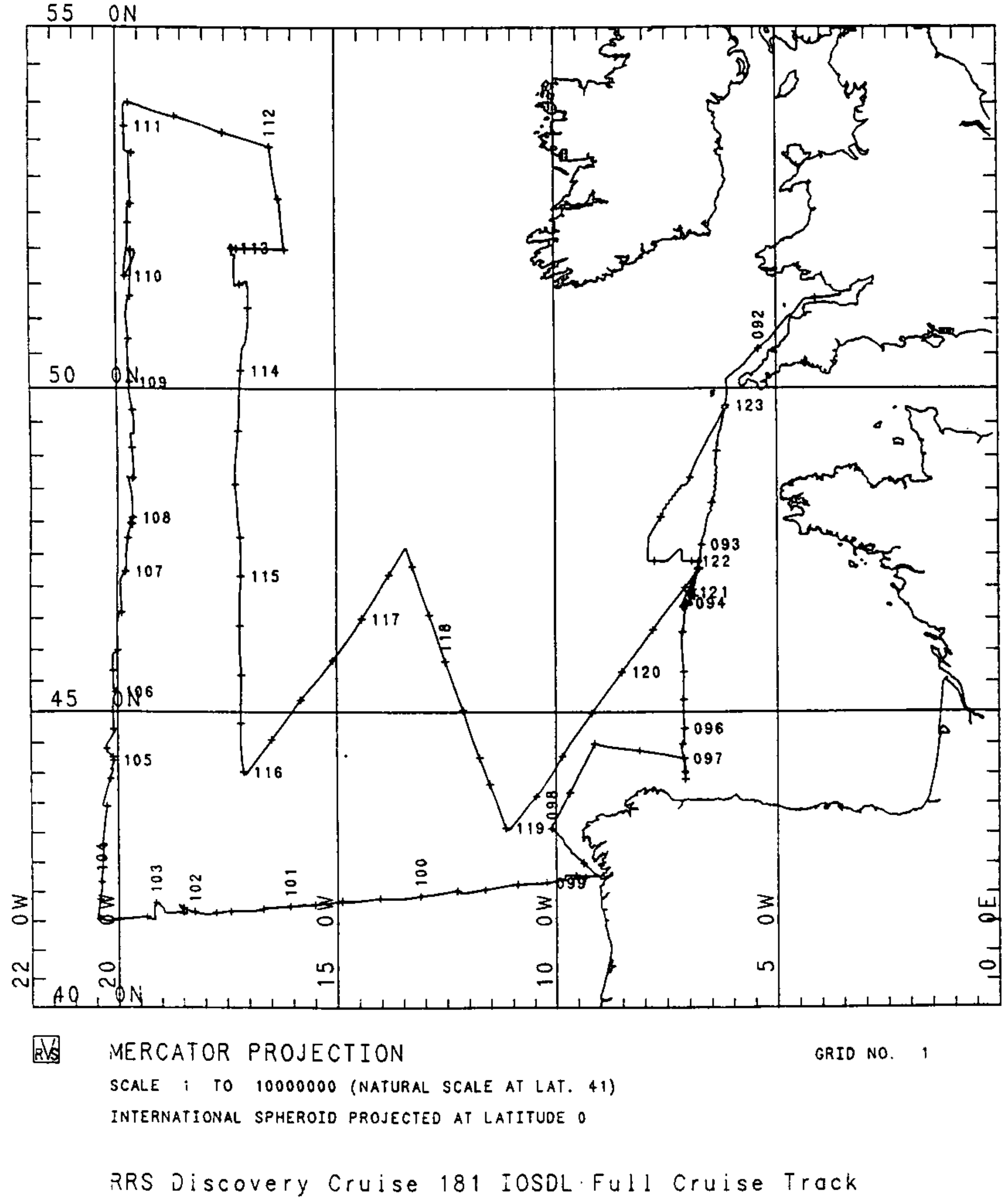

Figure 1. RRS *Discovery* Cruise 181 01 April - 03 May 1989

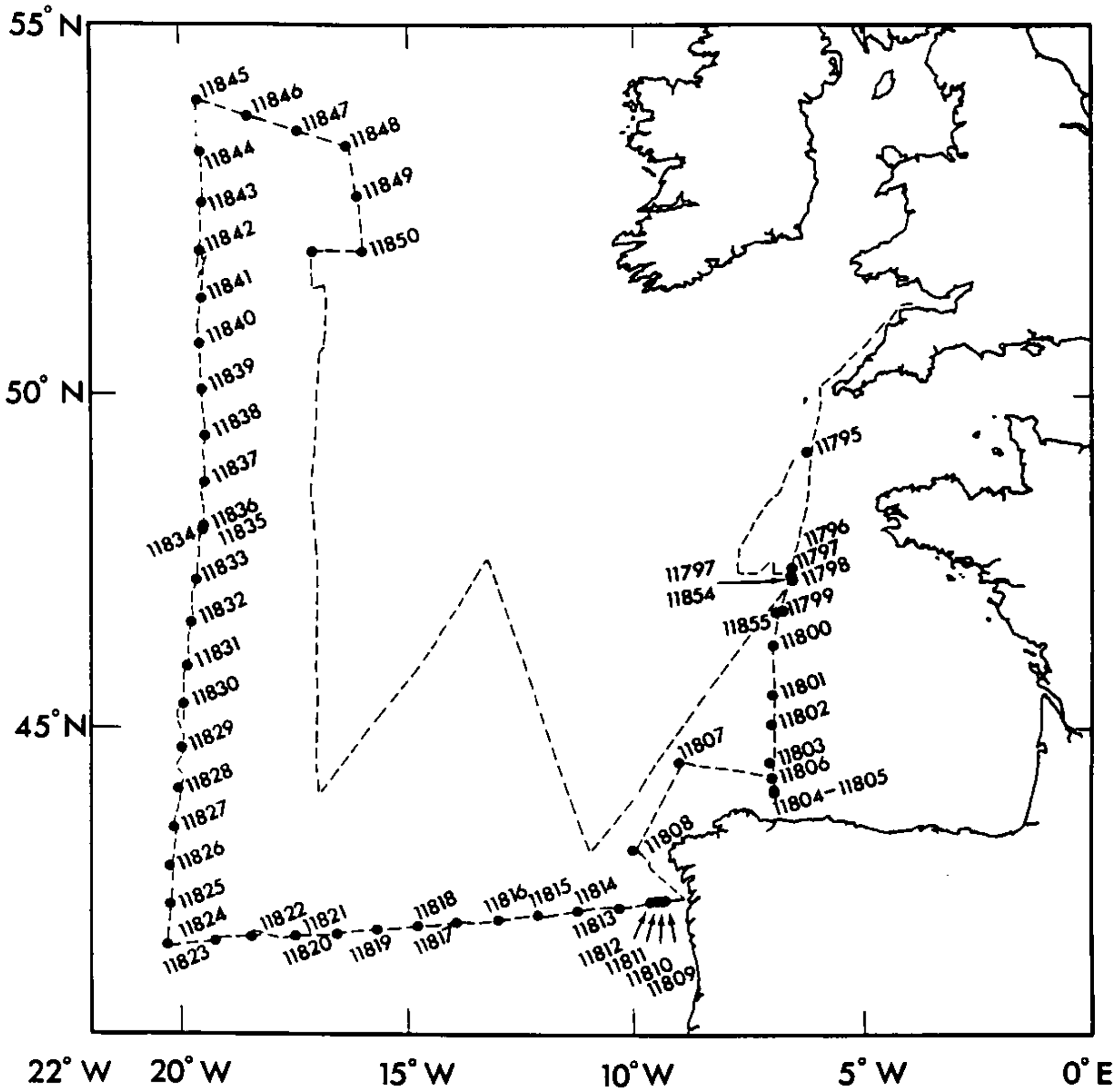

Figure 2. CTD Casts

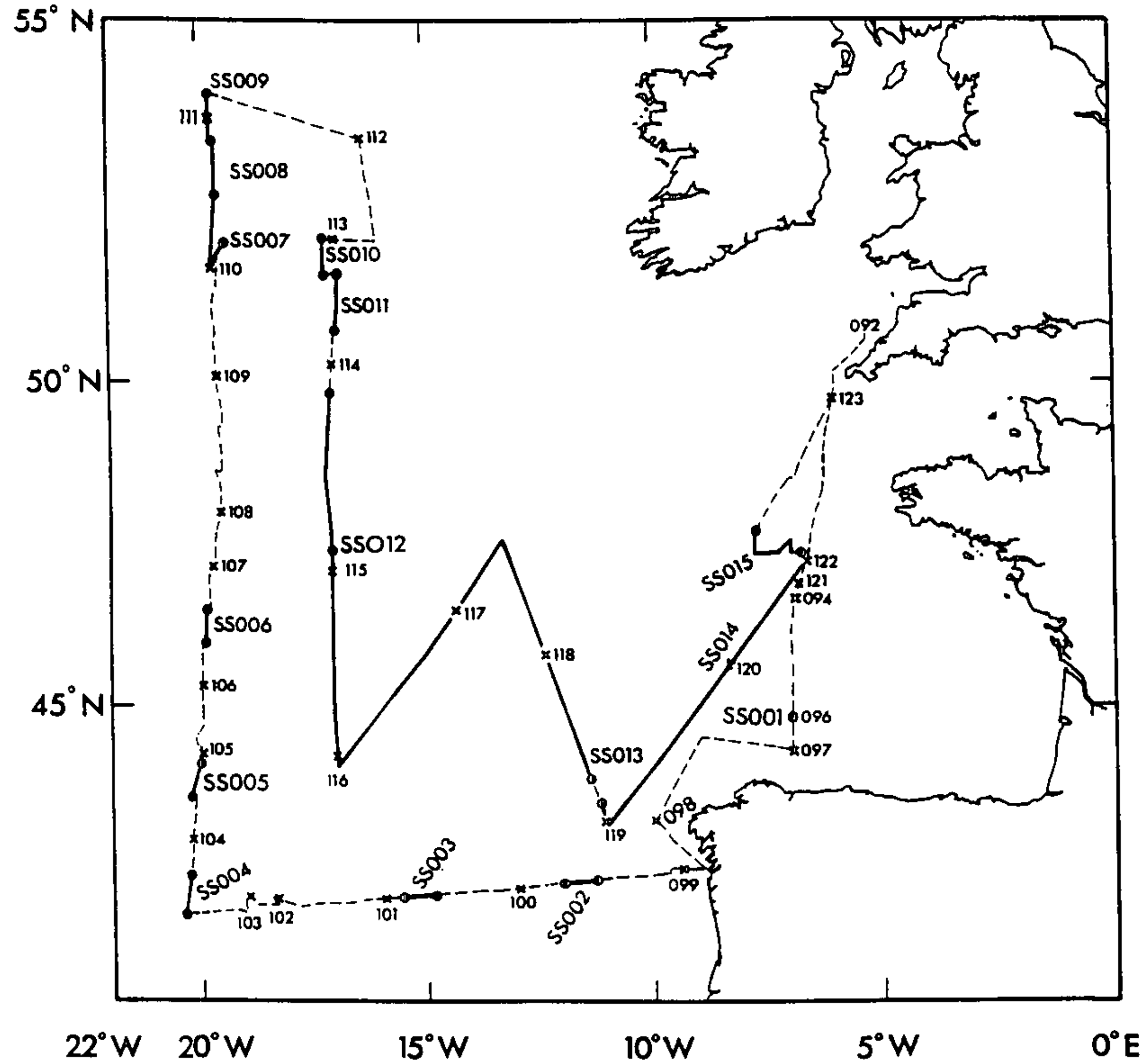

Figure 3. SeaSoar Deployments

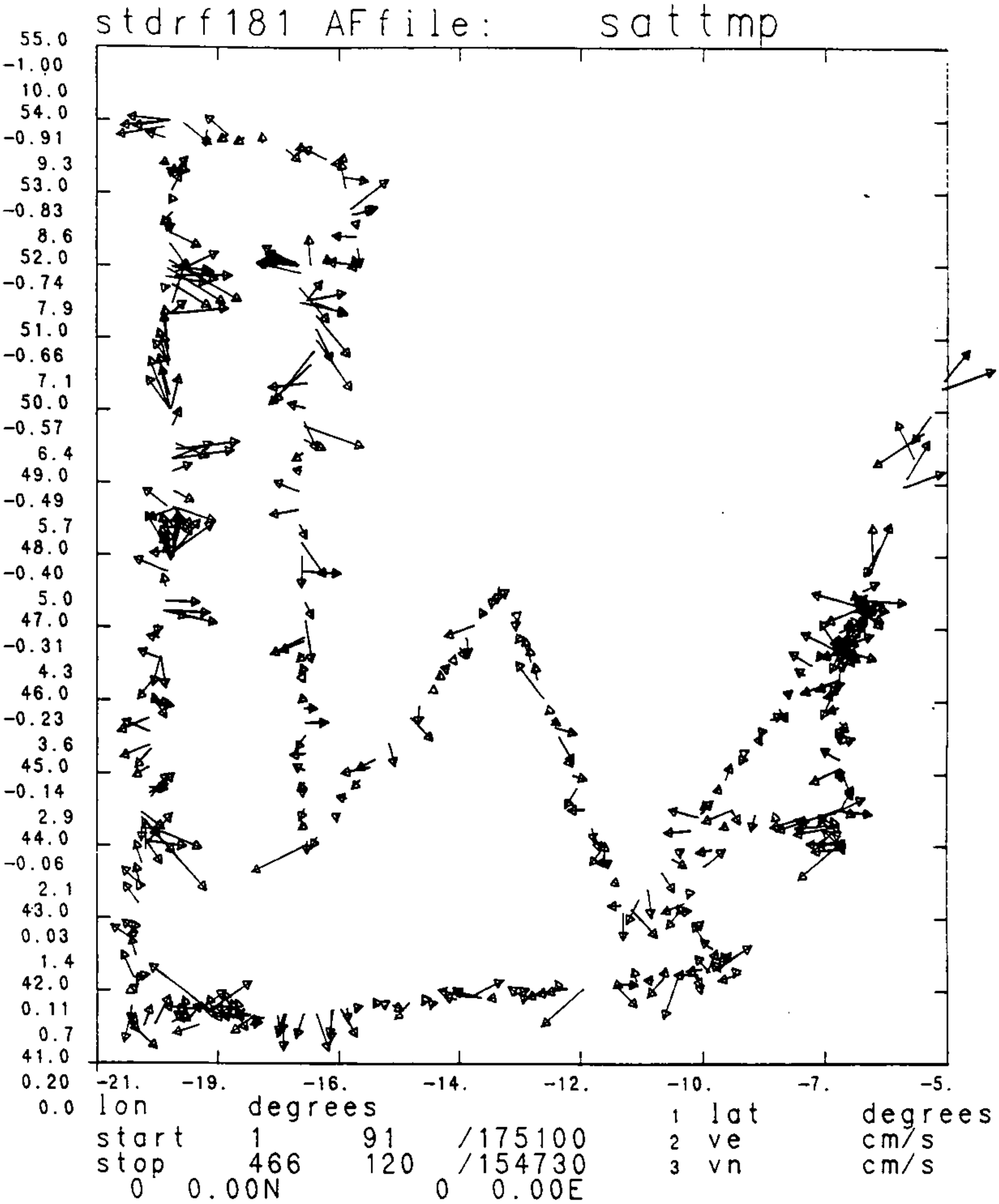

Figure 4. EM log and satellite derived surface currents

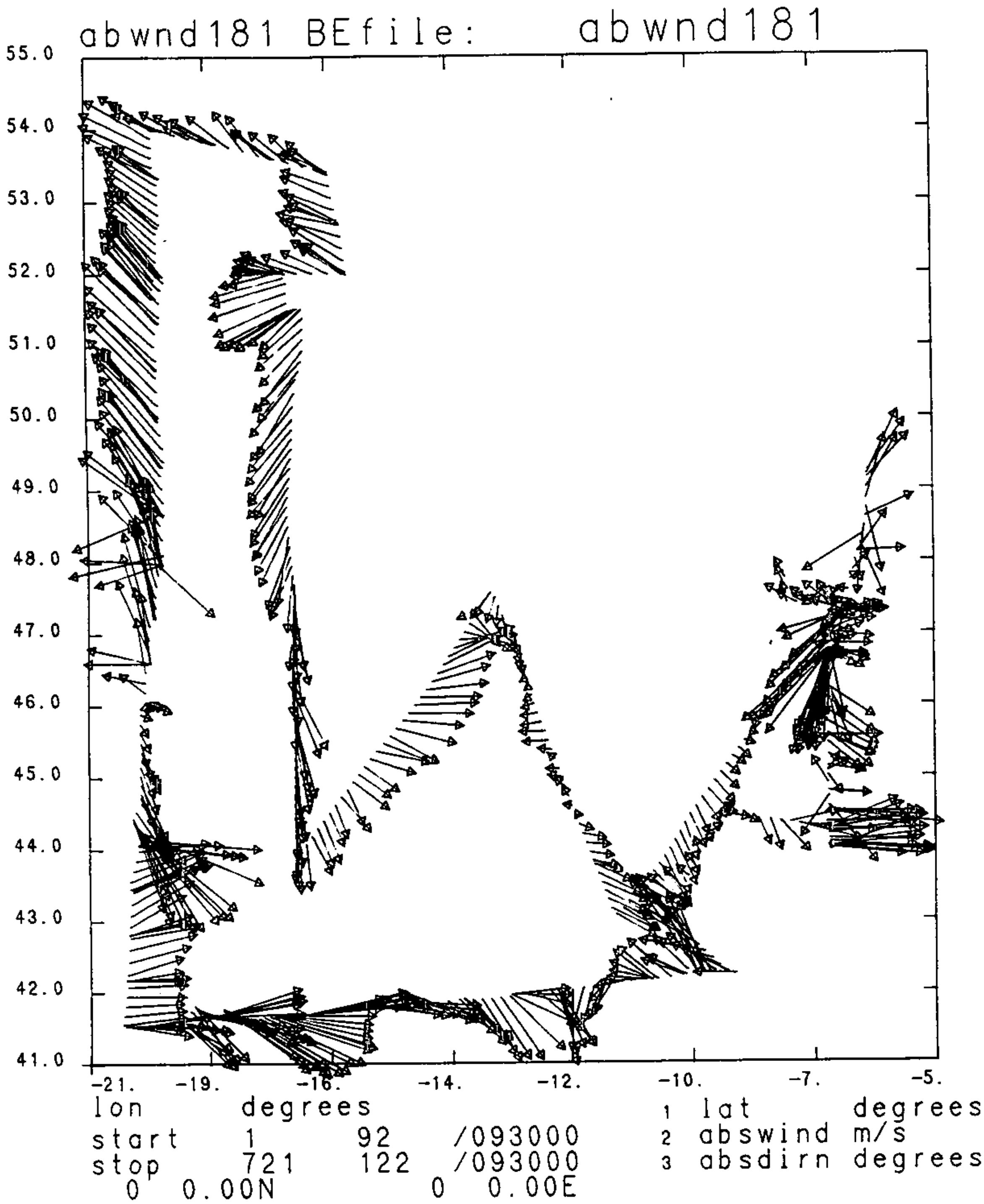

Figure 5. Hourly averaged winds

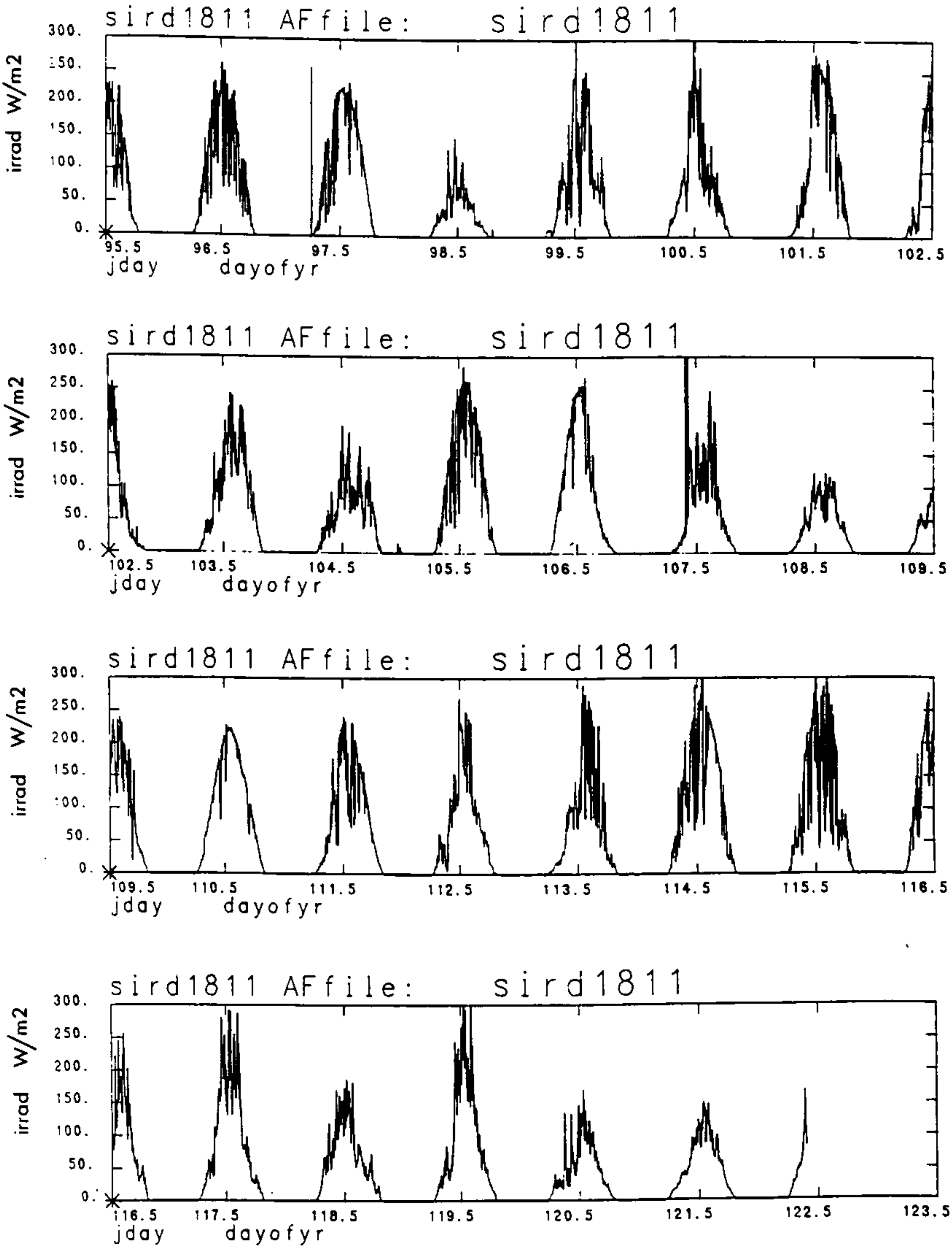

Figure 6. Surface irradiance