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DEACON LABORATORY

RRS CHARLES DARWIN

CRUISE 42

22 SEP - 16 OCT 1989

OVERFLOW STUDIES
IN THE
CHARLIE-GIBBS FRACTURE ZONE
AND NEAR THE
FAEROE ISLANDS

CRUISE REPORT NO. 209

1989

Natural
Environment
Research
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OCEANOGRAPHIC SCIENCES
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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

Director: Dr. C.P. Summerhayes

Natural Environment Research Council

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RRS CHARLES DARWIN

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Overflow studies

in the Charlie-Gibbs Fracture Zone and near the Faeroe Islands

Principal Scientist

P.M. Saunders

1989

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AUTHOR

SAUNDERS, P.M. *et al*

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ABSTRACT

The third in a series of cruises concerned with measuring the strength of the overflow of cold dense water from the Norwegian Sea into the eastern North Atlantic visited the Charlie-Gibbs Fracture Zone and the Faeroe Bank Channel (in that order).

At the first site eight moorings with 16 current meters (400 day records) were successfully recovered. 14 of the instruments appear to have yielded usable records. It is believed these will furnish the first measurements of the mass flux of cold water through the Charlie-Gibbs Fracture Zone. At the second site five moorings with current meters were deployed along with two ATTOM (Acoustic Travel Time Ocean Monitor) instruments. One of the ATTOM units failed shortly after launch and was recovered. Repairs were made and wire tests conducted successfully. It is planned to relaunch the unit on the following cruise of *RRS Charles Darwin* (43).

This report contains a narrative of the work, descriptions of individual research components and lists of mooring and CTD/XBT station positions.

ISSUING ORGANISATION

Institute of Oceanographic 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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OVERFLOW

CONTRACT

PROJECT

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SCIENTIFIC PERSONNEL

Saunders, Peter M.	IOSDL	Principal Scientist
Bacon, Sheldon.	IOSDL	
Beney, Martin G.	RVS	
Goy, Keith M.	IOSDL	
Haine, Tom W. N.	Southampton University Department of Oceangraphy	
King, Brian A.	IOSDL	
Millard, Nicholas W.	IOSDL	
Philips, Gregory R. J.	IOSDL	
Poole, Anthony W.	RVS	
Read, Jane F.	IOSDL	
Sherwood, John	RVS	
Smith, W. Kevin	RVS	
Smithers, John	IOSDL	
Waddington, Ian	IOSDL	

SHIPS PERSONNEL

Avery, K. D.	Master
Louch, A. R.	Chief Officer
Sykes, S.	2nd Officer
Atkinson, R. M.	3rd Officer
Baker, J. G. L.	Radio Officer
Batten, G. M.	Chief Engineer
Lovell, V. E. D.	2nd Engineer
Perriam, R. J.	3rd Engineer
Parker, P. G.	Electrical Engineer
Harrison, M. A.	CPO (D)
Cook, S. C.	SIA
Rogers, M. T.	SIA
Poland, R. J.	SIA
Robinson, M. J.	SIA
Hughes, V. H.	SIB
Perry, C. K.	CPO (C)
Welch, G. A.	Cook
Stephen, R. M.	2nd Steward
Coleman, J. T.	Steward
Jenkins, D. E.	Steward
Ramsey, D. J.	MM

ITINERARY

RRS Charles Darwin sailed from Barry, South Wales on September 22nd, 1989. The ship steamed westward to the Charlie-Gibbs Fracture Zone (53°N, 35°W) and spent 5 days there. The ship then travelled north eastward to the Faeroe Islands (61°N, 9°W) and worked south and west of them for 10 days before returning to Troon, Scotland, docking on October 16th, 1989. It may be helpful if reference is made to figures 1 to 3 at the end of the report.

SCIENTIFIC OBJECTIVES AND TASKS

RRS Charles Darwin cruise 42 was the third in a series of cruises starting with *RRS Challenger* cruise 15/87 followed by *RRS Discovery* cruise 174 (1988), all concerned with measuring the strength of the overflow of cold dense water from the Norwegian Sea into the eastern North Atlantic and its variability. On this cruise the targeted areas were: (1) the Charlie-Gibbs Fracture Zone, where the cold water leaves the Iceland basin and passes into the Irminger basin and (2) the Faeroe Bank Channel, where the cold water enters the Iceland basin in a persistent inflow. The programme for these two areas on *RRS Charles Darwin* cruise 42 was as follows:-

1. To recover an array of eight moorings and sixteen current meters from the Charlie-Gibbs Fracture Zone: the array was laid on *RRS Discovery* cruise 174 about 16 months earlier.

2. To lay an array of five moorings and sixteen current meters in the Faeroe Bank Channel: the array to be short-term and recovered on the *RRS Charles Darwin* cruise 43.

3. Simultaneously with task 2 to carry out a test of the ATTOM instruments (Acoustic travel time monitor) designed to measure the outflow of cold water employing a form of acoustic tomography: ATTOM also to be recovered on *RRS Charles Darwin* cruise 43.

4. To carry out hydrographic observations with CTDs and XBTs in support of the moored instrument observations and to sample the water for the measurement of salinity and dissolved oxygen.

5. To carry out measurements of currents employing the ships acoustic doppler profiler and to perform the calibration exercises necessary to ensure their quality.

Tasks 1, 4 and 5 were carried out entirely successfully but setbacks were encountered in respect of tasks 2 (minor) and 3 (major).

NARRATIVE

Cruise 42 of the *RRS Charles Darwin* sailed from Barry on the 22nd of September 1989 (Day 265). The ship left the Dock at 1140Z passed through the lock, and beyond the harbour breakwater swung the compass. About 1330Z the ship set course for the first of the two working areas of the cruise which was the Charlie-Gibbs Fracture Zone. It was not until the 28th (Day 271) that we arrived there.

En route, in a mixture of mostly stiffish headwinds and strong southerlies a stop was made to tension the new 7000 m long CTD wire which had been wound in Barry shortly before departure. On the 24th (Day 267) a 150 kg weight was lowered on it in approximately 4200 m of water. Initially the aft sheave on the midships A frame was used but this proved a wrong choice and the wire was shifted to the forward sheave. Spooling was found unsatisfactory on retrieval from 4000 m and despite strenuous efforts (the dip lasted 6 hours) the wire would not lay up evenly. This problem was to hinder the deep stations worked in the Charlie-Gibbs Fracture Zone.

On the following day the 25th a mid-day stop (stn 42001) was made to test the CTD, multisampler and data logging. The lowering went to 3000 m and problems, mostly minor, were encountered with virtually all of the components. These were almost entirely rectified by the time of the first lowering in the Charlie-Gibbs Fracture Zone and demonstrated the benefit of an early test station.

Work in the Charlie-Gibbs Fracture Zone (see figure 2)

Shortly before daylight on the 28th (Day 271) *RRS Charles Darwin* arrived at 35°W near a latitude of 53°N. The principal task was the recovery of eight moorings which had been deployed there on *RRS Discovery* cruise 174 during June 1988. The moorings were 20-1200 m long, supported in total 16 current meters and were in depths of water ranging from 2500 to 3850 m. During the daylight hours of the following 3 days all the moorings were safely recovered (see the individual reports for details). This was a tribute to the skill of the IOSDL staff from the applied physics group, the willing and able assistance of the crew and the seamanship of the bridge officers. During the hours of darkness CTD stations were worked and water samples drawn for the analysis of salinity and oxygen; acoustic releases were also tested. Only 5 lowerings were made, in part due to the difficulty encountered in rewinding the wire on the winch drum, but also bearing in mind the lateness of the season, the distance to be steamed and the work yet to be accomplished. On the evening of the 30th (Day 273) the last CTD station (42006) was completed. The ship then proceeded about 20 miles to a nearby deep hole (4500 m deep approximately) and a second wire laying up exercise performed. Again the spooling of the deep Layers was found uneven but eventually a base was prepared which allowed the last 2000 m of wire to run on evenly.

On the 1st of October (Day 274) at 0100Z the ship left for the second work area which was concentrated mostly in the Faeroe Bank Channel. The distance of over 1000 miles was accomplished at nearly 11 kts average speed (remarkable at this time of year), the ship arriving there at 2200Z on the 4th (Day 277). Winds were south easterly for most of the passage and 15-25 kts only.

Work in the Faeroe Bank Channel (see figure 3)

In this region there were four types of work, the laying of current meter moorings, hydrography of the cold water overflow (CTDs and XBTs), acoustic doppler current measurements and ATTOM trials. The priorities were with the first and last items of the list.

The laying of moorings got off to a slow start because of strong winds and rough seas. A line of 5 moorings across the narrowest part of the Faeroe Bank Channel was planned 'A' at the South end and 'E' at the north end. 'E' was laid anchor first at 0900Z on the 5th (Day 278) in very strong winds which arose with a frontal passage and conditions were unsuitable for similar work for two days thereafter . In the meanwhile after being hove to/jogging for the night of the 5/6th October lines of XBTs were launched across the channel (line L, M, N, P in figure 3) together with a down channel section (5th Oct), the latter to define the sound velocity structure for the ATTOM trials.

On the 7th (Day 280) conditions were sufficiently improved (but still not favourable) to allow mooring work to continue. Moorings 'A' and 'B' were laid anchor first but the steel sphere buoyancy of mooring 'C' failed to sink and a loss of anchor was diagnosed. The mooring was retrieved and a faulty retractor, part of the release mechanism, found. Overnight a further line of XBTs was launched (line R) and an acoustic doppler calibration exercise performed under GPS navigation, the exercise consisting of a series of zig-zag tracks.

On the 8th (Day 281) mooring 'C' was laid and 'D' started, both in quite large swells. During the laying of 'D' the jacketed wire, of which the mooring was composed, parted and 3 current meters, release and anchor were lost, all falling swiftly to the sea floor. The wire (breaking strain 2.5 tonnes) parted between the spooling winch and the double barrelled winch and on the low tension side of the latter. Subsequent behaviour of the wire on the spooling winch suggested it had taken a back turn on a shackle. After this disaster the first of the two ATTOM moorings was laid (ATTOM 2) in 750 m of water. This too for quite different reasons was also to prove a failure. During the night a line of four CTD stations 42008 to 42011 and one XBT were worked in support of the ATTOM measurements and to provide a T-S relationship for the XBTs.

On the 9th of October (Day 282) the second of the ATTOM moorings was laid 12.2 miles or 22.5 km away from the first. (Note the numbering of the ATTOM moorings was in the reverse order to that in which they were laid!). ATTOM 1 mooring was followed by a relaying of mooring 'D'. The latter was redesigned with available materials and laid somewhat deeper. Like its predecessor it was to prove ill-fated. Hydrophones were attached to the CTD wire and a lowering made to 750 m at a location between the ATTOM sites. The second unit ATTOM 1 was clearly heard but ATTOM 2 was not. It was decided to retrieve the malfunctioning unit but darkness had set in when this plan was proposed.

During the night ADCP zig-zags were conducted along the positions of the XBT lines M, N and P under GPS navigation. At first light (10th October, Day 283) the ATTOM 2 mooring was recovered in order to rectify instrument malfunction and *RRS Charles Darwin* then steamed NW for 50 miles to carry out a pair of CTD sections Q and S (see figure 3) on the flanks of the Iceland Ridge beyond the exit of the Faeroe Bank Channel. Initially 4 XBTs were launched followed by 13 CTD stations, numbers 42012 (1800/10th) to 42024 (2230/11th). At this point strong and rising winds and a gloomy forecast drove us back to the Faeroe Bank Channel Area.

On arrival (0500 on the 12th, Day 285) it was decided to interrogate the moorings: all eventually responded except for the relaid mooring 'D' from which nothing was heard. It was thought likely the release had let go and the entire mooring was adrift. This supposition was relayed to the Faroese who broadcast a hazard to navigation warning on the same afternoon. A search pattern was instigated both NW and SE of the mooring site that afternoon and continued on the following morning. The weather was excellent, bright sunshine with very scattered showers and a bridge watch was maintained in addition to the acoustic one.

Overnight 12/13th October ADCP stations were occupied (hove to for 25 minutes) on the XBT launch sites of lines N and P. After the morning search for mooring 'D' on the 13th October (Day 286) had revealed only fishing boats, the ATTOM 2 instrument was satisfactorily wire tested (13-15Z) 12.2 mi SE of ATTOM 1 mooring site. A second less satisfactory test was conducted at the same range on the NW side of the ATTOM 1 mooring (1830-2130Z). The *RRS Charles Darwin* then steamed NW a distance of 50 miles in large swell to complete the CTD and scientific programme of the cruise. CTD stations 42025/26 were worked between 03 and 07Z on the 14th of October (Day 287), the PES fish was then recovered and the ship set course for Troon.

The ship was met by the Ayr pilot on the 16th of October (Day 289) and docked at 1130Z in Troon, on the west coast of Scotland. The track of the ship for the entire cruise is depicted in figure 1 at the end of this report.

REPORTS OF SCIENTIFIC WORK

1. Moorings and Recording Current Meters

Recovery of Moored array in the Charlie-Gibbs Fracture Zone

An array of eight current measuring moorings was recovered. These had been deployed from *RRS Discovery* cruise 174 1st to 5th June 1988. The moorings consisted of subsurface glass sphere buoyancy supporting Aanderaa recording current meters with IOSDL Command release units for recovery. The mooring lines were all Polyester braided construction prestretched and measured on *RRS Discovery* cruise 174. The 16 month duration is the longest IOSDL moorings have achieved and from careful observation and inspection of components much should be learned about survivability for future long term (2 year) moorings for the WOCE experiment.

RVS Barry provided a portable electro-hydraulic Double barrel capstan and storage winch positioned on the after deck. This winch was used to haul the moorings onboard over an IOSDL supplied wide throat mooring sheave suspended in the after A frame from the Starboard Rexroth winch wire.

Rigging and testing of this arrangement was made on passage from Barry to Charlie Gibbs Fracture Zone. The system functioned well throughout the mooring operation with mooring line being flaked off the winch into a steel cage for storage.

The details of the moorings recovered are found in table 1.

Moored Array data (preliminary evaluation)

Decoding of the Aanderaa tapes was carried out onboard using the P3059 program running on the PC 1512 with plots output to printer. All the recording tapes had run out, which is reflected in the varying record length.

Mooring No.	ACM No.	Records	Comments
472	3726	9802	
471	3727	9814	
471	420	9871	Track 1 poor signal. 2 OK.
468	2406	9944	Encoder arm failed
468	1260	10118	
468	1259	9557	Encoder malfunction. C6 fail
469	6372	0000	No detected data on tape.
469	6225	9812	
467	8010	9836	
467	2107	9810	Poor signal level + errors.
466	6705	9947	Some short records
466	5205	9648	
466	5204	9641	Fluctuating tape signal.
474	2108	9951	
474	8011	9719	Deteriorates towards end.
473	7943	9836	Some bit errors.

A preliminary inspection of the data tapes reveals that:-

12 are good
2 are usable
1 is short (3 months)
1 is blank

Faeroe Bank Channel Array. Current meter moorings

The instrumentation for the Array was all set up and calibrated at IOSDL prior to loading. Cold tests to - 2°C were carried out on all instrumentation to ensure correct operation at the expected minimum temperature.

Instrumentation was then all retested at sea at 20°C to check correct operation after road shipment.

Pressure sensors for the ATTOM mooring were fitted onboard with ACM 9655, a new RCM 8, requiring the locating recesses to be machined out. All the stock of new instruments will require checking for this fault.

Details of deployment (see Table 1 for a summary)

Five current meter moorings were to be deployed across the channel in water depths ranging from about 400-850 m and two ATTOM moorings were to be deployed along the channel in about 750 m of water. Two shallow moorings in the former array had 300 kg anchors, IOS release, 10 m Kevlar, a Aanderaa RCM4 current meter and buoyancy provided by 6 x 17" diameter Benthos glass spheres. These were designated A and E. The two ATTOM moorings (A1 and A2) were of similar design with 10 m of SPB between the release and an RCM8 current meter with the Attom unit directly above that. 10 m of Kevlar separated the ATTOM unit from the buoyancy (6 x 17" diam glass spheres).

The three other current meter moorings were constructed of 6 mm jacketed steel wire with buoyancy provided by steel spheres of diameter 1.3 m, and anchors consisting of 750 kg of chain. Each of the 3 moorings supported Aanderaa RCM4s and at the shallowest level (near 400 m depth) an RCM4 was duplicated by an RCM8 to compare performance of the old and new generation instruments. In addition, on mooring 'C' two 100 m long thermistor chains were fastened with plastic retaining clips. The RCM4s and thermistor loggers were set to a sampling interval of 15 minutes and the RCM8s to 10 minutes.

The Double barrel capstan (RVS) was again used for anchor first deployment supplemented with the diesel hydraulic hauling winch for lifting anchors and ATTOM units over the centre block of the A frame.

The IOSDL sheave was re-sited on a 6 tonne chain hanging from the A frame. The system worked well but the DBC reeler required careful attention as the plastic jacket wire could be seen to slide over itself when the vessel was pitching. This is believed to be exaggerated in heavy pitching conditions when the load can come off the DBC unit and momentarily a high snatch load can be transmitted to the reeler winch.

As mooring 'E' (488) was being deployed, a cold front passed and winds veered sharply gusting to 40 kts. 48 hours passed before wind and sea had gone down sufficiently to allow the launch of moorings 'A' (489), 'B' (490) and 'C' (491). On launch of the buoyancy of the last mooring the sphere was seen to float: a lost anchor was suspected and confirmed when all the gear was recovered. One of the retractor units had become mechanically detached on the release mechanism causing loss of the anchor.

On the following day mooring 'C' was relayed (492), followed by the last of the current meter moorings 'D'. During the deployment of 'D' (493) the wire parted on the storage winch 1 m from the top of a 99 m section causing loss of the anchor, release and three current meters which fell to the sea bed. The release was left in the command mode to facilitate relocation for a possible dragging attempt.

Twenty-four hours later on the 9th October the 'D' mooring (496) was relayed with available materials, 3 Aanderaa current meters and jacketted wire but employing 100 m 13 mm Parraline below the steel sphere buoyancy.

This mooring 'D' like its predecessor seemed ill fated for on the 12th October (285) all of the moorings were interrogated and all were heard save 'D' from which no response could be detected. An acoustic search was made running zig-zags North and West and then South and East along the projected drift path should the mooring be adrift at the surface. No contact was established. The search was carried out from 1130 GMT to 1815 GMT then abandonned when extremes of drift had been reached and with failing daylight. Acoustic transmissions were of frequency 320 Hz only. On the following day a further search was conducted, this time along the 400 m contour of the Faeroe Plateau where it was supposed the mooring might have become 'anchored' by the release and deepest current meter. Nothing was found.

IW, KMG

2. Acoustic Travel Time Ocean Monitor (ATTOM)

The two instruments used in previous trials were again brought to sea with some software modifications designed to ease data interpretation and with improved clocks.

Two moorings containing an ATTOM and a current meter 20 meters above the bottom were laid obliquely up and down the channel in close to 750 meters of water. Mooring 494 was 22.5 Km to the north west of mooring 495 (see table 1).

Listening from a hydrophone lowered to 700 m on the CTD wire revealed that the southerly instrument was not transmitting and was therefore recovered. The CPU chip was replaced and the instrument was lowered on the CTD wire on two occasions, both with the ship at approximately 22 Km from the other moored instrument. The results of these tests showed the instrument to be operational and on the first occasion, in communication with the other moored instrument. The mooring could not be relaid as there were no retractor refurbishing kits for the acoustic release on board. It is planned that it will be deployed on *RRS Charles Darwin* cruise 43.

NWM

3. Mooring Acoustics

Charlie-Gibbs Fracture Zone

The eight moorings in this area were deployed in the first week of June 1988 in water depths between 2500 and 3850 metres. All were relocated and recovered easily. The older four units (10, 12 and 13 years old) all released much faster than on the redeployment wire tests. This is potentially dangerous during deck handling as very little warning would be given of premature operation. Fast operation is an indication of instability due to ageing in the very low power tuned circuits used. Replacement electronics for these units were tuned during the quieter periods in the middle of the cruise. There was no significant corrosion of the aluminium pressure cases and none at all of the titanium. All the units had at least one Hydroid growing on it and most had a fine biological net over their surface.

Faeroe Bank Channel

Three of the units recovered from the CGFZ were reused with fresh batteries to ease the problems caused by clashes of operating frequency within the original nine prepared.

The ATTOM moorings and the Thermistor chain mooring were fitted with transponders both to ease relocation and provide acoustic backup for the release units. It was intended to fit transponders to the other four moorings but the new style units on order were not delivered in time for the cruise and the two other units owned by Marine Physics (1976 prototypes) had serious faults and are now unrepairable.

All the moorings were fitted with new pairs of retractor units. One of the units used on mooring 'C' had an oversize toggle bar location hole, this allowed the unit to slip off the toggle bar in turn dropping the anchor during the deployment. Unfortunately this was not realised until the end of the deployment so the mooring had to be recovered and then relaid after replacement of the offending component. This component should be a struggle to fit and to remove from the toggle bar - if it is not - it should be replaced.

During the lay of mooring 'D' a two year old release was lost when the mooring wire snapped. The release used on the replacement mooring was the only unit not to respond when all the moorings were interrogated on October 10th. This unit was less than five years old and has performed perfectly including a twelve month deployment in the Porcupine Seabight at 1000 metres and one month this year in the Bay of Biscay at 4500 metres. Since then it has been overhauled and retested at minus five degrees Centigrade. It was successfully tested on a CTD cast to 1000 metres before this deployment and then successfully interrogated twice during the deployment. Sudden failure was deemed unlikely so a visual and acoustic search was carried out of both the immediate area and then a zig-zag to a range of 11 miles in the likely direction of drift. The following day a similar search was mounted along the 400 metre contour on the assumption that this is where it would come to rest if it was dragging it's anchor. All was to no avail.

Waterfall Display Unit

Software and hardware had been purchased to convert a PC-AT computer to a stand alone 'facsimile' type display unit for use with the IOS acoustic command system. This was based on work commissioned at IOS for the new precision echosounder about to enter service with NERC. It was run very successfully throughout the cruise both on signals provided by the old echosounder and by the acoustic command system deck unit. The 800 x 600 resolution would not operate reliably in scrolling mode but was run extensively in overwriting mode. The 640 x 480 resolution worked well and reliably in both modes. The colour palettes need further thought with some of the more garish being very useful at low signal levels but appearing differently on different monitors at the different resolutions.

GRJP

4. RVS Mechanical Equipment

Three major pieces of equipment were used during the cruise, namely:

a) CTD Winch

b) 'Lebus' Hauling Winch, SWL 3 tonne

c) Double Barrelled Traction Winch

The CTD winch had a new wire installed at Barry prior to sailing. Consequently early in the cruise it was necessary to play out as much wire as possible (4480 m) for tensioning and spooling adjustment. It was found necessary to 'pack' the wire with cloth at certain places to aid the correct laying of the wire onto the drum. Fortunately this was only necessary for wire-out >2000 m and therefore no problems were encountered for the CTD stations carried out in the Faeroe Bank area.

The 'Lebus' hauling winch was mainly used for 'stopping-off' during mooring deployment and proved to be a useful piece of equipment for this type of work. The controlability and speed of the unit ensured that the stopping-off and load transfer from/to the double barrelled traction winch could be carried out both safely and with confidence.

The Double Barrelled Traction Winch performed well throughout, however some problems were encountered with the use of 6 mm plastic coated mooring cable.

Due to the reduced co-efficient of friction between the plastic coating and the winch drum, extreme care had to be taken when deploying in a moderate swell. With the slight decrease in load due to the ships movement the wire tended to slip around both barrels, the result being that some of the load was momentarily seen by the take-up winch.

A further problem caused by the 6 mm plastic coated wire was that there was a tendency for the wire to slip when being played off the take-up winch drum, causing loose turns and associated problems. This was overcome by wrapping the take-up winch drum in canvas between lays.

AWP and WKS

5. CTD and Multisampler

The NBIS mk IIIb CTD was mounted in a frame of IOSDL design in a side by side position with a General Oceanics rosette multisampler. Up to 12 bottles were loaded on each cast, each bottle of volume 1.7 l. A Sea Tech Inc 1 m transmissometer was mounted horizontally at the top of the frame. 26 CTD stations were occupied, seven in the Charlie-Gibbs Fracture Zone (2712-3877 dbar) and the remainder near the Faeroes (517-1274 dbar). A list of CTD station details will be found in Table 2 at the end of the report.

Throughout the cruise the CTD performed flawlessly except on the second station where noisy data was encountered. The CTD sea cable was then reterminated and no further problems were met with. CTD lowerings were made on the midships A Frame on the starboard side.

A new conductivity cell was fitted en route to the first station. Unfortunately this required unsoldering the temperature sensor and enlarging the seating of the conductivity cell. The rewiring caused a shift in the calibration of the temperature sensor, as was apparent on the first test station; prior to this the sensor/electronics had shown remarkable stability with the temperature calibration changing by only a few Mk in a 6 year period. A working calibration for both temperature and conductivity was derived from digital reversing thermometers and salinity samples, the latter good to ±.002. A complete temperature recalibration will be performed on the return of the CTD to Wormley.

On the cruise 6 SIS digital reversing thermometers (RTM 4002) and one reversing pressure meter (RPM 6000) were available and were installed on three frames of the multisampler. The instruments proved easy and convenient to use, except for difficulty in reading the faintly inscribed instrument number. After the first two casts it was apparent that even after the manufacturer's calibration corrections had been applied there were differences of the order of .01°C between the values obtained by instruments which were reversed on the same frame. This provisional finding was confirmed by the summary table of pair differences (see Table 4 following).

TABLE 4

Differences in temperature (corrected) between pairs of thermometers reversed on the same frame

Pair	T_{256}-T_{204}	T_{208}-T_{238}	T_{259}-T_{260}
number	22	24	20
mean diff mK	7	3	7.5
std dev mK	4	4	2.5
excluded	3	1	0

A comparison of the thermometer (DRT) and CTD measurements is shown below:-

TABLE 5

Difference in temperature (corrected) between DRT and CTD (T ctd- Tnnn)

Thermometer	T_{256}	T_{204}	T_{208}	T_{238}	T_{259}	T_{260}
number	18	18	18	18	17	17
mean diff mK	-1	4.5	3	1.5	7	-1
std dev mK	6	5	3	4	4.5	4.5

Because the CTD had only a provisional temperature calibration, mean differences in the above table are not significant but this is not true of the spread of mean differences (nearly .01°C). This figure, is several times larger than our experience reported earlier for *RRS Discovery* cruise 174 (1988) and also for *RRS Discovery* cruise 182 (Smithers, pc).

The age of the DRT calibrations varied from about 1 year (T_{204}, T_{208}) to approximately 6 months (T_{238}, T_{256}, T_{259}, T_{260}) and the differences encountered on the cruise suggest calibration drift rates of the order .01°C/year. These are within the manufacturers specification for the RTM 4002 but nevertheless, in the context of the high quality measurements required for the WOCE program, they are disappointing.

The standard deviation of the observed differences for pairs of DRTs and for CTD-DRT measurements is again higher than previously observed but the unsteady conditions of measurement were largely responsible for this. Most of the reversals were made in a quite stratified water column so that even when stopped at a fixed depth there were large temporal variations in temperature.

The pressure sensor (RPM 6000) agreed well with the CTD pressure for the shallow casts <850 db but exhibited large differences for the (moderately) deep stations of the Charlie Gibbs Fracture Zone. The differences between CTD pressures and RPM pressures are summarised in the following table:-

TABLE 6

Difference in pressure, CTD - RPM

Pressure range	20-30	500-850	950-1300	2500-3500
number	3	11	5	6
mean diff db	1	0.5	6	17
std dev db	0	1	1	2

The manufacturers specification is ±.1% of full scale or ±6 db: clearly the deepest values lie well outside of this value.

The Rosette Multisampler gave many problems throughout the whole cruise. Generally it took at least two firings to successfully trip each bottle. Occasionally a bottle confirmation signal would be received without the multisampler stepping round. The multisampler was stripped down on three occasions in an effort to locate the problems. The performance after this was moderately improved but not satisfactory. It seemed that a more consistent triggering without misfires was obtained if the instrument package did not encounter temperatures below about 3°C for any length of time.

The CTD deck unit and digidata back-up logging systems worked without fault throughout the cruise.

JS and PMS

6. Salinity Analysis

Seawater samples drawn from 26 CTD casts were analysed in the constant temperature laboratory on *RRS Charles Darwin* using Guildine Autosal 8400 Serial Number

42508 and standardised using Standard Seawater P111, of which 12 ampoules were consumed. No operating difficulties were experienced with the salinometer, with the exception of one day's slightly erratic operation when 10% of processed samples required re-analysis after insufficiently stable salinity determinations. The characteristic of 'going for a walk', i.e. the displayed sample value refusing to settle down and migrating up or down by as much as 20 or 30 points, has no immediately obvious cause.

Salinity determination from Guildine ratio was performed on the cruise using Ocean Scientific International's software package "Salinity". This is a highly efficient item, the ease of use of which results in a considerable saving in time spent working up salinities. An RVS IBM PS/2 was used to run the package. With increased familiarity and some consideration, the salinity determination process could be integrated, if required, into the shipboard computer systems, as "Salinity" can store values on disk files which could then be transferred.

SB

7. Dissolved Oxygen Analysis

Dissolved oxygen samples were taken on 16 of 26 CTD casts. Two samples were drawn from each Niskin bottle giving a total of 250 samples for analysis by the Winkler titration procedure.

The difference between duplicates was generally better than 0.01 ml/l but the average over the cruise was 0.012 ml/l with standard deviation (σ_{n-1}) = 0.014 (for 338 samples, the remainder had very much larger differences suggesting errors in the sampling or analysing procedure). This indicated that the accuracy of the measurements was better than 0.2 % compared to a possible accuracy of 0.1% for the Winkler titration procedure.

On all stations at least two bottles were fired at each sampling depth, but the difference between the two sets of samples was much greater, and varied more, than the duplicates drawn from one bottle. At station 001 all the bottles were fired at the same depth and the results varied by 0.5 ml/l between bottles. On the second cast, the first ten (of twelve) bottles were fired at the same depth and the differences between the bottles showed the same pattern as on station 001. After this various improvements were made to the bottles (new 'O' rings, lanyards, taps etc) and measurements improved. However the difference between the bottles over the cruises averaged to 0.04 ml/l with standard deviations of 0.07 (for 83 duplicate bottles). Further improvements could still be made to the bottles, and it seems clear that the Niskin bottles have been a major cause of 'poor' oxygen samples on previous cruises.

JFR

8. XBT Observations

T4 and T7 probes were launched from a hand-held unit in the Faeroe Bank Channel to observe the dense cold water flowing along its bottom. 5 Sections were occupied, designated lines L - R, and further XBTs were dropped on CTD sections Q and S. (See Fig. 3) In all approximately 60 probes were launched with a very small number of failures.

The data was logged on a Bathy systems SA810 deck-unit and replayed (plotted and listed) on the same unit. The lists provided a source for the manual entry of XBT data into the PSTAR system (via the programme YPSTAR). Towards the end of the cruise data was successfully transferred directly from the SA810 to the SUN system and thence to PSTAR using RVS developed software. A list of XBT drops will be found in Table 3.

PMS and SB

9. PSTAR/SUN Computing

This was the first cruise on the *RRS Charles Darwin* using the SUN system. A copy of the PSTAR source files was loaded onto disk and compiled before the ship sailed from Barry. A few minor bugs came to light during the cruise and were easily fixed. Most of these arose out of conversion from old PDP or Wormley IBM programs to SUN programs. The PSTAR source and executable files occupied about 40 Mb of disk space.

On the whole, the system was easy to use, and provided ample computing power for the work in hand. This included processing of 26 CTD stations, and the ADCP data collected continuously throughout the cruise. Navigation was computed by RVS and taken into PSTAR in processed form. Hardcopy (paper) graphical output was mainly via the colour plotter accessed via a screen dump of a SUN terminal. The screen dump mechanism of the workstation in the main lab. was not very reliable; this was attributed to vibration of the unit. There did not appear to be any transparencies for the plotter on board. Some difficulty was experienced in getting UNIRAS plots generated by PSTAR programs onto the drum plotter. Plots would have an unpredictable offset at the start, sometimes causing previous plots to be overwritten, or part of the plot to be lost 'off the edge'. Also plots generated in either HPGL or DIPF plotcode needed to be sent to the plotter via RVS programs 'hpgl' and 'nic'; both these programs automatically reduced plots larger than A3. There were four keyboards usually available for accessing the SUN systems. Two SUNs (one in the main lab., one in the computer room) and two M2250 colour terminals (arranged likewise). In addition there was one more terminal in the lab that was used as a monitor for the level A CTD. Thus there were two terminals generally available for scientists' use, plus the ones in the computer room when they were not being used by RVS staff. This was just adequate for the data processing requirements of the cruise, which were relatively light, but on a 'heavy' cruise would not allow users to exploit the considerable processing power of the SUNs. Since there are terminal servers for the SUN systems, users could possibly bring their own terminals if RVS cannot supply any extra.

Data was transferred from RVS files to PSTAR files using the 'datapup' program written by RVS. This worked well except when reading from an RVS data file that had 'cycled' in time (as was initially the case with the ADCP data file). The solution adopted was to create an RVS ADCP file sufficiently large to accept all the ADCP data from the rest of the cruise (55 Mb).

Routine PSTAR processing of CTD data on the SUNs was performed mainly through a set of procedures (collections of PSTAR commands put in a file and executed with a single command at the terminal), a total of five being used to take the data from uncalibrated raw data to calibrated downcasts averaged into 2 db levels.

ADCP were read into PSTAR files in segments of 24 hours. The data taken from the RVS file needed to have speeds scaled from mm/s to cm/s and absent data values changed to the PSTAR defaults. A correction for the ADCP deck unit clock drift was applied (the clock lost 24 seconds per day), but no other routine processing was done. Data collected during periods of calibration manoeuvres were extracted for processing, as described elsewhere.

Initially, XBT data were entered into PSTAR by typing in from listings generated by the HP85B deck unit. Later in the cruise, data were replayed into an RVS data file via the level B, and then moved into PSTAR.

Data transfer to Wormley was by means of archiving PSTAR binary data files onto quarter inch tape cartridges using the 'tar' utility (each cartridge holds about 60 Mb). When successful, dumping of files was quick and easy. However, there were a number of unexplained and unreproduceable errors while using 'tar' which need to be investigated. These only occurred when a partly-used tape was used for further archiving. Sometimes a tape I/O error occurred, but the system recovered when the command was repeated. On two successive occasions, however, the tar archive request 'hung' the SUN, which had to be rebooted.

BAK

10. Acoustic Doppler Current Profiler (ADCP)

An RD Instruments vessel mounted acoustic doppler current profiler was run continuously throughout the cruise, with ensembles of two and a half minutes. Since it had not been possible to get the direct link from the ADCP deck unit to the SUNs working reliably, data was transferred as follows: the pingdata files were copied to floppy disk (one pingdata file contained fifteen hours of data and three could be put onto one high density floppy), the floppy was taken to the IBM PS/2 in the computer room and the data read into ascii files on the SUN using the SUN command 'cat' with the output piped into the RVS program 'titsil', and finally using the RVS program 'datapup', moved into a PSTAR file. This data path was time-consuming and meant that often data was not available for inspection until many hours after it was collected. The only difficulty experienced was early in the cruise when it was discovered that the 'datapup' program did not work correctly after the RVS data file had started to 'cycle' in time. Since there was no shortage of file space on this cruise, the problem was solved by recreating the RVS data file sufficiently large to mean that it could accept the ADCP raw data for the remainder of the cruise without cycling.

The ADCP data were taken across into PSTAR files in segments of 24 hours. Once in a PSTAR file, the data were scaled from mm/sec to cm/sc, and absent data, represented by 19999 in the pingdata files, were replaced by the usual PSTAR absent data value. Also, a correction was applied to time values for the drift of the clock in the IBM PC deck unit. No other routine processing was carried out during the cruise, but periods relating to certain calibration manoeuvres of the ship were examined carefully. The aim of these exercises was to determine the correction to speed (multiply by a linear factor A) and direction (add angle phi degrees) that needs to be applied to motion relative to the ship measured by the instrument. Of course, phi should be the difference in alignment between the instrument and the ship's gyro. Two such periods were as follows:

On the run out from the UK to the Charlie-Gibbs Fracture Zone, transit satellite navigation was available while the ship was steaming steadily, with bottom tracking in 60-100 metres of water (Days 265 and 266). After comparing absolute ship's motion derived from well separated sat fixes with ADCP bottom speeds, a tentative calibration of

A = 1.016 and phi = 2.5

for the bottom tracking was arrived at. Further calibration work was not possible because of the depth of water and because of an interruption to GPS of about six days duration which hindered water tracing exercises. Later on, while working in the Faeroe Bank area (Day 280), a series of right-angle turns was executed at eight knots, while GPS and bottom tracking were available, so that A and phi could be estimated following the analysis of Pollard and Read (1989). This resulted in the following estimates of A and phi:

Bottom tracking: A = 1.004 phi = 2.5

Water tracking: A = 1.017 phi = 2.6

It was possible to estimate a similar correction for the ships em-log, viz:

A = 0.976 phi = 3.7

The location of the deck unit for the ADCP in the scientific plot is quite unsatisfactory. Since no routine scientific work was being undertaken in the plot, special trips had to be made (three decks up from the main lab and very unpleasant in rough weather) to check on the performance of the instrument. This situation was greatly improved when one of the ship's TV cameras was mounted in front of the IBM PC. The camera was mounted on a bar fixed to the wooden case that houses the deck unit, so that it did not obstruct access to the keyboard, and was at a distance of about 12 inches from the screen; this enabled three-quarters of the screen to be viewed on a monitor in the main lab. It was then possible to see all the data plotted for each ensemble, and read the values of water depth and bottom speed when bottom tracking was in operation.

Performance:

At the start of the cruise, the instrument was set up so that when bottom tracking was a possibility, the bottom would be searched for using 8m bins in processing the bottom ping. This was done using the direct command FB00003. Also, the known problem with the tracking filter was sidestepped using direct commands A06 and B000000. The latest RDI software with the tracking filter problem fixed apparently cannot be used with the transducer presently installed on the ship. The IBM PC was running version 2.46, with version 15.68 on the hardware. A depth offset of 5 m was allowed in the configuration file, and a heading correction of - 1° brought the deck unit heading into agreement with the magnavox in the plot and the master gyro on the bridge. When bottom tracking, the number of water-tracking pings per bottom ping was set to four, using FH00004. More frequent bottom pings seemed to reduce the number of water-tracking pings in 150 seconds from about 120 to about 50. The clock in the deck unit was set at the start of the cruise and allowed to accumulate errors during the cruise. It ran very consistently slow at the rate of 24 seconds per day. Clock errors were noted and corrected for after the data had been read into a PSTAR data file for processing. The clock was, however, set correctly using the AT diagnostics disk (and DOS then rebooted), at the time of calibration runs. The only other problem encountered was that three or four times, after pinging had been interrupted to download pingdata files to floppy disk, the 'ADCP' program crashed when trying to write the next ensemble to the partly-used pingdata file. The problem could be overcome by renaming the pingdata file and then copying back to the original name.

Previous suspicions that the instrument did not perform well in moderate to rough seas (especially when heading into the swell) were confirmed. Depth penetration in water tracking mode varied from less than 100 m to about 300 m while steaming, with performance apparently deteriorating if speed was increased above 8 knots. While on station bottom tracking depths of up to 850 m were achieved (although the data quality has not been scrutinised), with water tracking depths of about 350 m. On the night of Day 285/286 ADCP 'stations' were occupied along line P; on each station the ship was hove to for a period of about 25 minutes, under GPS navigation.

BAK and TWNH

11. RVS Shipboard Computing

The ship was equipped with a newly installed 'Level C' data processing system consisting of three networked SUN 3/60 workstations, and a colour screen dump plotter together with the terminals, printers, plotters and tape drives from the previous system. A networked IBM PS/2 was available for transfer of ADCP data (from disk) and for general use.

The SUN workstations were arranged somewhat differently from the installations of *RRS Discovery* and *RRS Challenger* to reduce the bottleneck imposed by a single fileserver. Instead, one of the workstations (141 Mbyte disk) was assigned to handle and store incoming raw data and a second acted as the main system fileserver (2 x 327 Mbyte disks). The third (diskless) machine was sited in the main laboratory for convenient access by scientists and for displaying processed CTD data in near real time.

The system performed well, though the demands on it were fairly light. Most of the CTD and XBT processing was done using PSTAR and UNIRAS. RVS software was used for near real time CTD/transmissometer/oxygen display (including calculated sound velocity) and for navigation. Use was made of live track plotting during periods of GPS coverage together with a live listing of GPS fixes and 'vecplot' to plot surface current vectors.

XBT data were replayed from the HP 85B recording computer into the SUN system for later analysis.

The data logger ran continuously apart form one very short break to change a cooling fan. The GPS 'Level A' interface was found to be unable to handle some of the longer messages resulting from the increased number of satellites being tracked. The missing position fixes were entered manually.

The shipborne wave recorder was logged as a test for Cruise 43.

MGB and JS

ACKNOWLEDGEMENTS

The willing co-operation of the Master, officers and crew of the *RRS Charles Darwin* on the cruise and the helpful assistance of personnel from the RVS Research Base at Barry prior to the cruise is gratefully acknowledged.

TABLE 1

Moorings Deployed and Recovered

(Geographically Arranged)

No.	Deploy Recover	Date 1989	Day	Time Z	Lat N	Lon W	Water Depth,m	Instruments	
Charlie-Gibbs Fracture Zone									
473	R	30 Sep	273	0929	52 48.23	35 06.84	2556	A7943	
474	R	30 Sep	273	0737	52 45.21	35 03.45	2938	A8011, A2108	
466	R	29 Sep	272	1451	52 41.34	35 04.21	3678	A5204, A5205, A6705	
467	R	29 Sep	272	1232	52 36.99	35 05.47	2933	A2107, A8010	
469	R	29 Sep	272	0847	52 26.35	35 02.07	2943	A6225, A6372	
468	R	28 Sep	271	1534	52 18.72	35 09.96	3836	A1259, A1260, A2406	
471	R	28 Sep	271	1152	52 07.36	35 08.49	3516	A3727, A420	
472	R	28 Sep	271	0619	51 48.14	35 07.38	3847	A3726	
Faeroe Bank Channel (Current meter moorings)									
489	D	7 Oct	280	0841	61 19.08	08 14.94	499	A421	'A'
490	D	7 Oct	280	1249	61 20.5	08 13.7	695	A4738, A6867, A7765 A7401, A9590	'B'
491	D/R	7 Oct	280	-	-	-	anchor lost/all recovered		'C'
492	D	8 Oct	281	0838	61 21.1	08 09.8	840	A3624, A2109, A7948 TL 879/1723, A7945 TL 805/1722,A7517, A9648	'C'
493	D/lost	8 Oct	281	-	61 25.1	08 07.3	-	wire parted	
							anchor + release + 3ACM lost		'D'
496	D	9 Oct	282	1403	61 24.17	08 10.20	769	A7451, A9651, A9647	'D'
488	D	5 Oct	278	0902	61 26.5	08 05.5	435	A7643	'E'

TABLE 1 (CONTINUED)

Moorings Deployed and Recovered

(Geographically Arranged)

Faeroe Bank Channel (ATTOM moorings)

494	D	8 Oct	281	1639	61 16.75	08 04.53	767	ATTOM 2, A9655	'A2'
	R	10 Oct	283	1048					
495	D	9 Oct	282	0838	61 27.1	08 17.4	745	ATTOM 1, A9657	'A1'

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 No./ Date, 1989	Lat N	Lon W	Water Depth,m	Closest approach	Comments
42001	1341	268:25/9	51°55.46	19°45.10	3876	≈870	Trial
42002	0009	272:29/9	51°48.47	35°06.94	3827	25	First CGFZ
42003	1823	272:29/9	52°40.88	35°05.62	3624	15	
42004	0035	273:30/9	52°17.48	35°08.72	3789	16	
42005	1257	273:30/9	52°48.68	35°07.78	2625	21	
42006	1721	273:30/9	52°33.27	34°59.82	2689	17	Last CGFZ
42007	2228	277:4/10	61°10.32	07°46.20	894	10	First Faeroes area
42008	2014	281:8/10	61°27.60	08°16.31	695	12	ATTOM1 posn
42009	2306	281:8/10	61°25.10	08°15.34	792	13	
42010	0119	282:9/10	61°15.43	08°02.32	755	10	
42011	0312	282:9/10	61°22.66	08°13.46	835	9	
42012	1824	283:10/10	61°32.12	09°29.39	935	12	Q ½
42013	2048	283:10/10	61°34.98	09°44.93	1125	10	Q1
42014	2315	283:10/10	61°39.63	09°32.40	954	15	Q2
42015	0106	284:11/10	61°44.97	09°23.99	828	15	Q3
42016	0305	284:11/10	61°50.13	09°13.36	686	13	Q4
42017	0508	284:11/10	61°56.29	08°59.97	527	10	Q5
42018	0938	284:11/10	62°07.76	09°39.39	690	10	S8
42019	1126	284:11/10	62°02.81	09°52.10	760	10	S7
42020	1331	284:11/10	61°57.54	10°06.09	835	12	S6
42021	1546	284:11/10	61°50.39	10°19.72	860	12	S5
42022	1713	284:11/10	61°46.61	10°24.00	1030	13	S4
42023	1927	284:11/10	61°42.35	10°32.35	1271	10	S3
42024	2138	284:11/10	61°36.35	10°45.89	1303	13	S2
42025	0329	287:14/10	61°36.37	10°23.08	1268	16	S1
42026	0612	287:14/10	61°43.42	10°08.59	1110	8	S0

TABLE 3

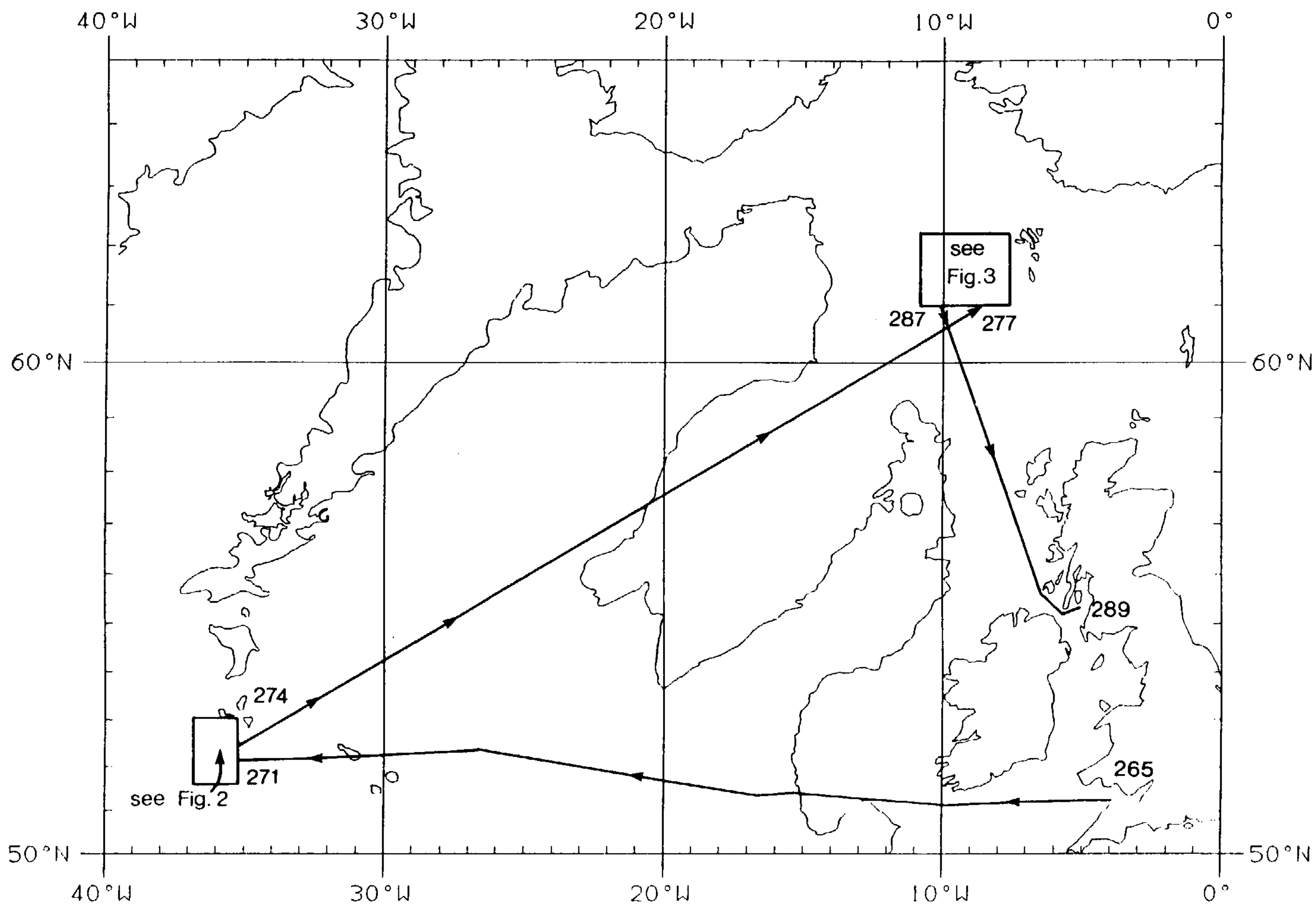
XBT Observations

Drop	Day	Time Z	Lat N	Lon W	Water Depth, m	Cassette	File	Comments
5	277	1528	60°38	9°49	490	1	43A	Test
6	278	0117	61°09	8°03	290	1	46A	Start ATTOM line
7	278	0136	61°11	8°00	502	1	77A	
8	278	0217	61°16	8°05	593	1	78A	
9	278	0257	61°20	8°10	840	1	79A	
10	278	0345	61°25	8°14	772	1	710A	
11	278	0435	61°31	8°21	673	1	711A	
12	278	0509	61°34	8°14	396	1	412A	End ATTOM line
13	279	1334	61°20	8°20	450	1	413A	
14	279	1500	61°09.2	8°02	400	1	414A	Start line L, L1
15	279	1511	61°10	8°00	485	1	715A	L1.5
16	279	1523	61°12	7°57	640	1	716A	L2
17	279	1550	61°13.5	7°54	905	1	717A	L3
18	279	1618	61°16.1	7°50.4	856	2	718A	L4
19	279	1647	61°19	7°46.5	791	2	719A	L5
20	279	1712	61°21.4	7°43.7	695	2	720A	L6
21	279	1740	61°23.8	7°37.5	386	2	421A	End Line L, L7
22	279	1911	61°27.7	7°55.4	180	2	422A	Start line M, M7
23	279	1937	61°25.5	7°59.2	535	2	723A	M6
24	279	1955	61°23.5	8°02	725	2	724A	M5
25	279	2018	61°21.0	8°05	835	2	725A	M4
26	279	2042	61°18.8	8°09.2	785	2	726A	M3
27	279	2102	61°16.9	8°12.1	500	2	727A	M2
28	279	2121	61°15.0	8°15.2	335	2	428A	End line M, M1
29	279	2323	61°21.0	8°37.9	345	3	429A	Start line N, N1
30	279	2356	61°24.7	8°31.7	475	3	430A	N2
31	280	0005	61°25.5	8°30.0	595	3	731A	N3
32	280	0020	61°27	8°27.3	810	3	732A	N4
33	280	0045	61°29.7	8°22.5	810	3	733A	N5
34	280	0105	61°30.8	8°19.3	620	3	734A	N6
35	280	0119	61°32.5	8°16.7	500	3	435A	N7
36	280	0139	61°34.2	8°14.5	345	3	436A	End line N, N8

TABLE 3 (CONTINUED)

XBT Observations

Drop	Day	Time Z	Lat N	Lon W	Water Depth, m	Cassette	File	Comments
37	280	0314	61°43	8°25	325	3	437A	Start line P
38	280	0325	61°42	8°27	500	3	438A	
39	280	0333	61°42	8°29	610	3	739A	
40	280	0354	61°40	8°33	752	3	740A	
41	280	0410	61°38.5	8°35.5	800	3	741A	
42	280	0436	61°36	8°40	880	4	742A	
43	280	0509	61°33	8°45.5	795	4	743A	
44	280	0531	61°31	8°49	590	4	744A	
45	280	0552	61°29.2	8°53	480	4	445A	End line P
46	281	0001	61°51.5	8°36.6	335	4	446A	Start line R, R1
47	281	0024	61°49.2	8°41.8	450	4	447A	
48	281	0044	61°47.3	8°45.8	600	4	748A	
50	281	0101	61°45.5	8°49.1	747	4	750A	
51	281	0110	61°44.5	8°50.7	803	4	751A	
52	281	0140	61°42	8°56.6	830	4	752A	
54	281	0212	61°38.3	9°03	840	4	754A	
55	281	0235	61°36	9°08	822	5	755A	Point R2
56	281	0306	61°32.6	9°03.8	690	5	756A	
57	281	0330	61°30	9°00	500	5	457A	End line R, R3
58	281	2131	61°31.1	8°21.1	670	5	758A	On ATTOM line
59	283	1636	61°30.0	9°12.0	700	5	759A	
60	283	1712	61°31.5	9°21.3	800	5	760A	
61	283	1724	61°31.9	9°24.6	900	5	761A	
62	283	1741	61°32	9°29	925	5	762A	At Q½
63	284	0009	61°42.0	9°27.7	900	5	763A	Between Q2 & Q3
64	284	0214	61°47.0	9°18.4	770	5	764A	Between Q3 & Q4
65	284	0629	62°01.8	8°46.7	330	5	465A	At Q6
66	284	0753	62°07	9°14.8	507	5	466A	Between Q6 & S8
67	284	1225	61°59.5	9°58.9	862	6	767A	Between S7 & S6
68	284	1450	61°52.9	10°15.3	810	6	768A	Between S6 & S5



Figures 1. Charles Darwin Cruise 42 Track. Day numbers of arrivals and departures are indicated.

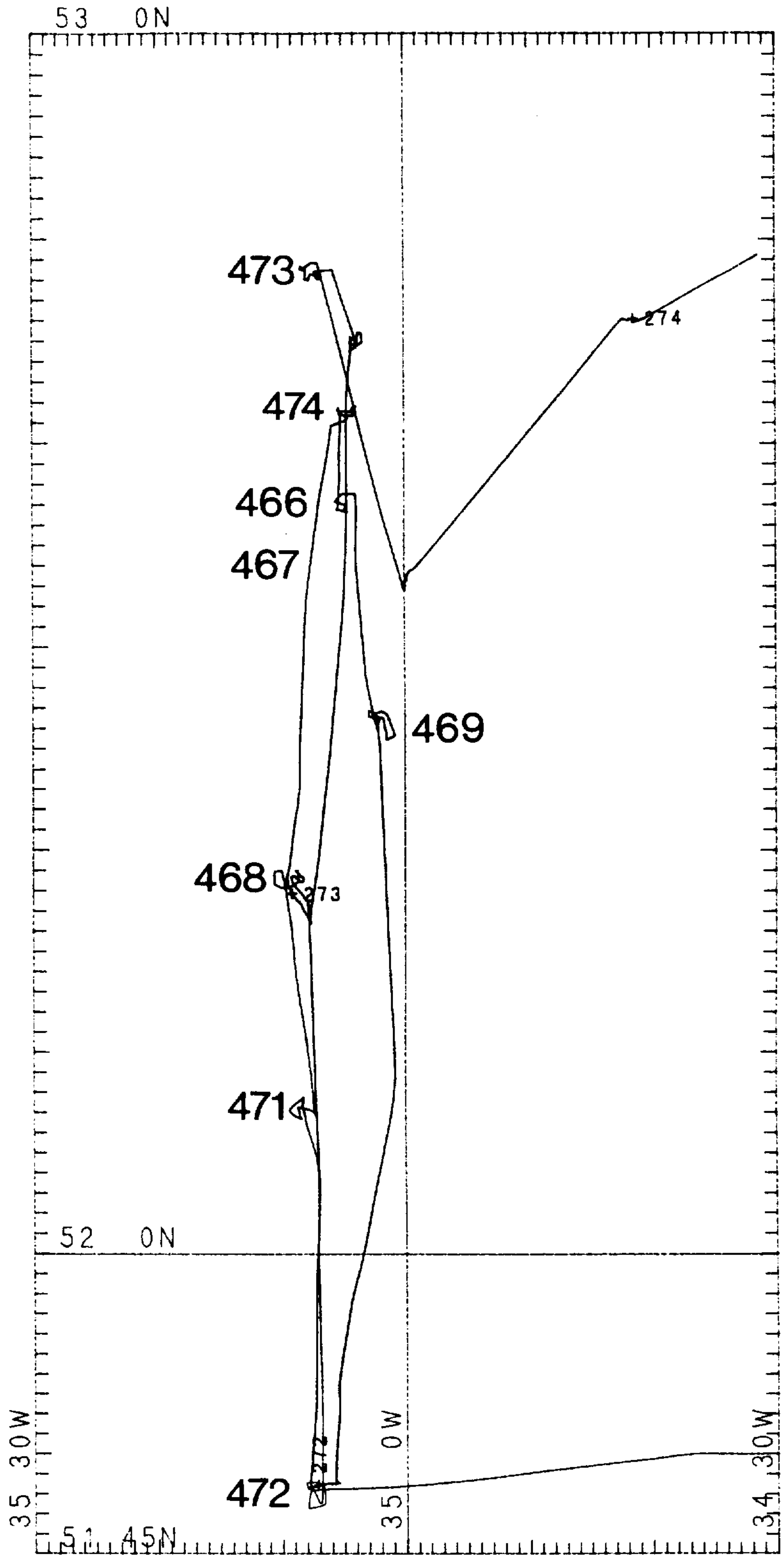


Figure 2. Charlie-Gibbs Fracture Zone. The number of each mooring recovered is shown.

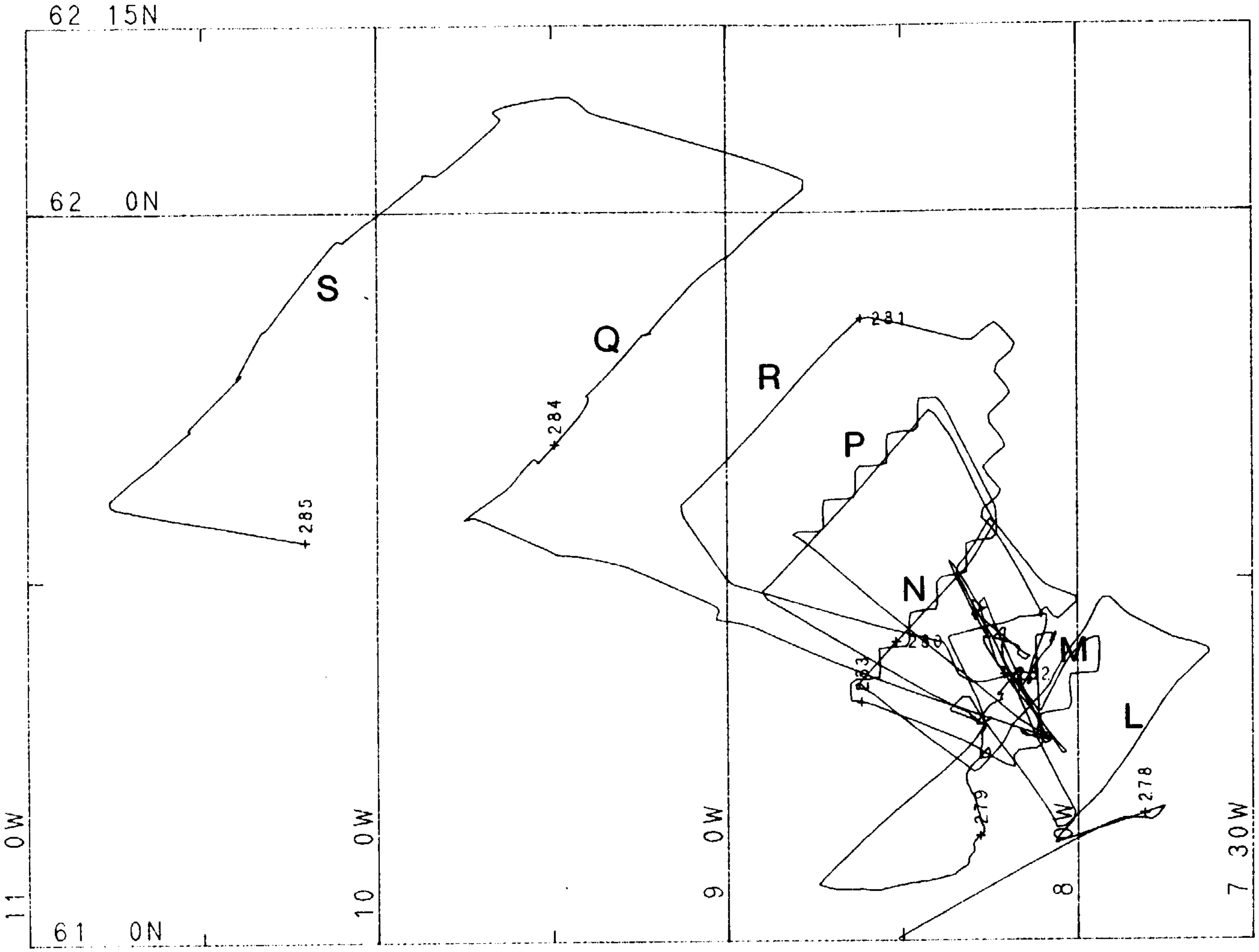


Figure 3. Faeroe Bank Channel. XBT and CTD sections are identified by the letters L - S.
Current meter moorings are NW of the line M.