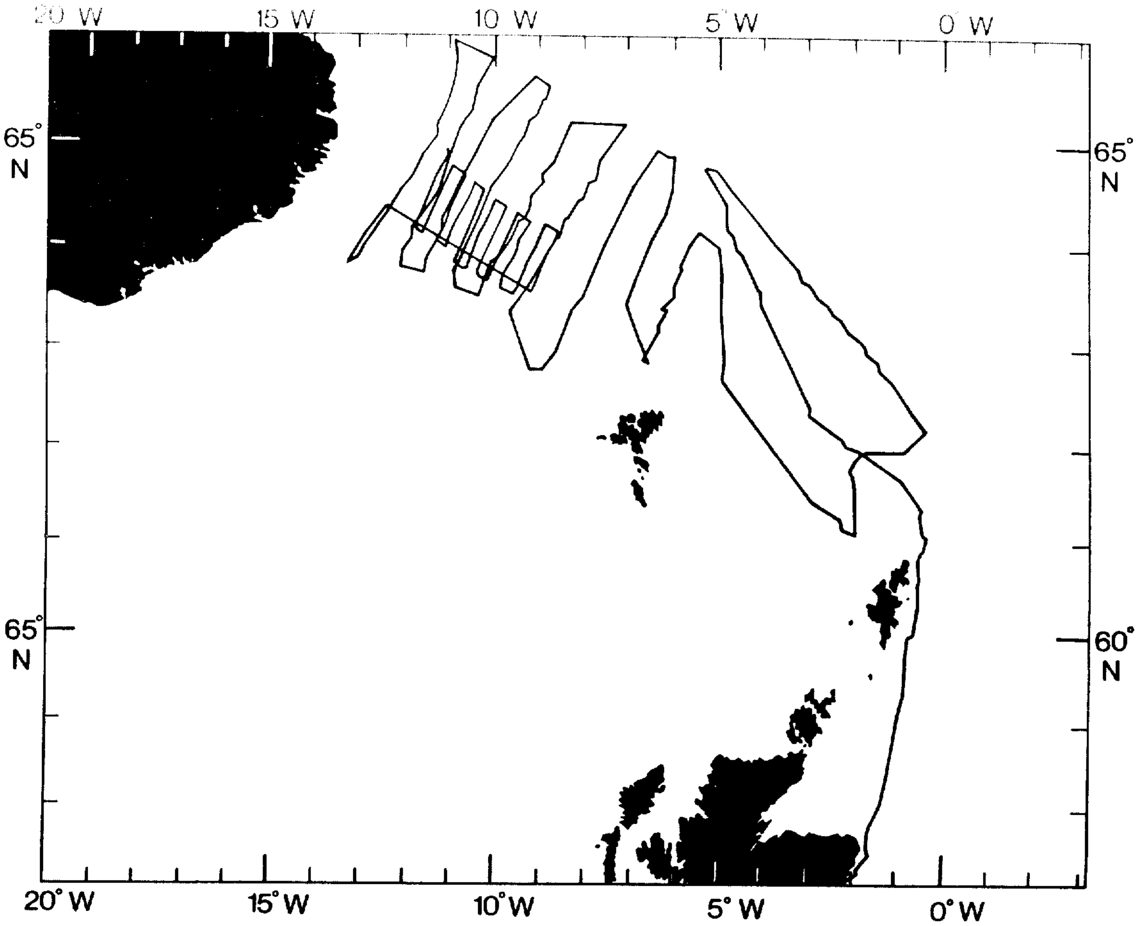
Institute of
Oceanographic Sciences
Deacon Laboratory

RRS Charles Darwin Cruise 51

24 Jul - 21 Aug 1990

Temperature salinity and velocity structure of the Iceland Faeroes Front and North Atlantic Water inflow to the GIN Sea

Cruise Report No 216 1990



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CRUISE REPORT NO. 216

RRS CHARLES DARWIN CRUISE 51
24 JUL-21 AUG 1990

Temperature salinity and velocity structure of the Iceland Faeroes Front and North Atlantic Water inflow to the GIN Sea

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ABSTRACT

RRS Charles Darwin Cruise 51 gathered information for an IOSDL Laboratory Research Project on "Processes determining the structure of the Upper Ocean". The operational area covered the inflow of North Atlantic Water to the Greenland-Iceland-Norwegian Sea between the Shetlands and Iceland. The survey method involved towing a CTD inside the SeaSoar profiling vehicle and combining the data with the shipboard Acoustic Doppler Current Profiler. Two wide area surveys, one east of, and one west of, the Faeroes were completed. The evolving eddy structure of the Iceland-Faeroes Front was then examined by three repeated small scale surveys.

KEYWORDS

ATLANTIC(NEN)
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GREENLAND SEA
HOB BUOY DRIFTER
ICELAND FAEROES FRONT
INFLOW
NORTH ATLANTIC WATER
NORWEGIAN SEA
SALINITY
SEASOAR
TEMPERATURE

ISSUING ORGANISATION

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EVANS, P	Chief Officer
SYKES, S	Second Officer
PROCTOR, G	Third Officer
ROWLANDS, D	Chief Engineer
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LOVELL, V	Third Engineer
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CRABB, G	Seaman
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WOOD, G	Cook/Steward
BISHOP, P	Cook
STEPHENS, M	Second Steward
JENKINS, D	Steward
DUHAMEAU, A	Steward
BRIDGE, A	Motorman

1. ITINERARY

The cruise gathered information for an IOSDL Laboratory Research Project on 'Processes determining the Structure of the Upper Ocean' and formed part of the UK contribution to the World Ocean Circulation Experiment (WOCE).

The Iceland Faeroes Front (IFF) runs from the east coast of Iceland and passes north of the Faeroes. As an extension of the Icelandic Current it forms part of the cyclonic circulation of the Greenland-Iceland-Norwegian (GIN) Sea. Warm, salty North Atlantic Water lies to the south of the front and a shallow layer of cold, fresh Icelandic Current Water overlays Norwegian Sea Water to the north. Satellite images show that the frontal region contains eddies on scales of order 50km that have not been resolved adequately by the restricted spatial resolution of previous surveys.

The survey method planned for Cruise 51 involved towing a CTD inside the SeaSoar profiling vehicle. We thus obtain the temperature and salinity structure of the upper 400m at a speed of at least 8 knots. When combined with velocity data obtained from the shipboard Acoustic Doppler Current Profiler (ADCP), the SeaSoar sections can resolve motions down to 4km. Additionally, deep CTD stations establish the characteristics of the whole water column.

The flow of water masses originating in the North Atlantic to the GIN Sea area provides an important route for the poleward oceanic heat transfer. Whereas the flow to the west of Shetlands has been established, the volume transport of the branch between the Faeroes and the IFF is poorly understood. Using SeaSoar and the ADCP we will survey the North Atlantic inflow and the circulation around the Faeroes.

Cruise Plan

We designed a systematic cruise track to span the IFF and the inflow into the GIN Sea. The track began with a CTD section of nine stations from the West Shetland Shelf to the Faroe Bank. A four day SeaSoar survey, involving three crossings of the region to the North East of the Faeroes established the limits of the North Atlantic Water in that area. Water masses of differing origin, signified by their temperature/salinity properties, were interleaved with the predominant North Atlantic Water. Due to seasonal heating in the upper 20m, we found little surface expression of a front. The eastern survey finished with a CTD section of nine stations from the Norwegian Sea south to the Faeroes. Both CTD sections repeated earlier measurements by IOSDL and contribute to our understanding of interannual variability in the water masses of the area.

The first part of the IFF survey, running from east to west, gave the large scale characteristics of the Front, with legs of 200km in a SSW-NNE direction, 40km apart. The survey showed the presence of eddies and frontal meanders, with a northward intrusion of warm North Atlantic Water at 10W. This intrusion, of some 100km, is seen on satellite images, but was not present during the cruise of the SACLANT research vessel 'Alliance' in June to early July. Our SeaSoar observations show that the intrusion occurs only in the upper 300m.

The coarse survey was followed by fine scale surveys with legs of 80km, 15km apart, designed to resolve eddies of scales down to 30km. By repeating the fine scale surveys, we obtained information on the movement of the front and eddies, and on how eddies were generated by the front. These surveys will make a significant contribution to our understanding of the structure of the IFF and its eddy field.

Additional information on the time variation of the IFF will be gained from the moored ADCP deployed by Dr. W.J.Gould on Cruise 50 and recovered on this cruise. To add to our picture of the spatial patterns of current, we released a drogued, satellite tracked buoy near the western extremity of the front and monitored its progress using the Argos system.

All the shipboard scientific systems worked very well indeed. In particular, the new Simrad Echo Sounder proved most effective. When towing SeaSoar in depths of less than 500m its facilities, including a minimum depth alarm, were greatly appreciated. The shipboard ADCP performed excellently, perhaps reflecting the recent upgrades.

The cruise met, and exceeded, each of its objectives; such an intensive survey could not have been carried out without the support, encouragement and professionalism of the officers and crew of the RRS Charles Darwin.

2. NARRATIVE

RRS Charles Darwin sailed from Aberdeen at 1330 on 24 July 1990. Soon after the pilot disembarked just outside the harbour, we deployed the PES fish and the sea surface temperature probe for Multimet. Underway sampling of the em log, gyro, MX1107 Transit satellite navigator, GPS, Multimet, thermosalinograph and the shipboard ADCP was started between 1400 and 1530.

By 1000 on the 25 July the ship was off the north east coast of the Shetlands, and in a suitable water depth to carry out an ADCP calibration. Nine zig-zags were made with each leg lasting 30 minutes, the extended time was necessary to reduce the errors due to degraded GPS accuracy. Soon after the completion of the calibration at 1430 a school of killer whales was seen close to the ship.

East of Faeroes survey

Meanwhile, the CTD equipment had been prepared for the first station of a section between the West Shetland shelf and Faroe Bank. This first station (5101 at 1712 on 25 July) was used as a training exercise for new seagoing staff and students in handling the equipment and in taking water samples for salinity and oxygen. Whilst on station, the Multimet sea surface temperature probe was replaced due to erratic readings. Also, the ADCP sampling was changed from a continental shelf configuration of 50 by 4 metre cells to 64 by 8 metre cells with a new automatic bottom tracking algorithm.

CTD stations 5102 to 5104 were completed without incident. On station 5105 (0240 on 26 July) the CTD was put on the bottom, partly because of a significant discrepancy between the echo sounder depth and the wire out, and partly due to the inexperience of the junior staff on watch. No damage was done to the CTD itself, and only minor damage was visible to the frame, but three of the 10 litre Niskin bottles were fractured. They could not be repaired with the facilities aboard. CTD stations 5106 to 5109 were then occupied, and the section ended at 1355 on 26 July.

As on Cruise 50, a radio schedule was kept daily at 1230 with the SACLANT research vessel *Alliance* that had been working in the area of the Iceland Faeroes Front since June. They gave us information on the position of the Front that proved valuable later in the cruise.

A minor problem with the SeaSoar controller delayed the start of the survey of the in flow of North Atlantic water into the Greenland Iceland Norwegian Sea. In the meantime, a series of tests was carried out for chemists at IOSDL and the University of Bristol on redesigned filter systems for the Stand Alone Pumps (SAP). At 1840 the SeaSoar was ready for deployment, and by 1853 the vehicle was in the water, deployment finishing at 1909. With IOSDL and RVS technical staff handling the winch, cable and A frame, and the deck crew, under the Bosun, handling the vehicle at the stern, the deployment went perfectly. The winds were light, 10kt, but with a swell of about 2 metres. The track chart of the survey is shown in Figure 1.

Routine underway sampling from the non-toxic seawater supply started at 2000, with hourly salinity, and four hourly chlorophyll samples. The newly installed Simrad echo sounder proved very useful whilst towing SeaSoar in depths of less than 500 metres. Using its minimum depth alarm, the watchkeepers were able to fly SeaSoar at a safe height above the bottom, whilst maintaining maximum depth coverage. SeaSoar continued to work very well through 27 July, though it suffered from interference from the ships HF radio transmissions during the schedule with *Alliance*.

Seasonal heating in the upper 20 metres reduced the surface signature of the polar front. To ensure that we had crossed the front, we steamed past the planned northernmost point of 64°30' N as far as 64°55' N, by that time a sharp thermocline at 25 metres had existed for the previous two hours. During the prevailing calm weather ADCP profiles were made to 400 metres, with no evidence of the problems encountered in heavy weather on other cruises.

A change of course was necessary at 2125 on 28 July, North West of the Shetlands, to avoid a Soviet research ship, the Akademik Shatsky, towing a 5km hydrophone array. The core of the boundary current on the shelf edge was crossed four times in all. High biological productivity was in evidence on a variety of sensors as we crossed the cold upwelling water just off the shelf. Having completed the survey, SeaSoar was recovered at 1737 on 30 July.

Immediately after recovery, another series of trials on the SAPs and filters was carried out. Upon completion at 2055, we headed for the start of the second CTD section. This section was a repeat of that made from RRS Challenger in May 1987, and from RRS Charles Darwin in October 1989. These repeated surveys are designed to add to our knowledge and understanding of the interannual variability of the water masses in the area. The section of nine CTD stations was successfully completed at 1849 on 31 July. On passage to the SeaSoar deployment position in 700m of water, XBT's were launched at 7 nm intervals.

Iceland Faeroes Front - wide area survey

At 2233 on 31 July we deployed SeaSoar for the start of the wide area survey of the Iceland Faeroes Front, Figure 2. All systems worked well until 0315 on 2 August when the SeaSoar hydraulic control was lost just as we crossed the front. Suspecting a cable termination failure, the vehicle was recovered and the termination checked then remade. When recovered, the cable was snagged between the vehicle body and the wing root. However, this was not the cause of the problem, and probably happened prior to the start of the recovery due to the ship pitching. Whilst waiting for the cable to be repaired, we crossed the front obliquely observing the temperature and velocity structure with XBTs and the ADCP. At 0809 SeaSoar was ready to be deployed; we then continued with the wide area survey, rejoining our original track 3nm north of the recovery position.

SeaSoar was recovered at the end of the survey at 0630 on 8 August. We then steamed to a position to the west of the ADCP mooring to deploy a drifting buoy within the front at 64°18'N 12°38'W. The buoy, drogued at 10 metres, was tracked using the Argos satellite system. We remained near the buoy whilst the Argos and direction finding beacon were checked. At 1332 we arrived at the site of the RDI 150kHz bottom mounted ADCP mooring deployed on cruise 50. The acoustics were checked on the beacon channel and two beam passes were made to confirm its position.

At 0747 on the 6 August a group of surface buoyancy spheres, appearing to be moored, had been seen whilst we were towing SeaSoar. Rather than interrupt the survey, their position was marked and, after checking the ADCP mooring, the ship returned to make a box survey of the area from 1620 to 1710. By 1922 we had returned to the ADCP site and began a 12.5 hour intercomparison experiment between the shipboard and moored ADCPs. This exercise also provided information on the local tidal currents. XBTs were launched every four hours to monitor the stratification. The intercomparison ended at 0800 on the 9 August and we then set course for the start of the first fine scale survey of the front.

Fine scale survey

SeaSoar was deployed at 1830 the same day, at the start of a grid of tracks, Figure 3, designed to resolve motions with scales of down to 30km. This required the tracks to synchronise with the semidiurnal tidal current. The area of the survey box was chosen after examining the preliminary maps and sections produced from data acquired on the wide area survey. The only incident occured a few hours before recovery on the morning of 12 August: a fault in the strain gauge unit gave a full scale reading for cable tension. As the weather was calm and the vehicle was due for recovery in a few hours, we continued the survey, maintaining a close watch on the vehicle depth and behaviour. The survey ended at 1437. It had been our intention to recover the ADCP mooring, but dense fog caused by a warm moist airflow over the cold surface water near the mooring prompted us to start the resurvey of the fine grid.

The maps and sections from the fine scale survey showed that there had been significant changes in the details of the density structure since the wide area survey. Therefore, we concluded that a resurvey should not be delayed, otherwise there could be a risk of significant spatial decorrelation.

The repeat survey, Figure 4, began at 2343 on 12 August and was completed at 2045 on the 15 August. Again, significant changes in the positions of the front and eddies were seen over the wide area survey and the first fine scale survey.

Mooring and drifter recovery

After recovering SeaSoar, the ship headed for the ADCP mooring position, with the object of recovering the mooring early on the morning of 16 August. Overnight, further SAP and filter tests were carried out following information recieved via IOSDL. Acoustic contact was made with the release at 0628, the ship was manouvered into a position east of the mooring, to stem the tide. At 0726 the release was fired, and the buoyancy was sighted on the surface in the expected position at 0730. The ship's inflatable boat then took a recovery line to the ADCP. By 0827 the mooring was safely aboard, competently and carefully handled by the deck crew and the RVS technicians.

After recovering the boat we set course for the last position of the drifting buoy. Poor quality data lines to a JANET modem and PAD via Inmarsat meant that we relied on positions telexed to the ship from IOSDL. When we were 8km from the last position fix, we received a signal from the direction finding beacon. Using bearings from the steerable antenna, the ship was guided to the buoy until it was sighted at a distance of 3 cables, dead ahead, at 1510. The buoy and drogue were easily recovered by 1539 and we set course for a resurvey of the central and western part of the fine survey box.

Resurvey

The resurvey started at a northern corner of the fine scale survey box, Figure 5. SeaSoar was deployed at 1901 on 16 August. The real time displays showing significant changes in the positions of the front and eddies. The resurvey finished at 1415 on 18 August, though as the water depth was too shallow for a safe recovery, the ship steamed on until, at 1650 in 500 metres of water, SeaSoar was recovered.

Course was then set for Troon and rostered watches finished at 2000.

GG

3. CTD

The IOSDL Deep CTD 01 mounted in the new 24 x 10 Litre General Oceanics rosette multisampler frame was used for all of the vertical CTD work. A Seatech 1 metre transmissometer and an IOSDL pinger were also mounted on the frame. The 10 litre Niskin bottles used were spaced around the multisampler in alternate slots to provide a balanced package. Three SIS digital reversing thermometers and two SIS reversing pressure meters were used on two thermometer frames to obtain calibration information.

Two CTD sections, each of 9 casts were worked with this equipment from 130-2045 metres. Using the acoustic pinger, the package was lowered to within 10 metres of the bottom. However, the fifth station occupied was an exception to this rule, when the package was briefly placed on the seabed. Unfortunatly three of the Niskin bottles suffered damage as the frame toppled over. Apart from this damage, the rest of the equipment was unharmed.

The performance of the CTD, multisampler etc and the new deck equipment was good throughout the cruise. The problem experienced on the previous cruise with the IBM PS2 crashing at the start of the upcast did not recur. It was thought that this was a result of not letting the system clear its data input buffers before firing the multisampler. Allowing approximately 30 seconds for the buffers to clear seemed to alleviate this problem. From salinity samples measured on the Autosal, the conductivity cell correction ratio remained stable throughout the two sections.

All CTD data was logged through the RVS level A,B and C system and backed up onto the PS2 tape streamer and copied into Pstar format on the SUN. It was then processed in a standard manner with a series of command files. Information such as the position, time and bottom depth of the CTD were added to the header of each CTD file, and simple automatic editing performed before the data was calibrated, converting from raw to physical units. The down casts were then averaged to 2 dbar intervals before being combined to give a gridded dataset covering a section.

Calibration coefficients were initially taken to be the values determined in the laboratory. The temperature sensor time constant and the conductivity-ratio factor were both later adjusted to improve the data quality. The latter was determined by comparing the CTD salinity with the salinity measured from bottle samples taken at the same depth. The temperature time constant was estimated by minimising salinity spikes in strong temperature gradients in the first guess calibrated data.

The cold flows from north to south are clearly revealed following the topography in the two sections. They will provide useful additions to the understanding of the climatology of the deep water in the overflow region of the North Atlantic.

JS, SJA, JFR and SBK

4. SEASOAR

A total of four SeaSoar runs were carried out using the IOSDL SeaSoar vehicle, shallow CTD 01 and Chelsea Instruments fluorimeter (fluorimeter loaned by RVS). These runs totalled 427.5 Hrs, and covered approximately 6350 kilometres

The first run was between the two CTD sections. The performance of the system was good, with a maximum depth of approximately 410 metres being obtained at 8 kt with maximum tensions in the region of 900-1000 Kgm. Run duration was 95 hrs.

During the second run, SeaSoar was recovered after 31.5 hrs due to loss of hydraulic control. On recovery, the cable was found to have taken a turn between the port wing and the SeaSoar body. It was felt that this had only happened during recovery as the ship heaved, and was not the original cause of failure, as no unduly high cable tensions were experienced. Four metres of cable were cut and the termination remade. SeaSoar was relaunched and the run completed without further problems. Data logging was briefly interrupted on two occasions, when the CTD deck unit serial port 'hung up'. The reason for this was unidentified.

During this run, a number of different waveforms generated by a BBC micro computer were used to control the SeaSoar vehicle. The first of these was a sinewave of 13 minutes duration whose maximum and minimum amplitudes could be individually adjusted. From the table below it can be seen that the depth capability was improved by 5-7 metres, with comparable cable tensions, at around 8 kt. The turning performance of the vehicle was slightly degraded at the surface due to the slower reversal of control signal compared with that of the standard sawtooth waveform. The period was altered to 12 and 14 minutes but without further improvement.

The second waveform was a combination of sinewave for the lower, ie deeper half and sawtooth for the upper half. This had the effect of giving the increased depth capability, but with better turning at the surface.

WAVEFORM SHAPE	SHIPS/ SPEED 1 kt	VEHICLE DEPTH metres	MAX TENSION kgm	MEAN TENSION kgm	PERIOD mins
SAWTOOTH	7.95	405	851	489	13
SINEWAVE	8.2	412	880	489	13
	8.0	409	840	476	14
	7.9	410	860	475	13
SINE+SAW	8.0	410	906	519	13

The third waveform was a sawtooth and squarewave combination. These were added in such a way as to provide a waveform that increased linearly to a maximum amplitude then decreased with a step. The second half of this waveform was the inverse: a linear decrease to minimum with a step rise in amplitude. The size of the step was adjustable, as were the period, and maximum and minimum amplitudes. The step size was varied from ± 9.5% to ± 30% of the peak to peak amplitude. The reasoning behind this choice of waveform was to produce large reversals of hydraulic valve current at the turns, giving faster wing angle changes. Cable tensions at 8 kt were comparable with those of the standard sawtooth but with some improvement in the turning speed of the vehicle both at the surface and bottom. **Duration was 147.5 Hrs.**

Four metres of cable were removed and the termination was remade before the third SeaSoar run. There had been no further problems on the previous run, but it was felt that a new termination might reduce the chances of cable failure for the further runs planned. Towards the end of this run, the cable strain gauge failed. The run was completed without cable tension being measured. The strain gauge was found to have become contaminated with seawater. The internal connections were remade after cleaning and drying the interior of the strain gauge. **Duration:69.25 hrs.**

The fourth and fifth SeaSoar runs was completed without problems. **Durations were 69.25 and 46.5 Hrs.**

Fouling of the conductivity cell with associated shifts of salinity was once again in evidence, but would usually clear when the vehicle reached the surface. On a number of occasions the vehicle was held on the surface to clear particularly obstinate fouling.

Throughout the SeaSoar runs, data were logged by the RVS level A,B and C system. Once a watch, at 4 hour intervals, the PS2 logging was stopped and a copy of the raw data (EDT file) and display screen files were backed up to tape streamer. To do this meant the removal of the PS2 serial data link to the CTD deck unit. Failure to do so caused the data flow to the level A to be halted as the PS2/CTD deck unit handshake was in control. Approximately four minutes of PS2 data loss would occur during these transfers but this was comparable with the old bulky 9 track tape drive used prior to cruises 50-51. Except for SeaSoar run 3, all raw data was backed up to tape streamer at the end of each run. During run 3, the PS2 hard disc became full and raw data files had to be deleted to make room. The alternative would have been to stop the PS2 system for a much longer period than four minutes to backup the raw data files. Each four hour period took up approximately 2.5 megabytes of storage meaning that a 3.5 day run could be completed without the need to delete data files.

Throuhout the cruise, the new CTD deck unit, PS2 system and EG & G software were operated by other watchkeepers without difficulty.

SeaSoar data processing followed a similar path to the CTD data upto calibration, except that data were acquired in four hour pieces. After calibration the data were plotted and then edited for spikes and offsets due to fouling of the conductivity cell. The latter were removed wherever possible. This editing was aided by the use of an interactive graphical editor.

The calibration coefficients were corrected by comparing the deeper salinities with the CTD data at a nearby station. The temperature sensor time constant was again estimated by examination of temperature steps in the data.

The four hour pieces of data were combined into a series of sixteen hour sections each overlapping the next by four hours. After combining with navigation data, the sawtooth distribution of pressure implicit in SeaSoar data was averaged to create a grid at regular distances along track and at regular pressures or densities. This allowed sections of data to be contoured and intepreted as the survey proceeded. Contour plots across the survey area provided by RVS were especially useful in this respect.

A further calibration was derived by comparing the SeaSoar gridded data at the grid point nearest the surface with salinities from bottle samples taken when the vehicle was estimated to be near the surface. This revealed a slow drift in the SeaSoar calibration which can be corrected in the laboratory.

The data clearly reveals the various water masses that interact in this area. The region to north and south of the front are strongly contrasted, with very linear TS characteristics and little biological activity (as indicated by the fluorescence) to the north, and highly convoluted TS curves near the front with intense biological activity. The front itself is in places barely resolved by the 4km repeat sawtooth that the SeaSoar executes. Many interesting small scale vertical processes are indicated at or near the front, with temperature inversions of 2 or more degrees in as many metres.

JS, SGA, JFR, SBK and BW

5. SHIPBOARD ACOUSTIC DOPPLER CURRENT PROFILER

The RD Instruments 150kHz ADCP was in operation throughout the cruise. Neither the instrument or the IBM PC AT data acquisition system (DAS) gave any hardware problems. The DAS (software version 2.46) crashed twice when restarting after transfering data to floppy disk.

At Aberdeen a new version of the firmware was installed (17.03), together with a minor modification to the power amplifier board. This upgrade contained a test version of an improved bottom tracking algorithm from RDI. The acoustic transducer unit had recently been upgraded, the unit installed was previously fitted to RRS Challenger. These upgrades, in conjunction with the relatively high backscattering observed in the area, provided water tracking to at least 400 metres, and automatic bottom tracking to over 700 metres. The penalty for automatic, long range bottom tracking was a reduced ping rate. Partly this was due to the long pulse used (adaptively controlled at 10% of the depth), though mostly due to the inherent round trip travel time. The algorithm had problems working in depths of less than 30 metres, when it was unable to give bottom depth readings. Water track velocities, when the ADCP was in bottom tracking mode, often showed contamination below a depth of 85% of the water depth. Velocities in this region, where the direct bottom echo interferes with the main beam, should normally be rejected by the DAS. Its failure to do so may be related to the new bottom track algorithm.

Several users of shipboard ADCPs have noted spurious shear in rough weather, especially with the ship heading into wind and waves. There was little evidence for such shear in our data, though with the ship pitching into 3 metre waves and heading into a 25kt wind, the velocity profiles were of significantly lower quality. Yet, they were essentially unbiased. It should be noted that RDI had made improvements to the bin to bin tracking in the new version of the firmware.

The majority of the data processing for the ADCP was carried out using Pstar command files. The initial processing stages were identical to those of previous cruises. An added option was to plot profiles in the form of current vectors relative to a layer average. Absolute currents were obtained by merging the ADCP water track velocities with the ship velocity obtained from differencing GPS positions 2 minutes apart. This was done after both velocity data sets had been averaged over 15 minutes. Plots of ADCP velocities and the velocities infered from GPS were used to identify bad data points before merging. A new command file plotted the absolute current vectors and the relative echo amplitude.

As we were surveying an area in which tidal currents were up to 60 cm/s, careful interpretation and analysis will be required before conclusions can be drawn from the ADCP data. On board, we were able to produce vector maps of hourly averaged currents at 100 metres, with the tidal and inertial components removed. This rudimentary processing showed that:

a) residual currents were weak away from fronts and eddies

b) currents of up to 50cm/s were associated with fronts

c) rotary currents of typically 20cm/s were seen in the vicinity of eddies.

Fluctuations in the backscattering amplitude were dominated by zooplankton diurnal migration, with strong near surface backscattering from about 2300 to 0500. In the vicinity of the front, the backscattering increased significantly. This was especially noticable during daytime crossings. These periods of increased backscattering were correlated with high values of surface fluorescence. The extremes of echo amplitude at 140 metres differed by 55dB, though the typical daily variation was 28dB.

GG and SW

6. LAB MEASUREMENTS

Salinity

At CTD stations, two salinity samples were taken per bottle fired and during the SeaSoar surveys one sample bottle was taken from the wet lab sea-water supply approximately every hour at a point when SeaSoar was ascending and 50 metres from the surface i.e. where SeaSoar would strike the surface water. Samples were generally well taken with the usual occasional stopper missing and over or under filled bottle.

It was hoped that both the new 8400A and the old 8400 salinometers would be used to measure the conductivity ratio of the samples. The new salinometer was cleaned with decon solution and eventually persuaded to draw in the water samples, however after a very short period of use the digital read-out became unsteady to the point that it was impossible to obtain consistent readings. On opening the cabinet it was noticed that a small amount of water had collected in the tiny capillary tubes to the cells. Thus for most of the cruise only the old salinometer was serviceable. However even the operation of this machine did not go without a few problems. The old salinometer had to be flushed with decon solution twice during the cruise and various joints in the plumbing required cleaning and re-seating. A week into the cruise one air pump stopped operating due to a slipping drive belt, which was duly replaced. Towards the end of the cruise it was noticed, by switching from 'norm' to 'ck1' and 'ck2' that the two thermistors were clearly out of balance or indeed that thermistor 2 might not have been working at all.

The standard sea water samples left something to be desired. Several ampoules had floating biological material and conductivity values often varied considerably from ampoule to ampoule even when sampled consecutively as a control test.

JTA

Oxygen sampling

On the two CTD sections four Niskin bottles were fired on each station for calibration purposes. Each bottle was sampled twice for analysis of dissolved oxygen content. A new SIS automated Winkler titration unit was used to analyse the samples. Unfortunately this had been supplied with a mismatched connector allowing the intake of air into the supply of titre from the burette into the sample. About half of the samples were thereby lost. The few remaining duplicates suggested that the precision was good: generally better than .01 ml/l. No estimate of accuracy has been made.

JFR

Chrorophyll 'a' sampling

To calibrate the SeaSoar fluorimeter and the Turner Designs fluorimeter a surface sample was drawn from the non-toxic seawater supply once every four hours. Each 200 ml sample was then filtered by vacuum pump on to a 2.5 cm glass microfibre filter. For the first few days these were put into 10 ml of 90% acetone with the intention of analysing them immediately. However the Turner 112 fluorimeter proved unstable and impossible to standardise. The samples for the four day eastern survey had to be discarded and after this each filter was wrapped individually in paper and frozen for analysis at IOSDL.

The Turner Designs fluorimeter was connected to the non-toxic seawater supply in series with the thermosalinograph. However, the flowmeter was unusable due to corrosion so no check could be made on the flow rate. The fluorimeter appeared to work well until the end of day 220, the end of the wide area survey of the IFF. After this, it went offscale on the minimum sensitivity range, this may have been the result of air bubbles in the water supply.

JFR

7. THE MAC SAT SYSTEM

The Apple Macintosh IIcx had a rather uncertain start to cruise 51, clearly it had not appreciated the journey to Aberdeen in the van. After being left to settle, and having the system discs reloaded twice, it was once again operational. Two problems remained with the mac for the duration of the cruise, firstly the video card caused lines to flash across the screen occasionally during mouse button operations (this was known about before the mac left IOSDL), and secondly the MacSat software would hang if the mac had been restarted without the system tools disc in place - although this could then be ejected before accessing the MacSat folder.

The receiver aerial proved simple to install on the wheelhouse top with care being taken to site it well away from the VHF radio transmission antennae. Running the co-axial cable link to the main lab effectively involved extending one of the pre-existing co-axial links that runs between the scientific plot and the computer room.

With few exceptions (Figure 6), cloud or fog cover prevented any infra-red remote sensing of the Iceland Faeroes Front and the rare occasions of clear blue skies coincided with gaps in satellite coverage. Over fifty images have been archived covering virtually every day of the cruise, only excluding those days of such complete cloud cover that no land could be seen to reference the images. Thus it may well be that on cruise 51 the macsat system will have provided a vast amount of added meteorological information but as a direct consequence, little oceanographic information.

All the scientific staff picked up the general operations of the software package quickly and, geographically positioning images as they were appearing provided an added interest. A world atlas, close at hand, was particularly useful when the images covered the Canadian coast of Baffin Bay, the far extremes of European Russia or the north coast of Greenland. Image processing was more skilled than expected and no one really seemed to master more than the grey scale option.

Only polar orbiting satellites were received as geostationary satellites require directional receiver dishes and therefore, for ship operation, a complex gimbal mounting. Satellite pass prediction times were reasonably accurate for NOAA 9, 10 and 11 and for the Russian Meteor 3-2 although it was important to update the ships position at least once every twenty-four hours. Reception was extremely variable and sometimes better on the thirteen or fourteen minute passes than on the full overhead fifteen minute passes, although this may have been just coincidence. Russian satellites had longer pass times and the picture quality was such that it was very difficult to identify land on the images, one image was identified and gave the impression that their images are at a much larger scale.

JTA

8. GPS

Recently, the accuracy of the GPS system has been downgraded for commercial users. To help determine the implications for position and velocity accuracy, position fixes every 5 seconds were obtained over a period of 15 hours and 30 minutes while the ship was docked at Aberdeen.

Variations in latitude and longitude for differing pdop and svc values were examined. Pdop is a measure of the accuracy of the positions (greater accuracy = smaller pdop) and svc is the number of satellites used to calculate the position fix. The highest accuracy was obtained when svc was three or four and pdop was four or less. Means and standard deviations of latitude and longitude were calculated and converted to metres. For pdop <= 4 and svc of 3 or 4, at a latitude of 57 N, the standard deviation of latitude was 42m, and 24m in longitude.

Velocity was calculated in various forms from the position data while stationary in Aberdeen: hvel is calculated by the GPS receiver from two position fixes within an ensemble period, and vdiff is calculated from the difference of mean positions at a chosen time interval. Graphs of hvel and vdiff with time showed a good correlation, though hvel was generally noisier.

The power spectrum of the velocity fluctuations Figure 7 showed three main features:

a) a broad peak at periods longer than 30 minutes - perhaps related to the changes in the space vehicle constellation used as satellites ascend and descend.

b) a flat spectrum from 30 minute to 40 second periods - perhaps related to the accuracy degradation introduced recently.

c) a low fluctuation level for periods less than 40 seconds.

The mean and standard deviations of hvel, for a sampling interval of around 5 seconds, were 0.14m/s (north component) and 0.11m/s (east component) implying that to achieve an accuracy of 1 cm/s in ships velocity derived from GPS, and average over 12 minutes has to be completed.

The minimum number of satellites needed for a position fix is two, however, this gives reduced accuracy. Initially, three or more satellites were available for 94% of the fixes, increasing to 100% by the end of the cruise.

AG

9. ADCP MOORING AND ARGOS SURFACE DRIFTER

An RD Instruments 150kHz self-contained Acoustic Doppler Current Profiler, supplied by RVS, was deployed by Dr W J Gould on Charles Darwin Cruise 50 at 64°24'N 11°55'W in 450 metres of water, Figure 8(a). The position of the ADCP was chosen to form part of an array of moorings, Figure 8b, deployed from *Alliance* by Dr T S Hopkins of the SACLANT Research Centre.

The instrument had been set up at RVS to give 75 by 4 metre depth cells, producing an ensemble average every 2 minutes. An Interocean S4 electromagnetic current meter was placed immediately beneath the ADCP, and an Aanderra current meter with pressure and temperature sensors was placed 10 metres below the S4, just above a pair of acoustic releases.

The mooring was recovered at 0827 on 16 August without any difficulty, though the use of the ship's inflatable boat (manned by Graham Proctor, Gary Crabb, and Colin Day) was necessary to attach a recovery line to the ADCP. The normal mooring recovery method of bringing the ship directly alongside, and grappling a stray line, could cause severe damage to the exposed and fragile acoustic transducers. This was the first deployment of an RDI ADCP mooring by IOSDL/RVS and, given the weather limitations of recovery using a small boat, the design was entirely satisfactory.

A HOB surface drifting buoy, kindly loaned by Dr R D Pingree of PML, equipped with a Mariner Radar Argos PTT and a Novatech radio direction finding beacon, was deployed within the frontal zone at the westernmost part of our cruise track. The buoy, figure 9(a), was drogued at 10 metres using several parallel lengths of 38mm polyproplene rope.

Prior to the cruise we had been provided with the details necessary to access the position data from Argos. However, a change of policy at PML after we sailed meant that we had to rely on positions relayed to us via Marinet. This was not entirely satisfactory. When staff at PML realised that the new procedure would make recovery very difficult, they released their new password. We were unable to use it though, as data communications via Inmarsat using Kermit proved to be too noisy. Keith Birch and James Perrett at IOSDL helped by sending positions by telex during the critical recovery period.

With these positions, and the expert interpretation by Gary White of the direction finder bearings, we sailed right up to the buoy and recovered it without difficulty.

The buoy track, figure 9(b), shows that it kept to the cold water side of the front and hence traced its northward path. In the few days before recovery, the buoy drifted east and then south, again following the path of the front.

Gwyn Griffiths

10. MULTIMET SYSTEM

The Multimet system was installed at the start of the cruise in Aberdeen with the help of K Birch and R Pascal. The system comprised:

1. Logger.
2. Port-side Vector Psychrometer.
3. Starboard-side Vector Psychrometer.
4. Fore-mast Vector Psychrometer.
5. Port-side Sea Surface Temperature (SST) sensor.
6. Fore-mast Two Short-wave Radiometers.
7. Fore-mast Long-wave Radiometer.
8. Fore-mast Young Anemometer.
9. Main-mast Vector Anemometer.
10. Main-mast Vector Wind Vane.

Once every watch the logger was visually checked by the watchkeeper to ensure that the system was operating. Once every day the whole system was visually checked to maintain that everything was still intact and that the psychrometer water bottles were not empty.

On day 205 the Fore-mast Psychrometer was giving higher than normal data values. This fault was traced to a poor connection on the cable which was re-terminated at approximately 1300 the same day.

For most of the cruise the SST readings were high, the most probable cause was broken thermistors in both sensor pods. Bench tests onboard ship seemed to confirm that the SST electronics boxes were working correctly but that the cables and/or sensor pods were faulty. Apart from the SST and the first psychrometer fault the rest of the system ran as expected.

Data from Multimet were logged onto the level A B C system. From there they were transfered to Pstar and calibrated according to the equations supplied by K Birch and R Pascal. The data were plotted weekly.

SBK and JFR

11. XBT's

Thirteen T7 XBT's were successfully launched during this cruise, the one failure was due to the new deck unit giving a time out error when too long a time was taken over launching.

Three were launched along the short leg 'I' - 'J' before the launch of SeaSoar at 'J' to start the large scale survey of the Iceland Faeroes Front. Five more were launched during the manoeuvre made to double back and rejoin the track when SeaSoar had to be recovered due to lack of hydraulic control. The other five were launched later in the cruise during the ADCP inter-calibration exercise.

Once supplied with the depth and temperature algorithms for T7 XBT's Andrew Cormack converted the XBT data files into temperature depth pairs in RVS format and these were then converted to Pstar format for later gridding and, where applicable, contouring.

JTA

12. RVS COMPUTING

The RVS computer system was used to log data from eleven instruments in real time, these being EM Log, Gyro, MX1107 and GPS satellite navigators, echo sounder, multimet, thermosalinograph, surface fluorimeter, CTD, SeaSoar and ADCP. In addition, data from XBT drops was transferred to the system from the XBT PC on floppy disks.

One Sun workstation Level C was used for data logging, with two others available for data processing by RVS and IOSDL staff. In addition there were three IBM PCs connected as terminals and two Microcolour graphics terminals.

Most data processing used the IOSDL Pstar suite of programs, but the RVS processing and display programs were used for navigation data and to provide summary plots of the data as it was collected. The contouring package was particularly useful in planning and interpreting the SeaSoar surveys.

The firmware for the echo sounder and thermosalinograph Level A interfaces were rewritten during the cruise. Both of these had previously suffered from the same fault which caused them to give zero readings for their instruments from time to time. A number of Level C programs were modified to add extra facilities or correct minor bugs.

The Tektronix thermal wax printer used for obtaining hard copies of screen images broke down during the cruise. A temporary alternative was found in the PostScript compatible laser printer which formed part of the MacSat system. PostScript files were generated by the plotting programs, using Uniras, and these files were moved to an IBM PC, either using kermit or floppy disk transfer, for printing. This gave adequate results although the final images were monochrome, as opposed to the colour images produced by the Tektronix system. Apart from this there were no major hardware problems.

A great deal of data was collected and processed on the cruise with the Level B handling about 2Mbytes per hour when both SeaSoar and ADCP were in use. On the whole, the system coped well, though frequent archiving was necessary to remain within the limits of disk space. With both RVS and IOSDL systems now using graphical data editors and contour plotting the Sun workstations were intensively used and it was felt that an additional workstation would have been helpful. If this option were used in future, extra disk space would be needed to provide root and swap areas for this machine.

AC

13. SIMRAD EA 500 AND PES MK 3 ECHOSOUNDERS

After initial problems setting up the sound velocity profile, the EA 500 ran faultlessly for the entire cruise. The EA 500 uses an on screen menu facility for setting up most parameters. As all modes of operation are software controlled, once the basic system parameters have been set, it is straightforward for anyone to select and alter the numerous options available using the joystick control.

The PES Mk 3 is still used for the tracking of pingers and releases; as this function will be possible with the EA 500 in the near future, the PES will be phased out. The PES Mk 3 operated well when required, although the main drive motor had to be replaced due to a bearing failure.

GW

14. RVS ENGINEERING

The cruise was quite uneventful, with only the CTD winch brake pump drive belt and the winch brake itself requiring adjustment. Otherwise it has just been routine servicing, all other mechanical equipment having performed satisfactorily.

JS and CD

Table 1 CTD Station List

Number	Time Down	Day Date 1990	Lat. °N	Lon. °W	Water Depth (m)	Closest Approach	Comments
1	1730	206 25/7	61 30.0	0 42.0	172	10	
2	1944	206 25/7	61 40.2	0 59.1	305	10	
3	2140	206 25/7	61 46.1	1 19.4	676	12	
4	0011	207 26/7	61 53.2	1 39.3	1369	7	
5	0240	207 26/7	61 59.9	1 55.9	1568	0	On bottom
6	0524	207 26/7	62 6.0	2 13.7	1648	10	
7	0733	207 26/7	62 11.8	2 31.4	1698	20	
8	1106	207 26/7	62 18.1	2 47.0	1176	70	
9	1325	207 26/7	62 24.9	3 4.9	606	20	
10	2220	211 30/7	64 9.9	5 32.4	3493	-	to 2000m
11	0119	212 31/7	63 59.2	5 43.2	3520	-	to 2000m
12	0413	212 31/7	63 47.6	5 51.0	2821	-	to 2000m
13	0700	212 31/7	63 36.0	6 1.4	2035	35	
14	0950	212 31/7	63 26.0	6 14.2	1533	25	
15	1235	212 31/7	63 13.9	6 20.3	1651	27	
16	1514	212 31/7	63 0.8	6 31.7	1220	25	
17	1709	212 31/7	62 51.8	6 37.0	536	30	
18	1859	212 31/7	62 39.8	6 45.2	172	20	

Table 2 XBT Deployments

Number	Time	Day Date 1990	Lat. °N	Lon. °W	Water Depth (m)	Comments
1	2003	212 31/7	62 44.5	6 58.5	~200	
2	2038	212 31/7	62 48.1	7 9.9	~450	
3	2119	212 31/7	62 52.8	7 24.4	~620	
4	0449	214 2/8	63 45.1	7 49.5	1154	
5	0545	214 2/8	63 53.1	7 51.1	1203	
6	0622	214 2/8	63 58.7	8 2.3	1232	
7	0709	214 2/8	64 5.4	8 10.2	1324	
8	0746	214 2/8	64 2.0	8 1.3	1279	

Table 3 East of Faroes SeaSoar Survey

Corner	Time	Day Date 1990	Lat. °N	Lon. °W	Comments
B	2000	207 26/7	62 19.5	2 58.7	On Course 337°
C	1828	208 27/7	64 55.6	5 19.8	On Course 141°
D	2342	209 28/7	61 54.9	0 19.9	On Course 276°
D1	0614	210 29/7	62 00.0	1 58.6	On Course 180°
E	1315	210 29/7	61 03.2	1 58.1	On Course 317°
F	0346	211 30/7	62 30.1	4 59.3	On Course 000°
G	1442	211 30/7	64 00.0	4 59.3	On Course 300°
H	1649	211 30/7	64 10.0	5 32.2	Recover SeaSoar

Table 4 Iceland Faroes Front SeaSoar Survey

Corner	Time	Day Date 1990	Lat. °N	Lon. °W	Comments
J	2233	212 31/7	62 57.2	7 40.5	deploy SeaSoar 025°
K	1324	213 1/8	64 43.6	5 45.8	on Course 316°
L	1615	213 1/8	64 50.1	6 18.2	on Course 207°
M	2021	214 2/8	62 42.5	8 59.0	on Course 303°
N	0100	215 3/8	63 00.5	10 00.1	on Course 030°
O	2126	215 3/8	65 14.5	6 59.7	on Course 289°
P	0053	216 4/8	65 23.5	8 00.0	on Course 208°
Q	1830	216 4/8	63 25.7	10 29.9	on Course 321°
R	2121	216 4/8	63 40.0	11 04.7	on Course 029°
S	1711	217 5/8	65 33.2	8 41.6	on Course 303°
T	2002	217 5/8	65 45.4	9 21.7	on Course 206°
U	1323	218 6/8	63 45.1	11 41.7	on Course 296°
V	1530	218 6/8	63 52.4	12 11.3	on Course 025°
W	0740	219 7/8	65 47.0	9 59.9	on Course 299°
X	1100	219 7/8	65 59.6	10 52.0	on Course 185°
X1	1505	219 7/8	65 25.1	11 00.8	on Course 207°
Y	2356	219 7/8	64 23.0	12 10.0	on Course 220°
Z	0600	220 8/8	63 48.0	13 14.8	recovery

Table 5 SeaSoar Fine Scale Survey 1

Corner	Time	Day Date 1990	Lat. °N	Lon. °W	Comments
A	1840	221 09/8	63 38.0	9 11.2	start of survey
B	2350	221 09/8	64 18.0	8 27.2	alter course
	0000	222 10/8	64 19.2	8 28.4	steady 288
C	0040	222 10/8	64 20.7	8 40.1	alter course
	0048	222 10/8	64 20.3	8 42.7	steady 205
D	0555	222 10/8	63 41.7	9 24.6	alter course
	0603	222 10/8	63 41.1	9 26.1	steady 295
E	0655	222 10/8	63 44.1	9 40.8	alter course
	0703	222 10/8	63 45.0	9 41.5	steady 025
F	1220	222 10/8	64 27.2	8 57.6	alter course
	1229	222 10/8	64 28.3	8 59.0	steady 295
G	1320	222 10/8	64 31.2	9 15.0	alter course
	1329	222 10/8	64 30.8	9 17.2	steady 205
H	1835	222 10/8	63 52.5	10 00.0	alter course
	1845	222 10/8	63 52.2	10 02.5	steady 295
I	1935	222 10/8	63 55.2	10 17.2	alter course
	1944	222 10/8	63 56.4	10 17.9	steady 025
J	2350	222 10/8	64 28.4	9 42.0	alter course
	2359	222 10/8	64 29.4	9 43.0	steady 295
K	0050	223 11/8	64 32.0	9 56.7	alter course
	0059	223 11/8	64 31.8	9 59.0	steady 205
L	0605	223 11/8	63 53.3	10 39.6	alter course
	0615	223 11/8	63 52.8	10 42.9	steady 295
M	0705	223 11/8	63 55.5	11 00.0	alter course
	0714	223 11/8	63 56.5	11 01.2	steady 025
N	1250	223 11/8	64 40.8	10 14.1	alter course
	1258	223 11/8	64 42.0	10 15.1	steady 305
O	1320	223 11/8	64 43.6	10 20.9	alter course
	1330	223 11/8	64 43.3	10 23.5	steady 205
P	1835	223 11/8	64 10.6	10 59.4	alter course
	1845	223 11/8	64 10.1	11 01.3	steady 305
Q	1936	223 11/8	64 13.7	11 13.9	alter course
	1944	223 11/8	64 14.7	11 13.8	steady 025
R	0050	224 12/8	64 54.9	10 28.0	alter course
	0059	224 12/8	64 56.0	10 28.8	steady 295
S	0150	224 12/8	64 58.5	10 43.3	alter course
	0159	224 12/8	64 58.0	10 45.5	steady 205
T	0705	224 12/8	64 18.6	11 27.1	alter course
	0714	224 12/8	64 18.2	11 29.2	steady 295
U	0805	224 12/8	64 20.8	11 44.5	alter course
	0814	224 12/8	64 21.8	11 45.6	steady 025
V	1320	224 12/8	64 59.5	11 03.8	end survey
	1408	224 12/8	65 05.6	10 55.8	speed to 2kts

Table 6 SeaSoar Fine Scale Survey 2

Corner	Time	Day Date 1990	Lat. °N	Lon. °W	Comments
A	0015	225 13/8	63 35.7	9 12.7	start of survey
	0026	225 13/8	63 36.0	9 10.3	steady 025
B	0525	225 13/8	64 10.6	8 34.4	alter course
	0535	225 13/8	64 11.7	8 35.7	steady 295
C	0625	225 13/8	64 15.2	8 47.8	alter course
	0635	225 13/8	64 14.5	8 51.2	steady 205
D	1140	225 13/8	63 34.8	9 34.4	alter course
	1149	225 13/8	63 34.5	9 36.7	steady 295
E	1240	225 13/8	63 37.8	9 51.0	alter course
	1250	225 13/8	63 39.0	9 52.3	steady 025
F	1755	225 13/8	64 15.3	9 12.2	alter course
	1805	225 13/8	64 16.4	9 13.3	steady 305
G	1855	225 13/8	64 20.4	9 25.3	alter course
	1904	225 13/8	64 20.1	9 27.4	steady 205
H	0010	226 14/8	63 41.9	10 08.2	alter course
	0020	226 14/8	63 41.6	10 10.9	steady 305
I	0110	226 14/8	63 45.2	10 23.8	alter course
	0118	226 14/8	63 46.2	10 24.2	steady 025
J	0625	226 14/8	64 23.6	9 41.6	alter course
	0635	226 14/8	64 24.6	9 41.7	steady 305
K	0725	226 14/8	64 27.9	9 53.0	alter course
	0734	226 14/8	64 28.1	9 55.7	steady 205
L	1240	226 14/8	63 48.3	10 36.9	alter course
	1250	226 14/8	63 48.7	10 39.4	steady 305
M	1340	226 14/8	63 52.3	10 52.0	alter course
	1348	226 14/8	63 53.3	10 52.3	steady 025
N	1855	226 14/8	64 33.1	10 09.8	alter course
	1904	226 14/8	64 33.7	10 09.5	steady 305
O	1955	226 14/8	64 38.3	10 23.0	alter course
	2004	226 14/8	64 37.9	10 25.1	steady 205
P	0110	227 15/8	64 01.7	11 01.7	alter course
	0120	227 15/8	64 01.3	11 03.8	steady 305
Q	0210	227 15/8	64 04.7	11 15.0	alter course
	0218	227 15/8	64 05.6	11 15.5	steady 025
R	0725	227 15/8	64 41.9	10 37.0	alter course
	0734	227 15/8	64 42.9	10 37.5	steady 305
S	0825	227 15/8	64 47.4	10 52.1	alter course
	0835	227 15/8	64 47.0	10 54.8	steady 205
T	1340	227 15/8	64 10.0	11 34.5	alter course
	1350	227 15/8	64 09.9	11 37.0	steady 305
U	1408	227 15/8	64 11.3	11 41.7	alter course
	1432	227 15/8	64 13.8	11 45.5	steady 025
V	2000	227 15/8	64 56.5	10 58.3	end survey
	2039	227 15/8	65 01.5	10 59.5	speed to 2kts

Table 7 SeaSoar Fine Scale Survey 3

Corner	Time	Day Date 1990	Lat. °N	Lon. °W	Comments
A	1930	228 16/8	64 28.5	9 21.1	start of survey
B	0040	229 17/8	63 49.1	10 02.3	alter course
	0049	229 17/8	63 48.7	10 04.5	steady 305
C	0140	229 17/8	63 52.2	10 18.4	alter course
	0148	229 17/8	63 53.0	10 18.9	steady 025
D	0655	229 17/8	64 28.2	9 37.9	alter course
	0703	229 17/8	64 28.9	9 39.4	steady 305
E	0655	229 17/8	64 28.2	9 37.9	alter course
	0755	229 17/8	64 32.5	9 55.8	steady 205
F	1310	229 17/8	63 53.2	10 36.6	alter course
	1320	229 17/8	63 52.8	10 38.8	steady 305
G	1410	229 17/8	63 56.1	10 50.5	alter course
	1418	229 17/8	63 57.0	10 51.0	steady 025
H	1925	229 17/8	64 30.6	10 13.5	alter course
	1933	229 17/8	64 31.3	10 13.6	steady 305
I	2025	229 17/8	64 34.4	10 24.2	alter course
	2034	229 17/8	64 34.1	10 26.6	steady 205
J	0140	230 18/8	63 57.3	11 07.4	alter course
	0150	230 18/8	63 57.0	11 10.2	steady 305
K	0240	230 18/8	64 00.8	11 22.6	alter course
	0248	230 18/8	64 01.8	11 23.0	steady 025
L	0755	230 18/8	64 37.5	10 45.0	alter course
	0803	230 18/8	64 38.3	10 45.4	steady 305
M	0856	230 18/8	64 42.5	10 59.4	alter course
	0905	230 18/8	64 42.3	11 01.7	steady 205
N	1415	230 18/8	64 07.7	11 45.6	end survey

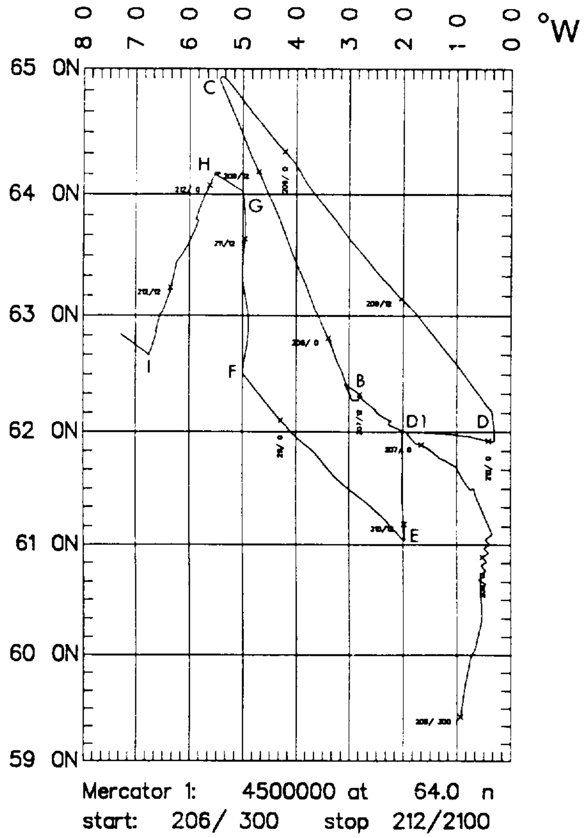


Figure 1 Track chart of the East of Faeroes Survey

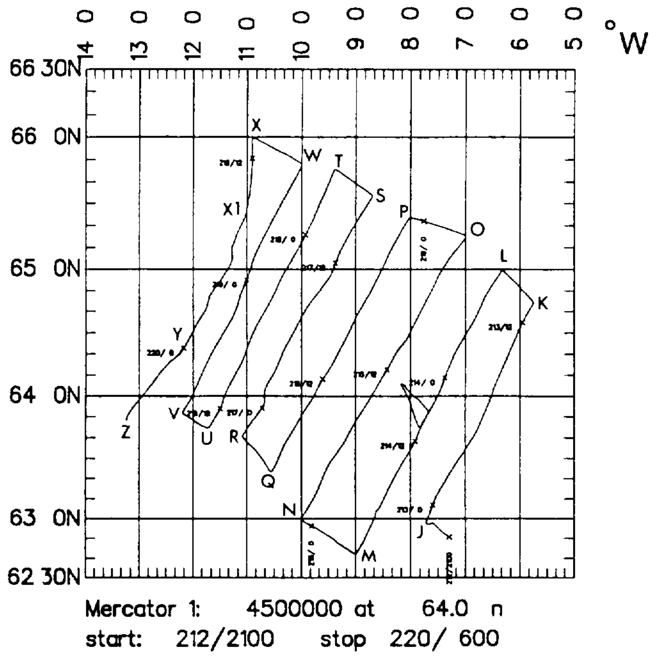


Figure 2 Track chart of the Wide Area Survey of the Iceland Faeroes front

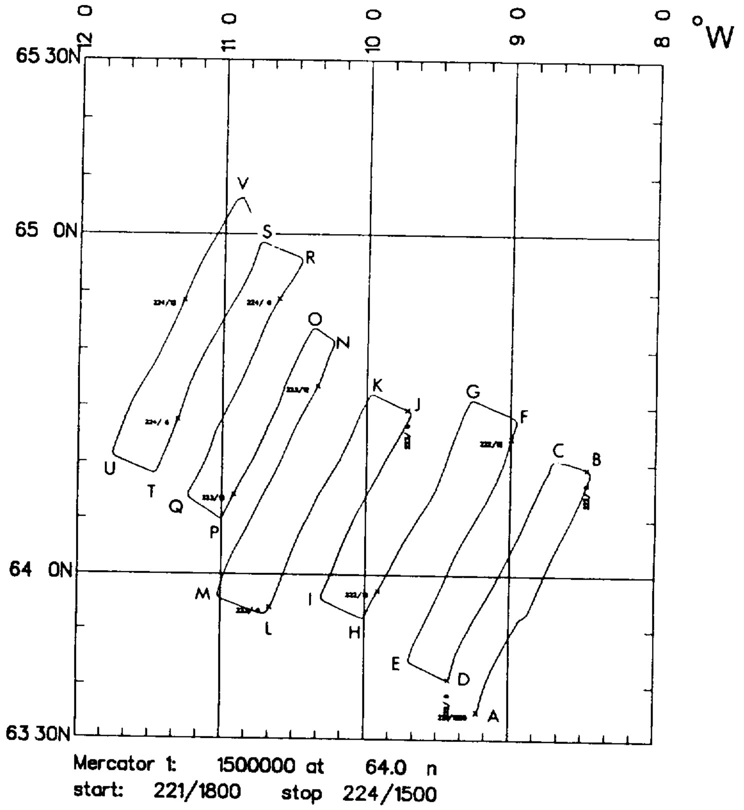


Figure 3 Track chart of the first fine scale survey of the Iceland Faeroes front

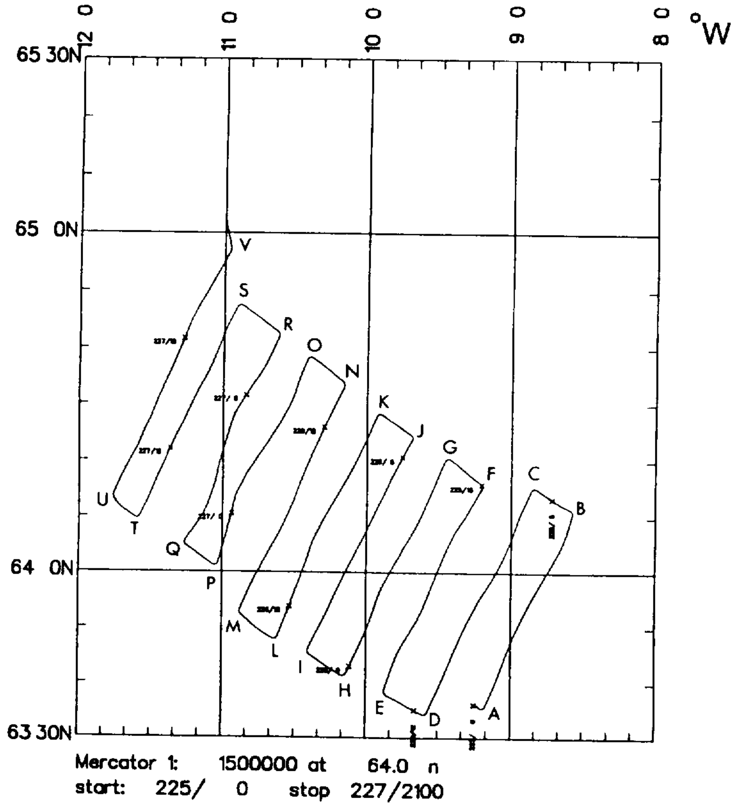


Figure 4 Track chart of the second fine scale survey of the Iceland Faeroes front

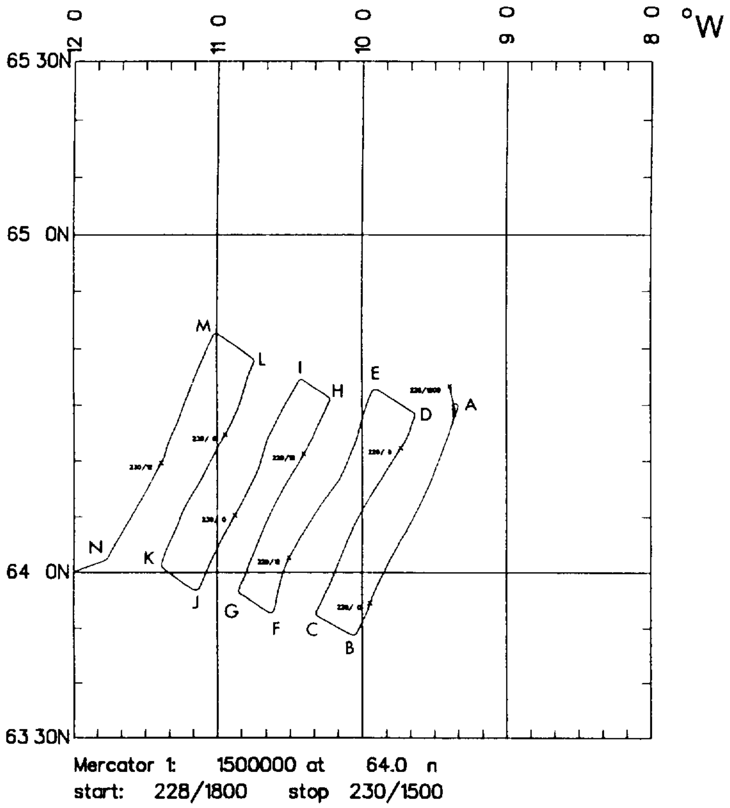


Figure 5 Track chart of the third fine scale survey of the Iceland Faeroes front

Figure 6 Mac Sat infra red image of the Iceland Faeroes front region

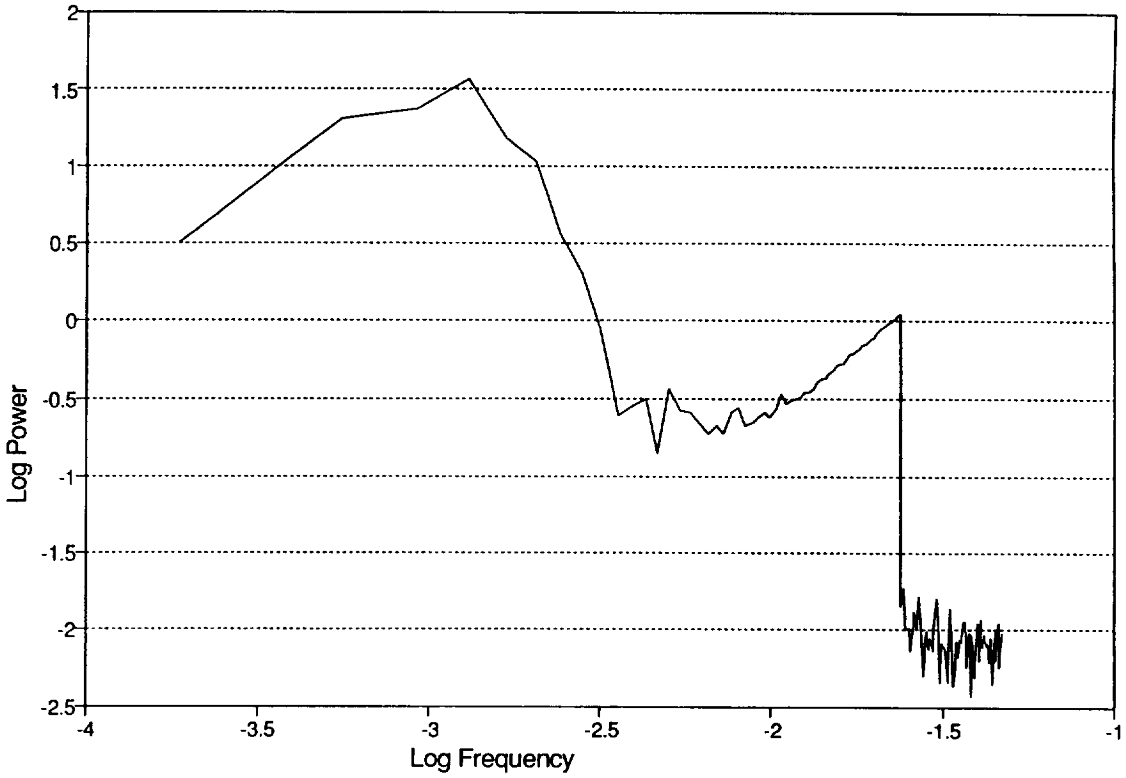


Figure 7 Spectrum of the velocity fluctuations derived from GPS position fixes whilst stationary in Aberdeen

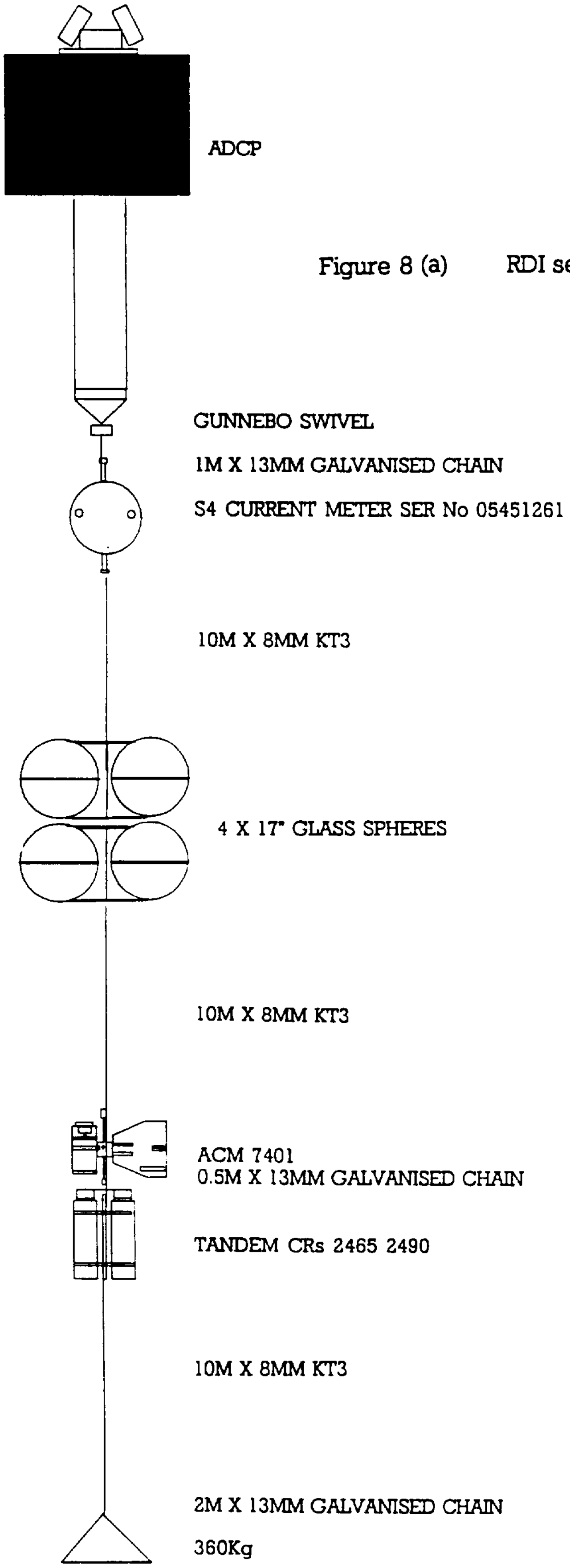


Figure 8 (a) RDI self contained ADCP mooring arrangement

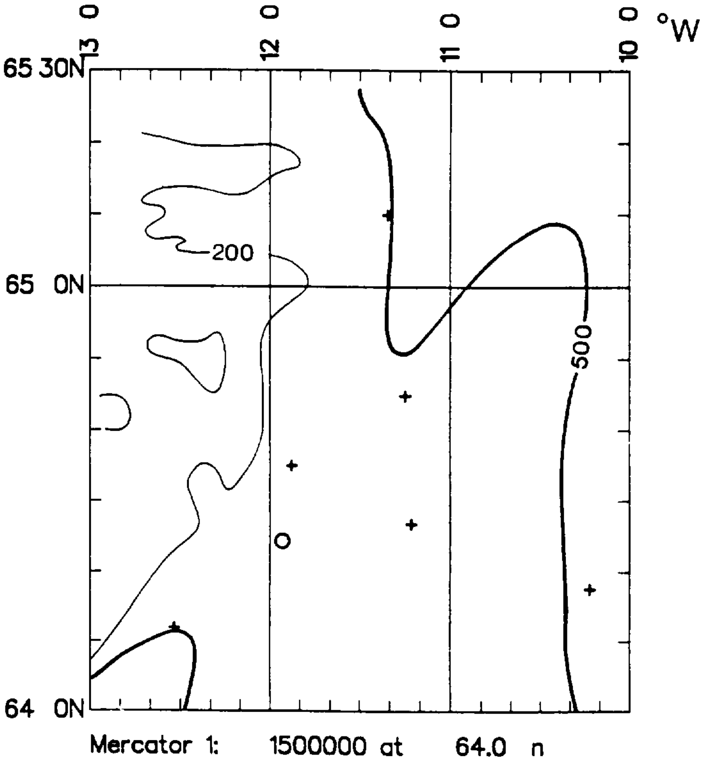


Figure 8 (b) Mooring array positions

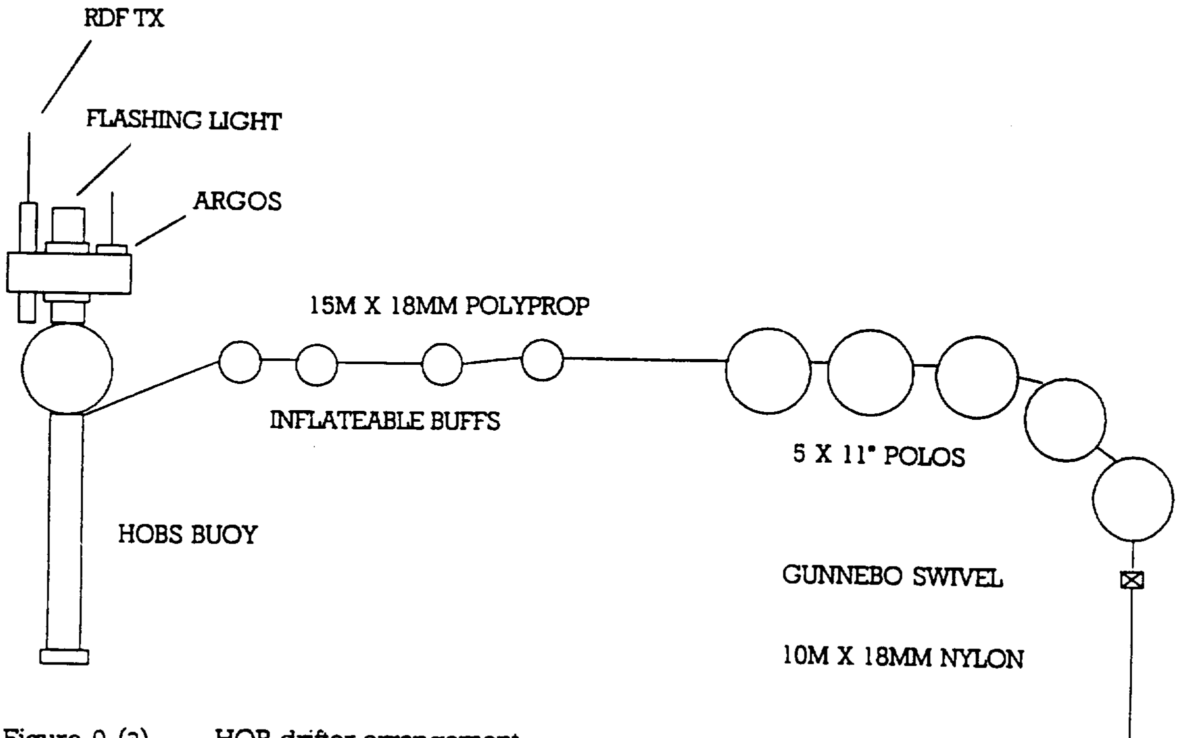


Figure 9 (a) HOB drifter arrangement

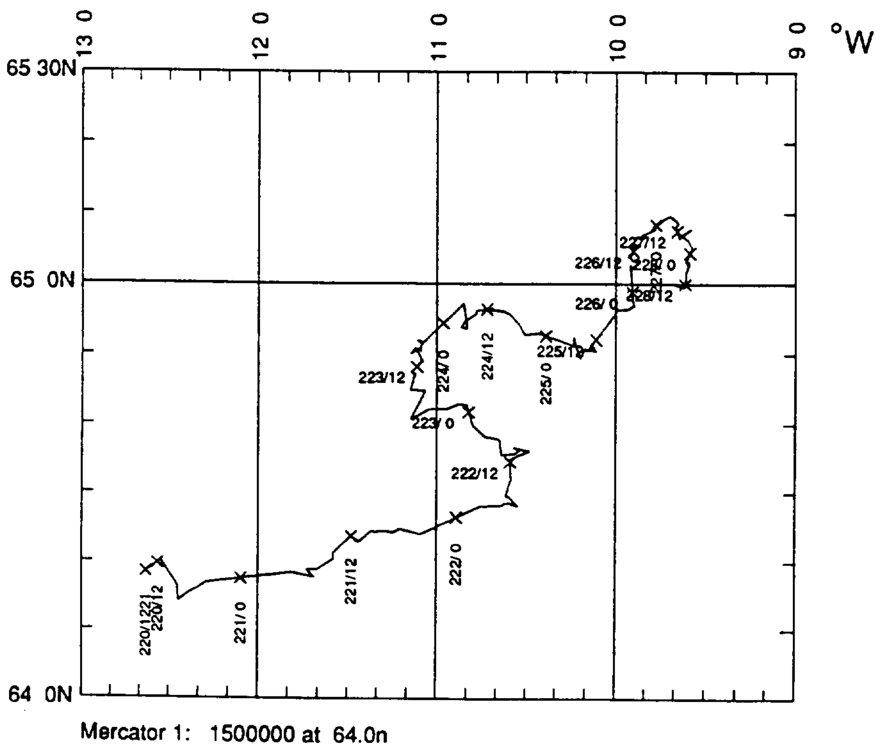
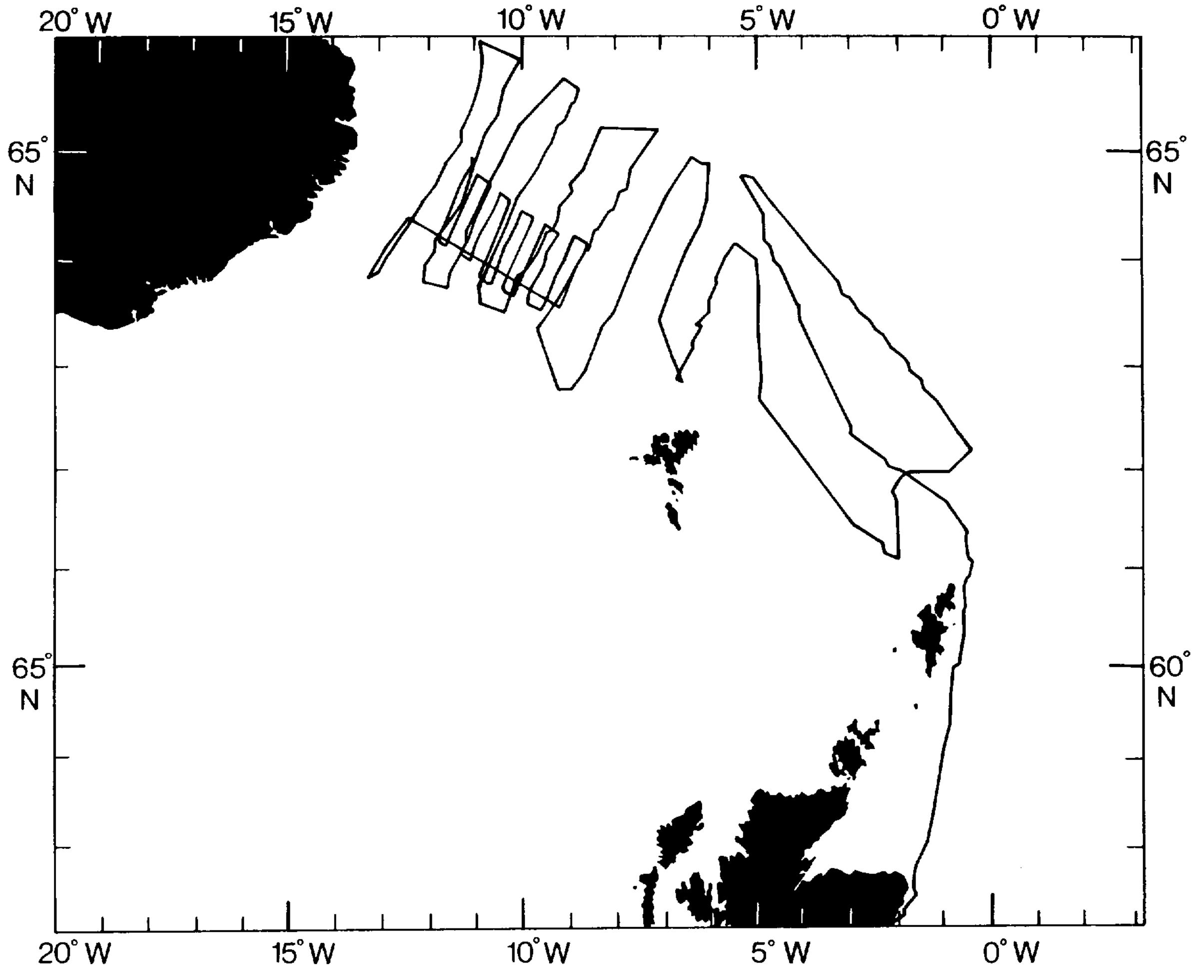


Figure 9 (b) HOB drifter track



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