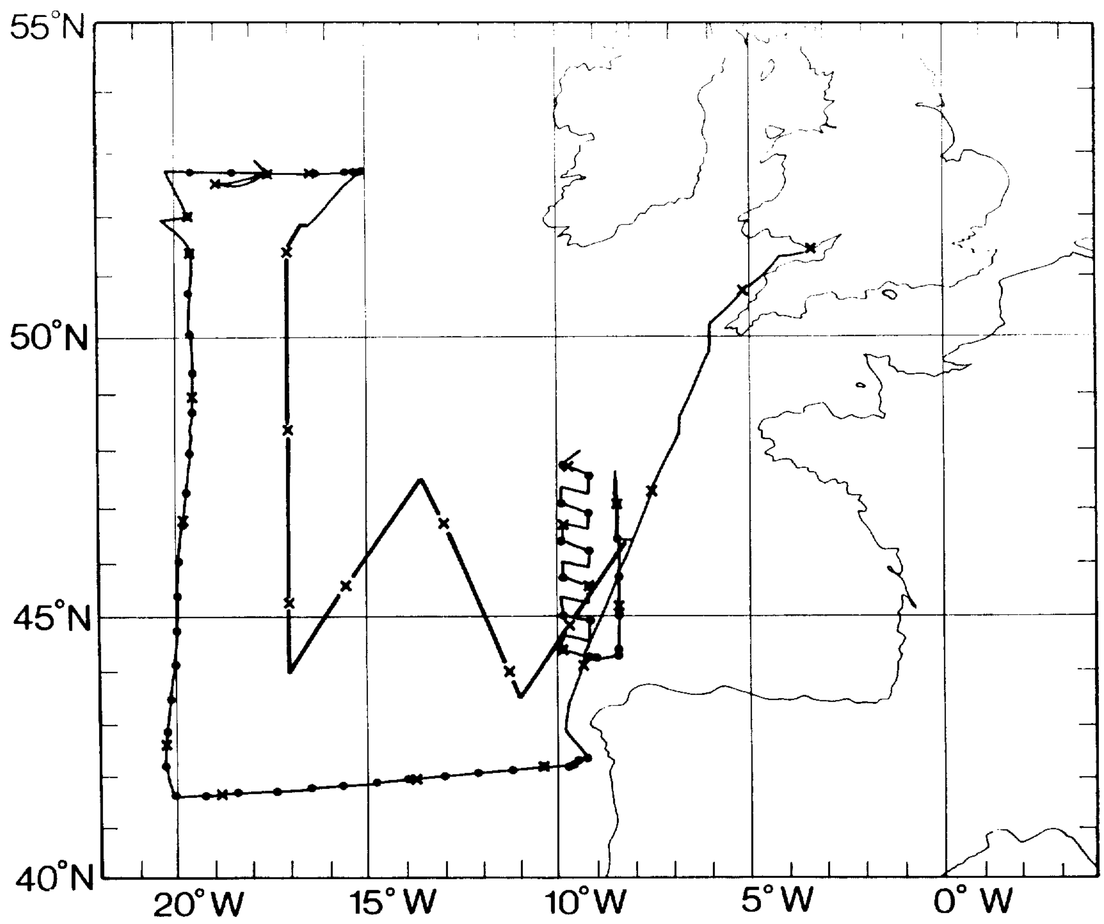
Institute of
Oceanographic Sciences
Deacon Laboratory

RRS Discovery Cruise 189

09 Mar - 08 Apr 1990

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

Cruise Report No 225 1991



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CRUISE REPORT NO. 225

RRS DISCOVERY CRUISE 189
09 MAR-08 APR 1990

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

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ABSTRACT

RRS Discovery Cruise 189 in March and April 1990 was the second of two cruises to examine the interannual variability of the ventilating North Atlantic Mode Water north east of the Azores. The first cruise, RRS Discovery Cruise 181 took place a year earlier. A box of full depth CTD stations was worked, enclosed by 42°N, 20°W, 53°N and the continental shelf of north-west Europe. The interior of the box was surveyed to a depth of 350m using SeaSoar.

In addition, three north-south sections of full depth CTD sections were worked across the Bay of Biscay, as part of the GASTOM experiment.

KEYWORDS

ATLANTIC(NE)
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TEMPERATURE

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1. SCIENTIFIC OBJECTIVES

The main scientific objectives of the cruise were as follows:

1. Study and quantify the circulation of the region of the Atlantic north and east of 42°N, 20°W, and south of 53°N, with a box of full-depth CTD casts; sampling to include CTDO measurements together with fluorescence and transmittance profiles, and salinity, oxygen and nutrients from Niskin bottles. The pattern of CTD and SeaSoar measurements (see also 3 below) to closely follow the track of Cruise 181, 12 months earlier (Pollard et al., 1989).

2. Continue a programme of SeaSoar development by means of trial deployments involving a package of sensors mounted on the towed vehicle.

3. Survey the interior of the box of CTD stations using SeaSoar, to quantify the T/S characteristics of recently-ventilated Mode water.

4. Make underway ADCP measurements throughout the cruise.

5. Make underway analysis of non-toxic pumped seawater supply using thermosalinograph and fluorometer.

6. Occupy a grid of CTD stations in the Bay of Biscay east of 10°W, as part of the GASTOM experiment.

7. Test a modification to a piece of coring equipment for IOSDL.

Of these objectives, numbers 4 and 7 could not be fulfilled, but the remainder were met satisfactorily. Objective 4 was abandoned early in the cruise, when the ADCP developed a fault that could not be corrected at sea. Objective 7 was a casualty of overzealous tidying of the deck prior to departure. Unfortunately, the core barrels required for the test were unloaded along with some equipment from Cruise 188, and their absence was not noticed until after the ship had sailed. Difficulties with nutrient data are discussed in the project report.

2. NARRATIVE

RRS Discovery sailed for Cruise 189 from Cardiff on the afternoon of Friday 9 March (Day 068; from now on all times will be given as a combination of day number and time GMT). This was three days later than expected, because failure of the bow propeller towards the end of Cruise 188 had required repairs in dry-dock. It had not been possible to arrange any extension of the cruise, because RVS felt that a full five days was required to mobilise the ship for Cruise 190, the first of three BOFS cruises to be held following Cruise 189. After clearing the lock, the ship set a course for the eastern end of a full-depth CTD section along 42°N. Logging of GPS and MX1107 satellite fixes to the shipboard computer system was begun immediately, as was relative navigation using the EM log, as soon as it was deployed, and ADCP (Acoustic Doppler Current Profiler). The ADCP was initially operated with the transducer pod retracted.

Day 069, the first full day at sea, found the ship steaming south-west on a rather uncomfortable course, with several of the scientific party feeling less than perfect. However, all hands continued with preparations for the first CTD station, which was to be a test station in deep water, en route to the start of the 42°N section. The ship's pumped non-toxic seawater supply was started. At 069/1520, before crossing the shelf edge and while good quality GPS fixes were available, a series of manoeuvres at 8 knots was started for the purpose of calibrating the ADCP and EM log. After deploying the transducer pod, 90 degree turns were executed at 20 minute intervals until 069/1840; the ship then hove to while the pod was retracted and secured in position, after which the base course was resumed. The pod was left in the retracted position to enable maximum speed on passage.

The following day, 070, three test CTD stations (11959-11961) were worked, en route to the first work area. Station 11959 was the first test of the brand new 2.5 litre multisampler system, and was taken to a depth of 4000m. Unfortunately, no samples at all were collected, the problem being traced to a faulty connector on the multisampler base (see project report). For the next station (11960), the old 1.7 litre system was installed and taken to 4000m; this was found to be useable, but far from satisfactory, with many misfires. The third test station was a calibration station for the shallow CTD, to 600m. Day 070 was the first day on which 24 hours of GPS coverage was achieved (three satellites or two satellites plus Rubidium clock). The precession of the satellites during the cruise meant that the amount of coverage varied between about 19 and 24 hours.

Day 071/1022 saw the commencement of the scientific programme, with CTD station 11962. A series of full-depth CTD stations was then worked westwards along approximately 42°N and northwards up 20°W, repeating stations occupied on Cruise 181.

By the time station 11964 had been worked (071/1455), the fault in the 2.5 litre multisampler system had been identified, and that system was reinstalled. It was used with near perfect results for the remainder of the cruise. Station 11970 was moved one mile compared with the corresponding station on Cruise 181 because a buoy was spotted on the surface after the ship hove to. Station 11992 was reached at 080/0000 and completed before severe weather seriously slowed the rate of progress.

A number of SeaSoar trial deployments were planned, to take advantage of steaming legs between CTD stations early in the cruise. A total of five deployments were made between stations 11971 and 11988. These passed largely without incident, and details are given in the project report.

On Day 076, the first of a number of serious problems with the ADCP was noticed. Steaming northwards, between stations 11980 and 11981, the transducer pod had been deployed. The ship was heading into a sea, so the requirement to keep below 10 kts with the pod deployed was not greatly reducing the rate of progress. Firstly, the data showed current shear parallel to the ship in the few bins nearest the surface; this effect has been widely noticed on RRS Discovery previously. Secondly, a potentially disastrous error in the heading control of the transducer head was discovered. Inspection of the equipment in the transducer trunk showed that the clamps designed to hold the transducer head fixed with respect to the ship's hull were not achieving this. The shaft on which the transducer head is mounted had slipped relative to the clamps through an angle of between 5 and 10 degrees in the six hours since the pod was deployed. This is further discussed in the project report. Finally, the following day, Day 077, the IBM PC deck unit stopped displaying data to the monitor, showing zero good pings at all depths; after a variety of investigations, it was concluded that the system had suffered a hardware failure that could not be repaired at sea; no further ADCP data were gathered during the remainder of the cruise.

The first serious hold-up for poor weather came on Day 080, after station 11992. The station was completed at 080/0216, but 35 knot winds and 35 foot swells from the west made it impossible to set a course for the next station. Instead, the Master set a course with as large a northerly component as was possible and after heading west or north-west for much of the day, it was possible to turn downwind towards the station at 080/1900. Commencing at 080/2223, station 11993 became the first of several stations to be worked in difficult conditions. After station 11993, another period of slow steaming towards the north-west was necessary before turning downwind towards station 11994. Upon arrival at station 11994 it was decided to make that the most northerly station on the section, at 52°40N. In view of the fact that time had been lost at the start of the cruise, it was felt that no further time could be allocated to slow progress northwards; accordingly, a section was defined along 52°40N. Stations 11994 and 11995 were worked without incident, still in difficult conditions, thanks to the concentration of the ship's Officers and their skill in handling the ship during deployment and recovery.

Station 11996 was reached at 082/0030, but 40 knot winds combined with a swell from a different direction made it impossible to commence the station. After daylight, heavy swell and winds gusting up to 50 knots made work impossible all day. An uncomfortable day was passed by steaming upwind at 2 knots, and with an RPC. Overnight, the ship turned downwind to arrive at the station at the start of daylight on Day 083 (this manoeuvre incurred the displeasure of a number of ship's personnel who were rolled out of their bunks). However, conditions were still unworkable, with squalls, occasional hail and winds still gusting up to 50 knots. However a weather forecast of better weather arriving later that day provided a cause for optimism, which was justified when station 11996 was commenced at 083/1728 in 30 knot winds and 30 foot swells. The following day, 084, the remaining four stations in the 52°40N section were worked, the last, number 12000, being completed just after midday. The fluorometer number SA240 was removed from the CTD frame after station 11999 so that it could be installed in the SeaSoar in preparation for the section southwards down 17°W. In addition, as a time-saving measure with closely-spaced stations, only six Niskin Bottles were used on stations 11999 and 12000. In all, over two days had been lost to weather, and it was doubtful at this stage whether the scientific programme would be completed.

After completion of station 12000, Discovery headed south-west towards the top end of the 17°W SeaSoar section. The weather was now much improved, with 20 knot winds, but quite a large swell. The SeaSoar had been reconfigured, with the fluorometer installed in place of the telemetry equipment that had been used during the trials earlier in the cruise. The SeaSoar was deployed at 084/2004, and towed southwards; the shape of the survey that ensued can best be seen in Figure 1. A summary of the SeaSoar deployments that formed the survey part of the cruise can be found in Table 1. The first turn towards the north-east was made at 087/0900, the next towards the south-east at 088/1734 and the next towards the north-east again at 090/0402. Day 089 saw a strengthening of the wind again, with speeds of up to 40 knots from the east by 089/2330, as Discovery neared the southern end of the survey leg. In choppy seas, and in order to limit cable strains to no more than about 1400kg, the command signal to the SeaSoar was modified so that the maximum depth was 300m; the ship steamed at between 6.5 and 7 knots.

On Day 090, seawater was collected for the IAPSO standard seawater service between 1300 and 1400. Not long before, the SeaSoar had suffered its first failure of the cruise, the CTD signal becoming noisy at 090/0940; the immediate assumption was that the cable termination was failing, after a tow of 134 hours, and the vehicle was recovered. The cable termination showed some signs of wear, and a new termination was made. The new termination failed to restore the CTD signal, however, and the true cause of the problem was traced to the slip-ring junction box in the SeaSoar winch, which was was found to be full of seawater; the unit was repaired. It was not clear whether the seawater got into the junction box as a result of sea spray from the choppy conditions or as a result of liberal use of fire hoses to wash the deck above. The ship having remained in the vicinity while repairs were made to the SeaSoar system, the survey was continued without a break in spatial coverage.

Early on day 091 Discovery received the close attentions of a French military plane. The French authorities had refused permission for Discovery to work east of the 8°W meridian, which we were now approaching. The intention had been to turn due north just west of 8°W, but this was pre-empted by a failure of the SeaSoar hydraulic unit at 091/1448, at a longitude of 8°09W. Since no further time could be allowed to await repairs, Discovery headed towards the northern part of a CTD section on 8°25W. This section formed part of a network of CTD's and XBT's to be occupied as part of the GASTOM experiment led by the EPSHOM, Brest. Stations 12001 and 12002 were worked at a latitude of 46°22N and 47°02N, respectively, and the SeaSoar was redeployed at 47°30N at 092/0450 for a southwards tow along 8°25W to complete the meridional SeaSoar coverage; recovery of the vehicle commenced at 092/1405.

The remainder of the cruise was devoted to attempting to fulfil the UK commitment to the GASTOM experiment. After working a total of six full-depth CTD stations on Day 093 (three to more than 4000m), station 12009 had been completed. It was now necessary to reach a decision about which of the GASTOM CTD stations to occupy on 09°10W and 09°55W. The stations on 08°25W having been worked in remarkably quick time, a bold plan was devised which, it was hoped, would allow all the GASTOM CTD and XBT stations to be occupied, together with two extra stations on the shelf slope. The plan was all but fulfilled, by a combination of skillful and efficient manoeuvring by the ship's Officers to bring the ship onto stations, tight discipline amongst the scientific party to ensure that they were properly prepared for each station, faultless functioning of the electronic instrumentation (the old multisampler had wasted tens of hours of valuable scientific time on previous cruises, and would certainly have ensured that Cruise 189 fell well short of its goals), and weather conditions that enabled passage speeds of over 12.5 knots between stations (thanks to the Chief Engineer for meeting a much-revised steaming pattern when he had just finished bunker calculations and engine maintenance plans).

Stations 12010 to 12019 were worked to full depth between 094/0643 and 097/0238. The five longer steaming legs seen in the cruise track were in the shape of the letter 'Z', and included XBT's at each of the two turns. The XBT's used were Sippican T5's which consistently reached a depth of 1600m at a speed of 8 knots, the record ending when the wire in the launcher ran out. By the time station 12020 had been completed at 097/0851, the sea state had once again deteriorated, with wind and sea from the north-east, and it was apparent that passage to Barry would be slower than hoped. Accordingly, it was decided not to occupy the last planned station, in about 1500m on the shelf slope at 10°02W; the key to this decision was not the station time, which would have been less than an hour, but the need to shorten the passage to Barry. It was not possible to occupy a station in that depth en route to Barry, because the British authorities had requested that we should not deploy equipment east of 10°W and north of 48°N.

The PES fish was recovered at the end of station 12020, whereupon a course was set for Barry. The majority of scientific data logging was stopped shortly afterwards, when Discovery crossed the shelf edge. Discovery docked at Barry on the afternoon tide on Sunday 8 April (Day 098), after a very successful cruise. A number of new capital items of scientific equipment had proved to be of great value, both in terms of high quality data return and scientific time saved. Additionally, time lost to mechanical problems and poor weather had been won back as a result of dedicated work by members of the ship's personnel and of the scientific party. Although it was possible to clear customs formalities on the Sunday evening, it was possible to do nothing further useful until after 0900 the following morning when shoreside personnel produced the container into which IOSDL equipment was to be loaded. All IOSDL equipment was clear of the ship by 1400 on Monday 9 April.

BAK

3. INDIVIDUAL PROJECT REPORTS

CTD casts

Underwater equipment

The CTD was deployed as usual from the midships winch. The underwater equipment consisting of the following:

1. Neill Brown CTD; the IOS "new" deep CTD, with Beckman dissolved oxygen sensor.

2. SeaTech 100 cm. folded path transmissometer, number SN35.

3. One of two full ocean depth fluorometers, supplied by RVS. Aquatracker 6000 m. ser. nos. SA240 and SA228. SA240 was used for all stations except 12000-12002.

SA228 was used for stations 12001 and 12002, because SA240 was at that time installed in the SeaSoar vehicle.

4. 12 bottle General Oceanics multisampler system. For stations 11960 to 11964 the old 1.7 litre system was used. For station 11959 and for all stations from 11965 onwards, a brand new 2.5 litre system was used.

5. Seven SIS digital reversing thermometers. Five on loan from RVS and two belonging to IOSDL.

6. 10 Khz pinger.

Shipboard equipment

The shipboard equipment was the same system used for the past 15 years, with little exception. IOSDL has since taken delivery of four new CTD deck units, and it is hoped that this equipment will not be required at sea again. The equipment consisted of the following:

1. Two Neill Brown CTD deck units (one as a back-up).

2. One Digidata tape unit for data back-up.

3. One BBC computer system for real time data monitoring.

4. One IOSDL FSK demodulator (ex-FIDO).

5. Several water bottle firing units type RMS Mk. VI (including one brand new unit).

Underwater equipment - deployments and performance

A total of 62 CTD stations were occupied (Figure 2 and Table 5), 61 being with the 'deep' CTD sea unit and one with the 'shallow' sea unit that was used in the SeaSoar vehicle. All the stations occupied with the 'deep' unit were taken to within 100m or so of the bottom. Problems with the CTD data were mainly confined to the shipboard equipment while the underwater system required three Brantner lead replacements. This was a reasonable figure, considering the number of deployments, and could be due to the uninhibited use of nylon ties to keep the cables in place. The main sea cable termination successfully lasted the whole cruise. All the CTD sensors performed satisfactorily (P, T, C and O_2), although the conductivity cell appeared to show larger pressure and temperature characteristics than normal. No action was taken to change this because the availability of a large number of high quality Niskin bottle salinity samples meant that this effect could be removed in the data calibration process. The dissolved oxygen sensor (which had previously been used on Charles Darwin cruises 42 and 43) performed well throughout.

The transmissometer worked well. At the start of the cruise, careful cleaning of the optical surfaces of the instrument produced an air calibration of 4.33 volts (immediately before station 11959). Since the air calibration value is sensitive to even the smallest droplets of sea spray, it is difficult to get a good stable air calibration value except in reasonable weather. The air calibration was measured from time to time when conditions permitted, and the following values were observed, immediately before the station number given in brackets: 4.32 (11975), 4.33 (11977), 4.24 (11996), 4.32 (12001), 4.28 (12015) and 4.31 after careful cleaning immediately after the last station.

Both fluorometers worked well, number SA240 being used for 59 of the CTD stations and all the SeaSoar work.

The new 2.5 litre, 12 bottle multisampler system was a joy to use after the problems with other systems on other cruises, particularly in comparison with the old 1.7 litre system. Unfortunately problems arose on the first shakedown station (11959) when no bottles at all were fired. On inspection, after recovery, it was found that the new M & M connector on the multisampler base showed signs of corrosion due to sea water contamination.

For the following station (11960) the 2.5 litre system was replaced with the old 1.7 litre system that had been extensively refurbished and tested before the cruise at IOSDL. Unfortunately this again met with little success, for although all the bottles were fired it required 46 attempts to do so. On deck the system worked successfully, both before and after the cast. On checking the winch cable, it was found to have a higher than normal series resistance, up to 100 ohms instead of 75 ohms. A megger test across inner and outer indicated a resistance of 3 to 4 Megohms instead of infinity. The fault was found to be due to sea water damage on the winch to rotary joint cable connection which is located in a junction box on the winch. The damage was repaired and the 1.7 litre multisampler tried again on stations 11961 to 11964. These stations had a maximum pressure of 1300 db and a minimum temperature of 10°C. Although an improvement in bottle firing was achieved (an average of only four misfires per station) it was still unreliable and the 2.5 litre system was re-installed.

With the new system, including the new deck unit, 654 bottles were fired, with near 100% success, on a further 56 stations. The problems that did occur were usually resolved to trapped lanyards. This triumph gave confidence, saved time, boosted moral and, last but not least, provided reliable samples. The time saving aspect should not be underestimated.

A loss of 60 seconds per bottle fired adds up to about half a day of scientific time, or approximately four full depth CTD stations that could otherwise not have been occupied.

The SIS Digital Reversing Thermometers were used on nearly all the stations, the exceptions being a few stations in the early part of the cruise when changes were being made between 1.7 litre and 2.5 litre Niskin bottles. Comparisons between pairs of thermometers and CTD temperatures are given in the section on Niskin bottle sampling. On recovery of the CTD at the end of station 11993, in heavy seas, the CTD frame struck the platform and damage was sustained to the frame, to bottle number 7, and to one of the SIS thermometers (number T207). The bottle was repaired using spares but the thermometer, although appearing to operate, does not have its full display.

Because the CTD was being deployed near the bottom, a 10 Khz pinger was used for all casts. Apart from a fault with a pressure switch the units operated successfully.

Shipboard equipment - deployments and performance

The operational performance of the deck equipment was satisfactory, in view of the age and condition of the instruments. Problems arose with both CTD deck units, one having a faulty power supply and the second having an unstable clock frequency. Fortunately a FIDO FSK demodulator had been brought for use during SeaSoar development tests and this was then used to provide the CTD signals for the Level A interface to the shipboard computer.

The Digidata system was used throughout, recording CTD and SeaSoar data. A total of 34 tapes were recorded.

TJPG, SK

Niskin Bottle samples

Salinometer operations

Two Guildline salinometers were carried on this cruise, the old IOS one and a new one not previously used at sea. Both were set up for parallel operations by S. Bacon and J. Swallow. Approximately 1450 CTD bottle samples and 300 samples drawn from the ship's non-toxic supply were processed. One hundred and twenty seven ampoules of standard seawater were consumed.

Both salinometers were sited initially in the 'constant temperature' laboratory in the ship's after hold. This facility proved to be a CT lab in name only; it is, in fact, a cold room unsuited to salinometer operations. It is comprised of an insulated room with a high-power cooling plant with internal atmospheric 'stirring' provided by three large fans. Its nominal temperature range is from 0 to 20 °C. For comfortable working and to run the salinometers in one of their mid-range settings (21 or 24 °C) it is desirable to work at an ambient temperature of 20 or 23 °C. The higher value was outside the nominal range of the lab and it was unable to achieve the lower value, so the room had to be run at about 17 °C and the salinometers at 18 °C. The cooling plant cycled over about 8 minutes and a temperature range from about 17 to 18 °C.

Having set up both machines in this facility, reasonably normal operations were achieved for about the first week. After this, however, matters went somewhat awry. The familiar characteristic of the machines' displayed readings 'going for a walk', which can be expected usually about once every two dozen samples, increased in frequency to as often as once every three or four samples. Occasionally the reading would jump from its initial value either up or down by as much as 50 digits, then meander back to some other value. In order to obtain a stable conductivity ratio in these cases, each bottle had to be drained necessitating about a dozen readings from each sample. As both salinometers' behaviour worsened, this became necessary for every sample, as one could not be certain that one was not merely observing a transient plateau in the machines' wanderings. A further complication was provided by the old salinometer picking up some 'fluff' (presumably vegetable) inside the conductivity cell. This could not be dislodged, but did not seem to affect the machine's performance. Some other problems were encountered, but were dealt with effectively: it was found that blockages in the water or air circuits could be cleared by applying pressure with a suitable instrument (a syringe and a 'puffer' were used) to either the sample intake pipe or the air exit port. Also, the intake pipe bung on the new machine broke after two days; the upper portion above the grommet-ring fell off. The bung was replaced with the spare, but since there was only one, there was no spare for the rest of the cruise.

The major concern after about two weeks was the machines' stabilities. Both had become virtually unusable, to the extent that it could take an hour just to process five samples. There was much speculation over the cause of this. The lab ran off the ship's dirty AC supply, so the old salinometer was plugged in through a mains filter, but to no effect. The new salinometer's display had by this time become very difficult to read. In normal operation, the display will wander around a mean value by +/- one to three digits at about 1 or 1.5 Hz. However, the standby value, which should be steady, flickered seemingly randomly around a mean value by +/- five digits at about 2-3Hz., and the sample conductivity ratios flickered at a similar frequency and over a similar range. It is believed that it was still producing the 'right' salinity, but it had become difficult to use. A fault may have developed in the electronics.

Both machines were then removed from the 'CT' lab into the after end of the Bio lab. The ambient temperature here was quite adequate for the normal operation of the machines, being generally steady at around 22 °C with the after lab door shut and occasionally opening a window. The old salinometer settled back to fairly normal operation for the remaining two weeks of the cruise. The new salinometer also stopped its wandering, but the flickering remained. This must be attended to. The most plausible suggestion offered as to the cause of the machines' poor performance in the 'CT' lab was that of the proximity of the lab to the ship's main engines: it is directly above them. It is likely that the lab was subject to heavy magnetic disturbance, which could have upset the salinometers' sensitive electronics. The was also considerable mechanical disturbance (vibration) in this location. No sensitive electric or electronic devices should be used there.

The old IOS salinity sample bottles seem to have reached the end of their useful lives. Many are etched and unclear, or have a rainbow patina about their glass. Some of the less regularly used crates of bottles employed on this cruise had very heavy salt fouling from old samples which had remained inside uncleaned and had partially evaporated over some years. Being an essential but relatively cheap component of the research, they should all be discarded and replaced.

Standard Seawater consumption under the 'new regime' of standardising at the end of each crate (once every 24), or preferably once per hour (about once every 12), was somewhat underestimated. All but one of the 128 standards taken along were consumed, and for the latter part of the cruise, 'economy measures' had to be introduced, such as organising runs of three crates at a time over six hours so that a standardisation could be carried out at the end of each crate without using two standards per crate. Some reliance was placed on sub-standards (pre-opened standards or deep ocean water calibrated against a standard) for stability checks during runs. A working figure for Standard consumption would be a minimum of three times the maximum anticipated number of CTD casts (if drawing 24 samples per cast). This cruise just about ran out on 62 casts with 128 standards.

A final matter of interest concerned the standardisation of the old salinometer. In the past, the cell used to be left with standard seawater inside. On this cruise, the cell was regularly and thoroughly flushed with distilled water at the end of a run, and left with the same inside. In the past, it used to standardise to some value at the start of a run. At the end, the standardisation would be much the same, +/- a few digits. On this cruise, it generally started with some (stable) value which at the end would be about 30 digits higher (and stable). At the very end of the cruise, it was tried with leaving standard seawater in the cell instead of distilled water; the subsequent standardisation behaviour was more like the old, roughly constant value. The new salinometer's standardisation was very steady throughout the cruise; its cell electrodes appear bright and new. However, the old ones' appear dull and tarnished. This cell may require replacement. This matter needs to be investigated further.

SB, JCS

Oxygen sampling and titration

After the initial CTD cast (11959) had failed to return any water, oxygen samples for the next five casts were drawn from the old 1.7 litre Niskin bottles. These had been improved since cruise 181 and gave reasonable results. However, most samples (from cast 11965 on) were taken from the new 2.5 litre Niskin bottles; three people were trained to draw the samples. Two analysts were trained to titrate the samples using Winklers procedure.

A total of 1300 samples were drawn and analysed. Two litres of chemical reagents were provided and these were barely sufficient for the number of samples required (62 CTD's, 24 samples from each).

The old IOSDL Marine Physics unit, for titration by starch aided, visual determination of the end point was taken on the cruise, together with a semi-automatic unit using photometric end point determination. This was borrowed from the BOFS community (Biogeochemical Ocean Flux Study) by courtesy of Prof. Peter LeB. Williams, School of Ocean Sciences, UCNW, Menai Bridge.

At the beginning of the cruise there was some difficulty using the semi-automatic system because its operation was unfamiliar. Therefore, samples from the first five casts were analysed on the old Marine Physics unit. Once the analysts had more practise on the UCNW unit it was used to analyse the remainder of the samples as it was (ten times) more precise.

The precision of the samples was judged by the difference between two samples drawn from the same Niskin bottle. The differences were generally better than 0.01 ml/1, but as the cruise proceeded the results improved, with practise at both sampling and titration, as shown in Table 2. For the last group of CTD casts (12001-12017) 75% of the duplicates were better than 0.005 ml/1, and 91% better than 0.01 ml/1. For stations 12018-12020 single oxygens only were drawn.

The results are considered to be precise (better than 0.01 ml/1) but the ultimate accuracy of dissolved oxygen analysis depends on the standardisation of chemicals used in the titration. The deep water values, within the stable part of the water column varied over

0.15 ml/l (5.60 - 5.75) between batches of titrations and did not agree particularly well with the results of Saunders (1986) of 5.67 ml/l. There remains a question over standardising procedure and this problem will be addressed on return to IOS.

JFR, RP, JCS

Chlorophyll sampling

Duplicate samples for Chlorophyll analysis were drawn from all 12 Niskin bottles on station 11961 to provide a rough calibration for the Fluorometer SA240. A further 12 samples were drawn on stations 12001 and 12002 when Fluorometer SA228 was in use. The procedure used for filtering and analysis is described in the section on underway sampling.

SIS thermometers

Seven SIS digital reversing thermometers (DRT) were used on the cruise, two from IOSDL (T204, T238) and five from RVS (T207, T183, T179, T215, T156). No digital reversing pressure meters were available. The thermometers were racked in groups as follows: (T204,T238), (T207,T183,T179) and (T215,T156); these groups were unchanged throughout the cruise, although the position of groups on the multisampler rosette was changed from time to time. The groups will be referred to as group 1, group 2 and group 3 respectively. Each DRT had been calibrated at IOSDL prior to the cruise, using the ITS-90 (Saunders, 1990), and linear calibrations were applied to the DRT readings at sea. The calibrations used were

T204: $T=0.999750\ T_{raw} + 0.0055$

T238: $T=0.999459\ T_{raw} + 0.0017$

T207: $T=0.999584\ T_{raw} + 0.0025$

T183: $T=0.999977\ T_{raw} + 0.0040$

T179: $T=0.999341\ T_{raw} + 0.0038$

T215: $T=0.999467\ T_{raw} + 0.0034$

T156: $T=0.999817\ T_{raw} - 0.0017$

For stations for which the Niskin bottles occupied their normal positions on the rosette, group 1 was in position 2, group 2 was in position 7 and group 3 was in position 11.

A comparison of DRT readings with other DRT's in the same group and with CTD temperatures immediately prior to the triggering of the bottle has been carried out. First, note that there were 25 instances when the CTD temperature differed from the average DRT value for the group (Tctd-Tdrt) by 0.015 K or more. These were distributed as follows:

group 1: 6 instances, 3 positive, 3 negative

group 2: 10 instances, all negative

group 3: 9 instances, 1 positive, 8 negative

The three instances in which the group 1 difference was positive, were stations 11970, 11971, 11973, and occurred in water where the in-situ temperature gradient was positive downwards. All six group 1 differences in fact imply that the DRT temperature is shallower than the CTD temperature. Thus 24 out of the 25 instances suggest that the DRT measurement was taken at a shallower depth than the CTD temperature. Furthermore, 22 out of the 25 instances occur in the first 31 stations.

It is believed that this effect is related to the way that the lanyards for the thermometer frames were secured when the bottles were cocked. Early in the cruise, the usual IOSDL method was used, in which the lanyard from the bottom of the frame is looped around the lanyard from the top end cap, before that lanyard was secured by the firing pin. After it was suspected that some thermometers were not reversing until after the CTD frame was in motion , an alternative was used. This involved securing the lanyard from the bottom of the thermometer frame in a slot in the top end cap, after the top end cap has been cocked. While the top end cap is in the cocked position, the lanyard is held in place by a bead that fits into a round depression in the end cap. When the bottle is fired and the end cap closes onto the body of the Niskin bottle, the thermometer lanyard is displaced from the slot in the end cap so that the thermometer frame can reverse. This new procedure drastically reduced the instances of obviously erroneous DRT readings.

Excluding differences of 0.015 K or more, Table 3 shows a comparison of CTD/DRT differences and DRT/DRT differences within a group. Although the table is a little cluttered, it repays study. The following conclusions may be drawn.

1) SIS all warmer, by one sigma or so, by several sigmas on data less than 3°C. Is there some difference between calibration procedures and measurement at sea?

2) sigma is order 3mK, but less when temperature < 3°C.

3) consistency between some pairs excellent eg 204/238 but see mean difference (despite calibrations). Offset mean in T179 after knock on station 11993, but CTD and other SIS's appear unaffected.

4) In general, carefully calibrated SIS thermometers seem capable of providing a temp measurement accurate to a small number of millidegrees. This would be a useful measurement if it became necessary to estimate a CTD calibration while at sea. Where vertical gradients are weak, between 75 and 90 percent of comparisons were within 0.002 K of the mean offset.

TJPG, BAK

Nutrients

Duplicate nutrient samples were drawn from all Niskin bottles, into plastic sample bottles. There being no autoanalyser on board, the samples were frozen for later analysis ashore. It had been intended that the samples should be analysed very shortly after return to IOSDL, on a new autoanalyser that had been purchased by the Marine Physics Group. Unfortunately, upon return to the laboratory, the new equipment was not yet working satisfactorily, and there was a considerable delay before the samples could be analysed. The quality of data will be assessed by comparison with historical data. They will not be included in the CTD Data Report.

RP, BAK

SeaSoar

SeaSoar deployments

The SeaSoar programme was in two parts. Part one consisted of tests on the vehicle to assess the feasibility of fitting a thermistor array to the SeaSoar. The array would be suspended below the vehicle with a depressor at the bottom end. These tests were carried out during the early part of the cruise, using the passage between CTD stations for SeaSoar test runs. No Fluorometer data could be collected because the space normally filled by the Fluorometer was occupied by telemetry equipment related to the vehicle tests. For the second part of the programme the vehicle was configured in the usual mode for scientific data gathering, with a Fluorometer fitted.

Equipment

The SeaSoar vehicle was deployed from the aft end using an 'A' frame mounted on a flatbed base on the port side of the poop deck, and the IOSDL vertical drum winch mounted on the main deck. The winch held approximately 515 metres of cable with Fathom fairing.

Underwater equipment

For the vehicle tests the underwater instrumentation included the following:

1. Shallow CTD No.1.

2. Telemetry electronics tube.

3. 30 metres faired cable with strain sensor and inclinometers top and bottom, suspended under the SeaSoar vehicle.

4. Depressor attached to 30 metre cable.

5. Wing and bridle angle sensors, pitch sensor and towing bracket strain gauge mounted on the vehicle.

For the routine scientific data gathering mode the instrumentation included:

1. Shallow CTD No.1.

2. Aquatracker 6000 number SA240.

Shipboard equipment

The shipboard instrumentation included the shipboard items described under the CTD project, plus:

1. SeaSoar control unit.

2. Telemetry data decoder and PS2 computer for the trials programme.

Deployment and performance

A total of five deployments were made for the thermistor chain feasibility tests.

Run number

1. Day 073. Duration 3 hours 34 minutes. Shakedown and partial repeat of previous (Cruise 181) vehicle tests.

2. Day 074. Duration 3 hours 50 minutes. Check on vehicle performance with ballast weight moved forward.

3. Day 075. Duration 3 hours 28 minutes. Measurement of vehicle performance with Attenborough depressor attached on 30 metres of unfaired cable below SeaSoar.

4. Day 077. Duration 4 hours 26 minutes. Repeat of Run 3, but now using Packwood faired cable.

5. Day 078. Duration 4 hours 33 minutes. Continuation of tests, configured as for Run 4.

For the normal data gathering mode a further three runs were made.

Run number

6. Deployed day 084. Recovered day 090. Duration 5 days, 16 hours, 4 minutes. Reason for recovery was loss of signal. After recovery, it was found that the winch slip ring assembly was contaminated with seawater. Cable termination at bridle was remade while vehicle was inboard.

7. Deployed day 090. Recovered day 091. Duration 22 hours, 4 minutes. Reason for recovery was loss of vehicle control in auto, manual and override modes pointing to a possible hydraulic fault. During recovery the slip ring assembly was damaged when the winch cable was torn out of the unit. Vehicle hydraulic unit was replaced.

8. Deployed day 092. Recovered day 092. Duration 8 hours, 20 minutes. Reason for recovery being the end of scientific programme.

Depressor tests

As part of the thermistor cable trials test it was intended to try a second type of depressor on the SeaSoar. After inspection of the data gathered with the first depressor it was decided that it was not necessary to deploy the second depressor with the SeaSoar but instead some tests were done by towing the cable from the boom near midships on the starboard side of the ship.

The second depressor, manufactured by EG & G, and loaned by RVS, was suspended by 18 metres of Packwood faired cable. A series of measurements of towing angle and cable strain against ship's speed over the range 0 to 10 knots were made. The measurements were repeated with the Attenborough depressor with and without the Packwood fairing.

Recommendations relating to CTD equipment

1. Damaged SIS thermometer returned to manufacturer for repair.

2. 1.7 litre multisampler returned to manufacturer for refurbishing.

3. Never use the two original CTD deck units again in an operational capacity.

4. Start a programme to look at a replacement for the SeaSoar control unit.

5. Refurbish existing CTD/Multisampler frame.

6. Purchase replacement stainless steel frame with modifications to tube clamps, protection rails for transmissometer.

Conclusion

Once again, we wish to thank the officers and staff of RRS Discovery for their assistance and friendliness in deploying and recovering SeaSoar and, in general, making our life aboard a little easier.

TJPG, SK, DG, RNB

XBTS

XBT's were controlled by a Bathysystems SA810 controller connected to an IBM PS2 in the Chemistry Laboratory. The PS2 was in place of the HP85 previously used to control the SA810, and was running Bathysystems software on loan from the Hydrographic Office, Taunton, for evaluation. The PS2 software performed mainly the same functions as the HP85 software (control launch, replay data to plot or listing, list isotherms), but had the considerable advantage that data logging and replay was almost instantaneous rather than taking several minutes per function.

Two weaknesses noticed in the software were that it was possible to lose the data between the XBT launch and the data storing phase by pressing the wrong key, and that the interactive part of the program concerned with input of position etc. requires a very specific (and rather cumbersome) input format. These faults are apparently hangovers from the HP85 software, and should be fixed.

After data had been stored on the PS2 in the Chemistry Lab., they were transferred to a PS2 connected to the ethernet. Data files recorded on the PS2 consisted of some header information and a list of voltages recorded at 10Hz; the SA810 manual gives equations for the conversion of voltage to temperature and time to depth. Voltage data were then read out of the PS2 files, converted to temperature and depth and stored in RVS data format files on the SUN system.

A total of 53 XBT launches were attempted, consisting of 34 Plessey T7's and 19 Sippican T5's. This resulted in a total of 26 good T7 records (to 760m) and 16 good T5 records. The suggested speed for launching T5's is 6 knots, with a suggested depth capability of 1800m. One launch at 10 knots produced a record of 1400m before the wire in the launcher ran out, and subsequent launches at 8 knots produced depths of about 1700m before the wire ran out. Since time was very short when the T5's were being used, 8 knots was used as the launch speed. The positions of the good records are given in Table 4. The failures of each type of probe were as follows:

Plessey T7 failures:

Operator error	2
Successful launch but suspect record	3
Probe fell to pieces on deck	3

The last entry refers to a number of probes, all from the same box. The problem was that the ballast weight fell off before the probe could be launched. Out of one box of 12 probes, three ballast weights fell off, three others produced suspect records, and five probes were left in the box, being saved for further investigation; clearly the box had been damaged at some stage. This box was one of four supplied to IOSDL in a single wooden crate, and it was suspected that damage to that single box must have occurred before it was packed with the other three.

Sippican T5 failures:

Operator error	1
PS2 error (wrote corrupted file to disk)	1
Unspecified (PS2 'hung';probably operator error)	1

There were no T5 failures attributed to the probes

The PS2 error refers to an occasion when an apparently good record was plotted to the screen in real time, but a faulty disk file was written. When an attempt was made to read the file, a disk read error occurred after about 250m worth of data had been read. An intermittent fault on the PS2 floppy disk drive was suspected, and thereafter data were logged to the hard disk with the floppy disk drive used only for data transfer.

BAK

ADCP

This system was initially working well but after a few days the signal gradually faded away. The IBM and the ADCP programs were checked through and found to be fully functional; the problem was then tracked down to a flooded junction box at the bottom of the ASDIC platform. This entails removal of the ASDIC from the ship to effect repair.

Prior to the failure of the ADCP system, there was some investigation of the measurement of the heading of the ADCP transducer. The ADCP transducer on RRS Discovery was mounted on a shaft that could be deployed beneath the ship's hull, in order to get the transducer further away from the layer of bubbles which is present, especially in poor weather. This shaft is of circular cross-section and was intended to be steerable for use with side-scan sonar. For ADCP use it is supposed to be fixed relative to the ship by clamps. It was found, however, that within a few hours of securing the transducer pod in the outboard position, the shaft had developed a heading offset of between five and ten degrees relative to the fixed clamps, by working round within them. Thus the heading of the transducer is not known to sufficient accuracy to correct underway data to absolute velocities using accurate ship navigation.

It is not known how long this problem may have been corrupting ADCP data collected on the ship. Data collected prior to the failure of the system have been discarded.

CHW, BAK

Navigation

Navigation was provided by transit satellites and GPS fixes, combined with EM log data. The EM log was calibrated using a series of zig-zag manoeuvres, as described by Pollard and Read (1989). GPS fixes were provided by a minimum of two satellites and the Rubidium standard clock. The cruise was noteable for a period of 24 hours continuous GPS coverage, although the precession of the satellites meant that about 20 hours per day was more usual.

RBL

PES

The PES system performed well, with only a few minor problems on the Mufax which were corrected as they occurred.

CHW

Surface sampling

Chlorophyll sampling and analysis

Duplicate surface seawater samples were drawn from the non-toxic supply for fluorometric analysis, at four-hour intervals while the SeaSoar was deployed. The samples were drawn to coincide with the rise of the SeaSoar to the surface, and were used for calibration of the Fluorometer on the SeaSoar.

After SeaSoar was recovered at the end of the survey track, sampling frequency was maintained at every four hours; however, due to time constraints on analysis, single samples only were drawn. A total of 118 samples were taken.

For each sample, 200 ml of seawater were filtered, using a 2.5 cm. Whatman Glass Microfibre Filter (0.7µm) and a suction pump. The filter was subsequently placed into a vial containing 10 ml of 90% acetone and left for a minimum of eight hours in the dark to allow extraction.

After extraction, all samples were analysed with the 'Turner Fluorometer, Model 113', using X3 sensitivity scale. After an initial reading, a further reading was determined following addition of three drops of 1M Hydrochloric acid.

Standardisation of the Turner 113 was achieved using appropriate dilutions of a 1 mg Chlorophyll A Standard (*Anacystis nidulans* algae - Sigma Chemical Co No. C-6144) in 90% acetone (BDH AnalaR was used throughout). It was apparent that two litres of acetone are required for the standardisation procedure.

An initial standardisation of the Turner 113 performed at the beginning of the cruise gave an unsatisfactory relationship between chlorophyll A and fluorescence. This could have been due to the relatively short time that the instrument had been on (overnight), or to poor standardisation technique. A second attempt brought no improvement. Much later in the cruise, towards the end of the SeaSoar deployment, a new Chlorophyll standard was made up and a satisfactory standardisation was obtained. A direct linear relationship was found between chlorophyll and fluorescence for both basic and acidified readings. This standardisation was used in the calibration of all the Chlorophyll samples drawn during the cruise.

The results obtained from the 118 samples gave values varying from 0.2 to 2.9 mg per m^3.

RP

Thermosalinograph

As soon as the non-toxic sea water supply was started a massive leak was apparent in the sensor housing. Upon investigation the fault was found to be caused by careless assembly in that the sealing O-ring was not in its groove. The BBC microcomputer, which provided local monitoring of the TSG, was troublesome from the start and declined to run at all by the end of the trip although data were still being logged from the electronics unit.

CHW

Meteorological Data/MET PAC

The system performed adequately, apart from the barometer which had failed at the start of the trip. Repair was not possible due to the lack of appropriate components.

CHW, RBL

Deck equipment

Midships Winch and Hydraulic Equipment

The midships winch was used for a total of 62 CTD stations and operated down to a maximum depth of 5550 metres.

No problems were experienced with its operation throughout the cruise, though shortly after starting work it became apparent that the bearings for the metering sheave were worn out. As the sheave carries very little load and the problem was not affecting the wire lay, we waited until the weather improved and took the opportunity to repair it during the SeaSoar survey.

The forward hydraulic ring main pump performed very well, with the only problem occurring at the start-up of the first station. As the pump was being started it failed to develop any pressure and cavitated continuously. It was suspected that the swashplate had gone over-centre and, by adjusting the stroke limiter, pressure was regained.

Aft platform and A frame

The aft platform and 'A' frame were used for all the SeaSoar deployments and towing; the only problem encountered being the operation of the brake on the Rexroth Winch. The winch was used for controlling the height of the towing sheave and it was found that when the height was adjusted the brake would not release fast enough, or completely, resulting in a jerky operation of the winch. The problem was not with the adjustment of the brake band but the lack of movement of the operating 6mm of movement. The ram fitted appears to be a replacement unit and may be the wrong model as the hydraulic pressure seems to be incapable of overcoming the spring-pressure. Arrangements will be made to have it replaced in port.

No other standard deck equipment was used for this cruise but each unit has been run up and updated. The aft winch conductor cable has been wound onto the storage drum and the coring warp was run up through the traction winch in preparation for the next cruise. (BOFS LEG 1)

RNB, MGS

Millipore system

At the beginning of the cruise, a two-phase water purification system was installed in the biology laboratory, mainly in preparation for the BOFS cruises which follow, but also to provide a clean water supply for oxygen and fluorometer measurements on cruise 189. Unfortunately, the installation could not be completed as scheduled due to some missing components, which only arrived shortly before the ship sailed. On inspection one connector has not been provided and the system had to be completed by improvising a connection to a tank outlet.

The system comprises a Milli-Ro water system feeding a large reservoir with distilled water, coupled to a Milli-Q purification system to provide highly purified water for chemical analysis purposes. The two parts of the system were set up as shown by the operating instructions and performed without incident for half of the cruise.

Unfortunately, the Milli-Ro system later broke down because the prefilter became clogged with debris from the ship's cold water supply which induced a pressure differential between the two sides of the filter and triggered an automatic cut-out. On inspection, the filter was not recoverable, and no spares were available. The most practical solution was to run the Milli-Q on the remaining water in the reservoir for as long as possible before switching it off and using its prefilter to replace the one in the Milli-Ro. This enabled analyses to continue with reasonable confidence about the water quality involved.

One other problem connected with the ship's water supply is the presence of water hammer in the pipework when supply is drawn at other points in the plumbing. At times all the pipework connected to the purification system was seen to wildly vibrate. It is not known what effect this will have in the long term on the two units.

In the light of this experience, it is apparent that the ship's water supply is not of sufficient quality for use in analyses at sea. It is not certain how much distilled water and of what quality the ship can supply, but if a quality source is to be ensured, then the user either supplies his own (which may be impractical for some cruises) or these water purification systems are installed as a matter of course on all ships. One further recommendation is, of course, that a number of spare filters are brought with each system.

SGA

Computing

Navigation

This cruise benefited from almost continuous GPS cover (using a minimum of two satellites and Rubidium standard). A problem occurred with fixes that used SVC 11 but this was resolved by disabling the use of this satellite.

For this and subsequent cruises the Trimble GPS receiver was interfaced to a Navigation Display Unit (NDU) providing 99 waypoints, crosstrack error display and all the facilities of the Magnavox MX1107 Transit satellite system. The documentation provided with the NDU is poor and it was only after trial and error it was discovered that all navigation calculations were based on Great Circle courses. For survey applications Rhumb line is needed. RVS have been asked to supply the more comprehensive manual that is known to exist.

The MX1107 performed well throughout the cruise and maintained navigation facilities on its internal battery during the complete powerfail that occurred on day 90.

Data logging

Level A's

CTD/SeaSoar

Two 8086 based Level A's were provided for this cruise enabling one to be set up for CTD and the other for SeaSoar, thus enabling rapid changeovers. One unit has a particularly poorly calibrated clock (4% fast) and was used for CTD work. The firmware in the SeaSoar Level A produced invalid variable syntax but this was corrected at a later stage or processing.

Anemometer/Metpac

These performed satisfactorily throughout the cruise. The analogue interface on the metpac was replaced on day 77 and a small positive offset was observed on all channels. The barometer interface was not functional during the cruise. No spares were available onboard.

TSG103/Turner Fluorometer

Both performed well. The thermosalinograph firmware was changed to log counts which should have allowed onboard calibration; however, the initial calibrations provided by RVS were incorrect and little time was available to work up new data.

EMlog/Gyro

This performed well, except for the usual RF interference.

GPS/MX1107

This performed well.

Level B

This worked well throughout the cruise with no crashes. It successfully buffered data when the SUN parser suffered overflow problems (this happened twice - see later).

XBT

Logging was done on a PS2 using proprietary software which proved largely successful. The user interface is derived from the HP85 software and needs some improvements. Operator error let to some lost data, for example, when 'P' for print was pressed in the absence of a printer. However, the software is an improvement on previous practice and, if modifications are forthcoming, would be a useful purchase.

The data was transferred by disc to the SUN network PS2 and thence to RVS format data files.

ADCP

The ADCP was interfaced via a serial buffer to the parsing SUN. The buffer is intended to overcome the lack of handshaking between the ADCP, IBM and the SUN. The system ran for five days when the buffer box failed. The ADCP itself suffered progressive failure over the next few days.

SUN Computer Network (Level C)

For this cruise an extra SUN 3/60 workstation was provided in the Bio Lab. This, and the 3/60 in the Clean Room, were used exclusively for PSTAR.

The two 3/60's in the Computer Room and their discs supported the logging. The raw data disc partition was restricted to 60Mb. and, while this imposed its own discipline upon backups, it was unnecessarily restrictive. Much use was made of a spare 150Mb. partition to form data sets for additional processing and archive.

On the raw data machine an additional process was inserted into the parsing stream to correct the SeaSoar data syntax reported above. It was a simple stream edit (sed) adding a leading zero to decimal numbers less than one.

On two occasions the raw data logging ceased due to a buffer overflow (zsl: silo overflow). Fortunately, the Level B recognised the lack of handshaking and buffered the data. The first instance went unnoticed for 90 minutes and, once corrected, the associated backlog cleared in some 40 mins.

During deep CTD dips it became clear that changes were needed to the SUN screen graphics interface (scgi). An option was provided to permit a white background and the window was changed to allow it to re-draw after re-sizing, or when an overlaid window was removed.

Extensive use was made of the Nicolet plotter for PSTAR and RVS plotting; however, it is apparent that their respective use of HPGL can be incompatible. Full investigations were not made but the problem is thought to lie in the way UNIRAS uses some of the more advanced facilities of HPGL. This problem should be investigated as it frequently meant that the plotter had to be re-threaded. Efforts should be made to introduce spooling and plot advance to ease remote use of the plotter.

Operational trials were made of the new RVS graphical editor. These were largely successful. The user interface is complex but, once mastered, becomes easy to use. There are delays in dealing with very large files (SeaSoar sections), and perhaps some more work is needed here. We were not able to achieve block offsets but this may not be fully implemented yet.

The RUN hardware and peripherals all worked well with no problems, except for the video adapter and personal display unit of the Tektronix plotter on the Computer Room SUN 3/60. Unknown problems using the cartridge drive occurred with the Clean Room 3/60. These did not happen when the cartridge drive in the Computer Room was accessed by the same software remotely.

RBL, PAD

PSTAR

The PSTAR suite of programs was mounted on the Discovery SUN system at the start of Cruise 189 without incident. On the whole, the system worked as expected. A number of programs were corrected for minor bugs and some new programs created. One concern is the growing number of similar programs which perform only slightly different functions - some rationalisation is required in this area.

A number of execs were written to perform routine processing of data from specific instruments. These are CTD, ADCP, SeaSoar, navigation data, and the various underway sampling instruments, such as the thermosalinograph. One problem with the use of execs previously has been the lack of error checking and the difficulty of keeping track of what processing has been done on a particular file (since the details are hidden in an exec, which may or may not change during a cruise). The execs were written so that the system status variable is checked after every program has completed, so that the exec can abort, if necessary. This further implied that all programs which seek to test for illegal input have to stop by resetting the status variable - a review and correction of the full suite of PSTAR programs was performed to achieve this.

The execs generally can be divided into groups which perform similar functions. The first grouping involved those execs which convert the RVS data format into PSTAR format, entering any extra information about the data and tidying up names and units of variables. Later execs then perform calibration and de-spiking on the data. At each stage an archive copy of the file is created so that it can be referred to in case of later problems. It has also been convenient to build plotting into execs, especially where a number of standard forms are required (e.g., for editing SeaSoar data).

A number of points have emerged from the attempted semi-automation of processing. For example, originally the choice of potential temperatures in the down cast corresponding to the same values in the up-cast at which bottles were fired was chosen by a program called 'refval' which looked for the first occurrence of a value which exceeded the value input. This proved to be in error in many cases, and the best method turned out to be to list the whole cast in steps of 10 and choose the values by eye.

A problem outstanding from the previous cruise, using PSTAR (Darwin Cruise 43), recurred. This was associated with the use of the UNIX tar command to archive data files to tape. On occasion, at the beginning of a write to tape, the SUN crashed (or hung) and needed re-booting. This only seemed to occur on the second or later tar file on the tape and never the first, so the tape had been positioned before writing with the command mt. No such problem is known to occur on the IOSDL SUN 4's, though it must be said that the quantity of data written to tape on that system is probably much less.

A new method for performing archiving (see below) was constructed using three execs (one for archiving, one for restoring and one for listing the contents of a tape) using the UNIX command dd. This is based around the use of a set of disk files, one for each tape used, which record the number of files and the content of each archive tape. The execs then use these files for positioning before reading or writing data. Another series of execs can then be used to obtain information from the tape summary files before performing a particular operation, e.g., removing the file from disk.

The problem which occurred with tar seemed to have been avoided at first by this use of the dd command to write to tape without housekeeping (which the tar command performs automatically), e.g., preservation of the original filename and ownership. However, near the end of the cruise a similar problem occurred with the dd exec when writing to tape. There is a suspicion that the problem lies in accessing the SCSI bus on the particular SUN that archiving was performed from. The problem seemed to go away when the SUN used for RVS processing was used remotely, writing to its tape drive.

Two further unresolved problems recurred, both involving the Nicolet plotter and its driver. The first problem was one of scaling: a program requesting a line of a certain length would produce a line slightly longer on the hardcopy, which could only be resolved by scaling the original length by 1.001. The second occurred between plots, when the pen would stop at a point removed from the origin at the end of one plot, and shift the equivalent distance to the origin at the beginning of the next, irrespective of whether or not the pen had been repositioned.

SGA, JFR, CH, BAK

5. ACKNOWLEDGEMENTS

Parts of RRS Discovery Cruise 189 were hampered by poor weather. The authors are indebted to the dedication and skill of the Master and Officers, which enabled station work to continue safely in difficult conditions. Without their willing cooperation, several days of scientific time would have been lost and the scientific objectives would have been met less fully. Later in the Cruise, the Chief Engineer exercised great patience as the Principal Scientist repeatedly revised the steaming requirements for last few days of the scientific programme; he also ensured that engines were available to meet them.

The considerable effort made by Tony Poole from the Research Vessel Base to help mobilise the Discovery in Cardiff prior to the Cruise is also gratefully acknowledged.

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6. REFERENCES

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Table 1 Start and stop times of SeaSoar runs.

run number	start time	latitude degrees(N) minutes		longitude degrees(W) minutes		stop time	latitude degrees(N) minutes		longitude degrees(W) minutes		comments
1	73/1250	41	49.56	15	01.41	73/1640	41	47.80	15	36.67	after CTD11971
2	74/1300	41	38.59	17	35.93	74/1600	41	40.15	18	00.80	after CTD11974
3	75/1330	41	45.05	20	07.18	75/1720	41	59.19	20	15.07	after CTD11977
4	77/0840	45	25.89	19	56.83	77/1330	45	56.23	19	55.74	after CTD11983
5	78/1320	47	53.86	19	34.37	78/1800	48	21.42	19	36.25	after CTD11987
6	84/2000	51	51.31	16	27.67	90/1035	44	04.53	10	24.95	134h 35min loss of CTD signal
7	90/1540	43	58.20	10	33.52	91/1420	46	23.01	08	10.87	22h 40min hydraulic failure
8	92/0520	47	27.34	08	25.30	92/1340	46	19.86	08	25.30	8h 20min end of survey

Table 2 Distribution of differences between duplicate sample oxygens.

Oxygen difference $\times 10^{-3}$ ml/l	0-5	6-10	11-20	>20	station numbers
Number in range	68	41	27	21	11966-11982
	99	33	32	11	11983-12000
	128	28	9	6	12001-12017

Note that for the last group of stations, 75% of duplicate pairs agree to within 0.005 ml/l, and 91% to within 0.01 ml/l.

Table 3 Differences between CTD (C) and SIS Digital Reversing Thermometers. Thermometer numbers omit letter T. All temperatures calibrated to ITS-90.

Pair	mean m°C	std.dev. m°C	n	n within 2 m°C of mean
C-204 (<3)[1]	-1	3	36	
C-238 (<3)	-4	2	36	
204-238 (<3)	-3	1	40	
C-204 (>3)	-3	6	7	
C-238 (>3)	-4	4	6	
204-238 (>3)	-2	5	8	
C-204 (all)	-1	3	43	34
C-238 (all)	-4	3	42	35
204-238 (all)	-3	2	48	44
C-207 (early)[2]	-5	1	13	
C-183 (early)	-4	2	13	
C-179 (early)	-4	2	14	
207-183 (early)	1	2	21	
207-179 (early)	1	3	21	
183-179 (early)	0	4	21	
C-207 (late)	-5	5	17	
C-183 (late)	-4	4	22	
C-179 (late)	0	6	23	
207-183 (late)	1	1	18	
207-179 (late)	5	5	19	
183-179 (late)	5	3	24	
C-207 (all)	-5	4	30	22
C-183 (all)	-4	4	35	26
C-179 (all)	-2	5	37	bimodal[3]
207-183 (all)	1	2	39	35
207-179 (all)	3	4	40	bimodal
183-179 (all)	3	4	45	bimodal
C-215 (<3)	-3[4]	3	10	
C-156 (<3)	-4	1	9	
215-156 (<3)	-3	3	17	
C-215 (>3)	-2	5	33	
C-156 (>3)	-4	6	31	
215-156 (>3)	-2	2	33	
C-215 (all)	-2	5	43	26
C-156 (all)	-4	5	40	25
215-156 (all)	-2	3	50	38

Note 1 : Temperature values less than 3°C, see p. 11.
2 : Early and late refer to before and after CTD frame accident, see p. 11.
3 : Due to the calibration offset on T179, the distribution of differences is bimodal. The number of differences within 2 m°C of the mean is therefore a poor indicator of performance.
4 : The modal value is -1.

Table4 RRS Discovery Cruise 189 XBT position list

XBT number	March day	Year day	time	probe type	max depth (m)	latitude degrees(N)	minutes	longitude degrees(W)	minutes
18902	13	72	1511	T7	0763	42	00.24	12	35.58
18903	13	72	2209	T7	0763	41	56.34	13	26.64
18905	14	73	0637	T7	0763	41	52.74	14	27.06
18906	14	73	2243	T7	0763	41	45.78	16	11.76
18907	15	74	0605	T7	0763	41	43.14	17	01.68
18908	15	74	2354	T7	0763	41	39.24	18	51.78
18909	16	75	0806	T7	0763	41	34.98	19	41.40
18910	16	75	2342	T7	0763	42	32.52	20	15.30
18911	17	76	0737	T7	0763	43	09.30	20	11.34
18912	17	76	1406	T7	0763	43	45.54	20	05.88
18913	17	76	2039	T7	0763	44	24.18	20	00.24
18914	18	77	0305	T7	0763	45	02.28	19	58.62
18915	18	77	1831	T7	0763	46	17.52	19	49.02
18916	18	77	1837	T7	0763	46	18.42	19	48.84
18917	18	77	2341	T7	0763	46	36.30	19	48.48
18919	19	78	0137	T7	0763	46	55.02	19	45.00
18920	19	78	0831	T7	0763	47	36.00	19	37.20
18921	20	79	0028	T7	0763	48	58.02	19	31.02
18922	20	79	0748	T7	0763	49	41.34	19	30.48
18923	20	79	1421	T7	0763	50	21.00	19	37.02
18924	20	79	1426	T7	0763	50	22.62	19	36.60
18928	20	79	2112	T7	0763	51	03.90	19	28.50
18929	20	79	2125	T7	0173	51	16.86	19	31.44
18931	21	80	0946	T7	0763	51	43.14	19	53.10
18932	21	80	1510	T7	0763	51	51.24	20	09.96
18933	25	84	0429	T7	0763	52	39.70	15	50.08
18934	32	91	2136	T5	1395	46	41.76	08	25.14
18935	33	92	0356	T5	1681	47	29.22	08	24.96
18936	33	92	1536	T5	1646	46	01.92	08	24.90
18937	33	92	2232	T5	1605	45	22.14	08	26.22
18939	34	93	0524	T5	1681	44	40.44	08	25.14
18940	35	94	0119	T5	1786	44	40.98	09	55.02
18941	35	94	0419	T5	1751	44	32.40	09	10.74
18942	35	94	1711	T5	1740	45	20.82	09	54.90
18944	36	95	0847	T5	1581	46	01.08	09	54.90
18945	36	95	1141	T5	1599	45	51.96	09	11.10
18946	36	95	1157	T5	1792	45	53.58	09	10.14
18947	36	95	1212	T7	0763	45	56.40	09	10.26
18948	36	95	2326	T5	1728	46	41.22	09	55.26
18949	37	96	0222	T5	1722	46	31.98	09	10.08
18950	37	96	1416	T5	1681	47	21.48	09	54.54
18952	37	96	1804	T5	1728	47	12.66	09	09.18
18953	38	97	0439	T5	1699	48	01.08	10	01.98

Table 5 RRS Discovery Cruise 189 CTD station list

Station number	March day	Year day	start time	down time	end time	max press (db)	corrected depth (m)	latitude degrees (N)	minutes	longitude degrees (W)	minutes
11962	12	71	1022	1026	1047	0161	0177	42	15.75	09	13.63
11963	12	71	1215	1231	1259	0659	0659	42	15.87	09	28.12
11964	12	71	1434	1455	1535	1281	1293	42	14.27	09	32.36
11965	12	71	1703	1739	1830	2139	2144	42	13.10	09	41.00
11966	12	71	2159	2245	2354	2783	2773	42	09.14	10	19.80
11967	13	72	0422	0459	0550	2443	2454	42	05.70	11	13.40
11968	13	72	1043	1141	1302	4057	4100	42	02.24	12	07.70
11969	13	72	1711	1841	2022	5395	5339	41	57.80	12	59.60
11970	14	73	0112	0234	0414	5327	5340	41	54.10	13	57.50
11971	14	73	0824	0938	1137	5265	5336	41	51.00	14	47.00
11972	14	73	1725	1847	2030	5275	5231	41	47.82	15	40.47
11973	15	74	0044	0213	0353	5131	5154	41	43.24	16	33.42
11974	15	74	0821	0956	1155	5515	5573	41	38.97	17	26.51
11975	15	74	1824	1937	2125	5075	5148	41	40.49	18	23.60
11976	16	75	0232	0356	0532	4515	4531	41	34.56	19	13.38
11977	16	75	1019	1052	1150	2137	2200	41	34.04	20	03.82
11978	16	75	1853	1952	2113	4133	4126	42	10.10	20	17.43
11979	17	76	0152	0325	0515	5309	5339	42	47.83	20	14.37
11980	17	76	0957	1053	1204	3959	3989	43	26.52	20	09.26
11981	17	76	1619	1713	1823	3865	3856	44	03.84	20	02.58
11982	17	76	2252	2351	0110	4079	4086	44	42.72	20	00.23
11983	18	77	0511	0620	0744	4461	4459	45	18.96	19	57.52
11984	18	77	1411	1515	1640	4367	4380	45	58.98	19	53.42
11985	18	77	2034	2147	2347	4853	4804	46	35.88	19	47.40
11986	19	78	0337	0448	0615	4567	4556	47	14.50	19	41.95
11987	19	78	1039	1151	1320	4519	4566	47	54.76	19	34.85
11988	19	78	2000	2100	2219	4011	4034	48	38.67	19	31.78
11989	20	79	0247	0354	0501	3849	3846	49	19.46	19	31.39
11990	20	79	1004	1106	1230	3989	4005	50	01.81	19	35.92
11991	20	79	1630	1725	1833	3781	3775	50	41.23	19	36.45
11992	21	80	0000	0104	0216	3711	3683	51	20.01	19	33.71
11993	21	80	2223	2328	0050	3821	3807	52	00.91	19	34.32
11994	22	81	1116	1201	1305	2643	2675	52	40.18	19	33.10
11995	22	81	1709	1812	1936	3987	4022	52	39.75	18	29.22
11996	24	83	1728	1830	1953	3745	3744	52	39.96	17	24.23
11997	25	84	0033	0130	0236	3443	3461	52	39.76	16	17.50
11998	25	84	0615	0703	0753	2879	3017	52	39.90	15	27.58
11999	25	84	0918	0946	1015	1567	1570	52	39.91	15	13.17
12000	25	84	1144	1200	1222	0993	1109	52	39.72	15	02.24
12001	32	91	1652	1804	1937	4851	4788	46	22.11	08	25.65
12002	33	92	2342	0050	0202	4197	4164	47	02.36	08	25.53
12003	33	92	1745	1859	2040	4929	4868	45	41.52	08	24.92
12004	34	93	0040	0159	0320	4969	4901	45	01.41	08	24.75
12005	34	93	0724	0829	0942	4495	4475	44	22.08	08	24.56
12006	34	93	1039	1106	1145	1791	2003	44	14.96	08	25.06
12007	34	93	1432	1454	1520	1205	1243	44	11.28	09	02.60
12008	34	93	1614	1649	1723	2307	2314	44	12.41	09	10.31
12009	34	93	2051	2204	2338	5003	4954	44	21.62	09	55.45
12010	35	94	0643	0743	0910	4989	4916	44	53.42	09	09.84
12011	35	94	1228	1355	1525	4987	4922	45	01.95	09	55.94
12012	35	94	2240	2355	0121	4911	4891	45	32.45	09	09.29
12013	36	95	0449	0548	0654	4803	4834	45	42.34	09	55.82
12014	36	95	1350	1504	1618	4889	4824	46	12.35	09	10.43
12015	36	95	1952	2047	2155	4805	4743	46	22.07	09	54.38
12016	37	96	0424	0512	0608	4209	4196	46	51.66	09	10.68
12017	37	96	1020	1124	1238	4539	4497	47	02.25	09	54.76
12018	37	96	1958	2036	2120	2883	2875	47	32.32	09	10.14
12019	38	97	0030	0137	0238	4075	4009	47	42.39	09	55.48
12020	38	97	0716	0800	0851	2991	3188	48	22.26	10	02.61

Day numbers of stations are the day numbers corresponding to the time at which the CTD was at the bottom of the cast. Positions are given in degrees, minutes and decimal minutes.

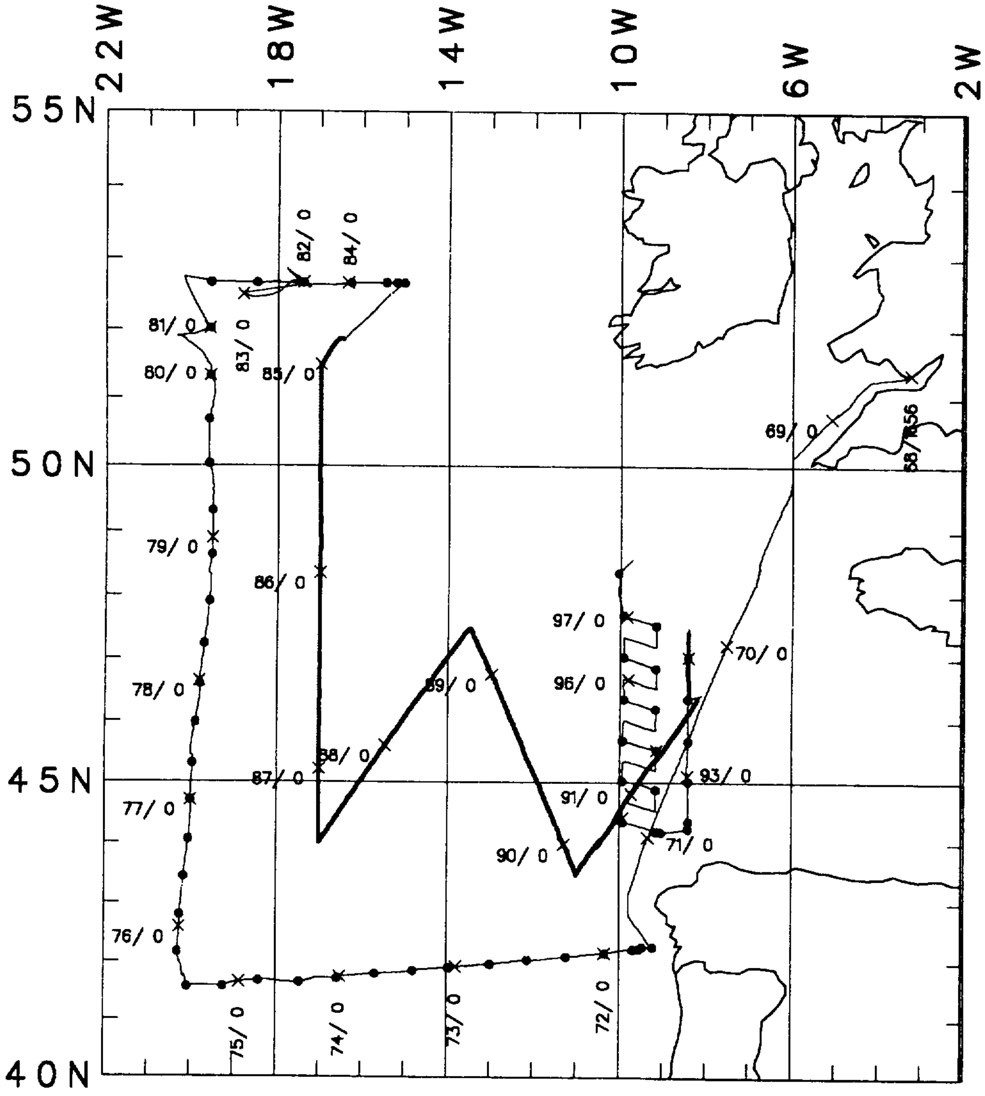

Figure 1. Cruise track for RRS Discovery Cruise 189. 09 Mar - 08 Apr 1990. Bold line indicates portion of track covered with SeaSoar deployed.

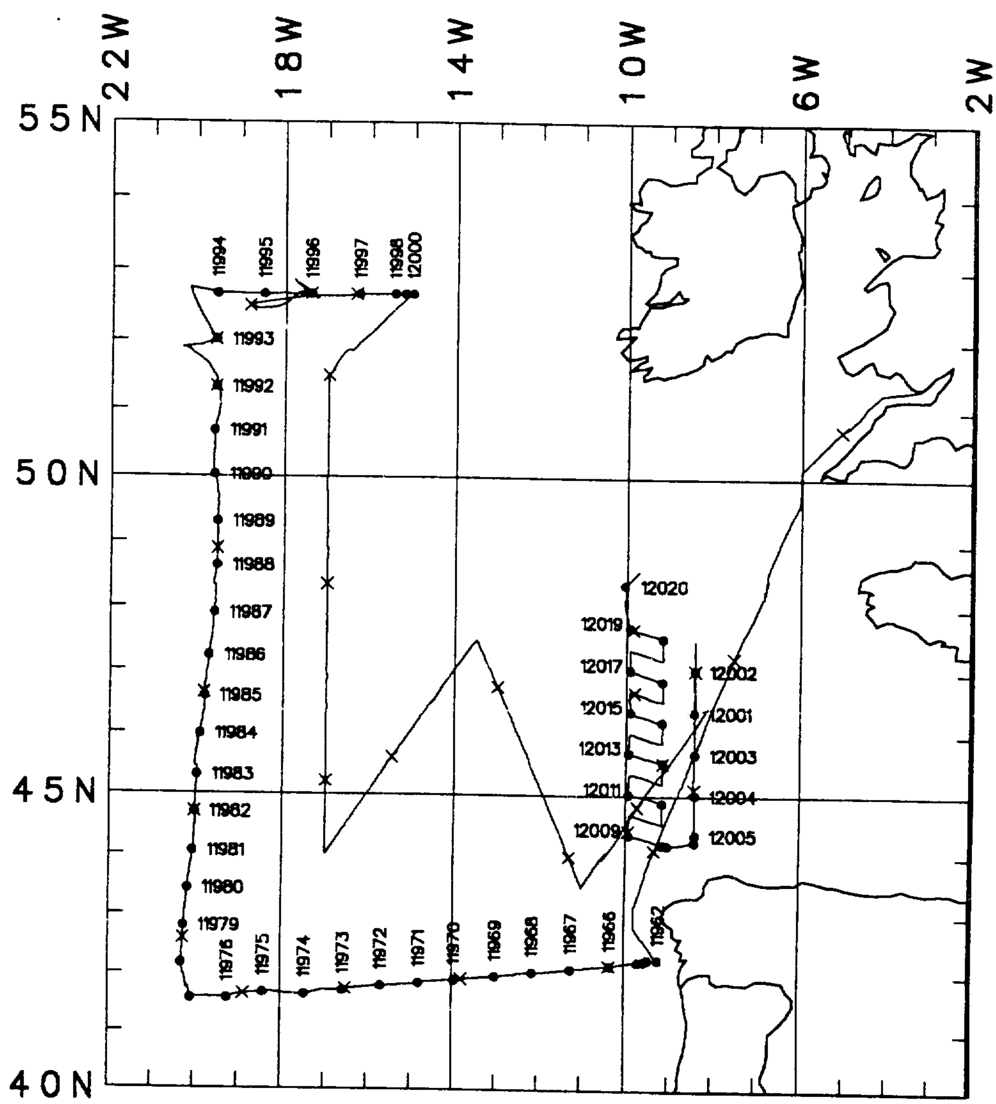

Figure 2. RRS Discovery Cruise 189. CTD station numbers and positions are indicated.