SOUTHAMPTON OCEANOGRAPHY CENTRE

CRUISE REPORT No. 29

RRS *DISCOVERY* CRUISE 245
27 JAN - 20 FEB 2000

A hydrographic section from Scotland to Iceland

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2000

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ABSTRACT

The report describes the RRS *Discovery* Cruise 245, designed as a repeat of the hydrographic section that includes the Ellett line from Scotland to Rockall, and the SOC extension to Iceland.

The section consisted of stations for CTD, LADCP, chemistry (nutrients, oxygen) and biology (chlorophyll). Continuous measurements of high precision position and heading navigation data were made, also of surface currents (VM-ADCP), depth, surface temperature and salinity, surface nutrients and high-quality meteorological measurements. The cruise objectives also included recovering two deep ocean and two shelf current meter moorings, and collecting shallow sediment cores in the Muck Deep, a shelf depression. The cruise was severely hit by bad weather and as a consequence not all the scientific objectives were achieved.

KEYWORDS

ADCP, ATLN, CHLOROPHYLL, CRUISE 245 2000, CTD OBSERVATIONS, CURRENT METERS, *DISCOVERY*, ICELAND BASIN, IRISH SEA, LADCP, METEOROLOGICAL DATA, MULTICORE, MUCK DEEP, NORTH ATLANTIC, NUTRIENTS, OXYGEN, REPEAT HYDROGRAPHY, ROCKALL TROUGH, SALINITY, SHELF-EDGE CURRENT, SURFACE TEMPERATURE, VM-ADCP, WATER EXCHANGE, WINTER CONVECTION

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Allen	John	LADCP PI	GDD/SOC
Black	Kenny	Coring	CCMS-DML
Bonner	Rob	Salts PI & CTD driver	OTD/SOC
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Day	Colin	Shipboard Engineering (TLO, SEG)	RVS/SOC
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* Sailed Oban to SOC

The following sailed SOC to Oban only:

Elliot	John	Underway nutrients	Chelsea Instruments
Dodds	Simon	Shipboard Eng. (SEG), winch trials	RVS/SOC
Mason	Pete	Shipboard Eng. (SEG), winch trials	RVS/SOC

Key

SOC	Southampton Oceanography Centre
GDD	George Deacon Division
JRD	James Rennell Division
OTD	Ocean Technology Division
RVS	Research Vessel Services
SOES	School of Ocean and Earth Sciences
CCMS	Centre for Coastal Marine Sciences
POL	Proudman Oceanographic Laboratory
DML	Dunstaffnage Marine Laboratory

Ship's Personnel

Surname	First Name	Duty
Avery	Keith	Master
Chamberlain	Roger	Chief Officer
Graves	Malcolm	Second Officer
Owoso	Titus	Third Officer
McGill	Ian	Chief Engineer
Jethwa	"Jet"	Second Engineer
Phillips	Clive	Third Engineer
Crosbie	Jim	Third Engineer
Stewart	Dave	ETO
Pook	"Tiny"	CPO(D)
Lewis	Greg	PO(D)
Dollery	Perry	S1A
Edwards	Tim	S1A
Hebson	Harry	S1A
Perkins	Joe	S1A
Tuppenney	Nigel	S1A
Pringle	Keith	Motorman
Dane	Paul	Catering Manager
Lynch	Peter	Chef
Isby	Wilmot	Mess Steward
Mingay	Graham	Steward
Osborn	Jeff	Steward

Acknowledgements

The fact that we achieved some of our objectives despite the trying conditions is down to the professional skills and dedication of all members of the ship's company; both scientific and ships personnel. The PSO's thank all D245 participants for their contribution to the cruise. In particular special thanks are due to the catering staff for continuing to produce excellent food throughout the worst ship's motion, and for the Master and Bridge officers for their excellent ship handling skills which allowed us to work in sometimes very marginal conditions.

We thank the various people who helped us to prepare for the cruise, in particular Andy Louch for logistics, Nick Crisp and Brian King for the preparing the LADCP hardware and software, and Martin Beney and Steve Alderson for pre-cruise preparation of computing facilities which worked extremely well despite potential problems associated with Y2K, new workstations and a new network.

Thanks to Mags Yelland for promptly working up the high quality met and SBWR data from our storms.

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N.P. Holliday and C.R. Griffiths

1. The Cruise

1.1 Scientific Objectives

The principal objective of the cruise was to continue the long time series of hydrographic sections from Scotland to Rockall (the Ellett Line) and its recent extension to Iceland. The objectives of this time series are to identify the pathways for the warm Atlantic water into the Nordic Seas and to quantify variability on timescales of interannual and longer. Winter occupations of the section are rare and one objective of the cruise was to make direct observations of the deep winter mixed layer and heat loss to the atmosphere. Associated with the Ellett Line are current meter moorings which have been deployed sporadically throughout the duration of the time series. Moorings in the deepest parts of the section (Stations F and M) were deployed in May 1999 along with some shelf moorings, and a further objective of D245 was to recover them all. Dunstaffnage Marine Laboratory has been investigating the shallow sediments in an unusually deep shelf depression, the Muck Deep. This depression acts as a sediment trap for shelf water flowing north from the Irish Sea, and during D245 it was planned to take some shallow sediment cores and to photograph the seafloor with the bedhop camera. The cruise being scheduled for winter provided an excellent opportunity to study nutrient levels in surface water and throughout the water column in the open ocean, across the shelf edge current, and in shelf waters including the Irish Sea. Historically such observations are sparse and a further objective of the cruise was to quantify winter nutrient levels and to investigate across-slope exchange using nutrients as tracers.

Other objectives included winch trials on the 20T and 10T systems on the passage leg between SOC and Oban (for which two berths for RVS Engineers were provided); the testing of a new underway nutrient analyser between SOC and Oban, through co-operation between CCMS-DML, SOC and Chelsea Instruments (for which one berth was provided for a Chelsea Instruments technician); the collection of plankton samples on behalf of Jan Backhaus to test a theory of "phyto-convection"; and the carrying out of a cetaceans and seabirds survey by an expert from University College Cork.

1.2 Overview

Cruise D245 was battered by ferocious weather which led to it acquiring a reputation of suffering the worst conditions experienced in recent years. As a consequence of the strong winds and high seas not all the objectives outlined above were achieved. Most significantly the Ellett Line was not completed, the Rockall to Iceland section not even attempted, and one of the deep moorings (F) was not recovered. During the 25 day cruise, there were only 9 days during which conditions allowed us to deploy CTDs, corers or recover moorings. However, on a more positive note we did obtain 44 high quality CTD stations with associated nutrient, oxygen and Lowered ADCP profiles; recover 1 deep and 2 shallow moorings; and collect unprecedented underway temperature, salinity and nutrient data from open ocean, across the slope current and into the shelf seas around the British Isles. Needless to say the meteorological and wave height data are also unprecedented, with exceptionally high wind speeds and significant wave heights exceeding previous observations. Meteorological data and surface temperatures will provide flux measurements for comparison with the SOC climatology. Planned comparisons with synoptic satellite data will provide interesting information about how satellite data relate to in situ measurements.

In summary the cruise proceeded as follows: underway sampling of surface currents, meteorology, surface temperature, salinity , fluorescence, transmittance and nutrients began in the English Channel as soon as instruments were set up and running, and subsequently proceeded throughout the cruise (with the exception of surface nutrients) until the day we docked. Exchange of personnel occurred on 30 January off Dunstaffnage, via the DML boat the *Seol Mara*, allowing winch engineers to disembark and the remaining CCMS staff to embark. Ellett line CTDs commenced immediately, followed by the recovery of the Tiree Passage mooring (not the spar), the recovery of the Muck Deep mooring and the bottom ADCP mooring. Overnight CTDs were completed and multicoring attempted in the Muck Deep on Tuesday 1 February, only to be abandoned due to deteriorating weather conditions. CTDs commenced and proceeded with some weather interruptions until Friday 4 February when Mooring M was recovered. CTDs re-commenced until the following morning when the weather forced us to hove to. There followed 4 days of non-stop storms with winds persistently at around 60 knots with gusts reaching over 75 knots according to the Bridge anemometer. Highest recorded significant wave height was 18m with the largest waves being 28.8m according to the shipborne wave recorder. On Wednesday 9 February the winds reduced enough for us to head back to Barra with further bad weather forecast. During this steam XBTs were deployed with limited success. During the night we had to hove to again as the wind and swell increased. Eventually we made it back to the Sea of Hebrides on Thursday 10 February, where we sheltered until Sunday 13 February when conditions allowed us to steam back to Station G, deploying XBTs on the way. Station G was occupied in marginal conditions on Friday 11 February, and the last CTD station was Station C also in marginal conditions. With time running out and more bad weather approaching, hopes of completing the Ellett line and recovering Mooring F were abandoned, and we steamed back to Muck Deep, deploying XBTs and taking surface nutrients on the way. Wednesday 16 February was spent redoing the Muck Deep CTDs which showed remarkably changed T/S properties, getting successful multi-core samples, and recovering the spar buoy. CCMS staff disembarked off Dunstaffnage on Thursday 17 February, and the steam home commenced.

Cruise track, CTD station positions and XBT positions are shown in Figures 1.1-1.3. CTD station numbers are *Discovery* Station numbers starting at 13758 and reaching 13811. Days of the cruise are referred to by Jday (day of the year), starting at 27 (Jan 27) and ending at 51 (Feb 20).

1.3 Narrative

Tuesday 25 January 2000 (Day 025)

Mobilisation of scientific equipment began. Part of the DML contingent arrive midday with their lorry full of equipment. RVS winding on new CTD cable.

Wednesday 26 January 2000 (Day 26)

Mobilisation continues. RVS complete winding on of new CTD wire.

Thursday 27 January 2000 (Day 027)

Sailed from Southampton at 0900 into calm seas. Day spent continuing the setting up of equipment and computers. Non-toxic supply switched on in the afternoon, temporarily filling the ship with the delicate fragrance of unflushed pipes. Briefing held at 1500 in the plot to inform scientific party of the plans for the next few days, explain the watch system etc. Watches to start at 1200 on Sunday; though Roussier, Wright and Rabe to start Friday night to take nutrient and salinity samples through the Irish Sea. First muster and boat drill held at 16.15. Winch testing continuing. One salinometer had leaked during filling yesterday, causing water to flow over some electronics; today it is dry and the problem traced to screws which do not tighten sufficiently over rubber seals under the cell.

Friday 28 January (Day 028)

Weather somewhat worse today - winds up to F8. ADCP is logging data but the gyro information is apparently not being routed through the DAS PC causing problems for processing. RVS SIG and ISG unable to discover the setting required to route the Gyro through the PC. This means delaying the planned zigzag calibration run, but the weather is pretty bad anyway. Problems with the new winch instrumentation panel; it is not giving wireout readings. Peter Mason modifying system to receive pressure and altimeter data from the CTD as temporary fix. LADCP is talking, but we await results of test dip to see whether the processing path is Y2K compliant. Watches start for Ben and Adrian, collecting TSG salt and nutrient samples. 1300 PSOs gave briefing to officers and crew in the plot. The main request from RVS TLO was that they be given plenty of warning when CTD vs. mooring vs. coring would be done.

Saturday 29 January (Day 029)

Some Y2K problems discovered in pstar processing, but fixed in scripts. Winds remain strong all day so no stops for test CTD. Communication with home results in the ADCP unit being set-up to enable processing with the gyro which apparently had been logged all along. Winch trials continue, but no zigzag run for the ADCP because of the weather. Both salinometers apparently in operation, awaiting samples.

Sunday 30 January (Day 030)

0900 test CTD (13758) without bottles to test the winch performance, but also giving us a chance to check CTD and LADCP data logging and processing. Some problems; the winch and CTD level A were not logging. Rob Lloyd and Martin Bridger fixed the CTD Level A with a new cable, and Pete Mason showed them how to reset the winch Level A to restart logging. 1045 Off Oban. Seol Mara arrived bringing Ciaran Cronin, Kenny Black, Phil Taylor and Mike Smithson. 11.15 Seol Mara left taking Pete Mason, Simon Dodds, John Elliot. Stayed on station while the new people received their safety briefing. PES fish deployed at about 1200. Steamed slowly through the Sound of Mull with forecasts of Force 9 wind at Tiree. 1200 Watches started in full. No more underway nutrient samples required for David Hydes. 1600 First CTD station of the Ellett line (13759, 1G) at the Sound of Mull. All bottles fired, at 8 depths, to give the samplers practice, and to see if any of the bottles are leaking. Bridge Officers requested to make met observations at 2 additional times for Simon Josey (standard times are 0000, 0600, 1200, 1800, requested also 0900 and 1500). Extra observations be to made in the Rough Log. After CTD back onboard we steamed slowly back into the Firth of Lorne to shelter from a F9 storm. Spent the night sheltering.

Monday 31 January (Day 031)

Wind dropped completely, barometer rising, muted sunrise over Mull. Steamed to Tiree Passage where the mooring spar was unexpectedly sighted, though off position. Spar grappled and lost. Mooring grappled and hauled in on deck by 1300. Planned CTD at mooring site was abandoned for steam to Muck Deep to recover moorings there during daylight. Muck Deep mooring recovered by 1545; somewhat tangled wire, but all instruments recovered. Steamed to position of bottom ADCP; pinged and released, recovered by 1700 as dusk fell. CTD cast at the ADCP position, then 3 CTDs on the shelf part of the Ellett line, followed by a line of CTDs through the Muck deep during the night. During the night the LADCP suffered a shorting out of the benchtop communication box due to the power cable being accidentally inserted incorrectly.

Tuesday 1 February (Day 032)

Break off CTDs to try multicoring in the Muck Deep. After 3 attempts during the morning, the coring was abandoned. With winds up to 20 knots and increasing the Bridge was having difficulty keeping the ship on station, and with the sloping topography this meant the cores were not successful. The spar buoy nearby was not recovered because of the wind; the intention is to return here towards the end of the cruise. The LADCP was removed from the CTD frame and J.Smithers tested the internal electronics. The replacement comms box was used and the spare LADCP is being used from 13770. Ellett line CTDs begun in the afternoon, but high winds forced an end to CTDs after midnight.

Wednesday 2 February (Day 033)

Sheltered behind Barra during the night all day awaiting 40 knot winds to die down. 21.30 in evening winds had dropped sufficiently to begin CTDs again during heavy swell. During the day TSG was stopped logging for a short time while Phil Taylor and Terry Edwards checked the temperature calibrations.

Thursday 3 February (Day 034)

Continued CTDs along Ellett line in heavy swell but manageable winds. TSG showed strong temperature and salinity front from shelf waters into slope current. CTDs through the day and into the night.

Friday 4 February (Day 035)

CTDs through dark hours, followed by recovery of Mooring M which started at 8.30am. PES fish brought on deck at 11.20 to avoid tangling with mooring wire; redeployed at 1400. Mooring fully recovered by 1400, set course for station L. CTD stations through the evening

Saturday 5 February (Day 036)

Hove to for a short period in the early hours; big roll at 0230 caused damage throughout the ship - the microwave in the galley, a Centris Mac monitor, and a table outside the engine room unexpectedly moved and blocked a doorway. CTDs resumed after 4am, slow progress because of the need to dogleg between stations to avoid being beam on. At 13794 the winch recorded a transient tension of 3T at 300m during a roll - very marginal conditions, CTDs suspended and we remained hove to for the rest of the day and night.

Sunday 6 February (Day 037)

Hove to at Station G all morning with winds of around 50 knots and further increasing wind forecast. During the afternoon the centre of the storm hit us with a sudden decrease in air temperature, sharp rise in pressure and apparent windspeeds of up to 75 knots (hurricane force). Amazing scenes of wind streaked waves, but of course no work.

Monday 7 February (Day 038)

Remained hove to through the night, with the twin of yesterdays storm bearing down on us. PES fish brought in on deck at 1300 as storm approaches. Planned emergency drill at 16.15 - cancelled because of weather.

Tuesday 8 February (Day 039)

Another day, another storm. Wave height reached a max of 29m, with significant wave height of 18m.

Wednesday 9 February (Day 040)

Winds dropped to 30 knots westerly, so we turned and headed east back to Barra for shelter. Started XBT section at 14.30, with one every hour subsequently. Stopped XBTs at 17.35 as waves being shipped over stern. Hove to during very bumpy seas and surprise, surprise, winds of 60-75 knots.

Thursday 10 February (Day 041)

During the night the starboard lifeboat came loose and had to be secured by crew, with extent of damage being unclear. Daylight brought reduced winds and slightly flatter seas so we were able to proceed towards Barra Head, deploying XBTs from outside the Bosuns locker as we went. Reached Barra Head by early evening and ceased XBTs. Hove to in Sea of Hebrides.

Friday 11 February (Day 042)

After a marvellously calm night despite high winds, the lifeboat was examined and repaired; a real relief since an inoperable lifeboat would have meant the end of open ocean work. Arrangements made for Colin Day to leave the ship because of a family bereavement; he was transported to Craignure, Mull in the inflatable boat. From there he will get a ferry to Oban and a flight home. Winds still very strong, even in the shelter of Sound of Mull. Quiz night in the Officers and Scientists Bar.

Saturday 12 February (Day 043)

The day and night spent pottering around in Firth of Lorne near Lismore, admiring the scenery, enjoying waves of less than 1m high for a change, and awaiting a drop in the windspeed. Fire and Flood Drill at 10.30am. Surfmet temporarily stopped at 1600 in an attempt to get some sensible data from the starboard PAR sensor by re-booting the system. The sensor has not been producing good data since early in the cruise, but the RVS SIG techs have obviously not been able to take a trip up the foremast so far. No success with the reboot. Optimism abounds about the possibilities of work during rest of the cruise, with news that the weather charts show a developing high pressure system.

Sunday 13 February (Day 044)

Weather showed signs of improvement and so at 0400 we started back up the Sound of Mull with the aim to head back out to Station G. PES fish deployed at 0915 in bright sunshine. XBTs deployed once an hour. Winds up to 55 knots during the night, despite the good forecast.

Monday 14 February (Day 045)

Station G reached at 0530, winds quite high and CTD recovered in marginal conditions. Steamed slowly towards Station F with strong winds and increasing swell. Remained hove to until about 1430 when we steamed to downwind of the mooring site to assess the possibility of recovery. Conditions still marginal, so course set for Station A, hoping the wind would drop to allow CTDs to start again. With winds increasing, we decided it would be more prudent to wait around Station C and D (shallow) in case of the possibility of doing a CTD, but reducing the steaming time back to F in the conditions improved.

Tuesday 15 February (Day 046)

At 0630 Station C (13796) was occupied, but generated tensions of 3T on the winch during heavy swell rolls. Conditions were of large swells and strong winds, so CTDs and mooring recovery was impossible. A forecast of Force 9 was received, and based on experience of winds higher than forecast, we made the decision to head back towards Barra Head. With the remaining 2 days of work time we hoped to return to Muck Deep and attempt coring and bed-hop camera work. The Ellett line CTDs were left incomplete and Mooring F was not recovered; a real disappointment, but we were beaten by the weather in the end.

Wednesday 16 February (Day 047)

CTD station MD3 (13797) started at 0430, quickly followed by another station at MD4 to collect some water for taking back to DML, but no sal/oxy/nuts samples. The water mass properties were so different from the last occupation that it was decided to re-occupy all the

Muck Deep CTDs. After a glorious pink sunrise, multicoring starting in sunshine and calm seas, with snow-covered islands on the horizon. Three successful cores taken at MD7, followed by the recovery of the spar buoy. Engineers had discovered a engine problem that meant a 3 hour delay while the main engines were switched off, during which time we steamed slowly to the next station with the bow thrusters. Team photo on the foredeck at 15.30, followed by coring at MD6. Muck Deep CTDs through the evening.

Thursday 17 February (Day 048)

Last CTD completed at 0130. Watches stood down at 0400 except for the oxygen chemists who will continue to take underway nutrient samples through to the end of the cruise. Mike Smithson and Kenny Black departed on Seol Mara off Dunstaffnage at 0830. The long steam home started after than. The journey will include a circumnavigation of the Isle of Man to collect underway surface nutrient data.

Friday 18 February (Day 049)

Underway sampling of nutrients and salinities continues through the Irish Sea and into the English Channel. Packing of scientific equipment began, some data sets finalised and archiving of data begun.

Saturday 19 February (Day 050)

PES fish recovered in the midst of a large school of leaping and singing common dolphins. Packing and finalising data and archiving data continues. Underway sampling of nutrients ceased at 23.30.

Sunday 20 February (Day 051)

Underway data logging switched off at 0800 and final processing completed. Docked at Empress Dock, Southampton just before midday, and scientific party dispersed not long after that.

Monday 21 February (Day 052)

Demobilisation completed by the end of the day. DML party left with their lorry-load of gear early afternoon.

N.P. Holliday and C.R. Griffiths

2. CTD Measurements

2.1 Equipment

The CTD equipment used during cruise D245 was as follows:,

CTD DEEP03	
FSI Rosette Pylon 24 Bottle	SN 02
Chelsea Instruments Aquatracka	SN 161/2642/003
Chelsea Instruments Fluorometer	SN 88/2360/108
Simrad 200 metre Altimeter (Old Pressure Case)	
RDI LADCP, 20 degree Beam	
RDI LADCP, 30 degree Beam	
SUV6 Valeport Nitrate Sensor	
SIS Reversing Thermometers	T995, 1545.
SIS Reversing Pressure Meters	P6394H,6534

A test cast was occupied 30th January to a depth of approximately 200 metres without water bottles. All of the instruments apart from the SUV6 Nitrate sensor worked performed satisfactorily. This power supply for this instrument is taken from the same source on the CTD as the Altimeter. Due to a voltage drop under load across the filter components there was insufficient to start the SUV6 although the Altimeter continued to perform.

A total of 44 stations were occupied during this cruise with a depth range of 50-2200 metres. All of the CTD equipment performed well apart from failure of a self contained LADCP. This was removed and replaced with the spare 30 degree beam unit, and later repaired. One Niskin bottle was removed and repaired when it's securing bracket came loose. Work ceased for 9 days after station 13794 due to repeated heavy weather. The Altimeter mounting bracket sheared off during this weather. The Altimeter was replaced with a 10 kHz pinger enabling further casts to be made with the SUV6 working. A new oxygen sensor was also fitted as the processed data indicated that the existing sensor was faulty.

The CTD pressure and Altimeter data were collected and displayed as part of the winch readout (fitted by P.Mason). This addition proved useful to the winch drivers with the added benefit of increased security for the CTD package during near bottom approach. Whilst this was only a prototype operation it should be developed fully for future CTD operations.

J. Smithers

2.2 Data capture and processing

A total of 44 CTD stations were carried out, and these are detailed in Appendix 1.1. These included a test station, 13758, from which no discrete water samples were taken, nor was winch data available for this cast. Station depths ranged from 33 to 2233 metres, with the majority being in shallow water of less than 350 metres during the shelf-edge work.

Raw CTD data were logged in three distinct ways. Raw data files were stored on the hard disk of the CTD console PC. The RVS Level A also logged these data and passed it on to the RVS Level B system. And the SOC DAPS (Data Acquisition and Processing Software) system, running on a SUN Ultra-Sparc workstation, recorded the data directly from the CTD console. The DAPS data were used for further processing. DAPS data consist of CTD profile data from the various instruments stored in one ASCII file for each cast, plus bottle firing data stored in a second ASCII file for each cast. DAPS checks the data for pressure jumps and averages the 25Hz data to 1 second time intervals. The temperature gradient throughout the cast is also calculated. The ASCII files have the time included as the first column, given as decimal Julian day to 1 millisecond resolution.

Firing data were found to be accurately recorded (not always the case with the level A data in the past), with only one exception when the "fire 3 bottles" option was selected, and only 2 bottles were recorded as having been fired, which was easily corrected during processing (editing of the fir13nnn.tim file).

The CTD instrument used was DEEP03, and no problems were encountered with this instrument. DEEP03's calibration history has been monitored since purchase in 1993, and the most recent calibrations by Ocean Scientific International (OSI) in December 1999 are consistent with the trends reported in the cruise report for D242 (Cunningham, 2000), which also used DEEP03. That is to say, the pressure calibrations have been stable, varying only by 1-2 dbar at full scale, and the magnitude of the temperature offset has increased slightly, consistent with the trend towards measuring warmer as the instrument ages. Description of the conversion and calibrations applied to each instrument which is logged via the CTD datastream are given below.

Temperature

The ITS-90 temperature scale was used throughout. The readings from the temperature sensor were scaled according to

$T_{raw} = 0.0005\ T_{raw}$

then calibrated using the coefficients provided by OSI (December 1999)

$$T = -2.142635 + 0.991186\, T_{raw}$$

There is a mismatch in the timing of the temperature measurement and the conductivity sensor measurement, which is corrected for by using a “deltat” correction to “speed up” the temperature measurement according to

$$T = T + \tau\, \partial T/\partial t$$

where the rate of change of temperature is determined over 1 second intervals and the time constant used during D245 was

$\tau = 0.25$.

Pressure

The pressure sensor measurements were first scaled according to

$$P_{raw} = 0.1\, P_{raw}$$

then calibrated using the coefficients provided by OSI (December 1999)

$$P = -38.1 + 1.07482\, P_{raw}$$

Laboratory calibrations have shown that the pressure sensor has little temperature dependence or pressure hysteresis so no further corrections were made.

Salinity

The conductivity measurements were first scaled according to

$$C_{raw} = 0.001\, C_{raw}$$

then calibrated initially using the coefficients provided by OSI (December 1999)

$$C = -1.721e\text{-}3 + 0.946\, C_{raw}$$

which was later changed, after comparisons were made between bottle samples and CTD measurements for stations 13759 through 13790, to

$$C = 1.4372576e\text{-}2 + 0.945609882\, C_{raw}$$

Data from all stations were reprocessed using this calibration. Conductivity was also corrected for distortion of the cell due to changes in temperature and pressure (Crease, et al, 1988) according to

$$C = C\,(1 - 6.5\text{e-}6(T - 15) + 1.5\text{e-}8\,P).$$

Finally, conductivity, C, was converted to salinity using the PEXEC programme *peos83*.

The improved conductivity calibration given above was determined using bottle samples which were analysed for salinity. These samples were taken from the Niskin bottles mounted on the CTD frame, which were "fired" to collect water at depths of 5, 10, 20, 40, 60, 80, 100, 150, 200, 250, 300 m, 20 m off bottom and bottom, on shelf casts and 5, 10, 25, 50, 100, 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800, 2000, 2200 m, 100 m off bottom, 50 m off bottom and bottom, on deep casts. Samples were taken from each bottle fired, except for the 5 m ones, and analysed by salinometer to determine their salinity. Duplicate samples were taken from the deepest bottle. The bottle conductivities were then determined from the bottle salinity and CTD pressure and temperature at the time of firing, and the difference (residual) between bottle and CTD upcast conductivity was calculated. These residuals were then plotted against pressure, station number and bottle conductivity for to examine their behaviour. It was decided to exclude bottles from shallower than 250 m as their residuals were much more variable than deeper samples, and a linear regression was performed between the bottle conductivity and the upcast CTD conductivity. The coefficients of this fit were used to modify the conductivity calibration coefficients as given above, and the residuals were recalculated. After this, the salinity residuals showed no pressure dependence or station dependence (Figure 2.1). It was decided that it was unnecessary to apply a further offset correction to the salinity because the mean was sufficiently close to zero. The mean of the residuals was 0.0000 and the standard deviation 0.0015 for n=109 (of 109 samples deeper than 250m). The absence of deep water stations means that no better calibration could be achieved.

It is worth noting that the instrument did not exhibit any "spikiness" in conductivity which was experienced with the DEEP03 instrument during D242. As was suggested after that cruise, part of the horizontal metal bracket mounted on the frame close to the CTD had been cut away prior to D245, and the longer models of LADCP were used. This appears to have cured the problem.

Fluorimeter, Transmissometer and Altimeter

Fluorimeter measurements were converted to voltages using the calibration of the voltage digitiser in the CTD as provided by OTD:

$$\text{fvolts} = -5.0326 + 1.5359\text{e-}4\ \text{fvolts}_{raw} + 3.383\text{e-}14\ (\text{fvolts}_{raw})^2$$

Samples were collected from the Niskin bottles for chlorophyll analysis after the cruise, and these will be used to calibrate the fluorimeter.

Transmissometer measurements were also converted to voltages using the calibration provided by OTD:

$$chvolt = -5.027 + 1.534e\text{-}4\ chvolt_{raw} + -3.704e\text{-}13\ (chvolt_{raw})^2$$

This was then calibrated to give transmittance by using the clear air and blank voltages which were measured only once during the cruise (before station 13795). Ideally, these should be monitored throughout a cruise, but the measured values were in close agreement with the manufacturer's figures and previous cruise values, so these were applied to all stations:

$$chtran = -0.030 + 4.80\ chvolt$$

The altimeter was calibrated using the equation provided by OTD:

$$alt = -249.7 + 7.62e\text{-}3\ alt_{raw} + -1.04e\text{-}10\ (alt_{raw})^2$$

The altimeter was disconnected after station 13794 and a pinger used instead to judge distance from the sea floor for the remaining stations. This was because the altimeter shared power supply with the nitrate sensor, and was causing the latter to fail.

Nitrate Sensor

The nitrate failed to give any meaningful data until the altimeter was disconnected from the shared power supply after cast 13794. Three channels were measured, namely nit220, nit235 and nit250, and these were converted to voltages according to the coefficients provided by OTD:

$$nit_{raw} = 0.0001\ nit_{raw}$$

$$nit\ = -4.49986 + 1.37329\ nit_{raw} + -3.452e\text{-}15\ (nit_{raw})^2$$

No further calibrations were applied to these data

Oxygen

The oxygen sensor on the CTD frame has to be calibrated against the sample bottle oxygen measurements. The output from the sensor is oxygen current (oxyc), which has a complex relationship to temperature, pressure and oxygen saturation. The process for calibrating the oxygen sensor is to determine 5 parameters which best fit the CTD oxygen data to the sample bottle data using the model:

$$oxygen = \rho.\ oxysat(S,T).\ (oxyc - \chi).\ \exp\{-\alpha.\ [f.\ T_{CTD} + (1\text{-}f).\ T_{lag}] + \beta \times P\}$$

where ρ is the slope, oxysat(S,T) is the oxygen saturation value after Weiss (1970), oxyc is oxygen current, χ is the oxygen current bias, α is the temperature correction, f is the weighting of T_{CTD}, the CTD temperature and a lagged temperature T_{lag} and β is the pressure correction.

As oxygen temperature is not measured directly, a lagged temperature is calculated instead from the CTD temperature values. The values of oxygen current, temperature, lagged temperature and salinity from the downcast are merged with the bottle oxygen values on pressure. The program *oxyca3* takes initial estimates of the five parameters and alters them iteratively until a best fit to the sample data is obtained. The parameters for this best fit are returned by the program and can be applied to the 1hz CTD files using program *oxygn3*. The 2db file can then be recalculated and merged with the original sample files to give the final residuals of the calibrated oxygen-bottle values.

First attempts to calibrate the oxygen sensor were made after station 13794, when several deeper stations had been occupied, showing oxygen minimum at depths of around 1000 m. The oxygen sensor had showed quite variable response over all stations, sometimes having smooth, sometimes spiky behaviour. There was no indication of the oxygen minimum. After some attempts to calibrate the sensor, it was decided to set these to absent values in all but the raw CTD files, and to try a new oxygen sensor on subsequent casts. In the event, only 9 more stations were occupied, and only one of these was deeper than 350 metres. Problems were encountered with *oxyca3* and *oxygn3*, and it was not possible to find a good fit to the sensor data.

4. References

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A. Jolly

3 Lowered ADCP Measurements

3.1 Equipment.

Both of the SOC's RDI 153KHz LADCP instruments were loaded on RRS *Discovery* at the SOC prior to the departure of cruise 245. Similar redundancy was built into the supporting laboratory equipment; also loaded were two PCs, two battery chargers, etc. The two LADCP instruments are different, the older one having a 20 degree inclination of the transducer faces and the newer one, a 30 degree inclination. It had been expected that the newer LADCP would be a better instrument for our open ocean deep profiling applications, however it had proved unreliable on preceding cruises, and had been returned to RDI several times. Therefore the older, 20 degree beam inclination instrument was fitted to the CTD frame. Two lead acid battery packs were taken on the cruise, these contained four 12 volt batteries each, and further spare batteries were also packed in an ally box and stowed in the deck lab.

During the first 24 hours steaming round the S.W. coast of the UK, the newest of the two battery packs was fitted to the CTD frame and connected to the LADCP instrument. This battery pack had been internally wired such as to allow interrogation for individual battery voltage as well as overall in series voltage. The deck communications lead was fed through the wet lab to the aft-most thwart-ships bench in the deck lab, where a dedicated PC and the battery charging equipment had been set up. The battery charging lead was shorter and had to be extended in the deck lab to reach the bench (an extension cable was provided). Battery charging was interfaced by a control box, fabricated by Nick Crisp, which enabled the monitoring of individual battery voltage and its logging through software, also written by Nick, on the dedicated PC.

Following recovery of the CTD on station number 13762, Jday 031, some difficulty was encountered trying to reconnect the LADCP battery charging lead to the battery pack. During the struggle to make the connection, the wrong pins had made contact and communication to the LADCP was lost. The most obvious sign of damage was the loss of ~1/8th inch off the end of one of the connector pins; this caused no problem in itself and the lead remained in use for the rest of the cruise. Several stations then followed in quick succession and, as we were unable to communicate with the LADCP, no current observations were made on these stations. During the morning of the 1st February, Jday 032, the LADCP was removed from the CTD frame and John Smithers began to dismantle the instrument. The 30 degree beam inclination LADCP was fitted to the CTD frame, and following a successful deployment during station 13772, this instrument remained in use for the rest of the cruise.

The misconnection of the charging lead had burnt out the battery charging interface box and so this was replaced with a spare. The built in redundancy in the LADCP equipment loaded at SOC was beginning to pay off. Within the damaged LADCP, two comms fuses had blown and were replaced with two unused fuses, 1 and 2. However, this did not restore communication with the instrument. The CPU board, Ass. no. 721-2010-00 sn. 794, was replaced with the old board, Ass. no. 721-2010-02 sn, 351, found in the LADCP spares case. At the same time, firmware chips 5.52L and R were swapped from board sn. 794 to sn. 351 and the old 4.22L and R were fitted for storage to the damaged board sn. 794. Following this, the LADCP instrument communicated as normal, however it was not used again during the cruise. To ensure that an instrument could not be damaged again even if problems were experienced making the charging lead connection, the launch/recovery procedure was changed. Firstly, prior to launch and before disconnecting either the communication or charging lead from the CTD frame, the battery charge lead was removed from the battery charging interface box. Secondly, on recovery the leads were connected in a strict order; the battery lead was connected first at the battery pack, then the communications lead was attached to the CTD frame connector, finally the battery charge lead was connected to the battery charging interface box.

We believe that the 30 degree beam inclination LADCP, used predominantly during this cruise, has not been swung in the CTD frame to establish compass offset. However we have carefully marked the orientation of the instrument in the CTD frame so that this can be done at some later date.

Once a week, the battery pack vent plug was released, removed, had the 0-ring re greased (silicon grease) and was replaced. To access the vent plug, two of the nylon screws and spacers, holding the protective plastic cage ring to the connector end of the battery pack case, had to be removed and replaced after the battery pack had been vented. On only the first occasion could any venting of accumulated gases be heard. But as all four batteries remained within 0.35 V of each other we did not expect a large build up of charging gases, which is though to be a significant risk when a battery fails and the 50 V charge is then only divided between three batteries.

The LADCP instruments were set up prior to deployment with the command file, Bbsc.cmd shown in Appendix 3.1. For the shallow 'Muck Deep' stations, we set the LADCP to record forty, four metre thick bins rather than the more usual ten, sixteen metre thick bins. In addition the blank before transmit was set to eight metres (rather than sixteen) and the ambiguity velocity to 150 cms^{-1} (rather than 400 cms^{-1}) for these stations.

3.2 Data Collection and Calibration.

The LADCP data processing route is unnecessarily convoluted and inconsistent. It is based on software written in three different programming languages by RDI and a team at the University of Hawaii. Bottom tracking data follow a different path to UNIX operating system based processing than water track profiles despite both data sets being incorporated in the same raw binary file. Some of the software was found not to be Y2K compliant despite having been written during the 1990s. If, as an organisation, we are to consider the LADCP as a valuable research tool, as I hope this and previous data sets suggest we should, then the whole data processing route should be re-written in a single programming language – I suggest FORTRAN based PSTAR.

Like other Doppler principal current profilers, the LADCP determines the velocity of sound scatterers in the water column relative to the instrument by resolving the frequency shift between coded pulses transmitted and received by four transducers. The raw data are scaled to velocity units initially by assuming 1500 ms^{-1} sound velocity and later by deriving a sound velocity profile from the CTD cast. The calculations that derive the direction of the current incorporate the relative geometry of the set of four transducers, the magnetic and gravitational orientation of the instrument from an internal compass and pitch and roll sensors, and the geographically dependent declination of the magnetic pole from true north. The instrument depth is estimated initially by integrating the measured vertical velocity, later this is refined by matching with the differential w.r.t time of the CTD pressure measurement.

The horizontal displacement of the package during the cast is removed by differentiating between adjacent depth bins the velocity profile of each ping ensemble to create profiles of vertical shear. Each shear profile is then reduced to a mean vertical shear by averaging over the depth of the profile. Over the total cast these mean vertical shears are integrated to produce up and down current velocity profiles with a zero mean. This whole process also removes the barotropic flow. This is obtained from an accurate knowledge of the total displacement of the ship, derived for example from differential GPS positions, in a rather elegant fashion. The barotropic flow is given by

$\mathbf{U}_{barotropic} = \frac{1}{T}\int \mathbf{U}_{measured}(t)\partial t - \frac{1}{T}\int \mathbf{U}_{baroclinic}\left[z(t)\right]\partial t + \frac{1}{T}\int \mathbf{U}_{ship}\partial t + \frac{1}{T}\int \mathbf{U}_{package}\partial t$, where T is the duration of the cast, $\mathbf{U}_{baroclinic}\left[z(t)\right]$ are the baroclinic current velocity profiles derived as discussed above, $\int \mathbf{U}_{ship}\partial t$ is the distance between the ship's positions at the beginning and end of the cast and $\mathbf{U}_{package}$ is the horizontal velocity of the LADCP instrument relative to the ship where, conveniently, $\int \mathbf{U}_{package} \partial t \equiv 0$. In the next two pages we will illustrate the processing stages presently used to carry out the analysis from an operators point of view.

The deployment and data recovery uses a PC as the user interface and the stages are best indicated on the log sheet (Appendix 3.2). Following data recovery the binary data files were sent to the unix directory /data1/ladcp/raw/di0001/ladcp by binary FTP transfer. Bottom track data were extracted from the raw binary files using BBLIST on the PC and transferred to /data1/ladcp/raw/di0001/ladcp as ASCII files, despite the presence of these data in the raw binary files already transferred, this seems rather inconsistent and should be addressed in future.

The processing of LADCP raw data was achieved using software developed by a group at the University of Hawaii. The software uses a combination of PERL and MATLAB scripts to process the data as outlined in the SOC LADCP Data Processing Manual. The main stages are given below:

1). Load the LADCP data into a CODAS (University of Hawaii format) database, including nominal cast position, with PERL script 'loadbb.prl' that runs a binary executable called 'loadbb'. This executable was not Y2K compliant and had to be replaced by email file transfer early in the cruise.

2). The PERL script 'domerge.prl' calculated mean shear profiles and applied corrections and editing options which were generally kept constant throughout the cruise. This script ran a binary executable called 'mergeb', of which there were two, one for the 20 degree beam inclination instrument and the other for the 30 degree instrument; the program has to know when to cut off the profile for acoustic side lobe interactions with the sea bed.

3). The MATLAB script 'do_abs.m' calculated current velocities and produced a standard set of profiles. In this step the uncorrected data (down, up and mean profiles) were viewed and plotted as unreferenced velocity profiles with the depth-average set to zero.

4). Next the calibrated CTD data were interactively matched to the ADCP vertical velocities within MATLAB ('fd.m', 'pp.m' and 'ladcp2.m'). True depth and position information for the cast was merged into the database together with sound speed data corrected for temperature and salinity using the PERL script, 'add_ctd.prl' and steps 2 and 3 were re-run..

5). The depth-averaged (barotropic) velocity component was restored by interrogating an ASCII format navigation file 'sm.asc' in MATLAB script 'do_absN.m' which calculated an plotted absolute velocity profiles.

6). Bottom track data were processed through the MATLAB script 'Bottomjta.m'. This was almost identical to previous scripts, adjusted to accept absent bottom track data values of 9999 and the bottom cut off for a 30 degree beam inclination LADCP. After adjusting for speed of sound variation and magnetic declination, the absolute velocities were calculated as simply the difference between the water track velocities and the bottom track velocities.

A number of LADCP casts were not processed on board. In these cases, the processing route failed because the CODAS database, created by PERL script 'loadbb.prl', could not be interpreted by the subsequent routines. There appear to be three causes for this, firstly shallow casts with a large bin depth, 16 metres for example, are difficult to interpret and a smaller bin depth should clearly be used. Secondly, occasionally the instrument would create two files rather than one; one of these would be very small and therefore the other was chosen for download to the PC. This would normally be accompanied by an error message from the instrument, CY 00004000. This did not always result in subsequent data processing failure. Thirdly, CTD deployments that required a significant return to the surface before making a full up and down cast were not interpreted properly by 'loadbb'. Generally, however, the period of acclimatisation for the oxygen sensor at 10 metres and then a return to surface before full deployment did not affect the processing route.

Processed water track profiles were read into PSTAR from MATLAB written ASCII files. These were appended into relevant sections and plotted either as vector profiles, using 'parrog', to compare with the VM-ADCP data or contoured crosstrack velocity, calculated with 'crossvel' (see J. Allen for the FORTRAN-PSTAR source code) and plotted with 'ucontr', to compare with geostrophic velocity derived from inferred density gradients between CTD stations.

On station averaged VM-ADCP profiles were compared with the LADCP profiles to 350m depth over the 'Ellett' line, stations 13759-96, and a generally good agreement was found. It was the result of this comparison during the cruise that persuaded us to continue using the 30 degree transducer inclination LADCP for the remainder of the cruise. The full depth LADCP current profiles indicate a predominantly northward and offshore flow on the eastern side of the Rockall trough east of the Anton Dohrn seamount at all depths. At about 750 metres depth on the Hebridean shelf edge there is an indication of a southward on-shelf flow which may indicate a significant internal tide possibly associated with the base of the winter mixed layer. Further west towards the Anton Dohrn seamount, the flow in the upper 1000 metres of the water column was predominantly south-westwards. At depth the flow was rather more confused. West of the Anton Dohrn seamount we see a strong north-eastward flow in the upper 1000 metres with once again a rather more confused flow at depth. It should be noted that further analysis of the bottom track data will be necessary before giving too much credence to the deep flows.

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4. VM-ADCP and Navigation

4.1 Navigation data

The ship's best determined position was calculated by the RVS process "bestnav". The main data source was the ships GPS Trimble 4000 system corrected for selective availability by the Racal MarineStar mark III Differential GPS system. The MarineStar system uses a network of "Virtual Reference Stations" spread throughout Europe (e.g. Belfast, Oxford, Limoges, Bergen) at which selective availability corrections are determined and broadcast by the ESA satellite. Output from the MarineStar unit was output in RTCM SC-104 standard format and fed to the GPS receiver. Coverage extends to 20°W so was available throughout cruise 245. During gaps in the GPS Trimble data further GPS data were available from the GPS glonass system, which uses both the Russian and American satellite networks. When no GPS was available the Chernikeef electro-magnetic log velocity data and gyro heading were used to dead-reckon the ship's position.

Data were transferred daily from the RVS level C "bestnav" file to the pstar absolute navigation file "abnv2451" for use in pstar processing. The gps_4000, gps_glos and gyro (gyronmea) data streams were also transferred daily. During a 30 hour period in Empress Dock before sailing neither GPS streams had been corrected with differential GPS and the selective availability errors were estimated to be approximately 150 m in both.

4.2 Ashtech data

The ships attitude was measured every second by the 3D GPS Ashtech ADU2 system. System default settings were used throughout the cruise. Four antenna, two on the boat deck, two on the bridge top, measured the phase difference between incoming satellite signals from which the ship's heading, pitch and roll were determined. The data were used to calibrate the gyro heading information, which, compared to the satellite measurements varied by up to 8° during manoeuvres on the cruise (Figure 4.1).

Ashtech and gyro heading data were logged by the RVS level abc computers. Data were transferred daily to the pstar system for processing. The 1 second Ashtech data were merged with the 1 second gyro heading and differenced and the data edited to remove differences greater than 10°, pitch greater than ±5°, roll greater than ±7°, attitude flags other than 0 ("0" = precise attitude, "1" = code phase estimate), root mean square (RMS) of the measurement residual (MRMS) greater than 0.01 and RMS of the baseline vector lengths (BRMS) greater than 0.1 (where the maximum MRMS is 6-7 mm and the maximum BRMS is 40 mm). After editing, the Ashtech data were averaged to 2 minutes for merging with the 2 minute VM-ADCP ensembles.

During cruise 242 severe weather conditions were encountered (see Narrative) leading to excessive ship motion. The raw, 1 second, Ashtech pitch and roll data provided interesting traces of the ship's motion during these periods. In heavy seas the ship rolled about ±20°, but in a few extreme cases reached over ±30°. Pitch was much smaller, generally less than ±10°, but reached over ±15° at times (see Section 11)

Ashtech 3D GPS coverage was generally good. Dropouts occurred daily for approximately half an hour between 15:30-16:00, other gaps were small and infrequent. However, the extreme sea conditions meant that more data was deleted by the criteria listed above, than was probably necessary. The ADCP data quality was very poor and it was not felt worthwhile improving the Ashtech data. However, if the gyro heading correction is needed for other data sources, for example accurate wind measurements, some re-processing of the Ashtech raw data is recommended.

4.3 Acoustic Doppler current profiler data

The vessel mounted 150 kHz RDI ADCP was logged using IBM Data Acquisition Software (DAS) version 2.48, with profiler software 17.10. The transducer unit, serial number 34 with frequency 153 kHz, was installed in the hull approximately 2 m to port of the keel and 33 m aft of the bow at the nominal waterline. The depth of the transducer varies between 4-5m depending on the trim of the ship. No technical problems were encountered during the cruise.

The instrument was configured to sample over 120 second intervals with 64 bins of 2^3 m depth, using pulse length 8 m, and blank beyond transmit of 4 m. Since the cruise was operating in both shallow and deep water the special menu was used to give 1 bottom tracking ping to every 4 water tracking pings (FH00004). This enabled automatic bottom tracking (without having to switch configuration files) whenever the water depth was sufficiently shallow, although reduced the number of pings per ensemble to about 50. The configuration file listing is "start.cnf".

Spot gyro heading data were fed into the transducer deck unit where they can be incorporated into the individual ping profiles to correct the velocities to earth co-ordinates before being reduced to a 2 minute ensemble. The gyro instrument is the most reliable direction indicator on the ship and applying the correction to individual profiles is more accurate than correcting averaged ensembles. However, for this correction to take place a switch must be set in the configuration file. This was not done until a day into the cruise, therefore good ADCP data collection started at 028/213000. Logging stopped at the Needles (051/0830) on the return journey.

DAS was installed on a "new" Viglen pentium PC. Theoretically this should have avoided any Y2K bugs, but the computer was set up with a year of 1980 so that problems across the 1900/2000 year boundary were avoided. Like all ADCP PC's this one lost a significant amount of time, approximately 3 seconds per hour. A continual check was kept on the time difference so that the data logged via the level C computer could be corrected. By the end of the cruise the time difference amounted to about 25 minutes.

The ADCP data were logged continually by the level C computer. From there they were transferred once a day to the pstar processing system. Standard processing was used, thus; the clock error was corrected, the gyro heading was corrected using the Ashtech heading information, the velocities were calibrated for misalignment angle and scaling, and finally corrected for ships velocity and converted to absolute velocities using the ships position from the absolute navigation file (abnv2451).

The quality of the ADCP data was monitored by daily plots of near surface vectors and 500m sections. The weather during the cruise was bad (see Narrative) and on the whole the underway and hove-to ADCP velocities were complete rubbish. The characteristic feature of poor quality data collected on the RRS *Discovery* is large velocities in the direction of travel. It is caused primarily by air bubbles beneath the hull. No correction for this problem has been found. However, the on-station data appeared good and compared well with the lowered ADCP data collected during CTD dips.

Because of the bad weather and shortage of time no calibration run was attempted for the ADCP misalignment angle and scaling factor. The numbers used on the previous cruise (*Discovery* 242) were used, i.e., phi = 3.80° and A = 0.9881. Examination of the bottom track velocities during on-shelf steaming gave a slightly lower misalignment angle and higher scaling factor; phi = 3.52° (s.d. 0.409, N=94) and A = 1.0077 (s.d. 0.0179, N=104). The measurements were made over a range of velocities (2-6 m/s) and directions. But weather conditions were poor, downgrading the data, and there were no strong reasons to change the calibration from the *Discovery* 242 values.

The depth of the mid-point of each bin of data is determined by the formula:

Distance from the surface to the centre of the first bin = [Blank beyond transmit] + [depth cell] + ([transmit pulse length] - [depth cell]) / 2 + [transducer depth].

Where [Blank beyond transmit] = 4 m
[depth cell] = 8 m
[transmit pulse length] = 8 m
[transducer depth] = 5 m

gives a mid-bin depth range of 17 - 521 m (total sampling range 13 - 525 m). It should be noted that this is deeper than former measurements made on *Discovery* since the bindepth has, in the past, been wrongly calculated.

J. Read

5. Chemical Measurements

5.1 Nutrients (SOC)

The nutrient compounds Nitrogen (as Nitrate plus Nitrite) Silicon (as Silicate) and Phosphorus (as Phosphate) were determined by auto-analyser both in samples of water from Niskin bottles closed on the CTD rosette and in samples taken while the ship was underway from the "non-toxic" seawater supply feeding the ships TSG system. A brief summary of these measurements is given. A full data quality report (e.g. Holley 1998) will be prepared after the end of the cruise.

The intention was to use gather high quality nutrient measurements to (i) aid the interpretation of other hydrographic information collected along the Rockall and Iceland basin sections (ii) better determine the degree of transport of nutrient rich winter deep mixed water across the shelf break, and its influence on the concentration of nutrients in the shelf seas sampled during this cruise. In addition inter-calibration was carried out between the SOC and DML systems used on the cruise.

A limited number of tests were also carried out of the SOC-Valeport solid state nitrate analyser both attached to the CTD, and as a flow through system in the laboratory attached to the non-toxic sea water supply. This data has still to be analysed.

A Chelsea Instruments "Aqua-sensor" which is a flow injection analyser design for the measurement of nitrate in-situ was also tested in line with the non-toxic supply.

Sampling Procedures

Samples for the analyse of dissolved inorganic nutrients: dissolved silicon (also referred to as silicate and reported as sio3 in cruise data base headers), nitrate and nitrite (referred to as nitrate or no2+no3) and phosphate (po4), were collected after oxygen samples had been taken. All samples were collected into 30 ml "diluvial" sample cups, rinsed 3 times with sample before filling. These were then stored in a refrigerator (at 4 oC) until analysed (between 1 and 12 hours after collection).

A total of 114 casts were sampled for nutrients during the cruise. Samples were transferred into individual 4 ml samples cups, mounted onto the sampler turntable and analysed in sequence. The nutrient analysis was performed using the S.O.C. Burkard segmented flow "AAII" type auto-analyser coupled to a Digital-Analysis Microstream data capture and reduction system.

Calibration

The primary calibration standards for dissolved silicon, nitrate and phosphate were prepared from sodium hexaflurosilicate, potassium nitrate, and potassium di-hydrogen phosphate, respectively. These salts were dried at 110 °C for 2 hours, cooled and stored in a dessicator, then accurately weighed to 4 decimal places prior to the cruise. The exact weight was recorded aiming for nominal weight of 0.960g, 0.510g and 0.681g for dissolved silicon, nitrate and phosphate respectively. When diluted using high purity (18 meg ohm) water, in calibrated 500 ml glass (or polyethylene for silicate) volumetric flasks these produced 10 mmol/l standard stock solutions. These were stored in the refrigerator to reduce deterioration of the solutions. Only one standard stock solution was required for each nutrient for the duration of the cruise, checked daily against OSI standards.

Mixed working standards were made up once per day (or more if required) in 100 ml calibrated polyethylene volumetric flasks in artificial seawater (@40g/l NaCl). A set of working standards was run in duplicate at the start of each analytical run to calibrate the analysis. "Drift peaks" were measured immediately after the standards this was followed by two artificial sea water (carrier solution) blanks. This group was repeated at the half way point of the run and at the end. At the start of the run the blanks were followed by two cups of the OSI Ltd "low nutrient sea water -LNS" using to prepare the control standard solution prepared with OSI nutrient calibration solution. This solution was made up to 15 uM NO3 15 uM Si and 1.5 uM PO4. This solution was also prepared daily. In the analysis tray the 2 OSI standard followed the LNS cups at the start of the run and preceded the drift cup at the end of the run.

Analysis

Silicon

Dissolved silicon analysis followed the standard AAII molybdate-ascorbic acid method with the addition of a 37 oC heating bath (Hydes, 1984). The colorimeter was fitted with a 15 mm flow cell and a 810 nm filter.

Nitrate

Nitrate (and nitrite) analysis followed the standard AAII method using the sulphanilamide and naphtylethylenediamine-dihydrochloride with a copperised-cadmium filled glass reduction column. A 15 mm flow cell and 540 nm filter.

Phosphate

For phosphate analyse the standard AAII method was used (Hydes, 1984) which follows the method of Murphy and Riley (1962). A 50 mm flowcell and 880 nm filter.

Operation and maintenance

Reagents for each of the nutrients analysed were made up as and when required from pre-weighed salts. All pump tubes were replaced once per week. The bearing of the peristaltic pump motor main drive shaft ceased shortly after sailing. This requires complete disassembly of the pump and gear box so it could be re-greased. No other maintenance was required.

Precision - Duplicate and quality control measurements

All samples were run in duplicate, samples were placed in number order on the analyser tray, the complete sequence being repeated. A total of 335 samples were taken from Niskin bottles of the CTD rosette. In Table 5.1 the reproducibility of the duplicate analyses is compared to the WOCE target standard of a precision in the absolute duplicate difference relative to the measurement scale employed. The percentage targets are 0.2% for Si and NO3 and 0.4% for PO4. The precision of the measurements of underway samples were similar.

Table 5.1 Precision of duplicate analyses

	mean abs dif uM	mean % diff	count	WOCE std	count WOCE
NO3	0.07	0.27	335	0.2	204
Si	0.05	0.16	335	0.2	276
P	0.35	0.77	318	0.4	146

Ocean Scientific International Ltd nutrient solutions made up in OSI Low Nutrient Seawater. Cups filled with LNS were also analysed on each run. There results are shown on Table 5.2

Table 5.2. Precision of results from OSI quality control solution measurements

OSI standard			
mean	15.70	15.07	1.492
stdev	0.19	0.19	0.060
OSI low nutrient seawater			
count	120	120	117
mean	0.92	0.32	n/a
stdev	0.14	0.07	n/a
count	66	66	n/a

References

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Hydes, D.J., 1984. A manual of methods for the continuous flow determination of nutrients in seawater. IOSDL Report 177, 40pp.

Murphy, J. and J.P. Riley, 1954. A modified single solution method for the determination of phosphate in natural waters. *Anal. Chem. Acta,* **27** 31-66.

D. Hydes

5.2 Nutrients (DML)

Water samples were taken from all depths at all stations where the CTD was deployed. Analysis for nitrate/nitrite, silicate, phosphate, and ammonium was carried out on the DML Lachat "Quickchem 8000" flow injection analysis equipment.

Duplicate samples were taken from each depth and refrigerated until used. A separate 6 point calibration was carried out for each run of one samples from one or two stations. Quality control standards from independently produced standards were run with each batch.

I. Ezzi

5.3 Chlorophyll

As with normal DML practice the CTD fluorimeter is calibrated against measured chlorophyll levels from CTD bottle samples. Samples were taken for chlorophyll estimation at a total of 32 stations. At each of these stations water a separate shallow sample (approximately 5m) was taken , four litres of which was filtered and the filter paper frozen for later chlorophyll estimation at the laboratory by acetone extraction and HPLC measurement. This data will be supplied to SOC for calibration of sensor.

The other cruise objective regarding chlorophyll measurement i.e. the experiment to investigate "phyto-convection" in the deep stations on the Rockall-Iceland leg, was not carried out due to inclement weather.

I. Ezzi

5.4 Salinity Samples

Salinity samples were drawn from each Niskin bottle with the exception of the 5 metre samples which were being taken for chlorophyll analysis. Samples were taken in the normal 200ml glass sample bottles and were sealed with disposable plastic inserts and screw caps. Duplicates were always taken from rosette position 1.

Due to the generally shallow nature of the Scotland - Rockall section, many stations provided only a few samples per cast and even the deepest station (13789) gave only 19 samples. In the instances of several very shallow stations occurring successively, one crate of 24 sample bottles was used for multiple stations.

Samples were also taken from the outflow of the thermosalinograph in the Water Bottle Annexe, once every four hours to calibrate the thermosalinograph salinity measurements.

Two Guildline Autosals, each fitted with a peristaltic sample pump were installed onboard and due to the requirement for the Constant Temperature Laboratory to be operating at 10° C for another experiment at the beginning and end of the cruise. A model 8400A was fitted in the C. T. Lab and a model 8400 was fitted in the Chemistry Laboratory, to enable continuity of analysis. The C.T. Lab temperature was set at 19° C and the Autosal operating temperature at 21° C. The operating temperature of the 8400 Autosal in the Chemistry Lab was set at 24° C, as it was found that the Lab temperature stayed fairly constant at around 22-23° C.

On day 33, after the 8400A had analysed less than 3 crates of samples the salinometer became partially blocked somewhere between the sample inlet and the cell inlet, forcing the peristaltic pump outlet tube off the pump. It was noticed that the pump on the 8400 salinometer, had cable ties fitted to the pump outlet to make it more secure, whereas the 8400A had none. As no ties of the right size were immediately available, the pump from the 8400 unit was removed and fitted in its place, enabling the batch to be finished. The pipework and cell of the 8400A were then flushed and filled with a methanol/detergent solution and left to soak overnight. The following day the solution was flushed through with 400ml of distilled water. But it was found that although the solution had made some improvement, the pump could only be operated at speed position 1, without creating too much back pressure at the pump outlet.

After only two more crates of samples had been analysed, the pipework had become almost completely blocked again and it was decided to switch to the 8400 salinometer in the Chemistry Lab, to prevent a build-up of samples waiting for analysis. The 8400A was again flushed with the methanol/detergent solution and left to soak overnight. On the following day the solution was drained out of the cell, but in attempting to refill the system with distilled water, it was found that none could get through to the cell, due to the blockage. The next option was to open up the salinometer and try to backflush the blockage with a syringe. However sea conditions precluded that for a further 6 days and in the meantime, to prevent the cell drying out, the cell was refilled with distilled water fed back up through the drain outlet.

Upon checking the sample bottles on day 37, it was discovered that almost every one had unidentifiable debris in suspension in the sample. The debris was evident in both unused bottles from previous cruises still containing seawater, as well as in bottles that had already been used for sampling on this cruise. Much of the debris appeared to be like a very thin semi-transparent curled layer with blotches on it. The debris varied in size from that just visible, to approximately 10mm across and when the bottle was gently shaken, most of it would settle on the bottom within 5 minutes. On closer inspection it was discovered that many bottles had a visible organic deposition on the inside surface of the glass, so it was decided to clean every sample bottle to ensure that any further debris could only belong to that specific water sample. All bottles were washed and soaked overnight in a hot water and Decon solution. Upon checking the bottles the following day, before they were emptied, it was found that almost every one contained debris in the Decon solution, showing the problem was greater than we had imagined. After thoroughly rinsing the bottles, they were refilled with hot fresh water and stored back in their crates.

After six days of storms, we managed to get shelter in the Sound of Mull on day 43 and used the opportunity to clear the blockage in the 8400A unit. By backflushing each section of the sample tubing with a syringe of distilled water. It became apparent from the effort required, that the blockage was as suspected, in the heat exchanger coil, though no distinct pieces of debris were found whilst flushing. The water bath was refilled the following day and distilled water was successfully flushed through the sample tubing. However it is recommended that the heat exchanger tubing is checked more thoroughly back at SOC as we are not convinced it is completely cleared and on checking some earlier cruise reports, this machine has some history of becoming blocked.

Due to the bad weather preventing the 8400A blockage being cleared earlier, only 5 crates of samples were analysed in this machine during the cruise. The 8400 unit analysed 22 crates (33 CTD stations & 5 TSG) and generally performed well, though liable occasionally to give unstable reasons for no clearly obvious reason. Though it was suspected that the bad weather may have been a factor, either by variations in the power supply, or simply the physical forces acting on the salinometer. On two occasions also, the standby figure was varying by 0.0005 - 0.0009, but this did not appear to affect the variability of the sample reading on these occasions. It is suggested that some form of stabilised power supply should be tested next time they are used at sea, to eliminate the possibility of power variations.

Standardisation was obtained using IAPSO standard seawater batch number 35 N 1. These were supplied in the new shaped bottles with halo-butyl seals held in place by an aluminium "pull-tag" rather than the older style ampoules They were much easier to use than ampoules, being completely stable in the sample holder and not requiring hand support during sampling. However the reduced volume of the SSW bottles meant that duplicate readings in case of apparent drifts in the standards were difficult to obtain. Standards were normally run at the start and end of a pair of crates being successively analysed. Future cruises should consider taking more SSW bottles than the equivalent number of ampoules.

R. Bonner, L. Duncan, A. Jolly

5.6 Oxygen

Dissolved oxygen samples were drawn from each niskin. Between one and four duplicate samples were taken on each cast, from the deepest bottles. The samples were drawn through short pieces of silicon tubing into clear, pre-calibrated, wide necked glass bottles and were fixed immediately on deck with manganese chloride and alkaline iodide dispensed using precise repeat Anachem bottle top dispensers. Samples were shaken on deck for approximately half a minute, and if any bubbles were detected in the samples at this point, a new sample was drawn. The samples were transferred to the constant temperature (CT) laboratory, and then shaken again thirty minutes after sampling.

The temperature of the samples drawn from all depths were measured using a hand held electronic thermometer probe. The temperature was used to calculate any temperature dependant changes in the sample bottle volumes at time of fixing.

Samples were analysed in the CT laboratory starting at a minimum of one hour after the collection of samples. The samples were acidified immediately prior to titration and stirred using a magnetic stir bar set at a constant spin. The Winkler whole bottle titration method with aperometric endpoint detection (Culberson, 1987) was used with equipment supplied by Metrohm. The spin on the stir bar was occasionally disturbed by the movement of the ship and also by the uneven bases on some of the glass bottles, leading to less effective stirring of the sample and thus longer titration times, although this probably did not effect the accuracy of the endpoint detection. The Anachem dispensers were washed out with deionised water each time the reagents were topped up, to avoid any problems caused by the corrosive nature of the reagents.

The normality of the thiosulphate titrant was checked against an in house potassium iodate standard of 0.01 N at 20°C at the beginning of each analytical run and incorporated into the calculations. A total of 2 standards were used throughout the duration of the cruise. Consistency of the thiosulphate normality improved with time. Blank measurements were also determined at the start of each run to account for the introduction of oxygen with the reagents and impurities in the manganese chloride, as described in the WOCE Manual of Operations and Methods (Culberson, 1991). Thiosulphate standardisation was carried out by adding the iodate after the other reagents and following on directly from the blank measurements in the same flask, as on the cruises D223 and D227. Changes in the thiosulphate normality are shown in Figure 5.1a.

Absolute duplicate differences for each station are shown in Figure 5.1b for cruise D245, for a sample size of 87 pairs of duplicate measurements. Duplicate differences greater than 1.0_mol/l accounted for 14.9% of these duplicate pairs and ignoring these high duplicate differences the mean (±SD) duplicate difference was 0.0828 (± 0.4876). The duplicate difference achieved was not related to the individual calibrated bottle (Figure 5.1c) and high duplicate differences seemed to occur at random.

Problems

The ambient temperature range of the CT laboratory often varied by ± 2°C throughout the cruise. The temperature of the laboratory was noted at the start of each analytical run.

Temperature recordings using the hand held electronic thermometer were subject to a certain amount of variability and on occasion it was difficult to determine an accurate temperature of the water sample.

On station 13792 the Metrohm 10ml exchange unit used for the in house thiosulphate broke due to the exceptionally high sea state. This was replaced by a 5ml exhange unit.

References

Culberson, C.H. and Huang, S. 1987 . Automated amperoteric oxygen titration. *Deep Sea Research*, 34: 875-880.

Culberson, C.H. 1991. WOCE Operations Manual (WHP Operations and Method) WHPO 91/1 Woods Hole. 15pp

6. Underway Measurements

6.1 Surface Meteorology and Thermosalinograph (RVS SurfMet)

Instrumentation

All the instruments performed as expected except for the Starboard PAR sensor. This was indicating between a factor of around 10 higher than expected and also below zero. The fault is thought to be the sensor itself which shall be investigated thoroughly on return to SOC.

Table 6.1. SurfMet instrumentation.

Sensor Type	Manufacturer	Serial Number
TSG Housing Temp	FSI	1401
TSG Remote Temp	FSI	1370
Fluorometer	Wetlabs	117
Transmissometer	SeaTech	T1005S
Barometric Pressure	Viasala	U1420016
Atmospheric Temp / Humidity	Viasala	U1850014
PPAR	Didcot	0151
SPAR	Didcot	1078
PTIR	Kipp and Zonen	994133
STIR	Kipp and Zonen	994132
Conductivity Probe	FSI	1376
Sensor Collector	Viasala	R381005
Anemometer	Viasala	S22308
Wind Vane	Viasala	S22308

T. Edwards

Data Processing and Calibration

Processing of the meteorological data occurred on a daily basis. The processing involved running four scripts whose function is described below:

i) The first stage involves running smtexec0. This script transfers underway surfmet data from RVS format into PSTAR format using datapup. Start and stop times are requested, which must coincide with the averaged ashtech files used in stage three. The file smt245**.raw is created.

ii) Running smtexec1a, ensures absent surfmet data is set to -999. It calculates TSG salinity using the housing temperature, conductivity and dummy pressure variable set to 0 dbar, using peos83. The calibration to the temperature variables is included:

temp_h   -0.0004835 +1.0012x -0.0001078x^2

temp_m   -0.008604 +1.000735x -0.00007122x^2

Finally, the bestnav positions every 30 seconds are merged into the file, smt245** and averaged into a two minute file smt245**.av.

iii) Using smtexec1b the smt245**.av file is merged with the two second master ashtech file, containing the gyro and as-gyro heading. These added together give the ashtech heading.

iv) Finally, smtexec2 computes the vessel speed and subtracts this from the relative winds to get true wind speed and direction. Wind directions are measured relative to directions based on the ship heading at 90 degrees. This creates the file smt245**.met.

Three daily plots were produced from the final smt245**.met files displaying changes in the variables air pressure, wind speed and direction, calculated TSG salinity, housing and remote sea temperatures, humidity and downwards radiation (shortwave and photosynthetically active).

At the end of the cruise the surfmet data was combined into a master file called smt245.all, merging all smt245**.met files. The meteorological measurements are relatively smooth, only occasional spikes and no effort has been made to de-spike records.

There were a few minor problems in the processing of met data. The main problem derived from unreliable data on spar (starboard photosynthetically active radiation) throughout the cruise. This has been edited from the final master file to absent data values. At the beginning of the cruise, some of the exec's had to be edited to fit with d245 variable names and files. This was complicated due to previous variable entries identified by number and not their variable names. These have been replaced to variable names wherever possible.

The TSG salinities were calibrated using bottle samples collected every 4 hours during the cruise. The bottle conductivities were re-calculated using the housing temperature, and used to derive a linear fit to correct the TSG conductivities and minimises the residuals. The housing temperature was then utilised again to re-calculate salinity with the calibrated conductivities. The mean salinity difference between the TSG and bottle samples is 0.0003, the standard deviation 0.0074 for n=98 (of 103 samples).

Weekly summaries of the meteorological data are shown in Figures 6.1-6.4.

L. Duncan

6.2 Surface Meteorology (Grhomet) and Shipborne Wave Recorder)

The SOC high resolution meteorology instruments and data collection system (Grhomet) was installed by Robin Pascal and Ben Moat prior to sailing. The Shipborne Wave Recorder was also operational during the cruise. Both systems were monitored by hourly watchkeepers but required no attention. The SBWR display provided us with interesting if alarming maximum and mean significant wave heights during the worst storms. The data were stored on the Grhomet workstation and were backed up daily through cross mounting the disk with Discovery6. The data were not retrieved and processed during the cruise, but will be processed at SOC.

6.3 Precision Echo Sounder

The bathymetry equipment aboard during D245 consists of a SIMRAD EA500 Hydrographic Echosounder (hull mounted transducer array) and a Precision Echo Sounding (PES) towed "fish" transducer located on the port side of the ship. The hull mounted transducer is located 5.3m below the sea surface, and the depth of tow of the PES fish is 11.5m below the water line on station. While steaming the echosounder was approximately 2.0m shallower and so the measured depth is deeper than the real depth.

A visual display of the return signal was displayed on the SIMRAD VDU and a hardcopy produced on a dedicated printer. The original printer ceased to work at one point but was replaced by another. A uniform sound velocity of 1500m/s was used during the cruise, and the PES fish was generally used in preference to the hull transducer. During very stormy weather the PES fish was brought on board to avoid damage to the fish by wave action.

Raw data were corrected daily for the speed of sound using Carter tables (RVS Level C stream prodep) and transferred to PSTAR format (simexec0). Data files were merged with the daily

GPS navigation file bestnav and averaged to 5 minute intervals (simexec1). Three master files were created (simexec2). The file dep24501.nav was appended from the single daily files onto the cruise depth file. The file dep24501.5min was appended from the daily files onto average data into 5 minute intervals. In the third master file, dep24501.track, data were rejected where the ships speed was less than two knots, thus removing on station data.

N.P. Holliday

6.4 Expendable Bathythermographs (XBTs)

The data from launched Expendable Bathythermographs (XBTs) were collected on the SEAS Mark 12 XBT deck unit situated in the Plot. The data were stored in the SEAS format, and periodically copied from the system via a 3.5" floppy disk drive. The output from the SEAS unit is binary files, so RVS software was used to convert them to ascii files and a series of Level C files, one for each cast. The RVS Level C files have depth correctly calculated (using fall-rate equations specific to each probe type) but incorrectly labelled as pressure. They were given a time variable, but this was correct only for the first datacycle, and was taken from the (unreliable) PC clock of the SEAS unit at launch time. Watchkeepers recorded on a logsheet the correct launch time from the ships master clock.

Each Level C file was read into PEXEC format using *datapup* and the (incorrect) time variable discarded (*xbtexec0*). The user input the correct time (jday, hour, minute and seconds) and a one-datacycle PSTAR file with the launch time in seconds was created. This file (xbt$num.tim) was used to extract water depth and location at the time of launch from the files abnv2451 and dep24501.5min, and these were subsequently merged into the header information of the XBT file (*xbtexec1*). The time was written into the header as start time, but no time variable created.

The XBT thermistor generally takes a small period of time before it equilibrates with the ambient water temperature. This is particularly true in the case of water colder than the probe when it is launched. As a result the upper few data cycles were generally bad and were deleted from each main file (xbt$num). The data suffered greatly from wire stretch due to ship motion during big swell, and from shorting out when the wire touched the ship in high winds. Any data below these spikes are not reliable and were deleted. All data deletions were performed manually with *pcopya*.

N.P. Holliday

7. Moorings

Five moorings were deployed during Challenger 143 May/June 1999. Three shelf moorings and two deep moorings. All the shelf moorings were recovered but only one of the deep moorings was recovered (M). The deep single point mooring at F (Figure 7.3) was not recovered due to adverse weather conditions. The mooring is on position and vertical. There has been no Argos alert from this mooring which indicates the mooring is intact. It is hoped to recover this mooring sometime during the year. Various avenues will have to be explored.

The Tiree U shape mooring was the first to be recovered (Figure 7.1). Spotting the Spar as we sailed down the Tiree Passage came as a pleasant surprise. Reports had been received that the Spar was well out of position. The pickup line was intact but we were unable to hook in at the first attempt. During this attempt the pellet line was severed. The Spar handle was subsequently grappled and the safety strop from the handle to the bottom of the chain was intact. The mooring was safely recovered, both instruments were in good condition. A quick look of the data revealed that the upper meter had been tangled for the entire deployment, speed and direction are useless. The bottom current meter produced a complete record.

The Muck Deep single point mooring (Figure 7.2) and associated marker Spar were in position. Again a surprise as reports had been received that the Spar was several miles out of position. The single point mooring was released and recovered without incident. The backup buoyancy was tangled with the current meters though no instruments were damaged. The top meter was badly fouled. The middle current meter had a faulty vane spindle. The bottom current meter had a loose transmissometer connector which caused the instrument to flood during calibration. All miniloggers were recovered in good condition. Data was recovered from all instruments.

The top meter had been tangled for the duration of the deployment, speed and direction are useless. The transmissometer record falls below threshold soon after deployment. Data from the other instruments seems fine though the speeds from the middle current meter are lower than the bottom current meter.

The recovery of the Spar was left until the end of the cruise, the pellet line was missing and there was no evidence of the safety strop. The 13mm down line parted on recovery but by this time the Spar was safely aboard.

The SC-ADCP deployed to the West of the Muck Deep was recovered without incident. Data has been down loaded from the instrument but as yet not viewed.

Mooring M was in place and vertical (Figure 7.4). After releasing, it took a wee while to spot the mooring. The Argos receiver did not pinpoint the mooring. Sea conditions were not ideal and the usual problems were encountered with intermediate buoyancy moorings. The mooring did not stretch out in the wind, initially we tried to grapple one of the buoyancy packs without success. Eventually we were able to grapple the sub-surface pellet but by this time the pickup line had become entangled with the sphere. Once hooked in all went well for the recovery of the top two current meters. The following current meters were all tangled with their respective buoyancy packs. Meter 8248 was damaged during recovery. Vane spindle and rotor guard bent, rotor broken. Data was recovered from all instruments and on viewing all looks well.

All recovered moorings had Argos beacons on them, alerts were forwarded to the ship from DML within a couple of hours of recovery.

P. Taylor and C. Griffiths

8. Coring and Photography

The DML multicorer was deployed a number of times at two stations in the seabed depression south west of Muck. The deployments are detailed in the following table. Times and positions were recorded when the corer made contact with the seabed, indicated by a reduction in the tension readout on the wire metering system.

Table 8.1 Multicore Deployments

Number	Station	Station Number	Date	Time (Z)	Lat. (N)	Long. (W)	Depth	No. cores
MC1	MD7	13770	1/2/00	1114	56 48.650	06 31.006	321	0
MC2	MD7	13771	1/2/00	1223	56 48.51	06 30.97	304	0
MC3	MD7	13799	16/2/00	0833	56 48.514	06 29.839	248	0
MC4	MD7	13800	16/2/00	0859	56 48.559	06 30.463	286	9
MC5	MD7	13801	16/2/00	0957	56 48.499	06 30.589	276	8
MC6	MD7	13802	16/2/00	1045	56 48.530	06 30.576	284	9
MC7	MD6	13803	16/2/00	1556	56 49.094	06 40.126	173	9
MC8	MD6	13804	16/2/00	1646	56 48.952	06 39.989	173	9
MC9	MD6	13805	16/2/00	1724	56 48.976	06 39.836	174	0
MC10	MD6	13806	16/2/00	1739	56 48.945	06 39.630	170	0
MC11	MD6	-	16/2/00	1804	56 48.954	06 40.144	170	0

The failure to retrieve any cores on 1/2/00 can be ascribed to the poor weather conditions prevailing at the time. The drift of the ship during deployments took it outside the 'target' area, which at MD7 is small. Conditions were much better on 16/2/00 and a number of successful deployments were made at both stations. The reason for the failures was not apparent.

The cores from MD7 were used as follows:

3 (one from each deployment) for sediment community oxygen demand (SCOD)
2 (from different deployments) for sulphate reduction rate measurement
2 (from different deployments) for porosity and total organic matter determination
All remaining cores - the top 2cm of each core was removed and frozen separately for lipid determination.

Cores from MD6 were used similarly. However, since there were only two successful deployments at this station only two cores were used for the measurement of SCOD.

Adverse conditions meant no bedhop camera work was carried out.

M. Harvey

9. Computing

9.1 RVS Level ABC

The following data was logged using the ISG Level ABC system:

Table 9.1 RVS Data Streams

Instrument	**RVS Data Stream**	**Source**
Chernikeeff Log	LOG_CHF	Mk II Level A
Ships Gyro	GYRONMEA	Mk II Level A
Trimble GPS	GPS_4000	Mk II Level A
Ashtec ADU	GPS_ASH	Mk II Level A
Ashtec Glonass GPS	GPS_GLOS	Mk II Level A
Surface Logger	SURFMET	SIG PC
CTD	CTD_12C	VME Level A
Winch Monitoring	WINCH	New SEG PC to LEVB
*Echo-Sounder	EA500D1	Mk II Level A
ADCP		Direct to Level C

In addition Argos Positions were used by Phil Taylor to confirm operation of the Argos beacons.

Level A

The level A's were all reprogrammed with Y2K compliant software prior to the cruise, and performed satisfactorily. However occasionally the input baud rates for EA500D1, and Ashtec changed. There is an offset between the Ashtec heading and the gyro of between 4 and 6 degrees, though the Bridge officers do not agree. It is possible that the Ashtec requires recalibrating.

Level B

The Level B suffered some unusual resetting at the start of the trip, this was thought to have been caused by experiments with the new winch logging PC.

Level C

Surfmet was turned off on jday 033 1300-1440 and Pro_wind was interpolated over that period. A change was made in 'windcalc' for the m/s to knots conversion with a scale setting for windspeed of 1.94385. The winddirection offset was -90 as in the previous cruise (meaning the windvane was pointing 90 degrees towards port). The new editor was taken for a test run (rvsedit), but the old editor was used despite its Y2K rollover problems. The program xwin was used to preview dip format files instead of the old Sunview scgi command. The windcalc menu required reworking.

The MO drive was tested and found to have a faulty power supply. This could explain why it didn't work with Solaris. The copyit menu is not Y2K compliant. The surfmet PC clock was 30 secs fast 31-Jan. The ADCP PC clock was >6 mins slow 3-Feb.

The cruise had a web page set up running Apache web server. An good use of this was to produce a cron script that would generate a plot of the ships position on the our, which could then be viewed on any web browser on the network. This script used the following utilities:

post - to convert between dipf and postscript
convert - to convert between postscript and jpeg/gif

Backups of level B tapes were done to QIC 160 tapes, approx 10 compressed levelB tapes to one tape. The level C data files were backed up daily to DLT

XBTs

On the translation PC in the directory c:\xbt there lies the files required to process XBT data. As the XBT data was provided to us on 3.5" floppy, and the PC disk drive not working under win98, this posed some problems. A directory was created in pro_data called x(bt)-files and the files loaded directly to this place from the disk. Then from the PC, the directory pro_data was mapped to G:\ and the xbt2.exe program put in the x-files directory. Then at a DOS prompt go to G:\x-files. Type xbt2.exe g:\. This ensures the program doesn't attempt to read from the a: or b: drive(and crash).

PCs

It was suggested by Phil Stanford, that the Sun and Novell systems be synchronised to the master clock.

Windows 98 was installed on the Translation PC prior to sailing, and was not tested thoroughly. The A drive would not work, and the machine was unstable. Recommend reverting back to win95.

Email

The HSD mail system did suffer from the 'dropping out mid-transfer' problem. Pinging the base computer enabled the connection to be maintained by using a command 'repeat 40 ping base_comm'. The comms machine (d4) required rebooting, after becoming very slow, "panic too many soft calls". The NetWare GroupWise server was thought to have been to blame, by sending out duplicate messages.

Novell IntranetWare: Arcserve was crashing, leading to backup failures. Full backups were done weekly. It required rebooting 15th Feb, and had problems with attachments from GW. GroupWise continues to be unpopular with the scientists, as it has been for the last 2 years. During the cruise the POP3 access was found, this gets around GroupWise and its oddities.

Mobilisation/handover

New computers, printer and network was installed prior to the cruise. Postshop was installed on D2 as print server, and worked satisfactorily

Damages

Due to rough weather, one chair in the computer room now has a broken back rest. The NEC laptop mysteriously has a broken screen, but should still be useable with an external monitor. The window between the computer room and the main lab shattered, and was removed, and replaced by a wooden board. There may still be fragments of glass around the area.

One morning there was a lot of water in the computer room. Apparently it had entered through the exhaust vent just above the door. There was no apparent damage to systems.

R. Lloyd, M.Bridger

9.2 Additional Computing and Archiving

Systems available on board

This cruise was the first to utilise the new RVS computing facilities on *Discovery*. These included the provision of switched 10/100 Base T network ports to the Main Lab and Computer Room (the Deck Lab presently still has to use shared 10 Base 2 Ethernet).

A SUN Ultra 10 ("Discovery 2") provided 5Gb of disk for use as a package server, and a further 1Gb for user home directories. The system also hosted an Apache Web server. Other packages installed at SOC prior to sailing included PEXEC, Matlab, NAG, PERL, UNIRAS, the RVS 'Level ABC' software and SUN Workshop (F77 and C compilers). The 'utilities' package (Ghostview, gzip, xv etc), GMT, GIMP, EMACS, Adobe Acrobat and 'Star Office' were also made available.

The main 'data' machine was 'Discovery 6', an ULTRA 5 with one 18Gb external drive, and 7Gb spare on another drive. This machine also had a DLT (Digital Linear Tape) drive attached to it.

The SOC 'sohydro1' workstation, with about 5Gb of available storage and an EO drive, was also taken, together with a number of Mac and PC workstations.

Backups

The main body of cruise data was stored on Discovery 6. Since the DLT drive was local to this machine, this allowed most of the backup to take place without creating network traffic.

The DLT tapes had a capacity of 70Gb (compressed) and about 35Gb if compression was not used, or the data being backed up was already well compressed.

The user home directory area (on Discovery 2) and also the data areas on the Met workstation 'southerly' and the CTD workstation 'wodaps' were mounted on Discovery 6 to enable these to be backed up.

It was anticipated that around 10Gb of data would be gathered, which meant that it was possible to do a full backup daily. A simple weekly rotation scheme using 7 tapes was implemented. A script ("**dlt_backup**") was written to carry out the task, and produce logs of what was backed up. This could easily be modified to suit later cruises.

Transfer rates to tape of 3MB/sec were measured for disks local to Discovery 6, and approx. 1.8MB/sec was achieved for backup over the network.

Archiving

Since the backup regime copied the entire cruise dataset daily, the preferred method of archiving was to carry out two final backups onto DLT tapes. As a precaution the data was also archived onto EO disk. The EOs were written on one drive ('sohydro1') and checked for readability on another system ('wodaps'), because of the EO compatibility problems noted below,

Web site

A 'D245' web site was produced using Discovery 2's Web server, with the intention of providing a forum for dissemination of information about both the work and social aspects of the cruise. The content did not perhaps reach 'critical mass' on this voyage as not many contributions were received. However it would be worth repeating for future cruises, perhaps with a bit more content being made available as part of normal cruise preparation – e.g. any relevant past results, present cruise programme, etc. Any research content added during the cruise could then quickly be uploaded to the main SOC site on return (or even during the cruise if the results were sufficiently exciting to justify the transmission costs!). Similarly, a digital camera could be of benefit in providing pictures for the Web site, both to aid publicity and for entertainment purposes!

PC File/Print services

The 'Samba' public-domain software was implemented on 'sohydro1'. This acted as a gateway to the main data storage area on Discovery 6, and enabled PC users to map a network drive, and store data on Discovery 6 for purposes of backup or sharing with other users. In addition it made networked printers available to PC users, without their having to install Sun's 'Solstice' networking software. This proved of value to some of the PC users on this cruise, although it did not give an ideal solution as there was no public-domain software available which would allow Mac users to store their data on the network in the same way. A better solution would be for the extension of the existing RVS NetWare service to provide more than the current 10Mb of filespace, and more compatibility with land-based systems. This would allow both PC and Mac users to move from a land-based to ship-based networking environment more easily.

Systems & software performance

No problems were encountered with the performance of the new 'package' and 'data' servers, or the backup system. The CPU usage on 'Discovery 6' seemed adequate to cope with the simultaneous processing load placed on it. However, the decision to use the more powerful Ultra 10 as the package server rather than the data server may need to be reviewed if overall processing loads were to increase. In general though, the model whereby processing and storage were centred on the host with the backup device has worked well this cruise. The DLT drive is likely to be used as the archive medium of choice on future cruises, because of its high capacity and performance. Consideration should therefore be given to purchasing a drive for use at SOC for reading cruise tapes.

There were a few comments about the speed of the network as seen on occasions from some Macs. It proved difficult to substantiate these feelings, although the PEXEC 'lookd' program was found to create a significant network load between the 'abcgate' system and whatever host was running 'lookd'. The loading was measured at about 250KB/sec, which should not have been enough to affect the network performance of Discovery 6 (using a 100Mb/sec network port) adversely. It probably would be prudent however to run 'lookd' on another system, for example Discovery 2.

The GroupWise mail system worked well, although there were minor problems early in the cruise caused by confusion about the correct format required by the GroupWise gateway for Internet mail (the normal Internet address needed to be in quotes, and prepended by 'world:'). The GroupWise Web Access client proved to have a few quirks, and sometimes users found that their laboriously-typed messages got lost before they could be sent, if they had pressed the wrong button on the form.A better solution, tried on this cruise, was to configure people's normal mail user agents (Eudora, Netscape, etc) to read and send to the GroupWise Internet gateway. This allowed people to continue using familiar software, and had the advantage that normal Internet addressing could be used.

Some compatibility problems were again encountered with an EO disk written at SOC (on 'sohydro2'). This could not be read using the EO drive on 'sohydro1', but read without difficulty on 'wodaps'. Even after re-labelling the blank side of this disk on 'wodaps' it still could not be read on 'sohydro1'. Tests were carried out with other EO disks and these interchanged between the two drives with no problems. It is possible that the one EO disk that had the problems is itself faulty – it may have undergone a low-level format in the past, which is not recommended for pre-formatted disks.

The PEXEC Version 5 software, previously untried at sea, seemed to perform well with very few problems – a couple of minor bugs were resolved by Steve Alderson at SOC, and the amended code was compiled on board.

It was noticed that many of the on-board systems had clocks that were not synchronised to any time source, and were thus showing times that differed considerably from reality. It should apparently be possible to synchronise one RVS UNIX workstation to the ship's master clock, with a high degree of accuracy. If this were to be done, then other systems (the NetWare server, PCs serving the ADCP and SBWR systems, UNIX workstations and users' PC and Mac systems) could run public-domain software to synchronise with the primary UNIX machine.

While scientific data processing would still use the master clock, the ability to synchronise any other system to the correct time would be of benefit.

Bearing in mind how much new equipment was being tested for the first time this cruise (new network, servers, and backup device), very few problems have occurred. Those involved in developing, implementing and operating the new systems can consider these first tests as a success.

P. Stanford

10. Shipboard Engineering

Winch Monitoring System

A new monitoring system had been installed on *Discovery* at SOC just prior to D245. Pete Mason and Simon Dodds were on board for the passage between Southampton and Oban to commission and calibrate the system. After an initial problem with a power supply unit was rectified the system was calibrated for both the 10 and 20 tonne winches using an electronic load cell. Several test deployments were made using a chain clump over the rear gantry to prove the operation of the system. The new system was found to operate correctly and worked well throughout the cruise.

CTD deployments

A new CTD cable had been fitted just prior to D245. The cable was terminated and load tested at the start of the cruise. A total of 44 CTD deployments to maximum depth of 2200 metres were made using the 10 tonne winch system and the starboard gantry. Both Winch and Gantry operated without problems with no disruption to the science program.

Several deployments were carried out in marginal conditions with heavy rolling of the ship. This made it difficult to maintain sufficient outboard tension on the wire which resulted in the necessity to use low veer speeds and frequent stop/starting of the winch to prevent it from losing traction during the deployment of the CTD.

Multicore deployments

A total of 10 deployments to maximum depth of 306 metres were made using the 20 tonne winch system over the starboard gantry. A pinger was fitted for the first deployment but as the deployments were all shallow this was not used for further operations.

Five of the deployments were unsuccessful in that the Corer failed to trigger on the bottom. The reasons for this failure were not established but it was apparent the corer had been on the bottom as the core tubes were seen to be full as it left the water.

The 20 tonne winch system and starboard gantry operated without problems throughout the cruise. Some problems were experienced in paying out slack wire whilst the corer was on the bottom during the more shallow deployments (less than 200 metres). This was due to the fact there was not sufficient weight of wire out to maintain outboard tension across the winch causing slippage.

Non Toxic Water

The non toxic system was run for the duration of the cruise without problems.

PES Winch/Davit

A temporary remote power pack was installed at the beginning of the cruise due to problems with the PES power pack before the cruise started. The fish was deployed and recovered several times during the cruise without problems.

30Tm Cranes, aft port and stbd

Both cranes were used for the recovery of several moorings with no faults reported.

Millipore Water Purifier

An RO12 plus and milli Q 185 were used in the wet lab for the duration of the cruise. The RO unit cut out several times on low water supply pressure and had to be restarted.

C. Day, A. Sherring, R. Keogh

11. Storm Highlights (Lowlights?)

As mentioned previously, D245 was unfortunate enough to suffer some of the worst storms ever experienced by many of the scientific staff and ship's personnel. In this final section we highlight the conditions during 5 days of particularly high wind speeds and large waves which resulted in damage being caused to the ship and to people. The worst of the weather occurred during days 37 to 41 when we felt the effects of 4 rapidly moving storms in 5 successive days. The storms were tight depressions whizzing through the Iceland Basin, with the greatest pressure gradient and hence strongest winds generally occurring after the centre had passed (Figure 11.1). Sudden changes in wind direction caused the amazing sight of large swell being flattened almost instantaneously, only to be whipped up in the new direction within a matter of minutes. Figure 11.2 shows significant wave height as recorded by the SBWR during the stormy days, and Figure 11.3 shows the uncorrected wave heights (wave spectrum suggests correction may increase the wave height by ~10%). The largest waves developed during the evening of Day 39 when we had strong winds persisting for several hours. Figure 11.4 shows some of the worst rolls, including the infamous "lifeboat roll" in the early hours of Day 40, which caused the dramatic suicide of the Bridge fridge with the roll to port (27°) and more seriously the starboard lifeboat coming loose on the subsequent roll to starboard (33°).

Some interesting statistics:

	Maximum	Minimum	Mean	s.d.
Windspeed (all cruise)	31.2m/s	0.5m/s	12.9m/s	5.1
Windspeed (Days 37-41)	31.2m/s	2.1m/s	16.3m/s	5.7
Significant wave height	18.3m	0.1m	4.5m	3.4
Biggest Wave (uncorrected)	28.8m (peak to trough)			

Fortunately we survived these storms (mostly) in tact, though the ship suffered some damage (broken internal window between the main lab and the computer room, and a split in the hangar roof), and some computers and countless amounts of crockery were broken. Several people suffered injuries as a result of the motion, ranging from cuts and bruises to cracked ribs. However throughout the trials and tribulations, people's spirits remained high and all the ship's personnel did a marvellous job of keeping the ship safe, and normal operations running under very difficult circumstances. We were unfortunate with the timing of the weather; a couple of weeks earlier and we would have been fine.....

N.P. Holliday

Figure 1.1 Cruise Track

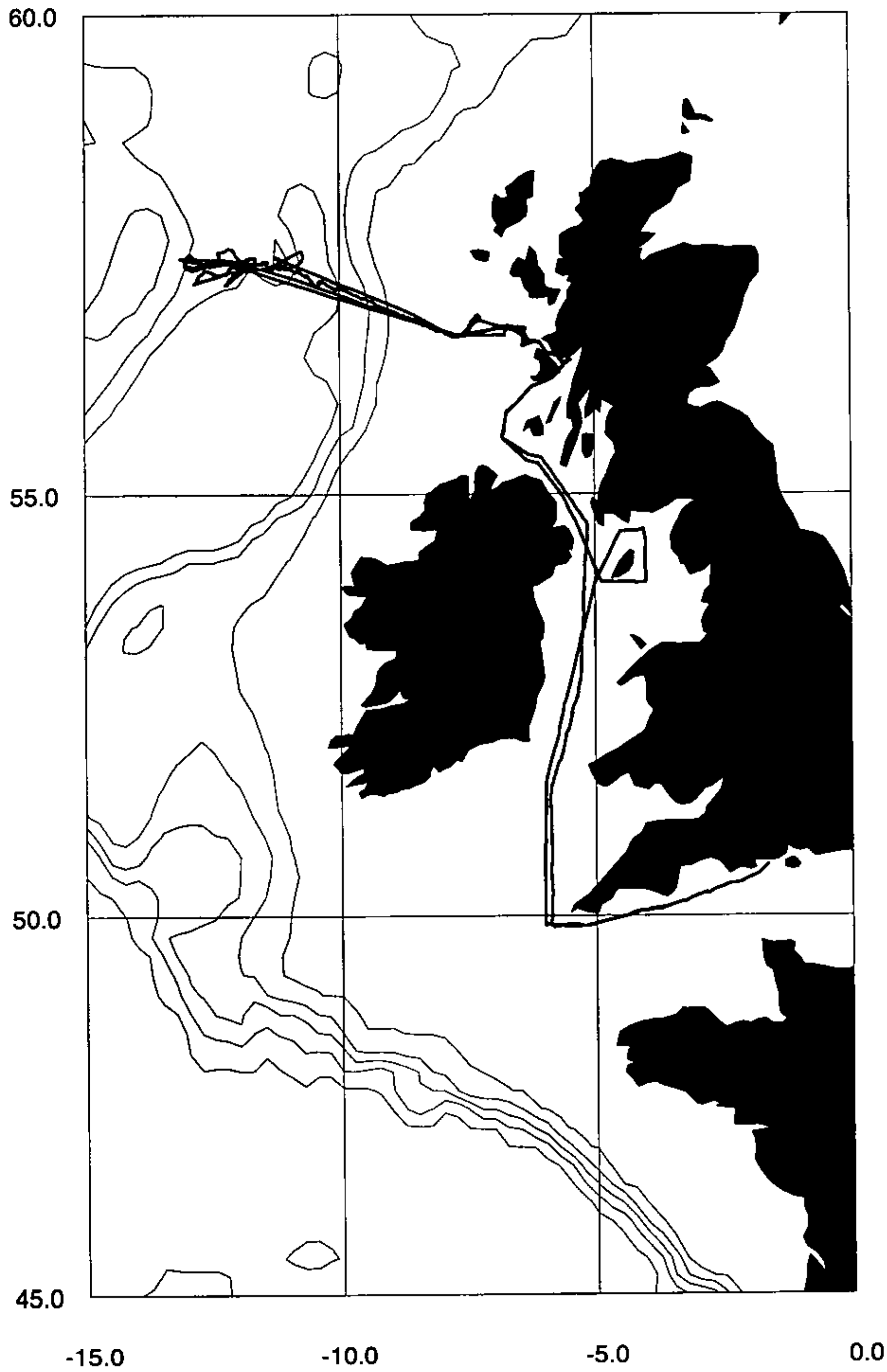
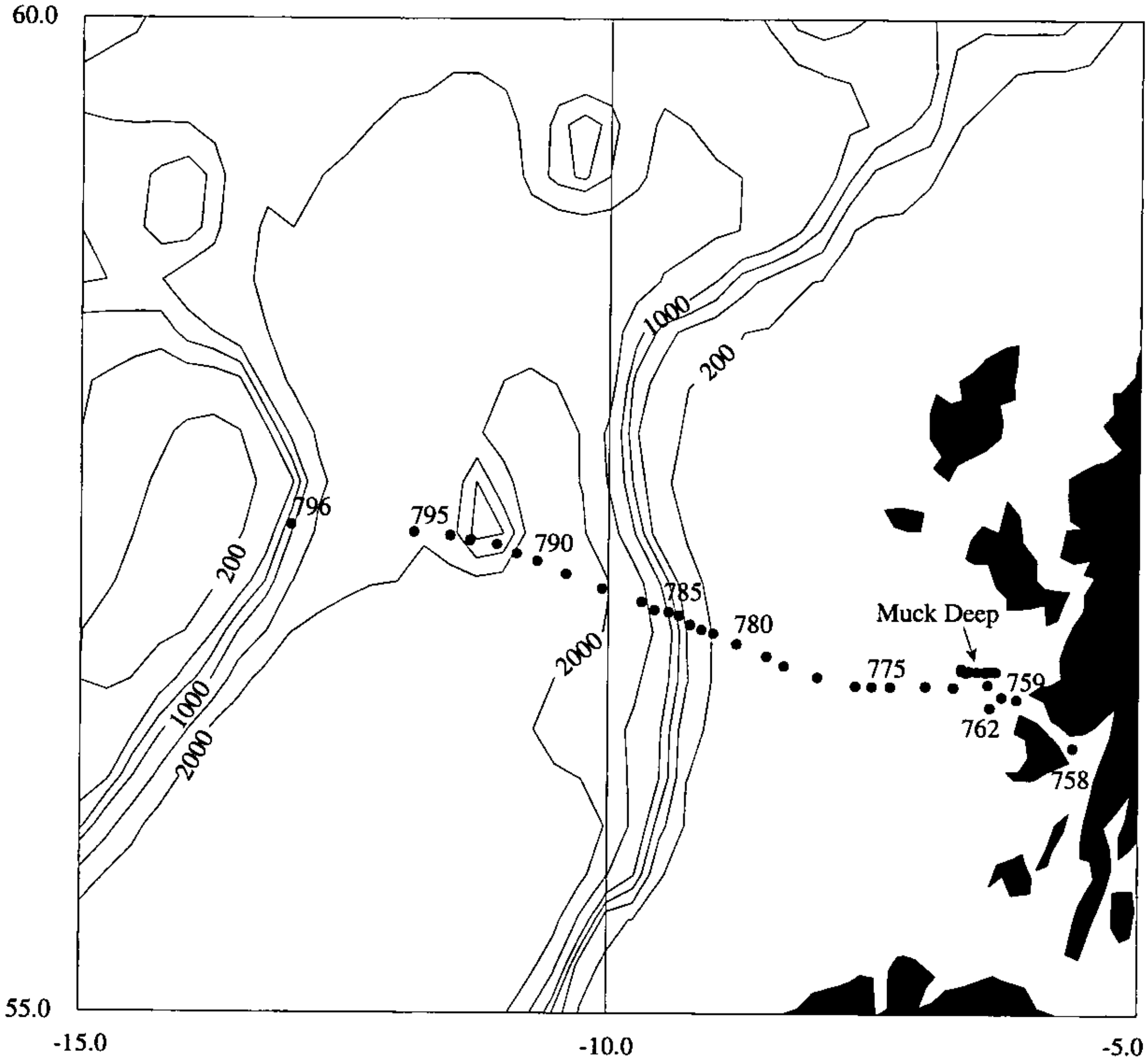
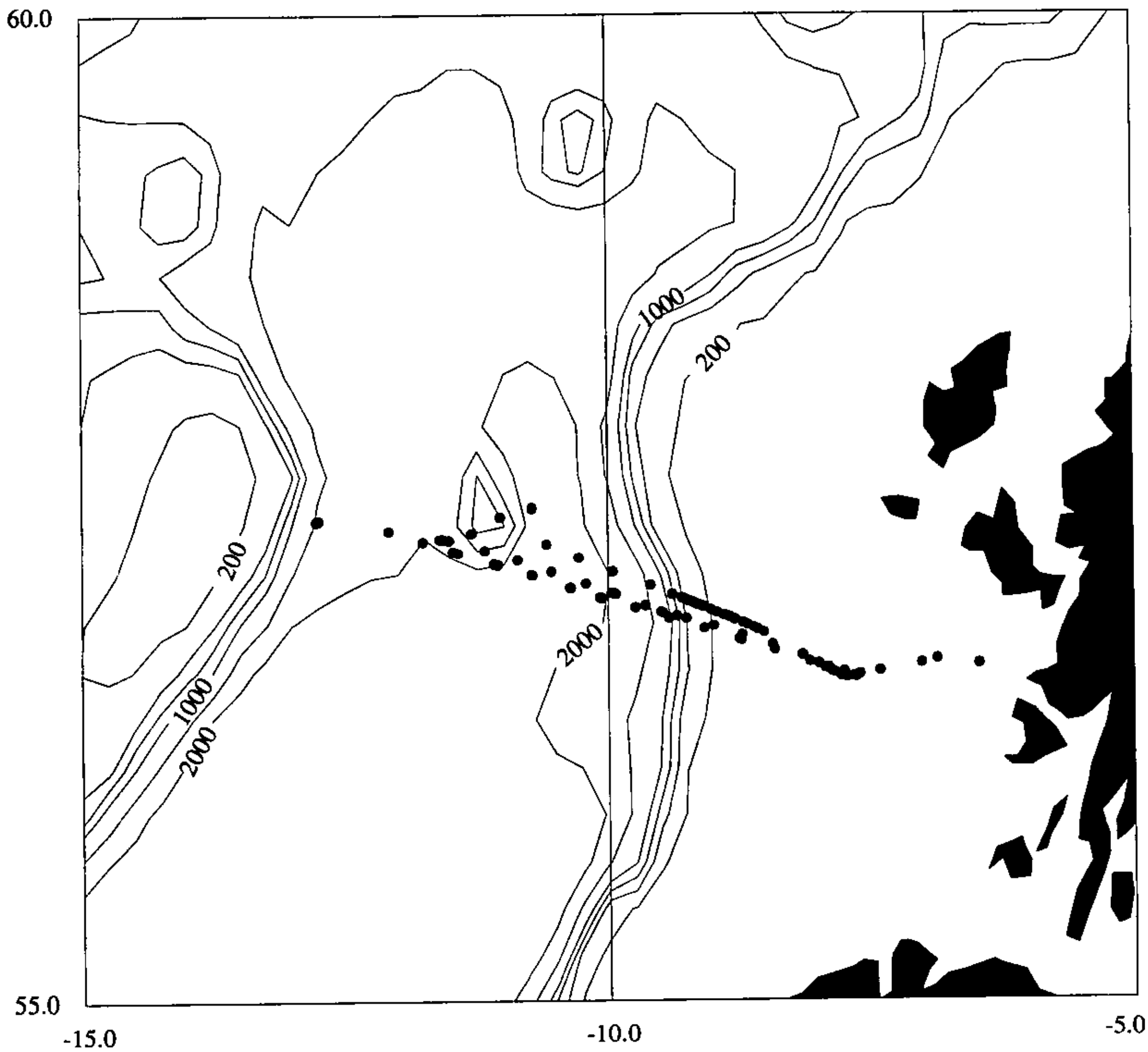


Figure 1.2 CTD Positions



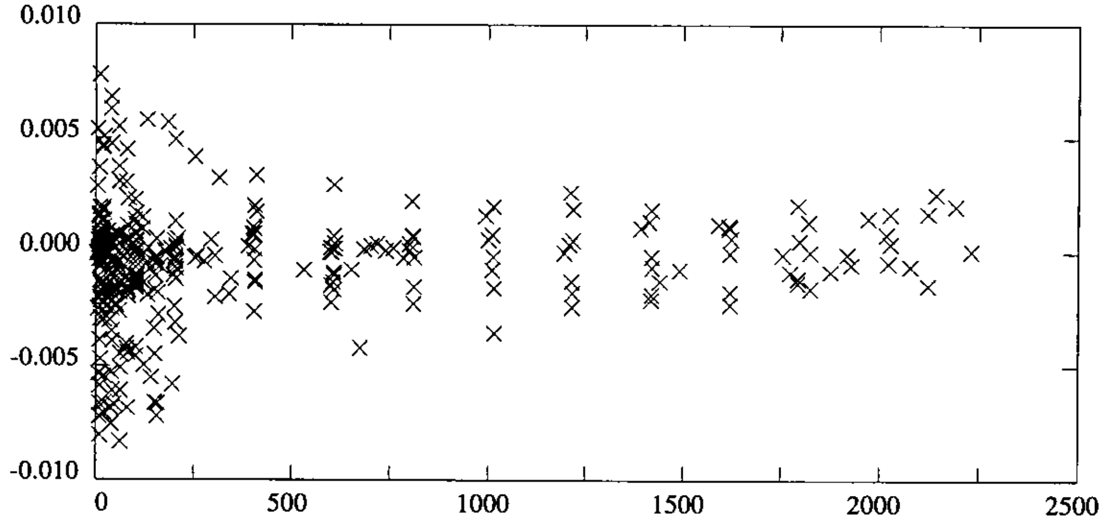
Contour intervals 200, 500, 750, 1000, 1500 and 2000m

Figure 1.3 XBT Positions

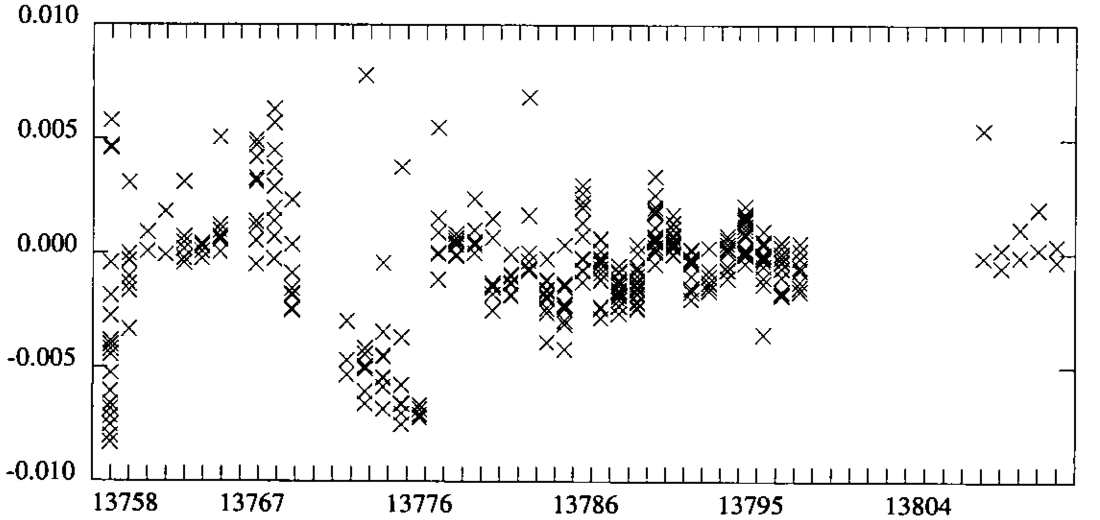


Contour intervals 200, 500, 750, 1000, 1500 and 2000m

Figure 2.1 Salinity Residuals

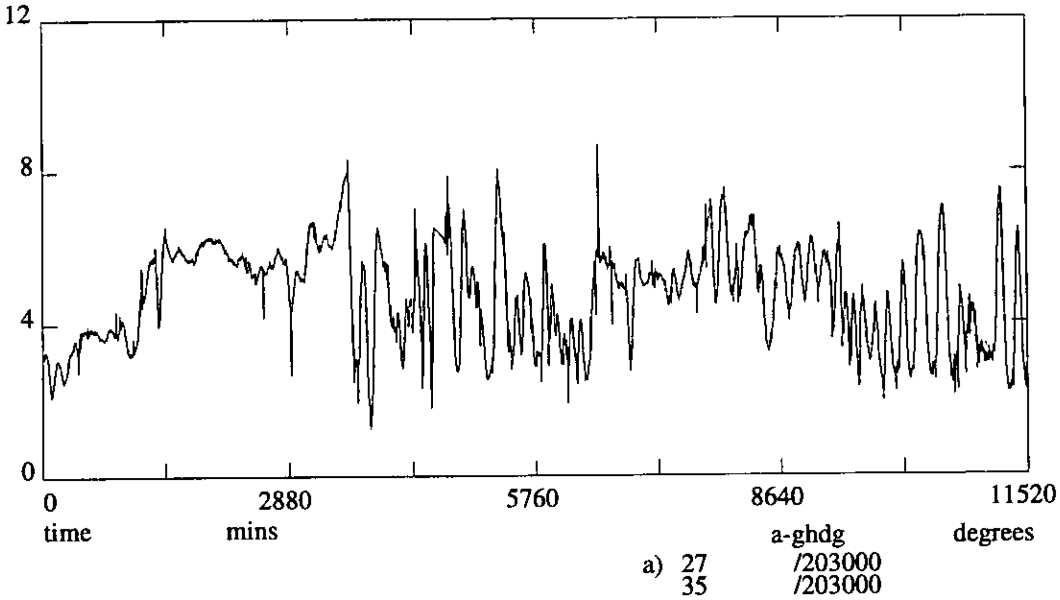


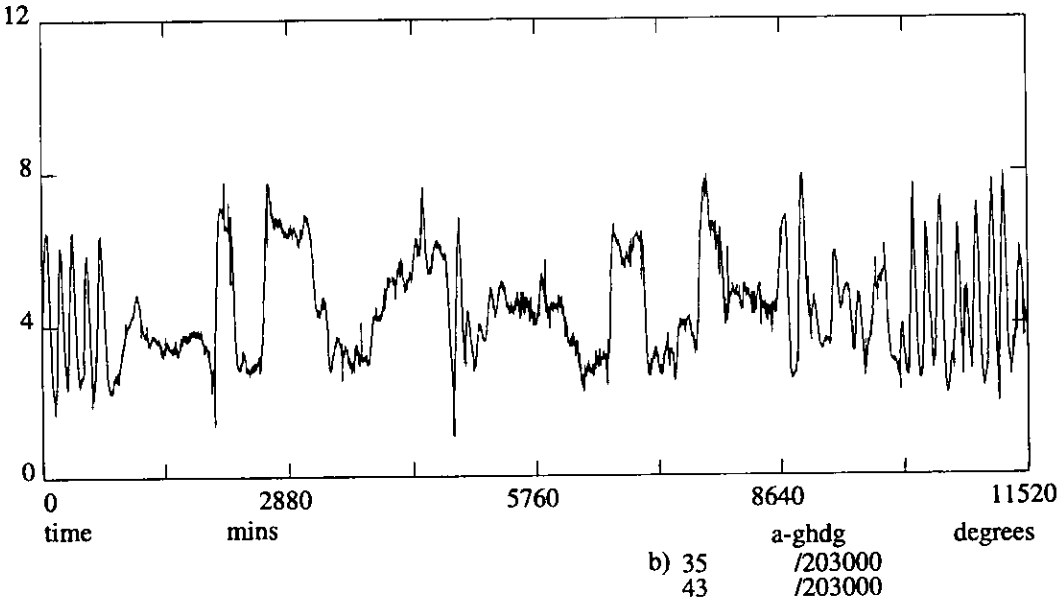
a) (Bottle Salinity - CTD) against Pressure



b) (Bottle Salinity - CTD) against Station Number

Figure 4.1 Ashtech Minus Gyro Heading





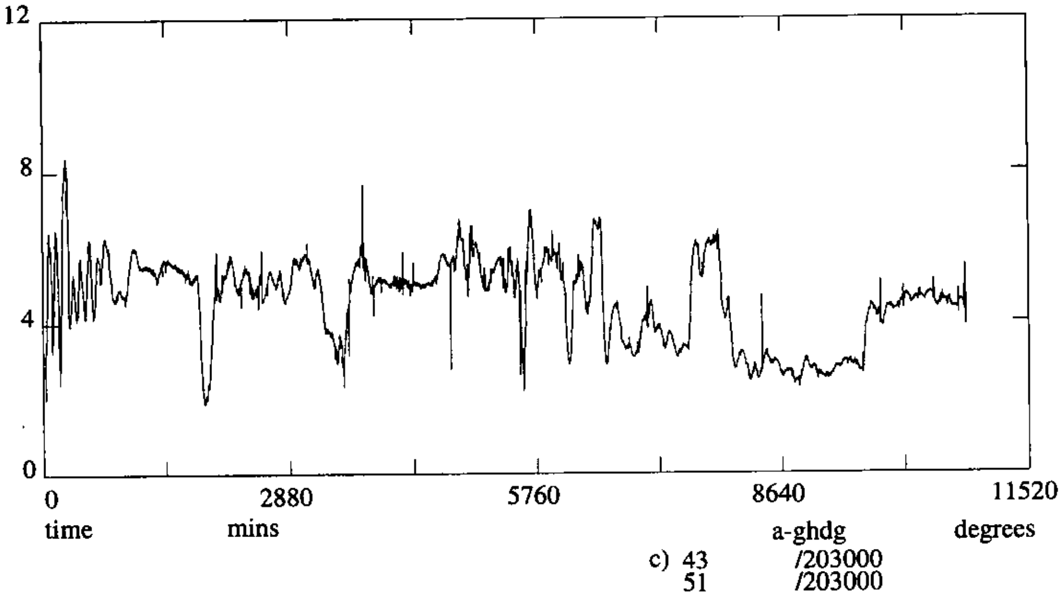
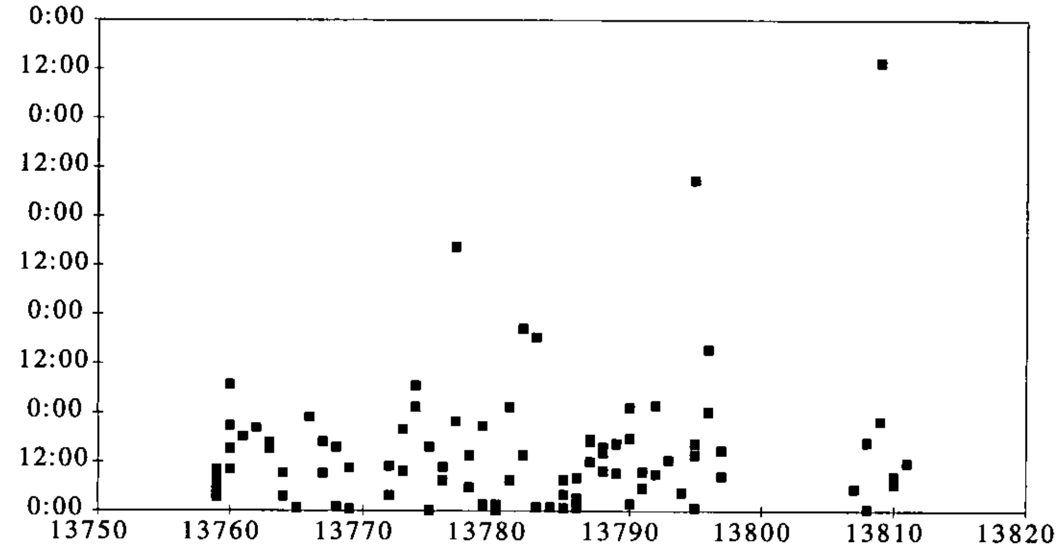
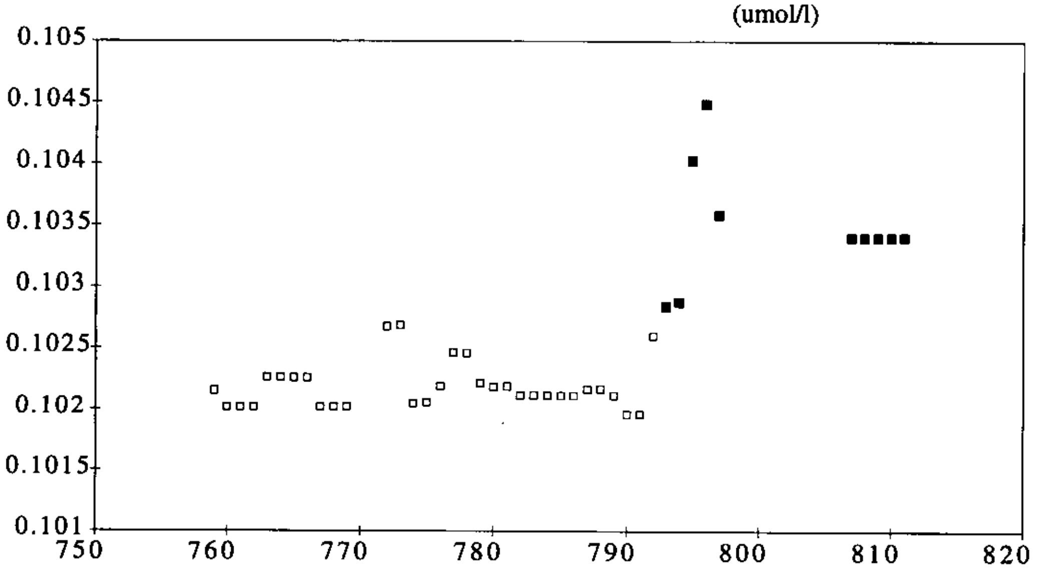


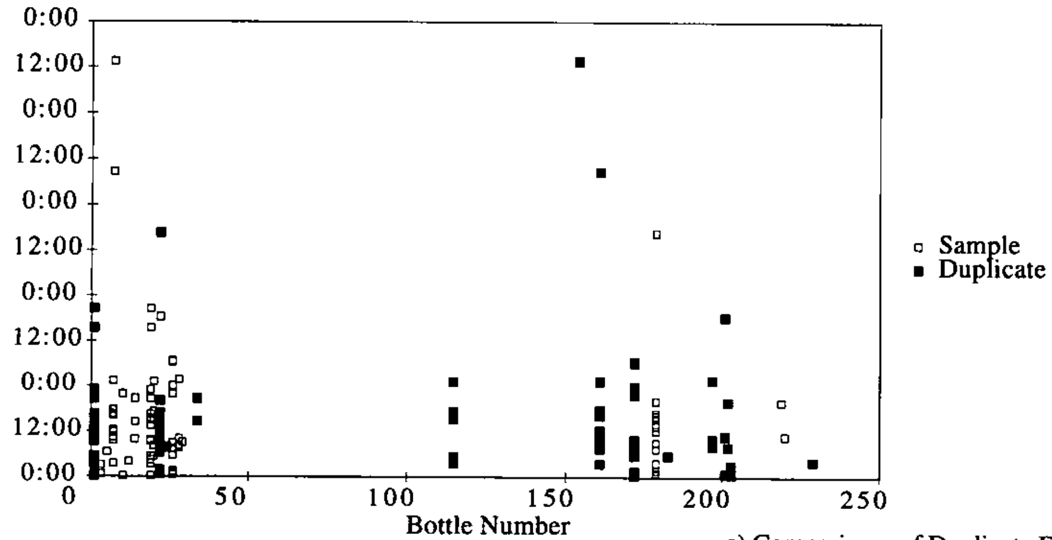
Figure 5.1 Oxygen Duplicates



a) Duplicate Difference at Each Station (umol/l)

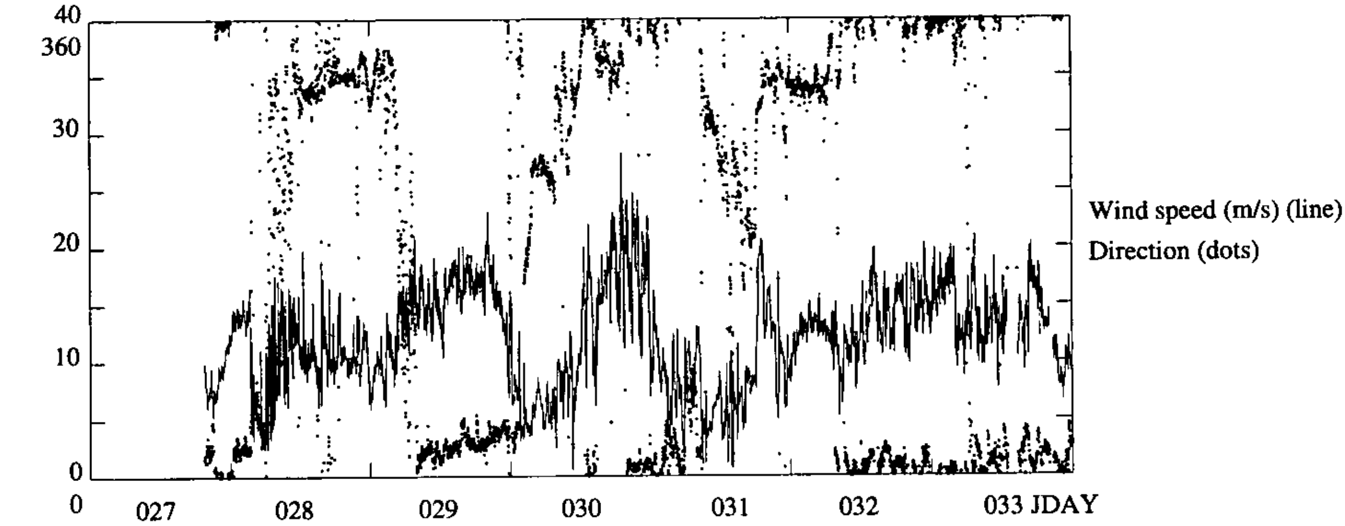


b) Thiosulphate Normality

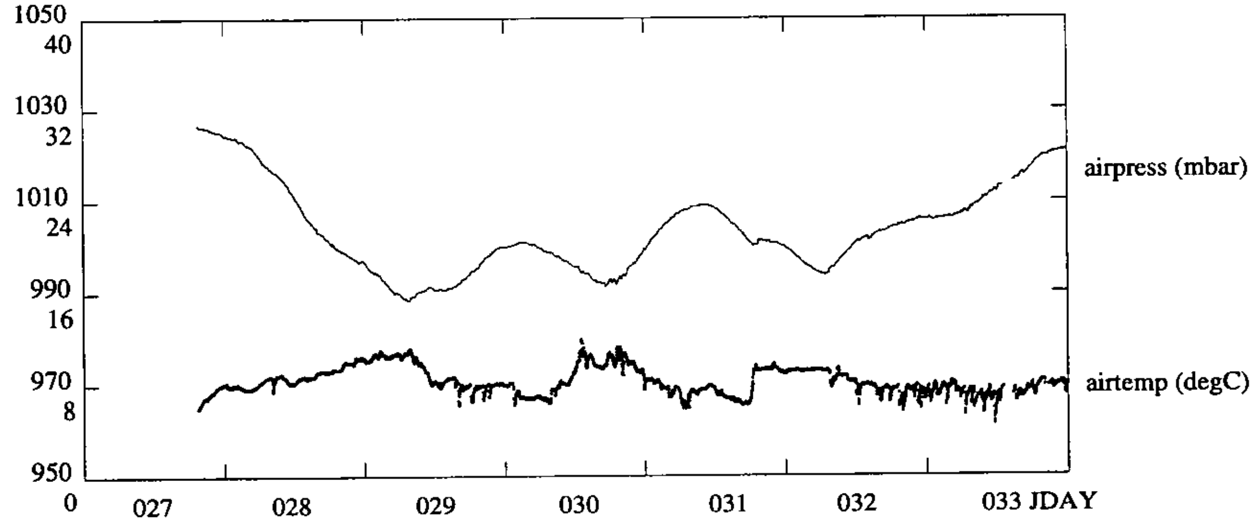


c) Comparisons of Duplicate Difference with Bottle used (umol/l)

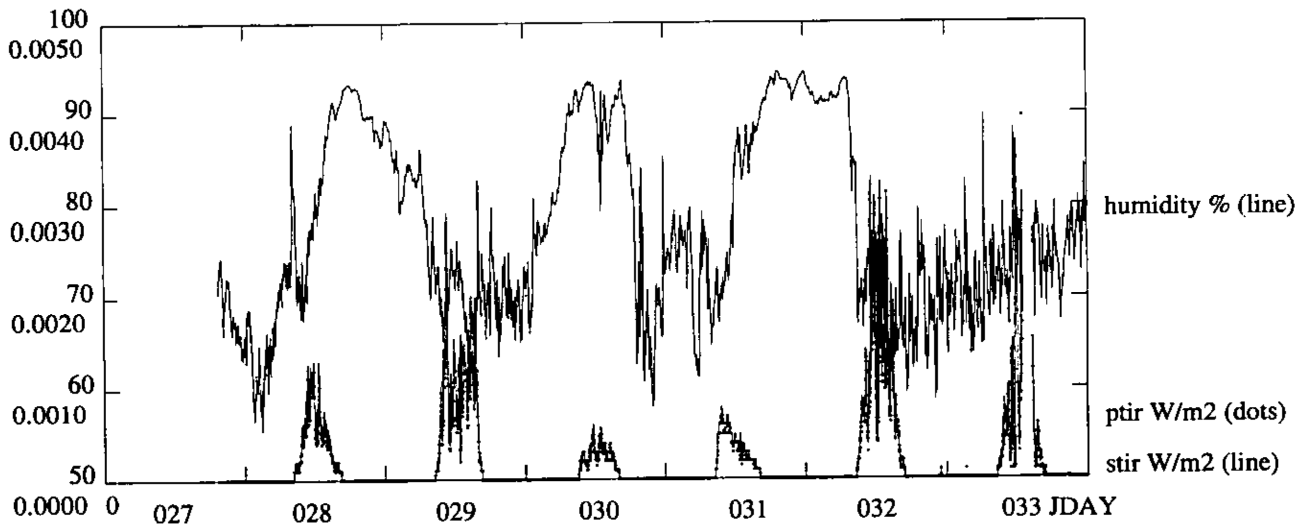
Figure 6.1. Surface Meteorology: Week 1



a) Wind Speed and Direction

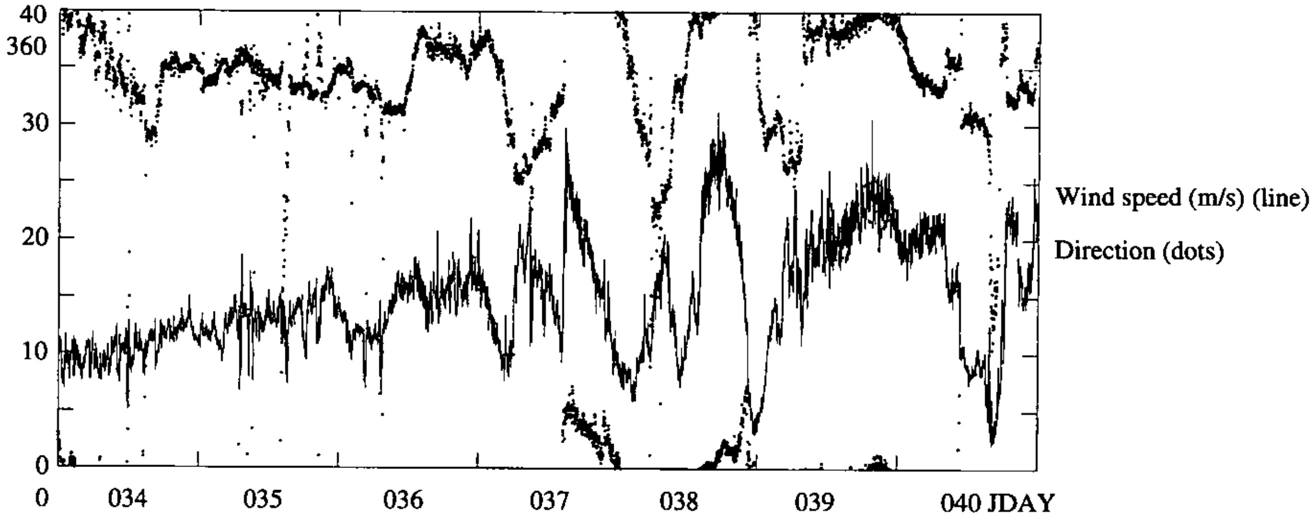


b) Air Temperature and Pressure

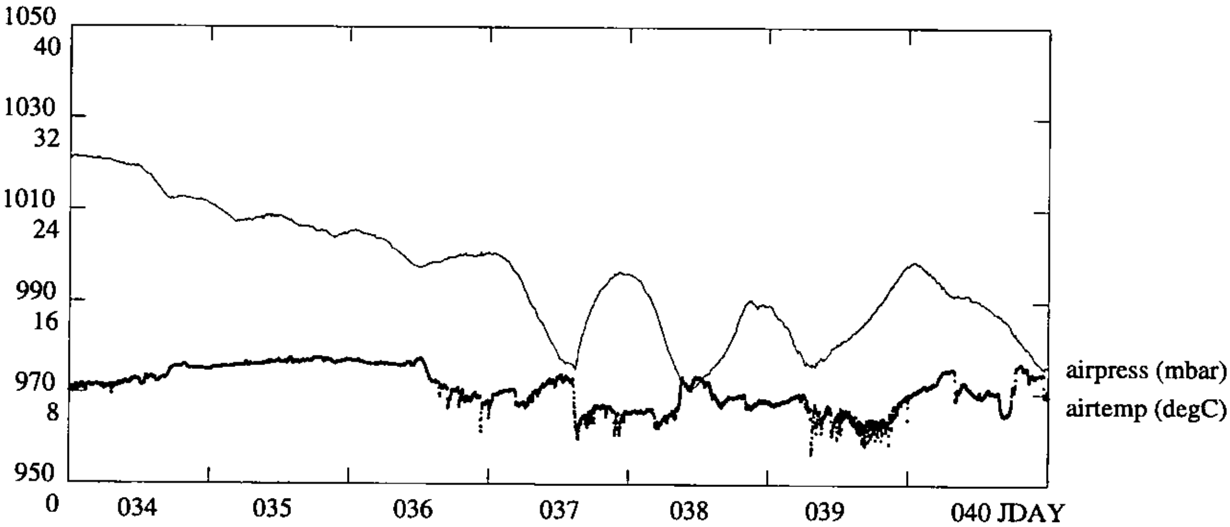


c) Humidity and Light

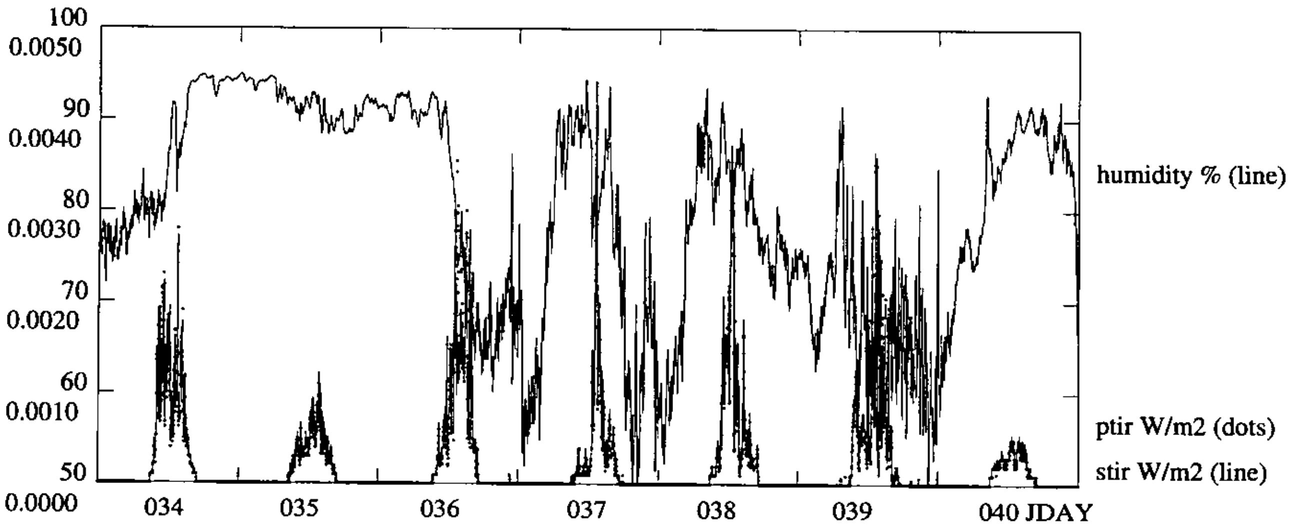
Figure 6.2 Surface Meteorology: Week 2



a) Wind Speed and Direction

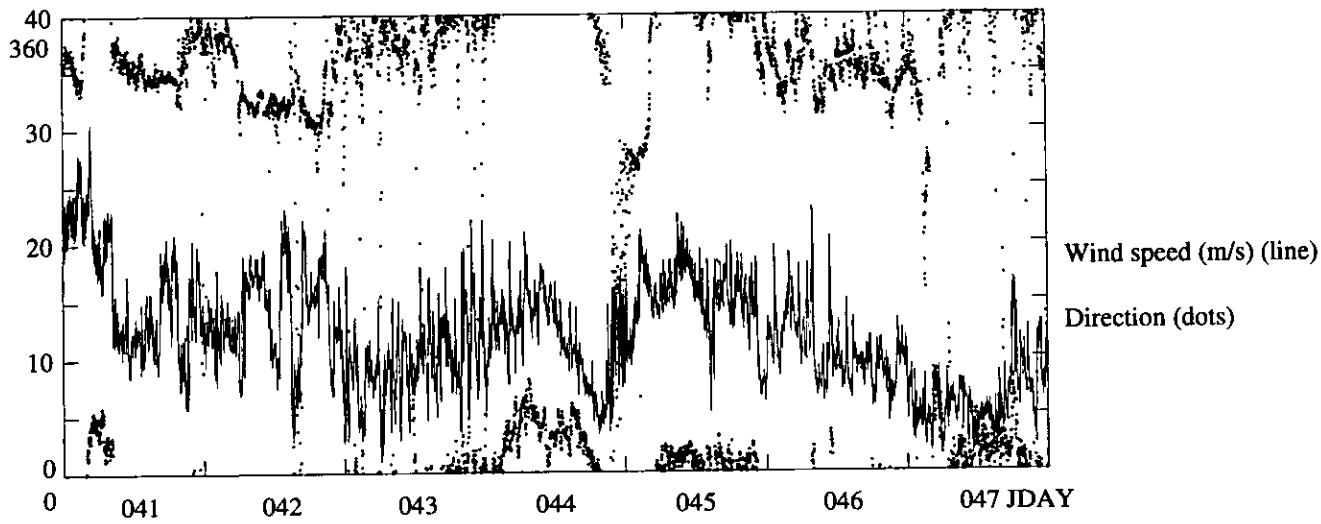


b) Air Temperature and Pressure

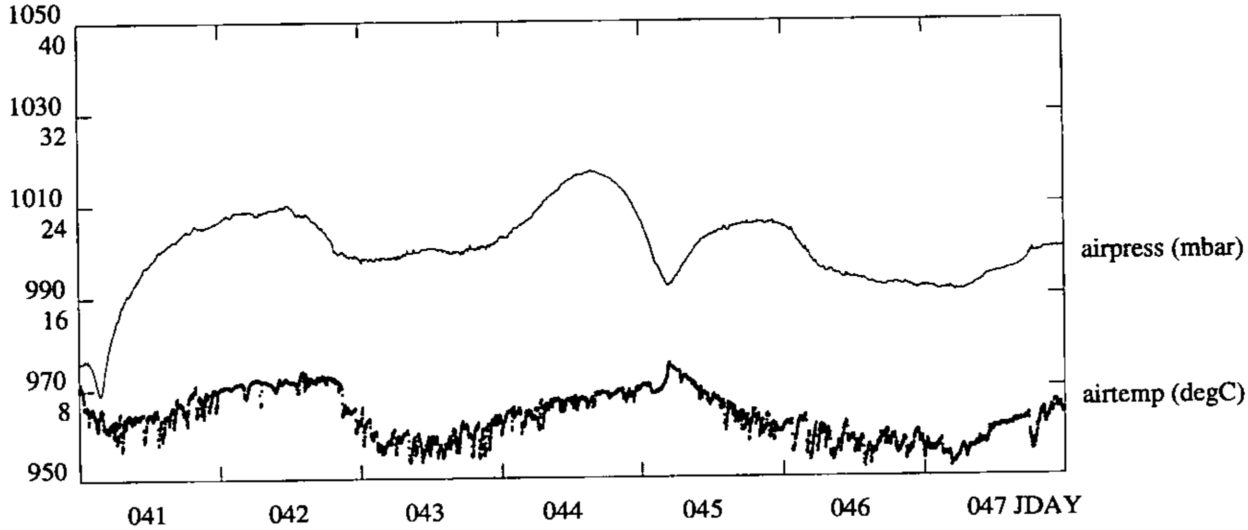


c) Humidity and Light

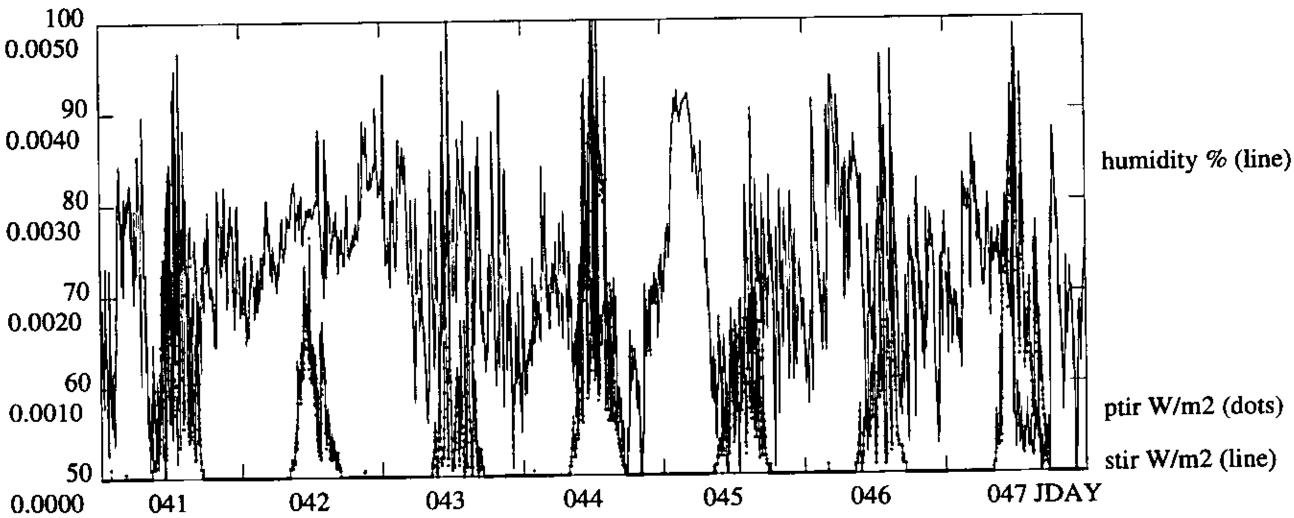
Figure 6.3 Surface Meteorology: Week 3



a) Wind Speed and Direction

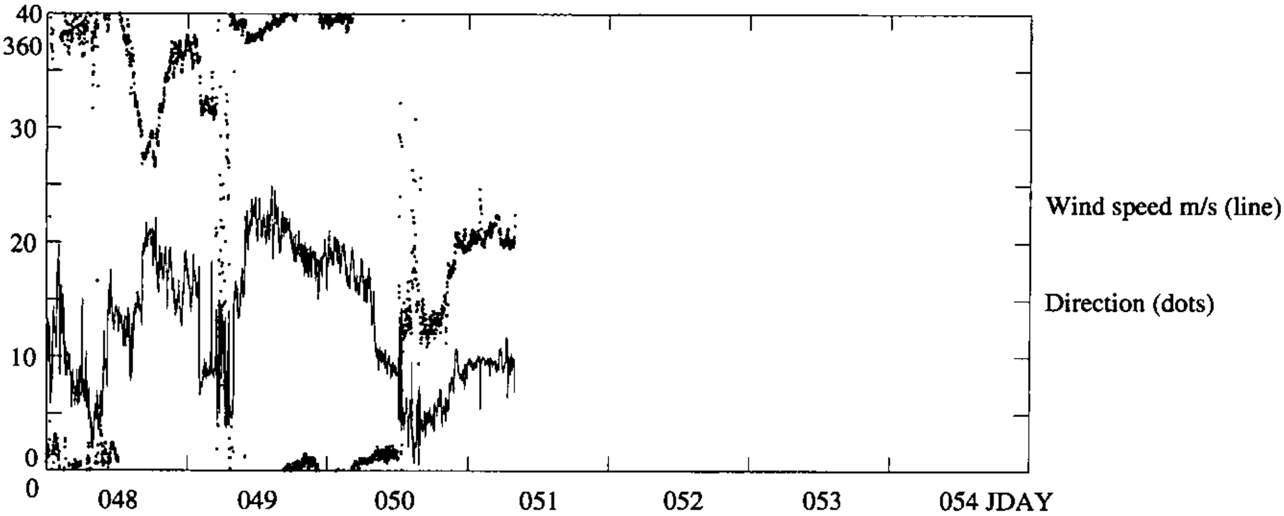


b) Air Temperature and Pressure

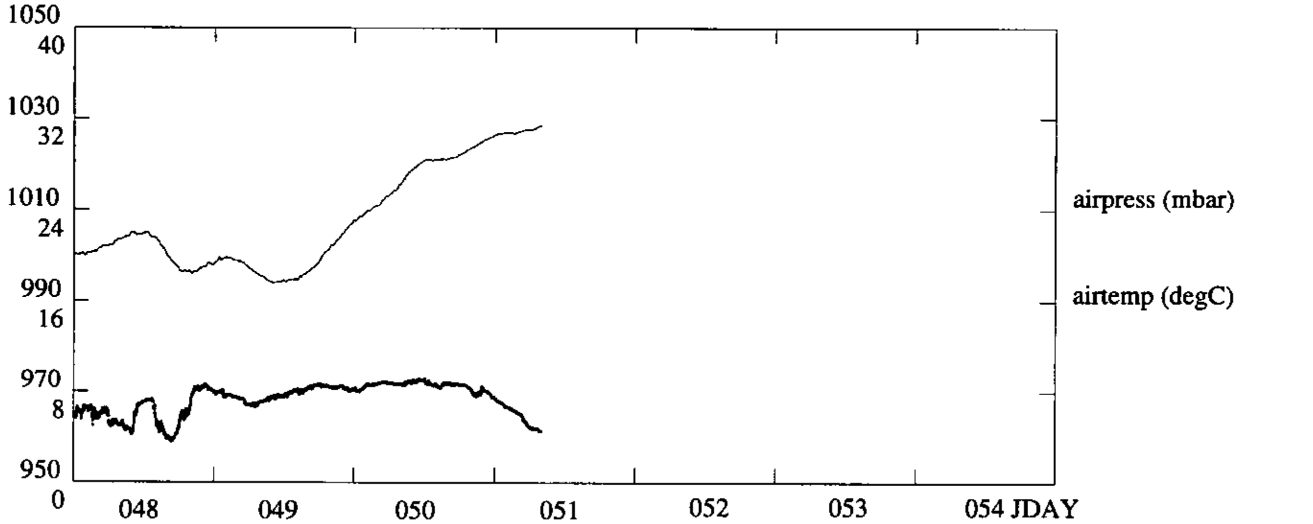


c) Humidity and Light

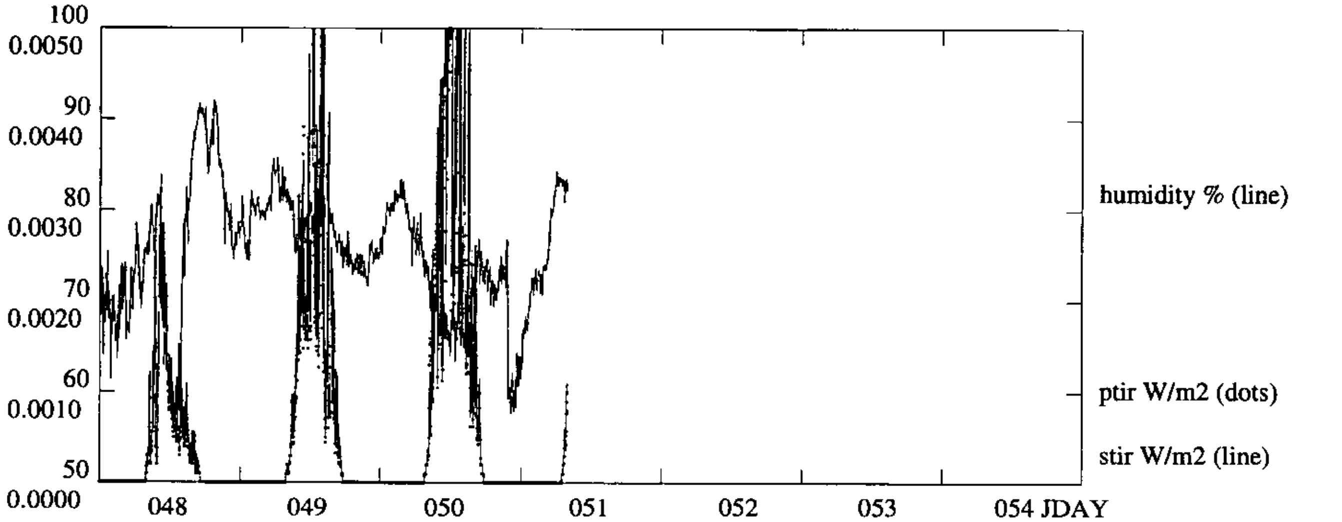
Figure 6.4 Surface Meteorology: Week 4



a) Wind Speed and Direction



b) Air Temperature and Pressure



c) Humidity and Light

Figure 7.1 Tiree Passage (Mooring Y)
Lat 56 37.53 N   Lon 6 24.51W
Depth 45m

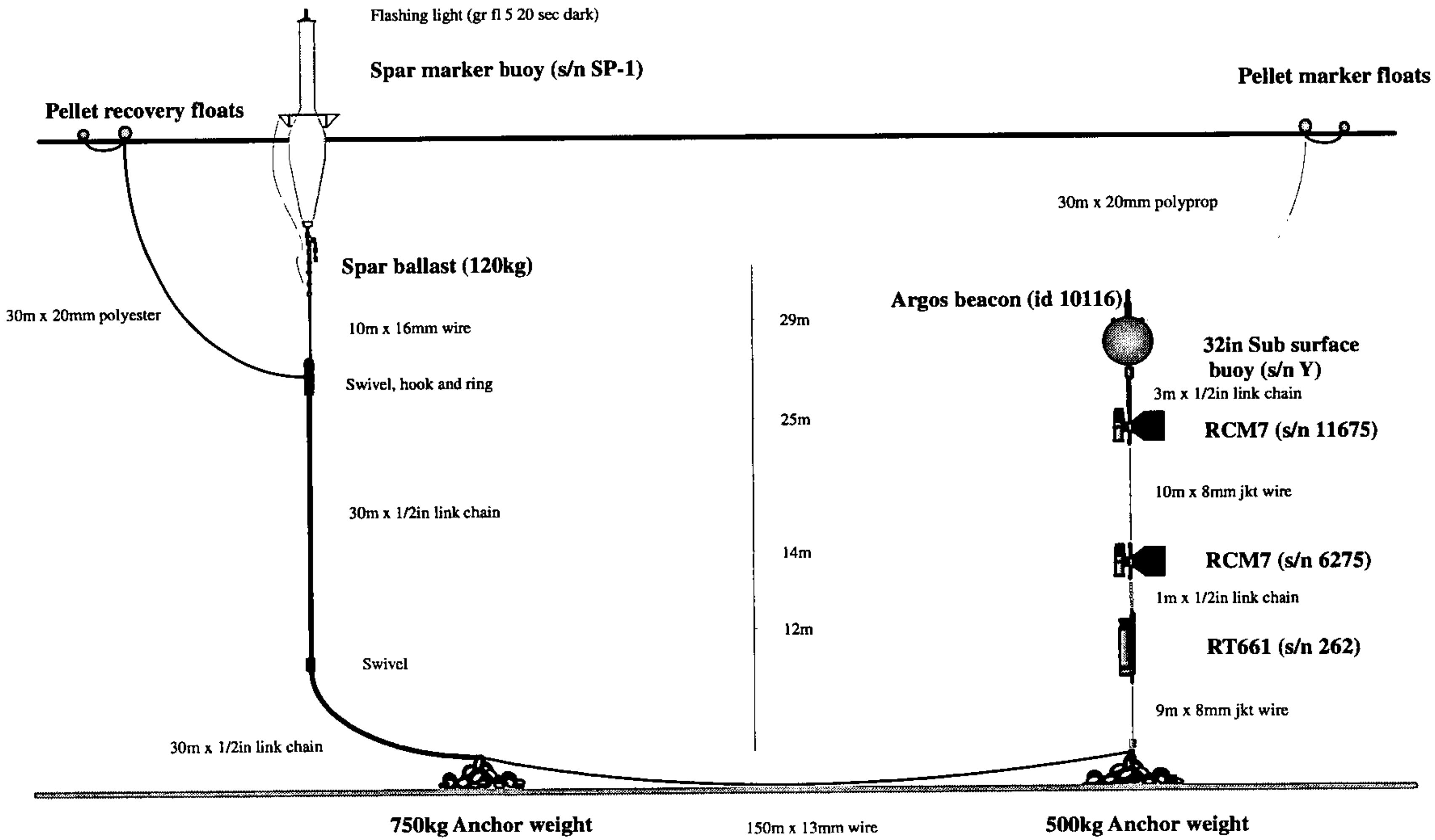


Figure 7.2 Muck Deep (Mooring MH)
Lat 56 48.61 N   Lon 6 30.86 W
Depth 311m

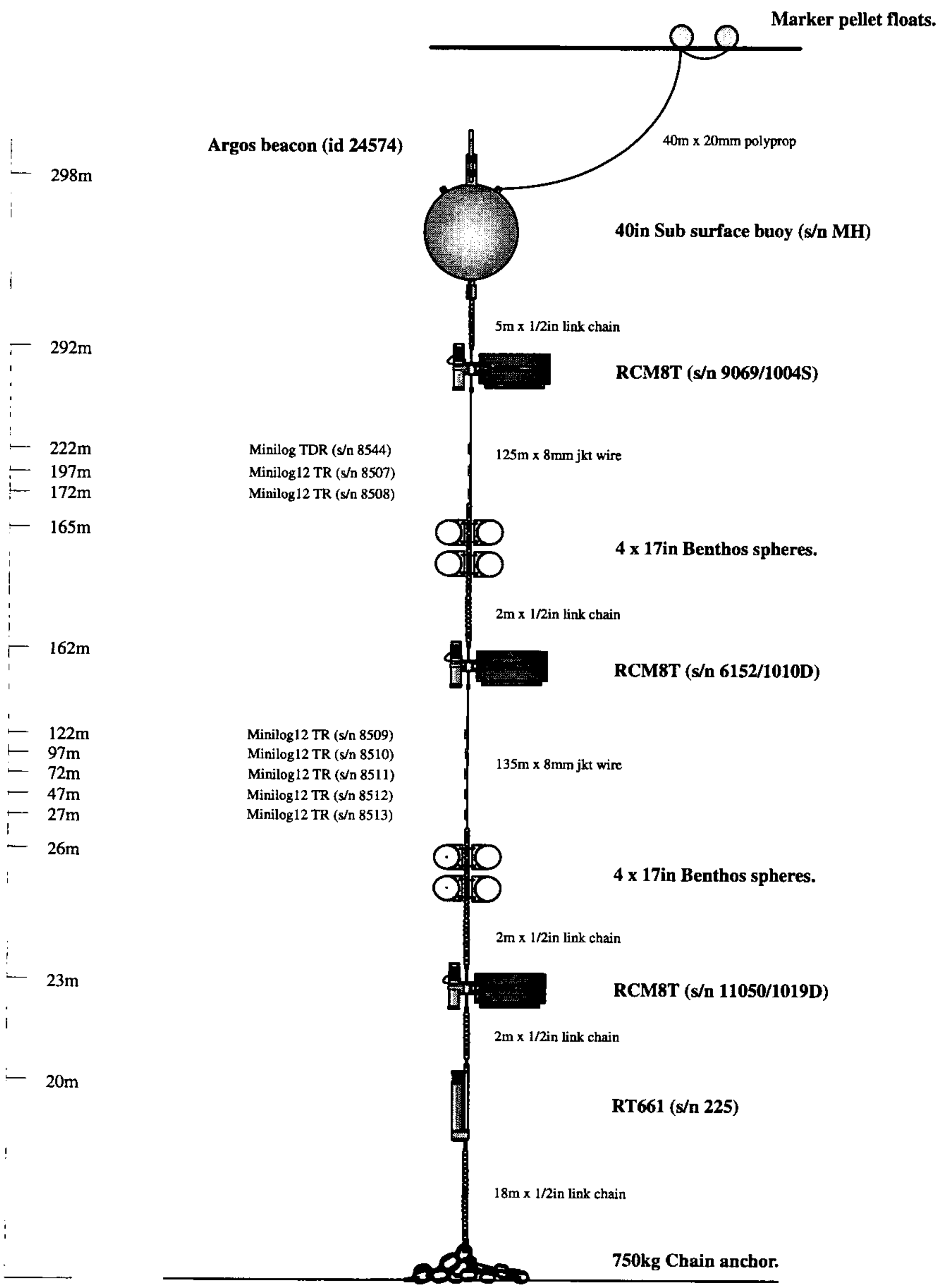


Figure 7.3 Station F (Mooring F)
Lat 57 31.54N Lon 12 14.54W
Depth 1805m

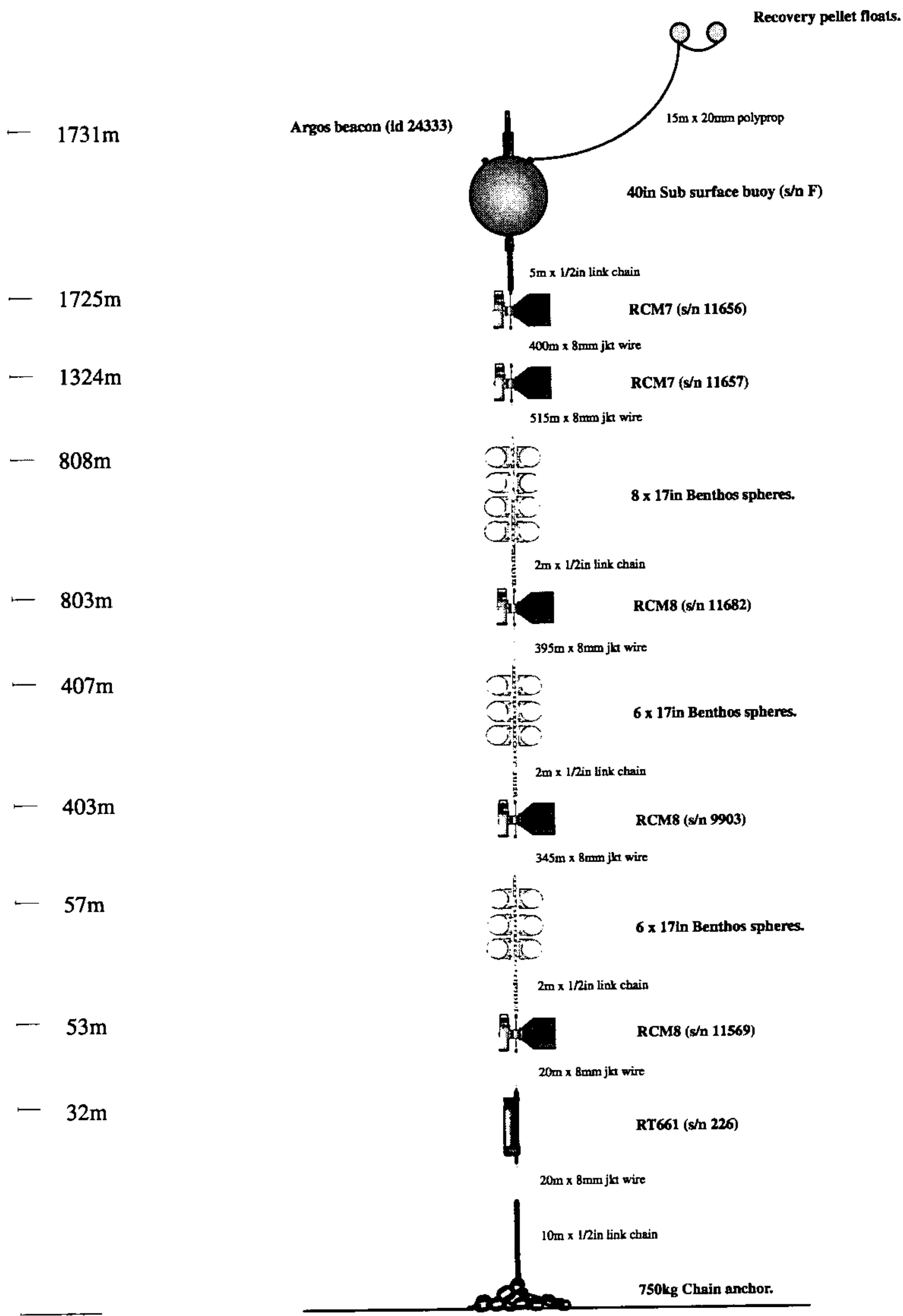


Figure 7.4 Station M (Mooring M)
Lat 57 17.25N   Lon 10 23.09W
Depth 2222m

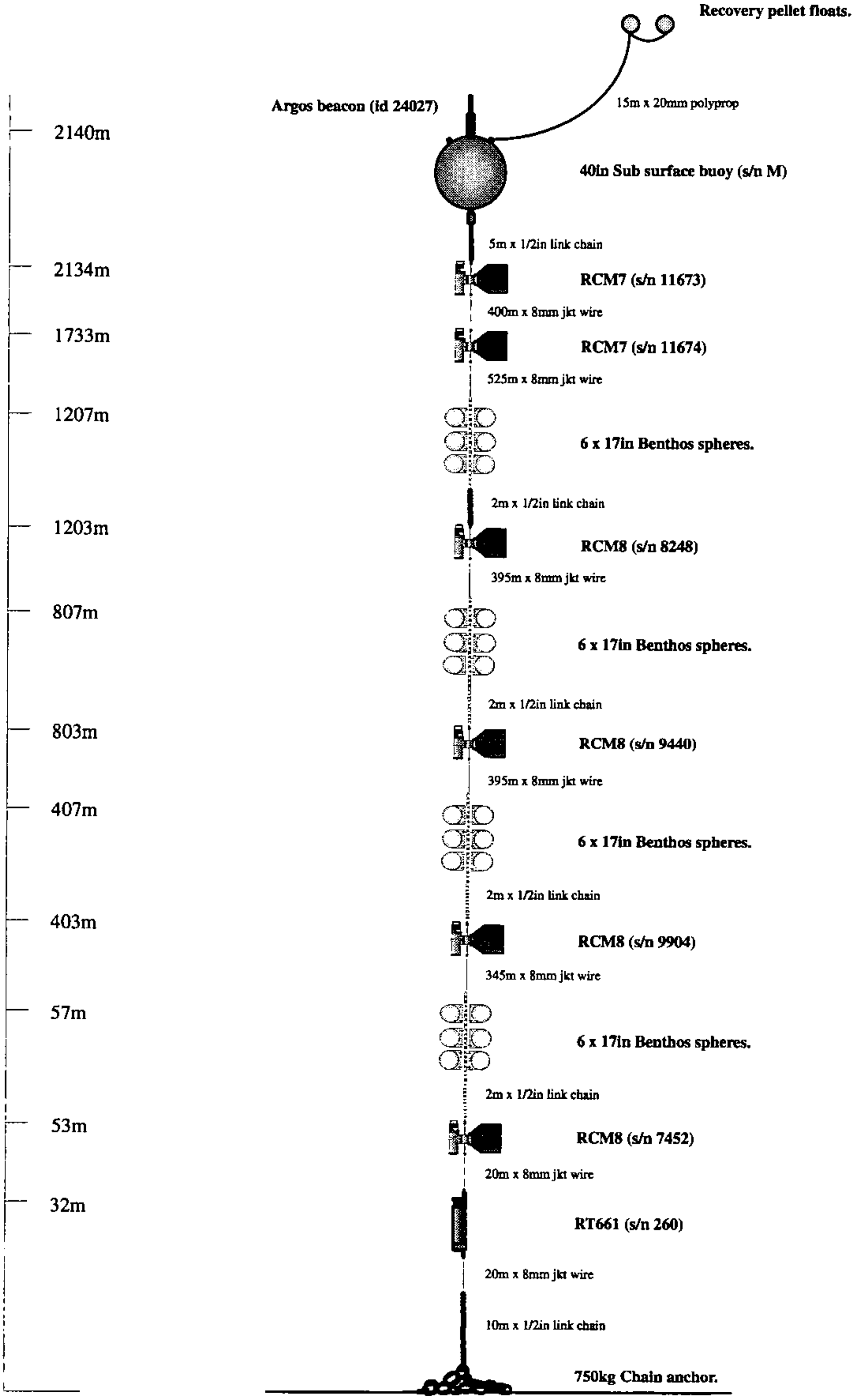
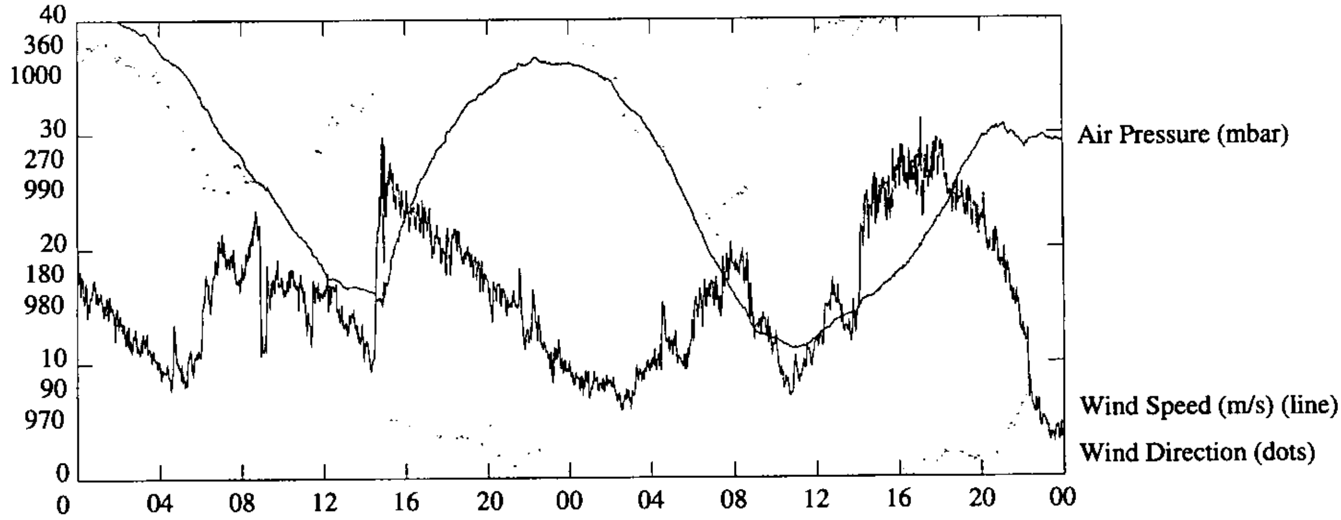
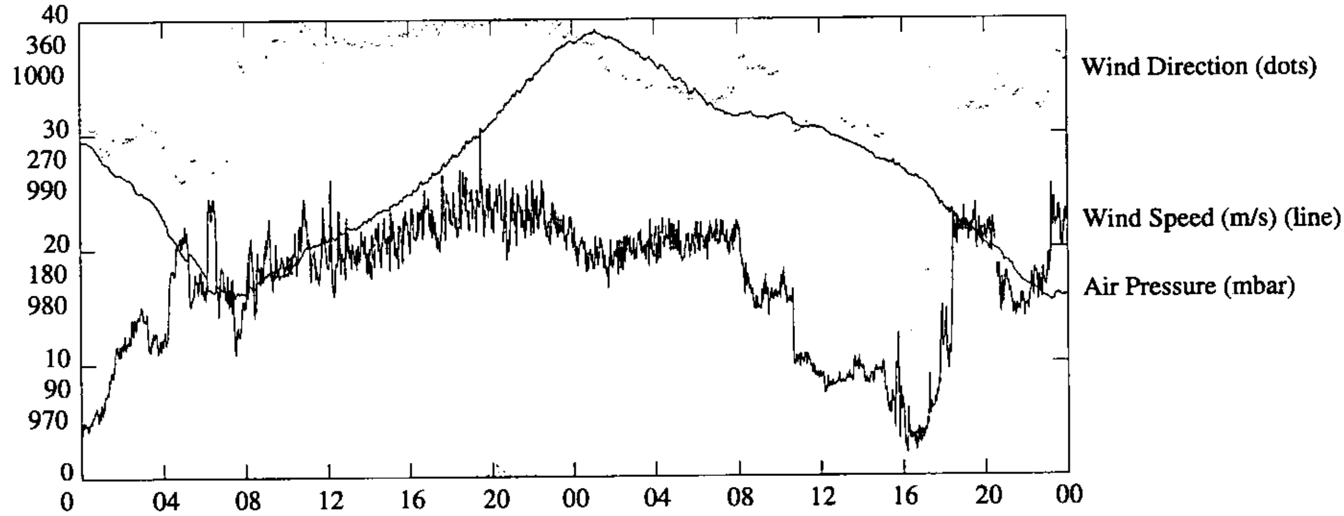


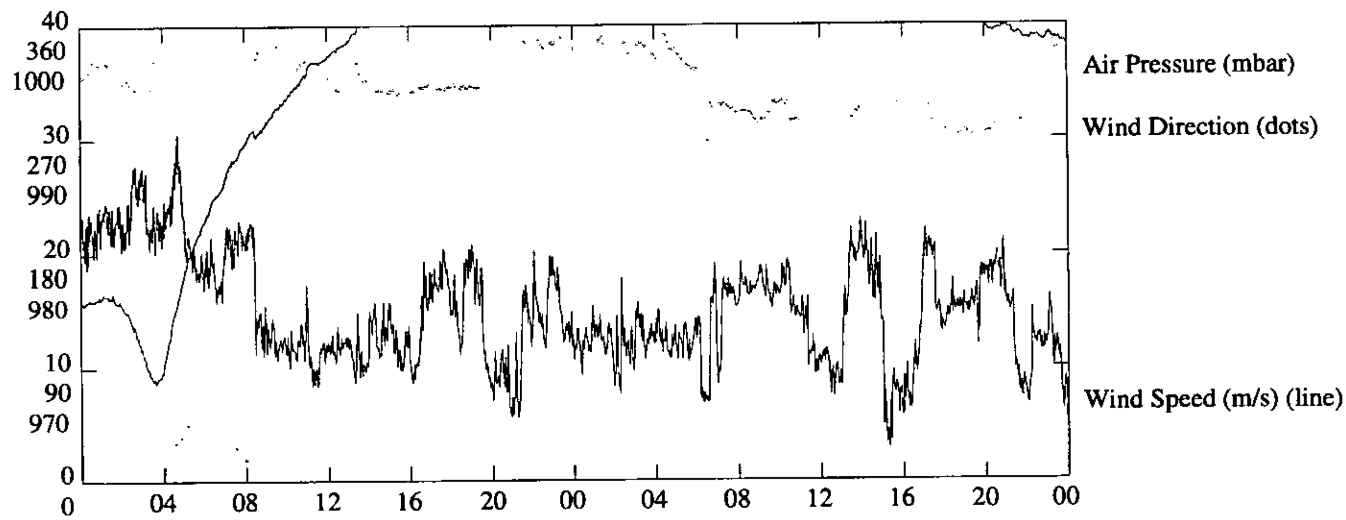
Figure 11.1 Stormy Weather



a) Days 37 and 38

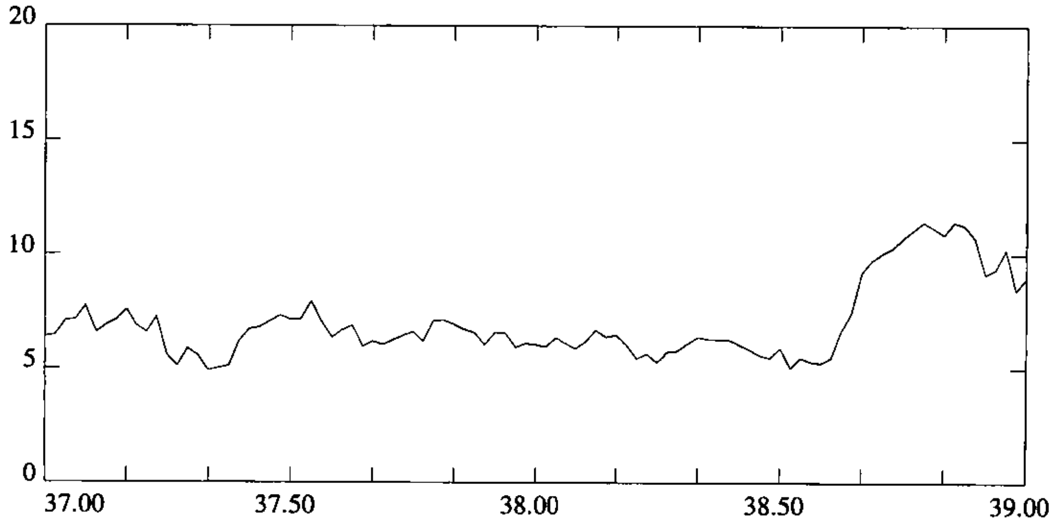


b) Days 39 and 40

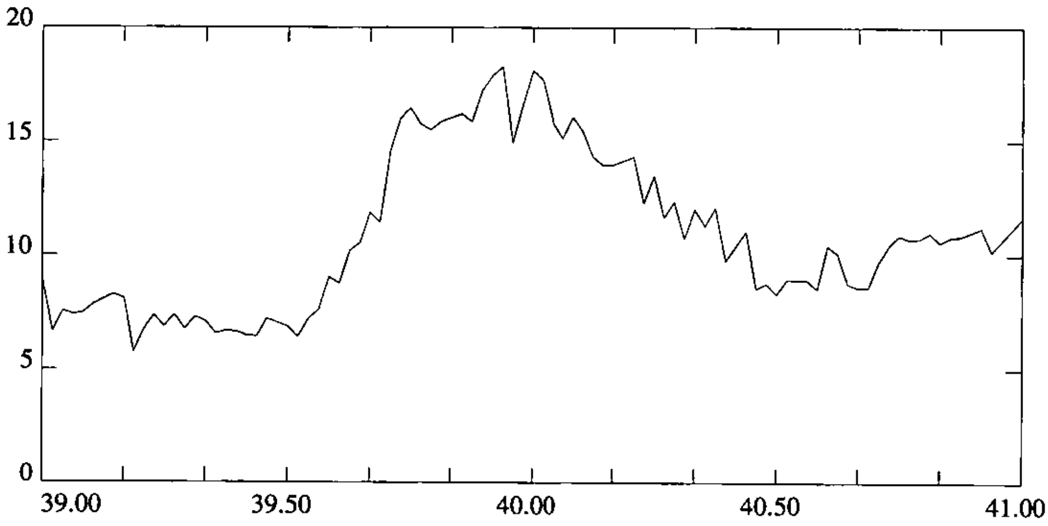


c) Days 41 and 42

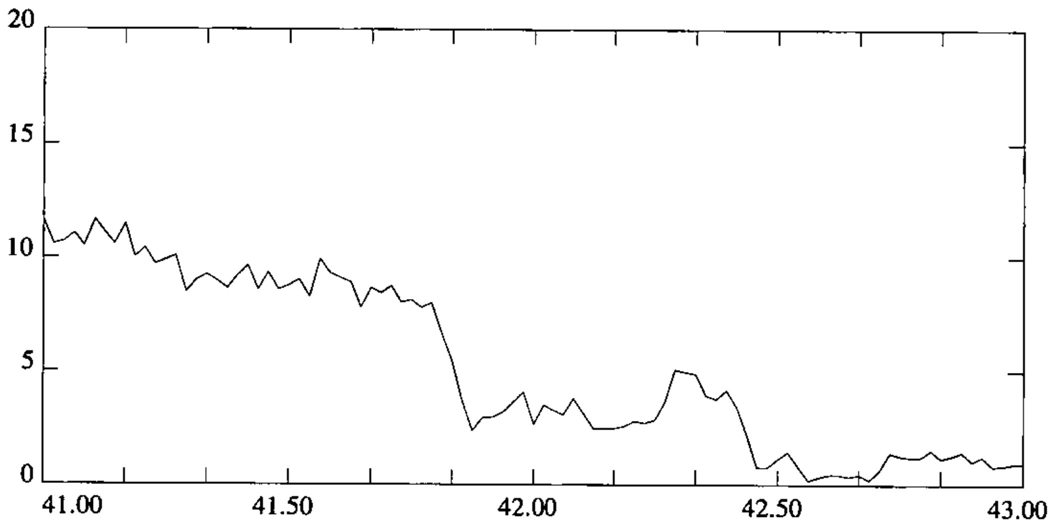
Figure 11.2 Significant Wave Height (m)



a) Days 37 and 38

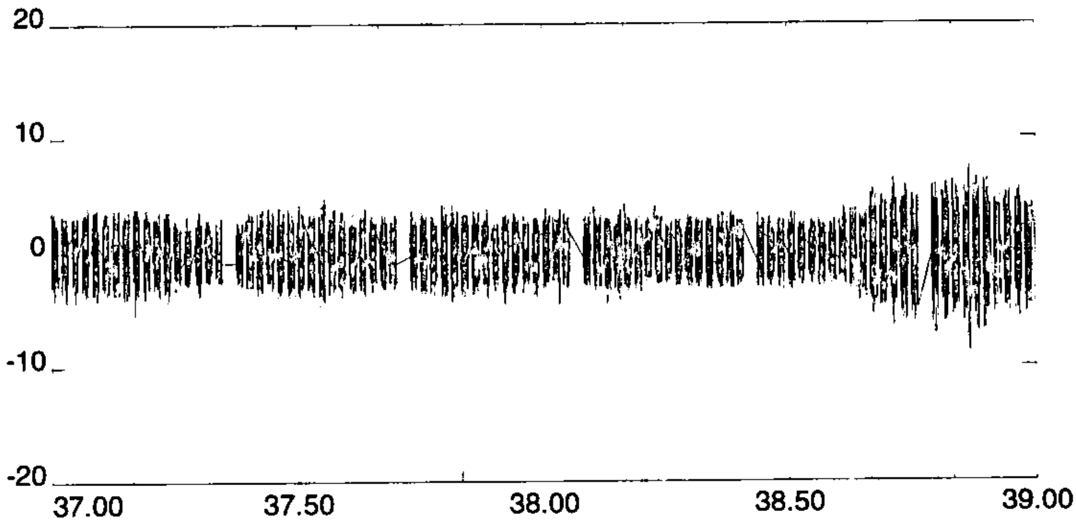


b) Days 39 and 40

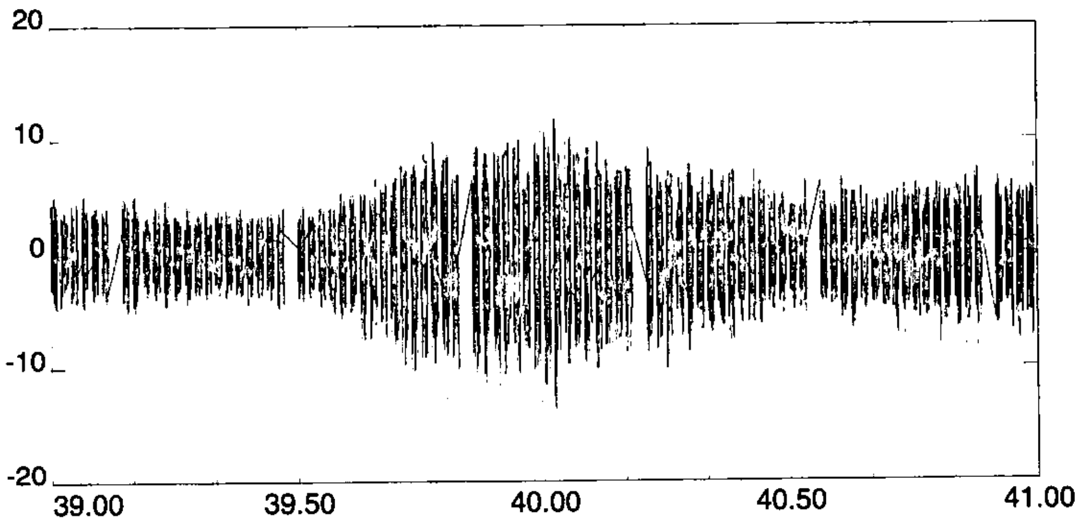


c) Days 41 and 42

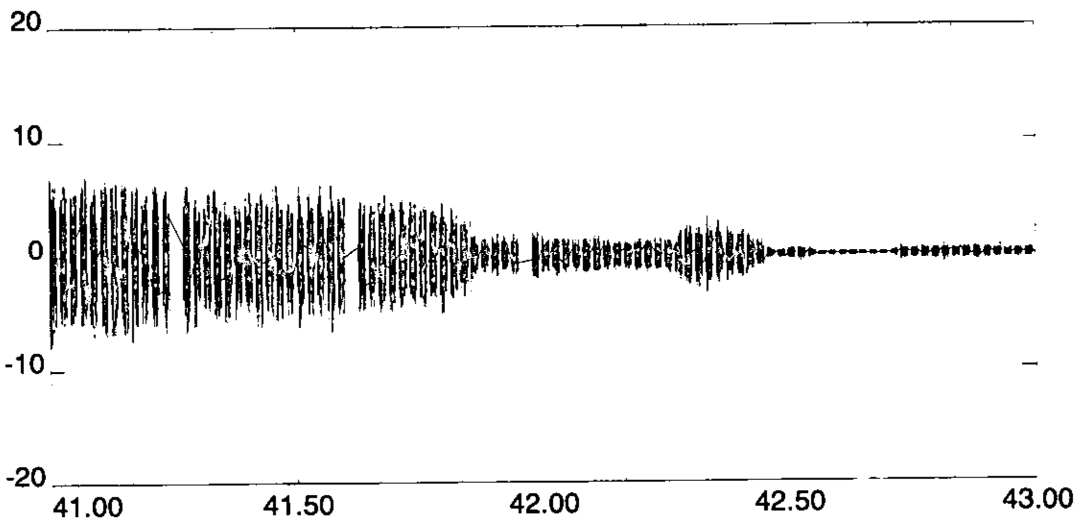
Figure 11.3 Uncorrected Wave Height (m)



a) Days 37 and 38

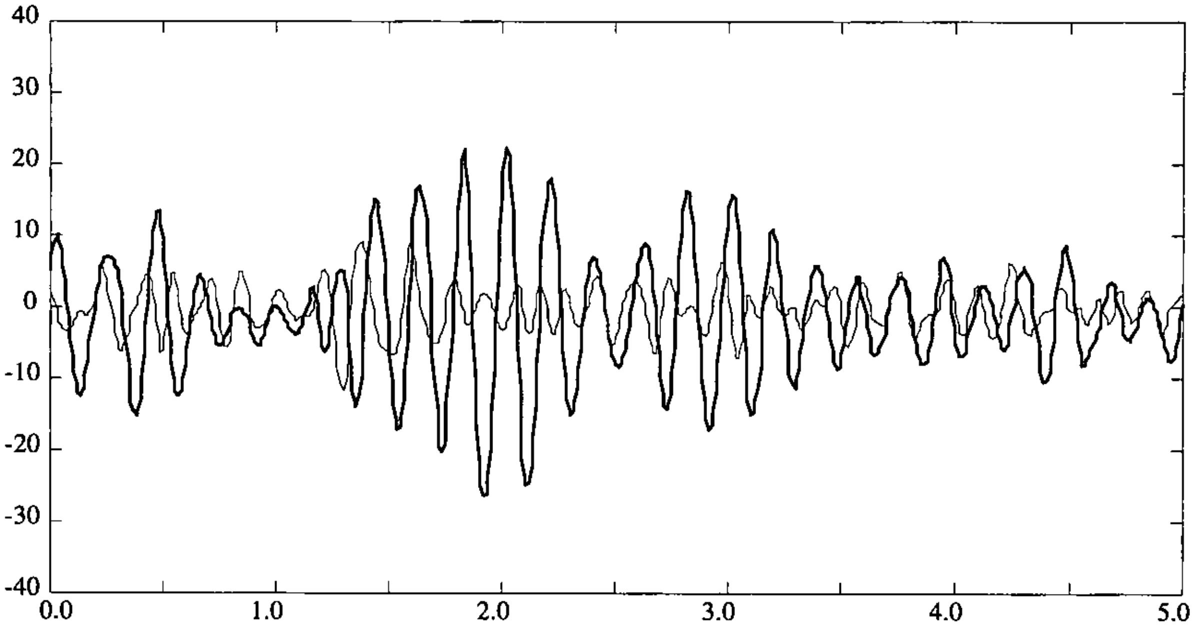


b) Days 39 and 40

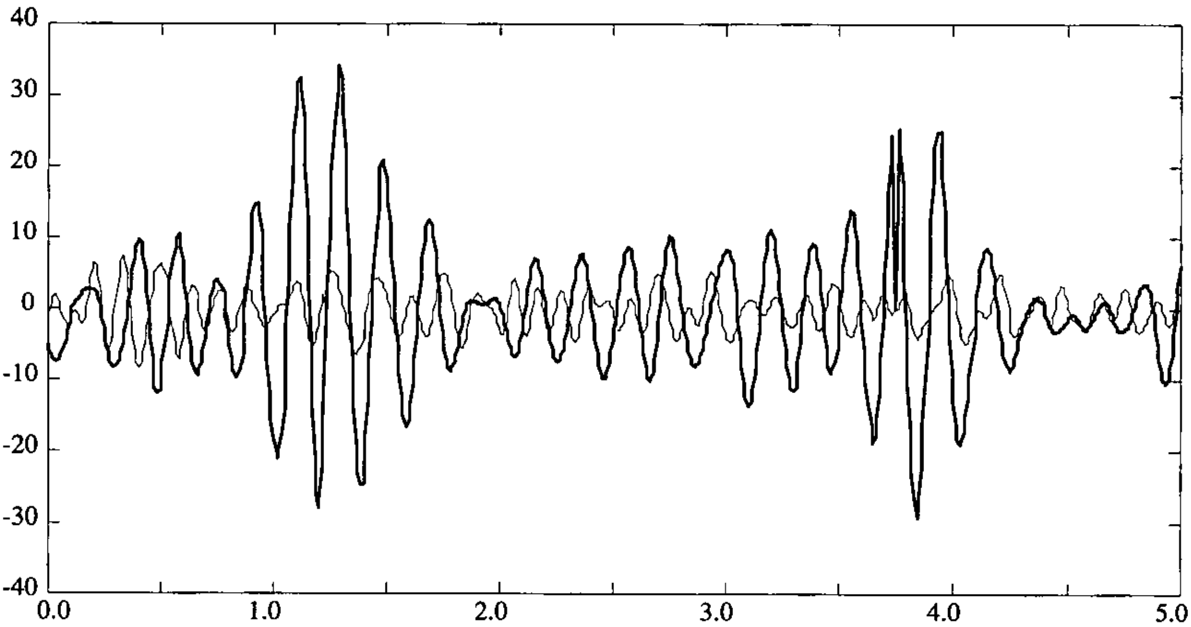


c) Days 41 and 42

Figure 11.4 Storm Highlights: the pitch and roll



a) Day 40 0000 to 0005
Pitch (thin line) and Roll (thick line)



b) Day 41 0423 to 0428 (the "Lifeboat Roll")
Pitch (thin line) and Roll (thick line)

Appendices

1.1 CTD Stations

Station number	JDAY	Start time	Bottom Time	End Time	Lat			Lon			Water depth (m)	Hght off Bottom (m)	Max press	Max wireout	Number of Bottles	Station	LADCP Cast	Chl
13758	30	093754	094535	095500	56	25.03	N	6	36.76	W	-	5.2	189.0	-	0	Test CTD	001	
13759	30	162329	163343	170318	56	40.04	N	6	08.76	W	159.7	24.0	159.6	161	24	1G	002	
13760	31	173615	174236	180804	56	48.44	N	6	37.63	W	187.8	9.8	170.4	175	9	ADCP	003	
13761	31	194657	194819	195642	56	40.79	N	6	17.18	W	45.1	10.4	32.1	33	4	2G	004	y
13762	31	210359	210546	211659	56	37.58	N	6	24.09	W	47.7	5.9	38.2	39	4	Y	005	y
13763	31	223030	223532	225300	56	44.46	N	6	24.95	W	145.7	7.8	133.0	137	8	4G	-	y
13764	31	234304	234549	235859	56	48.46	N	6	20.48	W	58.4	8.3	45.6	49	5	MD1	-	
13765	32	005813	010322	011959	56	48.68	N	6	23.91	W	189.8	10.2	172.2	177	8	MD2	-	
13766	32	021523	022025	024300	56	48.51	N	6	26.59	W	181.0	9.5	167.1	171	9	MD3	-	
13767	32	034300	035032	042400	56	48.57	N	6	31.26	W	325.8	8.6	310.3	317	21	MD4	-	
13768	32	061709	062324	064600	56	48.76	N	6	35.94	W	197.0	8.3	182.9	187	10	MD5	-	
13769	32	074610	075544	081159	56	49.43	N	6	39.97	W	170.4	11.8	154.7	157	8	MD6	-	y
13772	32	153115	153256	154707	56	43.82	N	6	44.61	W	47.1	9.9	34.0	37	4	6G	006	
13773	32	172118	172649	175200	56	44.09	N	7	00.21	W	145.5	9.6	130.8	135	9	7G	007	y
13774	32	193101	193719	200159	56	43.92	N	7	19.81	W	161.0	7.0	148.8	153	10	9G	008	y
13775	32	214842	215533	221559	56	43.95	N	7	30.26	W	228.2	9.4	213.0	215	11	10G	009	
13776	32	234319	234519	235200	56	43.99	N	7	39.65	W	62.4	8.6	45.2	47	4	11G	010	
13777	33	214241	214952	220857	56	46.69	N	8	01.12	W	125.9	6.5	115.0	119	8	13G	011	y
13778	34	005532	010136	012059	56	50.15	N	8	19.99	W	136.3	8.1	120.6	127	8	T	012	y
13779	34	033214	033659	035500	56	53.05	N	8	29.81	W	132.7	8.8	117.4	123	8	15G	013	y
13780	34	061244	061811	063845	56	56.85	N	8	46.77	W	131.1	5.9	119.1	125	8	S	014	y
13781	34	080121	080807	082359	57	00.08	N	9	00.04	W	137.2	12.1	119.8	125	8	R	015	y
13782	34	091924	092755	095000	57	01.21	N	9	06.70	W	160.5	13.7	139.9	145	8	R1	016	y
13783	34	104445	110054	113108	57	02.66	N	9	13.31	W	359.2	10.1	345.6	349	13	Q	017	
13784	34	124027	130430	134659	57	05.52	N	9	19.66	W	717.3	9.1	708.3	721	10	Q1	018	y
13785	34	144938	153321	163244	57	06.57	N	9	25.65	W	1472.8	9.8	1480.1	1495	14	P	019	y

Station number	JDAY	Start time	Bottom Time	End Time	Lat			Lon			Water depth (m)	Hght off Bottom (m)	Max press	Max wireout	Number of Bottles	Station	LADCP Cast	Chl
13786	34	175029	182157	193831	57	07.17	N	9	33.63	W	1783.0	6.9	1768.2	1797	15	P1	020	y
13787	34	204048	212852	222059	57	09.65	N	9	41.06	W	1915.5	7.5	1901.5	1931	16	O	021	y
13788	35	004756	012754	023400	57	13.53	N	10	03.43	W	2110.5	9.0	2094.7	2125	17	N	022	y
13789	35	045022	052730	065242	57	17.95	N	10	23.91	W	2214.8	9.9	2202.6	2233	21	M	023	y
13790	35	155348	162732	174000	57	21.77	N	10	40.16	W	2110.9	10.0	2093.1	2123	16	L	024	y
13791	35	191143	192609	200657	57	24.08	N	10	51.94	W	789.9	7.7	775.7	789	11	K	025	y
13792	35	214905	220954	223700	57	26.98	N	11	03.26	W	606.3	8.2	617.0	601	9	J	026	y
13793	36	051758	053451	061200	57	28.20	N	11	18.70	W	751.3	9.3	741.6	745	11	I	027	y
13794	36	091258	100148	110336	57	29.50	N	11	29.93	W	1993.4	8.2	2015.9	2021	18	H	028	y
13795	45	054539	063644	075459	57	30.62	N	11	50.48	W	1788.9	1.2	1768.3	1797	18	G	029	y
13796	46	061315	063538	070859	57	32.78	N	13	00.33	W	298.6	1.8	278.8	285	13	C	030	y
13797	47	043257	044612	050459	56	48.42	N	6	26.47	W	178.1	1.6	160.8	165	9	MD3	031	y
13798	47	055928	061217	062614	56	48.57	N	6	31.22	W	323.1	1.5	310.8	317	16	MD4	032	y
13807	47	193122	194055	200058	56	48.91	N	6	40.11	W	167.5	1.5	153.8	157	8	MD6	033	y
13808	47	205235	210043	212300	56	48.47	N	6	37.00	W	210.8	1.5	206.4	205	10	MD5	034	y
13809	47	222138	222854	225352	56	48.54	N	6	31.29	W	318.2	1.5	309.8	307	12	MD4	035	y
13810	48	235738	000413	002500	56	48.72	N	6	23.74	W	201.8	1.4	189.9	193	10	MD2	036	y
13811	48	012159	012418	013559	56	48.30	N	6	20.19	W	60.2	1.4	49.8	51	5	MD1	037	y

1.2 XBT Stations

Drop No.	Probe Type	JDAY	H/M/S	Lat	Lon	Water Depth	Notes
1	T5	040	14/26/00	57.434	-11.603	2003	Start Rockall-Scotland 1
2	T5	040	14/30/00	57.435	-11.580	2008	
3	T5	040	15/20/00	57.466	-11.305	746	
4	T7	040	16/17/00	57.547	-11.036	709	
5	T5	040	17/31/15	57.595	-10.728	2201	Failed
6	T5	040	17/35/20	57.587	-10.725	2201	Failed
7	T5	041	10/32/00	57.406	-10.585	2226	
8	T5	041	11/28/40	57.337	-10.277	2236	
9	T5	041	12/29/00	57.266	-9.957	2058	
10	T5	041	13/34/45	57.197	-9.598	1806	
11	T5	041	14/13/12	57.151	-9.393	886	
12	T5	041	14/19/30				Failed
13	T7	041	14/31/38	57.131	-9.300	429	
14	T7	041	14/36/11	57.126	-9.276	338	
15	T7	041	14/40/25	57.121	-9.254	279	
16	T7	041	14/44/00	57.117	-9.235	244	
17	T7	041	14/47/15	57.113	-9.219	219	
18	T7	041	14/53/25	57.106	-9.188	202	
19	T7	041	14/56/10	57.103	-9.173	201	
20	T7	041	14/59/01	57.100	-9.158	201	
21	T7	041	15/1/35	57.097	-9.145	201	
22	T7	041	15/4/42	57.093	-9.130	166	
23	T7	041	15/12/04	57.085	-9.093	147	
24	T7	041	15/25/15	57.071	-9.026	145	
25	T7	041	15/35/08	57.059	-8.973	143	
26	T7	041	15/48/02	57.045	-8.905	146	
27	T7	041	15/57/24	57.034	-8.856	144	
28	T7	041	16/7/13	57.022	-8.804	136	
29	T7	041	16/22/45	57.003	-8.723	137	
30	T7	041	16/31/25	56.993	-8.679	137	
31	T7	041	16/41/28	56.980	-8.626	137	Failed
32	T7	041	16/49/04	56.971	-8.585	133	
33	T7	041	17/00/28	56.954	-8.527	140	
34		041					Test launch
35		041					Test launch
36	T7	041	18/45/15	56.790	-8.000	126	
37	T7	041	18/58/15	56.768	-7.936	109	
38	T7	041	19/10/45	56.749	-7.875	92	Failed
39	T7	041	19/14/25	56.744	-7.855	84	
40	T7	041	19/28/00	56.723	-7.781	68	
41	T7	041	19/36/40	56.718	-7.730	61	
42	T7	041	19/47/22	56.724	-7.665	-999	
43	T7	041	19/56/55	56.734	-7.608	-999	End Rockall-Scotland 1
44		041					Test launch
45		044					Test launch
46	T7	044	08/32/28	56.786	-6.470	-999	Start Scotland-Rockall 2
47	T7	044	10/2/26	56.811	-6.870	177	
48	T7	044	10/31/53	56.790	-7.021	191	
49		044					Test launch
50	T7	044	11/48/44	56.752	-7.414	231	
51	T7	044	12/36/44	56.722	-7.647	134	Failed
52	T7	044	12/40/16	56.724	-7.663	125	
53	T7	044	13/35/51	56.769	-7.908	123	
54	T7	044	14/31/36	56.833	-8.149	133	Failed
55	T7	044	14/33/53	56.835	-8.158	133	Failed

56	T7	044	15/33/38	56.889	-8.441	132	Failed
57	T7	044	16/32/54	56.940	-8.731	135	Failed
58	T7	044	17/27/49	56.988	-9.001	138	Failed
59	T5	044	18/18/33	57.028	-9.261	240	
60	T5	044	18/35/56	57.039	-9.349	417	
61	T5	044	19/2/04	57.057	-9.483	1324	Failed
62	T5	044	19/5/00	57.060	-9.498	1210	
63	T5	044	19/35/35	57.094	-9.649	1597	
64	T5	044	20/32/00	57.152	-9.927	1991	Failed
65	T5	044	20/37/51	57.157	-9.957	2073	
66	T5	044	21/26/40	57.205	-10.210	2223	
67	T5	044	22/27/40	57.267	-10.538	2237	
68	T5	044	23/31/20	57.329	-10.871	927	
69	T5	045	00/30/07	57.376	-11.182	659	
70	T5	045	01/33/42	57.429	-11.518	1997	
71	T5	045	18/55/48	57.532	-12.745	638	Failed
72	T5	045	18/59/27	57.530	-12.752	629	Failed
73	T5	045	19/4/26	57.528	-12.760	616	Failed
74	T5	045	19/8/45	57.526	-12.768	606	Failed
75	T5	046	11/39/21	57.478	-12.088	1837	End Scotland-Rockall 2
76	T5	046	12/34/55	57.423	-11.763	1876	Start Rockall-Scotland 3
77	T5	046	13/30/44	57.364	-11.434	1785	Failed
78	T5	046	13/22/50	57.372	-11.480	1944	
79	T5	046	14/27/46	57.308	-11.100	766	Failed
80	T5	046	14/30/00	57.306	-11.087	776	
81	T5	046	14/34/57	57.302	-11.060	804	
82	T5	046	15/29/54	57.251	-10.738	2304	Failed
83	T5	046	15/32/40	57.249	-10.722	2300	
84	T5	046	16/37/37	57.185	-10.362	2277	Failed
85	T5	046	16/39/58	57.183	-10.349	2275	
86	T5	046	17/31/27	57.134	-10.078	2141	
87	T5	046	17/34/18	57.131	-10.062	2124	
88	T5	046	18/32/20	57.083	-9.743	1972	
89	T5	046	19/30/22	57.029	-9.423	1568	
90	T5	046	20/31/16	56.977	-9.089	166	
91	T5	046	21/31/58	56.918	-8.754	130	Failed
92	T5	046	21/35/12	56.914	-8.736	134	
93	T5	046	22/30/14	56.864	-8.422	133	
94	T5	046	23/29/38	56.802	-8.083	132	Failed
95	T5	047	00/26/30	56.751	-7.758	56	

3.1 LADCP Setup Command Files

The command file, Bbsc.cmd with which the LADCP instruments were set up prior to deployment

STATIONS 13759-62, 13772-98	STATIONS 13807-11
CR1	CR1
PS0	PS0
CY	CY
CT0	CT0
EZ 0011101	EZ 0011101
EC 1500	EC 1500
EX 11101	EX 11101
WD 111100000	WD 111100000
WL 0,4	WL 0,4
WP 00001	WP 00001
WN 010	WN 040
WS 1600	WS 400
WF 1600	WF 800
WM 1	WM 1
WB 1	WB 1
WV 400	WV 150
WE 0150	WE 0150
WC 056	WC 056
CP 255	CP 255
CL 0	CL 0
BP 001	BP 001
BD 25	BD 25
BX 2500	BX 2500
BL 0,200,600	BL 0,200,600
BM 4	BM 4
TP 000100	TP 000100
TE 00000200	TE 00000200
&R20	&R20
CF11101	CF11101
&?	&?

3.2 LADCP Deployment Logsheet

LADCP Deployment / Recovery Log Sheet – D245

Pre-Deployment **Connect with ADCP comms lead & run** *BBTALK*

Log to file	D _01 .txt	Hit **'F3'** key and enter filename
Wake up time _		Wake-up with **'END'** Key
Check ADCP Time with GMT, reset if necessary.	GMT: ADCP:	***TS?*** ***TS*** *yy/mm/dd,hh:mm:ss (to reset)*
Battery Volts _		***PT2*** *(VMVDC)*
Recorder Free Space		***RS?*** *(You may need to erase the recorder, RE ErAsE)*
Get factory defaults		***CR1***
Run Tests		***PT200***

Quit BBTALK using <ALT> X and then close the window

Deployment **run** *BBSC*

- go to **'deployment'** menu, use command file: Bbsc.cmd, **'DEPLOY'**, verify **'YES'**, deploy **'OK'** & record time of deployment : : (from master clock)
- **set up deployment sequence log file** 'FILE' D###_01.log
- **exit BBSC by <escape> x2 and then** EXIT **under** FILE
- turn off battery charger
- Now Fit blanking plugs on the ADCP & Battery case
- Tell CTD / Winch operators to proceed with deployment

Recovery

Connect instrument and battery pack, run ***BBTALK***
'END'

Battery Volts _ **(PT2)**		Now charge the batteries
Time _ **(TS?)**		
CY ? (usually 0)		

Quit BBTALK using <ALT> X and then close the window

Run ***BB-ADCP.ht,*** and **'return'**

Set deployment no. to recover **'RY#'** (check it's the latest use **'RA?'**)	
'Transfer', 'Receive file', 'receive' *note the filename* ***'return'*** *and enter* ***'CZ'*** *to put the instrument to sleep* *Quit program ('file','exit')*	
Using 'explorer' rename file in c:\ladcp\jr44\data to J###_01.000 where ### is station number	

Run **BBLIST** (f10 to main menu)

File Size when recovery complete (bytes)	
Ensembles Read ?	

And start and stop times of recovered file from BBLIST START

STOP

Comments

5.1. CTD Calibration File

```
: This is a calibration file for a Mk III CTD
: File d245.ctd03.cal
: SOC CTD DEEP03 serial no. IM960512
: Data from OSI Dec '99 calibration
: nph 27 Jan 00
: aij 29 Jan 00
:
:
temp      0.0005    -2.142635      0.991186      0.          0.        0.
press     0.1       -38.1         1.07482       0.          0.
press_t   0.001     65.3          -2.33         1.78e-4     0.        0.
:Initial cal for d245 from OSI
:cond     0.001     -1.721e-3     0.946         0.          0.        0.
:cond     1.        0.            1.            0.          0.        0.
: but used 1 0 1 0 0 0 initially to make further calibration easier (D245)
: which did not work cos it produced huge potemp and salins. Then reverted
: to OSI cal, but missed e-3 on shift, so sals were way out. Redid all with
: above OSI cal.
: D245 New cond cal figured from stations 760 to 790 (exc.766) > 250 dbar
cond      0.001     1.4372576e-2  0.945609882   0.          0.        0.
fast_t    0.0005    3.23738       1.0568        -6.2633e-3  1.34e-4   0.
deltat    0.25      0.            0.            0.          0.        0.
alt       1.        -249.7        7.62e-3       -1.04e-10   0.        0.
ctdvolt   1.        -50.0         1.53e-3       0.          0.        0.
:
pcorstat  10.       0.            0.            0.          0.        0.
pcordyn   0.        0.            0.            0.          0.        0.
:
:
oxyc      1.        -0.348        3.84e-5       -2.78e-11   0.        0.
:oxyt     1.        -14.5         1.31e-3       -1.72e-8    1.45e-13  0.
:oxyfrac, alpha, beta, CTD-T-wt, tconst, lagt.wt, rho
oxyfrac   -0.04668  -0.0003418    0.23          300.        0.77      3.3438
:
: CHELSEA 0.25 m
: chtran converts mac volts to 100 percent, with blank offset
chvolt    1.        -5.027        1.534e-4      -3.704e-13  0.        0.
: D245 These values left from D242, used initially.
:chtran   0.        -0.024        4.75          0.          0.        0.
: D245 These values measured after 13794.
chtran    0.        -0.030        4.80          0.          0.        0.
fvolts    1.        -5.0326       1.5359e-4     3.383e-14   0.        0.
fluor     1.        0.            1.            0.          0.        0.
: nitrate sensor on D245, 3 channels, 220, 235 and 250
nit1      0.0001    -4.49986      1.37329       -3.452e-15  0.        0.
nit2      0.0001    -4.49986      1.37329       -3.452e-15  0.        0.
nit3      0.0001    -4.49986      1.37329       -3.452e-15  0.        0.
```