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RRS DISCOVERY

CRUISE 174

19 MAY - 12 JUNE 1988

OVERFLOW STUDIES:
THE FAROE ISLANDS TO THE CHARLIE-GIBBS FRACTURE ZONE

CRUISE REPORT NO. 203

1988

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INSTITUTE OF OCEANOGRAPHIC SCIENCES

DEACON LABORATORY

Wormley, Godalming,
Surrey, GU8 5UB, U.K.

Telephone: 0428 79 4141
Telex: 858833 OCEANS G
Telefax: 0428 79 3066

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CRUISE REPORT No.203

RRS DISCOVERY

Cruise 174

19 May - 12 June 1988

Overflow studies:
the Faroe Islands to the Charlie-Gibbs Fracture Zone

Principal Scientist

P.M. Saunders

1988

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ABSTRACT

Studies of the northern overflows and the production and transport of North Atlantic Deep Water were carried out around the Faroe Islands, at 57°N across the Iceland basin and in the Charlie-Gibbs Fracture Zone. Primary tasks were:-

1. To recover moored instruments in the Faroe Bank Channel deployed 1 year ago on *Challenger* Cruise 15/87.

2. To lay current meter moorings in the Charlie-Gibbs Fracture Zone.

3. To carry out CTD, dissolved oxygen, silicate and Freon measurements at both the above locations and on a mid-basin section near 57°N.

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

ISSUING ORGANISATION

Institute of Oceonographic Sciences
Deacon Laboratory
Wormley, Godalming
Surrey GU8 5UB. UK.

TELEPHONE 0428 79 4141

TELEX 858833 OCEANS G

TELEFAX 0428 79 3066

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FAROE BANK CHANNEL
ICELAND BASIN
NORTH ATLANTIC DEEPWATER

CONTRACT

PROJECT

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SCIENTIFIC PERSONNEL

Saunders, Peter M.	IOSDL	Principal Scientist Marine Physics
Alderson, Steven G.	IOSDL	Marine Physics
Bacon, Sheldon	IOSDL	Marine Physics
Beney, Martin G.	RVS	Shipboard Computing
Dawe, Garreg L.	RVS	Shipboard Computing
Hooker, Nigel J.	IOSDL	Applied Physics
Lin, Hongjun	IOSDL	Visiting Scientist
Millard, Nicholas W.	IOSDL	Applied Physics
Moorey, John A.	IOSDL	Marine Physics
Perrett, James R.	IOSDL	Applied Physics
Phillips, Gregory R.J.	IOSDL	Applied Physics
Smythe-Wright, Denise	IOSDL	Marine Physics
Waddington, Ian	IOSDL	Marine Physics
Wallace, Robert F.	IOSDL	Workshop

SHIPS PERSONNEL

Warne, P.H.	Master
Jackson, S.	Chief Officer
Ellison, R.H.	2nd Officer
Leather, C.M.	3rd Officer
Kirkwood, S.J.	Radio Officer
Bennett, I.R.	Chief Engineer
Byrne, P.J.	2nd Engineer
Clarke, J.R.C.	3rd Engineer
Phillips, C.J.	3rd Engineer
Smith, B.A.	Electrical Engineer
Pook, G.A.	C.P.O. (Deck)

ITINERARY

RRS Discovery sailed from Barry, South Wales on May 19th, 1988. The ship proceeded northward and worked south and west of the Faroe Islands before crossing the Iceland basin near 57°N to the mid-Atlantic Ridge. The Charlie-Gibbs Fracture Zone was the final area visited before the ship returned to Barry, docking there on June 12th, 1988.

SCIENTIFIC OBJECTIVES AND TASKS

The objective of the cruise, which is one of a series, was to study the overflow of Norwegian sea water across the Iceland Faroes Ridge and through the Faroe Bank Channel, the formation of North Atlantic Deep Water in the Iceland Basin and to observe its passage through the Charlie-Gibbs Fracture Zone into the western Atlantic. To these ends the following tasks were undertaken on Cruise 174:-

1. Recovery of an array of moorings in the Faroe Bank Channel and an inverted echosounder/pressure recorder at its exit (all deployed on Challenger cruise 15/87).

2. Further trials of an acoustic travel time monitor (ATTOM).

3. Hydrographic observations with a CTD together with water samples drawn for the analysis of salinity, dissolved oxygen, silicate and Freon 11 and 12. These observations to be made where moorings were laid/recovered and on a section across the Iceland Basin near 57°N.

4. Deployment of an array of moorings in the Charlie-Gibbs Fracture Zone for a period of 1 year.

It will be helpful if reference is made to Figures 1 and 2 at the end of this report. Except for task 1 these objectives were carried out successfully.

NARRATIVE

Work in the area of the Faroe Islands

RRS Discovery sailed from Barry at 0920/May 19th (Day 140). After passage through the Bristol Channel and Irish Sea in calm conditions course was set for the location 60°N 7°W at the east end of the Wyville Thomson Ridge. On arrival (1440/May 21st), a trial CTD lowering (Station 11730) was made but after reaching the bottom the CTD failed. An XBT section (#2-17) was then worked along the Wyville Thomson Ridge (1715-2115) which was augmented by Acoustic Doppler Profiler current estimates. The overflow of Norwegian Sea water was revealed. A second CTD lowering, station 11731, was made at 2328/May 21st (142) and the multisampler and two acoustic releases tested successfully. The ship then steamed northward along 8°W working on XBT section (#18-27) in the Faroe Bank Channel between 0330 and 0715 on the 22nd (143).

Attention then focussed on the mooring array laid on RRS Challenger cruise 15/87: moorings were interrogated between 0715 and 1000 but only three of the six were heard, and one of these three was lying on the bottom the upper part having been trawled up and recovered on the Challenger cruise. Mooring 435, the southernmost, was released at 1020 (143) and recovered by 1130. Two ATTOM (Acoustic Travel Time Ocean Monitor) moorings numbered 462 and 463 were laid at 1425 (143) and 1921 on the southern and northern sides of the Faroe Bank Channel respectively in about 700m of water. They were positioned close to the XBT line worked earlier in the day.

Between 2100/May 22nd and 0630/May 23rd (144) CTD stations 11734 to 11741 were worked across the Faroe Bank Channel close to but somewhat east of the mooring locations. This section was coordinated with a similar CTD section worked by the Faroese R.V. Magnus Heinason 40km to the south-east. During this work the wind increased to 30kt and the use of the multisampler was abandoned.

Between 0730 and 1530 on May 23rd (144) search was made for the three moorings (numbers 434, 436,437) which had not been heard on the previous day. The area was criss-crossed with closely spaced lines using mooring 433 as reference and GPS navigation when available. Nothing was heard and the decision taken to steam NW a distance of 80km to reoccupy a CTD section worked on the Challenger cruise 15/87. Stations 11742-11747 interspersed with XBTs (#28-30) were accomplished between 1900/May 23rd and 0600/May 24th (145). Shortly thereafter at 0715 the Inverted Echo Sounder and Pressure gauge mooring was released and recovered by 0806. RRS Discovery returned to the Faroe Bank Channel and carried out further acoustic searches on approach to and around the missing mooring locations. Again nothing was heard.

Between 1500 and 2030 attempts to release mooring 438 failed despite every effort by Greg Phillips, the last of which involved lowering a transducer to a depth of 800m very close to the mooring. Thereafter an XBT section (#32-38) was worked along 8°W, 2145-2345/May 24th, repeating that carried out on 0330-0715/May 22nd. The line of XBTs passed close to the ATTOM moorings which were both released and recovered safely, the former at 0440, the latter at 0800/May 25th (146). Prior to the ATTOM recoveries a CTD station 11748 was worked close to the southern end of the R.V. Magnus Heinason section.

RRS Discovery returned to the recalcitrant mooring 438 and at 0910/May 25th released it! All gear was recovered and the ship proceeded NW along the channel about 35km interrogating for the 3 missing moorings: again nothing was heard. The loss of equipment (4 releases, 2 Thermistor Chains and 10 Aanderaa current meters plus steel sphere buoyancy) is particularly unfortunate at a time of financial stringency: the loss of data is a setback too. Almost certainly the cause was the trawling operations which were being carried out by an east European fishing fleet during Challenger cruise 15/87. On this Discovery cruise no such fleet was sighted.

Work in the Iceland Basin

About 1400/May 25th (146) a course was set for 56°N 22°30'W to carry out a CTD section from Edoras Bank on the Rockall Plateau to the Reykjanes ridge at 59°N the line running SE to NW (see Figure 1). En route to the first station XBTs were launched (#39-44).

Between 1400/May 27th (148) and 0930/May 30th (151) 14 CTD lowerings were made with the multisampler and transmissometer: 12 x 1.7 litre samples were drawn for salinity, dissolved oxygen, silicate and Freon analysis. The station numbers were 11749-11762. A prominent feature of each station was a layer of low transmittance immediately above the bottom: only on 3 stations at the ends of the section was it missing. On station 11754 the bottom transmittance fell to 54% per metre, the lowest value outside of those in the upper photosynthetic layer observed by the author to date.

Multisampler performance was erratic and frustrating but had the merit of ONLY indicating successful firings. Various repairs were made but none was entirely successful in eliminating the problem. On station 11758 May 29th (150) there was a delay of 2.5 hours when the electric motor, which provides the power for the hydraulics operating the midship winch, suffered a runaway. No fault could be found but the problem would recur.

Work in the Charlie-Gibbs Fracture Zone

En route from the last CTD station on the Reykjanes Ridge 0900/May 30th (151) XBTs (#43-51) were launched at 6 hour intervals. Nearing the site of the first CTD station there was a failure of the ship's gyro and a loss of navigation 1540-1730/May 31st (152). On the approach to the site at 11 kts the difficulty of finding the bottom in this extremely rough mid-ocean ridge area was made apparent, a difficulty recurring for the next several days.

The scientific programme for this region called for the working of a CTD section of 9 casts along 35°N a distance of approximately 170km from the first station and the laying of 8 year-long current meter moorings along this line, measuring the flow below 2500m. ATTOM trials would also be carried out. See Figure 2 for the layout of moorings and CTDs. This programme was accomplished between 2200 (152) and 2330 (157). Sufficient time remained at the completion of the programme to allow a further short section of 9 CTDs to be worked near 32°W.

To return to the narrative, a CTD lowering station 11763, was made at the site of mooring 473, and was completed by 0001/June 1st (153). Between 0100 and

0500 two bathymetric surveys were carried out at sites for the ATTOM moorings on the northern and southern sides of the Northern Transform Valley: GPS coverage made a real time plot of positions invaluable. Mooring 464 or ATTOM 2 was laid on the southern side of the valley at 1213 and mooring 465 or ATTOM 1 on the northern side at 1517/June 1st. This was followed by the first of the current meter moorings, mooring 466 at 1742 in the deepest part of the N. Transform Valley. A CTD lowering at the centre of the Southern Transform Valley station 11768 was completed by 0030/June 2nd (154).

During darkness a bathymetric survey under the control of GPS navigation was carried out at the sites for moorings 467 and 469 but before either was laid a CTD lowering station 11769 was made near the ATTOM 1 mooring. It was completed by 0800/June 2nd (154). Mooring 467 was laid by 1046 in calm seas but the next mooring launch was delayed 24 hours due to the breakdown of the electric motor powering the forward hydraulic ring-main, which operates both the double barrelled winch as well as the CTD winch. The failure took the form of a runaway or lack of speed control, a potentially lethal situation.

In this situation we decided to investigate the performance of the ATTOM instruments and from 1700 to 1800 the transmissions from ATTOM 2 were examined. The instrument was found to be transmitting but not transponding. Accordingly RRS Discovery proceeded to the ATTOM 1 site and released it. The mooring (465) was recovered by 2130/June 2nd (154) using the forward crane. Meanwhile the forward electric winch had been rigged with the 6mm conducting wire and a test lowering made to 3500m with a load of 130kg simulating the CTD package. This was completed by 0100/June 3rd (155).

Between the hours of 0100 and 0600 an Acoustic Doppler Profiler (ADP) calibration exercise was carried out. A zig-zag pattern was steamed at 10kts under GPS navigation to determine the speed correction factor and the misalignment angle of the instrument. Between 0800 and 1100/June 3rd a wire test was made of two acoustic releases on the forward electric winch: the lowering went to 3800m and the winch performed excellently after a 2 year period of disuse.

By this time the fault on the electric motor had been identified by the ship's electrical officer as a burnt out wire wound resistor: fortunately a replacement was available and once fitted the motor worked as well as ever. Consequently we were able to proceed with the launching of mooring 468 in the deepest parts of the Southern Transform Valley. This was accomplished by 1344/June 3rd. At 1647 a second mooring, number 469, was laid and at 2030 ATTOM 1 was redeployed as mooring 470 at its original site without the 10kHz transponder which had caused the earlier problems. Mooring operations were suspended for the day and a CTD lowering made within 1 mile of mooring 467, station 11774 which was completed by 0015/June 4th (156).

A bathymetric survey was made at the next mooring site, a CTD lowering made as station 11775 and mooring 471 deployed by 1014/June 4th. RRS Discovery movements were hampered at this time by dense fog which worsened as we steamed south to next mooring site, where mooring 472 was deployed by 1519. Heavy rain made launch conditions unpleasant. On the CTD lowering, station 11778 2 miles west of the mooring completed by 1900/June 4th the weather improved strikingly. The southern end of the 35°W CTD section was completed by station 11779 at 0001/June 5th (157).

RRS Discovery steamed back north to recover the ATTOM moorings; ATTOM 2 (mooring 464) was released at 0744 and ATTOM 1 (mooring 470) was released at 1015. Then a bathymetric survey of the site for mooring 473 was carried out under GPS navigation and mooring 473 the penultimate was laid at 1421 in increasing swell. En route to the next CTD station at 1538 the main engine stopped and a total power failure ensued: not until 1708 was the ship's gyro re-established and normal operations resumed. Accordingly plans were changed and the last mooring, number 474 was launched at 2011/June 5th (157). The last CTD lowering of the group was made as station 11782 at the northern end of the 35°W section. It was completed by 2330 and Discovery steamed eastward, the swell still quite large, to 32°W.

The final series of CTD stations on the cruise stations 11783 to 11791 were worked in the next 38 hours, the first starting at 1145/June 6th (158) and the last ending 0215/June 8th (160). On station 11785 two casts were made; on the second we exchanged transmissometers trying out a unit repaired at Wormley. On station 11786 the repaired unit was again tried and again showed large differences between the up and the down trace. Accordingly we reverted to unit SN0035 to complete the programme. On the night of the 6th of June a second ADP calibration exercise was carried out with aims identical to those of the zig-zag trials of June 3rd. Left handed and right handed boxes were steamed under GPS navigation whose coverage was slightly disappointing. Overall the two trials were very worthwhile.

On completion of station 11791 ending at 0215/June 8th (160) RRS Discovery headed homeward docking in Barry at 0620/June 12th (164).

REPORTS OF SCIENTIFIC WORK

1. RD Instruments Vessel Mounted Acoustic Doppler Current Profiler

The RDI ADCP was installed at Barry between the 11th and 18th of May. The transducer array was mounted on the ASDIC pod which was used throughout the cruise in a retracted position. The main ADCP electronics and the IBM PC-AT data acquisition system were situated in the plot with an RS232 serial data link to the PDP11/34 computer. Heading information was obtained from the ship's gyro compass with pitch and roll information being obtained from a Colnbrook Instrument Development Vertical Reference Gyro.

IBM Data Acquisition

Version 2.28 of the RDI ADCP data acquisition software was installed on the IBM PC-AT hard disk before the start of the cruise. A new version of software, version 2.34, was obtained just prior to sailing but there were no details of exactly what updates had been made. It was decided to run V2.28 for the first part of the cruise although it became apparent that there were certain bugs in the software which caused the system to crash occasionally. Version 2.34 was therefore installed in the hope that it might prove more reliable and so it proved to be.

Regular backups were made of data from the hard disk onto floppy disks. A few problems were encountered with disk drive A not ejecting disks properly and one floppy disk was found to be bad. As before, the IBM clock needed regular resetting.

Instrument Performance

The RDI ADCP has the facility to measure the depth and the velocity of the ship relative to the sea bed where the water depth is shallow enough. One of the objectives of this cruise was to optimise the parameters used in this measurement to allow bottom tracking to a greater depth. It was found that the default parameters would only allow bottom tracking down to 500m, no matter how good the return signals were. The size of the depth bins, and hence the resolution, was changed to 8m. This change alone increased the bottom tracking range to over 800m under favourable conditions with 700m range obtainable under all conditions encountered.

Current profiles were obtained down to depths of 400m under favourable conditions. This depth could be obtained when the ship was both steaming and stationary although the quality of the data was severely reduced if the bow thruster was in operation, even resulting in no currents being measured at all on some occasions.

The low transmitter current error flag seen on previous cruises was again noticed. It occurred very rarely at water temperatures over 11°C but was on approximately 70% of the time at 8°C.

Pitch, Roll and Heading

The pitch and roll gyro gave the occasional bad value on its output which may have caused the problems with the version 2.28 DAS software. With version 2.34 a message appears to say the bad value has been thrown away.

The heading gyro interface generally worked well although it sometimes missed a step thus requiring a constant check to be kept on the ADCP heading compared to the master gyro. The results of these checks are shown below.

Day	**Time**	**Difference from reference (ADCP - MG)**	
141	08:48	-0.02	
141	18:30	-0.34	
142	07:00	-0.25	
142	17:30	-0.74	
144	16:30	-1.65	
145	20:40	0.61	After adding 1.6° correction to ADCP (1848/144)
146	14:40	0.7	
147	10:00	0.3	
147	18:30	0.4	
148	09:25	0.06	
148	20:00	0.08	
149	07:45	-0.03	
150	00:10	0.25	
150	18:00	0.1	
151	09:45	0.55	
152	20:02	-0.11	After problems with ship's gyro.
153	14:00	-0.08	After further problems with ship's gyro.
154	19:30	-0.71	After swapping to Arma-Brown gyro.
155	14:45	-0.25	
156	12:11	-1.06	
157	10:00	-0.31	
157	20:30	1.65	After ship's power failure.
158	10:00	1.43	
158	22:10	-0.5	After removing 1.6° heading bias.
158	23:00	-0.28	
159	13:15	-0.45	
159	23:10	-0.39	
160	13:30	-0.59	
161	09:30	-0.15	
162	08:50	-0.48	
162	16:00	-0.58	
163	09:00	-0.65	

The difference figures are the mean difference of four sets of readings from the ADCP and the ship's gyro.

Logging and nature of data

Data was transformed from the IBM PC controlling the ACP via an RS232 link to the PDP. Except for periods of IBM system maintenance and IBM and PDP crashes, the data was logged continuously throughout the cruise. Problems with the PDP did not affect the logging or preliminary data analysis.

The data divides into four classes. The first corresponds to shelf regions at the beginning and end of the cruise. In particular during the early passage leg up the Irish Sea, 1 and 3 minute averaged data for 30 bins of 4 metres each were logged. The return passage to Barry involved 20 minute averages for 75 bins of 8 metres each. Both of these sections included periods when bottom tracking produced values of the ships velocity over the ground. The second data class corresponds with the bulk of the data and comprises 3 minute averages over 75 bins of 8 metres each, which covers a region extending from the Faroe Bank Channel to the Charlie-Gibbs Fracture Zone. Two ADP calibration experiments were attempted whilst in this region. Both produced 1 minute data over 75 bins of 8 metres each. The first followed a zig-zag pattern and the second a series of boxes making a figure of eight. By comparing adjacent straight sections and assuming the local current does not change over this interval, corrections to the ADP derived speed and direction can be estimated. Preliminary calculations suggest speed errors of the order of 3% and direction errors of order 1°. The last class is the smallest and was collected during the final passage leg. Here a 1 hour average was made over 75 8-metre bins.

JRP, SGA

2. Moorings and Current Meters (see Table 1 for a summary)

Faroe Bank Channel Array

An array of 5 moorings deployed from RRS Challenger 15/87 were scheduled for recovery. Three moorings were of the proven long term jacketed wire design with two moorings being all Kevlar fibre line.

Moorings Recovered

Mooring 435 site A, of the Kevlar line design, was released successfully and recovered using the foredeck system of DBC and A frame.

Extensive marine growth was seen on components extending over the total mooring length. This growth was a fibrous filament type with individual strands up to 10mm in length at the subsurface buoy and of the same order at the lower current meter but less dense per square cm by a factor of approximately 3.

Future deployments in this area should be carefully treated around the rotor sensors and vanes with new antifouling to prevent possible misreading of the instrument.

The Kevlar line used on the mooring was 6mm diameter jacketed 3 strand kevlar in a polyester braided sheath. This line is considerably smaller in diameter than lines used by IOSDL previously, the object being to reduce line drag and weight. Analysis of the current meter pressure record should give an indication of mooring performance. Mechanical testing of the recovered line should be undertaken to determine its durability looking forward to longer term mooring deployments of 2 years plus.

Mooring 438 Site D, of the long term jacketed wire design, was released and recovered in the same way as 435. However considerable difficulty was encountered in picking up the subsurface buoy due to the strong line being tangled beneath the buoy. The mooring was in excellent order with no marine growth seen on any component. Removal of the thermistor chain from the jacketed wire proved a simple operation with the plastic retaining clips breaking free easily.

Moorings 434 (F), 436 (B), 437 (C) could not be located acoustically and the sites were eventually abandoned.

The most likely cause of loss of these moorings would be fishing activity. Moorings 435 (a), 438 (D) being in such good condition that mooring component failure would be doubtful. During the recovery operation a large pelagic factory fisher was seen fishing in the vicinity and deep scattering layers observed on the echo sounder down to 250 metres.

Current meters recovered

Mooring 435

ACM7517 rec. no. 43501 7358 recs. 29 errors. Battery failure.

Mooring 438

ACM 3622 rec. no. 43801 8549 recs. 32 errors. Full data.

ACM 7947 rec. no. 43802 6784 recs. 2377 errors. Battery failure.

ACM 6867 rec. no. 43803 8550 recs. 1 error. Full data.

T.L. 879 T.C. 1402 rec. no. 43804 4271 recs. 16 errors. Data loss during deployment possibly due to vibration of tape on recording head.

ACM 7945 rec. no. 43805 8588 recs. 5 errors. Full data.

ACM 7517 and 7947 both exhibited catastrophic battery failure. When run on test these instruments performed correctly with current drain valued normal. Both instruments tested in deep freeze successfully to check low temperature operation. The conclusion is drawn that the batteries became faulty or of low current capacity during operation, a fault not apparent prior to deployment. All the ACMs recovered were overhauled and checked onboard: they required no repair work.

Faroe Bank Channel ATTOM Moorings

Moorings 462 and 463

Two simple moorings were provided for the ATTOM package with an ACM to record local conditions for deployment duration.

The moorings with glass sphere subsurface buoyancy were deployed anchor first from the foredeck. The ATTOM package required the use of the foredeck crane as the 'A' frame lift height was inadequate.

Recovery of the moorings was achieved by the same technique.

Current meters

Mooring 462.

ACM 8011 rec. no. 46201 452 recs. 8 errors. This mooring was used to test the instrument which failed predeployment checkout for long term moorings. Data quality good.

Mooring 463.

ACM 2108 rec. no. 46301 452 recs. 0 errors. Similar to 8011 failed predeployment. Data quality good.

Charlie-Gibbs Fracture Zone ATTOM Moorings

Moorings 464, 465, 470.

These were moorings similar to 462 with the anchor line extended 200m with polypropylene disposable line. Deployment and recovery technique were the same as those for 462. Mooring 470 was a redeployment of 465.

Current Meters

Mooring 464

ACM 2108 rec. no. 46401 545 recs. 0 errors. Full data.

Mooring 465

ACM 8011 rec. no. 46501 219 recs. 0 errors. Full data.

Mooring 470

ACM 8011 rec. no. 47001 167 recs. 0 errors. Full data.

Charlie-Gibbs Fracture Zone Mooring Array

An array of 8 current meter moorings were deployed for a 1 year duration.

The moorings were all subsurface glass sphere buoyed: moorings lines were polyester braided line all of which had been previously used. Anchor weights were scrap steel chain with $^3/_8$" galvanised chain straps holding the chain lengths together. Seizing of shackles was done by the use of plastic cable ties which have proved successful in the Faroe Bank Channel Array. Shackles $^1/_2$" diam. proved troublesome to undo and 200 had to be retapped and threads on pins run down with a die. On investigation several had bent pins which appears to have occurred during the testing procedure on manufacture. These shackles were rejected and one is to be returned for testing.

The deployment was anchor first for all the moorings, using the foredeck DBC and 'A' frame. Free fall descent rates were monitored acoustically. It should be noted that the storage winch tails were replaced for this cruise with 18mm polypropylene ropes to prevent damage to the soft polyester mooring lines. By using a BOSS S6 hook on the tail, rewinding of short mooring lines was considerably speeded up as quick attachment to the lines could be attained.

IW

3. Acoustic Mooring and Monitoring Systems

Faroe Bank Channel

Two of the three shallow water (<2000m) acoustic releases prepared for the ATTOM moorings planned for this site had been built from spare electronics of varying vintage. Serious problems were experienced with both units such that by the time we arrived on site only the third unit was available for deployment.

A run down the line of moorings deployed last year succeeded only in operating the units deployed at sites E (known to be lying on the bottom), D, and A. The most responsive unit was on A and so this mooring was recovered. After changing the Titanium load bearing assemblies (required later) for the now 'short term use only' stainless steel version this was redeployed on the first ATTOM mooring. The good unit mentioned earlier was deployed on the second ATTOM mooring after successfully passing the usual operational trials while attached to a CTD cast.

On the run up to the area two 10kHz transponders were built from spares and deployed with the ATTOM units. These units respond to the high power transmissions from the ATTOM units and produce signals that can be detected and displayed on the ship's 10kHz PES system. These signals confirmed that both ATTOMs were transmitting on schedule and responding to one another's transmissions although one 10kHz transponder was also frequently responding to sea noise. Both 10kHz transponders responded reliably to the 10kHz PES transmissions to ranges in excess of 4km (water depth 750m) using the beam electronically steered 60° forward.

Both ATTOM moorings were recovered uneventfully and used pairs of standard retractor units as the active release devices.

An extensive acoustic 'box' search was navigated at sites B, C and F using GPS and DECCA. Every acoustic variation of technique known to me was tried regularly throughout the search. The performance of the unit lying at site E regularly confirmed the proper operation of the shipborne acoustics. The units deployed at B and C near the centre of the channel were also sought during two long runs down the centre of the channel in case currents or trawlers had moved them in that direction. No sign was found of B, C, or F.

The acoustic unit on the mooring at site D had been difficult to operate during the first search run. It subsequently proved very difficult to release. Seven hours were spent trying to release this mooring trying all the usual techniques of ship movement and wider transmitted FM bandwidth. A new technique was also tried; that of lowering a transducer of better horizontal directivity than the PES system to the level of the release unit (which should also peak acoustically in the horizontal plane) using the CTD cable; the effectiveness of this was probably somewhat thwarted by power losses in the cable. The area was then vacated leaving the release pinging in the 'release mode' with the intention of returning at a later date to drag for it. On the return for the dragging operation I continued to transmit the release command (which requires an accumulation of signal in the sea unit as a safety feature) from the moment the pinger signals were detected. As I manoeuvred the ship in position to start the dragging operation the release operated acoustically and a normal recovery was achieved. On testing the unit acoustically immediately after recovery the sensitivity was observed to gradually increase (temperature effect). All the units deployed on these moorings had successfully passed trials after 24 hours at -5°C at Wormley before being taken to sea. It will be further investigated at Wormley in the Autumn when time permits.

The seabed mounted Proudman, Inverted Echo Sounder was recovered successfully. It carries two IOS standard deep water acoustic release unit each operating one pyrolease. The first unit fired and achieved separation, the second was fired during the ascent to avoid bringing a line pyrolease back onto the deck. The initial stages of location when on the surface were carried out acoustically using the bottom echo from one of the units as received by the PES system.

Charlie-Gibbs Fracture Zone

All 11 remaining deep acoustic releases in Marine Physics stock were required to service the ten deployments required in this area. Five of the units had been recovered from long term moorings on the Porcupine Abyssal Plain on Discovery cruise 173 two weeks prior to this cruise. All 5 had been tested for operation at -6°C in that interval. Four were faulty but repaired in the early part of this cruise. Of the remaining 6 one was a special and used on one of the ATTOM moorings firing retractors. This was then recovered for reuse on Challenger cruise 31 two weeks after the end of this cruise. All eleven were successfully prepared for acoustic trials on CTD casts. One unit was faulty and could not be adequately repaired on board. One unit took on a cupful of water through a faulty underwater connector and water reached some of the electronics; no damage was visible but electronics for something as vital as an acoustic release cannot be used again long term. The unit was purged with fresh water and copious WD40. All the remaining units were deployed on moorings. The unit used at site 'B' was successfully used for two ATTOMs firing retractor units and then redeployed on the long term mooring using conventional pyroleases. All long term moorings made use of Titanium mechanics totally committing the Marine Physics stock.

The transponders used on the shallow ATTOM moorings were redeployed (but with opposite units) with serious reservations about the ranges obtainable due to the very much greater ranges required at this depth (2600 metres) and the strong horizontal directivity of their acoustic transducers. The high power unit (100 watts rms electrical) exceed expectations and gave totally reliable ranges locked to 8.5 kilometres. The other unit would only operate intermittently, to ranges of 6 kilometres, and with a very high occurrence of false triggers. It failed to indicate any correct operation of its ATTOM units and the mooring was recovered. The transponder was adjusted and equipped with a higher power transmitter and tested successfully on a CTD cast, it was not however reused. The ATTOM unit recovered (the slave) was found to have a high sensitivity to both noise and the false triggering transponder, so its redeployment did not use the transponder.

The flooded release was modified to operate a prototype electrically driven corrosion release (electrolytic fizzy link). A battery voltage starting at 18V was applied between a fine wire and large collector plate, removing material from the wire until it was weak enough to be parted by the spring driven lever mechanism. The unit is designed initially to replace pyroleases on short term (2 to 3 day) and cover deployments. The device was cycled 4 secs on and 4 secs off to allow the batteries to recover and ease the timing problem. A simple level mechanism operating a magnet and reed relay combination controlling acoustic pulse was used to indicate operation. Nine CTD casts were used to test two devices alternately. After initial operating times of 74 and 80 seconds by each unit they both settled to 54 to 65 seconds.

The bottom topography in some areas of interest fluctuated about 3000m; this is normally hard to follow at the standard 2.00 second PES rate so the ACMS units were used to drive the PES at 2.30 seconds (1725 metre repeats). this put these echoes firmly in the clearest area of the PES facsimile display.

GRJP

4. Acoustic Travel Time Ocean Monitor (ATTOM)

Two experimental instruments were brought to sea after modifications resulting from previous trials carried out in May 1987. The purpose of these instruments is to monitor the mean current flowing between them by measuring the difference between the up stream and the down stream acoustic travel times.

At the first site, in the Faroe Bank Channel, two moorings were laid obliquely across the channel. Mooring 463 being laid 28km to the north of mooring 462 at depths of close to 750m, chosen to be at or below the sound velocity minimum. Both moorings had the instruments 10m above the bottom with a current meter 10m above that. An acoustic release and a transponder were mounted along side the ATTOM. The transponder served dual purposes, as a location beacon and as an indirect means of monitoring the transmission from the ATTOM, the signals from which triggered the transponder but could not be heard directly at the ship. They were deployed for about 60 hours.

Two similar moorings were prepared for deployment obliquely across the channel at the second site in the Charlie-Gibbs Fracture Zone. An echo sounder survey of the sites showed the topography to be rough and so extra lengths of rope were added to make the ATTOMs 230m above the bottom to ensure a clear line of sight between the two moorings (moorings 464 and 465). This time they were about 23km apart and in a depth of about 2900m, a depth chosen to ensure that the grazing acoustic ray would reach the other instrument. After a day, by monitoring the acoustic transponders, it was decided that the two ATTOMs probably were not 'talking' to each other and that the problem was with the northern mooring 465. This mooring was recovered and after finding that the problem was caused by interference from false triggers from the transponder, it was relaid in roughly the same position, this time without the transponder (mooring 470). Mooring 464 was in the water for about 90 hours, mooring 465 for about 30 hours and mooring 470 for about 38 hours.

During deployment all data was recorded on magnetic tape. A cursory inspection of the data shows the ATTOMs to have instrumentally worked and to have been in acoustic contact with each other. Software is currently being written to extract any signal from the data.

NWM

5. CTD and Multisampler

50 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 2). The winch was driven by a member of the scientific party and communication with other areas in the ship were via the Mimco Intercom which was almost trouble free.

The $CTDO_2$ was interfaced with a 1m transmissometer (SN35) from Sea Tech Inc. In support of the hydrographic measurements samples were drawn for salinity, dissolved oxygen, silicates and Freons, half of the bottles being reserved for the latter measurement. A 12 x 1.7 litre bottle General Oceanics multisampler was employed for sampling at pre-selected levels on the up-cast with the CTD stopped. Initially all the bottles were fitted with uncoated steel springs but after the stations around the Faroe Islands had been completed these were replaced by rubber bungey in the six bottles used for salinity and oxygen samples. A 10kHz pinger with a pressure switch activated at 30m depth was used to measure height above bottom. Mooring releases were tested on about a dozen stations.

The performance of the CTD during the cruise was excellent: the sea cable was remade at the connection above the CTD frame only once. The connecting cable between the CTD and the junction box was replaced as was a bulkhead connector on the CTD. Comparisons between the salinities derived from the CTD and about 200 sample salinity values showed the CTD conductivity cell somewhat less stable than usual. Employing about 150 dissolved oxygen sample values we were able to derive the constants for the $CTDO_2$ algorithm.

On the cruise we had the use of a pair of SIS digital reversing thermometers which provided temperature measurements on 31 casts. For the first half of those casts the digital reversing thermometers were on separate frames but for the last half they were placed on the same frame. Thus we are able to compare the digital thermometers with each other, with IOS calibrated mercury reversing thermometers and with the IOS calibrated CTD values. The agreement in these intercomparisons is shown in an accompanying table below and is remarkably good.

Performance of RTM 4002 Digital Reversing Thermometers

T_{156} mfs. corrected RTM temperature (SN 156)

T_{180} mfs. corrected RTM temperature (SN 180)

T_{CTD} IOS corrected CTD temperature

T_{Hg} IOS calibrated mercury in glass reversing thermometers

Comparison	Number of Observations	Difference Mean, 10^{-3}°C	Difference std dev, 10^{-3}°C	Temperature Range, °C	Pressure Range, db
$T_{180}-T_{156}$	18	-3.6	1.1	2.4 to 2.9	1500 to 4100
$T_{CTD}-T_{179}$	27	-0.3	3.3	-0.3 to 8.1	300 to 4100
$T_{CTD}-T_{156}$	28	-2.6	3.8	-0.3 to 9.6	100 to 4100
$T_{180}-T_{Hg}$	36	-5.6	7.5	-0.3 to 9.6	100 to 4100

The multisampler never worked reliably throughout the entire cruise: it was usual for at least one misfire to occur on a lowering. The sea unit was opened up, inspected and the oil replaced: there was no evidence of a sea-water leak. The external moving parts on the underwater unit were also cleaned and lubricated. Modifications were made to the electronics to cause a larger current to drive the stepper motor. All these actions improved performance without leading to complete reliability. In the course of this work it became apparent that rather than wait after a misfire a second attempt should be made as soon as possible.

Logging of the CTD data was achieved on the ship's level ABC system and worked without fault. The back-up logging system of the Digidata tape deck which also worked extremely reliably should therefore not need to be called on.

PMS, NJH, HL

6. Hydrographic Observations

Frequently on arrival on Discovery it is necessary to retrieve the sample bottle fiddle from storage in the lower hold and fit it back in the hydro lab. On this occasion it couldn't be found and our information is that it was left in an alley way (near the engine room) and was later thrown overboard on the orders of the Chief Officer. Whoever removed the fiddle and didn't stow it correctly must take some blame, but it is unbelievable that a Chief Officer can have thrown overboard something obviously designed for a special purpose. Thanks to suggestions and help from Arthur Fisher and I.O.S. workshop personnel a temporary replacement was improvised before sailing. After sailing the water bottle rack and fiddle were transferred from the forward rough laboratory to the after chemistry laboratory and the doors of this laboratory left permanently open so that freon sampling could take place in almost open air conditions.

The G.O. bottles were only just adequate for the job. Of the twelve usable bottles the six best were earmarked for freon sampling, consequently the salinity and oxygen sampling was carried out at first with bottles with obvious leaks. These were hopefully cured using the meagre spares. However there were some puzzling differences between CTD and water bottle salinities which may be partly explained by leaking bottles.

The rosette multisampler was used on most CTD dips and salinity and oxygen samples taken from the even numbered bottles and freon, nutrient and aluminium samples taken from the odd numbered bottles.

The salinity samples were measured by two different operators (S.B and J.M) one of the pair measured one day and the duplicate usually the next day. The salinometer was very stable over the period of the cruise, requiring only occasionally slight adjustment of the Rs standardising dials. This salinometer stability shows up in the good duplicate pairs. Standard Seawater used was P107 date of bottling 11 November 1987. Oxygen samples were also taken and titrated by both operators S.B. preferring British samples bottles, J.M. the French.

Two R.V.S. digital reversing thermometers were used on this cruise they agreed well with each other. The difference between the CTD temperature and the "digital" temperature was of the same order that we have found over the years using mercury in glass thermometers.

Hydrolab. One of the problems in using the forward rough laboratory as a hydrolab* is that it is so big it is not surprisingly, used for other purposes. very often just dumping large packing cases, stanchions, rope, canvas covers and other deckgear. A hydrolab is ideally a space adequate but not large enough to allow the dumping of large objects in it i.e. as it was when *Discovery* was first built. It is hoped that in re-modelling of the ship's space this might be taken into account.

Freon-oxygen/salinity/temperature. On this cruise we managed to coordinate work between the two, however freon sampling requires open laboratory or even open air sampling, oxygen and salinity sampling could tolerate an open laboratory system only in temperate climates. An open air system would be almost impossible especially since oxygen, salinity, nutrient sampling and thermometer reading requires the presence of the samplers of the bottles for much larger than the freon sampler, also the taking of oxygen requires protection and relative stability. A better solution would be that once the bottles are inboard they are divided into two groups and handled separately.

JAM, SB

7. Nutrient Analysis and Aluminium Samples

Nutrient samples were not collected until the beginning of the Iceland-Basin section. Silicates were measured in samples from a total of 26 CTD

*We didn't in fact use the forward rough laboratory on this cruise!

stations (Stations 11749-91) and nitrates from a total 16 CTD stations (11763-91). Nitrates were not measured prior to station 11763 because of leakages in the autoanalyser system.

All samples were measured using the IOS Chemistry Group Chemlab. autoanalyser, using the classical molybdate reaction for silicate and a diazo compound/azo dye for nitrate. Colour intensity was measured using filters of 810nm and 540nm for silicate and nitrate respectively. All data followed the expected concentration versus depth profiles for nutrients, with lower values in the surface waters than at depth. Silicate values ranged from 0.2 μ moles l^{-1} in surface waters at stations 88 and 89, clearly indicating a plankton bloom, to 18.2 μ moles l^{-1} at 3523 m, station 84. Nitrate concentrations showed similar profiles with values ranging from 0.8 μ moles l^{-1} in surface waters at station 89 to about 20 μ moles l^{-1} in the deep waters of a number of stations.

Samples were collected for David Hydes (IOSDL) at selected CTD stations for subsequent aluminium analysis. All samples were frozen after collection.

DS-W

8. Freon Analysis

This was the first occasion tnat the freon analytical system was used in earnest at sea. It had been envisaged that there could be contamination of the freon samples from air in the ship and so the system, together with the autoanalyser for nutrient analysis was sited in the IOS Chemistry container on the starboard side. Nevertheless contamination was still a major problem and this was disappointing since the analytical equipment was in perfect working order.

Prior to sailing there had been two substantial leaks of freon-12 on the ship, one in the hold and the other as a result of a compressor blowing up in the hydrographic laboratory. Consequently it was impossible to use the hydrographic laboratory for taking samples and so the water bottle rack was moved to the after chemical laboratory. This was isolated as well as possible from the main body of the ship by closing all internal doors and vents and sealing them with packaging tape. The large exterior double doors were left permanently open so as to obtain as near to outside conditions as possible. Unfortunately because of other constraints it was impossible to achieve the optimum of keeping the hydrographic bottles and all sampling outside on deck.

To obtain good freon data it is imperative that sampling be carried out in outside conditions and facilities for such need to be made available for future cruises. A rough three-sided metal or wooden construction which keeps rain and dust out would be sufficient. A completely enclosed structure is of little use, there needs to be a good flow of clean marine air to eliminate contamination from the ship. This is particularly true for RRS Discovery which uses Freon-12 for refrigeration and air conditioning. RRS Charles Darwin and RRS Challenger are marginally better since Freon-22 is used on these vessels. Further study into the design and siting up of an exterior hydrographic laboratory is required.

Initial work with both air and water samples showed extreme variability in the data. However the source of the contamination was difficult to pin point and it was some time before it was eliminated. The poor taps on the hydrographic bottles made sampling for freons extremely difficult. It is imperative that water samples are collected without even the smallest bubble entering the sampling syringe and this was only possible with six of the hydrographic bottles. Also the contents of the 1.7l bottles was not sufficient for freon, oxygen nutrients and salts bearing in mind that both freon and oxygen samples necessitate the loss of large quantities of sample to eliminate air bubbles. A compromise was made and the six bottles with good taps were assigned for freon and nutrient samples and the other six for nutrients and salts. The rubber bungies in the six freon hydrographic bottles were replaced with metal springs and the 'O' rings baked at 70°C for 36 hours before reinserting in the bottles. The latter was carried out after the initial measurements had been made and it made a drastic reduction in the data variability. A new suite of larger water bottles is an essential requirement for good hydrographic measurements in the future.

The air intake for atmospheric freon sampling had been positioned in Barry high on the foremast. After 10 days at sea it was realised that immediately below the intake there were two exhaust vents from the main body of the ship and this was why there was extreme variability in the atmospheric freon data when there was little wind and/or when the ship was on station. The situation was remedied by moving the air line intake to the jackstaff in the bows and the pump driving the air intake to a windy location outside the container laboratory. (It was thought that there might be a slight leak in the metal bellows pump and this needs investigation).

Having eliminated the contamination problems as best as I could, water samples were collected and analysed for Freon-11 and Freon-12 from station 11758 to the end of the cruise (some samples were collected at earlier stations but the data are suspect). Air and standards were also analysed with every suite of water samples for calibration.

The data requires considerable reduction before absolute concentrations can be quoted. Contamination was much less a problem for freon-11 than freon-12 and at a first look the data for the former look of reasonable quality. Without further study it is impossible to rule out that some of the freon-12 data might be suspect.

DS-W

9. XBT Observations

T4 and T7 probes were used at various times in the cruise to observe the overflow of cold water across the Wyville-Thomson Ridge, to get a quick look at the outflow in the Faroe Bank Channel, to augment CTD sections and generally observe the structure of the thermocline.

The data was recorded on a Bathysystems SA810 unit and employed a hand-held launcher. Failures were few and data returns were high. Some traces were coded and transmitted via the GTS. The times and positions of XBT drops are given in Table 3.

PMS

10. Shipborne Computing

Level ABC

During the cruise the following parameters were logged and processed on the ship's ABC computer processing system; ship's speed from the starboard em-log, heading from the ship's gyros, navigational data from a Magnavox 1107 satnav and Trimble GPS 4000A, and CTD. The data rate from the CTD was 8 frames per second and this was averaged in a special Level A. During CTD stations, the processed data was displayed live on a monitor in the computer room and hard copies produced at end the of each dip.

The output from MNS2000 Decca/Loran navigator was made available on a printout for use while searching for moorings. It was also briefly logged but as this was not successful and the ship moved outside the area covered by this type of navigation, the attempt was abandoned.

Survey work of intended mooring sites was undertaken during coverage by GPS and the positions plotted live onto the drum plotter. Depths were then entered manually and contoured. A live plot was also utilised to aid the calibration of the ADCP.

Coverage by GPS was in the order of two 5 hours periods a day. There are recommended default parameters for use in the GPS receiver but it was possible to stretch these to increase the time coverage without too much degradation to the positions. It was necessary though that a careful watch was kept on the receiver during these stretched times. As the system is still experimental and has not been fully implemented, it is not unusual to find that some of the satellites have not been regularly updated from the ground stations, especially during the weekends, with consequent reduction in coverage.

During the initial stages of the cruise, the metpac and anemometer were also logged. Both however, needed re-calibration. In the case of the anemometer this was achieved by reversing the order of the constant and coefficients of the polynomial. A similar solution was found for some of the metpac parameters.

Opportunity was taken during the cruise to test PBM PC/PS-2 software for generating ASCII files from the ADCP data files on disc. These were then transferred to the Level-C with Kermit and converted to standard RVS data files. Only six parameters were extracted from the datafiles, the timestamp, depth bin number and four velocities (East, North, Vertical and Error). The results of this test were:

1. 320Kb ADCP file generated 2.4Mb ASCII file,
2. Conversion to ASCII took 45 minutes,
3. Kermit took 80 minutes to transfer ASCII files,
4. Conversion to RVS Data File took 30 minutes,
5. RVS Data File occupied 800Kb.

Towards the end of the cruise. CTD data was archived to GF3 format tapes for delivery to the PSO. The software on the system was an older version but did not give any problems.

MGB, GLD

PDP

The PDP was mainly employed in logging Acoustic Doppler current profile data. This was accomplished successfully but a number of problems were encountered in running other tasks. The most serious was the occurrence of a system crash when using certain combinations of commands. One such combination was the command file used to compile and task-build FORTRAN programs. It was discovered that a crash could be avoided in these circumstances by performing the compilation and task-build outside a command file. This made the writing or debugging of programs a little cumbersome.

Another system crash occurred when investigating the use of a system package for copying from tape to disk and vice versa (BRU). This meant that updates to PSTAR and PDP system backups could not be copied from tape without some risk, since both were produced by the BRU package. The PDP was therefore used with the existing disk copy of PSTAR.

Unfortunately difficulties arose in the use of some PSTAR programs which could not be resolved. In particular a program for plotting ship tracks on a Mercator grid produced unaccountable shifts in origin. Recompiling and replacing some subroutines in the PSTAR library modified, but did not remove these shifts. A similar problem with an XY plotting program had been solved by recreating the task file earlier in the cruise.

An intermittent error also occurred on loading the PDP tape drive when tensioning the tape, as many as 4 attempts had to be made to get it to load properly.

On the whole, these errors were nuisances only, since they did not prevent the successful logging of data, but they obviously require investigation before this particular PDP is taken to sea again.

SGA

ACKNOWLEDGEMENTS

The willing cooperation of the Master, officers and crew of RRS Discovery in carrying out this cruise is gratefully acknowledged.

TABLE 1

Moorings Deployed and Recovered
(Geographically Arranged)

No.	Deploy/ Recover	Date 1988	Day	Time Z	Lat N	Lon W	Water Depth,m	Instruments	
Faroe Bank Channel			- Long term						
435	R	22 May	143	1020			520	A7517, A3624	
438	R	25 May	146	0910			703	A3622, A7947	
								A6867, T879, A7945	
			- Short term						
462	D	22 May	143	1432	61 06.08	07 51.01	762	A8011, ATTOM 1	
	R	25 May	146	0413			762	A8011, ATTOM 1	
463	D	22 May	143	1927	61 21.09	07 52.04	745	A2108, ATTOM2	
	R	25 May	146	0721			745	A2108, ATTOM2	
Charlie-Gibbs Fracture Zone				- Short term					
464	D	1 June	153	1237	52 34.96	34 51.33	2798	A2108, ATTOM2	
	R	5 June	157	0744			2798	A2108, ATTOM2	
465	D	1 June	153	1544	52 45.45	35 02.53	2963	A8011, ATTOM1	
	R	2 June	154	2040			2963	A8011, ATTOM1	
470	D	3 June	155	2056	52 45.59	35 02.8	2953	A8011, ATTOM1	
	R	5 June	157	1018			2953	A8011, ATTOM1	
				- Long term					
473	D	5 June	157	1442	52 48.23	35 06.84	2556	A7943,	'A'
474	D	5 June	157	2033	52 45.21	35 03.45	2951	A2108, A8011	'B'
466	D	1 June	153	1934	52 41.34	35 04.21	3678	A6705, A5205, A5204	'C'
467	D	2 June	154	1107	52 36.99	35 05.47	2933	A8010, A2107	'D'
469	D	3 June	155	1709	52 26.35	35 02.07	2943	A6372, A6225	'E'
468	D	3 June	155	1411	52 18.72	35 09.96	3836	A2406, A1260, A1259	'F'
471	D	4 June	156	1041	52 07.36	35 08.49	3516	A3727, A420	'G'
472	D	4 June	156	1549	51 48.14	35 07.38	3847	A3726	'H'

Times are for arrival on bottom (D) or release from bottom (R).

A - denotes Aanderaa current meter, T - denotes Aanderaa thermistor chain.

TABLE 2

CTD Station List

Station Number	Time Down,Z	Day/ Date 1988	Lat N	Lon W	Water depth m	Closest approach	Comments
11730	1512	142 21 May	60 12.7	06 47.5	1180	20	Failed on recovery
11731	2328	142 21 May	60 30.8	07 59.1	912	8	2 Acoustic Releases tested
11734	2117	143 22 May	61 28.2	07 55.5	187	10	Start Faroe Bank Channel section
11735	2224	143 22 May	61 26.4	07 58.7	417	10	
11736	2351	143 22 May	61 25.2	08 01.3	594	9	
11737	0118	144 23 May	61 23.0	08 04.5	776	11	
11738	0330	144 23 May	61 20.8	08 08.5	833	13	
11739	0433	144 23 May	61 19.2	08 09.6	773	10	
11740	0530	144 23 May	61 17.0	08 11.9	493	12	
11741	0615	144 23 May	61 15.4	08 13.3	371	8	End Faroe Bank Channel section
11742	1925	144 23 May	61 59.7	08 50.1	383	8	Start Faroe Iceland Ridge section
11743	2115	144 23 May	61 53.7	09 06.2	589	8	
11744	2235	144 23 May	61 49.8	09 16.8	706	8	
11745	0048	145 24 May	61 46.4	09 23.9	794	12	
11746	0309	145 24 May	61 39.9	09 32.0	936	13	
11747	0538	145 24 May	61 35.1	09 43.2	1050	10	End F-I Ridge section
11748	0130	146 25 May	61 00.9	07 41.7	926	9	Near mooring 436
11749	1441	148 27 May	55 59.9	22 30.0	1230	14	Start of Iceland Basin section
11750	1810	148 27 May	56 09.1	22 51.5	2174	7	
11751	2228	148 27 May	56 19.8	23 24.6	2468	12	
11752	0335	149 28 May	56 33.7	23 57.4	3269	12	In Maury Channel
11753	0919	149 28 May	56 46.5	24 35.4	3031	15	
11754	1523	149 28 May	57 00.6	25 15.8	2858	12	
11755	2025	149 28 May	57 14.7	25 52.8	2692	15	Gardar Ridge
11756	0127	150 29 May	57 30.5	26 35.1	2728	13	
11757	0628	150 29 May	57 45.0	27 22.3	2525	8	
11758	1505	150 29 May	58 01.4	28 11.3	2382	15	2 Acoustic Releases tested
11759	2055	150 29 May	58 17.8	28 55.7	2120	7	2 Acoustic Releases tested
11760	0137	151 30 May	58 35.0	29 40.1	2085	40	
11761	0546	151 30 May	58 48.5	30 27.6	1610	36	
11762	0851	151 30 May	59 00.3	30 57.1	1306	14	Reykjanes Ridge End section

TABLE 2 (continued)
CTD Station List

Station Number	Time Down,Z	Day/ Date 1988	Lat N	Lon W	Water depth m	Closest approach	Comments
11763	2257	152 31 May	52 48.3	35 05.6	2615	18	CGF Zone mooring 'A'
11764	0705	153 1 June	52 41.2	35 03.2	3689	10	at site mooring 'C'
11768	2314	153 1 June	52 19.2	35 08.1	3845	8	at site mooring 'F'
11769	0654	154 2 June	52 45.0	35 03.9	2942	15	at site mooring 'B'
11774	2306	155 3 June	52 37.8	35 02.9	3078	15	at site mooring 'D'
11775	0641	156 4 June	52 07.5	35 08.1	3525	5	at site mooring 'G'
11778	1746	156 4 June	51 47.6	35 08.6	3862	13	at site mooring 'H'
11779	2253	156 4 June	51 20.7	35 11.1	3435	28	most southerly of section
11782	2222	157 5 June	52 53.5	35 08.6	1940	26	most northerly of section
11783	1213	158 6 June	52 55.3	32 17.7	1935	20	Begin 32°W section
11784	1523	158 6 June	52 49.1	32 11.9	3550	8	
11785/1	1830	158 6 June	52 43.5	32 10.4	2803	15	
11785/2	2056	158 6 June	52 43.3	32 10.1	2891	13	Repeat with old transmissometer
11786	0819	159 7 June	52 33.7	32 08.0	3993	16	Last with old transmissometer
11787	1116	159 7 June	52 25.6	32 06.2	1631	12	
11788	1342	159 7 June	52 26.7	31 54.8	2434	13	Sheave on CTD winch traveller collapses: is repaired on recovery
11789	1749	159 7 June	52 23.2	31 41.1	3529	8	
11790	2036	159 7 June	52 20.6	31 34.9	1980	10	Conductivity glich on descent
11791	0044	160 8 June	52 08.2	31 00.0	4258	18	End with deepest stn.

TABLE 3
XBT Observations

Drop	Day	Time Z	Lat N	Lon W	Water depth m	Cassette	File
1	142	0911	59 20.0	07 52.5	875	1	71A
2	142	1716	60 03.1	07 06.4	480	1	72A
3	142	1737	60 04.7	07 12.7	485	1	43A
4	142	1758	60 04.5	07 16.0	490	1	44A
5	142	1815	60 05.6	07 21.1	480	1	45A
6	142	1840	60 07.4	07 28.4	510	1	46A
8	142	1902	60 09.0	07 34.9	550	1	48A
9	142	1912	60 09.5	07 37.9	585	1	49A
10	142	1926	60 10.4	07 41.8	640	1	710A
11	142	1941	60 11.7	07 45.7	630	1	711A
12	142	1956	60 12.8	07 49.8	580	1	712A
13	142	2011	60 13.8	07 53.3	545	1/2	713A/H
14	142	2028	60 15.1	07 58.3	515	2	414A
15	142	2044	60 16.1	08 02.6	525	2	415A
16	142	2057	60 16.8	08 07.2	520	2	416A
17	142	2111	60 17.9	08 11.5	515	2	417A
18	143	0340	61 05.3	07 52.1	610	2	718B
19	143	0359	61 07.4	07 52.8	652	3	719B
20	143	0424	61 09.1	07 52.9	821	3	720A
21	143	0440	61 10.6	07 53.2	863	3	721A
22	143	0507	61 13.3	07 53.5	883	3	722A
23	143	0539	61 16.8	07 55.0	850	3	723A
24	143	0609	61 20.0	07 55.5	810	3	724A
25	143	0639	61 23.0	07 56.3	722	3	725A
26	143	0658	61 25.0	07 57.4	580	3	726A
27	143	0714	61 26.4	07 58.0	360	3	427A
28	144	2151	61 51.8	09 12.5	655	3	728A
29	144	2356	61 47.0	09 23.3	780	4	729A
30	145	0155	61 43.7	09 29.0	877	4	730A
31	145	1618	61 20.9	08 15.4	707	4	731A
32	145	2145	61 24.5	07 51.8	620	4	432A

TABLE 3 (continued)

XBT Observations

Drop	Day	Time Z	Lat N	Lon W	Water depth m	Cassette	File
34	145	2159	61 22.1	07 51.9	755	4	734A
35	145	2218	61 18.9	07 53.4	825	4	735A
36	145	2249	61 13.9	07 54.5	905	4	736A
37	145	2318	61 09.1	07 54.0	700	4	737A
38	145	2335	61 06.3	07 53.5	585	4	438A
39	147	0848	59 21.5	14 07.4	970	4/5	739A
40	147	1438	58 40.9	15 52.1	1174	5	740A
42	147	1910	58 08.4	17 04.7	1058	5	742A
43	148	0627	56 52.0	20 25.1	1460	5	743A
44	148	1023	56 25.1	21 31.2	1507	5	744A
45	151	1230	58 32.8	31 17.9	1630	5	745A
46	151	1629	57 49.1	31 47.1	1750	5	746A
47	151	2359	56 42.5	32 30.8	2215	5	747A
48	152	0443	55 44.2	33 09.4	2220	5	748A
49	152	1008	54 46.9	33 48.0	2650	5	749A
50	152	1534	53 49.5	34 22.0	2650	6	750A
51	152	2112	52 58.1	35 00.8	>3000	6	751A

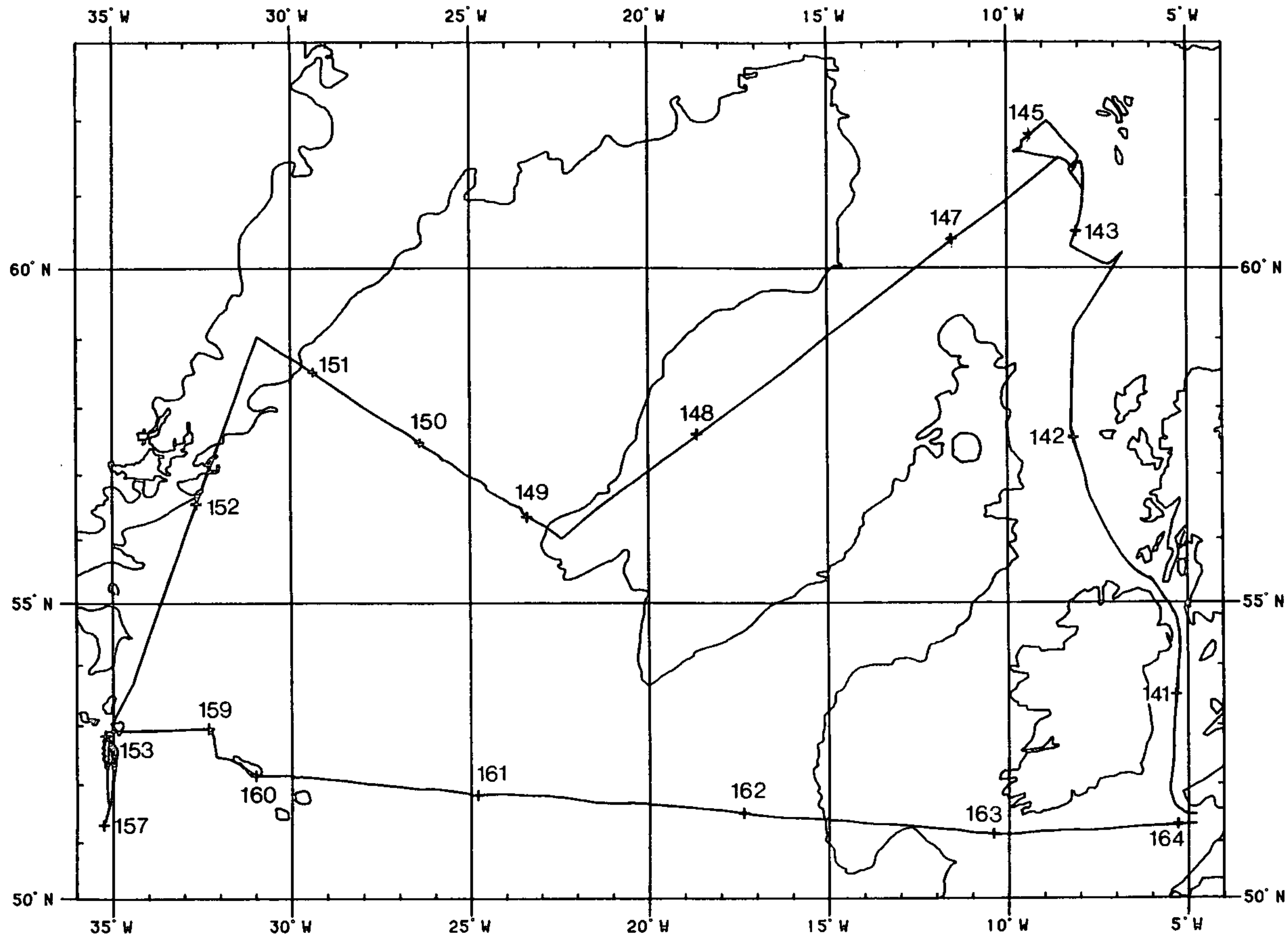

Figure 1. Discovery Cruise 174: 00z times are indicated thus +(Day)148

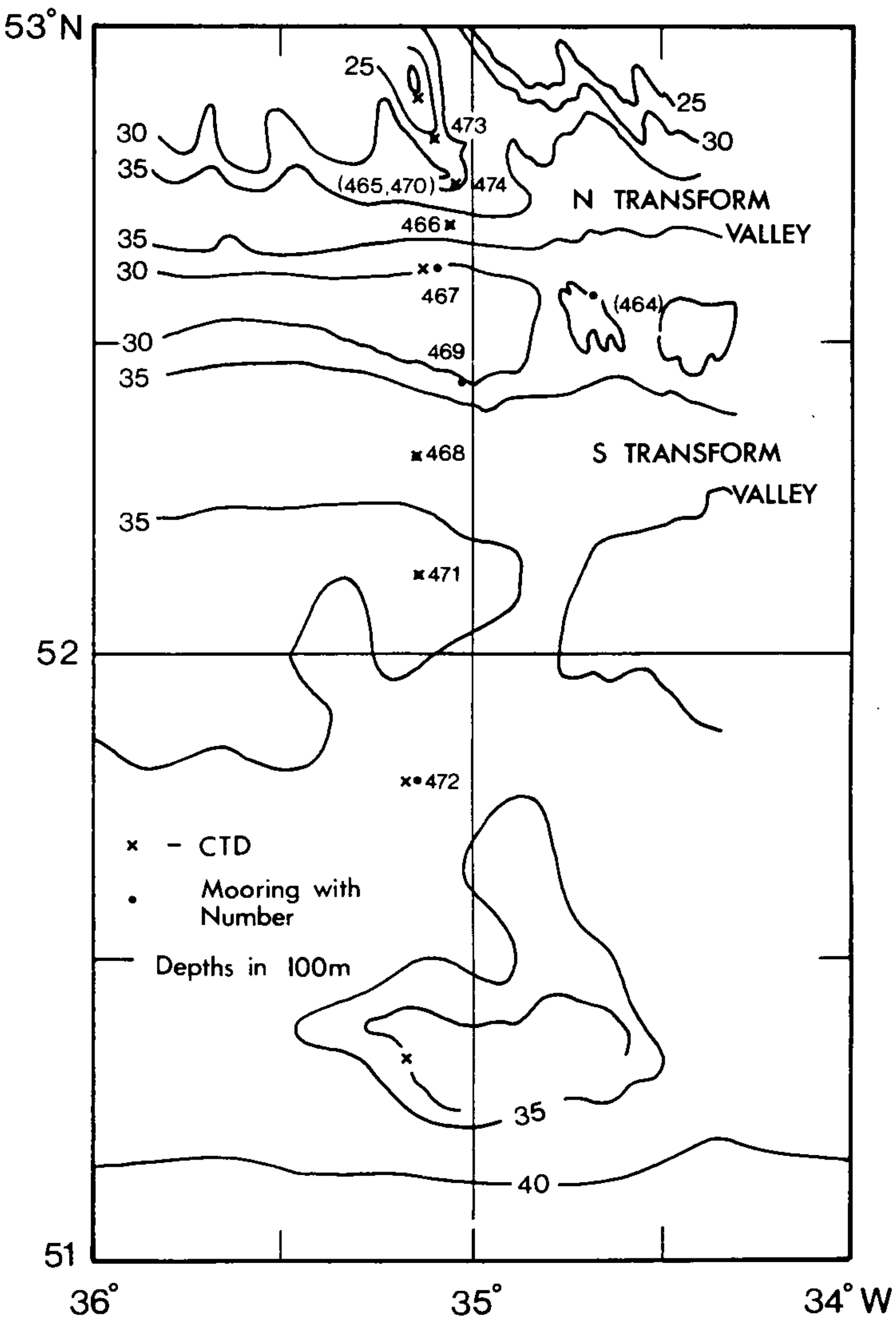

Figure 2. Moorings and CTDs in the Charlie-Gibbs Fracture Zone near 35°W