INSTITUTE OF OCEANOGRAPHIC SCIENCES

DEACON LABORATORY

CRUISE REPORT No.197

RRS CHALLENGER

Cruise 15/87

9 May - 5 June 1987

Oceanographic variability around the Faroe Islands

Principal Scientist

W.J. Gould

1987

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ABSTRACT

Physical oceanographic measurements were made in May and early June 1987 primarily between Scotland and Iceland and also west of the Hebrides. Primary aims were:

1. Towed CTD (SeaSoar) observations of the Iceland-Faroes Front

2. High precision CTD stations in the Faroe-Shetland and Faroe Bank Channels

3. Deployment and recovery of current meter moorings in the Iceland-Faroes Front

4. Deployment of current and temperature recorders in the Faroe Bank Channel

The report contains a narrative of the work, descriptions of the individual research projects and lists of station positions.

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SCIENTIFIC OBJECTIVES

The objectives of the cruise were

(1) The deployment and recovery of a mooring at the foot of the continental slope NW of St Kilda. The mooring carried current meters and a recording benthic resistance thermometer chain (BERTHA).

(2) A SeaSoar (towed CTD) survey of the Iceland-Faroes Front.

(3) The deployment for 1 year of an inverted echosounder and pressure recorder north of the Faroe Bank.

(4) The deployment and recovery of three moorings in the vicinity of the Iceland-Faroes front for a short period during the SeaSoar survey.

(5) The working of full depth CTD,O_2, transmissometer stations throughout the area.

(6) The deployment of an array of current meters and thermistor chains in the Faroe Bank Channel for a period of 1 year.

(7) Trials of an acoustic travel time ocean current monitor (ATTOM) in the Faroe Bank Channel.

(8) Continuous recording of depth (PES), current shear (ADCP), and sea surface temperature and salinity (thermosalinograph).

(9) Multi frequency echo sounding.

ACKNOWLEDGEMENTS

The willing cooperation of the Master, officers and crew of RRS Challenger in carrying out this most successful cruise is gratefully acknowledged. The cruise was partly supported by a grant (D/ERI/20/3/24) from the U.K. Ministry of Defence.

NARRATIVE

RRS Challenger sailed from Ardrossan at 1400A/May 9th (129). Course was set towards a position on the continental shelf northwest of St Kilda in preparation for the deployment of a mooring carrying recording current meters and a benthic resistance thermometer chain (BERTHA) at the foot of the continental slope near 58 20N 09 20W. The area was reached at 2000Z/10th (130) and after an echo sounding transect across the slope between the 400 and 1900m contours, the first of a planned series of CTD stations was worked 10km downslope of the proposed mooring position. The CTD station (CTD 1) was completed by 0235Z/11th (131) but by this time the weather had deteriorated so that the second planned station at the mooring site could not be occupied. Later in the morning there was a slight moderation in conditions and the mooring (428) was deployed between 0851 and 1022Z.

Course was then set towards 61 00N 08 30W, on Faroe Bank, and between 0650 and 1740Z/12th (132) a section of 10 CTD stations (CTD 2-11) was worked. On completion of this section the ship steamed towards 61 35N 09 45W for the deployment of an Inverted Echo Sounder and pressure gauge north of the Faroe Bank. The deployment, which was not given an IOSDL mooring number, was completed by 0231Z/13th (133).

A further line of CTD stations was started at 1400Z/13th (133) running northeastwards from the northwest corner of the Faroes Plateau. The stations were a repeat of a line worked a few days previously by HNLMS Tydeman as part of the NATO Saclantcen Ginsea project. The stations (CTD 12-20) lay between 62 40N 06 50W and were completed by 1600Z/14th (134). They located the position of the frontal boundary as lying between stns 15 and 16 (near 63 20N 06 15W). In order to further identify the frontal position and trend a series of XBT drops were made on courses running southwards on 05 30W and then back towards 63 07N 06 15W.

During May 15th (135) three moorings were deployed near the frontal boundary (as indicated by the thermosalinograph sea surface temperature values), with each carrying Aanderaa current meters at nominal depths of 100, 200, 300, 500 and 1000m. The moorings were on a line hopefully perpendicular to the front and separated by approximately 6nm. Mooring 429 was close to the front, 430 to the south and 431 to the north. The moorings were all in place by 2000z/15th (135) and course was then set towards 65 00N 11 30W for the start of the first SeaSoar survey.

On passage towards the northwest, transitions between warm and cold water were detected by the thermosalinograph. SeaSoar was deployed at 1530Z/16th (136) and the survey commenced at tow speeds between 7.5 and 8.5 kts. The initial run was eastwards on 65 00N to 09W then southwards to 64N and finally towards 65 00N 07 00W where SeaSoar was recovered. A relatively warm intrusion of water was crossed on 65N at 10W and the front proper was encountered near the southernmost limit of the survey.

By this time radio contact had been made with the Tydeman and the recovery of SeaSoar (at 1930Z/17th (137)) was to enable an intercomparison CTD station to be worked near Tydeman. Shortly after SeaSoar had been recovered a large killer whale (Orca) approached the Challenger and spent almost half an hour around the ship. The whale had a very large dorsal fin which was completely bent over. It showed no inclination to dive.

The Challenger took the opportunity while in deep water to carry out an implosion test on a 32inch dia aluminium buoyancy/instrument sphere. The sphere was suitably ballasted, connected to a leak-detecting pinger and lowered on the main warp. The implosion occurred at 1772m.

Challenger rendezvoused with Tydeman at 0400Z/18th (138) and as the ships lay one mile apart simultaneous lowerings of the CTD/multisampler packages were made to 2500m. The stations (Challenger CTD 21) were completed by 0650Z and course was set towards 64 30N 07 00W to resume the SeaSoar survey.

SeaSoar was relaunched at 1600Z/18th (138) and commenced a survey that continued until 0700Z/21st (141) and ran via 63 00N 09 00W, 62 40N 07 40W, 64 00N 06 00W, 64 00N 05 00W, 62 30N 05 00W to 61 05N 02 00W on the northwest Shetland slope. During the course of this survey the front was crossed and recrossed several times.

After recovery of SeaSoar a line of CTD stations (CTD 22-31) was worked which repeated another line of previous Tydeman stations and which lay close to the Muckle Flugga-Nölsö line traditionally worked by the DAFS Aberdeen laboratory. The stations ended at 61 50N 05 05W at 1035Z/22nd (142) and trials were then made of the Acoustic Travel Time Ocean Monitor (ATTOM) with one unit adrift on a dhan buoy while the second was lowered on the CTD wire. The opportunity was also taken to carry out calibration runs for the electromagnetic and acoustic doppler logs by steaming up and down wind at a range of speeds while making acoustic measurements of the range to a 10kHz transponder on a free drifting drogue.

On completion of these trials at 1415Z/22nd (142) course was set towards the recovery of moorings 429-431. In order to determine the position of the eastern limit of the front, passage was made via a line of XBT drops northwards on 04W and then westwards on 63 00N to the mooring position.

The moorings were recovered between 0720 and 1322Z/23rd and the opportunity was taken to carry out further trials of the ATTOM units and to do additional log calibration runs. These were all completed by 1835Z and course was set towards the start of a further line of CTD stations running from 62 25N 03 05W (CTD 32) to 61 30N 00 40W (CTD 40). This last station was completed by 0410Z/25th (145) and a further line of CTD stations (CTD 41-47) worked back across the Faroe Shetland Channel between 61 17N 04 00W and 61 00N 05 45W. These were completed by 1030Z/26th (146) and course set for a reoccupation of the section across the Faroe Bank Channel (CTD 2-11) but in the reverse sense.

CTD 48 was started at 1637Z/26th (146) and the section completed (CTD 56) by 0426Z/27th (147). A brief analysis of the CTD data was made and a site chosen for the deployment of a mooring with the first ATTOM unit. The mooring (432) was deployed by 0914Z/27th and after approximately 30 minutes had been spent monitoring the ATTOM performance via a 10kHz transponder on the mooring Challenger moved about 2nm away and the second ATTOM unit was lowered on the CTD wire.

All indications were that the ATTOM units were working correctly and between 1500 and 1930Z the first three moorings of a cross channel array of current meters and thermistor chains were deployed (moorings 433, 434, 435).

Overnight 27-28th a series of lowerings were made of the second ATTOM unit at increments of 50m between 400m and the sea bed on the CTD wire at nominal ranges of 5, 10 and 15 nm from mooring 432. However, the working of the lowered unit was clearly unsatisfactory and indicated that there were problems with the electronics design. The Challenger returned to mooring 432 and again its performance was monitored via the 10kHz transponder and found to be in order.

The three remaining moorings of the cross channel array were deployed between 0940 and 2050Z/28th (moorings 436-438) with additional tests of the second ATTOM unit on the CTD wire interspersed. At the end of the day the operation of ATTOM mooring 432 was rechecked prior to the repeat of the acoustic trials of the previous night. This time however no signals could be heard from the ATTOM and its 10kHz transponder and the acoustic trials were abandoned. It was by this time too late to recover mooring 432 to investigate the ATTOM malfunction and overnight measurements were made of the upper ocean currents along the line of current meter moorings using the ADCP at 4kts in order to optimise the navigational accuracy.

Mooring 432 was recovered by 0730Z/29th and in order to allow sufficient time to investigate and rectify the ATTOM problems further CTD sections were occupied between 61 20N 08 50W and the IES position and then towards 62 07N 08 35W (CTD 57-67). (During these stations the IES was seen to be operating correctly). This work was followed by a CTD section across the NW exit of the Faroe Bank Channel (CTD 68-74) towards the end of which work further trials of the ATTOM unit revealed that the faults had been rectified and between 1830 and 1846Z/30th the ATTOM unit, current meter and transponder were deployed on mooring 439. (The current meter was attached in order to reveal the position of the ATTOM unit relative to the deep thermocline.)

Overnight 30th/31st the second ATTOM unit was lowered on the CTD wire at nominal ranges of 5, 10 and 15nm from mooring 439 although at the last position the water depth was found to be too shallow to allow meaningful results to be obtained and the position was moved to a range of 12nm.

With both ATTOM units now apparently working correctly the deployment of the second ATTOM mooring was planned for early on the 31st (151). As the vessel was coming into position for the mooring deployment a buoyancy sphere was spotted at the surface. It was recovered by 0738/31st (151) and found to be the buoy and uppermost current meter of mooring 433 from 500m on the Faroe end of the moored current meter section. The area was now filled with many (over 20 within a 6 mile range) large eastern bloc stern trawlers and after the ATTOM mooring (440) had been deployed, the rest of the day was spent checking the positions and integrity of the current/thermistor chain moorings. All except 433 were located close to their launch positions and apparently undamaged.

ATTOM moorings 439 and 440 were recovered by 2052Z/31st (151) and course was set across Faroe Bank for the start of an XBT and ADCP traverse along the top of the Wyville Thomson Ridge. This was commenced at 0330Z/1st (152) and cold water was observed overtopping the ridge at its deepest position. This was further investigated by four CTD stations along the ridge top (CTD 75-78) between 0925 and 1705Z/1st (152). Further CTD stations 79-84 were worked overnight on the south side of the ridge and in the Ymir channel in order to try to locate the overflowing water. CTD 80 was worked as a "drift" station in order to get a detailed picture of the upper limit of the cold water. The ship steamed slowly downslope with the CTD being towed but surface currents were by 0100Z/2nd (153) setting the ship into shallower water and the station was abandoned.

On completion of the CTD stations at 0837Z/2nd the XBT/ADCP traverse of the Wyville Thomson ridge was resumed, terminating by 1940Z/2nd on the UK continental shelf edge. Course was then set along the shelf edge towards a position inshore of the BERTHA mooring 428. This position was reached by 0800Z/3rd (154) and following a further PES traverse of the slope the BERTHA mooring was recovered uneventfully by 1206Z/3rd. This was followed immediately by the occupation of a CTD station at the mooring site (CTD 85), CTD 86 10 km downslope and CTD 87 10km upslope of the mooring position. CTD 87 was then repeated as CTD 88 using the SeaSoar shallow CTD unit for calibration purposes. This work was completed by 2111Z/3rd and course set towards Ardrossan.

The RRS Challenger berthed at Ardrossan at 0800A/June 5th.

CTD and Multisampler

88 stations were occupied utilising a NBIS CTD which was lowered from the midships A-frame on the starboard side: See the CTD station list (Table 1). Crew manned the controls in an enclosed cab one deck up but with a poor view of the CTD on the deck. A walkie-talkie proved an effective means of communication during launch and as the CTD approached the bottom of the cast the ship's intercom position in the lab was employed. Overall the system, including the winch, worked very well and the co-operation and attention of the crew was appreciated by the scientific party.

The CTD was interfaced with a 1m transmissometer (SN35) from Sea Tech. In support of the CTD, samples were taken for salinity, dissolved oxygen and silicates employing a 12 bottle General Oceanics Multisampler. Samples were taken at the pre-selected levels on the up-cast with the CTD stopped. A 10kHz pinger with a pressure switch acting at 10m was used to measure height above bottom. Mooring releases were tested on approximately 10 lowerings.

The performance of the CTD was flawless: twice the sea-cable was remade at the connection just above the CTD frame. The second remake, before station 31, was totally successful, curing the failure of the multisampler to reply affirmatively when a bottle fired. Comparing derived CTD salinity with the over 500 sample salinity values, the conductivity cell calibration on the CTD was shown quite stable, drifting no more than .01 PSU during the cruise.

Relatively few reversing thermometer measurements were made but these revealed

(1) that the calibration made prior to the cruise was in error by .06°C and that the stable calibration used for the previous 3 years was still in effect and

(2) that given a group of high quality thermometers very good agreement (a few millidegrees) could be obtained between a small number of observations and the platinum resistance thermometer of the CTD.

The confidence this produced allowed us to dispense with thermometers except for periodic checking of the CTD calibration.

The multisampler system worked well after the inevitable initial problems of finding non-leaking bottles: in about one half of the bottles the rubber cord was replaced by an uncoated stainless steel spring (in the hope of making freon measurements) and some needed adjustment. After 20 stations the failure rate (leaky samples) fell to about 1 every other station, as low as ever achieved by Marine Physics in the writer's experience.

Logging of the CTD data was achieved on the ship's level ABC system and also via level A on the PDP11/34. Lists and plots were eventually made to agree from the two computers once the operation of the temperature correction on the level C was understood and activated. (This simultaneous test of software was a valuable exercise.) The level A, which furnishes 1 second averaged but raw data, gave problems especially when restarted after bottles were fired and also in some of the remarkably sharp temperature gradients encountered. Late in the cruise two discoveries were made:

(1) the software was not always fast enough to cope, and

(2) some of the wire connections parted and needed to be reconnected.

In these circumstances the back-up system of the Digidata tape deck, which was totally reliable, proved invaluable.

(P.M. Saunders, J. Smithers)

SeaSoar and Thermosalinograph

The IOS SeaSoar vehicle made two extensive surveys of the Iceland-Faroes front and the Faroe-Shetland Channel as described in the narrative and illustrated by the track chart. At tow speeds of ca. 8kts the vehicle profiled the top 300m of the water column while measuring temperature, conductivity, and pressure. The maximum depth reached was somewhat less than expected and this was attributed to a new design of tail that had been fitted and was possibly not correctly designed, and an asymmetry of the wings that tended to make the vehicle tow to one side of the ship's track.

The vehicle and CTD performance were faultless and allowed uninterrupted tows to be achieved. The data loss through fouling was very small, perhaps due to the fact that the spring bloom had only just reached the southern limit of the survey area.

The data were passed to the PDP 11/34 computer for processing. This was carried out in two stages. Every 2 hour segment of data was inspected for spikes and salinity jumps and was corrected at the end of the two hour period. These segments were then combined into 12 hour pieces which were then gridded (4km x 10m) merged with the navigation data and plotted as contoured sections of potential temperature, salinity, density and sound speed.

Salinity calibration of the SeaSoar was achieved by (a) taking hourly salinity samples from the ship's non toxic sea water supply which were later analysed on the Guildline Autosal salinometer and (b) by comparing these with the continuous output of the ship's thermosalinograph. The comparison of the SeaSoar near surface values with these other values permitted the thermosalinograph and hence the SeaSoar salinities to be adjusted to true values.

(W.J. Gould)

Silicate analysis

Silicate analyses were carried out on water samples from a total of 59 stations using an autoanalyser system borrowed from the chemistry group at IOS. The analysis was based on the classical ammonium molybdate colourimetric method and by using an 810 nm filter a linear working range between 0-16 μ mol ℓ^{-1} was achieved. All samples analysed had concentrations below 12 μ mol ℓ^{-1}.

The autoanalyser system worked without a single problem through the cruise giving very good duplicate values and results comparable to those from the TTO programme for this region. All stations showed classical nutrient profiles of low surface and higher deep water concentrations. Samples taken in the Faroe Bank Channel and North of the Faroes at the beginning of the cruise showed surface values of 4-5 μ mol ℓ^{-1}, clearly indicating a plankton bloom. This was confirmed by the CTD transmissometer data. The highest silicate concentration found was at a depth of 2400 m North of the Faroes.

There appeared to be a strong correlation between silicate concentrations and temperature and in general the silicates followed profiles expected from the Θ-S curves for a particular station. However, this was not true for the section across the exit of the overflow from the Faroe Bank Channel. Here the silicate values indicated that simple dilution was not occurring, in contradiction to the Θ-S curves. The silicate values from stations to the south had higher values than those to the north. On comparing the data with that from the TTO programme a likely explanation was that the overflow was being diluted by two water masses, one from the north with a deep water silicate concentration ~ 9.0 μ mol ℓ^{-1}, the other from the south, and probably North Atlantic water, with a silicate value of ~ 11 μ mol ℓ^{-1}. Since the θ-S curves for the two water masses were similar this phenomenon would not have been obvious without the silicate data.

(D. Smythe-Wright)

Freon Analysis

This was the first occasion that the freon analytical system had been assembled completely and so no real data were expected at the outset. This was just as well since numerous problems were encountered due to a faulty valve, design faults with the glass line attachments, and to extreme contamination masking the freon signals.

It was known that the chromatography packing material contained substances which would contaminate the chromatograph detector, and so initial work involved baking the molecular sieves at 300°C and the chromatography and trapping columns at 100°C for 36 hours, during which time carrier gas was allowed to flow through the system at 100 cc/min and vent into the laboratory. The gas lines were then attached to the detector and flow rates adjusted. Flow rate through the ECD vent was set to 30 cc/min without any problem; however, no flow at all could be monitored at the purge housing vent. Tests showed that all the main lines had flow and so it was assumed that the plastic ferrules in the purge housings were the problem. These were all systematically changed but with little effect. Finally tests with a pressure gauge showed that two of the valves were leaking from the main body. Both were removed from the board and stripped down and one was found to be minus an 'O' ring. A silastic seal was made in its place and both valves replaced in the system. This gave a positive result and the flow was set to 50 cc/min.

Unfortunately, tracking the leak took a great deal of time and with the pressure of other work, it was 10 days into the cruise before any chromatographic runs were carried out. Software was developed to switch the electronic valves on the freon extraction board from the chromatopac integrator/computer and a program for monitoring and integrating each analytical run was set up.

The first analyses were of clean marine air pumped from the foremast into the laboratory. (The air line installation worked very satisfactorily.) The results showed very small peaks and these were only achievable by setting the attenuation of the GC to its lowest setting. None of the peaks corresponded to the expected retention time for Freon-11 or Freon-12. A major improvement in peak height was obtained when the lead between the chromatopac and the GC was changed from the recorder to the integrator socket. This was in total contradiction to the manufacturer's handbook which suggests that when using the chromatopac alone, without a recorder, it should be plugged into the recorder socket of the GC. Nevertheless it was left in the integrator socket for the remainder of the cruise.

It was then decided to spike a large volume of seawater with Freon-12 and by analysing small subsamples see if the response corresponded with any of the peaks obtained from the analysis of marine air. In this way it was hoped to discern whether the chromatography columns were trapping and separating correctly or whether the system was so contaminated that everything was completely masked.

It was at this stage that it was found that the glass stripping column was broken at its junction with the stainless steel piping. This had obviously occurred whilst searching for the initial gas leak but had not been detected because the gas flow had been set to bypass the stripper up to this time. The stripper was repaired with araldite but when repositioned in the board it was impossible to obtain a gas tight seal without overtightening the swagelock fittings. The stripper was broken twice more in trying to achieve a seal and finally stainless steel ends were machined and fitted over the glass. A seal was achieved but only as a result of careful positioning and adjustment. Whilst the stripper was gas tight for the remainder of the cruise it was clearly evident that the use of glass/stainless steel linkages on the freon extraction board were problematic although these had been used by SIO. It was decided once back at IOS to investigate encasing both the stripper and glass drying columns in stainless steel to ease fitment.

Initial tests with spiked seawater did not resolve the peaks and so a new trapping column was packed and fitted to the board. Again it was impossible to discern the freon peaks from the other compounds present. Further tests using progressively more and more freon spiked seawater were also to no avail. Finally the detector became contaminated and it was necessary to condition the cell for 3 days at maximum working temperature before even a moderately stable baseline was achieved. During the last week of the cruise it was clear that it was impossible to progress much further and that on returning to IOS the system should be dismantled and every component thoroughly cleaned with hexane/methanol and new columns packed and refitted.

Whilst the lack of any meaningful data was disappointing substantial progress in attaining an IOS freon analysis capability was made. Trials with sampling from the 1.7 l Niskin bottles with the glass syringes were very encouraging. The Rocket syringes performed extremely well and were certainly comparable to the much more expensive syringes used by SIO. The cryocool and hot water bath systems were also adequate although the analysis could perhaps be made easier and more automated using a peltier cell. This is something to be looked into once the system is up and running.

(D. Smythe-Wright)

XBT Observations

T4 XBT probes were used at various times during the cruise to identify frontal positions, to get a quick look at thermocline structure and to observe the overflow of cold water across the Wyville-Thomson ridge.

The use of T4 probes was due to deeper probes not being available and in certain circumstances the lack of depth penetration hindered data interpretation. The data were recorded on a Bathysystems SA810 unit. Data returns were high with very few probes giving bad data.

The fact that RRS Challenger does not carry a radio officer meant that only a small number of traces were coded and transmitted via the GTS. The times and positions of XBT drops are given in table 2.

(W.J. Gould)

Mooring work

Mooring 428

The mooring carried the Benthic Resistance Thermometer Chain (BERTHA) which covered the bottom 110m of the water column together with two VACM current meters near the top and bottom of the chain for intercomparison purposes and three Aanderaa current meters at nominal depths of 700,1200 and 1500m.

The mooring was deployed anchor first from the auxiliary winches. The VACM-BERTHA combination was attached as the mooring line was paid out with the BERTHA cable and sensors held to the wire and around the VACMs with plastic cable ties. Problems were encountered when paying out the mooring wires due to their having been inadequately pretensioned. This resulted in damage to the 6mm wire which had to be recovered and replaced with 8mm wire. Deployment was otherwise straightforward. The freefall descent rate of the anchor was 0.73 m/s.

Recovery was uneventful. The buoy rose 281 m to the sea surface. The Aanderaa current meters showed signs of abrasion on the tilt stops which suggests that there had been considerable mooring motion.

The mooring recovery line was marked with a flashing light buoy made up from two 10 inch glass spheres and an ORE light. On recovery this light buoy was well streamed out and was at all times upright suggesting that this is a suitable design for use with a 4 ft dia buoyancy sphere.

Mooring 429

This was the first of three full depth moorings deployed close to the Iceland-Faroes Front (as revealed by CTD and XBT data). The mooring carried Aanderaa current meters at nominal depths of 100,200,300,500 and 1000m. Indications are that the current meters were close to their intended depths.

The mooring was deployed buoy first from the auxiliary winches using an electric reeler to tension the wires onto the winches. This significantly improved the pretensioning. The freefall descent rate for the anchor was 2.47 m/s. Recovery was uneventful with the wire being respooled using the electric reeler.

Mooring 430

This was the same basic design as mooring 429. Deployment and recovery were uneventful.

Mooring 431

As for 429 and 430, on recovery it was found that the current meter at the nominal 200m level had a broken rotor and that at the 500m level had leaked slightly via an electrical leadthrough in the end cap.

Mooring 432

This was the first deployment of the ATTOM unit in the Faroe Bank Channel. It was recovered after 2 days when it was found that the ATTOM unit was no longer working correctly.

Mooring 433

Deployed (anchor first) close to 500m depth contour on the Faroe side of the Faroe Bank Channel. The mooring carried two Aanderaa current meters at nominal depths of 300 and 490m. The mooring was damaged by trawlers during the night 30/31 May and the top current meter and buoy were recovered adrift. The Kevlar mooring line showed evidence of abrasion and grease presumably from a trawl warp. The remainder of the mooring appears to be still in place.

Mooring 434

This is the shallowest mooring on the Faroe side of the Faroe Bank Channel and was deployed (anchor first) in approx 300m of water. It carries a single Aanderaa current meter 10m above the sea bed.

Mooring 435

This is a similar design and deployment method to 433 but located on the Faroe Bank side of the channel.

Mooring 436

This mooring carries three Aanderaa current meters at nominal depths of 300,500 and 750m with an Aanderaa thermistor chain between the the deepest instruments. The mooring was deployed buoy first.

The mooring used PVC coated wires and in order to avoid damage prior to launch all shackles between wire lengths were well wrapped with canvas. As with BERTHA the thermistor chain was attached to the mooring line with plastic cable ties. A new design of mounting was used to attach the thermistor chain logger to the mooring.

Mooring 437

Similar to 436 with Aanderaa current meters at nominal depths of 300,500 and 750m and a thermistor chain between the deepest current meters.

Mooring 438

In all respects similar to 436 and 437.

Mooring 439

Redeployment of ATTOM unit but with an Aanderaa current meter immediately above the ATTOM in order to monitor temperature.

Mooring 440

Same design as 439.

Additional work

Other overside deployments included the use of free drifting dhan buoys for sound ranging trials on the ATTOM units. These used inflatable polyfoam buoy bodies with additional plastic polo floats to support the instrumentation. All connections between rope lengths on these buoys were made with snap hooks in order to speed deployment and recovery.

A simple transponder buoy was also deployed on two occasions for log calibrations. The buoy was drogued and had low windage.

The deployment of the combined Inverted Echo Sounder and Pressure Gauge was carried out by allowing the unit to free fall to the sea bed. The signals from the IES were monitored 16 days after launch and found to be in order.

(I. Waddington, K. Goy)

Calibration of the ship's electromagnetic log and ADCP

On the 23rd and 24th May (143/4) attempts were made to calibrate the ship's electromagnetic log and check the Acoustic Doppler Current Profiler. A transponder was laid under a 10m drogued float at a depth of approximately 7m and runs were made past it. On the 23rd, runs were made at 5, 7 and 10kt before the unerring aim of the principal scientist captured the transponder/drogued float on the ship's PES fish and brought the trials to an end for the day. This experiment lasted about 2 hours and was performed in a water depth of 230m when direct acoustic ranges of about 1000m were achieved.

Somewhat longer trials lasting 3 hrs were conducted on the following afternoon in a water depth of 1900m. Runs were made at 8.5, 6 and 9.5kt with acoustic ranges again of about 1000m. The Challenger lay to for about 20 minutes with the 10-15kt wind on each of the port and starboard beams to calibrate the athwartships component.

The trials produced consistent but puzzling results. Using a sound speed of 1483m/s for the surface waters (the upper 200m had a uniform value) the true fore and aft speed of the ship was compared with the computer logged 2 minute output averaged over 10-12 minutes. The table below represents the results.

Nominal fore-aft speed, kt	5.57	6.75	7.77	9.24	9.91	10.08
Error, kt (True-Nominal)	-.38±.1	-.43±.1	-.45±.1	-.34±.1	+.07±.1	-.07±.1

The ship's em-log clearly overestimates ship's speed at all but the highest speeds: here the two high speed runs on successive days confirm that the log is accurate. Such a highly non-linear behaviour suggests a change in flow regime around the log; it is remarkable for not being noted before - although a similar phenomenon was hypothesised for the Discovery em-log (See Discovery cruise (162) report No.186). It makes the determination of currents from the ship's navigation and dead reckoning an uncertain matter.

The athwartships calibration was similarly problematic. Lying to on both port and starboard sides the ship drifted away from the transponder at 0.59 kt. On the port side the em-log gave +.11 kt (10 min average), on the starboard side -.07 kt (12 minute average). No cause could be discovered for such a large discrepancy.

The Acoustic Doppler Current Profiler exhibited a more 'regular' behaviour. For the athwartships trials with true drift speeds of 30.5 cm/s, the ADCP gave north speeds of 30 cm/s and 29.5 cm/s for the 10 m (1st bin) water motion relative to the ship. (The wind was from the north.) For the runs past the transponder/drogued-buoy a correction was made to the ADCP listed values, multiplying them by 1483/1500, the numerator being the true speed of sound in water during the trials and the denominator being the sound speed assumed in the ADCP. The table below presents the results:

True ship's speed, cm/s	267	325	372	458	512
ADCP error, cm/s (True-observed)	8±2	9±3	4±3	21±5	23±10

Evidently the ADCP underestimates the relative ship-water speed by about 3%. Having deduced this result one should note that in bottom-tracked mode there is no evidence for any systematic discrepancy between the ship's navigation and the ADCP velocity of the bottom relative to the ship. It is possible that the transponding/drogued-buoy measurements are not as good as conventionally supposed but the difficulty of deriving currents from underway navigation is amply demonstrated here.

(P.M. Saunders)

ATTOM (Acoustic Travel Time Ocean Monitor)

A system is being developed to monitor the mean flow of water through an array of at least 3 moored instruments, positioned about 20 km apart, by measuring the travel times of acoustic pulses sent between them.

This cruise was used as a trial for two prototype instruments. These instruments have two modes of operation. The 'Master' mode is where it generates a swept frequency acoustic pulse (a 1 KHz sweep centred on 5.6 KHz) every 8 seconds, listening for replies in between, and the other 'Slave' mode is where they behave as transponders, replying to received signals from the Master instrument with a similar pulse. One was programmed to operate in the master mode for 2 mins, followed by 2 mins in the slave mode every 10 mins. The other operated in the slave mode followed by the master mode. The time of every received or transmitted pulse was internally recorded to an accuracy of better than 1 millisecond.

Teething problems were sorted out with a series of wire tests and by floating the instrument away from the ship under a dhan buoy. These tests also gave information about signal strengths and noise levels as these parameters are also internally recorded.

One of the instruments was then deployed in mooring 432 with the intention of carrying out ranging trials with the second instrument on the CTD wire. However in the event the second instrument failed and the trial was completed using a simple sound source generating a pulse every 8 seconds. A lowering was made at 5 mile intervals out to 15 miles.

Mooring 432 was recovered and, after another wire test to evaluate some modifications, it was relayed in mooring 439 with a current meter immediately above it.

Ranging trials were, this time successfully, completed with the second instrument on the CTD wire which was then deployed in mooring 440, again with a current meter above it. Both moorings were recovered about 12 hours later.

A cursory analysis of the data revealed that the instruments seemed able to reliably 'talk' to each other out to 10 miles separation but became spasmodic at 15 miles, being very reliant on the sound velocity structure. This structure was unfortunately not favourable during the majority of the time that both moorings were in position, although the short window where conditions improved gave encouraging results.

(N.W. Millard)

10KHz acoustics

BERTHA

The lowest thermometer on this array was required to be as close to the sea bed as possible; it was therefore fastened to the acoustic release and the release positioned within 1 metre of the anchor clump. This close to the anchor the release is subject to high vibration during descent and a high risk of collision both during surface handling and upon reaching the sea bed. To safeguard the release against premature mechanical operation, solid state switches were fitted in series with the relay contacts; the relay indication facility had to be removed to prevent discharge of the beacon battery as the firing batteries were no longer electrically isolated. The release successfuly used retractors and 1000kg SWL stainless steel release mechanism.

Inverted Echo Sounder

Both releases used on this unit were from Proudman Laboratory stock. They were successfully tested between 600m and 800m at a temperature of minus 0.7°C. Details were CR 2323 - 317 to 326, 277 to 285, 281 x 10 x 11; CR 2164 - 317 to 325, 455 to 465, 460 x 10 x 9. The rig was deployed in 1123 uncorrected metres and sank at approximately 0.9m/sec. The release beacons were monitored until they timed out and the inverted echo sounder was heard to operate correctly before the site was left. The site was reoccupied on 29/5 and the IES was heard to operate correctly at 1730 GMT.

Norwegian Sea Moorings

The releases used were standard 'mushroom transducer' types that had been tuned in the laboratory to operate successfully at minus 5°C. The bottom water temperature at the sites was about minus 1°C and no performance problems were encountered. The buoy first deployments resulted in initial descent speeds up to 5 metres per second. This caused the relay contacts in one unit to open several times; luckily there was insufficient mechanical energy to complete the changeover and fire the pyroleases. All three units performed normally and were successfully recovered after nine days.

Sphere Implosion

The Engineering Group needed to know if the sphere leaked. A standard pinger was modified by fitting a monitor style delay card accepting a frequency input and a simple voltage controlled oscillator was fitted inside the sphere with its own small battery supply. The lead from the sphere to the pinger was 10 metres allowing the pinger to be mounted about 8 metres from the sphere on a bar shackled into a length of chain. The pinger gave separate and positive indication of no leak, open circuit at the sphere, open circuit at the pinger, and short circuit at the sphere. During the implosion run the pinger gave indication of no leak until 1772 metres of wire out when it moved straight to short circuit at the sphere. On the echo sounder trace at this point a 100 millisecond pulse was received then after about 2½ seconds more than 2 seconds of echoes. Upon recovery the lead had been severed at the sphere, most of the sphere and its steel net had vanished, and everything else was intact.

Faroe Bank Channel Moorings

All the units used on these moorings had been tuned in the laboratory to operate at minus 5°C and were fitted with Titanium mechanics. The two deeper moorings (B and C, see Table 3) used standard 'mushroom transuducer' types one of which had successfully operated on a Norwegian sea mooring. The four shallower moorings used 'ceramic ring' type transducers of three different 'marks'; the Mk I (IOS) and Mk III (Marine Acoustics) were about 6 dB more efficient in transmission than the Mk II (Bell/DBE) version although all were more than adequate in performance. All behaved normally during deployment and during subsequent interrogations. Mooring E however is known to be lying on the sea bed due to trawling of its buoyancy which we recovered adrift; interrogation after this even confirmed it was on the sea bed by the 60° tilt pulse firmly made.

EM and Doppler Log Calibrations

A high powered (~60 watts into the water) transponder was used to aid calibration of the speed logs. It was deployed about 10 metres below two trawl floats as surface buoyancy with a small 'blind' type drogue. Ranges to about 3.5 kilometres were obtained without benefit of a beam steering unit. The rig was accidentally caught by the PES fish on one occasion but no damage was suffered.

Telemetry from ATTOM Moorings

Again the releases used had been adjusted for low temperature operation. Both releases were shallow water types (ceramic ring Mk I and Mk II) and performed normally. On the first deployment a 10kHz transponder was added to aid accurate ranging; the dead time had been set to facilitate the log calibrations (0.92 seconds) but this unfortunately coincided with the surface reflection travel time (717 metres ~0.95 secs). This resulted in the transponder locking to this path after every interrogation, and not losing lock until being internally timed out (5 secs every 15 secs). However, it also operated on transmission from the tomography unit, failure of which was an initial problem. On subsequent wire trials and moorings transponders with adjusted dead times (1.8 secs) were used for both monitoring and ranging. Retractors were successfuly used on one side of the release for the three deployments.

Monitoring CTD Bottom Approach

A standard 10kHz pinger was used for all deployments. The standard technique used was to stop the CTD cast approximately 50 metres off the sea bed, accurately measure the bottom separation acoustically, then to carry on to 10 metres off the bottom by paying out the calculated wire required.

Ship's Precision Echo Sounder

Several faults existed in the equipment as supplied and several other shortcomings were exposed during the cruise. Mechanically, 8 fairing clips had been destroyed on the previous cruise and not replaced. Electrically, the wiring to one of the banks of transducers in the PES fish was shorted to earth. Further, the non-computer space available in the plot is no longer suitable for a full suite of 10kHz acoustic monitoring gear; a full PES junction box should be reinstated in the main laboratory; the argument that equipment could be damaged by inadvertent wrong selection of transducer combinations only applies if the overrestrictive transducer switching box is retained. The switching box is not compatible with the PES Mk III and IOS Acoustic Command System Mk IV as it stands - the output 14ad has to be manually transferred between units. All cruises requiring use of the full range of facilities carry scientists technically experienced enough to connect correctly to the junction box to suit their needs; cruises requiring only echosounding capability can be serviced by suitable dedicated labelled leads direct from the junction box. Other comments: both facsimile recorders are suffering from the effects of exposure to a sea atmosphere: general degradation of all electrical components. When the new PES towing cables, allowing access to all transducers, becomes standard, a plug-inbeam steering unit would be a valuable asset.

(G.R.J. Phillips)

The RDI Acoustic Doppler Current Profiler

On the whole, the performance of the Doppler Profiler was completely satisfactory in both shallow and deep water. Apart from providing data which was physically reasonable, the instrument performed well in the calibrations and tests which were carried out. However, a number of minor problems were encountered, the solution of which would lead to improved operation of the system.

After an initial trial period, three working configurations were set up, with maximum depth ranges of 200, 400 and 600 m (called aln2, aln4 and aln6 respectively), and a sampling interval of three minutes, which typically resulted in 80-100 pings per ensemble. The first two of these configurations consisted of 50 x 4 m bins and 50 x 8 m bins respectively, and employed bottom tracking. This enabled velocities to be displayed relative to the fixed bottom, and so allowed an easy interpretation of the results. Neither of these configurations was operable in water depths much less than about 50 m, but were otherwise successful in depths down to about 250 m and 450 m respectively. The third of the above configurations (also set up as the default file) consisted of 75 x 8 m bins, did not use bottom tracking, and, displaying the velocities relative to the mean, was used in deeper waters.

Tests were later performed which revealed that bottom tracking was actually effective down to about 530 m, even though the maximum bottom depth displayed on the screen was only 500 m. This lead to the creation of a fourth working configuration, aln6b, which was similar to the two bottom-track configurations already described, but was set for a maximum depth range of 600 m (in 75 x 8 m bins).

Typically, good data (95-100% good pings per ensemble) was obtained down to about 450 m with the above configurations, with the exception that only 70-75% good data could be typically obtained with aln2. However, in rougher weather (force 4-5), the depth to which good data could be obtained was reduced to approximately 350 m. Further, when in bottom-tracking mode, no data could be obtained within about 50m of the bottom, where the acoustic return signal started to increase.

A number of opportunities arose to compare the ship's speed and direction as resulting from Doppler data with that derived from navigation (Satfix) data. Sufficiently large averaging times were needed in order to reduce the effect of navigation errors. Thus two Satfixes each with a rms error in position of 300 m would lead to a velocity error of $300\sqrt{2}/3600$ = 12 cm/s if separated by 1 hour, but only 3 cm/s if separated by four hours. The table below shows the result of 4 comparisons made when steaming at high speed on straight courses; the Doppler data is taken from bottom tracking.

		Navigation		Navigation-Doppler log	
Day	Duration	spd cm/s	direction °	spd cm/s	direction °
132	04-06Z	443.5	015.2	-2.7	-0.8
145	04-09Z	465.7	233.1	+5.0	-0.6
145	13-18Z	500.9	234.6	+0.4	-0.7
146	09-13Z	388.5	295.2	-1.7	-1.2

In the Doppler data speeds have been reduced by 1% to take account of the near surface values of 1485 m/s for the speed of sound as compared with the 1500 m/s assumed by the Doppler software. Clearly the agreement is very good - within the errors expected of the navigation. There does appear, however, to be a small heading correction since the expected error is only about ±0.3°.

The ship's heading, read into the Doppler programme from the main gyro, was checked regularly (by taking two-minute averages), and agreed with that shown on the gyro to within ±0.5° throughout the cruise. On the other hand, the clock in the Doppler programme was consistently between 36-38 seconds ahead of the ship's time, and could not be reset.

Apart from not being able to obtain a hard copy of graphical display on the printer, the only real drawback concerned the input of position fixes from the MNS2000 navigation system. At the end of an ensemble, the Doppler programme would wait for the next position update from the MNS2000 instead of, for example, simply taking the last recorded position. This meant that typically 30 seconds of each three minute ensemble was lost in waiting for a position update instead of pinging, thus reducing the accuracy of the ensemble. Further, the times at which positions became available were not exactly on every whole minute ship's time (as they should have been), but drifted slowly throughout the cruise. This meant that the Doppler had to be restarted typically three times per day to reduce the waiting time for the position fixes to a minimum. Finally, the MNS system once became inoperative for a period of about five minutes, due possibly to interference from the ship's communication system, and this appeared to cause the Doppler programme to suspend pinging for the duration of the interval (and also the link to the PDP to be broken).

The drawbacks mentioned above should be remedied if at all possible.

(A.L. New, P.M. Saunders)

Internal waves

Under suitable wind and sea conditions, the presence of internal waves in the ocean is often revealed by bands of anomalous surface roughness which align with the direction of the underlying internal wave crests and troughs. These bands, or "rips", result from a horizontally-varying surface current imposed by the internal waves, and are often visible to the naked eye, as well as being detectable by ship's radar and from space.

The occurrence of such a phenomenon was observed firstly on May 23rd (143), whilst recovering current meter moorings 430 and 429, at approximately 63°00'N, 06°12'W. This location is on the slope of the Norwegian Basin, about 40 nm N of the Faroe Islands, and in water of 1500 m depth. The internal wave rips appeared to be oriented approximately with the isobaths, that is, along the line 300°-120°N, and had an apparent spacing of the order of 0.5 km. XBT casts revealed a weak thermocline at about 15 m which corresponded to a long internal wave phase speed of about 11 cms^{-1}. However, the propagation direction of the internal waves could not be determined.

Nevertheless, a preliminary investigation revealed that the location of these internal waves was consistent with their formation from internal tides which in turn could have been generated by the interaction of the surface tide with the Faroe shelf/slope. The presence of internal waves at this location has not, to our knowledge, been previously reported in the literature, and an analysis of the current meter data obtained here needs to be undertaken.

Internal wave rips were also observed when crossing the Wyville-Thompson Ridge on June 2nd (153). The presence of internal waves at this location has already been reported in the literature (from satellite observations), and again is presumed to result from tidal flow over the ridge. Although occasionally some of the rips, which again had a spacing of 0.5-1.0 km, appeared to be perpendicular to the axis of the ridge, they were predominantly parallel with the depth contours, in accordance with expectations.

It had been intended to look for subsurface evidence of internal wave activity by making observations with a high frequency echo sounder on loan from ARE Portland. However, when tested it was found that only one (50 kHz) transducer was in working order, the other (123 kHz) showing a short circuit. The 50 kHz transducer was towed at a depth of 10 m in an IOS pattern PES fish and the output displayed on an EPC recorder. The electronics gave continual problems with power transistors being blown at regular intervals. Thus little data was obtained before spares were exhausted and the work abandoned.

(A.L. New)

Shipborne computing

During the cruise the following parameters were logged and processed on a NERC ABC processing system; ship's speed, heading and navigational data from the em-log, gyro, Magnavox 1107 satnav, Decca-Racal MNS2000 Loran/Decca receiver and Simrad LC-156 Loran receiver; bathymetry; thermosalinograph; CTD and SeaSoar data.

Track charts were produced daily and annotated charts and navigation listings as required. Near-real-time plots of processed CTD and SeaSoar data were displayed on a monitor in the main laboratory.

In addition to the ABC processing system already on the vessel, a PDP 11/34 logging and processing system was installed and mounted with the IOS Wormley PSTAR suite of programmes in order to provide processing for CTD, SeaSoar and Acoustic Doppler Current Profiler (ADCP) data.

The output from the MNS2000 Decca/Loran navigator was interfaced to the ADCP in order to provide true motion information.

The equipment functioned properly and was able to meet the logging and processing requirements throughout the cruise with the following exceptions:

(1) The CTD level A displayed a tendency to generate backwards and erroneous times after data to the interface had been interrupted (e.g. at bottle stops).

The temporary solution to this was to re-download the hex file and restart the level A. This solution worked but caused inconvenience, since resumption of operations was delayed whilst the download was effected.

The fault was traced to a programme instruction which was implemented when the sampling routine had all its output buffers full and limited the rate at which the interface could handle data.

A solution is being sought to the problem and should be implemented for future cruises.

(2) Loran navigation was unreliable.

Two different types of receiver were available to provide Loran fixes to the computing system, a Simrad LC-156 and a Decca-Racal MNS2000. Neither set of equipment gave consistently good results since the received signal strengths were low throughout the cruise, despite the fact that for a considerable time the vessel was operating in what was ostensibly a good Loran area. A Dutch research vessel HNLMS Tydeman operating in the same area reported that they were receiving good Loran signals.

The antennae for both receivers were similarly sited (mounted on top of the 'monkey-island' guard rail aft of the funnel). Repositioning the Simrad antenna at other positions around the 'monkey-island' at the same level produced no improvement in performance. Perhaps the antennae should be mounted in a more elevated position for future operations when Loran is to be used as the prime navaid.

In the southern part of the working area, Decca navigation produced by the MNS2000 was fairly consistent and was used as the preferred navigation aid.

(3) Throughout the cruise, whenever the ship's telex equipment was used, corruption of both data and clock signals occurred. This is an old problem which has been tolerated in the past, but on this cruise it caused particular inconvenience since good dead-reckoning was required in order to process data from an Acoustic Doppler Current Profiler. The instruments particularly affected by the telex transmissions were the em-log and the MNS2000 receiver. This problem should disappear away when the telex is replaced by satellite communications equipment during the coming refit.

The PDP 11/34 system worked well throughout the cruise. It hung up once and about 9 hrs of acoustic doppler current profiler (ADCP) data were lost while the instrument failed to synchronise with the computer.

SeaSoar and CTD data were logged from the level A, ADCP data were logged from the IBM PC and navigation (em-log and satellite fixes) and thermosalinograph data were transferred from the level C by magnetic tape. When the level A system had problems logging the CTD, data were recovered from the back-up system of Digidata tapes.

(K.E. Potter, D. Lewis, J. Read)

Table 1 CTD Station List

Consecutive Number	Time Down	Day/Date 1987	Lat N	Lon W	Water Depth, m	Closest Approach, m	Comments	Stn Repeat
1	0142	131 11-V	58 20.0	09 57.9	1885	10	Acoustic Release Test	
2	0715	132 12-V	61 13.3	08 22.8	159	10	Begin Section in FB channel	
3	0820	132 12-V	61 14.4	08 20.0	222	9		
4	0923	132 12-V	61 16.3	08 17.6	361	5		
5	1032	132 12-V	61 18.0	08 15.1	474	7		
6	1144	132 12-V	61 19.7	08 12.0	683	14	Acoustic Release Test	
7	1350	132 12-V	61 21.6	08 10.0	840	15	Acoustic Release Test	
8	1510	132 12-V	61 23.7	08 07.2	786	12		
9	1742	132 12-V	61 25.6	08 04.5	583	15		
10	1842	132 12-V	61 27.1	08 00.7	295	11		
11	1925	132 12-V	61 28.4	07 57.5	184	8	End F-B section	
12	1419	133 13-V	64 40.2	06 46.9	185	15	Begin Faroes current section	
13	1630	133 13-V	62 51.5	06 39.9	543	10		
14	1855	133 13-V	63 01.1	06 31.1	1226	10		
15	2210	133 13-V	63 13.5	06 21.1	1637	0	CTD put on bottom	
16	0129	134 14-V	63 24.9	06 13.9	1597	15		
17	0438	134 14-V	63 36.0	06 02.4	2029	120	Acoustic Release Test	
18	0826	134 14-V	63 48.4	05 53.6	2854	-	To 2000m only: A-R test	
19	1157	134 14-V	63 59.3	05 43.3	3461	-	"	
20	1456	134 14-V	64 09.9	05 32.9	3500	-	" : end section	
21	0519	138 18-V	55 44.4	06 38.4	2466	90	Tydeman intercomparison	
22	0852	141 21-V	61 04.8	01 37.9	179	12	Start Faroe-Shetland Channel (F-S.C) section	
23	1050	141 21-V	61 09.8	02 03.1	526	10		
24	1312	141 21-V	61 15.5	02 27.0	929	23		
25	1512	141 21-V	61 19.6	02 45.7	1167	21		
26	1822	141 21-V	61 25.1	03 11.9	1385	21		
27	2218	141 21-V	61 30.6	03 33.0	1304	17		
28	0130	142 22-V	61 34.9	03 56.3	1197	8		
29	0412	142 22-V	61 40.0	04 21.9	675	19		
30	0614	142 22-V	61 44.5	04 41.7	327	20	Sea-cable remade: Multisampler OK	
31	1012	142 22-V	61 49.6	05 04.9	234	8	End Faroe-Shetland section	
32	0342	144 24-V	62 25.2	03 05.3	610	12	Begin 2nd section in F-S.C	
33	0547	144 24-V	62 18.2	02 48.8	1086	15		

Table 1 CTD Station List (continued)

Consecutive Number	Time Down	Day/ Date 1987	Lat N	Lon W	Water Depth, m	Closest Approach, m	Comments	Stn Repeat
34	0927	144 24-V	62 12.4	02 33.6	1712	13		
35	1250	144 24-V	62 06.3	02 14.5	1662	12		
36	1707	144 24-V	62 00.4	01 56.3	1579	25	Acoustic Release Test	
37	2025	144 24-V	61 52.8	01 39.6	1359	9		
38	2317	144 24-V	61 46.2	01 19.8	691	10		
39	0150	145 25-V	61 40.3	01 00.9	341	9		
40	0357	145 25-V	61 29.9	00 40.3	189	13	End 2nd section in F-S.C	
41	1944	145 25-V	60 16.9	03 59.8	243	12	Begin 3rd section in F-S.C	
42	2118	145 25-V	60 22.3	04 13.5	498	11		
43	2318	145 25-V	60 28.3	04 27.3	991	14		
44	0148	146 26-V	60 34.0	04 44.5	1074	10	Acoustic Release Test	
45	0437	146 26-V	60 40.5	05 01.7	938	12	Acoustic Release Test	
46	0740	146 26-V	60 50.0	05 19.7	744	12		
47	1020	146 26-V	60 59.3	05 45.4	311	7	End 3rd section in F-S.C	
48	1845	146 26-V	61 28.7	07 56.5	178	9	Begin repeat of Faeroe Bank Section	: 11
49	1933	146 26-V	61 27.1	07 59.8	296	12		: 10
50	2024	146 26-V	61 25.8	08 03.7	548	13	Trouble with level A	: 9
51	2203	146 26-V	61 23.5	08 07.2	784	10		: 8
52	2313	146 26-V	61 21.7	08 09.3	838	16	Strong current shear large wire angles	: 7
53	0052	147 27-V	61 19.9	08 12.3	737	11	Amazingly sharp thermocline	: 6
54	0210	147 27-V	61 17.9	08 14.1	513	10	Level A computer reloaded	: 5
55	0330	147 27-V	61 16.5	08 17.5	372	10		: 4
56	0415	147 27-V	61 15.1	08 20.5	258	10	End F-B repeat section	: 3
57	0945	149 29-V	61 20.2	08 47.4	284	9	Start section downstream of exit	
58	1136	149 29-V	61 24.1	09 07.6	475	7		
59	1315	149 29-V	61 28.0	09 20.5	647	8		
60	1458	149 29-V	61 32.8	09 32.0	965	10	Lying to	
61	1724	149 29-V	61 35.6	09 43.8	1145	10	Tide gauge site	
62	1934	149 29-V	61 38.5	09 33.6	957	4	Detect overflow	
63	2128	149 29-V	61 45.0	09 24.8	851	5		
64	2311	149 29-V	61 48.6	09 15.8	751	14		
65	0052	150 30-V	61 53.4	09 06.3	618	10		

Table 1 CTD Station List (continued)

Consecutive Number	Time Down	Day/ Date 1987	Lat N	Lon W	Water Depth, m	Closest Approach, m	Comments	Stn Repeat
66	0300	150 30-V	62 00.0	08 50.9	400	10		
67	0503	150 30-V	62 06.9	08 35.4	193	9	End section downstream of exit	
68	0824	150 30-V	61 47.0	08 20.0	188	8	Begin exit section	
69	0931	150 30-V	61 42.6	08 24.4	373	12		
70	1048	150 30-V	61 41.1	08 29.2	669	16		
71	1232	150 30-V	61 38.6	08 36.7	813	10		
72	1420	150 30-V	61 35.3	08 42.5	882	12		
73	1724	150 30-V	61 32.4	08 48.0	667	7		
74	1954	150 30-V	61 30.4	08 53.9	523	12	End exit section	
75	0949	152 1-VI	60 06.6	07 18.3	518	10	Wyville Thompson Ridge	
76	1142	152 1-VI	60 08 0	07 29.5	523	10		
77	1419	152 1-VI	60 09.0	07 45.2	631	6	Cold overflow	
78	1623	152 1-VI	60 11.8	07 52.8	549	14		
79	2000	152 1-VI	60 20.1	08 31.2	579	12	End work on W-T Ridge	
80	2118	152 1-VI	60 18.8	08 32.4	641	15	Yo Yo: 1st Down	
	0123	153 2-VI	60 16.4	08 29.7	791	15		
81	0229	153 2-VI	60 14.0	08 35.7	879	15		
82	0412	153 2-VI	60 07.3	08 37.1	638	10		
83	0542	153 2-VI	60 11.2	08 41.0	806	9		
84	0801	153 2-VI	60 10.0	08 19.5	935	12	Cold in shallow valley	
85	1306	154 3-VI	58 20.0	09 44.1	1691	7	At BERTHA mooring	
86	1614	154 3-VI	58 21.3	09 56.5	1880	15	No level A logging	
87	1946	154 3-VI	58 17.9	09 31.5	663	13		
88	2045	154 3-VI	58 18.3	09 30.6	654	-	Repeat of 87 with SeaSoar CTD to 3000m	

Table 2 XBT Observations

Drop No.	Day	Time (Z)	Lat N	Long W	Water Depth, m	Cassette	File
1	133	1214	62 29.5	07 14.0	95	1	41A
2	133	1517	62 45.8	06 45.5	296	1	42A
3	133	1736	62 56.9	06 36.1	815	1	43A
4	133	2033	63 07.5	06 25.2	1582	1	44A
5	133	2357	63 19.0	06 15.7	1640	1	45B
6	134	0307	63 30.7	06 08.0	1804	1	46A
7	134	0645	63 42.8	05 57.7	2400	1	47A
8	134	1033	63 55.1	05 49.3	3430	1	48A
9	134	1908	63 41.5	05 32.1	2500	1	49A
10	134	2030	63 28.5	05 31.5	2010	1	410A
11	134	2119	63 20.2	05 30.0	2055	1	411A
12	134	2221	63 10.4	05 29.3	2150	1	412A
13	134	2326	63 00.0	05 30.0	1880	1	413A
14	135	0027	62 50.6	05 30.3	820	1	414A
15	135	0124	62 41.4	05 27.0	520	1	415A
16	135	0353	63 01.2	06 07.5	990	1	416A
17	142	1459	61 50.2	04 57.9	218	1	417A
18	142	1558	61 53.5	04 40.6	230	1	418A
19	142	1659	61 56.6	04 22.4	406	1	419A
20	142	1800	61 59.2	04 03.3	558	1	420A
21	142	1900	62 06.8	03 59.9	364	2	421A
22	142	1959	62 15.1	03 59.9	419	2	422A
23	142	2055	62 24.0	03 59.3	537	2	423A
24	142	2159	62 33.3	04 00.4	700	2	424A
25	142	2302	62 43.3	04 00.5	910	2	425A
26	142	2357	62 52.1	04 00.0	1350	2	426A
27	143	0057	63 01.7	03 58.9	2300	2	427A
28	143	0159	63 01.9	04 19.0	2341	2	428A
29	143	0302	63 01.2	04 42.0	2250	2	429A
30	143	0359	63 00.4	05 02.7	2190	2	430A
31	143	0457	63 00.2	05 23.7	1960	2	431A

Table 2 XBT Observations (continued)

Drop No.	Day	Time (Z)	Lat N	Long W	Water Depth, m	Cassette	File
32	143	0557	62 59.9	05 45.0	1750	2	432A
33	143	0658	62 59.1	06 05.8	1464	2	433A
34	143	1118	63 04.4	06 10.0	1693	2	433B
35	147	2009	61 20.1	08 04.5	842	3	445A
36	147	2317	61 19.6	07 52.0	810	3	446A
37	148	0211	61 20.0	07 42.0	733	3	447A
38	149	0832	61 19.2	08 31.4	330	3	48A
39	150	0639	61 56.0	08 29.0	205	3	439A
40	150	2352	61 32.2	08 36.4	862	3	440A
41	151	0019	61 21.9	08 28.9	820	3	441A
42	151	D401	61 26.0	08 22.1	753	3	449A
43	152	0332	60 32.2	08 59.7	250	3	451A
44	152	0416	60 27.6	08 46.2	305	3	452A
45	152	0432	60 26.3	08 41.8	432	3	453A
46	152	0502	60 23.6	08 33.0	510	3	454A
47	152	0533	60 21.1	08 23.9	525	3	455A
48	152	0606	60 18.3	08 14.8	518	3	456A
49	152	0637	60 15.8	08 06.2	532	3	457B
50	152	0700	60 14.3	07 59.8	524	3	458A
51	152	0726	60 12.4	07 52.2	547	3	450A
52	152	0743	60 11.1	07 47.4	593	3	461A
53	152	0801	60 09.9	07 43.0	635	3	462A
54	152	0829	60 08.4	07 35.4	574	4	463A
55	152	0858	60 07.5	07 25.4	504	4	464A
56	152	1237	60 09.1	07 47.8	527	4	465A
57	152	1308	60 09.4	07 40.2	630	4	466A
58	153	1100	60 21.3	08 22.3	507	4	467A
59	153	1200	60 17.1	08 04.2	522	4	468A
60	153	1230	60 14.1	07 55.2	522	4	469A
61	153	1250	60 12.1	07 49.5	550	4	470A
62	153	1300	60 11.3	07 46.5	610	4	471A

Table 2 XBT Observations (continued)

Drop No.	Day	Time (Z)	Lat N	Long W	Water Depth, m	Cassette	File
63	153	1315	60 10.0	07 42.3	635	4	472A
64	153	1330	60 09.1	07 37.7	580	4	473A
65	153	1337	60 08.7	07 34.5	550	4	474A
66	153	1348	60 08.3	07 30.9	522	4	475A
67	153	1359	60 07.8	07 26.5	505	4	476A
68	153	1430	60 06.4	07 17.7	512	4	477A
69	153	1457	60 04.7	07 09.4	448	4	478A
70	153	1601	60 00.5	06 49.7	428	4	479A
71	153	1700	59 56.7	06 33.1	345	4	480A
72	153	1804	59 48.5	06 22.1	435	4	481A
73	153	1859	59 41.0	06 13.7	222	4	482A

Table 3 Moorings Deployed and Recovered

No.	Deploy/ Recover	Date	Time Z	Lat N	Long W	Depth m	Instruments
428	D	11.5.87	1016	58 19.6	09 44.8	1705	BERTHA + 2VACM + 3ACM
-	D	13.5.87	0203	61 34.8	09 45.6	1114	Pressure gauge + IES
429	D	14.5.87	0920	63 04.3	06 10.5	1688	5 Aanderaa current meters
430	D	14.5.87	1456	62 59.7	06 12.1	1415	5 Aanderaa current meters
431	D	14.5.87	1948	63 09.0	06 04.3	1893	5 Aanderaa current meters
430	R	22.5.87	0745	62 59.7	06 11.5	1415	
429	R	22.5.87	1013	63 04.2	06 10.0	1688	
431	R	22.5.87	1225	63 09.0	06 04.7	1893	
432	D	27.5.87	0919	61 20.0	08 12.0	841	ATTOM + transponder
433	D	27.5.87	1539	61 26.0 (61 25.8	08 03.0 08 02.8)	504	2 Aanderaa current meters (Mooring E)
434	D	27.5.87	1610	61 26.9 (61 26.7	08 00.4 08 00.9)	315	1 Aanderaa current meter (Mooring F)
435	D	27.5.87	1904	61 18.9 (61 19.0	08 15.3 08 16.1)	520	2 Aanderaa current meters (Mooring A)
436	D	28.5.87	1117	61 21.7 (61 22.1	08 08.6 08 09.1)	824	4 Aanderaa + 1TC (Mooring B)
437	D	28.5.87	1532	61 24.2 (61 23.2	08 05.3 08 05.8)	734	4 Aanderaa + 1TC (Mooring C)
438	D	28.5.87	2009	61 20.2 (61 20.3	08 12.3 08 12.3)	703	4 Aanderaa + 1TC (Mooring D)
432	R	29.5.87	0704	61 20.1	08 12.1	-	ATTOM + transponder
439	D	30.5.87	1846	61 33.2	08 47.2	724	ATTOM + Aa + transponder
433	R	31.5.87	0735*	61 30.0	08 22.8	-	Cut adrift. 1 Aa recovered
440	D	31.5.87	0826	61 30.5	08 22.9	737	ATTOM + Aa + transponder
439	R	31.5.87	1826	61 33.7	08 46.8	-	
440	R	31.5.87	2028	61 30.8	08 23.0	-	
428	R	03.6.87	1056	58 18.9	09 44.9	1705	

Note: Times for deployment or recovery are times at which the mooring reached or left the sea bed.
(Bracketed figures on moorings 433-438 are checked positions on 31.5.87)

* Mooring 433 recovered adrift. Time is time of instrument recovery.

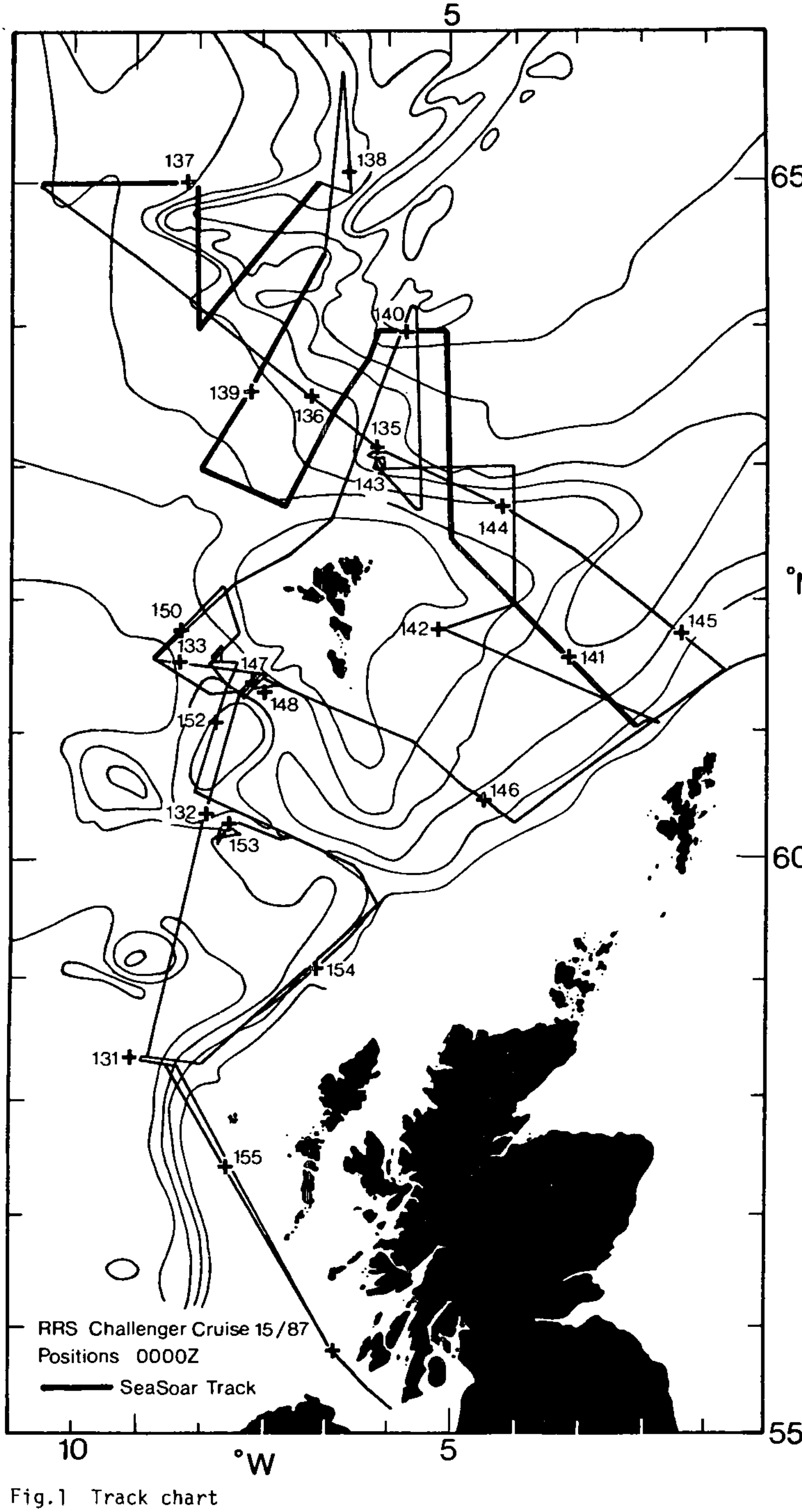

Fig.1 Track chart