RRS Discovery cruise 258

Biophysical studies of zooplankton dynamics in the northern North Atlantic: winter, 1 Nov - 18 Dec 2001

MARINE PRODUCTIVITY CRUISE REPORT NO. 1

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Document Data Sheet

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ABSTRACT

Discovery 258 was the first of four multi-institute and multidisciplinary research cruises supported by the NERC Marine Productivity thematic programme within the wider context of the international Global Ocean Ecosystem Dynamics project (GLOBEC). It provided information on biological and physical conditions during early winter in the Irminger Sea, along the Reykjanes Ridge and in parts of the Iceland Basin. The main scientific effort was directed at: mapping physico-chemical features, and estimating future water mass fluxes and particle trajectories (using CTD, ADCP and TSG systems, float deployments, SST satellite imagery, and analysis of nutrients, oxygen and SF_6); collection of water samples for analysis of microplankton and plant pigments; assesments of phytoplankton physiology (using FRRF); and determination of 3D abundances of the copepod *Calanus finmarchicus*, other mesozooplankton, and their main invertebrate predators (using ARIES, Dual Methot, and Ocean Sampler net systems; also lowered and towed scientific echosounders).

The cruise was divided into two legs. The mid-cruise port call at Reykjavik allowed for some personnel changes and for discussions at the Icelandic Marine Research Institute. Good coverage of the ocean areas of interest was obtained, despite unworkable weather conditions for around a third of the cruise, and other downtime and passage (also around a third, including a medical evacuation). Provisional data from the Optical Plankton Counter on ARIES indicated that *Calanus*-sized particles occurred throughout the water column, with a maximum between 500-1500 m. Depth-integrated densities did not show much geographical variability. Subject to post-cruise OPC calibration, they indicated that *C finmarchicus* winter abundances in the Irminger Basin region were lower than had been expected (on the basis of summer upper ocean data, and winter full-depth data from other parts of the species' range).

KEYWORDS

ADCP SYSTEMS, ARIES SYSTEM, CALANUS FINMARCHICUS, COPEPOD, CTD OBSERVATIONS, DISSOLVED OXYGEN, DUAL METHOT NET, EUPHAUSIID, FRRF SYSTEM, GLOBEC, ICELAND BASIN, IRMINGER SEA, MARINE PRODUCTIVITY THEMATIC, MICRO-PLANKTON, NORTHERN NORTH ATLANTIC, NUTRIENTS, OCEAN SAMPLER, OPTICAL PLANKTON COUNTER, PHYTO-PLANKTON, REYKJANES RIDGE, RRS DISCOVERY, SALINITY, SCIENTIFIC ECHOSOUNDER, SEA SURFACE TEMPERATURE, ZOOPLANKTON.

ISSUING ORGANISATION

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BODC, British Oceanographic Data Centre; FRS, Fisheries Research Services; SOC, Southampton Oceanography Centre; UKORS, UK Ocean Research Services

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Acknowledgements

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1. The cruise

1.1 Introduction

RRS Discovery cruise 258 was the first of four supported by the NERC Marine Productivity (MarProd) thematic programme. The vessel sailed from King George V Dock, Glasgow on the morning of 1 November 2001 (Thursday) and returned to Empress Dock, Southampton in the evening of 18 December 2001 (Tuesday), a total time at sea of 47 days. There was a mid-cruise port call at Reykjavik, Iceland from 25-27 November that included scientific discussions at the Marine Research Institute and a visit to *Discovery* by the British Ambassador, Mr John Culver.

1.2 Scientific objectives

The MarProd cruise series provides the main opportunity for data- and sample-gathering to address the overall programme goal, viz: "to develop coupled modelling and observation systems for the pelagic ecosystem, with emphasis on physical factors affecting zooplankton dynamics". The principal cruise-specific research objectives for *Discovery* 258 were as follows:

- Map the physical features of the survey region (Irminger Sea and parts of the Iceland Basin) in terms of water mass distribution, velocity field and mixed layer properties
- Obtain additional information to estimate future water mass fluxes and particle trajectories, via float deployments and tracer analyses
- Collect water samples for plant pigment and microscopic analyses, to estimate the biomass of different taxonomic/functional groups of microplankton
- Measure high resolution profiles of inorganic and organic nutrient concentrations
- Determine the 3D abundance of mesozooplankton of interest (primarily the copepod *Calanus finmarchicus*), and their planktivorous predators (primarily euphausiid spp), obtaining material for further taxonomic, physiological and biochemical studies.

There was strong emphasis on obtaining an integrated, interdisciplinary data set, not only to bring together researchers involved in survey-related MarProd projects, but also to "set the scene" for subsequent cruises during 2002 (involving additional groups) - and to facilitate comparisons with historical datasets (eg NORWESTLANT, 1963 and Continuous Plankton Recorder surveys); EU-supported zooplankton programmes (TASC and ICOS); and other national and international studies. The MarProd programme provides the main UK contribution to the Global Ocean Ecosystem Dynamics project (GLOBEC), co-sponsored by IGBP, SCOR and IOC.

1.3 Cruise overview

It was clear to the MarProd Steering Committee from the start that a winter cruise carried high probability of significant downtime due to weather. However, given the total lack of winter zooplankton data for most of the Irminger Basin (and few measurements elsewhere), it was considered that the cruise would be worthwhile even if only a small number of stations could be worked. In the event, while there were prolonged periods of downtime, useful coverage of the Irminger Sea and southern Iceland Basin was achieved.

The split of time between major activities given below (Table 1, based on statistics kept by the Master) shows that there was 40% downtime in leg 1, and 29% in leg 2. Despite this, 18 ARIES stations were worked in the third of the total cruise that was science time, 11 of them also with Dual Methot net tows and 5 also with the Ocean Sampler. In addition, there were 27 lowered CTD stations, 6 of them followed by lowered EK500 scientific echosounder (LEK) deployments. Note also that 24-29% of the time was passage. The passage time was actually longer, because around two days were entered as downtime due to bad weather. Thus there is a considerable penalty in working in the Irminger Sea (or even the western Iceland Basin) when the passage is from Southampton or even the Clyde.

Table 1. Time distribution between scientific and non-scientific activities

		Science	Passage	Weather downtime	Other downtime	Manoeuvring
Leg 1	hours	182.9	141.9	208.5	20.4	28.3
	per cent	*31%*	*24%*	*36%*	*4%*	*5%*
Leg 2	hours	165.9	151.1	97.6	50.9	48.5
	per cent	*32%*	*29%*	*19%*	*10%*	*9%*

A detailed cruise diary is given in Appendices A1.1 - A1.2, the sites occupied are shown in Fig 1, and a complete list of sites and stations (= gear casts) is given in Appendix A1.3. An overview of sampling locations is appropriate here. Note that the original cruise plan envisaged four lines (A, B, C and D, from north to south) to be worked across the Irminger Basin. To close the circulation, a fifth line (E) was to be run along the Reykjanes Ridge. Line D was deemed the highest priority, to be completed on leg 1 if possible. It soon became clear that these lines could not be achieved. For one thing, working northwestwards was into the prevailing wind and swell. For another, with weather windows often only a day or so, it was more fruitful to work a site wherever we happened to be rather than to head for a line, which might be reached just as conditions deteriorated again. In the end, line D was partly run, line A was replaced by line F west from Iceland to Greenland, and line G replaced lines B and C. Line G was extended usefully into the Iceland Basin at the end of the cruise. Line H consists of odd stations down the length of the Irminger Basin.

From a physics perspective, it was always going to be impossible to occupy sufficient stations to map in detail the circulation of the Irminger Basin. We were most fortunate therefore that Dr Robert Pickart of Woods Hole Oceanographic Institution had occupied over 150 CTD stations on *RV Oceanus* 369 in August 2001, only three months previously. Following agreement to share our data, Dr Pickart kindly made available his station positions and CTD files, and our station positions were to some extent designed to fill in gaps in *Oceanus'* coverage. The combined map of station positions is shown in Fig 2. An example of what can be done by combining the two data sets is shown in Fig 3, the potential temperature at 1000 m.

After two days of vital trials in sheltered waters, *Discovery* headed west. This passage (3-8 Nov) took a day longer than expected because of persistent westerlies. Line D was worked from the middle of the Iceland Basin to the Reykjanes Ridge (D19-D12). These sites showed problems with the net deployments, so CTD stations E2-E5 were worked up the Ridge to give time for these to be resolved. Unfortunately, the weather broke on 14 November after only three sites on line D across the Irminger Basin (D11-D9) had been worked. For the next six days no further sampling was possible, and line D subsequently had to be abandoned. Off the SE tip of Greenland, we were fully exposed to westerlies and southerlies, giving unworkable swell conditions even when the wind reduced.

We began to head towards Iceland, thus reducing the passage to port time and intending to occupy a line G somewhere between lines C and B. The start of the line was determined by when conditions became workable, and four sites (G10-G7) were occupied. At site G6 conditions deteriorated so fast that the planned ARIES deployment had to be abandoned at the very moment that it was ready to go outboard, conditions having been relatively benign half an hour earlier. This was the first example of how rapidly conditions can worsen in the area. After being hove to overnight, it became clear that no further work was possible, and our best course of action was to head for Reykjavik early. After so much severe weather, it was considered essential to have an extra night in port for all to get sufficient rest before leg 2. By heading in early, we gained that extra night ahead of the intended arrival on 26 November, thereby not reducing the duration of leg 2.

Departure from Reykjavik was delayed by some hours because of poor weather, but conditions quickly improved, and leg 2 began well, with sites F7, F5, F3 and F1 occupied over two days. The site numbering allows for further sites to be interleaved on future cruises if desired. Note that F7 was occupied in the central Denmark Strait, to look at the biological features of the Denmark Strait Overflow Water (DSOW). While *Calanus* was fairly abundant above the DSOW, it was sparse in the dense DSOW at the bottom. Tentatively, it does not seem that there is major transport of *Calanus* from the Greenland Sea. Note too that F5 was a repeat of an Icelandic TASC site T13 (see Fig 2).

From the Greenland Shelf at F1, it was intended to head south to complete line G, sites G1-G7. One or two sites might be occupied *en route*. However, encountering icebergs well off the coast changed things. First reaction was to head further offshore, but persistent westerlies had driven icebergs over 300 km offshore, so it was necessary to work in the area of possible bergs. After another ARIES deployment had to be abandoned at the last minute on 1 December when the weather blew up, it decreased equally rapidly, and a CTD was worked the next morning at H1. Over the next two days, the western end of line G was completed (except for the shelf site G1) in remarkably good conditions, except for icebergs. The good weather was the result of what appeared to be a common weather pattern, with the mountains of Greenland driving northerlies very close to land, which then turned offshore to become westerlies. Working close in was therefore good, because of the low fetch.

From line G it was planned to work sites across the Irminger Current back to pick up line E at E6. Shortly after heaving to at the first intended site in bad weather, the second engineer was injured when a lever recoiled and hit him in the face. It took two days to reach Reykjavik for the medical evacuation (the engineer was able to fly home after treatment) and a further day to return to deep water. Clearly line E had now to be occupied from NE to SW. Useful ARIES sites (E16 and E13) were worked on two days to fill in the NE of the Irminger Sea, but bad weather again stopped work on 9 December. We could not get far enough west to complete G11, but a CTD was possible at G12, and priorities were revised to ensure an ARIES deployment in the Iceland Basin, in order to see if *Calanus* advect around the Reykjanes Ridge. E9, G13 and G14 were occupied, and a decision had to be made whether to continue east (then returning home via the Irish Sea) or try to work southwards. Scientifically, the latter was highly desirable, and there appeared to be time, so three further sites (G15-G17) were worked south from G14 towards D19. Work ceased for the homeward passage, when a mean speed of 8.25 kn needed to be maintained. Unfortunately the persistent westerlies had by now change to persistent southeasterlies, which were against us for the entire passage to Lands End. Thus arrival at Southampton was at 1900 instead on 0900 on 18 December.

Note that time records for *Discovery* 258 relate to GMT throughout the cruise. Whilst dates in the text of this cruise report are mostly given as calendar days, Julian days are also used in the context of data-logging (where 1 Nov and 18 Dec, the cruise start/end dates, are JD 305 and JD 352 respectively).

Raymond Pollard, Stephen Hay

2. CTD operations

2.1 CTD operations - rosette and frame

The CTD package consisted of:

- 24 way stainless steel frame
- 24 x 10l sample collection bottles
- Sea-Bird SBE32 bottle-firing rosette
- Sea-Bird 9+ CTD with two TC pairs and SBE43 oxygen sensor
- Chelsea Instruments fluorometer
- Chelsea Instruments transmissometer

- RDI 150 kHz LADCP
- RDI 600 kHz WHLADCP
- Benthos altimeter
- Seatech LSS
- 10 kHz pinger

A total of 28 CTD casts were carried out, including the initial test cast. Each cast generated .dat, .hdr,.bl and .con files related to the station number. Data backup is on zip disk.

Sea-Bird SBE32 bottle firing rosette

Generally performed satisfactorily, although on several casts there was a single bottle that did not fire. The misfire appears to be random and no error messages were returned. This will be investigated at SOC. The problem continued through leg 2, when bottle position 7 did not fire at all and the occasional other misfire occurred.

Sea-Bird 9+ CTD with 2 TC pairs and SBE43 oxygen sensor

Instrument performance in terms of accuracy appears good, with derived salinities being checked against Autosal. The data on several casts however had large spikes on all channels, including the auxiliary instruments. Up to 300 modulo error counts were recorded. The cause of this was not found, despite the cable being re-terminated and electrical connections checked. Further attention will be given to this matter.

While preparing for cast 14236 the sea cable fuse in the deck unit blew. Fuse changes proved unsuccessful and the cast was aborted (hence 14236 became an ARIES cast.) It appears that a leaking connection caused the problem and that the sea cable interface board within the CTD has been damaged.

CTD serial no. 0635 was removed and replaced with serial no. 0637 which appeared to perform satisfactorily, but once again spikes occurred in the data.

For an outline of calibrations and serial numbers for each cast, open the .con file as if to modify it and generate a report which gives the user a notepad document of the instrument set-up including the auxiliary instruments. The .con files are called D258MAIN.con prior to cast 14239 and 0637.con afterwards. Additional reference data are given in Table 2.

Table 2. Sea-Bird CTD sensors and calibration dates

	SBE 0635		SBE 0637	
Temperature primary	03-2919 21	21vi01	2728	27ii01
Conductivity primary	04C-2637	29vi01	2164	9iii01
Pressure	83007	9i01	79501	6xi99
Temperature secondary	03-2758	4vi01	2729	8ii01
Conductivity secondary	04-2407	3vi01	2164	6iii01
SBE oxygen	43-0086	12ix01	43-0076	17ix01
CI transmissometer	161047	20iv01	same	
CI fluorometer	088241	28iv01	same	
Seatech LS6000	346	5vii97	same	

Data spiking continued to be a problem after the CTD was exchanged and the cable re-terminated. In port, further attempts were made to find the causes. The sea cable was cut back 100 m and re-terminated. The BOB was checked and was found to contain water. This was cleaned and a spare unit fitted as well.

Attempts were made to repair CTD serial no. 0635. A replacement DC-DC converter was obtained from the Marine Research Institute, Reykjavik but this proved not to be the fault. Problems were eventually traced to damage on the bulkhead connector, caused by the sea cable extension leaking.

Data spiking continued on the first few casts of the second leg with no identifiable hardware problems being evident. The replacement BOB was removed from the frame and tested. It is possible, however that these spikes are software-induced, as the data acquisition software has displayed some locking-up and restarting. Further investigations showed leakage had occurred at the altimeter connection. This was cleaned and dried and the spiking ceased. The problems with connectors did not seem to occur once the weather became warmer. This was maybe a coincidence, but there is no doubt that impulse connectors are much less malleable when very cold.

Data collection and software

Seasave for Windows V5.22 was used to collect data. Occasionally the software would lock up for a few seconds and then continue. No other problems were apparent, although it was suspected that an occasional spike in the data was software created and not real. During leg 2 the DAPS data collection system was discarded in favour of running a second PC with Seasave as backup. This worked well, the only problem being that the backup PC cannot log bottle details. For this reason, bottle firing times were also recorded.

Chelsea Instruments Fluorometer

Performance satisfactory, calibrations were carried out. Results are given in Sections 2.3 and 6.2 below.

Chelsea Instruments Transmissometer

Performance satisfactory with little or no hysteresis. Good correlation to the Seatech LSS.

Seatech LSS

Performance generally good. However on several upcasts (eg 14231) the signal appears to drift for a period for no apparent reason, ie there is no corresponding change in the transmissometer signal. This was found to be a function of the leak having occurred in the BOB. Performance was fine afterwards.

RDI 150kHz LADCP

Data was collected and processed by science personnel. From an operational point of view the instrument worked well, although problems were experienced with the battery chargers. These issues were resolved for leg 2.

RDI 600kHz WHLADCP

As above. It was noted that the 'star cable' arrangement (modified to allow use with the Wynall chargers) has live male pins on the charging and data download cable. Care must therefore be exercised when connecting and disconnecting this cable. During leg 2 the star cable connection leaked at the WH bulkhead connection. This appeared to be the cause of split data files collected occasionally. The cable was replaced and the problem did not re-occur.

Benthos altimeter

Performed quite well. Usually a stable reading was obtained from about 30 m from seabed, but sometimes as high as 70 m (max range being 100 m). For this reason it has been standard practice to use the pinger and PES for seabed approaches.

Terry Edwards, John Wynar (leg 1), Jeff Benson (leg 2)

2.2 CTD salinity calibration (including ARIES)

2.2.1 Lowered Sea-Bird CTD

CTD measurements of salinity from around the time of bottle firings were compared with the salinity of water sampled from the bottles, measured using the salinometer. The CTD values were averaged over a period from 2 sec before to 5 sec after the bottle firing; this period is set as a pair of parameters to the DatCnv stage of the Sea-Bird processing on the PC, discussed elsewhere. Raw errors

$$E = S_{CTD} - S_{SAL}$$

are plotted against pressure in Fig 4. Only values from the primary conductivity sensor will be considered here. Most of these errors are already small, between –0.002 and 0.000, but the accuracy can be improved still further by using the salinometer values for calibration, as follows. As on earlier cruises, the fundamental correction is applied to conductivity rather than salinity. A slope correction only is applied, with zero offset, as recommended in the Sea-Bird software manual:

1. Calculate the conductivity C_{SAL} from the bottle salinities and CTD pressures and temperatures, using either `peos83` or the Matlab routine `sal2cond.m` (in `/data61/sjb394`, like all other Matlab routines mentioned here). CTD conductivites C_{CTD} are already present in the `sam` files.
2. Calculate the average value

   $$K = \langle C_{SAL} / C_{CTD} \rangle$$

   of the ratio of the salinometer to the CTD conductivity. Anomalous values are excluded from this calculation *ad hoc*; in the present case, stations where the raw error *E* in salinity was less than –0.004 or greater than 0.002 were excluded (Fig. 4a). Such anomalies occurred only in the surface layers, where the vertical gradients of salinity tend to be large. Because some motion of the CTD package is inevitable due to motion of the ship, the properties of the water sampled instantaneously by the firing of the bottle may well not be the same as those measured in the time average by the CTD.
3. Calculate corrected CTD conductivities as *K* times the uncorrected conductivities.
4. Calculate corrected CTD salinities from the corrected conductivities and the temperature and pressure data, using `peos83` or `cond2sal.m`

Steps 1-3 may be carried out, and step 4 applied to the CTD data corresponding to bottle fires, as follows, when logged in to discovery2 as user pstar.

1. Ensure that all appropriate `sam` files are listed in the `for`…`in` statement of script `sjbsals.exe` in directory `/data61/bottle`
2. Run `sjbsals.exe`
3. Run `sjbsals` in a Matlab session.

This prints the calculated value of *K* on the screen. Results of this procedure are plotted in Fig 4b. With a K value of 1.00004637, errors in salinity have been reduced to order 0.001, which is better than the accuracy claimed for the CTD salinity sensor. The horizontal axis in this figure is the standard deviation of pressure during the 7 sec averaging period of the CTD data. This value is large where the CTD package was moving vertically due to ship motion. It is clear that there is no strong dependence of the error on this standard deviation; only when vertical motion is combined with a large vertical gradient are the errors relatively large.

Fig 4c displays the mean and standard deviation of the corrected errors at each CTD station. No drift in the calibration is apparent over the admittedly quite short timespan of these observations. We can be confident that the CTD measures accurately the salinity of water going past its sensors. The extent to which the water going past the sensors is representative of the ambient water is a different question, addressed elsewhere (see section 2.2.2 below for a brief discussion).

Salinity calibrations for the second CTD used, and for the CTD package on ARIES, were carried out in a similar fashion, with slight variations on the method of excluding rogue data points. The corresponding executables for the second CTD are sjbsals2.exe and sjbsals2.m; and for ARIES they are sjbasals.exe (in /data61/abottle) and sjbasals.m.

These last two calibrations are illustrated in Figs 5 and 6, and a table summarising all three calibrations is (salcal.xls). Note that the error for ARIES appears to vary systematically with depth. A least squares fit of a straight line to the remaining error yields the following correction to be added to the product of K and the uncorrected conductivities for ARIES:

$$-1.4545\mathrm{x}10^{-6}\ P + 0.0018615$$

where P is the pressure in decibars.

Table 3. CTD salinity calibrations

	First CTD	Second CTD	ARIES
K	1.0000492	1.0004386	1.000155
Std deviation of error, post cal	0.0014	0.0011	0.0035
Mean absolute error, post cal	0.0009	0.0009	0.0030

2.2.2 ARIES Sea-Bird CTD sampling and implications for calibration

The calibration was less good for ARIES than for the lowered CTD (though the errors remaining are only of order 0.003 in salinity, which is quite close to the state of the art). This is due to two factors. Firstly, the ARIES CTD records 1 second mean data, rather than the raw 24 Hz data recorded by the lowered CTD. There is no filtering for spikes or other rogue values, which may therefore contribute to the values used in the calibration. Secondly, and probably more importantly, there are limitations in the sampling of water from the bottles on ARIES. A description of ARIES sampling procedures is relevant here.

After the biologists have removed the nets and the three large yellow floats have been removed from the back of the vehicle, the bottles can be sampled. First the two screws on either side of the axle on which the rosette pivots are loosened. Then the rosette is swivelled towards the back of the vehicle and clipped into position. To sample from a particular bottle, first locate the numbered outlet from the bottle on what is now the underside of the rosette, and the lid to the same bottle on the upper side; this is a two-person job. Next, clip the blue sampling tube provided onto the outlet. Then when the lid is raised, water will flow out of the bottle through the tube, and can be decanted into glass or other sample bottles. The flow can be arrested by raising the free end of the blue tube.

One also has to be careful to sample only from bottles fired during the upcast (ARIES fires about half its bottles during the downcast). The ARIES operators provide a printed list of which bottles fired at which depths, shortly after recovery of the vehicle.

One problem with this sampling procedure is the use of the blue tube, that makes it difficult to be sure that the sample is not contaminated by water remaining in the tube from previous samples. The other main problem is that the ARIES bottles are only 300 ml, so that there is not much water for rinsing the 200 ml salinity bottles, especially when the tube also needs to be rinsed. On this cruise, the bottles were rinsed two or three times with a small amount of water (approx 25 ml each time).

Given these shortcomings, calibration to within about 0.003 in salinity is probably about as good as could be achieved. One possibility for future cruises might be to use a shorter sampling tube, though this would make some of the bottles difficult to sample from.

2.2.3 Deleterious effects of ship roll and package dynamics

Despite the CTD temperature and salinity sensors being calibrated to high precision, many of the casts on this cruise show fairly large and physically unrealistic excursions (of order 0.1°C, for example) at a period of several seconds, especially in regions of sharp vertical gradient. This happens even during the downcast, when the CTD sensors are ahead of the main bulk of the package and theoretically unaffected by wakes and such. It is believed that this error is a result of ship roll, one possible mechanism being as follows. It is likely that a bolus of water is carried along with the rosette package. When the package decelerates (during the downcast) due to the ship rolling, the bolus will not be decelerated, but will flow down over the sensors. At this point, the properties of the water in the bolus, entrained from some metres higher up the water column, will be measured. Hence broad spikes of, typically, higher than ambient temperature are observed.

Corroboratory evidence for this is provided in Fig 7, which shows the downward velocity and acceleration of the package, and the time rate of change of the measured temperature (dT/dt), from a minute-long section of an arbitrarily chosen downcast, when the package was passing through a thermocline region. The 24 Hz data have been filtered with a running mean of length approximately 1.5 seconds. The figure clearly shows the periodic acceleration and deceleration of the package associated with ship roll, and that dT/dt oscillates at a similar frequency. Close examination of the figure shows, furthermore, that dT/dt is at a maximum shortly after the deceleration is a maximum, or equivalently shortly before the velocity is a minimum. This observation is made more quantitative in Figs 8a and 8b, where lagged correlations between changes in dT/dt and speed, and with acceleration, respectively are shown. The correlation of largest magnitude is that between dT/dt and the acceleration, with the latter leading the former by about 0.83 seconds. The velocity lags dT/dt by about 1.1 seconds.

This is only a first step towards solving this problem, which has the potential to be quite serious – in regions of sharp vertical gradient, at least half the data seem to be contaminated by this effect. Other mechanisms need to be considered, perhaps involving the effect of the large number of sensors at the base of the package, which may provide an effective barrier to flow through the package. There is also a hysteresis between up- and downcasts which is particularly apparent in benthic boundary layers in which there are sharp gradients. Is this hysteresis also due to a bolus effect? does it perhaps take a relatively long time for ambient water to be entrained far enough into the package to be felt by the sensors? More work is required.

Stuart Brentnall

2.3 Chlorophyll calibration

Samples were regularly drawn for chlorophyll *a* analysis from the top 6 rosette bottles on each CTD cast. The Sea-Bird calibration was used to convert the fluorometer reading in volts to nominal "fluor" in mg m^{-3}. For casts 14191 to 14263, these fluor values were plotted against the filtered chlorophyll values "chla" (Fig 9). A good straight line fit was found:

$$\text{Chla} = -0.028 + 2.812 \text{ fluor}$$

with $R^2 = 0.963$, albeit over the limited range of low chlorophyll a values found. Since nearly all sampled values fell within 0.05 mg m^{-3} of this line, it was accepted as a good fit for the cruise and applied to all lowered Sea-Bird CTD data. A later calibration using all CTD casts gave a revised fit:

$$\text{Chla} = -0.0186 + 2.752 \text{ fluor}$$

However, over the range of fluor values found (0-0.25) the differences in chlorophyll are insignificant.

For ARIES, calibration was much more problematic. The small water bottles do not give sufficient water for a good calibration, and with bottles only tripped every 50m in depth there is at most one bottle in the mixed layer. Therefore calibration was done by comparison with the lowered CTD, by using mixed layer values from a nearby cast for the upper end values, and by forcing a straight line fit through the fluorometer zero (i.e. the deep values) which decreased gradually from 0.01 at the start to 0.008 at the end. Fig 9 shows the data used and the chosen fit:

$$\text{Chla} = -0.022 + 2.73 \text{ fluor}$$

2.4 Sea-Bird oxygen calibration

In each deployment of the CTD rosette, oxygen was first measured with an oxygen sensor on the Sea-Bird CTD and second by analysis of samples taken from the bottles. The results from the oxygen titrations of the samples were used to calibrate the Sea-Bird sensor. Before calibration, the results from the oxygen titrations, which measure oxygen in µmol/l, had to be converted into µmol/kg, the WOCE standard. The equation to convert the units is the following:

$$O_2\ (\mu mol/kg) = O_2\ (\mu mol/l)\ /\ (1 + 0.001\ \sigma_0)$$

where σ_0 is the density of the oxygen sample at the time at which the sample is fixed. It can be computed using T_{fix}, the temperature of the sample at time of fixation, and the salinity of the sample (the pressure is set to 0, since the samples are fixed on deck, ie. at sea level).

Our first attempt to calibrate the Sea-Bird oxygen values used data from casts 14191 to 14223. Fig. 10 shows a scatterplot of botoxyk, the bottle oxygen in µmol/kg, versus oxygen from the sensor. A regression line (produced by performing a least squares fit to the data) for the upcast was as follows:

$$\text{Botoxyk} = 11.9098 + 0.9962\ O_2\ (\text{sensor})$$

As there is an observed hysteresis between the oxygen measurements of the upcast and the downcast of the CTD, the same least squares fit was done for the bottle oxygen against the sensor oxygen of the downcast. The oxygen data from the downcast were extracted from a 2 dbar averaged CTD file by matching the pressure values at the bottle firing points with the pressure values in the `.2db` file. The regression line takes the following form:

$$\text{Botoxyk} = 12.2775 + 0.9924\ O_2\ (\text{sensor})$$

While it appears that the most significant adjustment is the addition of 11.9 or 12.3 µmol/kg on the up and down casts respectively, plotting against pressure (Fig 11, upper graph) shows that there can be a depth dependence. The Sea-Bird CTD was changed after cast 14231. Therefore we show first the corrections (botoxy - oxygen) that would need to be added to the SB-computed oxygen values for downcasts 14191 to 14231 (oxygen sensor SBE 43-0086; new and factory-calibrated on 12 Sept 01). Below 1500 dbar, there is no obvious drift with depth, and the mean (± st dev) fit is 13.7 ± 1.5 µmol/kg. In the top 180 dbar, the fit over 45 points (excluding 4 obvious outliers) is 7.8 ± 1.6 µmol/kg. With rather scattered points between 200 and 1500 dbar, our final choice is a correction of 7.8, 13.7, 13.7 µmol/kg at 0, 1500 and 5000 dbar respectively, linear between, as shown in Fig 11 (upper).

For the second Sea-Bird (oxygen sensor SBE 43-0076; new and factory-calibrated on 17 Sept 01), used for the remaining casts, the oxygen (bottle - CTD) differences are plotted against pressure in Fig 11 (lower graph) for casts up to 14275. Strange behaviour is shown for the first two casts, 14239 and 14244, with wild variation in the first cast and a fairly constant low value (5.6 ± 2.1) for the second of these. Remembering that the bottles are fired on the upcast, but the CTD values have been taken from the downcast (at the same pressure) shortly after the sensor went in the water for the very first time, it appears that the sensor has taken a while to settle. From cast 14245 on, there is a reasonable fit (over 82 points, after excluding 3 outliers) with a constant value, independent of pressure, of 26.8 ± 2.8 µmol/kg. The correction 5.6 has been applied to the first two casts, and 26.8 to the remained. However, it is not clear why there should have been a jump in the calibration. It is probably that the jump is a consequence of the time history. CTD14244 was the last cast of leg 1, on 22 November. CTD14245 was the first cast of leg 2 on 28 November, six days later. In between, the CTD and sensors sat exposed on deck, and temperatures in Reykjavik and often were below freezing. For that reason, the usual practice of filling the sensors with milli-Q water (to avoid biofouling) was abandoned, for fear of freezing. Could this have changed the calibration?

After applying these calibrations, the scatter of (bottle oxygens - recalibrated SB oxygens) is shown in Fig 12. Following a gap of several days for the medical evacuation to Reykjavik, 6 more CTD casts were done with the second oxygen sensor SBE 43-0076. The calibration for these casts is shown in Fig 13 and mean fits for individual casts are given in Table 4 below.

Table 4. Oxygen calibration data for CTD casts 14283-14295

Cast	No points	Mean	St Dev
14283	7	18.0	2.1
14287	10	16.5	1.2
14288	8	17.1	1.2
14289	8	17.3	3.4
14294	7	16.1	3.4
14295	9	17.0	2.9

From these numbers the calibration appears stable, and a constant offset of 17.0±2.4 was applied, although there is a hint in Fig 13 of depth dependence, with lower offsets in the top 600m and higher ones below that. It appears that the calibration is stable as long as the sensor is in regular use. After a gap of a few days, it may jump - for unknown reasons.

Raymond Pollard, Ulrike Riemenschneider

2.5 150 kHz LADCP

The 150 kHz LADCP is configured as for previous cruises and processed in exactly the same way using Eric Firing's software. [See for example, Allen JT *et al*, 2001; SOC Cruise Report 37, *Discovery* 253 (FISHES)] A copy of the command file used is provided in Appendix A2.3.2 and the log sheet is given in Appendix A2.3.5, together with the deployment steps required.

On leg 2, there appears to be a problem with the 150 kHz data from station 14283. The raw velocity data is about 600 m short of the full depth range.

2.6 600 kHhz LADCP

Leg 1 report

The 600 kHz Workhorse LADCP is new to SOC on this cruise. The instrument proved accessible only via the RDI Workhorse application. Separate applications used to talk to the 150 kHz such as BBTALK, did not appear to work. A command file was created using the PLAN application (see Appendix A2.3.2). This was then loaded by the Workhorse application (see log sheet in Appendix A2.3.6 for the sequence of steps required). Two points should be noted:

- Be careful to choose the cast name correctly. The log files associated with cast 14214 were lost because those for 14215 overwrote the contents of this directory.
- The application only downloads all data from the instrument, so individual files cannot be selected. This means that the instrument's memory needs to be cleared regularly or there is the danger that the download time becomes greater than the time between stations.

The main interest in the 600 kHz ADCP for this cruise was the backscatter calculation. Indeed, velocity calculations produced no sensible results for the configuration we selected. This needs to be further investigated. However, after a range correction (see next sections), the calibrated backscatter data seem to correlate with biology in the water column.

2.6.1 Backscatter

Backscatter may be calculated from echo intensity using the following equation:

$$Sv = C + 10\log_{10}(T + 273.16) + 20\log_{10} R - 10\log_{10} L - 10\log_{10} P + 2\alpha R + k_c(e - e_r)$$

where Sv is the backscatter coefficient (dB), C is a constant dependent on the instrument, T is the transducer temperature (°C), P is the transmit power (watts), R is the range (m) to each bin, L is the binlength (m), α is the absorption coefficient (dB/m), k_c a conversion factor from counts to dB, e the echo intensity and e_r a reference or noise value of intensity [see Deines K *et al* 1995 (Sea Technol 36, 61 -) for details]. The above equation was applied to data from the current cruise. Fig 14 shows results from a single cast, CTD 14200. Backscatter is plotted as a function of depth (averaged to 10 m); the four profiles correspond to each of the four beams. There is clearly a range error in the data, since bins at different ranges should 'see' approximately the same scatterers with depth.

2.6.2 Backscatter range correction

To correct for this error, consider Fig 15 in which the backscatter (blue line) is plotted as a function of bin number. Deeper bins exhibit a linear trend with range, while the decay towards the origin may be represented by a log term, in line with the form of range dependence in the original calibration equation above. So we choose to fit:

$$\Delta Sv = a\log_{10} R + bR + c$$

where R is range from the transducer and y is the estimate of backscatter. Form a least squares fit of the model to the data:

$$S = \sum(\Delta Sv - \Delta Sv_i^2) = \sum(a\log_{10} R_i + bR_i + c - \Delta Sv_i)^2$$

Solve by finding a local minimum:

$$\frac{\partial S}{\partial a} = 2a\sum(\log_{10} R_i)^2 + 2b\sum x_i \log_{10} R_i + 2c\sum\log_{10} R_i - 2\sum\Delta Sv_i \log_{10} R_i = 0$$

$$\frac{\partial S}{\partial b} = 2a\sum R_i \log_{10} R_i + 2b\sum R_i^2 + 2c\sum R_i - 2\sum\Delta Sv_i R_i = 0$$

$$\frac{\partial S}{\partial b} = 2a\sum\log_{10} R_i + 2b\sum R_i + 2c\sum 1 - 2\sum\Delta Sv_i = 0$$

Solving this system of linear equations in three unknowns for station w200_01 results in the equation:

$$\Delta Sv = 11.4763\log_{10} R + 0.2608R - 5.4650$$

Fig 15 shows the fit of the model to the range error curve. The blue curve is the backscatter in each bin relative to the second bin. The red curve represents the model fit to this data including 'a'. Pragmatically we would like simple powers of R in the equation. Since the 'a' coefficient is near to 10, we instead apply:

$$\Delta Sv = 10\log_{10} R + bR + c$$

where R is range from the transducer and y is the estimate of backscatter range correction. Form a least squares fit of this model to the data:

$$S = \sum(\Delta Sv - \Delta Sv_i^2) = \sum(10\log_{10} R_i + bR_i + c - \Delta Sv_i)^2$$

Solve by finding a local minimum:

$$\frac{\partial S}{\partial b} = 2\sum 10R_i \log_{10} R_i + 2b\sum R_i^2 + 2c\sum R_i - 2\sum\Delta Sv_i R_i = 0$$

$$\frac{\partial S}{\partial b} = 2a\sum\log_{10} R_i + 2b\sum R_i + 2c\sum 1 - 2\sum\Delta Sv_i = 0$$

The green curve in Fig 15 represents the two-parameter model fitted to station w200_01. It represents the equation:

$$\Delta Sv = 10\log_{10} R + 0.2856R - 4.1918$$

For the 600 kHhz, typical figures for the terms in equation (1) are:

$$\begin{aligned} Sv &= -139.3 + 10\log_{10}(T + 273.16) + 20\log_{10} R - 10\log_{10} L - 9.0 + 2\alpha R + k_c(e - e_r) \\ &= \Omega + 10\log_{10}(R^2) + 2\alpha R \end{aligned}$$

rewriting the equation into a part dependent on the range, and a part involving all the rest, where

$$\Omega = -139.3 + 10\log_{10}(T + 273.16) - 10\log_{10} L - 9.0 + k_c(e - e_r)$$

T is the transducer temperature and L is the blank beyond transmit. To correct the range error, this term must be subtracted from the backscatter calculated from equation (1). This gives a corrected backscatter, $\hat{Sv}$:

$$\begin{aligned} \hat{Sv} &= Sv - \Delta Sv \\ &= \Omega + 10\log_{10}(R^2) + 2\alpha R - 10\log_{10} R - 0.2856R + 4.1918 \\ &= \Omega + 10\log_{10} R + (2\alpha - 0.2856)R + 4.1918 \\ &= \Omega + 10\log_{10} R + 0.02R + 4.1918 \end{aligned}$$

For reasons not yet understood, the correction removes the quadratic dependence on range from the backscatter equation. Apparently the beam spreads linearly and not quadratically. Further, the effective absorption has become almost negligible at the ranges used here. Note that this correction is effective for 2 m bins only. For longer bins there is an increasing range error per bin, which again is characterised by a logarithmic plus linear equation. Fig 16 shows the profile for station 14200 after correction.

(Leg 1): Steven Alderson, Paula McLeod, Ulrike Riemenschneider
John Allen, Terry Edwards, John Wynar

Leg 2 report

2.6.3 Temperature

The temperature dependence of the backscatter was found to produce stepped results in the final backscatter plots. The LADCP derived temperature is lagged, therefore when bottle samples are taken on the upcast there is a resulting step in the temperature. As a result it was decided to use 'independent' temperatures taken from the CTD data (for which a line was added to the loadascctd2 script). As a result the final plots were much smoother.

2.6.4 Software

There appears to be a problem with the navigation file. Occasionally the data is out of order giving a matlab error, claiming that the file is not monotonic. To overcome this a 'sort' command has had to be added to the donav code. It is not known why the software rewrites latlon.asc - as this appears to be a cause of the scripts falling over. A similar problem also occurs with get_adcp, however, this is believed to be a hardware problem.

2.6.5 Averaging the bins

As an alternative to the svavrge script, we attempted to use means of the ensembles rather than means of the bins (using svavrge2 script). The standard deviation was calculated after removing the vertical mean from each ensemble, in order to consider the standard deviation within one profile, rather than between profiles. This was for qualitative comparison with the OPC data. As a result of carrying out this step, the spikes in the data (discussed below) were observed.

2.6.6 Backscatter spikes

The backscatter plots appear to have spikes, as well as steps in the profiles (Fig 17, upper plots). These need to be treated with caution. Smoothing over these steps results in realistic-looking, yet erroneous, data.

2.6.7 Comparison with OPC data

There appears to be a good initial comparison between the LADCP backscatter profiles and the OPC data, for example CTD station 14245 (Fig. 17, lower plots) and ARIES station 14246.

(Leg 2): Mark Sidall, Richenda Houseago-Stokes. Stuart Brentnall

3. Lowered EK500 scientific echosounder (LEK)

The lowered EK500 scientific echosounder package (LEK) comprises a drop frame housing the 'Behemoth' (an EK500 echosounder with a logging/control notebook PC), a battery pack, two transducers operating at 38 kHz and 120 kHz, and a Scanmar transmitter. It is deployed on station to collect good resolution higher frequency echo sounder data from depths greater than 500m, and this cruise provided the first opportunity to deploy the equipment in the current configuration. Before any data were collected, and as part of the trials in the Clyde, the equipment was calibrated to allow the correct integrator and target strength gain values to be applied during post-processing (see Appendix A3).

At the beginning of the cruise, a successful trial deployment of the frame was achieved in the Clyde, in calm sea conditions, using the ship's main winch and trawl wire run over the A-frame at the aft end of the ship. The Scanmar tow-fish, deployed over the port side to communicate with the various nets, proved suitable for receiving the Scanmar transmitter's signal from the frame, and a deployment depth of 100m was achieved. However, the first full deployment of the frame (at CTD station 14191) had to be aborted due to the relative lightness of the frame in water, which meant that it would not sink sufficiently fast under the swell conditions. A lead weight (approximately 60 kg) was bolted to the calibration plate stand, which allowed a full second deployment to 500m (at CTD station 14199), although problems were still experienced with the lightness of frame effecting the main winch's efficiency. Also, it was noted that the transducers stopping transmitting at the water's surface on recovery. The frame was again successfully deployed at CTD station 14200, but as before the transducers stopped transmitting at the surface and signs of vibration damage were found. The bolt securing the Behemoth's platform and the Behemoth's metal banding were both lost, and the banding around the battery pack was loose. Retaining bars were fitted to secure the platform more firmly, and two sets of metal strap banding were fitted to the Behemoth for security. The frame was successfully deployed at CTD stations 14215 and 14223 before the problem of transducer cut-out was apparently resolved. The connectors between the transducers and the Behemoth had worked loose, and a small quantity of water had entered them. This was rectified before the deployment at station 14231. However, this deployment had to be abandoned, as Ethernet communications could not be achieved between the EK500 and its logging and control PC. On opening the waterproof housing, it was found that a connection was loose (probably due to the vibration experienced) and this was easily rectified.

No further deployment opportunities arose on leg 1 of the cruise. On leg 2, a successful deployment was made at station 14249 and a full set of data was recorded. However, communications could not be established with notebook PC on recovery and the transducers had again cut out on the surface. At the next attempted deployment (CTD station 14254) no communications could be established between the notebook PC and the EK500, and the deployment had to be abandoned. When the Behemoth's housing was opened evidence was found that suggested a failure in the EK500 itself. On investigation, it was discovered that the power board supplying the communications circuits had worked loose, and that this might provide an alternate explanation for the problems experienced with transducer cut-out. Although this problem was solved, no further opportunities for deploying the LEK arose during the cruise.

Deployment technique

The method for deploying the frame evolved during the cruise, and current best practice is to use a deck winch leading athwart ships to a large trawl block (braced with bar) and aft over the A-frame. To achieve this, two 250 m lengths of wire were attached to the deck winch and joined with paired Hammerlock shackles. Due to the loss of the Scanmar tow-fish, the 'birdcage' hydrophone was used to receive the Scanmar signal, and was deployed onto the lifting wire after the first 250m of wire had been run out. It was generally recovered before lifting the frame, and always well before the end of the first 250m of wire was recovered. This deployment technique is not ideal as the frame is very vulnerable to damage between the deck and the water's surface, and this problem is exacerbated by the extreme pitching motion experienced on the aft deck under all but the calmest sea conditions.

The experience on this cruise suggests that it is vital that the frame can be left in a position to receive mains power during start-up and shut-down operations, as the power drawn provides the primary diagnostic tool for finding out what is going on within the Behemoth without opening the waterproof housing. Also, it is both simpler and safer if the battery pack can be charged whilst it remains in the frame. In the future, the frame should ideally be deployed from amidships to reduce the risk of damage to the equipment and increase the range of sea conditions under which it can be deployed. To achieve this, the 5-ton Lebus winch (currently used for aft deployment of the LEK and deploying the TEK) could be sited in the water bottle annex on a bedplate attached to the deck matrix. The wire could then be led directly out over gantry using the coring block. If it is not possible to use the water bottle annex due to the pressure on lab space, the winch could be sited on the aft starboard side with two diverter sheaves, one on the deck and one welded to the side of the hanger, used to lead the wire to the back of the gantry. However, the water bottle annex option is heavily favoured due the simplicity of the installation and maintenance.

As part of same change in deployment strategy, the CTD railway would be extended aft with a new trolley built to fit the LEK, so that both the CTD and LEK could be moved easily in and out of the central deployment position. This arrangement would provide both a secure position for the frame when not in use, and a safe method for moving it along the deck. Additionally, the relocation of the winch would provide a method for deploying mid-ships plankton nets to depths greater than 100m. Under this arrangement, the mains and battery charger cables could be fed out from the hanger to the frame through a goose-neck, so that they could be used with both the Behemoth and the battery pack remaining on the frame. An external aerial could also be used, so that the Behemoth could be controlled remotely with the laptop kept in the main laboratory, rather than brought to the frame itself before and after each deployment.

Even with the change in deployment strategy, certain modifications need to be made to the frame before the next cruise. A more permanent method of making the frame heavier in the water is required, and the various elements need better protection from or securing against vibration damage. Specifically, the Behemoth's platform needs a permanent method of stabilisation, and the brackets used to support the Behemoth and the battery housing need improving to remove the need for separate banding to secure the upper parts of each housing to the frame. Also, the arrangement of the internal components of the Behemoth needs to be modified so that they are more resistant to both general vibration damage and the shocks associated with deployment and retrieval of the frame.

Data collected

During this cruise, full data sets were collected from a deployment depth of 500m at CTD stations numbered 14199, 14200, 14215, 14223 and 14249.

Cairistiona Anderson, Ryan Saunders

4. Towed EK500 scientific echosounder (TEK)

The towed EK500 echosounder package (TEK) comprises a towed body containing three transducers, operating at 38 kHz, 120 kHz and 200 kHz, directly connected to an EK500 echosounder, which in turn is connected to a desktop logging PC. The system is deployed whenever the ship is off-station, to collect broad-scale survey data in the top 1000m of the water column, both in conjunction with the various nets and on transects between stations. The towed body is deployed on the starboard side of the ship, aft of the winch cabin, using a lifting wire, and is towed from a boom deployed forward of the CTD gantry. The boom must be stowed inboard during each CTD deployment, so the towed body must be recovered before each CTD station and re-deployed afterwards. As with the LEK, before any data were collected, the equipment was calibrated to allow the correct integrator and target strength gain values to be applied during post-processing (see Appendix A3)

Deployment diary

Few problems were found in the use and deployment of the TEK towed body, once the initial difficulties with the deployment were resolved (see below). After the loss of the Scanmar tow fish, the Scanmar hydrophone was transferred to the towed body (between CTD stations 14211 and 14215), and it provided a suitable platform for this use, which did not appear in any way to affect its primary function as a platform for gathering acoustic data. Between the first and second legs of the cruise (between CTD stations 14244 and 14245) the aft lifting wire was replaced, as was the shackle connecting the towing wires to the boom. The lifting wire had to be replaced as it was showing significant deterioration. This was probably due to it being fixed at both ends, and the use of a swivel at the end of the replacement wire appeared to prevent the problem reoccurring. After an apparent deterioration in signal quality from the 38 kHz transducer, and problems experienced with the heel and pitch monitor on the towed body, the towing wire/transducer cable package was replaced between CTD stations 14276 and 14282. Although this provided a brief improvement in the signal from the heel and pitch monitor, it did not alter any other factors. Throughout both legs of the cruise, significant interference was detected in the data, particularly those from the 120 kHz transducer. The cause of this interference was not discovered, but it appeared extremely regular (approximately 18 – 20 min periodicity) and very consistent. It did not appear to be related to the ship's scientific echosounder, as this was slaved (via 'Ext. Trigger') to the TEK echo sounder during data collection, and the source was likely to be electrical rather than acoustic as it could be detected in the data whilst the towed body was on deck. The source of this interference should definitely be explored further on any future cruise if it remains a consistent feature.

Deployment techniques

During the Clyde trials, it was found that the planned deployment strategy (using the crane to lift the towed body directly from the end of the 25 m lifting wire) was not suitable even under flat calm conditions. A new best practice was therefore developed to minimise the risks of deploying and retrieving the towed body, and to maximise the range of sea states in which it can be used. The revised TEK deployment procedures are as follows:

- The initial phase of the deployment takes place with the ship steaming at 1.5 – 2 knots.
- The boom forward of the CTD is deployed with particular attention paid to the placement of the towing wires in relation to the stabilising line run aft to the side of the ship from the end of the boom.
- The lifting wire from the back of the towed body is run in through the fairlead in the side of the ship, via a snatch block fitted to the deck, to the deck winch placed athwart ships.

- A spring release hook is used to attach the lifting bridle at the back of the towed body directly to the crane hook, with the lifting wire running over the side of the ship and in through the fairlead.
- A line is looped through the front of the towed body to control its swing whilst it is lifted over the side by the crane. The lifting wire and the rapid deployment of the towing wires/transducer cable package over the side of the ship are also used to provide stability. Great care must be taken that the towed body does not twist or enter the water over or ahead of the end of the towing cable. The crane hook should not be released or the lifting wire paid out until it is clear that the towed body is hanging correctly in the water.
- Once the towed body is settled in the water the ship's speed is raised to the working rate (ideally 10 kn, no more than 11.5 kn max) and the lifting wire is paid out (at least 15 m out of 25 m total).

The towed body should fly out from the side of the ship at all speeds over 1 knot, although significant vibration in the towing cable and boom arrangement is expected at slow speeds.

TEK retrieval procedures are as follows:

- Whilst the ship is steaming at between 7 and 10 knots, sufficient slack should be taken in on the lifting wire that it can be removed from the snatch block on the deck and reset, using a wire stopper, so that instead of leading out through the fairlead it leads directly over the side of the ship from the deck winch.
- A snatch block is then set on the lifting wire and attached to the crane hook. The crane arm is swung out and forward over the side of the ship until it is above and just forward of the towed body. The snatch block on the deck (used during deployment and use) is removed so that it does not impede the retrieval of the towed body.
- Once the crane is in position over the towed body, the ship's speed is dropped to between 1.5 and 2 knots and the towed body is lifted using the lifting wire on the deck winch, and is manoeuvred inboard using the deck winch in conjunction with the crane arm.
- As soon as the towed body is over the side of the ship, the rapid retrieval inboard of the towing wire/transducer cable package helps stabilise its swing.
- The boom is then brought inboard, with particular care paid that the transducer cable does not get pinched as it is brought onto the side of the ship.

Currently, between deployments the towed body is stowed against the mooring bollards just forward of its deployment position. This provides easy attachment points and some security against the towed body sliding up and down the deck, and is well-placed to provide sufficient slack in the towing cable package for the boom to be brought inboard. However, it is not ideal, as it means the steel frame of the towed body is resting directly on the steel deck plates, which provide little resistance to movement. During passage out to the study area, the towed body was swung forward using the crane onto the wooden decking ahead of the winch cabin and fixed against the outboard side. The towing cable package was secured against the outer bulwark, with the slack placed in a figure of eight and secured at all points. Although this provided a secure attachment point, it is not ideal as the rear fins in particular are vulnerable to damage whilst in the scuppers. This is also true of the normal storage position, and significant changes in the behaviour of the towed body in the water were noticed after each extended period of storage on deck. This was attributed to the distortion of the rear fins by waves coming up through the scuppers or incorrect lashing of the towed body.

In future, a proper cradle for securing the towed body would greatly improve matters. This would provide a protected and secure fixing position on the metal deck. It would also reduce the problem of the towed body sliding across the deck as it is retrieved - assuming that the front of the frame could be caught in the cradle as it is lowered to the deck. The use of a davit (specifications of those available to be confirmed) in place of the crane would also help to control the deployment and recovery operations. The TEK would be deployed from the same place on the deck, and the 5 t Lebus winch currently used could be replaced with an equivalent 2 t winch. Overall, this would expand the range of sea conditions in which the towed body could be safely retrieved, and is likely to reduce the number of people required for the deployment and retrieval operations.

Data collected

During the cruise, TEK data were collected between the following stations (CTD except where stated):

14191 and 14199
14199 and 14200
14200 and 14205
14205 and 14206
14206 and 14211
14215 and 14223
14223 and 14231
14231 and 14233 (end of ARIES tow)
14236 (ARIES not CTD deployment) and 14239
14239 and 14244
14244 and 14244 (deployment curtailed due to bad weather)
14245 and 14249
14249 and 14254
14254 and 14259
14259 and 14262 (OS no. as CTD station aborted due to weather conditions)
14263 and 14267
14267 and 14272 (OS no. as TEK recovered due to Scanmar hydrophone problems)
14275 and 14276 (ARIES no. as deployment aborted due to weather conditions)
14282 and 14287
14287 and 14288
14288 and 14289

Cairistiona Anderson, Ryan Saunders

5. Salinometry

Two Guildline Autosal salinometers were installed in the chemistry laboratory (chemlab): a model 8400A (serial no. 57738), and as backup the older model 8400 (serial no. 43382). Both had been serviced by OSI Ltd. immediately before the cruise. The chemlab, rather than the constant temperature (CT) laboratory, was used because the latter was required for biological experiments. Not having access to controlled environmental conditions is a problem for salinometry. According to the manual, the 8400A can operate satisfactorily at lab temperatures between 4°C below and 2°C above the bath temperature, the preferred temperature being in the middle of this range. Operating at the extreme ends of the range can lead to a situation where, for instance, sample water introduced into the salinometer cell can cool the bath water sufficiently that the heaters stay on permanently, rendering the data worthless. This happened in a preliminary trial run.

Efforts to maintain the chem lab at an appropriate temperature were hampered by several factors: the lack of an adequate thermometer; temperature fluctuations associated with variations in the state of the air conditioning or the number of doors to the outside which were open; and leakage of heat to and from the neighbouring CT lab when the door to the latter was left open. The last problem was most severe when the CT lab was being dried out with heaters following the burst pipe. These fluctuations meant that the bath temperature had to be adjusted on several occasions. Since the instrument takes some 12 - 24 hr to re-equilibrate after each such adjustment, this represented a significant amount of down time for the salinometers. That no serious backlog developed was due to the fact that a relatively small number of samples from the CTD were taken for salinity analysis, for calibration purposes only. Attempts to cool the chemlab by drawing in air from outside using a fan were unsuccessful.

Despite these problems, good quality salinity measurements were obtained. The four duplicate samples measured 'blind' differed by 0, 0, 1 and 3 in the last digit of double conductivity ratio - where a difference of 6 corresponds roughly to a change of 0.001 in salinity, the precision claimed for the instrument. This result confirms that our sampling techniques were adequate. Measurements on standard sea water (SSW) before and after each crate likewise showed drifts of less than 0.001 in salinity over the 2 hours or so taken to process each crate. Occasional sample measurements during which no stable reading could be obtained were discarded. This happened for between 0 and 2 bottles per crate. We are confident that the remaining measurements are accurate to within 0.001 in salinity.

Salinity values were obtained from the double conductivity ratio measurements in the usual way, using an Excel spreadsheet, then transferred to the Unix system in the form of a tab-delimited ASCII file containing the four columns statnum, sampnum, botsal and botsalf – a simplification compared to the practice on earlier cruises. Data from the ASCII files were incorporated into the sam files using the new Pstar script passam.

If the CT lab is unavailable in future, a preferable location for the salinometers might be the stable laboratory (gravimeter room), next door to the gym on the lower deck. While not temperature-controlled, this laboratory is undisturbed and less prone to temperature fluctuations. The stable lab has been used for this purpose before, notably on the ACSOE cruise. Its only real drawbacks are the lack of a nearby source of deionised water, and the need to carry the sample crates down two flights of stairs, which could be a problem in bad weather.

Towards the end of the cruise, it became difficult to get water to flow through the 8400A, despite replacing the peristaltic pump with a newer one. Either a blockage or some problem with the air pump system is suspected; this problem will need to be addressed before the salinometer is taken to sea again. The backup salinometer (8400) was used for the last couple of crates on the cruise. Prior to the next cruise, we strongly recommend that proper packing cases for the salinometers are purchased, since the present plywood crates provide no protection for the salinometers during transport. It would also be a good idea to overhaul the spares box, service the peristaltic pumps and buy a good thermometer.

Stuart Brentnall, Penny Holliday

6. Phytoplankton and pigment studies

6.1 Pigment studies

Chlorophyll and HPLC sampling in leg 1 focused on the surface layer with the top 6 Niskin bottles from the CTD (usually fired at around 100, 75, 50, 25, 10 and 5 m) being sampled at 14 stations. However in leg 2 the number of samples drawn was extended to 8, with 150 and 200 m samples also being taken due to the increased mixed layer depth. Thirteen stations were sampled on leg 2. Samples were collected in 5 litre carboys which were rinsed in the sample prior to being filled.

For HPLC analysis, water samples (2 litre) and duplicates were filtered through 25 mm Whatman GF/F filters using a specially developed positive pressure filtration unit. The filter papers were then immediately stored in cryovials and stored in a –80ºC freezer for subsequent HPLC analysis at SOC.

For chlorophyll analysis, two 300 ml aliquots were filtered through Whatman GF/F filters at low pressure. The filters were then placed in amber glass vials containing 10 ml 90% acetone and immediately stored in the dark at 5ºC for 24 hr to extract the chlorophyll. In total, 27 CTD, 15 ARIES, 2 Ocean Sampler stations and 144 underway samples (to calibrate the FRRF and underway fluorometer) were analysed during the cruise.

6.2 Chlorophyll analysis

Samples were warmed to room temperature before the fluorescence was measured using a Turner Designs Fluorometer. Chlorophyll standard solutions (Sigma) covering the expected chlorophyll range were used for calibration of the fluorometer before each set of samples were analysed. The chlorophyll concentration of these were calculated from the absorbance measured at 750, 664, 647 and 630 nm in a Cecil spectrophotometer, using the equations of Jeffrey & Humphrey, 1975 (Biochem. Physiol. Pflanzen, 167: 191-4).

6.3 Phytoplankton studies

During leg 1, phytoplankton samples for microscope speciation studies at SOC were taken at the surface and at the chlorophyll maximum. In leg 2, a further sample was taken at around 150 m. Two amber glass bottles were filled for each depth and preserving agents (Lugol's iodine and buffered formalin) added to each.

Picoplankton samples were taken from the top six Niskin bottles (leg 1) and top eight (leg 2) and preserved with glutaraldehyde for subsequent analysis by flow cytometry at PML. Samples were also collected and preserved for ciliate and heterotrophic dinoflagellate analysis by Dr David Montagnes (Univ of Liverpool). A total of 148 phytoplankton samples and 188 picoplankton samples were taken from 27 CTD stations.

Russell Davidson

7. Oxygen, nutrients, and SF_6

7.1 Dissolved oxygen

Dissolved oxygen was measured on approximately half the bottles from all the CTD casts using a semi-automated whole bottle Winkler titration unit with spectrophotometric end point detection manufactured by SIS. Samples were drawn directly from the Niskin bottles into 100ml calibrated oxygen bottles, their temperature measured and fixed immediately using alkaline iodide and manganous chloride solutions prepared following Dickson AG, 1994 (Determination of dissolved oxygen in seawater by Winkler titration. WOCE operations manual; WOCE Report 68/91, Revision 1 Nov 1994).

The dispensers used to fix the samples were thoroughly cleaned in hot water at the start of the cruise and whenever they became sticky. Samples were shaken twice, once on deck and a second time shortly afterwards in the lab and then titrated in the Decklab within 12 hr. Acidification was performed using a 5ml Finn pipette. The user variable parameters in the SIS supplied software are in the parameters screen arrived at through the options menu. The following values were determined by trial and error at the start of the cruise and applied throughout: Stepsize 5, Wait time, 10, Fast delay, 5, Slow delay 5, Fast factor 0.5. This parameter set resulted in titration times of less than 4 min. A single one litre batch of sodium thiosulphate (25g/l) was prepared at the start of the cruise. This strength solution results in titration volumes of about 0.25 ml, thus all oxygens determined on the cruise were titrated using a single solution. This solution was standardised at the start and end of the cruise using a commercially available 0.01N potassium iodate standard (Ocean Scientific International, Petersfield, Hants). Between these points the thiosulphate breakdown was regularly (every few days) monitored using an in house standard prepared on board by dissolving 0.3567 g reagent grade KIO_3 in 1 l Milli-Q water. Changes in the volume of thiosulphate required to titrate 5ml aliquots of the in house standard were used to calculate the volume of thiosulphate that would be required to titrate similar aliquots of certified standard. This volume was then used in the calculation of oxygen concentration which was performed on an Excel spreadsheet following the equations supplied by Dickson (1994).

At the end of the cruise, the calculated volume of thiosulphate required to titrate the certified standard (determined from the volume required to titrate the in house standard) was compared with the actual volume of thiosulphate required to titrate the certified standard. The two volumes were within 0.1% of each other. The reagent blank was evaluated at the start of the cruise and found to be 0.0006ml for the single batches of reagents used during the cruise. This value was applied to all calculations undertaken. The thiosulphate solution was found to be extremely stable with the percentage increase in thiosulphate volume required to titrate 5 ml of the in house prepared standard being 1.15 % over the seven weeks of the cruise (Fig. 18). A minimum of one bottle of each cast was sampled twice to gain an estimate of the analytical precision. The mean difference in calculated oxygen concentration between all the duplicate pairs sampled was 0.38%. There is no indication of systematic changes in analytical precision with time (Fig. 18).

Richard Sanders

7.2 Nutrients

7.2.1 Methods

Concentrations of nitrate + nitrite (hereafter nitrate), reactive orthophosphate (hereafter phosphate) and orthosilicic acid (hereafter silicate) were measured on unfiltered water samples using a Skalar Sanplus autoanalyser situated in the forward port corner of the Decklab. This was unsatisfactory given the wildly fluctuating temperatures in this laboratory. The proposed containerisation of chemistry on the second MarProd cruise (*Discovery* 262) should assist in this respect. Samples collected using the CTD were drawn directly from the Niskin bottles into brand new 40ml Coulter Counter vials. Samples collected using ARIES were drawn through FRS-supplied tube into brand new 40ml Coulter Counter vials. Both sets of samples were stored at 4°C in darkness prior to analysis and analysed as soon as practicable. Analysis generally took place within 12 hr but was on occasions delayed by as much as 24 hr.

The analytical methods followed those laid out by Kirkwood in the Skalar user manual with the following exception. The flow rates of the two phosphate reagents were increased at the beginning of the cruise from 0.1ml/min to 0.23 ml/min and the flow rate of the phosphate sample was increased from 0.8 ml/min to 2 ml/min. This was in order to alter the peak shape from the pointed ‘nitrate’ shaped peak which resulted in high phosphate carryovers, a consequent requirement for long wash times and poor calibration curves observed on *Discovery* 253 (FISHES) to a square ‘silicate’ type peak which it was hoped would circumvent these problems. In the early part of leg 1 prior to 15 November both sample and wash times were 90 sec.

During the sequence of storms which prevented work from 15-20 November, extensive tests were carried out to examine the impact of decreasing the wash time on the linearity of the calibration curves. These tests produced satisfactory calibration curves and the wash time was therefore decreased to 45 sec. From 20 November, all samples were analysed in duplicate, a substantial increase over the two per station analysed in duplicate before 15 November. The following changes were also introduced during the 15-20 November storm:

- Air compressor controlled bubble injection was introduced to all bubble points, including the bubble point on the phosphate line which had previously been removed due to its adverse impact on peak shape and quality.
- All sample and reagent tubes were renewed (they had previously been renewed on 5 Nov)
- A new cadmium column was fitted (attempts to repack the existing Cd column fitted on 5 Nov in response to degrading peak shape on 15 Nov had resulted in an accelerated deterioration of the nitrate peakshape and carryover in the calibration curve).

The main autoanalyser power supply was replaced early in the cruise after it fused, a consequence of spray entering a poorly-secured deadlight behind the instrument in heavy seas.

Following the port call a new set of pump tubes was fitted. These were again renewed following the medevac approximately half way through leg 2. At this point the compressor controlled air injection on the phosphate line was converted to roller pump tube controlled injection in a bid to stop the phosphate baseline shifts that began to occur after the mid-cruise port call. The wash time was increased to 90 sec for leg 2 as the nitrate calibration curve was found to be non-linear on the first station following the port call. In hindsight this was probably caused by the new cadmium column bedding in, and thus a mistake - as it increased the run time by about 30% and possibly contributed to the phosphate problems observed throughout leg 2. The minimum sample time with the current analyser configuration (compatible with square N and Si peaks) is 90 sec; however, 45 sec appears to be an adequate wash time to get acceptable resolution of N peaks when the cadmium column is bedded in nicely.

The computer that logged the data from the analyser stopped communicating with the instrument on 12 December and was replaced by the computer that controlled the oxygen instrument (having taken the precaution of preloading the software onto both machines). Data files were compressed using winzip and transferred using floppy discs as the USB zip drive would not work with the Windows 95 software on the oxygen laptop. This computer failure had the knock-on effect of delaying the analysis of all subsequent samples taken on the cruise by at least 24 hr and in some cases by 36 hr.

Version 1.4 of the Scalar-supplied processing software was used with both the baseline and drift corrections applied. Following the completion of a run the peak assignment was manually checked and any electrical spikes/ bubbles, poorly formed peaks or mis-assigned peaks corrected. Excel files were then created of the results and these combined with the dissolved oxygen results to create a single results file for each station. Prior to 15 November the single analysis of each sample was reported; after 20 November the mean of the two determinations was reported unless there were reasons for rejecting one of them. This was particularly the case for some of the phosphate peaks (see later discussion). Finally a further QC check was undertaken by eliminating datapoints on a case by case basis that deviated from the bulk Redfield ratio calculated for the cruise split into four sections (pre and post-storm on leg 1, and pre and post-medevac on leg 2). Each line was cleaned daily using a solution of 10% decon and exceptionally 10% NaOH (phosphate) by pumping it through the lines for 15 min at the beginning and end of each day. On occasions when 3 runs of 70-100 samples each were analysed in a single day it is clear that additional cleaning of the phosphate line needs to be undertaken (see later), a regime of cleaning after each run, where time allowed, was introduced.

10 mM Standards were prepared fresh from weighed dried salts on 2 and 3 November. Working standards (40, 30, 20, 10 uM Si, 20, 15, 10, 5 N, 2, 1.5, 1, 0.5 μM P) were prepared on a daily basis by dilution into nutrient-free artificial seawater. It was noted that on occasions residual phosphate peaks were present in the diluting seawater (c 0.05 μM). This factor has not been corrected for. Secondary standards prepared on 4 November and 14 December were intercalibrated against Ocean Scientific International marine nutrients kit standards on the same days. The intercomparison conducted early in the cruise immediately after the replacement of the power supply was unsatisfactory as the concentrated solutions supplied by OSI contain nutrients in addition to the one they are the standard for. No further intercomparison was possible at this point as station work began almost immediately. The comparison undertaken on 14 December yielded the following values for the SOC standards (value in parentheses represents the nominal concentration):

P: 1.46, 1.48, 1.49, 1.52, 1.5 μM (1.5 μM)
N: 14.91, 14.95, 14.97, 14.93, 14.94 μM (15 μM)
Si: 15.68, 15.67, 15.68, 15.79, 15.6 μM (15 μM).

It is planned to use the same primary standards for the entire series of MarProd cruises, and they were returned to SOC at the end of this cruise for further testing (particularly the silicate standard). A bulk sample was taken on the first station in the western Iceland basin (14191) station in the deep Antarctic bottom water layer. This sample was run in duplicate on each analytical run. A 20 µM nitrite solution was run on each run to evaluate the reduction efficiency of the cadmium column. On a day to day basis the following instrument parameters were logged: slope of the calibration curve (bits/µM); baseline; the correlation coefficient (R^2 value) of the calibration curve; and a parameter described in the Skalar software manual as the relative standard deviation of the calibration curve. In practice this turns out to be closely related to the correlation coefficient of the calibration curve and it has therefore not been reported here.

The phosphate line gave problems throughout leg 2. This was manifested by sudden, dramatic increases in baseline and deterioration in peak quality, particularly in the second or third run of the day. Overall somewhere around one half of the runs were affected to some extent. If this were spotted early enough it could be rectified by removing the flow cell from its housing and shaking it vigorously to dislodge what I assume was accumulated reaction product. If left to itself then the baseline normally returned to close to its original value. When this occurred early in a run, the run was terminated, the lines cleaned and the run restarted. When it occurred mid way through a run, a decision was made on a case by case basis what to do. Generally this amounted to running second sets of standards after the baseline jump following flow cell shaking. On all but one occasion a set of sample analyses was completed with a large number of duplicates. This was the final run of ARIES cast 14296. For this station no P data has been reported. Further to this problem, odd individual phosphate peaks that appeared to be erroneous were manually edited from results files.

7.2.2 Performance of the analyser

Fig 19 shows time series of baseline values and calibration coefficients recorded for the analyser on each run. The nitrate baseline was relatively invariant over the course of the cruise. The silicate baseline increased over the course of the cruise and the phosphate baseline declined over the course of the cruise. The phosphate calibration constant was approximately constant over the course of the cruise, the silicate calibration constant steadily increased, and the nitrate constant rose and then fell.

Fig 20 (upper plots) shows time series of calibration curve correlation coefficients. Silicate correlation coefficients were uniformly high, nitrate and phosphate correlation coefficients suffered occasional lapses (P around 10 and 30 Nov) but were generally of a comparable magnitude to the silicate correlation coefficients.

7.2.3 Bulk concentration and nitrite column efficiency

Fig 20 (lower) shows time series of bulk nutrient sample concentration. The concentrations of nitrate and phosphate decreased by about 2 and 0.1 µM over the course of the cruise. The silicate concentration remained relatively static compared to the nitrate and phosphate concentrations. The maximum deviations of individual samples from the mean line (which provide some estimate of day to day precision of the analyses) are estimated to be Si 1.0 µM (3%), P 0.04 µM (3%), and N 0.3 µM (2%) where the values in parentheses indicate the approximate percentage of bulk nutrient concentration that these deviations represent. The reduction efficiency of the cadmium column used for nitrate reduction was 102±1.87 %.

7.2.4 Duplicate samples

The analysis of duplicate samples has been divided into two sections. The first concerns the period before the large storm on leg 1 (15- 20 Nov) and the second the rest of the cruise, split into three sections: post-storm on leg1; before the medical evacuation on Leg 2 (to 5 Dec); and after the medevac (after 8 Dec). During the first part of leg 1, one or two samples were run in duplicate on each run. The average difference between these duplicate pairs, expressed as a percentage of their average value was 0.4%, 1.7 and 1.06% for nitrate, phosphate and silicate respectively.

For the remainder of the cruise every sample was analysed in duplicate. The true and absolute differences between each pair of duplicate samples analysed has been computed as value 1 – value 2 (where values 1 and 2 are the first and second determinations respectively). The mean true and mean absolute differences were then evaluated, as shown in Table 5 below.

Table 5. Mean true and absolute differences for nitrate, phosphate and silicate determinations

Period	Nitrate				Phosphate				Silicate			
	True difference		Absolute difference		True difference		Absolute difference		True difference		Absolute difference	
	µM	%	µM	%	µM	%	µM	%	µM	%	µM	%
Leg 1 post storm (after 20 Nov)	0.04	*0.90*	0.20	*0.99*	0.00	*1.14*	0.05	*2.57*	0.08	*0.29*	0.16	*0.41*
Leg 2 pre medevac (to 5 Dec)	-0.08	*1.07*	0.15	*1.30*	-0.01	*0.81*	0.03	*1.21*	0.04	*0.50*	0.21	*0.54*
Leg 2 post medevac (after 8 Dec)	-0.30	*2.10*	0.40	*2.66*	0.00	*2.68*	0.03	*3.24*	-0.01	*0.98*	0.14	*1.52*
All data from above	-0.14	*1.40*	0.24	*1.72*	-0.01	*1.46*	0.03	*2.10*	0.03	*0.63*	0.18	*0.86*

The mean absolute differences for N, P and Si across the whole data set were 1.7, 2.1 and 0.86% respectively, and their maximum values (all of which occurred in the final period of the cruise) were 2.66, 3.24 and 1.52% respectively. The true differences were always smaller than the absolute differences. The mean true difference is lower because analytical precision, which is assumed to be random, is as likely to make value 1 greater than value 2 as it is to make value 2 higher than value 1. Thus in an ideal world we would expect this parameter to be zero. When these parameters are not zero it indicates that uncorrected instrument drift is occurring such that all determination 1 values are greater (or less than) all determination 2 values.

The absolute difference includes both this drift effect and the analytical imprecision effect since now a situation where determination 1 is larger than determination 2 for sample A is cancelled out by determination 2 being larger than determination 1 for sample B is not averaged away but included. The absolute differences are therefore the most appropriate values to compare with the figures derived for the pre-storm period of leg 1 shown above. They are much larger than these values, probably a consequence of the replicate samples from leg 1 being run close to their duplicate pair (a close analogue to this situation in this second period can be derived by considering the difference between the duplicate bulk determinations since they were done consecutively, these values were 0.47, 1.74 and 0.42% for N, P and Si which are very close to the values shown above for the first part of leg 1.

We can use the difference between the mean absolute and mean true differences shown above to gain an insight into the proportion of the total absolute difference which is due to analytical imprecision versus that which is due to uncorrected instrument drift (Table 6).

Table 6. Nutrient analysis errors due to uncorrected instrument drift and to analytical imprecision

Period	Nitrate		Phosphate		Silicate	
	Drift error (%)	Analytical error (%)	Drift error (%)	Analytical error (%)	Drift error (%)	Analytical error (%)
Leg 1 post storm (after 20 Nov)	91	9	42	58	70	30
Leg 2 pre medevac (to 5 Dec)	75	25	59	41	78	22
Leg 2 post medevac (after 8 Dec)	66	34	75	25	51	49
All data from above	75	25	61	39	67	33

Table 6 indicates that uncorrected instrument drift dominates the error involved in the determination of nutrient concentration, contributing around three quarters of the error in nitrate determination, 60% of the error in phosphate determination and two thirds of the error in silicate determinations. A possible solution to this problem is to use more drift corrections within the analytical run. On this cruise a drift standard was run every 20-40 samples (mainly because of the large volumes of samples that ARIES produces. This is clearly not adequate and one should be run every 10-20 samples.

7.2.5 N/P ratio

The N/P ratio of the entire dataset and of the four sub-datasets has been evaluated. A model II regression analysis has been undertaken to find the linear fit which best describes the data. This regression technique works by minimising the deviations of both parameters from the line of best fit and thus makes no *a priori* assumptions about the correctness or otherwise of either of the parameters. This contrasts with a model I analysis which assumes implicitly that the x parameter (normally P) is correct. Given the problems experienced with phosphate analyses on this cruise it seems logical to use the RMS deviation of the phosphate data points from the line of best fit as an indicator of data quality (Table 7).

Table 7. RMS deviations of phosphate data from best model II regression between nitrate and phosphate data from the entire cruise and for work periods within it.

Period	RMS phosphate deviation from line of best fit	
	µM	%
Leg 1 pre storm (to 15 Nov)	0.02	2.33
Leg 1 post storm (after 20 Nov)	0.02	1.81
Leg 2 pre medevac (to 5 Dec)	0.03	2.58
Leg 2 post medevac (after 8 Dec)	0.03	2.72
All data	0.04	3.03

The mean deviation of phosphate data from the line of best fit was 0.04 µM or 3%. This value ranged between 1.8 and 2.72%. Clearly the modifications to the phosphate line undertaken between the first and second work periods were useful. However the problems suffered by the phosphate line in the second half of the cruise reversed these gains to some extent.

Richard Sanders

7.3 SF_6

Samples for sulphur hexafluoride analysis were taken from the bottom bottles on nine stations. These stations, together with the date on which they were sampled, their locations and the Niskins from which samples were drawn are listed in Table 8 below.

Samples were drawn directly from the Niskin bottles into 500ml glass bottles using tygon tubing before any other samples were taken. They were then capped, either using a plastic seal and screw cap or by a ground glass stopper secured using elastic bands and cable ties. They were then placed inverted in an outer jacket containing water from the same Niskin bottle and sealed inside a plastic bag. They were stored in the cold room on *Discovery*, packed in ice-chests with freezer blocks and returned to the University of East Anglia for subsequent analysis by Marie-José Messias and Andrew Watson.

Table 8. SF_6 samples taken during cruise. Samples marked with an asterisk were drawn in duplicate.

Station	14239	14244	14245	14249	14254	14259	14263	14267	14275
Date	21 Nov	22 Nov	28 Nov	29 Nov	29 Nov	30 Nov	2 Dec	3 Dec	4 Dec
Latitude °N	60.65	61.04	65.25	64.33	64.45	64.57	62.74	61.99	61.43
Longitude °W	34.34	37.05	29.49	31.99	33.99	34.00	36.57	39.41	39.62
Sampled Niskin	1	1*	1*	1*	1*	2	1	1	1
	2	2*	2*	2	2	3	2	2	2
	3*	3	3	3	3	4	3	3	3
	4	4	4	4	4	5*	5*	4	4
	5	5	5	5	5	6	6*	5*	5*
	6	6	6	6	6	8	8	6	6
	8	7	8	8	8	11*	9	8*	8
	9	8	10	9*	10		10	9	
	10		12		12*				
	11*								

Richard Sanders

8. Floats

The original intention to deploy four floats on the southern transect (line D) of the Irminger Sea and two on the next transect (line C) was thwarted by the weather. Instead, four floats were deployed, one on line D and two somewhat further north, as documented in Table 9.

The Martec floats drift at 1950 m; the Apex floats at 2000 m. They surface every 10 days to have their position ascertained by Service Argos, and to broadcast the TS profile obtained during their ascent. These floats will provide information about the deep currents which advect the zooplankton.

The floats may also experience an episode of deep convection, which is suspected to take place during the winter in the Irminger Sea.

Table 9. Float deployments

Float	Argos ID	Deployment time (ddd/hh:mm)	Latitude °N	Longitude °W	CTD station
Martec 33	D64A4	318/01:08	56 34	36 54	14231
Apex 434	A2F9E	325/17:45	60 39	34 18	14239
Apex 436	A3072	326/12:00	61 03	37 03	14244
Martec 34	D66C9	338/07:14	61 26	39 37	14275

The Apex floats, manufactured by Webb Research Inc., are easier to set up. Apart from a desirable but optional test procedure (which was carried out and which we strongly recommend), all that is required is a reset of the float using a magnet, a couple of checks that the float has activated properly, and the replacement of a bung in the lower end of the float. The Martec floats also have a test procedure, which should be carried through because other users have experienced failures both at this stage and post-deployment. An inconvenient aspect of the test procedure is that the floats need to be in an upright position for the test of the hydraulic systems, which presumably depend on gravity. These floats also need to be programmed with the mission parameters. This makes deployment more time-consuming (of order 45 min), but gives more flexibility. In particular, one can decide at deployment time on the depth at which the floats are to drift, an option not available with the Webb floats.

Another shortcoming of the Martec floats is the nature of the packing cases in which they are supplied. There is nothing to prevent the floats from moving back and forth inside the cases during transport or storage on board. Two of the three floats examined had bent antennae as a result of this. One of these (serial no. 34) passed the Argos transmission test prior to deployment; the other (no. 35) has not been tested or deployed yet.

Two deployment methods were tried. The more successful involves lowering the float horizontally off the stern using two ropes attached to the rail, while the ship steams slowly forward at half a knot. This is a skilful operation, carrying the risk of the float being dropped from an undesirable height, but has been carried out successfully on all three occasions when it has been tried, by the Bosun and his mate. Webb Research suggest lowering the float on a line passed through a small hole in the stabilising flange. On the one occasion this was tried, the line became tangled and the float had to be cut loose with a length of line still attached. Fortunately this does not appear to have compromised the functioning of the float; indeed all three floats deployed on leg 1 have reported back satisfactorily. There was not the opportunity to query Service Argos concerning the fate of the fourth float during leg 2 of the cruise.

Stuart Brentnall

9. Underway data

9.1 Thermosalinograph and Surfmet data

9.1.1 Instruments

Underway surface meteorology and thermosalinograph (TSG) measurements were made by the RSU/UKORS Surfmet system throughout *Discovery* 258. The instruments used, together with their serial numbers and manufacturer are listed in Table 10 below and were the same as those used on *Discovery* 253 (FISHES).

Table 10. Sensors for Surfmet and thermosalinograph

Instrument	Manufacturer	Serial number
OTM (temperature) Housing	FSI	1374
OTM (temperature) Remote	FSI	1360
Fluorometer	WetLabs	117
Transmissometer	SeaTech	T1005
Barometric Pressure	Vaisala	S361008
Temperature / Humidity	Vaisala	1850014
PAR (DRP-5)	Didcot/ELE	30471
PAR (DRP-5)	Didcot/ELE	30470
TIR (Pyranometer)	Kipp & Zonen	994132
TIR (Pyranometer)	Kipp & Zonen	994133
OCM (Conductivity)	FSI	1376
Sensor collector (QLI50)	Vaisala	R381005
Anemometer	Vaisala	P50421
Wind Vane	Vaisala	R07101

9.1.2 Processing

Processing of the underway data was undertaken daily after 18:00 hrs GMT using a number of Pstar scripts described below.

1. **smtexec0**: This script was used to read the data stream Surfmet on the RVS level C into Pstar format using datapup. The resultant file was smt258**.raw. At first the dataname was just set to smt$CRUISE but on Leg 2 the script was modified to give the dataname smt258**.

2. **smtexec1a**: Ensured absent Surfmet data values were set to –999. The script also calculated TSG salinity using housing temperature, conductivity and a zero pressure value. Calibration of temperature variables followed the most up to date calibration sheets and the coefficients used were:

$$\text{Temp\_m (true)} = 2.3\text{x}10^{-3} + 1.0011\ (T_m) - 1.00\text{x}10^{-4}\ (T_m)^2$$

$$\text{Temp\_h (true)} = -7.5\text{x}10^{-3} + 1.0006\ (T_h) - 6.0\text{x}10^{-5}\ (T_h)^2$$

Bestnav positions from abnv258* were then merged into the output file smt258** and averaged into a 2 minute file, smt258**.av. Note that for smt25801, positions were taken from the gps4000 file, gp42581, as the RVS bestnav system was not started until after the beginning of surfmet logging.

The light sensor data have only 4 decimal place resolution on the level-B (measured in mV), this restricts the resolution to a coarse 10 Wm^{-2}. The conversion factors below were applied to the light sensors:

$$\text{Ppar (W/m}^2) = 1.0020\text{x}10^5\ \text{Ppar}_{\text{(raw)}}$$

$$\text{Spar (W/m}^2) = 1.0010\text{x}10^5\text{Spar}_{\text{(raw)}}$$

$$\mathrm{Ptir}\ (\mathrm{W/m^2}) = 0.9709\times10^5\ \mathrm{Ptir_{(raw)}}$$
$$\mathrm{Stir}\ (\mathrm{W/m^2}) = 0.8697\times10^5\ \mathrm{Stir_{(raw)}}$$

Some median de-spiking was added to this script because of noisy data (temp_h, cond, fluor and trans) and pintrp added to fill gaps in the data.

3. **smtexec1b**: The 2 minute average smt258**.av files were merged with the master Ashtech file to add gyroHdg and a-ghdg variables, and calculate true heading. In smt28514.raw, a large backward time jump occurred at 04:48 on Julian day 319 (15 Nov). This was a single point with a time stamp of 00:48:20 and originated from the Surfmet PC, it was subsequently edited out using pcopya.
4. **smtexec2:** This script computed vessel speed and subtracted it from relative winds to obtain true wind speed and direction. To save version codes on the dataname smt258, the script was run on the leg 1 master .hdg file and thus the resultant file was smt25800.met. Rob Lloyd advised that wind speed and direction from the Surfmet system should be viewed with caution since the Surfmet PC had a tendency to do a straight average of directions of 0 and 360°.

At the end of leg 1 the master file smt25800.met contained very spiky data, some periods of bad data and uncalibrated light sensors. Thus the daily files were abandoned and this master file cleaned up ready for salinity and fluorescence calibration, and renamed smt2581.met in keeping with file-naming protocol for other data streams. The clean daily files from leg 2 were appended to the master file smt2582.met. TSG (surface salinity and temperature) and windspeed data are shown in Fig 21.

The ship's non-toxic water supply was turned off at ~17:30 on Julian day 315 (11 Nov), following the discovery of a leak in the supply pipe behind the wall panels of the CT laboratory. This leak had caused a significant volume of water to flood the floors of both the CT and chemistry laboratories. Whilst the leak was fixed the following morning (when a panel was cut out of the wall of the CT lab to provide access), the non-toxic supply was not turned back on until ~16:30 that day (316; 12 Nov).

9.1.3 Salinity calibration of underway data

Samples for salinity analysis were collected every 4 hr from the non-toxic supply as it left the FRRF (low water pressure meant no sample could be collected from the TSG sample tap). The conductivity of the samples was recalculated using the housing temperature and zero pressure and compared to the TSG conductivities (Fig. 22). A linear fit was obtained, the coefficients applied to the TSG conductivity, and salinity recalculated. The residuals between the bottle salinity and the calibrated TSG salinity were 0.0030±0.0037 for leg 1 and 0.0049±0.0058 for leg 2.

9.1.4 Fluorescence calibration of underway data

Samples for chlorophyll analysis were also collected every 4 hr, analysed by Russell Davidson and compared to the underway fluorescence. On leg 1 there was a good range of fluorescence and chlorophyll values (though clustered in two groups thought to reflect two regions, the Iceland Basin/Reykjanes Ridge versus the Irminger Sea) and a linear regression ($r^2 = 0.89$, $n = 67$) provided the following coefficients to calibrate the fluor:

$$\mathrm{Fluor_{(cal)}} = -0.1193 + 2.8728 \times \mathrm{Fluor_{(raw)}}\ (\mu\mathrm{g/l})$$

The residuals after the calibration (chla-fluorcal) had a mean of 0.000±0.046.

On leg 2 the chlorophyll and fluorescence values were consistently low (at around 0.10 µg/l) and there was no statistically significant linear fit. Instead a constant offset applied to the fluorescence (0.0272) gave the residuals a mean of 0.0000±0.0325. The results (Fig 23) show the daily peaks of fluorescence observed during leg 1 are absent during leg 2, when - with the exception of the last three days - there were lower light levels and deeper mixed layers.

The final calibrated Surfmet files are smt2581.cal and smt2582.cal.

Penny Holliday, John Allen, Paula McLeod

9.2 Navigation and vessel-mounted ADCP

9.2.1 Introduction

Two RDI vessel-mounted Acoustic Doppler Current Profilers (VM-ADCPs) were operated on *Discovery* 258; the 150 kHz VM-ADCP and a new 75 kHz Phased Array instrument (Ocean Surveyor) that had been fitted immediately prior to *Discovery* 253 (FISHES; May/June 2001). The majority of this report duplicates that of Penny Holliday and Helen Johnson for *Discovery* 253.

The 150 kHz ADCP was mounted in the hull 1.75 m to port of the keel, 33 m aft of the bow at the waterline and at an approximate depth of 5 m. The 75 kHz ADCP was also mounted in a second well in the hull, but 4.15 m forward and 2.5 m to starboard of the 150 kHz well. The following section describes the operation and data processing paths for both ADCPs and describes a brief comparison exercise between them. The navigation data processing is described first since it is key to the accuracy of the ADCP current data.

9.2.2 Navigation

Discovery's best determined position was calculated by the process "bestnav". The main data source was a newly purchased Ashtech G12 positioning system. Thus the GPS Trimble 4000 system, used for most recent cruises was recorded separately. In fact the Ashtech G12 electronics board replaced the Sea Star Mark III Differential GPS system and continued to provide differential corrections to the GPS 4000 system. Thus an examination of positional accuracy, whilst tied up alongside in Govan and Reykjavik, showed that the corrected GPS 4000 system provided higher positional accuracy than the new Ashtech G12 system (calculated with Pstar program gpsrms).

However, results from all three of these systems (Table 11, below) indicate sufficient precision to enable a calculation of ship's velocities to better than 1 cms^{-1}, and therefore below the instrumental limits of the RDI ADCP systems.

Table 11. Comparison of port-based positional accuracy determinations

		Mean latitude ° N	SD	Mean longitude ° W	SD	rms pos error
Govan	Ashtech G12	55.86633	0.00002° = 2.16 m	4.35270	0.00003° = 1.86 m	2.85 m
	Trimble GPS 4000	55.86634	0.00001° = 1.08 m	4.35266	0.00001° = 0.62 m	1.25 m
	GPS GLOS	55.86629	0.00004° = 4.32 m	4.35274	0.00005° 3.10 m	5.32 m
Reykjavik	Ashtech G12	64.15010	0.00004° = 2.39 m	21.93873	0.00003° = 1.89 m	3.05 m
	Trimble GPS 4000	64.15014	0.00002° = 2.33 m	21.93879	0.00003° = 1.53 m	2.79 m
	GPS GLOS	64.15005	0.00003° = ?.?? m	21.93870	0.00006° = ?.?? m	?.?? m

If there were gaps in the G12 data, the bestnav process used other inputs as necessary. These were turned to in the strict preference order: GPS Trimble 4000 data, GPS Ashtech 3D, GPS Glonass (which uses a combination of Russian and American satellite networks). Or, as a last resort, if no GPS was available the Chernikeef electo-magnetic log velocity data and gyro heading were used to dead-reckon the ship's position.

Data were transferred daily from the Level C bestnav stream to the Pstar absolute navigation files, abnv2581 (leg 1) and abnv2582 (leg 2) The G12, gps-4000, gps_glos and gyro (gyronmea) data streams were also transferred daily. Processing scripts nav-, gyro-, gps-exec0 etc are summarized in Appendix A2.2

9.2.3 Heading

The ship's attitude was determined every second with the ultra short baseline 3D GPS Ashtech ADU2 navigation system. Configuration settings from previous calibrations (Trials cruise in April 2001) 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 using the ashexecs listed in Appendix A2.2.

Ashtech 3D GPS coverage was generally good. Dropouts occurred several times; but on only one occasion was it necessary to reset the Ashtech Unit in the Comms Room. Gaps over 1 min in the data stream are listed in Table 12 below.

Table 12. Gaps in Ashtech 3D GPS coverage

	Time gap (yr, JD, hr, min, sec)			Duration
Leg 1	01 307 21:01:00	to	01 307 21:02:07	~1 min
	01 313 13:52:54	to	01 313 13:54:08	~1 min
	01 313 13:56:54	to	01 313 13:59:04	~2 min
	01 317 14:27:26	to	01 317 14:31:03	~4 min
	01 317 14:33:34	to	01 317 14:36:53	~3 min
	01 324 23:52:23	to	01 324 23:56:24	~4 min
	01 325 08:48:00	to	01 325 08:49:05	~1 min
	01 325 09:22:33	to	01 325 09:23:36	~1 min
	01 326 09:39:29	to	01 326 10:15:54	~36 min
	01 326 21:42:40	to	01 326 21:44:14	~2 min
Leg 2	01 329 18:59:10	to	01 329 19:00:11	61 s
	01 330 19:02:54	to	01 330 19:04:00	66s
	01 331 20:42:00	to	01 331 20:43:04	64s
	01 333 09:20:17	to	01 333 09:33:25	13.1 min
	01 337 09:04:44	to	01 337 09:54:55	50.2 min
	01 340 00:44:54	to	01 340 00:46:28	94 s
	01 340 17:26:49	to	01 340 17:33:52	7.0 min
	01 341 08:30:45	to	01 341 08:31:50	65 s
	01 342 08:25:41	to	01 342 08:26:44	63 s
	01 345 20:22:13	to	01 345 20:23:47	94 s

9.2.4 150 kHz ADCP

The 150 kHz RDI ADCP was logged using IBM Data Acquisition Software (DAS) version 2.48 with profiler software 17.20. The instrument was configured to sample over 120 second intervals but unlike its use on *Discovery* 253 (FISHES) we chose to use 100 bins of 4 m thickness, pulse length 4 m and a blank beyond transmit of 4m: the higher vertical resolution would better support the remote detection of zooplankton patchiness. Early in leg 1 and during the steam into and out of Reykjavik the ADCP was switched to bottom and water track mode over shallow ground to enable calibration. The two vessel mounted ADCPs were configured to synchronise their pings over the ensemble period, with the 150 as the "master" and the 75 as the "slave" as recommended by RDI and discussed by Penny Holliday on *Discovery* 253. The result is that each ADCP has only 40 water track pings in the 2 minute period. Spot gyro heading data were fed into the transducer deck unit where they were incorporated into the individual ping profiles to correct the velocities to earth co-ordinates before being reduced to a 2 minute ensemble.

The main difference between the 150 ADCP on *Discovery* 253/258 and previous cruises was that it had been refitted in dry dock prior to *Discovery* 253 and given an offset of 45° on the advice of RDI. This offset was accounted for in the DAS software on *Discovery* 253, however it was missed out of the setup file at the beginning of 258. This is not a problem in itself, as the user's calibration process will correct for the orientation, however, it could be alarming to derive a $\tan\phi = O(1)$ if unaware of the offset. The other major advance was that the ADCP PC clock has been synchronised with the ship's master clock, so removing the tedious need for logging the drift of the PC clock and correcting for it in the processing (old adpexec1). As good practice, however, a check on the ADCP clock time was still made every 24 hr, as was a record of the ADCP electronics temperature - see the two sheets stapled to the inside cover of the 150 kHz log book.

The ADCP data were logged continually by the level C computer. From there they were transferred once a day to the Pstar data structure and processed using standard processing scripts in Pstar; which are presented below. Until Julian day 313 (9 Nov), we experienced communication problems between the ADCP PC and the level C. Three times a day, the data stream would hang and the adcppro level C process would have to be restarted. As there is no warning alarm, this frequently went unnoticed at the very beginning of the cruise leading to quite large gaps (up to a few hr duration) in the data logging. A strange artifact of this was that just the top (16 m) bin of the ADCP data would be logged for a particular time-step associated with each hanging of the adcppro level C process. Thus some manual editing was required to obtain a gridded data file of 100 bin profiles. In addition, one in every three dropouts each day would log bottom track info associated with the single bin data and thus this also had to be edited out of the bottom track file - these edits were made with mlist and pcopya. The problem was solved during the evening of Julian day 313. The header file log on the level C was write protected, and although we do not subsequently use this header, each time the PC began a new ping data file the communications fell over when it tried to write a new header.

Within a few days of the beginning of the cruise, it was clear that the quality of the 150 kHz data was deteriorating rapidly, with the maximum value of 100% good return echoes per 2 min ensemble in a 24 hr period dropping to less than 90%. This was indicative of air in the transducer well. In response to our queries, John Wynar, Bob Keogh and Steve Whittle investigated the problem. The quarter turn valve in the bleed pipe was open; however on closer inspection, following the removal of the bleed pipe, the valve was found to be blocked by scale build-up. The blockage was removed but did not solve the problem as the bleed pipe itself was blocked on the air side of the valve. This was more difficult to clear as around 8 cm of the flexible pipe was scaled up. However, following drilling and poking this too was cleared. This immediately solved the problem with ADCP data quality and was completed by the afternoon of Julian day 313. Subsequently Bob and Steve, also investigated the gate valve in the large bore steel stand pipe to which the aforementioned bleed pipe connects.

The processing exec's used on the ADCP are adpexec0-4, as given in Appendix A2.2.

A calibration of the 150 kHz ADCP was achieved using the limited high quality bottom tracking data available from our departure across the southern Hebridean shelf. As a result of the limited amount of good bottom track data available but the very low positional scatter in the Trimble GPS 4000 positions, as determined earlier, we experimented with a calibration based on standard two min ensemble profiles rather than the usual 10 or 20 min averages. The data used were between 306 19:00:41 and 306 22:08:42 After removing outliers of 2 standard deviations, this resulted in $\tan\phi = 1.1434\,(\pm s.d. = 0.0177), \therefore \phi = 48.82°$ and $A = 1.0005\,(\pm s.d. = 0.0050)$. These compared well with the values obtained during *Discovery* 253 ($\phi = 3.814°$ and $A = 0.9966$), particularly as I suspect the $\cos\phi$ term in the derivation of A (normally negligibly different from 1) was missed out and in fact A should have been 0.9988. As a compromise we used $\phi = 48.82°$ and $A = 1.0000$ in adpexec3.

A power cut on Julian day 340 (6 Dec) at around 1600 corrupted some software files on the 150 kHhz PC and logging was eventually restarted at 1940 after the software was reloaded. In fact the run into Reykjavik meant the ADCPs were switched off from midnight on JD 340 to 1154 on JD 341. On JD 344 the PC gave up the ghost and was replaced by another PC. The hard disk on the replacement PC was small and so data were logged only to the Level B, not the PC. The date on the new PC was set incorrectly and so the time stamp of the Level B data was 24 hours ahead of true time. The Pstar files were thus corrected to true time using pcalib after the datapup process in adpexec0 and before merging with navigation and header data.

9.2.5 75 kHz ADCP

Discovery 253 was the first scientific cruise on which the new RDI Ocean Surveyor 75 kHz Phased Array ADCP was used and thus a new processing path was written. No significant changes were made to this on *Discovery* 258. The instrument was configured to sample over 120 sec intervals with 60 bins of 16m depth, pulse length 16m and a blank beyond transmit of 8m. The instrument is a narrow band phased array ADCP with 76.8 kHz frequency and a 30° beam angle. The PC was running RDI software VmDAS v1.2.012 and WinADCP v1.1.0. Gyro heading, and GPS Ashtech heading, location and time were fed as NMEA messages into the software which was configured to use the Gyro heading for co-ordinate transformation. The software logs the PC clock time, stamps the data (start of each ensemble) with that time, and records the offset of the PC clock from GPS time. This offset was applied to the data in the processing path before merging with navigation. The ADCP was fitted in the forward well previously occupied by the unsuccessful ACCP and before that the ADCP prior to the 1992 re-fit. During fitting a nominal offset of 45° was intended, but the April 2001 trials cruise ascertained that the offset was in fact 60°, and this offset was accounted for in the RDI software. Bottom tracking was switched on early in the cruise and at the end of the leg 1 for calibration purposes.

The 2 minute averaged data were written to the PC hard disk in files with a .LTA extension, eg D258005_000000.LTA, D258006_00000.LTA. Sequentially numbered files were created whenever data logging was stopped and re-started. The software will close the file once is reaches 48MB in size (a user-specified size), though on *Discovery* 258 files were closed after ~24 hr, so they never became that large. The .LTA and .ENX files were transferred to a networked Mac for ftp'ing to the unix directory /data62/surveyor; .ENX files contain the raw ping by ping profiles ready for averaging and were recorded in case they could be useful for looking at deep acoustic backscatter signals. Broadly speaking the new processing path followed the steps outlined for the 150 kHz ADCP. In the following script description, "##" indicates the daily file number.

No decent calibration was obtained at the beginning of the cruise, and therefore the values derived during *Discovery* 253 were used instead. That calibration was established from bottom tracking data collected on long straight SeaSoar runs of Fine Scale Survey 2. The values were:

$$\Phi = 1.3578 \ (\text{sd} = 0.078) \qquad A = 1.0050 \ (\text{sd} = 0.0031).$$

The equivalent execs to the adpexec are the surveyor execs surexec0-4, summarized in Appendix A2.2. The ADCP files and their Pstar equivalents are listed below (Table 13) for the convenience of future users of the .ENX files.

Table 13. ADCP files and their Pstar equivalents

File	Date range (J day, hr, min, sec)				ADCP file name	Note
Leg 1:						
sur25801	307	150818	309	185847	D258Leg1005_000000.LTA	BT
sur25802	309	190017	310	190121	D258Leg1006_000000.LTA	BT
sur25803	310	190237	311	190445	D258Leg1007_000000.LTA	BT
sur25804	311	190615	313	004026	D258Leg1008_000000.LTA	BT
sur25805	313	004110	314	004517	D258Leg1009_000000.LTA	BT
sur25806	314	004621	315	003231	D258Leg1010_000000.LTA	BT
sur25807	315	003453	315	030856	D258Leg1011_000000.LTA	BT
sur25808	315	032128	316	013532	D258Leg1012_000000.LTA	
sur25809	316	013556	317	020601	D258Leg1013_000000.LTA	
sur25810	317	020756	318	023602	D258Leg1014_000000.LTA	
sur25811	318	023721	319	184930	D258Leg1015_000000.LTA	
sur25812	319	185102	320	183108	D258Leg1016_000000.LTA	
sur25813	320	183130	321	172138	D258Leg1017_000000.LTA	
sur25814	321	172347	322	172351	D258Leg1018_000000.LTA	
sur25815	322	172557	323	171805	D258Leg1019_000000.LTA	
sur25816	323	171855	324	172501	D258Leg1020_000000.LTA	
sur25817	324	172602	325	171607	D258Leg1021_000000.LTA	
sur25818	325	171706	326	171710	D258Leg1022_000000.LTA	
sur25819	326	171752	327	172602	D258Leg1023_000000.LTA	
sur25827	327	172645	328	172452	D258Leg1024_000000.LTA	
sur25828	328	172647	328	180047	D258Leg1025_000000.LTA	
sur25829	328	185037	328	185037	D258Leg1032_000000.LTA	BT *
sur25830	328	185401	328	185401	D258Leg1033_000000.LTA	BT *
sur25831	328	185507	329	120712	D258Leg1034_000000.LTA	BT
Leg 2:						
sur25820	331	165250	332	212256	D258Leg2035_000000.LTA	
sur25821	332	212511	332	223913	D258Leg2036_000000.LTA	
sur25822	332	224035	332	224238	D258Leg2037_000000.LTA	*
sur25823	332	224441	338	203709	D258Leg2038_000000.LTA	
sur25824	338	203825	339	202630	D258Leg2039_000000.LTA	
sur25825	339	202732	339	204933	D258Leg2040_000000.LTA	
sur25826	339	205135	340	155340	D258Leg2041_000000.LTA	
sur25832	340	163826	340	192228	D258Leg1038_000000.LTA	
sur25833	340	192422	340	194023	D258Leg1041_000000.LTA	*
sur25834	340	200552	341	001553	D258Leg2042_000000.LTA	
sur25835	341	115417	341	210424	D258Leg2045_000000.LTA	BT
sur25836	341	210503	342	123308	D258Leg2046_000000.LTA	BT
sur25837	342	123542	343	161150	D258Leg2047_000000.LTA	
sur25838	343	161311	343	210714	D258Leg2048_000000.LTA	
sur25839	343	211320	344	141727	D258Leg2053_000000.LTA	
sur25840	344	152759	344	160359	D258Leg2054_000000.LTA	
sur25841	344	160443	346	172857	D258Leg2055_000000.LTA	

BT indicates bottom track files too; * indicates data not processed beyond raw owing to short time range

9.2.6 Processed data handling

For leg 1 on-station data sections for the ADCP data (150 and 75 kHz) were identified using plxyed on the ship's velocities through speed.pdf. To create underway data files (150 kHz only), all data left after removing the station profiles were plotted again through plxyed using pos.pdf and areas of manoeuvring were identified. In each case, relevant profiles were then extracted with pcopya. Once each underway 150 kHz file had been extracted for particular legs, the top row was extracted using pcopyg retaining only two copies of the time variable. The second time variable was then overwritten with the time difference between profiles using fdiff. The time difference value was then merged into the 75 kHz data on time. datpik was then used to select only those 75 kHz profiles where the gaps between 150 kHz profiles was between 110 and 130 seconds. This was a neat trick to avoid the plxyed/pcopya routine a second time.

For leg 2 the times for on-station data were extracted from the start and end of CTD files (pinq, times in seconds after 20/010101/000000) and used to datpik the data from both of the master leg 2 ADCP files through the use of script do.getstns Times of underway sections, ARIES tows and Dual Methot tows were extracted manually, and sections for ADCP data extracted with datpik using do.getuway.

9.2.7 On-station profiles

The on-station data tends to be the best quality ADCP data, penetrating deepest into the water column. The on-station data for the CTD stations were selected and averaged into u and v profiles for each ADCP. The data were merged together and the differences in u and v calculated (75 minus 150). As on *Discovery* 253, the results were very encouraging, suggesting the ADCPs agreed within the expected noise level of the instruments:

U (east)	Mean = 0.129 cm/s, sd = 1.973 (n = 1356)
V (north)	Mean = 0.167 cm/s, sd = 2.161 (n = 1356)

However, it was clear from the %good values that the 150 kHz data appeared considerably poorer. This may be a result of the 4 m bin length chosen for the 150 kHz setup and sparse winter populations of zooplankton. Certainly the %good contour plots look like they show biological layering, but only a thorough investigation of the amplitude backscatter will confirm this.

9.2.8 Depth of penetration

The main potential advantage of the 75 kHz ADCP is that the lower frequency means greater depth penetration, though at reduced vertical resolution (16m bins vs 4m). During *Discovery* 258 the 75kHz ADCP managed to reach 700-750m on station, and 400-500 m steaming. In contrast, typical maximum depths for the 150 kHz are 350-400 m under the same conditions. It is noticeable though that the 75 kHz depth penetration during steaming suffered very readily with the onset of anything other than calm conditions. It was postulated on *Discovery* 253 that the forward well is more prone to contamination by bubbles than the aft well, and if the 75 kHz ADCP is to become the standard ADCP for *Discovery* it may be appropriate to move the 75 kHz to the aft well. However, the underway data during cruise 258 were generally poor as a result of poor weather and high steaming speeds when weather windows occasionally permitted them. The mid-depth spiking in the 75 kHz data at ~330 m, discussed on *Discovery* 253, was not obvious during cruise 258, however the small amount of good underway data available may make this observation unreliable.

John Allen, Penny Holliday, Paula Mcleod, Ulrike Riemenschneider

9.3 FRRF (Fast Repetition Rate Fluorometer)

The FRRF is an active fluorescence instrument which can be used to make rapid, non-destructive and *in situ* measurements of phytoplankton physiology (Kolber ZS, Prasil O & Falkowski PG, 1998; Biochemica et Biophysica Acta 1367, 88-106). Such data can then be used in bio-physical models to estimate the rate of phytoplankton photosynthesis at scales comparable to those of physical variability within the environment (Kolber ZS & Falkowski PG, 1993; Limnol & Oceanogr 38, 1646-65).

The instrument was kept permanently attached to the ship's non-toxic supply in order to provide a continuous record of changes in near surface phytoplankton physiology and provide a comparison and means of data quality verification with the other instruments deployed *in situ*. Power was provided to the instrument using a standard Chelsea Instruments deck box. Data from this instrument were recorded internally and downloaded every ~48 hr to a Mac laptop. A total of 9 files were collected during leg 1 and 11 files during leg 2 (Table 14). On day 338, the dark chamber of the FRRF was filled with filtered seawater (through GF/F paper) to determine the background optical properties of the seawater. The optical chamber was cleaned every 4 days using a small finger and white gentle tissues. The data were not analysed on board.

Table 14. FRRF files

File	Start: J day	hr, min, sec	Stop: J day	hr, min, sec	Gain
Leg 1					
d258001	310	14:20:53	312	17:25:30	auto
d258002	312	18:34:03	314	18:29:53	auto
d258003	314	19:22:49	315	18:35:00	auto
non-toxic turned off at 17:25 Jday 315. Back on am, 316					
d258004	316	17:30:34	318	18:53:00	auto
d258005	318	19:39:57	320	18:12:00	auto
d258006	320	18:54:31	322	16:29:20	auto
d258007	322	17:11:15	324	21:14:02	auto
d258008	324	22:04:14	326	21:41:35	auto
d258009	326	22:22:51	328	16:16:38	auto
Leg 2					
d258010	332	09:09:30	334	09:17:10	auto
d258011	334	10:18:20	336	11:27:45	auto
d258012	336	12:17:30	338	12:07:42	auto
d258flt	338	12:51:00	338	12:57:00	auto
d258013	338	13:05:10	340	12:34:48	auto
d258014*	340	13:17:14	342	13:38:20	auto
Non-toxic turned off at 22:00 Jday 340. Back on 07:00, 341. Two temporary files were written during this period, which appear to represent data collected on auto-acquire. File names were 340161050 and 342133928.					
d258015	342	14:29:33	344	13:33:10	auto
d258016	344	14:20:48	346	12:50:50	auto
d258017	346	13:38:01	349	14:44:04	auto

John Allen, Alexander Mustard, Mark Moore

9.4 Precision Echosounder (PES) data

A combination of two precision echosounders was used to record bottom depth throughout *Discovery* 258. The main instrument was the 10/12 kHz Simrad EA500 Hydrographic Echosounder mounted on a fish on the port side, and the secondary instrument was the hull mounted 12 kHz transducer. The data from both instruments were recorded as separate Level A/B data streams (ea500d1 for the hull and ea500d2 for the fish) but were merged, edited and corrected for the speed of sound in the Level C "prodep" data stream. Preference was given to the PES fish data in prodep, except during ARIES tows when the fish mounted transducer was switched to 10 kHz for tracking the movement of ARIES, and after the PES fish malfunctioned. For most of the cruise the data were of reasonable quality.

The Pstar processing steps are as follows:

simexec0: transferred data from the RVS ea500d2 and prodep streams to Pstar. Output: sim258## and sim258##.cal. After this stage some manual editing of the sim258##.cal file was carried out with plxyed, followed by pintrp.

simexec1: merged sim258##.cal with navigation and vessel speed data from the bestnav file and average to 5 minute intervals. Output sim258##.nav and sim258##.5min.

simexec2: append daily files to master files (dep2581.nav, dep2582.nav, dep2581.5min and dep2582.5min) and remove on-station data using a criteria of speeds less than 2 knots (dep2581.track, dep2582.track).

Penny Holliday

10. FRS towed zooplankton net systems

10.1 Sampling summary

We collected zooplankton and associated specimen samples with the Autosampling and Recording Instrumented Environmental Sampler (ARIES), Dual Methot (DM) and Ocean Sampler (OS) gear as outlined in Table 15, in order to obtain data on zooplankton populations and environmental conditions, and to integrate with standard CTD cast data. Water samples were collected from ARIES and a few Ocean Sampler tows, along with OPC, CTD, fluorometer and transmissometer data.

Technical problems with the plankton net systems were almost all resolved. There remained some outstanding deployment and repair issues, and there was some loss in data quality. However, the sampling programme has been successfully undertaken as far as the weather allowed. This has been due in no small measure to the efforts of the UKORS technical staff working with the science team. These were aided in the resolution of deployment strategies and safe working practices for these unfamiliar gears by the ship's officers and deck crew. The problems solved will go a long way towards ensuring the smooth operation of these complex gears on future MarProd cruises. The main technical problems with the plankton gears and some of the resolutions achieved are described below.

Table 15 Net haul summary (also see Tables 18 and 19 for further station information)

Key to associated sampling:

W = water bottles, O = Optical Plankton Counts, C = Sea-Bird CTD, F = fluorometer, T = transmissometer.
Plus specimens extracted for: L = lipids/hormones, G = genetics, I = isotope ratio studies

Haul no. (=*Discovery* 258 station number)	Site	Plankton gear	No of samples	Max sampler depth (m)	Seabed depth (m)	+Pup net hauls	Associated sampling (see Key above)
Leg 1:							
14192	D19	DM	1	802	3142		L,G,I
14193	D19	0S	0	402	3066	1	
14196	D19	ARIES	70	2720	3026	2	W(60),O,C,F,T,L,G,I
14201	D16	DM	1	534	2852		L,G,I
14202	D16	ARIES	64	1536	2600	2	W(60),O,C,F,T,L,G,I
14207	D13	ARIES	41	983	1500	2	W(41),O,C,F,T,L,G,I
14210	D13	DM	1	739	1468		L,G,I

14216	E4	OS	2	401	1924	2	G
14219	E4	ARIES	58	1416	1800	2	W(58),O,C,F,T,L,G,I
14222	E4	DM	1	739	1559		L,G,I
14224	D11	DM	1	805	2483		L,G,I
14225	D11	ARIES	78	1944	2456	2	W(60),O,C,F,T,L,G,I
14228	D11	OS	7	405	2611	2	G
14232	D9	DM	1	400	2980		L,G,I
14233	D9	ARIES	63	1563	2709	2	W(60),O,C,F,T,L,G,I
14236	G10	ARIES	70	1732	2456	2	W(60),O,C,F,T,L,G,I
14240	G8	DM	2	801	3009		L,G,I
14241	G8	ARIES	76	2667	2946	2	W(60),O,C,F,T,L,G,I
Leg 2:							
14246	F7	ARIES	62	1508	1600	2	W(60),O,C,F,T,L,G,I
14250	F5	DM	2	830	2520		L,G,I
14251	F5	ARIES	91	2220	2382	2	W(60),O,C,F,T,L,G,I
14255	F1	DM	2	492	521		L,G,I
14256	F1	ARIES	21	458	498	2	W(21),O,C,F,T,L,G,I
14260	F1	OS	7	508	470	2	W(7),G
14264	H1	ARIES	93	2269	2427	2	W(60),O,C,F,T,L,G,I
14268	G4	DM	1	807	1990		L,G,I
14269	G4	ARIES	62	1508	1962	2	W(60),O,C,F,T,L,G,I
14272	G4	OS	7	481	1948	2	W(7),G
14276	G6	ARIES	64	2485	2623	2	W(60),O,C,F,T,L,G,I
14279	E16	ARIES	50	1184	1340	2	W(50),O,C,F,T,L,G,I
14284	E13	ARIES	53	1269	1420	2	W(53),O,C,F,T,L,G,I
14290	G14	ARIES	75	1824	2038	2	W(48),O,C,F,T,L,G,I
14293	G14	DM	1	807	2136		L,G,I
14296	G17	ARIES	73	2787	3127	2	W(60),O,C,F,T,L,G,I

10.2 Deployment

Whilst the DM gear was stored on deck, it was essential to store both ARIES and OS inside the hangar, to protect the nets from damage by wind and water, and to allow sample removal under shelter. The two vehicles sat side by side, enabling either to be pulled from the hangar without moving the other. To this end, the hangar was cleared of features that narrowed it, primarily the paint locker and compressed gas bottle rack. A tugger winch was installed at the forward end of the hangar, and this was used to pull the vehicles into the hangar. To extract them, they were pulled out already attached to the main warp ready for deployment. Unfortunately, alternative stowage could not be found for the LEK, which was on a pallet on the starboard side, next to the steps up to the winch cab. This meant that ARIES had to be manhandled sideways every time it was extracted from the hangar, it. For future cruises, it is hoped the LEK will be moved to the starboard deck. Apart from this obstruction, the hangar space proved well fitted for the ARIES/OS operation.

Two, blue heavy-duty pipes were bolted to the deck as guides for the vehicles, to prevent them sliding sideways uncontrollably in rough conditions. This simple system worked well. Deployment and recovery were done in the usual way for vehicles of this size. They were lifted from the deck and paid out using the main warp and rear gantry, both controlled by the winch operator. Two trailing lines were attached to the rear of each vehicle. On deployment, these were slid round cleats on the bulkhead on either side of the gantry, operated by two deckhands both wearing safety harnesses. On recovery, boathooks were used to catch the trailing lines, which were then quickly taken up on the cleats. Lines were run from the gantry bulkhead to the rear of the hangar, so that the safety harnesses could be clipped onto them, giving the seamen freedom to move the length of the deck, and to clip on the harnesses well clear of the stern rail.

The only problem with sequential deployment of the net systems was the considerable time required to swap from one to the next. It took typically an hour to bring in one vehicle, download electronic data, then fire up and deploy the other vehicle. These deployment preparations could not be done ahead of time, because of limited battery life. Initially, the ship remained hove to during this transfer, but later it was decided to steam on between deployments in the direction of the following station. In fact, on this winter cruise, the OS was deployed only a few times. On the spring and summer cruises (*Discovery* 262 and 264), when it expected that all three systems will be routinely deployed, it will be important for there to be two experienced personnel on each watch to help speed up the changeover.

10.3 Results

Considerable sub-sampling of plankton specimens from the ARIES and DM nets has already been done, for biochemical analyses. This material will be used for studies of lipids, isotopic ratios and genetics. Steve Hay, Adrian Bunker, Anna Ingvarsdóttir, Ryan Saunders, Alex Mustard, Jen Mower and James Cresswell established the sampling methodology and spreadsheet databases for documentation, as documented below. All samples from the Ocean Sampler were preserved for later microscope examination and counting of species.

Full results for the zooplankton sampling await detailed onshore sorting and identification. However, some provisional data are available from the Optical Plankton Counter deployed on ARIES: Fig 24 shows the observed depth profiles of *Calanus*-sized particles (copepodite stages C4 and c5). Note that these are preliminary plots, requiring further calibration and refinement. The distribution of estimated *Calanus* standing stock at ARIES tow positions on this cruise is plotted in Fig 25, together with comparative data from previous winter studies mentioned on the figure.

At the sampling sites in the southwest Iceland Basin, *Calanus*-sized particles are mainly distributed between 300 – 1500m, centred generally around 1000m. These depths are consistent with those expected of overwintering *Calanus*. At the shallower stations along the Reykjanes Ridge the depth distribution becomes more even throughout the water column, and abundance is less. Once the ship moved across towards Cape Farewell into the southern Irminger Sea, *Calanus*-sized particles are again found mainly between 500 – 1500m, with some evidence of shallower concentrations on the more offshore station. Later and further north on the ARIES deployments across the center of the Irminger Basin, *Calanus*-sized particles could be seen between 500 – 2000m, and again with an apparent tendency for peak numbers to occur in the shallower depths of this distribution at the deeper stations. At the stations around the northern rim of the Irminger basin, the *Calanus*-sized particles are also concentrated in the depths below 400m or so with greatest numbers generally between 500 – 1500m. There are some intriguing near-bottom peaks which the net sample analysis and comparative analyses with the LADCP data should help to elucidate. A good example of this occurred in sampling of the overflow of deep cold water from the Greenland and Norwegian Sea spilling down into the Irminger Sea through the Denmark Strait.

Overall it appears that there are not very high densities of *Calanus* in any of the Irminger Sea areas surveyed, contrary to expectations (based on upper ocean summer abundances, primarily from CPR data). This also appears to be true in the Iceland Basin populations, with lower densities over the shallower shelf and ridge areas. This lack of high overwintering densities has important consequences in that the relationship between hydrographic features and overwintering populations in these regions may be different from that previously observed in the north-eastern Atlantic and Norwegian Sea. It implies too that the dynamics of production processes in the spring and summer may be a factor of greater importance than overwinter survival in maintaining the persistence of, and generating variability in, North Atlantic *Calanus* populations.

Cursory examination of the net-caught material also indicated that *Calanus* were distributed into the deeper water, but not at the high concentrations of overwintering populations that were anticipated. There was speculation - based on visual assessments by experienced researchers - that there were differences in size, lipid density and in the degree of lethargy/activity compared to hibernating *Calanus* from other regions. We encountered a wide range of other zooplankton species in the ARIES and Dual Methot nets, with visual assessments indicating lower diversity of species in the Irminger Sea compared with the Iceland Basin. As well as all of the MarProd target species (*Calanus* spp, and the euphausiids *Thysanoessa longicaudata* and *Meganyctiphanes novegica*), there were a number of other dominants. Notably, these included the predatory copepod *Euchaeta glacialis* and a range of other predator species including a variety of euphausiids, mainly *Euphausia krohnii*, in the southern samples and *Thysanoessa inermis* on the Greenland shelf. Also, the chaetognath *Sagitta maxima,* several exotic medusae, the amphipod *Parathemisto* sp. and a range of other species including some beautiful deep-water fishes. We collected additional specimens of some of these abundant non-target species for later biochemical analyses.

Steve Hay

10.4 Technical problems and solutions

The cruise started with testing of the new (NERC-funded) ARIES system in the Clyde. This proved fully operational. However, although the towing hydrodynamics of the sampler revealed an even heel, a positive pitch of approximately 11° was found. Two further tows, with additional ballast installed in the tail fin area, resulted in pitch being reduced to approximately 1.5° positive. These adjustments allow the frame balance to be fully rectified for MarProd cruises in 2002. The FRS ARIES sampler with integral CTD and OPC was then tested with 100% functionality along with its associated supporting components (navigation logging/merging programs, depth telemetry units etc). No initial testing could be performed on either the Ocean or the Dual Methot samplers due to extended testing of the EK500 towed system and failure of *Discovery*’s winch.

After the first three stations, early cable problems manifested with the acoustic hydrophone towed array mounted in the modified aft PES fish. Inspection revealed the PES fish was smashed beyond repair and its towing wire had suffered water ingress and conductor breakage. The shallow water (<1000m) depth telemetry receiver was then installed into a light towed paravane and tested over the ship's port quarter. This proved to be incapable of staying submerged at ship speeds >1.5 knots. The Scanmar receiver was then bolted onto the tail fin of the high-speed u/w towed EK500 tow-frame. This proved to be successful despite two further cable conductor breakages repaired. The deep water IOS type(<3500m) depth telemetry unit was rigged to utilise the ship’s for'ard PES fish 10 kHz hydrophone array with reasonable success, and with the ship’s echo-sounder using the 12 kHhz hull mounted transducer. A further unfortunate failure of the ARIES deep-water depth telemetry unit was traced to water ingress caused by anodising on the O-ring face seal flaking off. Re-facing of the O-ring seal by the onboard UKORS engineers, a positive 3000 dbar pressure test and electronics repair, resulted in later successful use of the modified system for deep ARIES tows.

18 ARIES tows have been very successful, deploying to a maximum depth of 2787m. On leg 1, only the first and last were able to get as close to the seabed as wished since the other tows had to be deployed “blind”, without the depth sensor. The only two net failures were attributed to a large fish and then an even larger jellyfish clogging the revolving cod end and sensor mechanism. The only CTD failure, on tow 202, was due to water in a connector causing complete battery pack collapse. Some spikiness in the readings of the conductivity cell in the early ARIES tows was caused by the

collapse of tubing in the plumbing circuit. This has since been adjusted yielding improved results. The reliability of the Optical Plankton Counter (OPC) has been 100%.

Ocean Sampler tows have generally been successful operationally to 400m. However the deployment and retrieval of this lighter sampler in all but calm waters has been a problem. The high radial flow onto and through the fine mesh nets, caused by heave and extensive stern movement in any swell, results in mechanical destruction of the nets. The first Ocean Sampler tow in rough weather destroyed 8 of its 9 nets: methods for alleviating this problem are being investigated. In calm conditions (rarely encountered on *Discovery* 258), the system worked well.

Dual Methot net sampler deployments suffered various problems. These included connector water ingress, optical sensor obscurity, and intermittent cable faults. One frame proved inoperable but all problems on the other were remedied. Despite early problems with obtaining two depth-stratified samples, each deployment has at least yielded a single integrated sample. The later use showed the sampler working fully to the operation depths of 400m and 800m.

Jim Hunter

11. Mechanical systems

Main equipment used: CTD, towed and lowered EK500, ARIES, Ocean Sampler, Dual Methot net.

11.1 Gantries

The starboard gantry was used for the deployment and recovery of the CTD. Although still noisy, this functioned without any problems. The stern gantry was used for the deployment and recovery of ARIES, Dual Methot net, Ocean Sampler, and lowered EK500. The gantry extension operates, but creeps back, probably due to a sticking valve.

11.2 Powerpacks

The midships scientific powerpack was used to power the starboard gantry. This functioned without any problems.

The aft scientific powerpacks were used to power the aft gantry, and two deck winches. The fault warning light on the start panel situated in the hanger came on several times after using the aft gantry or 5t deck winch. No obvious fault was found, and the light can be reset, suggesting perhaps a partially blocked filter. The drawers containing hydraulic fittings need to be secured.

11.3 PES winch, davit and powerpack

Two starboard tow PES winches were used during the cruise, and operated with faults noted. The valves used to change between the two winches need to be looked at with a view to reducing the chance of causing damage to the winch motor by not changing all four valves correctly.

11.4 300kW Powerpack, 20t and 10t Cobra Unit

The 10t cobra unit was used for CTD deployments, using the CTD wire. The 20t cobra unit was used to deploy ARIES, Ocean Sampler, Dual Methot net and lowered EK500, using the trawl wire.

The lowered EK 500 was found to be too light to deploy successfully using the trawl warp, due to a loss of traction on the cobra. The 5t Lebus deck-winch was used with the aft gantry to deploy the LEK 500 with much better results. It has been suggested that modifications to the CTD railway be made, to allow both the CTD and the LEK to be positioned under the starboard gantry without the use of a crane, and a deck winch be situated in the wet lab or on deck for the deployment of the LEK.

There was a problem with the 20t winch during the trials period at the start of the cruise. All hydraulic power to the winch was lost during the deployment of ARIES. This was traced to a faulty boost system relay. Further trials of the winch were carried out in sheltered water using the trawl warp and chain clumps, prior to heading for the work area.

11.5 Storage systems and sheaves

The 10t Storage System, including 37kW Powerpack, Inboard Compensator and Inboard Diverter Sheaves, was used for CTD deployments. No faults noted.

The 20t Storage System, including 37kW Powerpack, Inboard Compensator and Inboard Diverter Sheaves: during the lack of back-tension caused by the loss of boost pressure, the trawl warp jumped off the diverter sheave on the scrolling gear. A new keep plate was welded to the horizontal sheaves on the scrolling gear. As the cruise progressed, the winch became increasingly difficult to load up. An increase in boost pressure and high amps on motor 1 was also noted. This needs to be addressed during *Discovery*'s recertification period.

The 10t and 20t cable haulers were used throughout the cruise, and operated satisfactorily, however several problems were noted.

On the final recovery of ARIES a peak load of 7t was noted. This was caused by an exceptional roll of the ship at about 30m wire out. The wire should be cut at about 100m and re terminated. The cable haulers have caused some wear to the wire over this length.

The cooling water valve handles on the power pack need to be replaced with locking type handles, one of the handles has rusted away. The haulers tend to slip when in haul, possibly due to a dirty or worn valve. This should be investigated further whilst the ship is laid up.

No faults were noted on either the 10t outboard hangar deck diverter sheaves; the 20t system hangar deck diverter sheaves and roller assembly; nor the 30t cranes, port and starboard aft and power-packs.

11.6 Non-toxic water system

Used for the duration of the cruise. A leak was found in the Chemistry laboratory, the non-toxic system was shut down overnight to allow for a joint effort between the ship's engineers and OED technicians to gain access to the leaking pipe flange. A defect report has been made, requesting that new gaskets be fitted. There are no instructions onboard for the flushing of the system.

11.7 Workshop

The workshop was used for various repairs and modifications to scientific equipment. The workshop should be re stocked with materials and tools whilst the ship is laid up. The workshop was flooded due to water from the hangar leaking in past the door seal. The floor covering has lifted in places. The chuck guard to the lathe still needs replacing, this was noted during a safety inspection. The gym store ended up awash with oil again, better storage for the drums of oil would be a good idea.

11.8 Winch control cab

One of the aft window wipers is not working, the others are a bit tired.

11.9 Crane for TEK deployment

The towed EK deployment and recovery was mentioned in the safety meeting. The use of the crane in rough weather is not ideal. It has been suggested that a Schatt davit and deck winch may be used to deploy the towed EK. A base plate may have to be made to give enough height to swing the EK over the side. This should be looked at whilst the ship is laid up.

11.10 Clam system

The CTD display worked without fault. The trawl display crashed several times on startup. This should be investigated during recertification.

Bob Keogh, Robert Wallace, Steve Whittle

11.11 CAMM-2 engraver

On this cruise the CAMM-2 engraver was investigated. This instrument can be used to create signs in metal or plastic for display around the ship. Unfortunately, although it was purchased some years ago, no-one has found the time to get it working. On inspection it was discovered that an interface lead was missing. All that was required was a normal parallel port printer lead.

Operation turned out to be simple. A sequence of one line ASCII commands need to be sent via the parallel cable to the instrument. This can be achieved by printing from a text handler such as Notepad for Windows. Once the basic method had been devised, a front-end was constructed in Visual Basic. This has been loaded into the PC in the Technicians Office and is available for use. Labels can be made in either brass or trafflite. It would be a good idea to order some engraving media in the near future, if use of the system is to be encouraged.

Steven Alderson, Robert Wallace

12. Shipboard computing systems

12.1 Level ABC logging

Data were logged using the ISG ABC System. The Level A system collects data from individual pieces of scientific equipment. The Level B collects each of the Level A SMP messages and writes them to a disk, monitoring the frequency of the messages and warns the operator when messages fail to appear. The Level C system takes these messages and parses them into data streams (Table 16).

Table 16. Summary of data collected on *Discovery* 258 via level ABC logging

Chernikeef Log	LOG_CHF	MkII Level A
Ships Gyro	GYRONMEA	MkII Level A
Trimble GPS	GPS_4000	MkII Level A
Ashtec ADU	GPS_ASH	MkII Level A
Ashtec Glonass GPS	GPS_GLOS	MkII Level A
Echo-Sounder	EA500D1	MkII Level A
	EA500D2	MkII Level A
G12	GPS_G12	MkII Level A
Winch	WINCH	SEG PC
ADCP	Level C direct log	ADCP PC
Surface Logger	SURFMET	SIG PC

The new Ashtec G12 system is an integrated Seastar Differential GPS and normal GPS system that provides differential corrections for the other GPS systems. Paradoxically, observations by John Allen suggest the Trimble thus corrected is the most accurate system.

On two occasions (JD 313 and 314) the Level B crashed co-incident with the restarting of the Winch PC. The system was reset quickly with little data loss.

12.2 Email system

The system worked well whilst the ship was at sea but within the confines of the Clyde links were difficult to achieve. Three problems may well have contributed to this: the installation of a new high frequency cellphone mast adjacent to King George V dock; multi path errors due to mountainous terrain; and a problem at SOC (that was cleared by a reboot of the 'sea' system and its associated hardware).

Many cruise participants used their own PCs for email. It was some time before the disparate mailers in use were correctly configured, leading to problems in the scratch area on 'comms'.

12.3 GroupWise and Arcserve

The Novell system was rebooted once during the trip after a period of very slow response.

12.4 Data Processing

The GDD Pstar team did the majority of physics data processing. The Level C plotting suite was used extensively to produce annotated plotting sheets showing the GEBCO depth contours. True wind data was produced using 'windcalc' (see problems section). Depths corrected for Carter's area were produced from an edited composite of EA500D1 and D2 data.

Raw depth data existed on two data streams interrupted by the use of the pinger on the CTD. These data have been integrated into a single stream and corrected for Carter's Area into the 'prodep' stream.

The wind data were observed to be incorrect with the apparent wind from ahead. This is due to a naive averaging routine in the Surfmet PC that take no account of the 0 to 360° range of the sensor. There was no expertise or software onboard to correct this.

The initial logging of ADCP data was intermittent. This was corrected on Julian day 310 (6 Nov) when file permissions on the ADCP_header file were found to have been set incorrectly on a previous cruise. From JD 344 (10 Dec) 14:00 the ADCP PC clock was erroneously set 24 hours ahead; this was corrected in the Pstar processing.

From 17.00 on JD 315 to 16.30 on JD 316 (11- 12 Nov) the non-toxic water supply leaked affecting data from the Surfmet water sensors.

On the morning of JDs 326, 327, 333 and 337 (22, 23 and 29 Nov, 3 Dec) the Ashtec attitude sensing system needed resetting to force the resumption of logging.

12.5 Hardware problems

The HP2000CM plotter reported a problem with the black print head and a spare was unavailable. The reliance on software maintenance and the inaccessibility of vulnerable parts for cleaning makes this device difficult to use at sea. Once cleaned the HP1200 plotter provided an adequate substitute. The printhead was replaced with one supplied during the Reykjavik port call and plotting resumed. The AJP laptop display failed completely during the cruise. The Toshiba laptop battery is useless. The Ni-MH batteries bought at some expense for the Olympus digital camera have proved to be a disappointment.

A power blackout interrupted all data logging on JD 340 (6 Dec) between 15.56 and 16.20. The HP750 Designjet plotter was structurally damaged during a particularly violent roll; it hung inverted from its stand due to a failure of a restraining bolt. It was temporarily bolted and lashed back into place and continued to work.

12.6 DartCom satellite system

The lack of daylight in this region necessitated some experimentation with data channel combinations before adequate weather images could be processed. On the whole despite little solar illumination one or two weather images were created each day.

12.7 Training

Leg 1 provided an opportunity for Jeff Bicknell to receive training particularly on the Level C software. A number of ad hoc 'seminars' were held covering all the programs in 'rvs/bin' that Jeff has not used on previous cruises; the UNIX family of text processing utilities – grep, awk, sed, vi, pr etc.; the Level C software use of 'environment' variables; device independent plotting 'DIPF'. Jeff's extensive electronics and PC experience provided a valuable adjunct to the cruise support.

Robert Lloyd, Jeff Bicknell

13. Satellite imagery: sea surface temperature (SST)

It was not possible to obtain any ocean colour (eg SeaWiFs) images for the Irminger Sea and Iceland Basin during *Discovery* 258. Such sensors not only require clear skies, but also a relatively high angle of incident light – lacking in near-polar regions during winter. However, some remotely-sensed sea surface temperature (SST) data were available in cloud-free areas, providing relatively good coverage for the northern North Atlantic over the period mid-November to mid-December. This SST information was derived from the Advanced Very High Resolution Radiometer (AVHRR/3) sensor on board the US NOAA-16 satellite, processed at Plymouth Marine Laboratory.

Cloud-free data were composited together to calculate 7-day median SST images, together with composite front maps that enhanced thermal structures detected during each 7-day period. On the front maps, darker lines represent stronger or more persistent fronts (P.Miller: Composite front maps for improved visibility of sea-surface features on cloudy SeaWiFS and AVHRR data. Submitted to JGR-Oceans).

Table 17 below lists the relevant SST images (showing features of interest) made available, in near real-time, to *Discovery* 258 and the MarProd programme.

Table 17. SST imagery for Irminger Sea and Iceland Basin, Nov-Dec 2001

Single day images	Composites: SST	Composites: frontal analysis
15 Nov	14-20 Nov	15-21 Nov
20 Nov	19-25 Nov	19-25 Nov
	29 Nov - 5 Dec	29 Nov-5 Dec
	6-12 Dec	
	7-13 Dec*	7-13 Dec*
	8-14 Dec	8-14 Dec

* more easterly coverage, from Iceland Basin to Rockall, Faeroes, and northern Scotland. An unusually cloud-free image for this area in winter.

The late November SST images were relatively clear for the Greenland shelf (adjacent to the Irminger Sea) and also provided patchy coverage to the south of Iceland (Fig 26). They showed a system of frontal structures running from Cape Farewell to NW Iceland, with temperature changes of several degrees over a few km (eg from 4 to 7˚C at 64˚N 37˚W). This information was used to help plan the sampling strategy for leg 2 of the cruise.

Future users of the SST images should note that the colours represent different temperature values on each image, chosen to enhance the visual representation of the structures present.

Peter Miller, Stephen Groom (Plymouth Marine Laboratory)

14. Photography including video

An extensive photographic and video record was made during the cruise, particularly during leg 2 (eg Fig 27). Still photography used a 35mm SLR camera with 50 and 100 ASA slide film stock. Video was taken using a digital video camera. At times this was linked to a microscope-mounted analogue video camera, for recording live zooplankton specimens collected in the nets.

The subjects recorded in both the photographs and on video were similar and included:

Work on deck – deployment and recovery of ARIES, Ocean sampler and Dual Methot; CTD bottle rosette sampling; towed EK500 acoustics.

On-board laboratory work – Zooplankton sample sorting; ARIES set-up and instrument work; algal and plant pigment analyses; nutrient and oxygen analyses.

Wildlife – dolphins, seabirds, zooplankton and nekton from nets

Environment and miscellaneous – waves, icebergs, ice on the ship, RRS *Discovery* in port, Reykjavik.

This material will be available for scientific usage, also for PR and training purposes.

Alexander Mustard, James Creswell and Steve Hay

APPENDICES

A1 Diary and station information

A1.1 *Discovery 258* diary: Leg 1

1 November 2001 (Thursday, Julian day 305)

09:38* All clear from KGV Dock, Govan. Dropped pilot at 11:52. Passed Dunoon at 13:00. Trials were run in Bute Sound where there was over 100 m water depth on a straight 16 nm run from southeast to northwest. The PES fish was deployed at 14:20. [* all times are GMT]

Towed EK500: To detect larger zooplankton, the towed EK500 (TEK) carries echo sounders at 38, 120 and 200 kHz, to detect objects of order 7-8, 2 and less than 1.5 cm respectively. A pole extending 3 m outboard had been welded onto the starboard side just aft of the pilot gate, from which to tow the TEK on a 25 m long lead. The 10 cm diameter lead contains the strain cable, a backup strain cable, power and signal cables. The rig is deployed on another 25 m cable, attached to the stern fins on the TEK fish. When speed is picked up, the TEK rises, and any slack on the deployment cable can be taken up.

14:35 On the first deployment, the 25 m deployment cable was lifted on the crane. This was unworkable, as crane does not have the reach, and pendulum effect on the cranehook would be unacceptable. For the trial, the strop was doubled up. However, fish towed nose down. Recover for adjustment. Excessive heel was adjusted by hammering the wings.

16:50 On the second deployment, the 25 m deployment cable was led via two snatchblocks to the tugger winch in the hangar. The cable could not be fully paid out because snatch block too small. More serious was that there was no line of sight for the tugger winch operator. Towed better, but still needed adjustment to pitch angle.

Scanmar: The PES fish has been modified by FRS (Fisheries Research Laboratory, Aberdeen) to carry Scanmar and modified IOS receivers, for shallow and deep depth location respectively of towed gear and the lowered EK500. To deepen the interior, a panel has been welded round the centre line of the fish, so towing of new shape is untried. The zero depth of the Scanmar pressure transducers was calibrated, during a pause in TEK trials, by hanging them over the side at exactly 1 m depth.

18:10 *New ARIES:* A new ARIES system, constructed by FRS Aberdeen under contract for the NERC MarProd programme, required ballasting trials. Because it is not fitted with the 60 bottle rosette, ballasting is likely to be different from the standard ARIES. This ARIES was deployed over the stern using the A-frame and trawl winch. This worked very well. There is just enough lift to raise the rig clear of the deck, leaving little pendulum. System towed well. Further deployments will be needed to test adjusted ballast, as pitch of 11° is too large. To transfer gear from the hangar to the stern, two heavy duty plastic pipes have been laid along the deck to provide a track. These will act as guides to prevent the vehicles slipping far sideways if the ship rolls.

19:20 *CTD and EK calibration*: On completion of the ARIES trial vessel proceeded to anchorage in Brodick Bay, east of Arran. A test CTD cast (station no #14190) was completed without incident, firing all bottles at 10 m for sampler training (for salts and oxygens).

Meanwhile, the TEK was mounted on a calibration rig, which has four arms, each supporting a thin thread holding a calibrated steel sphere. This was deployed on the starboard side using the crane. Winds marginal, but eased later. Calibration of the TEK (2 frequencies) and Lowered EK500 (2 frequencies) continued overnight –

2 Nov (Friday; 206)

– and was completed at 06:20.

TEK: The TEK was redeployed briefly (09:17 - 09:33) using the capstan instead of the tugger winch. This was an improvement allowing both the crane and capstan operators line of sight of the bosun controlling the operation. Towing angle is improving but still further adjustment to be made.

ARIES: Two further deployments of the new ARIES were made during the morning with additional weights. These will be used to calculate the optimum ballast for correct towing. This vehicle was then stowed above the hangar, for emergency use only. After lunch the main ARIES vehicle was deployed (13:44 - 14:15) and worked satisfactorily.

Lowered EK500 (LEK): After a final trial of the TEK, the LEK was tested over the stern. This has 38 and 120 kHz echo sounders mounted in a metal frame, about $1m^3$. It has to be stowed in the hangar for charging and to allow setup with a portable pc. It records internally and is downloaded on recovery. The original plan was to deploy it over the starboard side using a crane, but this would have necessitated re-leading the trawl winch wire from stern to the starboard side whenever it was deployed. The solution is to deploy it using the trawl winch, but over the stern using the A-frame. The pallet truck is used to transfer it from the hangar to the stern. The LEK was deployed from 15:24 - 15:43 and proved satisfactory.

Trials of the final vehicle, the Ocean Sampler (Ocean), were not conducted. Nor was there time to trial the Dual Methot net (DM), a two-net system to be deployed to 800 m, collecting samples in the ranges 0-400 m and 400-800 m.

After completion of trials, the PES fish was recovered and course set for Ayr, where four scientists and an engineer were put ashore using the Ayr pilot boat at 18:30. Thereafter the ship remained hove to overnight sheltered behind Arran. This delay was necessitated by problems with the main winch, which had cut out several times during the trials, and is fundamental to the programme. Because of the long hours worked, it was deemed prudent for the UKORS mechanical engineers to investigate the problem in the evening before conducting trials the following day.

3 Nov (Saturday; 307)

08:00 Failed relay found in the winch system was replaced last night. Need tests this morning to see if problem is solved.

12:00 Tests satisfactory. On passage toward first open ocean sampling site.

14:00 Both battery chargers for LADCPs are u/s. Hopefully ingenuity will find a partial solution, but it may not be possible to use both the 150kHz and 600kHz LADCPs on every CTD cast.

14:20 Motor that drives the autoanalyser bubbles through the tubes has packed up. Will try to rig something and freeze samples as backup.

4 Nov (Sunday; 308)

On passage 263°. Hove to around 1100 for the service of committal of Dave Ellett's ashes in the Rockall Trough at 55°17'N 10°23'W.

5 -7 Nov (Monday - Wednesday; 309-311)

Continued on passage, with speed reducing due to head winds and swell, down to 4.5 kn at times.

8 Nov (Thursday; 312)

The scheme agreed for the first line D11 - D19 across the western Iceland Basin is nets at every third sampling site, D19, D16 and D13, and CTDs at the two intervening sites, with a CTD at the initial site D19 also for intercomparison.

After much improved passage speed overnight, arrived on site D19 at 09:12. Total passage time thus 4 days 21 hr, thus over a day of contingency used on the passage. Both PES fishes were deployed and CTD#14191 occupied. Couple of glitches in data, but otherwise very clean. Three hours for 3200m depth CTD. LEK out at 13:02 but not enough weight in water to sink at acceptable rate, so recovered.

TEK deployed at 13:57, then DM #14192 at 14:27. This was extremely slow to reach 800 m, not inboard until 17:38, so over 3 hours. One hour 20 mins turnaround needed before Ocean Sampler #14193/4/5 deployed at 18:57. Inboard at 20:38, so 1 hr 40 min for tow to 400m. Disaster. All nets shredded, probably when it first went into the water and took a while to sink out of wave zone. Finally, after 50 min turnaround, ARIES #14196/7/8 was deployed from 21:29.

9 Nov (Friday; 313)

ARIES recovered at 02:10, thus 4 hr 40 min for tow to 2720 m depth. The tows had been on passage, so by 04:45 we had reached the next sampling site. From start of recovery of the TEK to being hove to ready for the CTD took 20 min, beginning CTD #14199 at D18 at 05:15. Thereafter the LEK #14199 was lowered to 500 m and held there for 30 min. With extra weight, lowering rate of 20 m/min was achieved, just acceptable. This deployment took 70 min, but a further 20 min was needed to stow the LEK and prepare for TEK launch. By 10:27 the TEK was deployed and passage set for D17, a total on-station time of 5.75 hr. Later the LEK was found to have switched itself off on reaching the surface, but no data lost.

Site D17 was reached at 14:30 and the sequence repeated, CTD followed by LEK both #14200. A new deployment method for the LEK was tested. Instead of using the main trawl winch, a deck mounted winch (on board in case of emergency dragging) was used. This winch is on the after deck, and can be used, with a snatchblock diverter, both for the LEK and TEK deployments (replacing the capstan for the latter). This was a great improvement, lowering the LEK to 500 m in 11 min, a saving of 20 min each way on the previous deployment. On-station time 2.5 hr for the CTD, 1 hr for LEK, 4.3 hr in total from start of TEK recovery to end of TEK redeployment after the station.

On recovery the LEK electronics cylinder was found to be loose, with one out of 4 bolts gone, and a second loose. A metal band held with a jubilee clip to fix the cylinder had also gone. A bolt preventing the whole mounting from swinging 180° (to allow the cylinder to be removed) had also gone. Clearly there is significant vibration. Extra brackets were fitted to prevent motion and reduce vibration, and banding renewed.

A SW swell prevented us from making the course 298° towards D16, so course was 283°, passing about 10 nm to the south of D16. Thus the plan was to deploy the nets so that ARIES would reach maximum depth roughly when we were closest to D16. DM #14201 was deployed 22:25 - 01:24 (10 Nov), 3 hr in all.

10 Nov (Saturday; 314)

The modified PES fish failed to communicate with the DM on this deployment, so the PES fish was recovered. Cable damage was found, also signs that the fish had struck the hull. Beyond repair. After several hours, it was decided to continue with ARIES deployment, using the characteristics of the first tow to fly blind to about 2000 m, well short of the water depth. ARIES #14202/3/4 was deployed 05:20 - 08:32, 3 hr to about 2000 m. On recovery, it was found that the SB CTD had not operated, as the new battery had run down very quickly. Ocean Sampler not be deployed again until sea much calmer, to prevent nets shredding again, or some protection for the nets provided, e.g. by putting old DM nets around them. Thus work near D16 complete and course set for D15 at 09:04.

After recovering the TEK, CTD #14205 was worked at D15 from 13:52 - 16:20. No LEK until brackets can be fixed and advice received from Aberdeen. The TEK was deployed at 16:43 and passage resumed. This sequence was repeated at D14, CTD #14206 being worked from 20:48 - 23:22.

11 Nov (Sunday; 315)

Five nm short of D13, the vessel slowed at 02:42 for deployment of ARIES. The intention was to use the normal PES fish, switched from echo-sounding to interrogate the net monitor (modified IOS transducer) on ARIES. This was found to be leaking however, the problem being traced to breaks in the anodising on the end of the case, just where the O-ring seal is critical. An alternative way of deploying the scanmar receiver was attempted, it being mounted on a small metal fin-fish. This failed, as the fish was topheavy and overturned in the water. Thus ARIES #14207/8/9 had again to be flown blind. This station was right over the southern extension of the Reykjanes Ridge, with a water depth of only order 1500 m, so only 1760 m of trawl wire was paid out. The deployment therefore lasted only 2 hours from 04:37 to 06:35. After 1.5 hr of preparation, the DM net #14210 was deployed to 800 m from 08:13 to 10:36. This dual net is designed to sample two depth ranges, but the change over between the nets has not worked fully on deployments so far.

D12 was reached at 13:02, and the TEK recovered. CTD #14211 was worked from 14:06 - 16:05. To give time for resolution of the various net problems, it was decided to work up line E with CTD casts deploying nets on the way back to E1/D11, the start of the prime D line across the Irminger Basin. The TEK was therefore not deployed during the work from E2 to E5, because: a) there could be a straight run back along line E later; and b) the only remaining option for mounting the Scanmar receiver was to mount it on the TEK metal fish, which would be attempted during the passage north.

On passage towards E2, water was found to be flooding into the chemistry and constant temperature (CT) laboratories. The leak was traced to pipework in the bulkhead between the ship's hull and the panelling on the port side of the aft end of the CT lab. Turning off the non-toxic supply at 17:30 stopped the flooding, so the non-toxic supply would have to be left off until the leak could be fixed the next day.

CTD #14212 was occupied at E2 from 20:25 - 22:23. With prevailing winds from the southwest, the northeast course along line E was a much easier run than the previous line D. This could be a problem with any line across the Irminger Basin.

12 Nov (Monday; 316)

Continuing up line E, we occupied E3 CTD #14213 from 01:23 to 03:25; E4 CTD #14214 from 06:19 to 08:02; and E5 CTD #14215 from 10:55 to 12:35. The LEK had by now been satisfactorily secured within its frame by strapping and by welding on extra metal bars. After a delay therefore, LEK cast #14215 was worked over the stern from 13:06 to 14:34. Deployment was slow, because of the very loose lay of the wire on the drum from the first cast.

During the morning, the leak in the CT lab had been fixed by cutting away the bulkhead to gain access to the joint in the non-toxic pipework which had worked loose. The supply was restored at about 10:00.

Passage southwest back towards E1 was then set, after deploying the TEK at 14:55. About 7 nm short of E4, the Ocean Sampler #14216/7/8 was deployed from 17:04 to 18:21 with a reduced number of nets, given calm conditions, and reached around 400 m with 850 m of wire paid out. Next ARIES #14219/20/21 was deployed 3.6 nm short of E4, and towed past the station position from 19:16 to 22:32.

13 Nov (Tuesday; 317)

Finally, the DM #14222 was streamed from 00:11 to 02:22. Passage 224°T was then resumed back towards E1/D11, which was reached at 09:43. The intention was to work 11 sites along line D to Cape Farewell, with CTDs at even numbered sites and nets at odd numbered sites, but with a CTD at D11 for intercomparison purposes. Thus, after recovering the TEK, CTD #14223 was occupied at D11 from 10:04 to 12:42, immediately followed by LEK #14223 from 12:53 to 14:11. Beginning passage along line D, the TEK was streamed followed by the DM net #14224 as soon as it could be prepared, from 15:09 to 16:38. ARIES #14225/6/7 followed from 17:25 to 20:28. Finally, Ocean Sampler #14228/9/30 was deployed from 21:30 to 22:48. Thereafter passage was set for D10.

14 Nov (Wednesday; 318)

On arrival at D10, the TEK was recovered and the first ARGO float deployed. This was done at 01:06 over the stern in calm conditions by lowering it held horizontally on two ropes until close to the water. There were no attachment points on the float to allow it to be lowered in a more controlled way on a single slip rope. After moving a mile off, CTD #14231 to 2460 m was worked from 01:27 to 03:43. A planned LEK deployment was abandoned, instrument not pinging. The TEK was deployed and passage set for D9. At 06:35, 9.5 nm short of D9, the ship was slowed for the net deployments, but the DM was not ready to deploy until 07:32. DM #14232 was worked from 07:32 to 08:38, followed by ARIES #14233/4/5 from 09:40 to 13:04. With wire out of 2000 m, the weather conditions had deteriorated sufficiently that the vehicle was held until the ship could turn head to wind, and ARIES was then recovered. For safety, the TEK was also recovered and all gear lashed down. Further work was not possible.

15 -18 Nov (Thursday- Sunday; 319-322)

Remained hove to, occasionally steaming during daylight hours to regain position near to line D.

19 Nov (Monday; 323)

The weather is not abating, but has now switched from southerly to westerly winds. Swells come in from several areas, so that confused swell is probably more of a problem than the winds themselves. Decision therefore taken to abandon line D for this leg, and proceed further north into the Irminger Basin in the hope that there will less fetch and hence less westerly swell, and it may be possible to occupy part of another line towards the Greenland shelf.

20 Nov (Tuesday; 324)

Best course that can be made 050° takes us east of B11, now defined as G11. After turning at 15:00 only 5 kn could be made 285° Into wind and swell, which will pass south of G11. However, as pressure rose and wind abated, realistic chance of work in the next 24 hr along a line to the west approximating G.

21 Nov (Wednesday; 325)

CTD deployed at 06:03, after strapping on the ARIES transducer for pressure test. However, the CTD failed at ~50 m, and was recovered. After tests, the fault was shown to be in the CTD, which will take significant time to swop over. Therefore move on to net tows. Initial intent was to deploy ARIES first, in order to give time to rerig the Dual Methot. Before either of these, the TEK with Scanmar needed to be deployed, so that in turn needed initial tests after being exposed on deck throughout. Also the release hook being used to deploy it from the crane hook needed a load test after fixing the spring mechanism. Despite these delays, the TEK was deployed at 09:43 and ARIES #14236/7/8 at 10:11. Since ARIES lacked depth information, it could not be flown close to the bottom.

Weather maps indicated a weather window lasting until late Thursday, so it was decided to occupy a line of sites at 40 nm intervals, on a course between the current ARIES position, defined as G10, and the original C1 position. By deploying only ARIES and the CTD at alternate sites, with one DM tow, it was hoped to be able to complete three ARIES casts before the weather broke.

ARIES was recovered at 13:57, and passage set for G9, where the TEK was recovered and a float deployed at 17:42 before heaving to. As an alternative launch procedure, the float was lowered over the starboard rail on a single string through a hole in the plastic flange around the float body. This was not as satisfactory as the previous deployment, as the potential for the ship to run over the float was greater, and the string had to be cut when it tangled. CTD#14239 was worked from 18:08 to 20:24. The case for the modified IOS transducer was pressure tested on this cast, the end face having been ground flat to create a firm O-ring seal. The bottom ten rosette bottles were sampled for SF_6, which may have been transported from where it had been deployed in 1996 in the Greenland Sea. This will done for as many casts as possible in the Irminger Basin. After launching the TEK, passage was resumed, and DM #14240 deployed at 23:40 in the vicinity of G8.

22 Nov (Thursday; 326)

DM was recovered at 01:28, and the bar between the two nets found to have worked satisfactorily for the first time. The nets had been re-rigged on a different frame. ARIES #14241/2/3 followed from 02:57 to 08:55. This deployment took longer than planned for the positive reason that the transducer had passed the pressure test and been reinstalled. Thus it was possible to fly to within a few hundred metres of the bottom. Passage was continued to G07, where the TEK was recovered and a float launched at 12:00 (noon) over the stern. CTD#14224 was worked to the bottom, where a layer of DSOW (less than 2°C) was found. At 15:00 the TEK was deployed and passage set for the third ARIES deployment. This was scheduled for 18:30, as conditions had remained calm despite forecasts of gale to storm force winds. However, at 18:00, rapidly rising seas and winds forced cancellation of the TEK deployment. The vessel hove to overnight in storm force winds.

23 Nov (Friday; 327)

At 11:45 it was decided that no further scientific work was possible, and course was set for Reykjavik. It had been agreed that personnel needed two nights in port rather than the planned single night, in order to gain sufficient rest and respite from the continuous severe conditions. If it is possible to berth on Sunday, 25 November, then the extra night in port could be achieved without loss of time on the second leg.

24 Nov (Saturday; 328)

The PES fish was recovered at 13:00. Damage to the fish and cable found.

25 Nov (Sunday; 329)

Nearing Reykjavik, strong winds from NW made the final approach to the harbour likely to be difficult, so vessel hove to at 07:00. Later the wind abated a bit, and final passage was resumed, docking at 14:42, thus still ahead of the scheduled end of leg on 26 November.

Raymond Pollard

A1.2 *Discovery 258* diary: Leg 2

27 November 2001 (Tuesday; Julian day 331)

After a two night mid-cruise break in Reykjavik, *Discovery* sailed for leg 2 at 15:48. Sailing was delayed from the planned morning departure because of strong winds down the west coast of Iceland. However, it was preferred to depart in daylight, even if we needed to shelter later. In the end, this was not necessary, and the PES fish was deployed at 20:10 and speed picked up.

28 Nov (Wednesday; 332)

The first intention was to work a line of four sites F7, F5, F3 and F1 from the Denmark Strait across to the Greenland Shelf. By morning the wind had abated, and good progress was made along the whole of line F. F7 at the southern exit from the Denmark Strait was reached at 13:06, and CTD #14245 to 1540 m completed. As expected, a strong bottom boundary layer of Denmark Strait Overflow Water was found. Immediately after, the TEK was deployed and then ARIES #14246/7/8, from 15:44 to 18:52.

29 Nov (Thursday; 333)

Site F5 was reached at 03:53. This was a repeat of TASC station T13 previously occupied for *Calanus finmarchicus* by Icelandic researchers, so a fairly full suite of measurements was made. CTD #14249 was followed by LEK #14249. While the LEK data were recovered, there was a problem with connectors, believed to be a consequence of the LEK electronics having been designed for a quiet (Autosub) environment. This will necessitate opening up the instrument when conditions permit. The TEK was deployed at 08:34, followed by Dual Methot #14250 and ARIES #14251/2/3. Work was completed at 17:07. Conditions on deck were slippery, a consequence of snow cover ever since Reykjavik.

F3 was reached at 20:00, the TEK recovered and CTD #14254 worked from 21:54 to 23:44. The TEK was deployed at 23:55 and course set for the final site on the shelf.

30 Nov (Friday; 334)

The optimum order of work at a site with all nets and CTD is Dual Methot, ARIES, recover TEK, CTD, LEK, deploy TEK, Ocean Sampler. This allows time for the changeover from ARIES to Ocean Sampler. This order was adopted on arrival at F1, with the exclusion of the LEK, as the water depth (500 m) was too shallow to make this worthwhile. The Dual Methot #14255 from 04:27 to 05:36 was followed by ARIES #14256/7/8 from 06:20 to 07:12. After recovering the TEK, CTD #14259 was worked from 08:02 to 09:03. Finally, after deploying the TEK at 09:21, the Ocean Sampler #14260/1/2 was deployed from 10:04 to 11:38. Passage south (197°T) towards G8 commenced.

At 15:25 icebergs were sighted, which severely changed the cruise programme. Several bergs were seen in the vicinity of 64°N, 36.4°W, much further offshore than usual, driven out the continuing westerlies. To allow passage at full speed, our first inclination was to alter course to the east to seek the outer limit of bergs from the Greenland coast. A site was planned for 63°N 34°W. However, another berg was sighted at 63°N 34.5°W (c 300 km from shore), so speed was reduced to 6 kn at night and the sampling site moved to 63°N 33.5°W, a safe distance east of the berg.

1 Dec (Saturday; 335)

However, by the time the site was reached, and ARIES fully ready to deploy, conditions had worsened with a strong wind and swell, and the site had to be aborted. We remained hove to from 02:36 until 08:00. The TEK was recovered at 08:55 to try to hold station for a CTD cast, but it proved too difficult to hold the ship on station. At 10:12, it was agreed to begin to work slowly west back towards the original line from F1 to G8.

2 Dec (Sunday; 336)

At 04:00 vessel was hove to in blizzard conditions, but by 07:30 a CTD was possible, so CTD#14263 was occupied at site H1 from 08:43 to 11:20. After deploying the TEK, ARIES #14264/5/6 was worked at the same position from 12:09 to 16:25 in excellent weather, sunny though cold, light seas. Course was then set towards G4, at 10-11 kn during daylight, but 6 kn or less at night.

3 Dec (Monday; 337)

En route to G4, after recovering the TEK at 05:05, CTD#14267 was worked at site H02 from 05:20 to 07:12. The TEK was redeployed and passage resumed at 07:36. The afternoon was spent working site G4 within sight of the Greenland coast, in excellent conditions, apart from the need to plan courses between icebergs.

Swell and wind were from the north, so that net tows could be worked in deep water more or less parallel to the shelf edge. Dual Methot #14268 (13:44-15:14) was followed by ARIES #14269/70/71 (16:06-18:57) and finally Ocean Sampler #14272/3/4 (20:03-21:03). Between each deployment the vessel ran south so that the same berg-free track could be followed each time. This also avoided running into shallower water to the north, as the bathymetric contours run east for a short way along about 62°N. Sea surface temperature maps showed a cold water tongue extending east just north of that line. After completion of our westernmost site on line G, the TEK was recovered in order to look for a broken connection to the Scanmar receiver, and the vessel remained hove to for an hour while light on deck were required to locate the problem. At 22:35 course was set to the east (103°T) towards G5.

4 Dec (Tuesday; 338)

On arrival at G5, CTD#14275 was worked from 04:47 to 07:08, followed by deployment of a float at 07:14. The TEK was deployed at 07:31 before passage towards G6. On arrival at site G6, ARIES #14276/7/8 was occupied from 13:28 to 18:20. This at last completed the site that had been aborted on leg 1 on 22 November. Having completed the western end of line G, course was set towards E5, with the intention of occupying a couple of sites across the Irminger Current towards E5, then working up the Reykjanes Ridge.

5 Dec (Wednesday; 339)

However, on reaching the vicinity of the first intended site at H3, conditions had deteriorated and the vessel hove to at 10:53. Shortly afterwards, the second engineer received a serious injury to his upper jaw when the handle of the emergency generator recoiled. Both PES and TEK were recovered safely, despite the poor conditions, and course was set for Reykjavik for a medical evacuation. Luckily, with strong swell and wind from WSW, the ship was running before the wind and the course was reasonably comfortable.

6 Dec (Thursday; 340)

On passage all day. A helicopter rendezvous was scheduled for daylight, but the condition of the engineer was stable and the weather conditions bad, so it was decided that the risk of a helicopter evacuation was not warranted.

7 Dec (Friday; 341)

Second engineer put ashore at Reykjavik between 03:00 and 04:00, then reciprocal course back towards the Reykjanes Ridge. Tried tacking, 265°T then 180°T to make the course, but hove to from 14:00.

8 Dec (Saturday; 342)

By 11:00, conditions had eased sufficiently to consider working, and an ARIES deployment was possible, and particularly useful in the northeast corner of the Irminger Basin, close to a TASC site. After deploying the PES fish at 11:26, ARIES#14279/80/81 was deployed from 11:28 to 14:25 at site E16. Passage continued southwest along the Reykjanes Ridge.

9 Dec (Sunday; 343)

CTD#14282 was deployed at E13 at 08:30, but had to be recovered after a short time, because of loss of signal. While the cause of the problem was sought, three bottles, in positions 12 to 14, were removed from the rosette frame to test the theory that water trapped by the whole rig was being dragged down and biassing readings whenever the veering rate slowed. The CTD was redeployed at 08:30 until 10:23, and given a new station number #14283 to allow comparison between the two casts to be made. Although ARIES was not scheduled to be deployed, it seemed prudent to make use of the weather window, so ARIES #14284/5/6 was deployed from 11:28 to 13:46. A careful site survey was carried out first, as depths were variable between 1200 m and 1500 m, and two 100 m high cliffs were found just north of the CTD site.

Passage was then set 235°T towards G11, but by 18:00 the course could not be maintained, and from 18:00 the vessel was hove due on heading 180°.

10 Dec (Monday; 344)

In the morning an attempt was made to head towards G12 but excessive rolling again forced the vessel to heave to. Later however, a compromise course 300°T was set to take the vessel to the west of the Reykjanes Ridge to a new position G12. The swell precluded deployment of ARIES, as had been planned, but CTD#14287 was possible from 15:15 to 16:42 after recovery of the TEK. That recovery was not easy, as at present it requires the ship to reach over 6 kn in order to take the strain off the rear deployment cable to the

TEK, so that it can be unshackled and taken through the fairlead. This needs to be revised for future cruises. However, the TEK was redeployed after the CTD on passage.

With the swell easing, one site along line E was possible to the southwest, and CTD#14288 was completed at E9 from 22:07 to 23:58. From there, it was decided to head eastwards, partly to make passage towards the Irish Sea, at the time the preferred route for the passage home because of forecast of strong southerly winds and swell, and partly because an important scientific objective was to complete an ARIES tow east of the Reykjanes Ridge.

11 Dec (Tuesday; 345)

Sites at 40 nm intervals were planned, and the first, G13, was reached at 03:52. After recovering the TEK, CTD#14289 was worked from 04:19 to 05:53. The TEK was redeployed, and 40 nm further on, at G14, ARIES#14290/1/2 was towed from 11:12 to 15:11, followed by Dual Methot #14293 from 16:12 to 17:30. During this period a report of water in the forepeak, chain locker, and bowthruster space was investigated. A slight leak, possibly a popped rivet, was found and subsequently pumped out the following day.

While on site G14, the decision was taken not to proceed through the Irish Sea, which would allow significantly more science time, at the risk of adverse conditions on the long passage. The optimal science strategy therefore was to work south towards the very first site occupied, D19, with the expectation that it would be possible to complete several stations before breaking off for passage home. This line of sites, to be labelled G15, G16 etc, would now run almost due south along 28.5°W. After recovering the TEK, CTD#14294 was occupied at G15 from 21:21 to 23:14. As we were now well into the Iceland Basin, the primary objective was to determine the circulation, and it was decided not to deploy the TEK between the last two CTD and ARIES stations.

12 Dec (Wednesday; 346)

The next site, G16, was reached at 04:14, and CTD#14295 was worked. The final site, G17, was reached at 11:00, where ARIES#14296/7/8 was deployed until 15:43. During recovery, hauling had to be halted briefly when ARIES was close to the surface in order to clear the after deck of wire being rewound. The swell had increased by now, and on recovery the ARIES bridle was found to be seriously bent upwards by 10-20°.

From G17, the distance to run to the Needles (Isle of Wight) was 1104 nm, which required passage at an average speed of 8.25 kn to make the scheduled ETA on 18 December. Given the likelihood of a rough passage towards Lands End, it was decided to cease station work and begin the passage. After recovering the PES and firmly lashing gear, passage commenced at 16:18.

13 - 18 Dec (Thursday- Tuesday; 347-352)

The passage to Southampton was difficult, with continuous headwinds and heavy swells. Speeds of barely 5-6 kn were all that could be maintained for the first few days. In the event, we did well to dock on the Tuesday as planned, but arrival was in the evening at 19:00, rather than the morning as hoped for. This delayed demobilisation to the following day.

Raymond Pollard

A1.3 Site and station lists

Reference information on sites (sampling locations) and stations (gear casts/hauls) is given in Tables 18 and 19 below. Code: BE, begin; BO, bottom; EN, end.

Table 18. *RRS Discovery* 258 station list - leg 1

MarProd position (site)	Station no (cast/haul)	Instru-ment	Code	Date DD/MM/YY	Time (GMT) HH:MM	Latitude		Longitude		Comments
	14190	CTD	BE	01/11/01	20:48	55 35.56	N	5 6.72	W	Test
			BO	01/11/01	20:55	55 35.59	N	5 6.73	W	
			EN	01/11/01	21:11	55 35.56	N	5 6.71	W	
D19	14191	CTD	BE	08/11/01	09:35	53 57.23	N	28 14.35	W	
			BO	08/11/01	11:03	53 57.84	N	28 14.29	W	
			EN	08/11/01	12:43	53 58.19	N	28 14.84	W	
D19	14191	LEK	BE	08/11/01	13:02	53 58.27	N	28 15.00	W	14191: aborted, frame not heavy enough in water
			EN	08/11/01	13:18	53 58.48	N	28 14.96	W	
D19	14192	DM	BE	08/11/01	14:27	53 56.91	N	28 18.28	W	14192: trap didn't close on ascent > treated as 1 integrated sample 0-800 m
			BO	08/11/01	15:58	53 58.38	N	28 25.47	W	
			EN	08/11/01	17:34	53 59.73	N	28 31.52	W	
D19	14193	OS	BE	08/11/01	18:56	54 0.11	N	28 31.72	W	14193: most nets ripped from start (1 pup net ok only)
			BO	08/11/01	19:39	54 0.77	N	28 35.48	W	
			EN	08/11/01	20:36	54 1.36	N	28 38.99	W	
D19	14196	ARIES	BE	08/11/01	21:28	54 1.68	N	28 38.78	W	
			BO	08/11/01	23:46	54 3.99	N	28 45.88	W	
			EN	09/11/01	02:08	54 6.12	N	28 53.98	W	
D18	14199	CTD	BE	09/11/01	05:25	54 12.84	N	29 17.34	W	
			BO	09/11/01	06:31	54 12.30	N	29 17.46	W	
			EN	09/11/01	08:15	54 11.87	N	29 17.74	W	
D18	14199	LEK	BE	09/11/01	08:28	54 11.84	N	29 17.75	W	
			BO	09/11/01	08:56	54 11.55	N	29 17.94	W	
			BU	09/11/01	09:25	54 11.27	N	29 17.96	W	
			EN	09/11/01	09:58	54 11.08	N	29 17.98	W	
D17	14200	CTD	BE	09/11/01	14:41	54 29.88	N	30 18.04	W	
			BO	09/11/01	15:39	54 29.68	N	30 17.76	W	
			EN	09/11/01	17:08	54 29.60	N	30 17.69	W	
D17	14200	LEK	BE	09/11/01	17:22	54 29.62	N	30 17.81	W	
			BO	09/11/01	17:34	54 29.56	N	30 17.91	W	
			BU	09/11/01	18:07	54 29.29	N	30 18.34	W	
			EN	09/11/01	18:21	54 29.21	N	30 18.56	W	
D16	14201	DM	BE	09/11/01	23:11	54 35.50	N	31 16.30	W	14201: trap problem
			BO	09/11/01	23:53	54 35.56	N	31 17.72	W	
			EN	10/11/01	01:22	54 35.89	N	31 24.94	W	
D16	14202	ARIES	BE	10/11/01	05:20	54 34.64	N	31 29.85	W	
			BO	10/11/01	07:02	54 33.40	N	31 37.30	W	
			EN	10/11/01	08:37	54 33.11	N	31 44.29	W	
D15	14205	CTD	BE	10/11/01	13:55	55 2.92	N	32 22.11	W	
			BO	10/11/01	14:54	55 2.82	N	32 21.64	W	
			EN	10/11/01	16:20	55 2.70	N	32 21.39	W	
D14	14206	CTD	BE	10/11/01	21:14	55 19.74	N	33 26.58	W	
			BO	10/11/01	22:04	55 19.77	N	33 27.23	W	
			EN	10/11/01	23:22	55 19.46	N	33 27.71	W	
D13	14207	ARIES	BE	11/11/01	04:36	55 35.20	N	34 23.42	W	
			BO	11/11/01	05:37	55 36.58	N	34 27.47	W	
			EN	11/11/01	06:33	55 37.79	N	34 31.38	W	
D13	14210	DM	BE	11/11/01	08:12	55 39.54	N	34 32.91	W	14210: trap problem
			BO	11/11/01	09:23	55 42.73	N	34 36.83	W	
			EN	11/11/01	10:36	55 46.26	N	34 39.96	W	
D12	14211	CTD	BE	11/11/01	14:08	55 54.89	N	35 14.63	W	
			BO	11/11/01	14:54	55 54.91	N	35 14.85	W	
			EN	11/11/01	16:05	55 54.98	N	35 14.66	W	
E02	14212	CTD	BE	11/11/01	20:29	56 33.36	N	35 29.65	W	
			BO	11/11/01	21:12	56 33.04	N	35 28.97	W	

			EN	11/11/01	22:23	56	32.39	N	35	27.57	W	
E03	14213	CTD	BE	12/11/01	01:27	56	52.41	N	34	55.36	W	
			BO	12/11/01	02:05	56	52.22	N	34	55.22	W	
			EN	12/11/01	03:25	56	51.45	N	34	54.81	W	
E04	14214	CTD	BE	12/11/01	06:22	57	11.95	N	34	21.91	W	
			BO	12/11/01	07:00	57	11.84	N	34	22.57	W	
			EN	12/11/01	08:02	57	11.41	N	34	22.75	W	
E05	14215	CTD	BE	12/11/01	10:55	57	31.02	N	33	47.55	W	
			BO	12/11/01	11:30	57	30.93	N	33	47.02	W	
			EN	12/11/01	12:35	57	30.71	N	33	46.17	W	
E05	14215	LEK	BE	12/11/01	13:06	57	30.62	N	33	45.72	W	
			BO	12/11/01	13:36	57	30.56	N	33	45.23	W	
			BU	12/11/01	14:07	57	30.34	N	33	44.93	W	
			EN	12/11/01	14:34	57	30.28	N	33	44.49	W	
E04	14216	OS	BE	12/11/01	17:03	57	17.80	N	34	11.24	W	14216: 3 serial sampling nets only
			BO	12/11/01	17:35	57	16.50	N	34	13.47	W	+ 2 pup
			EN	12/11/01	18:21	57	14.64	N	34	16.91	W	
E04	14219	ARIES	BE	12/11/01	19:16	57	14.29	N	34	18.87	W	
			BO	12/11/01	20:57	57	10.36	N	34	24.97	W	
			EN	12/11/01	22:29	57	7.21	N	34	30.55	W	
E04	14222	DM	BE	13/11/01	00:11	57	7.28	N	34	33.23	W	14222: trap problem
			BO	13/11/01	01:16	57	4.81	N	34	35.47	W	
			EN	13/11/01	02:21	57	2.24	N	34	38.07	W	
D11	14223	CTD	BE	13/11/01	10:05	56	14.39	N	36	4.28	W	
			BO	13/11/01	11:08	56	14.58	N	36	3.96	W	
			EN	13/11/01	12:42	56	15.25	N	36	3.40	W	
D11	14223	LEK	BE	13/11/01	12:53	56	15.31	N	36	3.22	W	
			BO	13/11/01	13:16	56	15.56	N	36	2.99	W	
			BU	13/11/01	13:48	56	15.53	N	36	2.63	W	
			EN	13/11/01	14:11	56	15.61	N	36	2.42	W	
D11	14224	DM	BE	13/11/01	15:09	56	14.49	N	36	1.78	W	14224: trap problem
			BO	13/11/01	15:55	56	14.62	N	36	4.06	W	
			EN	13/11/01	16:37	56	14.83	N	36	6.29	W	
D11	14225	ARIES	BE	13/11/01	17:24	56	15.24	N	36	6.61	W	
			BO	13/11/01	18:57	56	17.02	N	36	10.93	W	
			EN	13/11/01	20:26	56	18.75	N	36	15.55	W	
D11	14228	OS	BE	13/11/01	21:29	56	19.64	N	36	17.68	W	
			BO	13/11/01	22:02	56	20.53	N	36	19.83	W	
			EN	13/11/01	22:49	56	21.72	N	36	22.67	W	
D10		Float	BO	14/11/01	01:06	56	33.67	N	36	53.56	W	
D10	14231	CTD	BE	14/11/01	01:32	56	33.51	N	36	52.40	W	
			BO	14/11/01	02:17	56	33.72	N	36	52.39	W	
			EN	14/11/01	03:43	56	33.76	N	36	53.28	W	
D09	14232	DM	BE	14/11/01	07:31	56	48.04	N	37	30.04	W	14232: trap problem
			BO	14/11/01	08:03	56	48.91	N	37	32.03	W	
			EN	14/11/01	08:36	56	49.63	N	37	34.02	W	
D09	14233	ARIES	BE	14/11/01	09:39	56	50.66	N	37	36.22	W	
			BO	14/11/01	11:20	56	52.96	N	37	42.70	W	
			EN	14/11/01	13:02	56	55.59	N	37	36.83	W	
G10	14236	ARIES	BE	21/11/01	10:10	60	26.63	N	32	49.68	W	
			BO	21/11/01	12:05	60	27.00	N	32	58.81	W	
			EN	21/11/01	13:56	60	28.50	N	33	7.57	W	
G09		Float	BO	21/11/01	17:42	60	38.87	N	34	18.44	W	
G09	14239	CTD	BE	21/11/01	18:08	60	39.04	N	34	20.22	W	
			BO	21/11/01	19:02	60	38.96	N	34	20.32	W	
			EN	21/11/01	20:24	60	38.76	N	34	19.69	W	
G08	14240	DM	BE	21/11/01	23:40	60	47.79	N	35	21.45	W	14240: DM worked OK
			BO	22/11/01	00:34	60	48.49	N	35	25.91	W	
			EN	22/11/01	01:27	60	49.31	N	35	30.36	W	
G08	14241	ARIES	BE	22/11/01	02:56	60	51.31	N	35	46.27	W	

			BO	22/11/01	05:59	60	53.83	N	36	2.41	W
			EN	22/11/01	08:53	60	49.99	N	36	10.19	W
G07		Float	BO	22/11/01	12:00	61	2.91	N	37	2.59	W
G07	14244	CTD	BE	22/11/01	12:24	61	2.46	N	37	3.04	W
			BO	22/11/01	13:19	61	2.36	N	37	2.56	W
			EN	22/11/01	14:43	61	2.58	N	37	2.73	W

Table 19. *RRS Discovery* 258 station list - leg 2

MarProd position (site)	Station no. (cast/haul)	Instru-ment	Code	Date DD/MM/YY	Time (GMT) HH:MM	Latitude			Longitude			Comments
F07	14245	CTD	BE	28/11/01	13:28	65	15.068	N	29	29.551	W	
			BO	28/11/01	14:03	65	15.147	N	29	29.168	W	
			EN	28/11/01	15:05	65	15.405	N	29	28.211	W	
F07	14246	ARIES	BE	28/11/01	15:44	65	14.865	N	29	29.183	W	
			BO	28/11/01	17:22	65	12.703	N	29	37.316	W	
			EN	28/11/01	18:52	65	11.064	N	29	45.797	W	
F05	14249	CTD	BE	29/11/01	04:14	64	20.111	N	31	59.536	W	
			BO	29/11/01	05:06	64	20.215	N	31	59.342	W	
			EN	29/11/01	06:43	64	20.441	N	31	58.932	W	
F05	14249	LEK	BE	29/11/01	07:00	64	20.439	N	31	59.011	W	
			BO	29/11/01	07:22	64	20.305	N	31	59.332	W	
			BU	29/11/01	07:55	64	20.136	N	32	0.333	W	
			EN	29/11/01	08:15	64	20.083	N	32	1.305	W	
F05	14250	DM	BE	29/11/01	09:18	64	20.184	N	32	6.307	W	
			BO	29/11/01	10:15	64	20.397	N	32	11.09	W	
			EN	29/11/01	11:08	64	20.165	N	32	15.267	W	
F05	14251	ARIES	BE	29/11/01	11:50	64	20.295	N	32	16.068	W	
			BO	29/11/01	14:37	64	21.23	N	32	32.671	W	
			EN	29/11/01	16:54	64	21.796	N	32	46.45	W	
F03	14254	CTD	BE	29/11/01	21:54	64	27.045	N	33	59.912	W	
			BO	29/11/01	22:37	64	26.9	N	34	0.332	W	
			EN	29/11/01	23:44	64	26.912	N	34	0.88	W	
F01	14255	DM	BE	30/11/01	04:27	64	33.478	N	35	48.505	W	
			BO	30/11/01	05:01	64	33.966	N	35	51.739	W	
			EN	30/11/01	05:36	64	34.42	N	35	54.899	W	
F01	14256	ARIES	BE	30/11/01	06:20	64	30.912	N	35	52.948	W	
			BO	30/11/01	06:45	64	31.616	N	35	54.643	W	
			EN	30/11/01	07:12	64	32.278	N	35	56.238	W	
F01	14259	CTD	BE	30/11/01	08:02	64	33.947	N	35	59.78	W	
			BO	30/11/01	08:23	64	34.011	N	35	59.921	W	
			EN	30/11/01	09:03	64	34.078	N	36	0.131	W	
F01	14260	OS	BE	30/11/01	10:04	64	34.176	N	36	2.218	W	
			BO	30/11/01	10:38	64	32.527	N	36	3.991	W	
			EN	30/11/01	11:38	64	31.912	N	36	6.932	W	
H01	14263	CTD	BE	02/12/01	08:43	62	44.517	N	36	34.217	W	
			BO	02/12/01	09:35	62	44.626	N	36	34.734	W	
			EN	02/12/01	11:20	62	44.64	N	36	35.101	W	
H01	14264	ARIES	BE	02/12/01	12:09	62	45.959	N	36	36.823	W	
			BO	02/12/01	14:19	62	50.803	N	36	42.648	W	
			EN	02/12/01	16:25	62	55.659	N	36	49.127	W	
H02	14267	CTD	BE	03/12/01	05:20	61	59.612	N	39	24.525	W	
			BO	03/12/01	05:59	61	59.534	N	39	24.245	W	
			EN	03/12/01	07:12	61	59.537	N	39	23.81	W	
G04	14268	DM	BE	03/12/01	13:44	61	35.472	N	40	37.821	W	
			BO	03/12/01	14:28	61	36.924	N	40	38.69	W	
			EN	03/12/01	15:14	61	38.346	N	40	39.342	W	

G04	14269	ARIES	BE	03/12/01	16:06	61	35.346	N	40	40.899	W
			BO	03/12/01	17:35	61	38.478	N	40	40.063	W
			EN	03/12/01	18:57	61	41.238	N	40	38.643	W
G04	14272	OS	BE	03/12/01	20:03	61	37.178	N	40	42.067	W
			BO	03/12/01	20:32	61	38.095	N	40	41.485	W
			EN	03/12/01	21:03	61	38.758	N	40	40.623	W
G05	14275	CTD	BE	04/12/01	04:47	61	25.861	N	39	37.011	W
			BO	04/12/01	05:38	61	25.758	N	39	36.923	W
			EN	04/12/01	07:08	61	25.696	N	39	36.885	W
G05		Float	BO	04/12/01	07:14	61	25.62	N	39	36.927	W
G06	14276	ARIES	BE	04/12/01	13:28	61	15.426	N	38	22.47	W
			BO	04/12/01	15:45	61	13.695	N	38	31.866	W
			EN	04/12/01	18:10	61	11.835	N	38	43.317	W
E16	14279	ARIES	BE	08/12/01	11:48	62	42.369	N	26	27.446	W
			BO	08/12/01	13:07	62	39.255	N	26	27.542	W
			EN	08/12/01	14:25	62	36.43	N	26	27.764	W
E13	14282	CTD	BE	09/12/01	07:10	61	21.088	N	28	21.5	W
			EN	09/12/01	07:41	61	21.268	N	28	21.08	W
E13	14283	CTD	BE	09/12/01	08:30	61	21.148	N	28	21.684	W
			BO	09/12/01	09:01	61	21.267	N	28	21.294	W
			EN	09/12/01	10:23	61	21.57	N	28	20.008	W
E13	14284	ARIES	BE	09/12/01	11:28	61	23.824	N	28	19.362	W
			BO	09/12/01	12:37	61	21.921	N	28	21.201	W
			EN	09/12/01	13:46	61	20.131	N	28	22.487	W
G12	14287	CTD	BE	10/12/01	15:15	60	10.008	N	29	59.749	W
			BO	10/12/01	15:47	60	10.116	N	29	59.819	W
			EN	10/12/01	16:42	60	10.271	N	29	59.448	W
E09	14288	CTD	BE	10/12/01	22:07	59	32.062	N	30	57.698	W
			BO	10/12/01	22:45	59	32.048	N	30	57.276	W
			EN	10/12/01	23:58	59	31.925	N	30	56.183	W
G13	14289	CTD	BE	11/12/01	04:19	59	19.975	N	29	45.063	W
			BO	11/12/01	04:51	59	19.87	N	29	45.184	W
			EN	11/12/01	05:53	59	19.254	N	29	45.051	W
G14	14290	ARIES	BE	11/12/01	11:12	59	8.315	N	28	31.106	W
			BO	11/12/01	13:12	59	3.378	N	28	29.567	W
			EN	11/12/01	15:11	58	58.367	N	28	29.652	W
G14	14293	DM	BE	11/12/01	16:12	58	57.028	N	28	30.252	W
			BO	11/12/01	16:50	58	55.932	N	28	31.183	W
			EN	11/12/01	17:30	58	54.828	N	28	32.341	W
G15	14294	CTD	BE	11/12/01	21:21	58	23.981	N	28	30.189	W
			BO	11/12/01	22:03	58	23.848	N	28	30.359	W
			EN	11/12/01	23:14	58	23.844	N	28	30.651	W
G16	14295	CTD	BE	12/12/01	04:14	57	39.486	N	28	27.204	W
			BO	12/12/01	05:02	57	39.488	N	28	27.142	W
			EN	12/12/01	06:23	57	39.416	N	28	27.325	W
G17	14296	ARIES	BE	12/12/01	11:10	56	55.157	N	28	23.86	W
			BO	12/12/01	13:09	56	52.304	N	28	18.035	W
			EN	12/12/01	15:43	56	47.979	N	28	11.35	W

A2 Processing paths

A2.1 Sea-Bird CTD processing

Using an SBE911 CTD on *Discovery* 258 mounted on the lowered rosette CTD frame, the processing path is as follows:

1. During CTD data collection, ensure that the latitude and longitude are written in the log at the end of the down cast. Enter lat as dd mm.mmN/S and lon similarly. (While these can in theory be entered later with an exec, using the `bestnav` file, GPS data are so good nowadays that it is recommended that they are entered immediately. Bear in mind that the PC is logging using its own internal clock, which may be a little out anyway. This is not important for a CTD, but does mean that the time variable cannot be used to cross reference the `bestnav` file accurately.

2. At the end of the cast, UKORS technician will back up the `.dat` file and copy it to another PC for processing with SeaSoft.

3. On the pc, using SeaSoft, run the following routines, all on the 24 Hz full rate data. These steps can be done in the script `c:\d258ctd\ctdstu.bat` (see below)

    3.1 `datcnv`. Original .`dat` file should be named `ctd14nnn.dat`, using *Discovery* station number. For output, use time (elapsed time in seconds), press, temp, temp2, cond, cond2, oxygen, fluor, V7fluor, trans, V3trans, OBLS6000, V6OBLS, and altim. Do not include derived variables (salin, potemp, sigma, etc) in the output. Output directory should be processed under the directory with the `.dat` files.
    3.2 `wildedit`. Spikes in the 24 Hz data should be edited right away before averaging. Edit all the parameters in the file, with first standard deviation set to 2, second to 10, 500 data points at a time. Overwrite the `.cnv` file.
    3.3 repeat `wildedit` with same parameters. Overwrite the `.cnv` file.
    3.4 `align`. This is primarily to advance the oxygen variable. The manual suggest that 2-5 seconds are enough. I found that 10 sec gave reasonable match over top half of deep profiles.
    3.5 Unless you swopped to ASCII in datcnv, run translate to convert `.cnv` file from binary to ASCII.

4. On the PC, open a DOS window (... programs DOS prompt)

    `cd ..\D258ctd\Processed` (to get to the processed directory.)
    `ftp 192.171.133.202` to link to Discovery2.
    login as pstar with the usual password.
    `ascii`
    `cd /data61/ctd`
    `put ctd14nnn.cnv`
    `quit`
    `exit` (which closes the DOS window)

Now swap to Pstar.

5. `ctd0`

The first CTD exec translates the `.cnv` file into a Pstar `ctd14nnn.24hz` file. It checks that the output file `ctd14nnn.24hz` does not exist and exits if it does. Use `rm` to remove it if you wish to recreate it. `ctd0` requires the number of the CTD (nnn) and its lat and lon. Take these from the logsheet. If not on the logsheet, extract them from bestnav. Either way, please write the lat and lon on the top of the Pstar logsheet. On the listing of the output file, check that lat and lon are correct, and enter the version code etc in the Pstar log.

6. `ctd1`

This exec does further editing on a copy of the `.24hz` file, averages over one second to a `.1hz` file, interpolates the pressure variable and calculates sal and potemp for both primary and secondary, also sigma0 and sigma2 for the primary.

PMDIAN - Although most spikes should have been removed in the wildedit PC processing, a few remain. These are removed by pmdian - check that I have not set the limits too fine.
PAVRGE - 1 second averaging, followed by PHEADR to reset the sample rate in the header to 1 sec.
PINTRP - on pressure is essential for later averaging on pressure.
PEOS83 - is run twice to calculate salinity, potemp and density.

Output file is ctd14nnn.1hz

7. ctd2

This exec extracts all data while the CTD was in the water into .ctu and the down cast, after 2db averaging, into the file .2db. Thus, before this exec is run, mlist should be used to find suitable data cycles for truncation. While automatic ways of extracting suitable data cycles can be found, my experience is that these can be fooled, for example by spikes, and I find mlist a quick way of checking the data quality at the same time. Thus, run MLIST, with vars press temp cond salin. Note the max pressure from the heading. Scroll quickly through the list to find:

a) the data cycle at which the CTD was nearest to the surface at the start (the SB only switches on once in the water, so is held at 5m, then raised to the surface before starting the down cast)
b) the data cycle at which the CTD reached its maximum depth
c) ditto when it came out of the water at the end. The most reliable indicator of this is when the conductivity starts going to zero. Pressure will be close to zero, but might have a slight zero offset, so is less reliable than conductivity. Pick a data cycle just before conductivity starts to drop.

NB Write the data cycles on the pstar log sheet,

"start=dc1, bottom=dc2, end=dc3"

You will find this invaluable when you have to redo the processing for whatever reason! Output files are ctd14nnn.2db and ctd14nnn.ctu

8. ctdplots

Finally, create some standard hardcopy plots. These are automated by typing ctdplots and pressing return when asked for the plotting device. Specify which colour plotter when asked. To look at the plots on screen, reply mx11 for the plotting device, and default the plotter. Of course, plotxy can be used to generate any plots, but hardcopy of these standard plots is most useful.

Documentation of c:\d258ctd\ctdstu.bat:

PSTAR processing. Located on seabirdpc. Arguments -

1. Input directory (assumed on C: drive and same for .con and .dat files).
   Full path, excluding the initial C:\ and the trailing \
2. Output directory (on C: drive)
   Again, full path excluding the initial C:\ and the trailing \

First level of name, eg. ctd14190. Example:

```
c:\d258ctd\sbebatch ctdstu.bat D258ctd D258ctd\Processed ctd14200
```

Two ASCII files are produced in the output directory: a .cnv file containing the entire data from the cast at 24 Hz, and a .btl file containing data averaged over the times surrounding each bottle fire. Note that .psu (program setup) files in C:\D258ctd\Processed are used, with names such as DatCnv258.psu, rather than the default psu files. This is an attempt to avoid accidental overwriting of the psu files, and to bring them all together in one location. This can be executed via Start/Run... A previously executed command should be easy to find; you should only have to change the station number - but beware that the edit keys behave slightly idiosyncratically - make absolutely sure that you've got the correct number.

Another version of the program, ctdstuNoBottles.bat, is available for the case when no bottles were fired. This happened once on *Discovery* 258, when a cast was aborted fairly soon after the beginning of the downcast but useful data were still recorded. This version uses a different DatCnv psu file (DatCnv258NoBottles.psu), and doesn't have a RosSum step, so that the program doesn't attempt to generate a .btl file.

Sam file for lowered SeaBird CTD:

Now we have to create the sam file, to hold the bottle samples (up to 24 usually). The old code (makeblanks, pasfir, etc) has been entirely revised. First, the .btl file is created on the Sea-Bird PC. This can contain a lot of useful variables, including the time of bottle firing and the standard deviation of each mean. Since this file is the greater part of the sam file, the new processing path turns this into the sam file by adding only the extra variables needed for bottle values of salts, nutrients, chla, etc.

9. On the PC, run rossum to average the .ros file into one value per bottle. Input file is .ros, output is .btl, both in the Processed directory under the cruise directory (D258CTD). Then use ftp to transfer the .btl files (which are ASCII) to /data61/bottle, the bottle directory. Same technique as for CTD files step 4.

10. sam0

This converts the ASCII .btl file into the firing file fir14191 or similar. It contains all the basic variables from the CTD master (.24hz) file excluding flag, and also their standard deviations. The firing file is written to the bottle directory and its permissions set to read only. To avoid cluttering the bottle directory, new conventions have been set up as follows. At the start of the cruise, mkdir sub-directories to the bottle file, with 3-character names matching those needed on the cruise, e.g. fir. sal, chl, oxy, nut. The relevant files will be held in each sub-directory, only sam and .btl being in the bottle directory.

11. sam1

This converts the fir file into the master sam file. First, derived variables salin (salin2) potemp (potemp2) are calculated by peos83. Then the file is copied to the sam file, adding names from the sam.names file (all in the bottle directory). sam.names contains only those names that are NOT already in the fir file. Thus, the names in sam.names are typically botsal, botsalf, nio2+3, sio3, po4, botoxy, toxfix and chla. A new variable is created for each of these names, with the units and value given in the sam.names file. Two further variables are added at the start of the sam file, namely sampnum and statnum. The station number is statnum (e.g. 14193) and the sampnum is 19301 through 19324 if there are 24 data cycles in the file. If fewer than 24 bottles were fired, then there will be fewer than 24 data cycles in the file. Sampnum is the key variable, used to paste in data from other files.

12. passam

(This exec replaces pasfir, pasnut, passal, etc). Passam takes as input a text file, usually tab delimited, and pastes it into the sam file. The first step is to get the text files from various people. Their format is now fairly flexible. More than one cast may be included in one text file. The column headings must at least include sampnum and the variables to be pasted in. The names of these variables must match those in the sam.names file (which is created in the bottle directory at the start of the cruise). However, the cases may differ (e.g. Sampnum and sampnum or even SampNum are all equivalent). **Names and units must NOT have any spaces in them**. If variables are found in the text file which are not in the sam.names files, then passam asks if they are to be omitted. The input files do not need to contain lines for bottles not sampled. The number of data cycles need not therefore be 24, nor need it match the number of data cycles in the sam file. The text files should be placed in the relevant subdirectory to the bottle directory, e.g. nut, sal. This is not essential, but is strongly advised for neatness and to avoid any name clashes.

Passam requires the full pathname for the text input file, for example /data61/bottle/sal/salts123_to_456.txt
It also asks for the 3-char station number and the 3-char character descriptor, i.e. sal, nut, oxy, chl. This is because passam now has no knowledge of which columns it is pasting. It uses the 3-char descriptor to name the Pstar interim file and place it in the relevant subdirectory, e.g. sal/sal14235.

Sea-Bird CTD on ARIES

Briefly, processing path is very similar, but stick an 'a' on the front of all execs, e.g. actd0, actdplots, asam0. Directories used are actd and abottle. First step is to read in .MRG and .CNV files, usually provided by Steve on a zip disk. On a PC, transfer these into the D258ariessb directory, thus creating a backup. Then ftp the .cnv file into /data61/actd and the .mrg file into /data61/abottle.

Try the following order of processing:

- vi the .MRG file, in order to delete the first data cycle, which appears to be always rubbish.
- asam0 creates the ari file. Mlist this to find the lat and lon for maximum pressure. Use fmt lat DEG and fmt lon DEG to get lat and lon in suitable format. Write these on top of the new CTD processing sheet.
- actd0 creates the ctd 1hz file, and you can now enter the correct lat and lon right away.
- actd1, actd2, actdplots should now work
- asam1 merges the ctd and fir data to create the sam file
- apassam - not yet fully tested

A2.2 ADCP and navigation processing

navexec0 transferred data from the RVS bestnav stream to Pstar, calculated the ships velocity, appended onto the absolute (master) navigation file and calculated the distance run from the start of the master file. Output: abnv2581 and abnv2582.

gyroexec0 transferred data from the RVS gyronmea stream to Pstar, a nominal edit was made for directions between 0-360° before the file was appended to daily master files.

gp4exec0 transferred data from the RVS gps_4000 stream to Pstar, edited out pdop (position dilution of precision) greater than 5 and appended the new 24 hour file to master files gp42581 and gp2582.

glosexec0 this was identical to gp4exec0 but transferred the RVS gps_glos data stream to Pstar in master files gls2581 and gls2582.

gpsexec0 this was identical to gp4exec0 but transferred the RVS gps_g12 data stream to Pstar in master files gps2581 and gps2582.

ashexec0 transferred data from the RVS gps_ash stream to Pstar.

ashexec1 merged the Ashtech data from ashexec0 with the gyro data from gyroexec0 and calculated the difference in headings (hdg and gyroHdg); ashtech-gyro (a-ghdg) (daily files).

ashexec2 edited the data from ashexec1 using the following criteria:

heading	0 < hdg < 360 (degrees)
pitch	-5 < pitch < 5 (degrees)
roll	-7 < roll < 7 (degrees)
attitude flag	-0.5 < attf < 0.5
measurement RMS error	0.00001 < mrms < 0.01
baseline RMS error	0.00001 < brms < 0.1
ashtech-gyro heading	-10 < a-ghdg < 10 (degrees)

The heading difference (a-ghdg) was then filtered with a running mean based on 5 data cycles and a maximum difference between median and data of 1 degree. The data were then averaged to 2 minutes and further edited for

-2 < pitch <2
0 < mrms < 0.004
-10 < a-ghdg < 10

The 2 minute averages were merged with the gyro data files to obtain spot gyro values. The ships velocity was calculated from position and time, and converted to speed and direction. The resulting a-ghdg should be a smoothly varying trace that can be merged with ADCP data to correct the gyro heading. **do.plotash** was the script used to produce diagnostic plots to check this and this script resided in the $P_ASH directory with the data files. During ship manoeuvres, bad weather or around data gaps, there were spikes which were edited out manually (plxyed).

ashexec3 appended daily Ashtech files to a master file (ash258smt.ave) after removing any overlapping time steps. The master file was subsequently used in ADCP and Surfmet data processing.

adpexec0 transferred data from the RVS level C "adcp" data stream to Pstar. The data were split into two; "gridded" depth dependent data were placed into "adp" files while "non-gridded" depth independent data were placed into "bot" files. Velocities were scaled to cm/s and amplitude by 0.42 to db. Nominal edits were made on all the velocity data to remove both bad data and to change the DAS defined absent data value to the Pstar value. The depth of each bin was determined from the user-supplied information. Output fles: adp258##, bot258##

adpexec2 this merged the ADCP data (both files) with the Ashtech a-ghdg created by ashexec2. The ADCP velocities were converted to speed and direction so that the heading correction could be applied and then returned to east and north. Note the renaming and ordering of variables. Output files: adp258##.true, bot258##.true.

adpexec3 applied the misalignment angle, ø, and scaling factor, A, to both ADCP files. The ADCP data were edited to delete all velocities where the percent good variable was 25% or less. Again, variables were renamed and re-ordered to preserve the original raw data. Output files: adp258##.cal, bot258##.cal.

adpexec4 merged the ADCP data (both files) with the Trimble GPS 4000 navigation file (gp42581) created by gp4exec0 and the bestnav navigation file (abnv2581) created by navexec0. Ship's velocity was calculated from 2 minute spot positions taken from the gp42581 file and applied to the ADCP velocities. The end product is the absolute velocity of the water. The time base of the ADCP profiles was then shifted to the centre of the 2 minute ensemble by subtracting 60 seconds and new positions were taken from abnv2581, this last stage was not done in the processing scripts on *Discovery* 253. Output files: adp258##.abs, bot258##.abs.

surexec0 data read into Pstar format from RDI binary file (psurvey, new program written on *Discovery* 253 by S Alderson). Water track velocities written into "sur" file, bottom track into "sbt" files if in bottom track mode. Velocities were scaled to cm/s and amplitude by 0.45 to db. The time variable was corrected to GPS time by combining the PC clock time and the PC-GPS offset. The depth of each bin was determined from the user-supplied information. Output files: sur258##.raw, sbt258##.raw.

surexec1 data edited according to status flags (flag of 1 indicated bad data). Velocity data replaced with absent data if variable "2+bmbad" was greater than 25% (% of pings where >1 beam bad therefore no velocity computed). Time of ensemble moved to the end of the ensemble period (120 sec added with pcalib). Output files: sur258##, sbt258##.

surexec2 this merged the ADCP data (both files) with the Ashtech a-ghdg created by ashexec2. The ADCP velocities were converted to speed and direction so that the heading correction could be applied and then returned to east and north. Note the renaming and ordering of variables. Output files: sur258##.true, sbt258##.true.

surexec3 applied the misalignment angle, ø, and scaling factor, A, to both files. Variables were renamed and re-ordered to preserve the original raw data. Output files: sur258##.cal, sbt258##.cal.

surexec4 merged the ADCP data (both files) with the Trimble GPS 4000 navigation file (gp42581) created by gp4exec0 and the bestnav navigation file (abnv2581) created by navexec0. Ship's velocity was calculated from 2 minute spot positions taken from the gp42581 file and applied to the ADCP velocities. The end product is the absolute velocity of the water. The time base of the ADCP profiles was then shifted to the centre of the 2 minute ensemble by subtracting 60 seconds and new positions were taken from abnv2581, this last stage was not done in the processing scripts on *Discovery* 253. Output files: sur258##.abs, sbt258##.abs.

A2.3 LADCP processing

A2.3.1 Acquisition

Data should be collected as described on the ADCP logsheets (A2.3.5 and A2.3.6 below). Copies of the logsheets are stored on BMac in Word format under the logsheets folder. When the data have been successfully recovered rename as specified on the logsheets. Data should then be transfered (via Zip disk). Currently a backup is held on the 150 kHz logging computer (c:/ladcp/d258...). Data are then transferred to Misha/ladcp and then ftp'd to required location as specified below.

All the log files should be transferred as well as the binary data files. For the 600 kHz, these are named with extensions: '.scl' '.whp'. A third file written by the software is binary. For the 150 kHz, two text files are created with extensions '.log' and '.txt'.

A2.3.2 Command files

150kHz command file

```
RS
CR1
PS0
CY
CT0
EZ 0011101
EC 1500
EX 11101
WD 111100000
WL 0,4
WP 00001
WN 010
WS 1600
WF 1600
WM 1
WB 1
WV 400
WE 0150
WC 056
CP 255
CL 0
BP 001
BD 50
BX 2500
BL 0,200,600
BM 4
TP 000100
TE 00000200
&R20
CF11101
&?
PD0
RD0
CF11101
CK
CS
```

600 kHz command file

```
CR1
CF11101
EA00000
EB00000
ED00000
ES35
EX11101
EZ0011101
TE00:00:01.00
TP00:02.00
WB1
WD111100000
WF0088
WN030
WP00001
WS0200
WV170
CK
CS
PS0
EC 1500
CP 0
&?
```

A2.3.3 Processing

cd ladcp goes to /data61/ladcp. Here there are two directory trees: 600khz and 150khz. Each started the same, with a copy of the Firing tree and the Visbeck directories.

Additionally there is a directory called data in which raw binary data files may be placed. At present neither of the LADCP PCs is networked. Data files must be transferred using zip disk, Mischa and ftp. Once in the data directory there are two symbolic links (150khz and 600khz) which point to the raw data directories in the relevant tree; just use mv.

Log files should be stored in 150khz/logs and 600khz/logs. Depending on which data are to be processed, source 150khz/LADall or source 600khz/LADall

This sets up various environment variables and adds the required directories to the MATLABPATH variable. If the computer responds with "too long", it is because this variable has already been modified and now cannot hold any more directories. Simply logout and start again.

One of the important settings is the cruise identifier. This is a six character ID di0111 (for the 150 kHz) and wi0111 (for 600 kHz). They have been made different so that the data files have different names and can therefore be distinguished. 150 kHz files should be named dccc_ss.000 and 600 kHz files should be wccc_ss.000, where sss is the station number (eg 191) and cc is the cast number which is usually 01. In the text below, D is also used to denote either the 'd' or 'w' identifier.

Firing must be used first. This is because the Visbeck software has been modified to find parameter values in the Firing tree (see below).

cd proc Firing processing is a mixture of programs written in C with a front end in perl, and matlab routines. Typically the perl routines write summary files into files in subdirectory casts/sss_cc/scanload (relative to proc)

perl -S scan.prl sss_cc Check that the information extracted from the data file is correct for the cast it is supposed to correspond to. (This is particularly important for the 150 kHz data, since the software used to download from the instrument provides an arbitrary name which must be changed manually to a station name.)

putpos sss cc latdeg latmin londeg lonmin This stores the latitude and longitude in an ASCII file for later reference. For the southern or western hemispheres the degrees, though not the minutes, should be negative.

matlab:
magvarsm(sss.cc) This puts up a small window with a "yes" and "no" button. Click "yes", and then quit. (Don't look at me, I didn't write this). The magnetic variation for this station is calculated and stored in file mag_var.tab.

perl -S load.prl sss_cc This converts the data into CODAS data format. The data is held in files in subdirectory casts/Dsss_cc/scdb.

perl -S domerge.prl -c0 sss_cc (The above is czero) Here the data is filtered and despiked.

matlab:
plist=sss.cc
do_abs
Note the '.' here in the cast ID. This should produce plots of velocity and various other fields. Copies are also written into subdirectory casts/Dsss_cc/merge as postscript format.

plotthem Dsss_cc (outside matlab) sends them to laser.

These steps produce velocity data with zero mean. The processing up to the load step does not need to be repeated for the next stage. However, if it goes wrong, note that there are various ASCII files in the proc directory which are appended to. These are: stations.asc, mag_var.tab, proc.dat and latlon.asc. If in doubt, remove the entry in each file for the current station, delete the directory Dsss_cc under the casts directory and start again from the beginning.

Once the CTD data have been processed and navigation is up to date, the absolute velocities for the 150 kHz can be calculated. These steps have been incorporated into a script called ladcpproc. They are:

```
cd proc
cd Rctd
```

Use mlist to create an ASCII listing of the CTD data.

```
mlist /data61/ctd/ctd14ccc.ctu
```

The output file should contain the four variables time, press, temp and salin. Time should be in seconds.

```
vars 1,2,3,16
fmt time 10.1
DC
```

```
ascii
list
```

There should be no ASCII header and no record numbers. Access MLIST.ASCII and remove by hand.

```
mv MLIST.ASCII ctd.sss.cc.asc
```

Rename MLIST.ASCII to ctd.sss.cc.asc (note dots rather than underscores).

```
doctd
```

When prompted give the three figure station number. Converts the LADCP times into Julian days.

```
cd proc
cd Pctd
matlab
  di0111ts(sss,cc)

cd proc
cd Fitd
matlab
  plist=sss.cc
  fd
```

This step examines the derivative of the pressure from the CTD and the vertical velocity from the LADCP in order to match the timebases. The automated matching is usually sufficient, but examine the plot carefully to make sure that bottle firing positions match. If there are problems, then choose the interactive option and match them manually. Alternatively, matching problems usually occur because of problems with the CTD data (eg pressure spikes), so look at this data carefully. If necessary, copy the CTD data to the Pctd directory and remove problem data.

```
cd proc
perl -S add_ctd.prl sss_cc
perl -S domerge.prl -c1 sss_cc
```

Note the 'one' here. These steps add the CTD data to the database and merge it with the LADCP data. Before the final step a navigation file is required. The same files are required by the 600khz and 150khz. For this reason one file is created and then copied to the other tree. From the 600 tree:

```
cd proc
cd Rnav
donav
```

The donav script is neither efficient nor tidy and should probably be changed. One option is to use the bestnavfile instead, but so far this has not been tried (up to you). The product required for the last step is called sm.mat. This should be copied to the 150khz Rnav directory.

```
cp sm.mat /data61/ladcp/150khz/raw/di0111/gps
cd proc
matlab
        plist=sss.cc
        have_sm=1
        do_abs
```

This creates the same set of plots as the first run of do_abs, but this time the velocities are absolute. Print off only dussscch.ps

Further steps involve conversion to Pstar and comparison with the shipboard 150 kHz ADCP and any Visbeck processed data. For this end there is a cshell script in proc:

```
toascii sss cc
```

converts the mat velocity data into an ASCII file (ccc.asc) in subdirectory prof.

In prof there are further scripts:

dopstar	converts ASCII file to Pstar, updating the header with correct position (creates la14ccc and la14ccc.asc in prof)
dogrid	grid a set of Pstar profiles into a section, doing stuff like calculating along and across track velocities
dosection	this uses dogrid and an ASCII file called 'section' to create a section file. It simply means you do not have to type in lots of profile numbers on the command line of dogrid
dosections	this uses the section file to create all gridded files
docomp	compare the LADCP profiles with on station shipboard averages (which must already exist) and Visbeck data
dopict	create a plot (part 1) (advanced - read indecipherable)
dodisp	create a plot (part 2) (advanced - read indecipherable)

The Visbeck route has mainly used to look at backscatter data from the 600 kHz system. The directory you need to be in to access this software is:

```
cd /data61/ladcp/600khz/backscatter/visbeck/d258
```

For reference the procedures are stored in:

```
/data61/ladcp/600khz/backscatter/visbeck/m
```

For this the Firing procedure must be run up to the first load step in order to set up the ASCII files (i.e. up to toascii). These are then used by a script created on *Discovery* 253 to run the Visbeck method. The original Visbeck code included an m-file called demo.m which has to be modified for each cast. On *Discovery* 253 a script was written called visbeck which starts with a copy of demo and edits in the correct information for each cast, creating a file called v14sss.m. One further modification made to visbeck on that cruise was to change its CTD loading from Sea-Bird format to simple ASCII format using m-file loadascctd.m. Now that we seem to be using Sea-Bird permanently, this step could be reversed, but has not been yet. Once v14ssscc.m has been created it can be run from within matlab. But note that the pathname of the m directory must be first added to MATLABPATH.

Further modifications have been made by Nick Crisp. The backscatter calculation (calibrated LADCP amplitude data) has piggy-backed the visbeck route since he reads the relevant data from the rdi format binary file. For this reason the original visbeck m-files have modified versions with number 2 at the end. The backscatter routine svcalc2.m is a new m-file inserted into laproc2.m to do the backscatter calculation. If this is all that is required, laproc2 can be exited after this step. On *Discovery* 258, svcalc3.m has been used since the data plot of backscatter has been changed.

The current structure on *Discovery* 258 for the 600 kHz uses an laproc2.m file which runs up to just before velocities are calculated, when it creates a mat file containing all variables required for the backscatter calculation, and then exits. For cast 200_01 for example the following sequence can be used:

```
visbeck sss cc
```

This creates a matlab procedure to get the LADCP data for an individual cast and make a .mat file of the backscatter for future reference.

matlab

v14ccc	Run the procedure.
svcalc3('sss_cc')	Calculating and range correcting backscatter.
svplot('sss_cc',1)	This plots the backscatter in a number of bins as a function of depth and horizontal beam angle.
svavrge2('sss_cc')	This generates and plots a simple mean of all the data ensemble forall four beams. Useful for indicating steps and spikes in the data but very slow.
svavrge('sss_cc',10)	This averages the four beams into vertical profiles of backscatter. Its only output at present is a plot.

A2.3.4 Bottom track data

The 150 kHz has been set up to emit bottom pings, so bottom track velocities can be extracted. The firing processing does not use them, so in the past the bottom data has to be extracted from the binary rdi file on the PC using application BBLIST. Visbeck extracts and uses the bottom data if requested in the `demo.m` file, so manual extraction may not be necessary. However visbeck and firing velocities have in the past found to differ, often significantly. Comparison of firing velocities with 150 kHz shipboard ADCP data showed close agreement, while the visbeck values differed by up to 20cm/s. Brian King on the Drake Passage cruise (at the same time as *Discovery* 258) is trying to resolve these differences, so it may not be worth using visbeck for velocities yet.

A2.3.5 Log sheet for 150 kHz LADCP

Lat.	LADCP Cast No.
Long.	CTD Cast No.
Date	Nominal Depth

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, 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: mprod.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 **N.B. Refer to Charging Safety Sheet**
- Now fit blanking plugs on the ADCP & battery case
- Tell CTD / Winch operators to proceed with deployment

Recovery Connect instrument and battery pack, **N.B. Refer to Charging Safety Sheet**

run ***BBTALK*** and **'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\d258\data to d###_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

Comments STOP

A2.3.6 Log sheet for 600 kHz LADCP

Lat.	LADCP Cast No.
Long.	CTD Cast No.
Date	Nominal Depth

Pre-Deployment Connect with ADCP comms. lead & run **RDI Instruments*SC ADCP***

- Configure ADCP for new deployment
- SAY NO TO DEPLOYMENT WIZARD

File--> ADCP terminal (File --> Break)

Wake up time -->		File--> Break
Check ADCP Time with GMT, (reset if necessary)	GMT: ADCP:	***TS?*** ***TS** = yy/mm/dd,hh:mm:ss* *(to reset, countdown to <RETURN>)*
Recorder Free Space	bytes	***RS?** (number after comma= free space)*
Sleep time -->		***CZ***

Quit Terminal

Deployment run ***RDI Software\SC ADCP***

- Functions--> Import planning file (c:\RDI Workhorse\mprod.cmd)
- Functions--> Deploy
  - Name deployment file
    - Location: c:\RDI Workhorse
    - Deployment directory name: w***_ (***= station number N.B. must be 5 characters)
  - Disconnect ADCP **N.B. Refer to Charging Safety Sheet**
  - ‘OK’ (no response given but ADCP will now be pinging)
  - Record time of deployment : : (from master clock)
  - Tell operators to proceed with deployment

Recovery Connect instrument and battery pack, **N.B. Refer to Charging Safety Sheet**
run ***SC ADCP***

File--> ADCP terminal (File --> Break)

Time --> (**TS?**)		

CR (usually 0)		
Send to sleep (CZ)		

Quit terminal

File --> Recover recorder data

Recording directory: c:\RDI Workhorse\w***_ (dir. as above)	
OK?	
Using 'explorer' rename file in c:\ladcp\d258\data to w***_01.000 where *** is station number	

Run ***RDI Software\BBLIST (from Explorer)*** (f10 to main menu)

File Size when recovery complete (bytes)	
Ensembles Read ?	

And start and stop times of recovered file from BBLIST START
Comments STOP

A3 Calibration of scientific echosounders (LEK and TEK)

The lowered EK500 (LEK) and the towed EK500 (TEK) scientific echosounders were calibrated at the beginning of the cruise using a standard method for a towed body calibration (after MacLennan & Simmonds, 1992, 'Fisheries Acoustics', Chapman and Hall, London). The calibration procedures were carried out between 2030 on 1 November and 0800 on 2 November, whilst the ship was at anchor in Brodick Bay, Isle of Arran (approximately 55º 35' N, 05º 06' W). Once the equipment was assembled, calibration data were collected from the TEK first (between 2230 and 0215), followed by the LEK (between 0300 and 0530), using the same calibration equipment. A 38.1 mm tungsten carbide standard target sphere was suspended approximately 10 m below each transducer in turn and data were collected using the usual logging systems for each echosounder. A CTD cast immediately before the calibration gave an average sound speed of 1494.5 ms^{-1} in the top 12 m of the water column, which gave the following expected target strengths for the standard target (taken from standard curves (Foote, 1990, J. acoust. Soc. Am., 88: 1543-6)):

38 kHz transducers	–42.34 dB
120 kHz transducers	–39.52 dB
200 kHz transducers	–39.15 dB

Data were collected to calibrate both the integrator (SV) gain and the Target Strength (TS) gain for each transducer. In most cases, after the initial data collection at the standard gain setting (26.5 dB in all cases), several further iterations of adjusting the gain to a new calculated value and collecting data were performed for each parameter for each transducer. The final calculations of the calibrated gain values were made at a later date.

The final gain values were calculated solely from on-axis 'pings' where possible, or in the case of the LEK 120 kHz transducer, pings which were as near on-axis as possible (0.18º off axis in one direction only). In the case of the single beam transducers (TEK 120 kHz and 200 kHz), the position of the sphere relative to the transducer was taken from the 38 kHz split-beam transducer single target detection data, adjusted for the relative positions of the transducers. The TS gain values were calculated using single target detection values exported directly from Echoview® (v. 2.10.39, SonarData, 1995) and the equation (all values in dB):

New TS Gain = Old TS Gain – ((Mean measured TS – Expected TS of sphere) / 2)

The SV gain values were calculated using the SA (= NASC in Echoview®) values derived from the integration, in Echoview®, of the target sphere's echo for single on-axis pings and the equation (gain values in dB, SA values in m^2nmile^{-2}):

New SV Gain = Old SV Gain + ((10 * Log (Mean measured SA / Theoretical SA) / 2)

Theoretical SA values are calculated from the expected TS of the sphere, the transducer's 2-way beam angle and the distance to the sphere from the transducer face. The final calibrated gain values are given in Table 20, below.

Table 20. Integrator (SV) and target strength (TS) gain values for TEK and SEK calibrations

Echosounder	Transducer Frequency	SV Gain	TS Gain
TEK	38	26.62	26.95
	120	20.55	20.70
	200	23.24	23.38
LEK	38	25.02	25.17
	120	20.44	20.29

NOTE: During the cruise all data were collected using the standard SV and TS gain settings of 26.5 dB (the calibrated gain values were only applied during post processing).

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A4. Pstar backup

Five rolling tapes. Do 'ls -lrt' to find the next number to use. Make sure you are on discovery6. Type 'dobackup <number>', where <number>=1,2,3,4, or 5. Leave for a few hours. Occasionally it will fail with a tape io error. The only way round this I have found is to erase the tape and start again.
Use 'mt -f /dev/rmt/0 erase'. The script dobackup is as follows:

```
#
if (`hostname` != "discovery6") then echo "need to be on discovery6"
exit
endif

echo -n "enter tape number: "
set tapenum = $<
set listname = tape$tapenum.`date '+%m%d'`.list
/bin/rm -f $listname
touch $listname

/bin/cp $VERS /users/nerc/pstar/shipexec
set device = "/dev/rmt/0c"
set dirs = (/data61 /data62 /data63 /users/nerc/pstar /users/pexec)
set here = `pwd`

set i = 0
while ($i < $#dirs)
@ i = $i + 1

echo -n "writing $dirs[$i] ... "
cd $dirs[$i]
tar cf ${device} .
```

```
if ($status != 0) then echo "problem - $status status returned "
exit
endif
echo "done"

echo -n "listing $dirs[$i] ... "
@ im1 = $i - 1
if ($im1 != 0) mt -f ${device}n fsf $im1
tar tvf ${device}n >> $here/$listname
if ($status != 0) then
  echo "problem - $status status returned "
  exit
endif
echo "done"
cd $here
end
```

A5. Zooplankton sorting procedures

A5.1 Sampling on deck

Always use safety clothing and safe working practices when on deck and in hangar area. Keep clear of launch and recovery operations if not actively engaged. Use seawater deck hose to wash down all sampling nets, or wait until samples removed and then clean nets with freshwater hose

Use seawater deck hose to wash down all sampling nets. Set up the sink and the wash down hoses using the non-toxic seawater supplied (not firehose seawater or freshwater)

A5.2 Preservation methods of samples for future analysis

In order of priority, specimens need to be picked out for future laboratory analyses as follows:

Lipids – use the plain cryovials; store in liquid nitrogen.
Genetics – use red banded cryovials; store specimens in pure ethanol.
Isotope ratio – use acetone cleaned foil; store envelopes in screw top vial within -20°C freezer.

A5.3 Species list

To date, the following plankton species have been picked out for further analysis. A typical number of sets of individuals, dependent on abundance, is given in parenthesis. [* denotes target species defined in Phase 2 of Marine Productivity.]

Copepoda – Picked from ARIES nets
  i) **Calanus* (3 – 4 sets x 10)
  ii) *Euchaeta glacialis* (3 sets x 10)

Euphausiidae – Mostly from Dual Methot nets.
  i) **Meganctiphanes norvegica* (3 sets x 5)
  ii) **Thysanoessa longicaudata* (3 sets x 5)
  iii) *Euphausia krohni* (3 sets x 5)

Chaetognatha *Sagitta maxima* (3 sets x 5)

Amphipoda *Parathemisto* (3 sets x 5)

A5.4 Sample labelling and data logging - DM, ARIES and OS

Printed labels for most samples can be obtained from the net launch/recovery team. However, specimen samples removed for future analysis (described above) should always be hand labelled with the Date, Haul number (= station no), Sampling gear/ Net type, Species and Number contained. Double labelling on cryovial and tape is used. Sampling details are available from the written deck file or the computer files for each tow.

Please ensure that all specimens removed from samples are detailed in the log book, which should then transferred to the Excel spreadsheet set-up for each sampling method.

A5.5 Dual Methot (DM)

1. Remove both sampling codends, placing upper net codend (red tape mark) in the bucket also marked with red tape and the lower net codend in plain bucket.
2. Gently wash each net sample separately into a sorting tray.
3. Carefully remove target species into partitioned petri dish, kept on a cold tray, measure using microscope measuring stage, recording values and preserve in order of priority. *Keep specimens chilled.*
4. If time permits repeat for other dominant species in sample.
5. Remove, identify and measure the diameter and volume of any large jellyfish, and if necessary store in formaldehyde solution.
6. Store the remainder of each sample in formaldehyde solution using either a 500 or 1000ml plastic container. Clearly label each sample, internally and externally, with Date, Sampling gear (DM), Net (upper/lower), Site and Haul numbers.

(NB. If the upper and lower Dual Methot nets do not close properly then treat as the haul as a combined sample)

A5.6 ARIES

A5.6.1 General storage of samples

1. Samples must be kept chilled and covered to avoid desiccation and/or decomposition. All specimens for biochemical analysis should be picked out within one hour on a frozen surface to maximise freshness of sample.
2. All samples should be gently washed through meshes: 200 μm for ARIES, 95 μm for Ocean Sampler.
3. All ethanol samples should be stored in push stopper, 26 ml glass tubes, and formaldehyde fixed samples in 28 ml screw cap tubes. Ensure that the ratio ethanol:sample is at least 10:1, and 3 ml of concentrated formaldehyde is added to each vial being preserved with formaldehyde.

A5.6.2 Processing of pup and reel net samples (AP and AR)

1. Remove and secure the two pup samples ("live" tube and "dead" codend net), fully wash and retain each pup net sample onto 200 μm mesh squares, preserving the dead sample in ethanol and temporarily storing the live sample in a petri dish on ice, or in a bucket of chilled water, in the fridge. Note; the live sample is retained in case additional specimens are required to be picked out for the future analysis priorities, after which the sample is stored in formaldehyde solution.
2. Record the position/ number of the last net as you remove the ARIES net reel and place it onto stand.
3. Transfer reel codend nets into lidded, individually numbered jars, noting which nets contain abundant *Calanus*. Use the chill room (5°C) to store the jar trays.
4. If possible, wash 2 nets containing abundant *Calanus* onto separate meshes and place in Petri dishes over ice. Ideally nets should be chosen from the upward sampling leg and include a deep and shallow sampling depth.
5. First carefully remove CV *Calanus* specimens and preserve in order of priority, Lipids,Isotope Ratios and Genetics, and only then pick out additional specimens of dominant species for future analysis.
6. Once specimens are picked then wash out and formaldehyde fix/preserve the remainder of these and all the other samples, then label and store them.
7. Refill the cod end reel with the clean, washed out nets and return to ARIES. Ensure sound net attachment of codends and no holes.

A5.7 Ocean Sampler processing and storage of samples (OP and OS)

- Remove both Pup nets (OP) from sampling frame, wash out onto 95 μm meshes and store one in ethanol and the other in formaldehyde solution.

- Remove the 7 depth numbered net samples (OS 1-7) from sampling gear and place in labelled holders, individually wash onto 95 µm meshes and store in 4% formaldehyde solution in 28 ml glass tubes.

A6. Data and sample management policy for the Marine Productivity programme

The policy document that follows provides the framework for short-term and longterm management of data and samples arising from the Marine Productivity thematic programme.

A6.1 Introduction

NERC requires all thematic programmes to carefully look after the data they collect - for the mutual benefit of programme participants (while the programme is running), and also to provide wider access and exploitation of datasets of longterm importance. Properly managed environmental data provides a key NERC resource, which will be used long after the formal end of individual projects and programmes. The scale of effort dedicated to data stewardship should reflect the anticipated longterm value of the data.

In the context of NERC Data Policy, "data may be held in either analogue or digital form and be stored either on paper or a variety of computer-compatible media... physical specimens in curated collections are outside the usual sense of the word". Nevertheless, it is appropriate for sample management issues to be also considered here, making clear which aspects apply in different sections.

A6.2 Role of BODC

The British Oceanographic Data Centre (BODC) is the NERC Designated Data Centre for digital information arising from the Marine Productivity programme. BODC has provided data management services for many other multi-laboratory and multidisciplinary marine programmes, NERC and non-NERC (eg BOFS, LOIS, PRIME and OMEX), and has delivered high quality, accessible data sets, primarily via CDs, for further scientific use. Costs have been allocated in the MarProd budget for BODC services, and Dr Gwen Moncoiffé (gmon@bodc.ac.uk) has been appointed contact person for liaison with the Steering Committee and individual projects.

BODC effort will focus on the quality control, integration and longterm stewardship of datasets obtained from MarProd-supported cruises, under Phase 2 of the programme. For Phase 1 data and laboratory-derived data and models, BODC will not necessarily have such close involvement. Thus for non-cruise data, BODC is not expected to undertake quality control, and other data stewardship arrangements may apply. For Phase 1 awards that involve joint work with non-NERC bodies, project-specific data storage and access procedures may need to be negotiated. Nevertheless, BODC needs to be aware of the totality of data arising from the MarProd programme, and the programme Steering Committee needs to be assured that similar quality standards for data stewardship (see A6.4 below) apply to all data collected through MarProd support.

The programme recognises the importance of direct involvement of BODC staff in planning MarProd fieldwork, including the opportunity to attend cruise planning meetings and relevant agenda items of Steering Committee meetings. BODC cruise participation is also welcomed (subject to berth availability), particularly when novel and/or relatively complex sampling arrangements are involved.

A6.3 Links with GLOBEC

Some additional data management considerations result from the Marine Productivity programme being the main UK contribution to the international GLOBEC project (Global Ocean Ecosystem Dynamics). Whilst it is not a condition of award, all MarProd PIs are encouraged to provide the following information to GLOBEC, for international access: i) a basic project description; ii) metadata [= coverage, scope and derivation of a dataset]; and iii) information on how actual data can (currently or in future) be obtained.

A DIF (Directory Interchange Format) entry should be used to provide this summary information to the GLOBEC International Project Office. Several projects have already done so, and their DIFs can be accessed via www.globec.org (click on Data in the Menu Bar, then Metadata Portal etc with UK selected as Location). Hester Willson (hew@pml.ac.uk) will be pleased to give further guidance on this matter.

A6.4 Minimum standards of stewardship for NERC corporate data

The following minimum standards are expected to apply when (digital) datasets form part of NERC's enduring data resource:

- The ownership and Intellectual Property Rights to the dataset must be established, and NERC's policy towards exploiting and making it available to third parties agreed
- The dataset must be catalogued to the level of detail required by a NERC Designated Data Centre, so that it can be mentioned in web-based NERC data catalogues
- Formal responsibility for the custody of the dataset must be agreed
- The data must be fully "worked up" (ie calibrated, quality-controlled etc) with sufficient associated documentation to be of use to third parties without reference to the original collector
- The technical details of how the data are to be stored, managed and accessed must be agreed and suitably documented
- The technological implications must be established (digital data stewardship implies the need for an underlying infrastructure of IT equipment and support)
- The resources need to carry out these intentions over the planned life of the data, in terms of staff (whether in project teams or the Data Centre) and IT equipment/infrastructure must be estimated and sources identified.
- A review mechanism must exist to reconsider periodically the costs and benefits of continuing to maintain the data. The intention to destroy or put at risk data should be publicised in advance, allowing time for response by interested parties.

The above NERC-wide requirements will be looked after "automatically" for the MarProd datasets managed by BODC. Nevertheless, PIs need to be aware of this framework, particularly if alternative means of longterm data stewardship are envisaged.

A6.5. Data and sample acquisition

A well-structured and user-friendly identification system is essential for cruise-based data collection and sample labelling. Such arrangements are traditionally the responsibility of the cruise Principal Scientist. For Marine Productivity, an overall consistency in approach is necessary - with cruise identifiers linked to unique combinations of site and station (gear cast) numbers. MarProd protocols are being developed in the context of the first North Atlantic cruise (*Discovery 258*; Nov-Dec 2001) with direct BODC involvement. Further information is provided in the D258 Cruise Report [*this document*].

Sorting procedures and sample preservation protocols are being developed for biological material collected on MarProd cruises. Whilst formaledehyde solution is used for bulk zooplankton samples (from ARIES and Dual Methot nets), other preservation techniques apply to sub-samples for specific purposes; for example, liquid nitrogen for lipid work, ethanol for molecular biology and genetics, and -20°C freezing for isotope ratio analyses. Investigators with other needs should discuss their proposed preservation methods with the cruise Principal Scientist. The longterm curation of biological material is discussed under A6.9 below.

Station identifiers, navigational information and "basic" oceanographic data (for which BODC will have quality-control responsibilities) must be provided to BODC by the Principal Scientist immediately after a MarProd cruise. Normal practice will be for BODC to meet the ship when it docks and to take delivery of this material together with a copy of the logs, calibration data and sensor information. A copy of the Cruise Summary Report (ROSCOP form) should be provided to BODC by the Principal Scientist within one working week of the end of the cruise. A copy of the full cruise report should also be sent to BODC, preferably electronically, as soon as it is completed. BODC will then assist the MarProd in making this more widely available (eg via a link from the main programme website).

Processed and project-specific cruise data must be provided to BODC by the Principal Scientist and project teams as they becomes available, not in the concluding few months or weeks of projects. However, great importance is given both by the programme and by BODC to protecting the interests of data originators, and restrictions on the wider availability of BODC-held datasets will therefore apply (see A6.8 and A6.10 below).

A6.6 Data formats and data media

Digital data should be collected and stored using standard, widely-available software products and their related data formats. Whilst BODC has experience in handling a very wide range of software, formats and media, Investigators should discuss with them the proposed use of any data-handling or storage protocols that might be regarded as "non-standard".

CD-ROMs are currently the preferred means for making integrated data products from marine thematic available to the wider research community. The MarProd Steering Committee will advise on the number of CDs, and set target times for their release.

A6.7 Data backup policy

Daily backup programmes apply at BODC (and other NERC Designated Data Centres) to safeguard major digital databases. Project PIs and Co-Is are responsible for providing appropriate back-up strategies for unique digital data stored locally and/or via other organisations.

As far as possible, analogue data (such as photographs) should be "disaster proofed" by transferring them into digital form, eg by scanning. Such duplication is not a waste of effort, even though the original, analogue version may have a longer lifetime than the format/media used for the digital transcription. Such data may then be included on a programme CD. Note that BODC has considerable experience in managing and publishing image data.

A6.8 Protection of data originators' Intellectual Property Rights

The following arrangements have been developed to ensure an appropriate balance between the protection of data originators' intellectual property rights and the potential benefits that may arise via data use by the programme, the wider research community and other interested parties.

- All data collected in the Marine Productivity programme through NERC funding and provided to BODC should be freely available to all programme participants (PIs and Co-Is) for MarProd purposes on the condition that the originator is kept informed about how the data are being used and is duly acknowledged in any exploitation of that data

- Due acknowledgement is considered to be co-authorship, specific reference to the data source or a share of any financial reward. The form of this should be negotiated between the data originator and the data exploiter. If a dispute should arise, then the problem will be referred to the Steering Committee for resolution.

- Until MarProd data enter the public domain, BODC will not transfer them to parties outside the programme without the explicit agreement of the originator. Steering Committee advice will also need to be sought if major data transfers are involved, to avoid compromising the interests of other programme participants.

- The mechanism for entry into the public domain is expected to be the release of the MarProd CD-ROM at the conclusion of the programme.

- A condition of CD-ROM usage is that it is regarded as a data publication and all usage of the data contained therein should acknowledge the data originator through citation

A6.9 Longterm sample curation

Biological material obtained on MarProd cruises is owned collectively by the programme. However, during the programme lifetime, sample-originators have responsibility for the stewardship of material, recording any removals and (if shared with other research groups) keeping track of its movements and usage.

It is recognised that indefinite storage of all biological material is impractical, and that some identification and analytic procedures require sample destruction. Nevertheless, it is expected that nearly all net-collected zooplankton and representative sub-samples of micro-plankton will be stored for the duration of the programme by sample-originators. [Exceptions may be made for larger-size zooplankton, eg jellyfish, and organisms removed for biochemical analyses and experimental purposes]. Subsequently, longterm archiving (of at least 5-10 yr) will be arranged by the programme for as many samples as possible, to maximise the exploitation of the taxonomic information that they contain.

Before MarProd researchers dispose of biological material in their possession, an assessment should therefore be made as to whether it might be of value to other groups, not necessarily part of the MarProd programme.

A6.10 Data and sample availability

It is NERC policy to ensure that "individual scientists, principal investigator teams and participants in programmes will be permitted a reasonable period to work exclusively on, and publish the results of, the data collected by such individuals and teams". Nevertheless, as the MarProd programme develops, there is necessarily a sequential widening of access to data and samples. This process has already been outlined with respect to data under A6.8 above. It can be generalised with reference to three access levels:

<u>Level 1 (Project).</u> Availability limited to the investigators responsible for data/sample collection (for MarProd cruises, data/sample collection is expected to be a shared responsibility; thus group ownership applies, under overall control of the Principal Scientist); any wider sharing at the discretion of the investigators

<u>Level 2 (Programme).</u> When data is transferred to BODC, their availability is automatically extended to other investigators within the MarProd programme. Nevertheless, their further use is still under the control of the data originator, and any wider sharing is at the discretion of the MarProd Steering Committee.

<u>Level 3 (Public).</u> Data publication, at or near the end of the programme. Availability extended to external users, either openly (for academic use) or at the discretion of BODC/NERC (for commercial exploitation, in consultation with data-originators). Post-programme availability of biological material to be controlled by the body responsible for its archiving, on the basis that 'ground-rules' will then have been established by the Steering Committee, and that sample-originators will be consulted wherever practicable.

It is to the benefit of the programme as a whole that inter-project collaborations are developed under Level 1, and that the transition between Levels 1 and 2 is made as rapidly as possible.

A6.11 Identifying data and samples for management purposes

It is important that the MarProd programme maintains an awareness of all data and samples collected through its support, including outputs from partnership arrangements (eg from use of non-NERC vessels, or through collaborations involving other funding agencies). Thus it is likely that a reporting system will be established to gain information on such data/samples, and their stewardship arrangements, if not via BODC. However, the Steering Committee is keen to minimise any duplication of reporting effort, and a version of the GLOBEC DIF system (see A6.3 above) may therefore be adopted for such purposes.

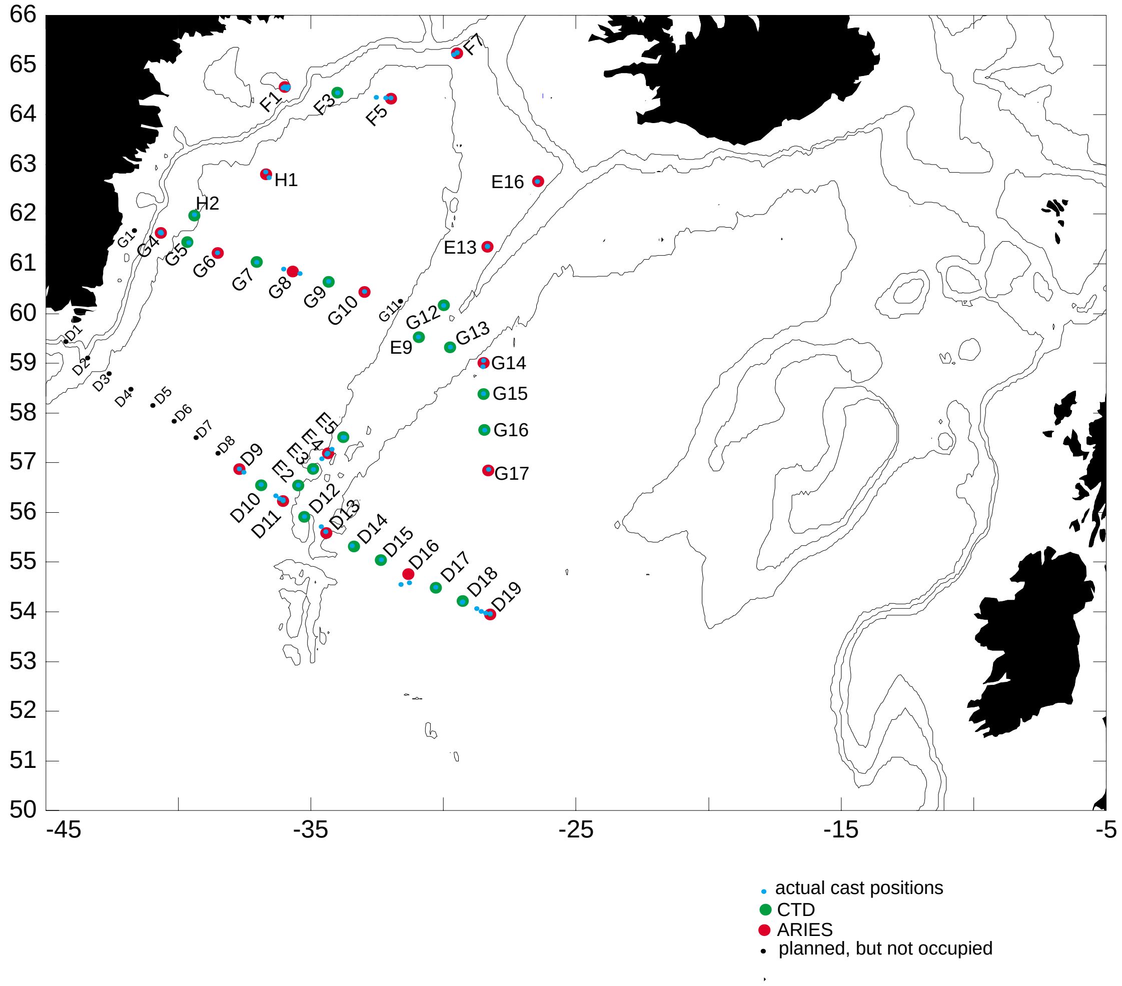


Fig. 1. Sampling sites for the first Marine Productivity cruise *Discovery* 258, and a few other planned stations. (Text section 1.3).

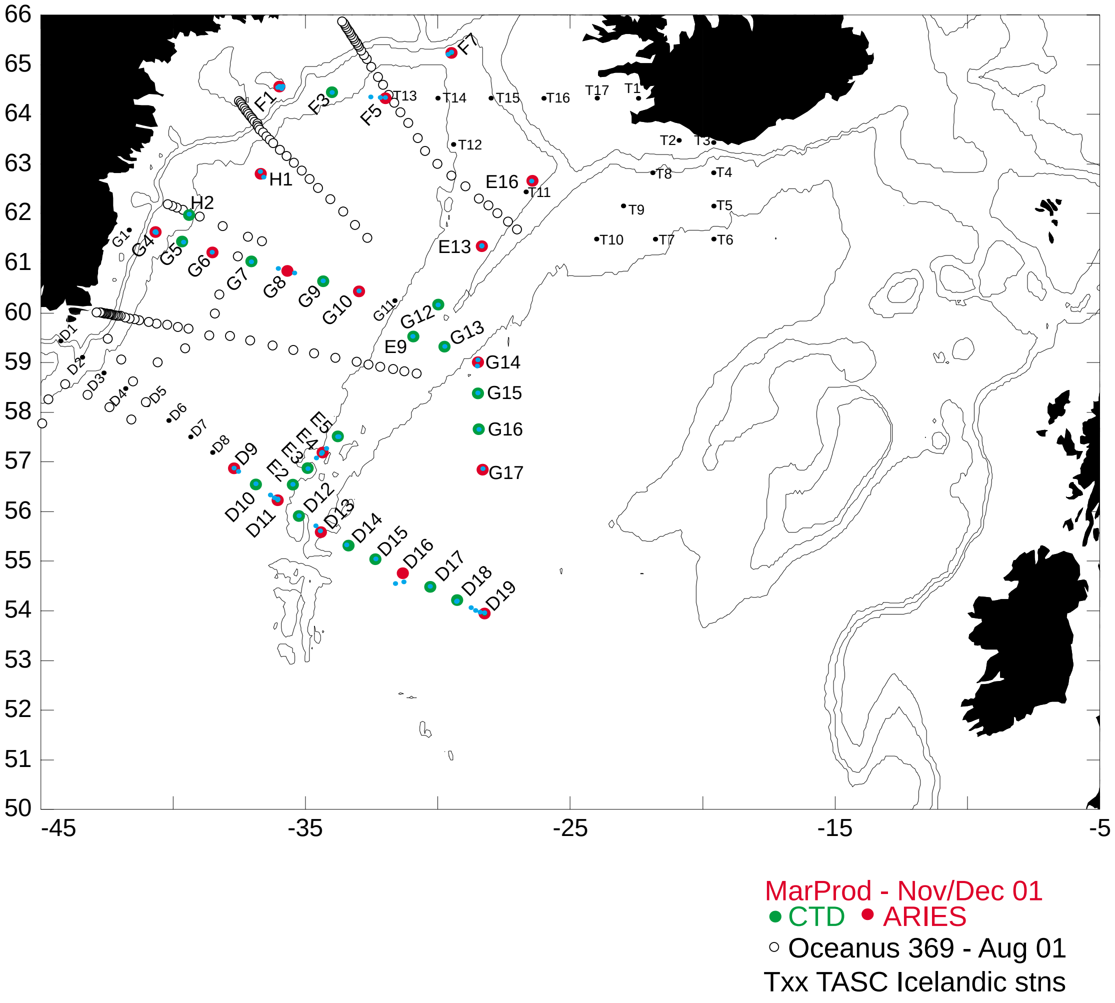


Fig. 2. Combined figure of *Discovery* 258 sampling sites, *Oceanus* 369 stations and Icelandic sites sampled during the TASC (Trans-Atlantic Study of *Calanus*) project. (Text section 1.3).

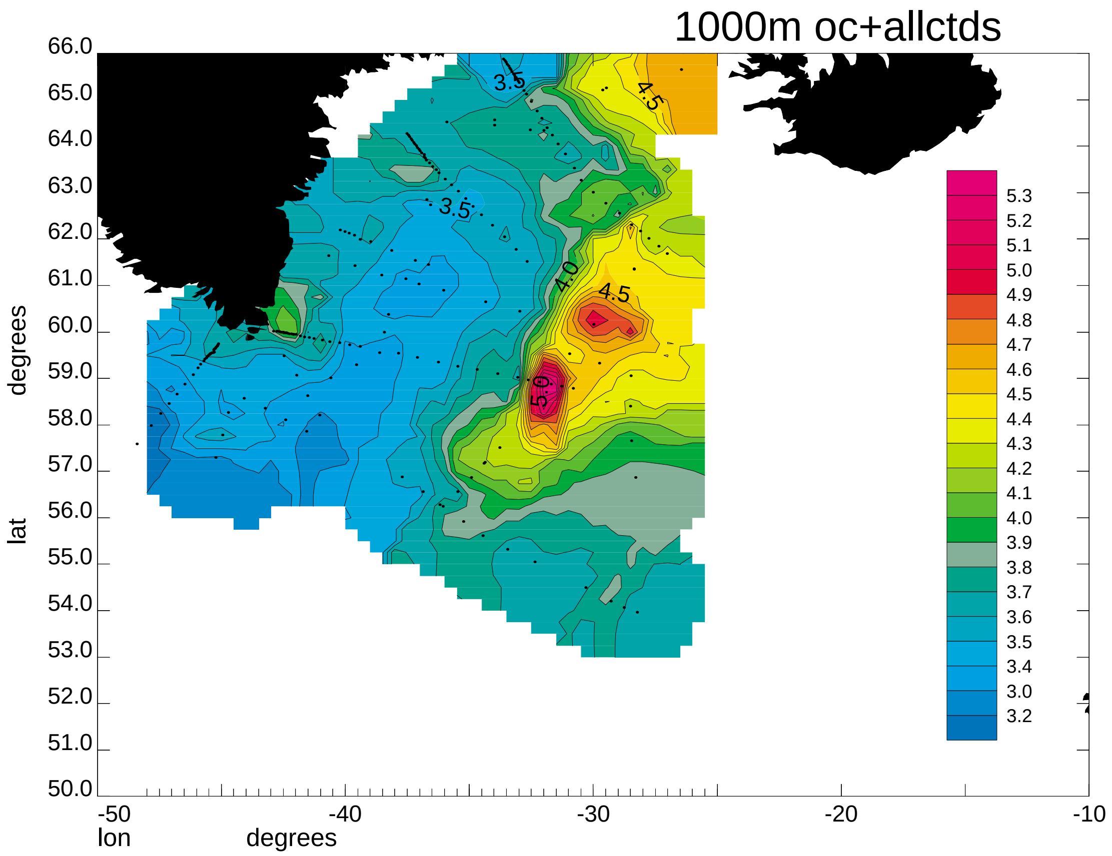
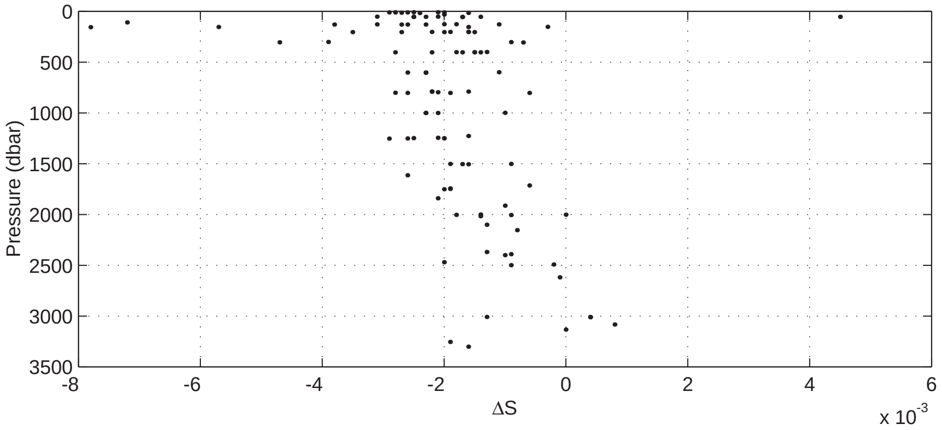
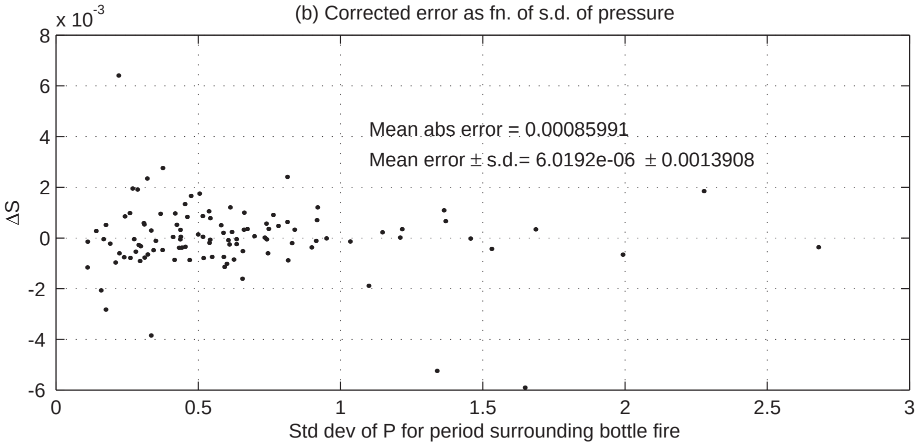


Fig. 3. Map of potential temperature (°C) at 1000 m, gridded from *Oceanus* 369 and *Discovery* 258 stations, shown as dots. Ellipse of influence for gridding was 3°lon x 1.5°lat, so beware extrapolation. (Text section 1.3).

(a) Uncorrected error in S



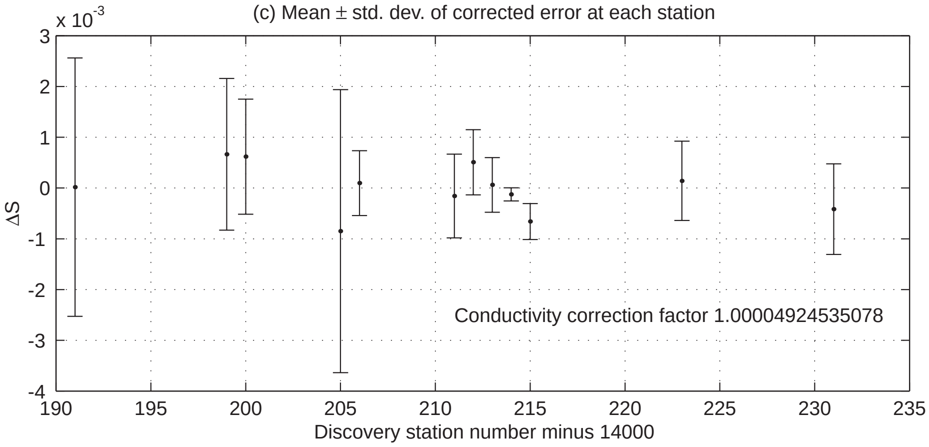
(b) Corrected error as fn. of s.d. of pressure



Mean abs error = 0.00085991

Mean error ± s.d.= 6.0192e-06 ± 0.0013908

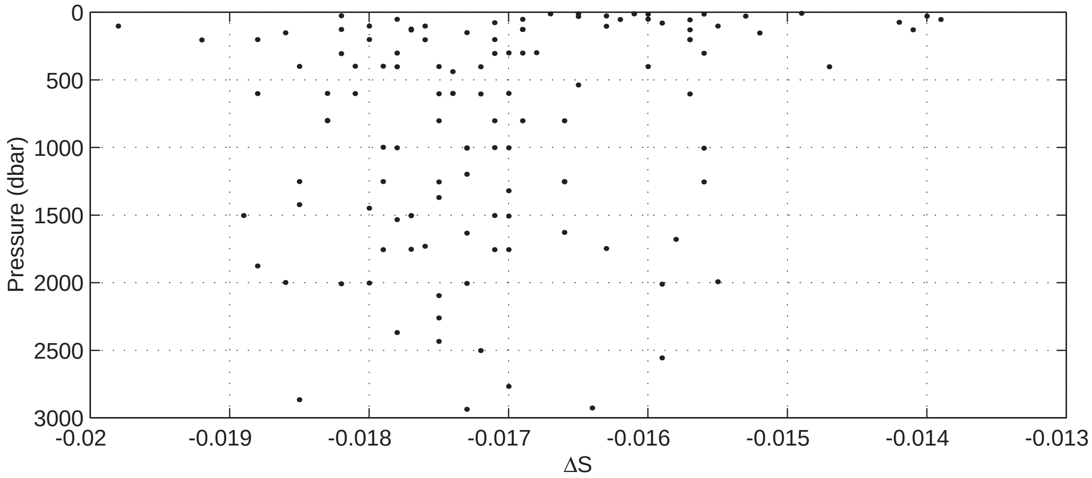
(c) Mean ± std. dev. of corrected error at each station



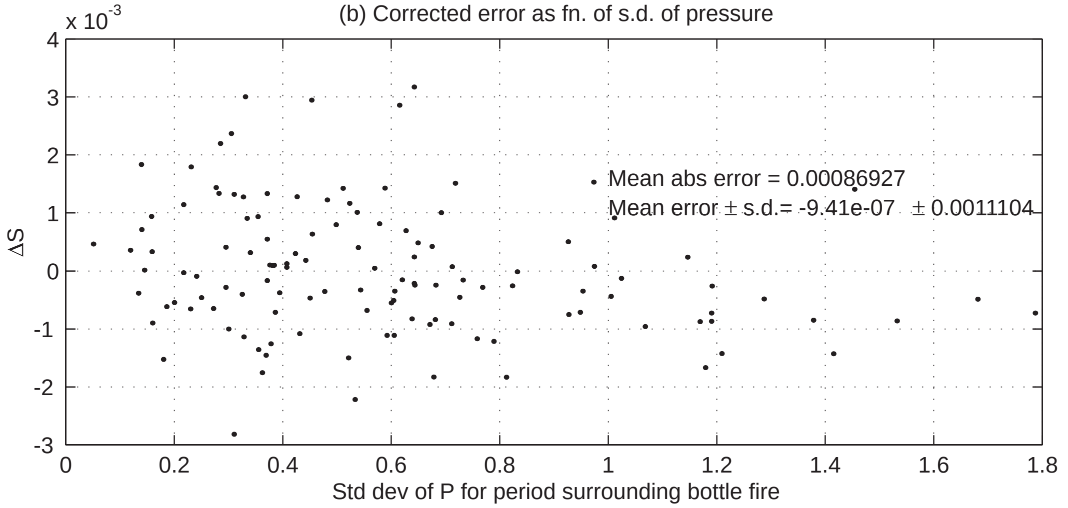
Conductivity correction factor 1.00004924535078

Fig. 4. Salinity errors for first lowered Sea-Bird CTD. (Text section 2.2.1).

(a) Uncorrected error in S



(b) Corrected error as fn. of s.d. of pressure



(c) Mean ± std. dev. of corrected error at each station

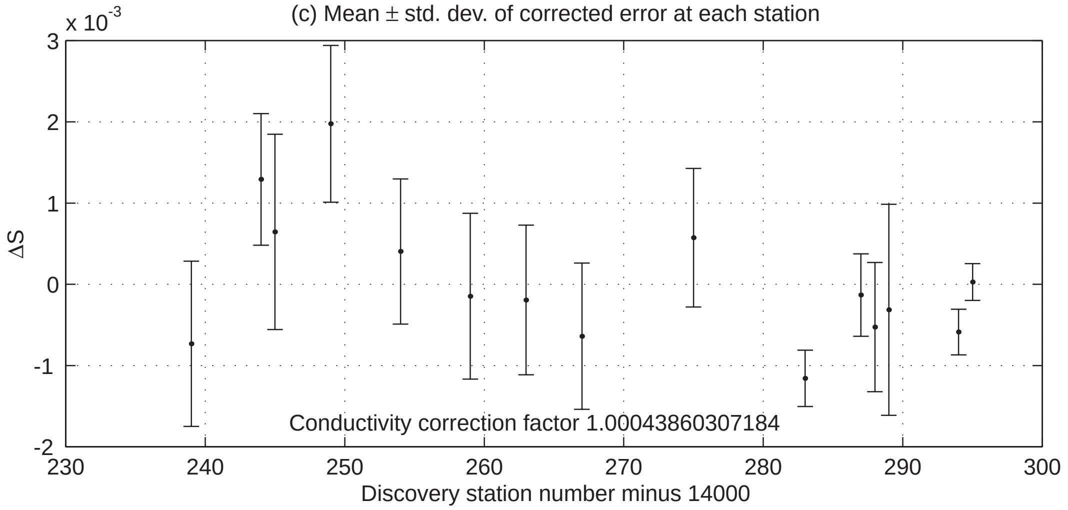
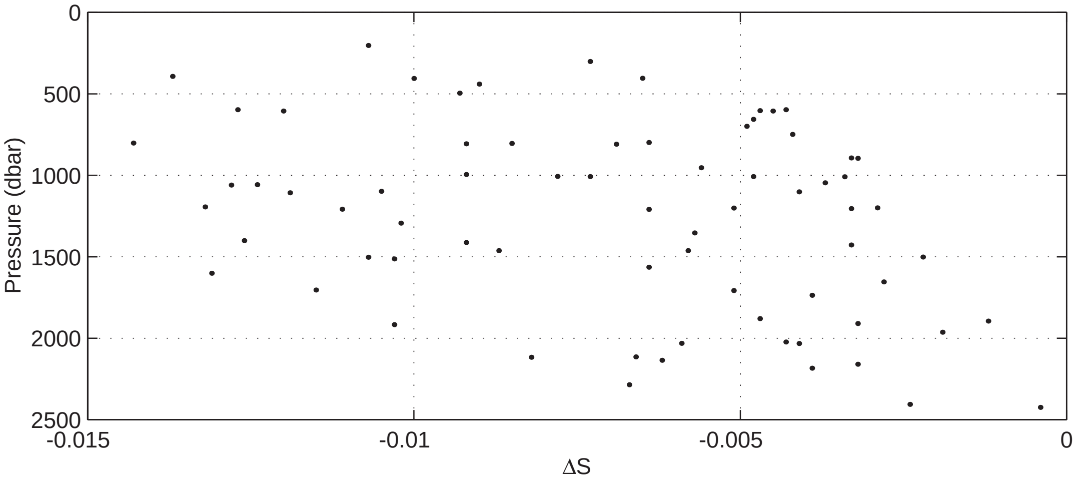
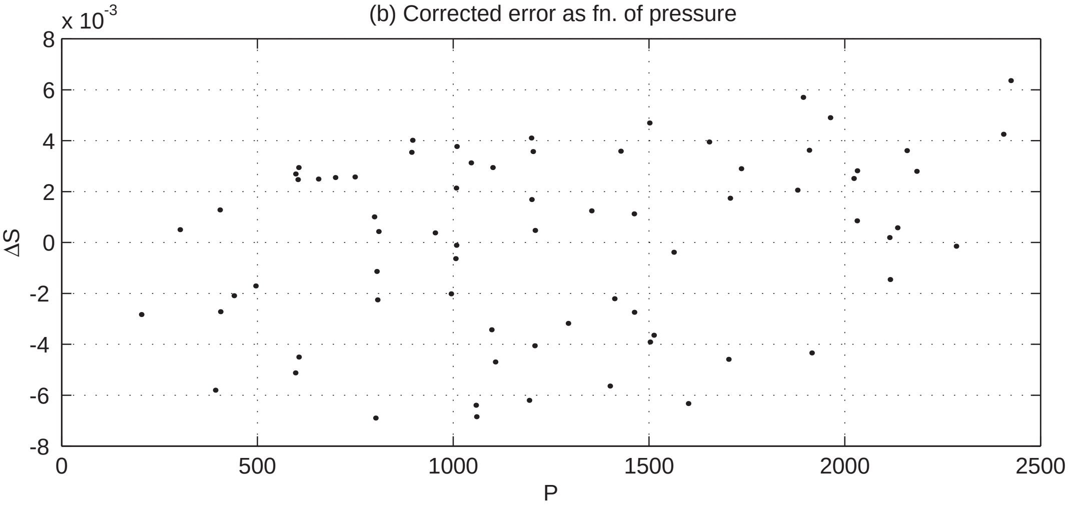


Fig. 5. Salinity errors for second lowered Sea-Bird CTD. (Text section 2.2.1).

(a) Uncorrected error in S



(b) Corrected error as fn. of pressure



(c) Mean ± std. dev. of corrected error at each station

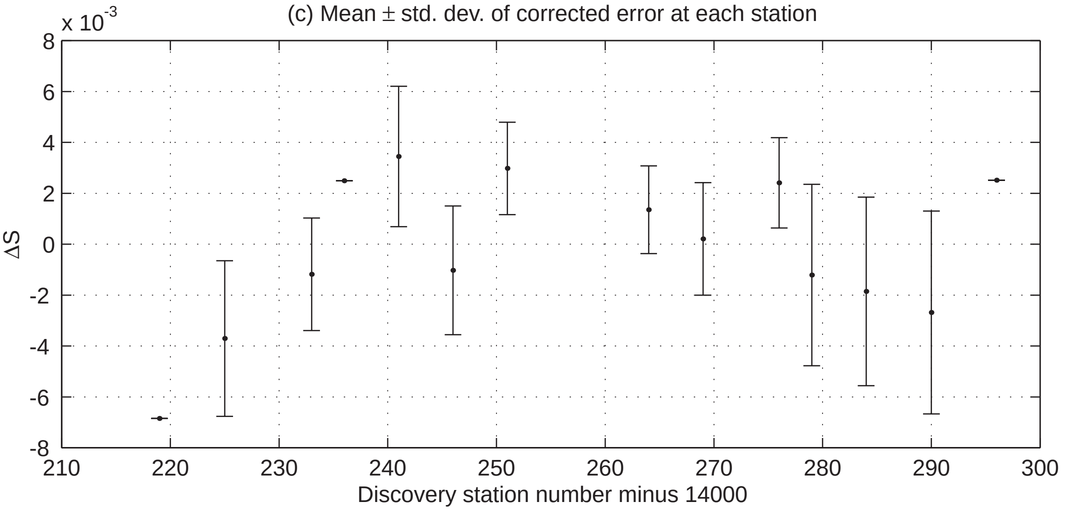
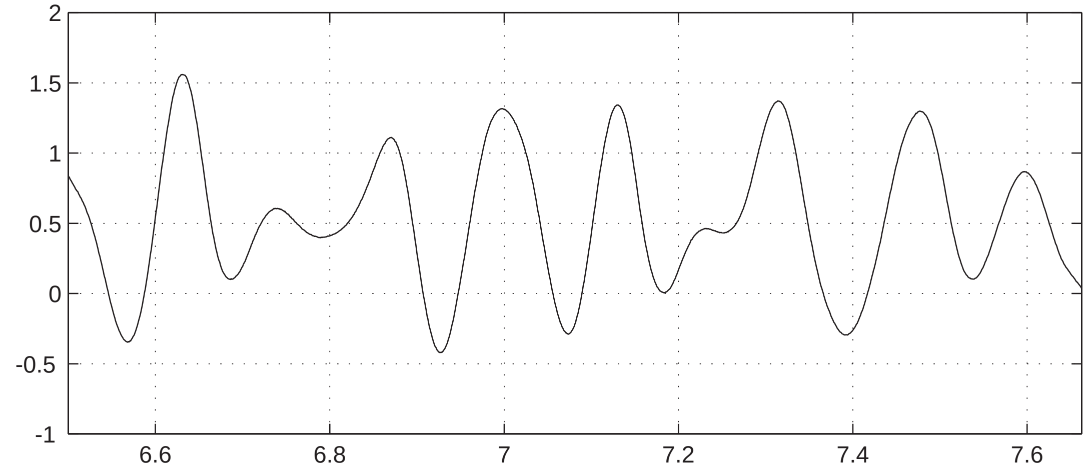
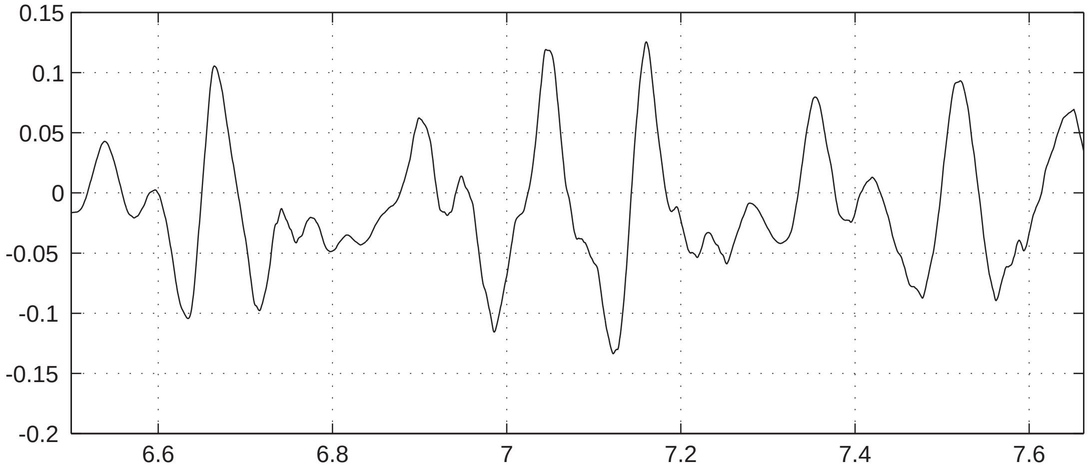


Fig. 6. Salinity errors for ARIES Sea-Bird CTD. (Text section 2.2.1).

(a) Package downward velocity, dbar s^{-1}



(b) Rate of change of temperature °C s^{-1}



(c) Package downward acceleration, dbar s^{-2}

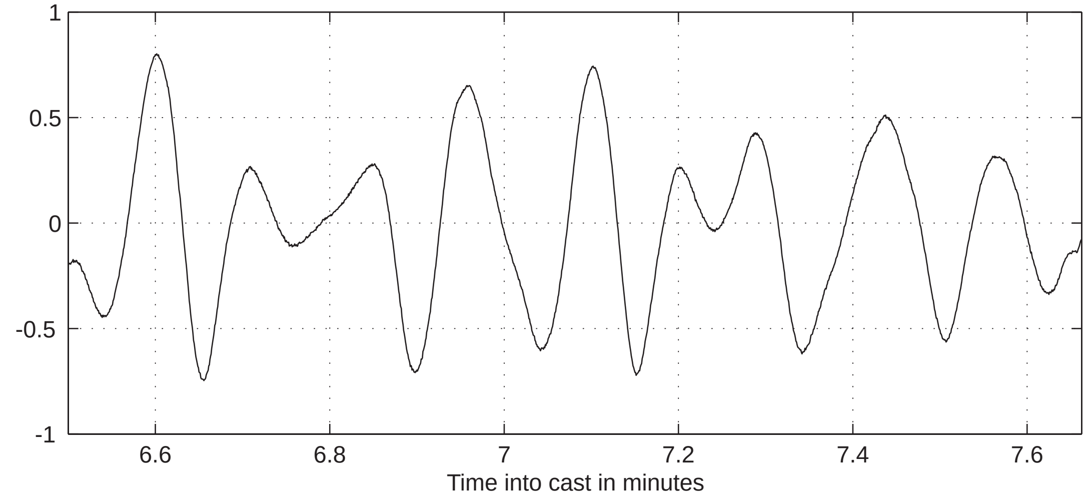
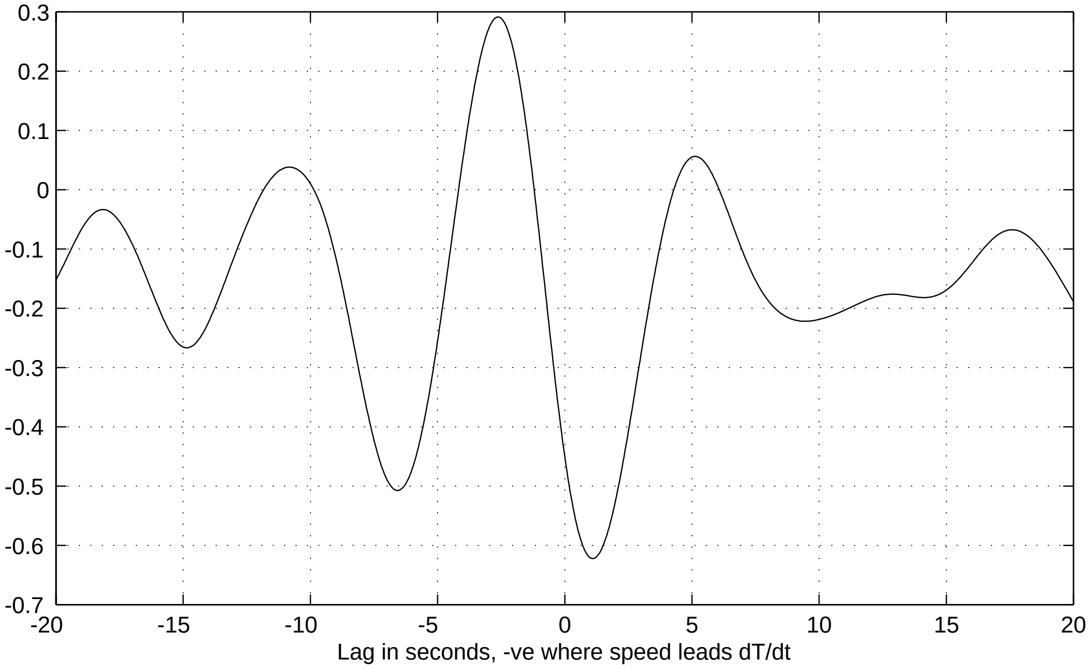


Fig. 7. CTD errors caused by trapped water in rosette; illustrated are the downward velocity (a) and acceleration (c) of the lowered CTD package, and the time rate of change of the measured temperature (b), from a minute-long section of a downcast when the package was passing through a thermocline region. (Text section 2.2.3).

(a) Correlation of dT/dt with speed



(b) Correlation of dT/dt with acceleration

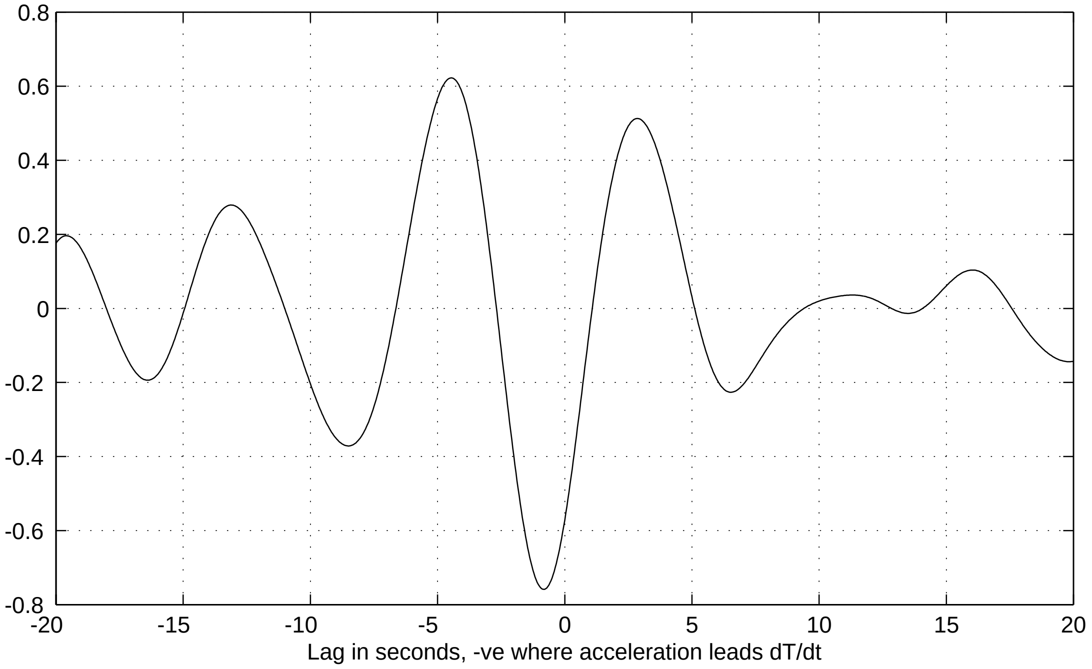
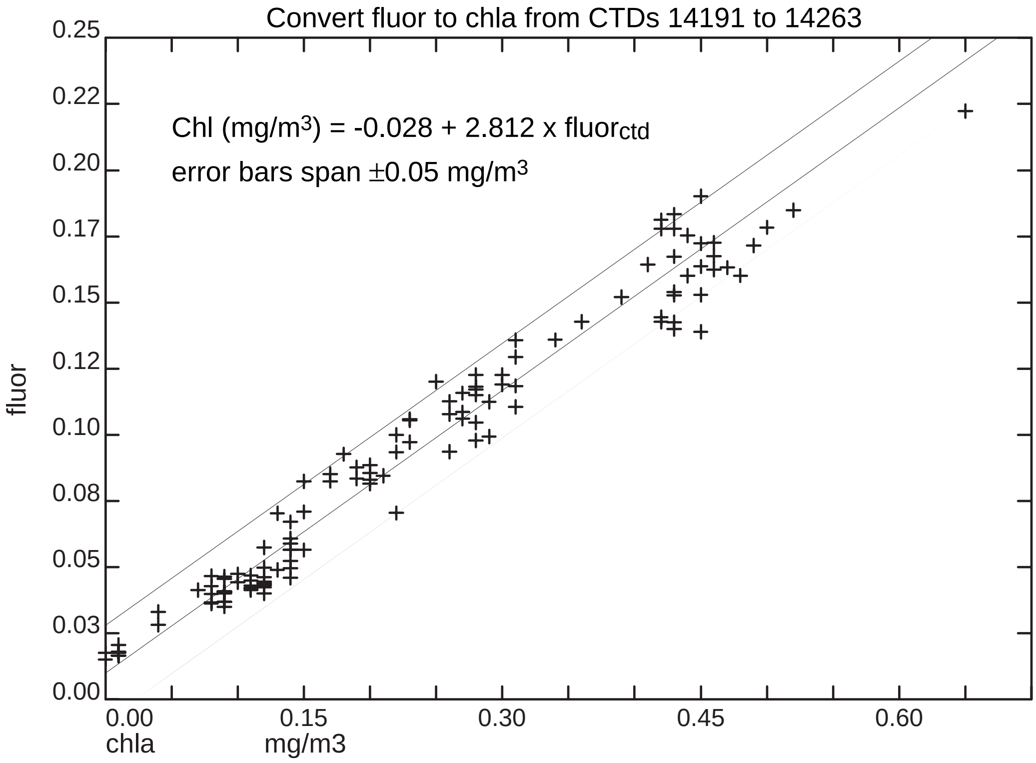


Fig. 8. CTD errors caused by trapped water in rosette: correlations of temperature change with (a) speed and (b) acceleration. (Text section 2.2.3).



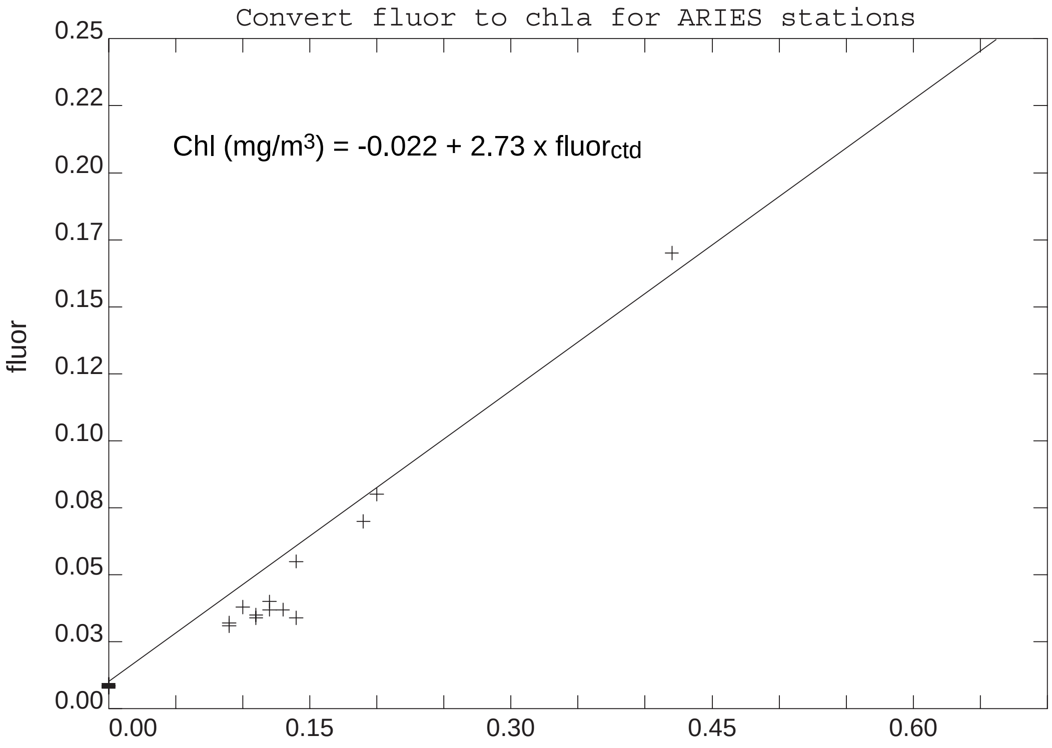


Fig. 9. Best fit of chlorophyll concentration to nominal fluorescence for the lowered CTD fluorometer (upper plot) and from the ARIES CTD fluorometer (lower plot). (Text section 2.3).

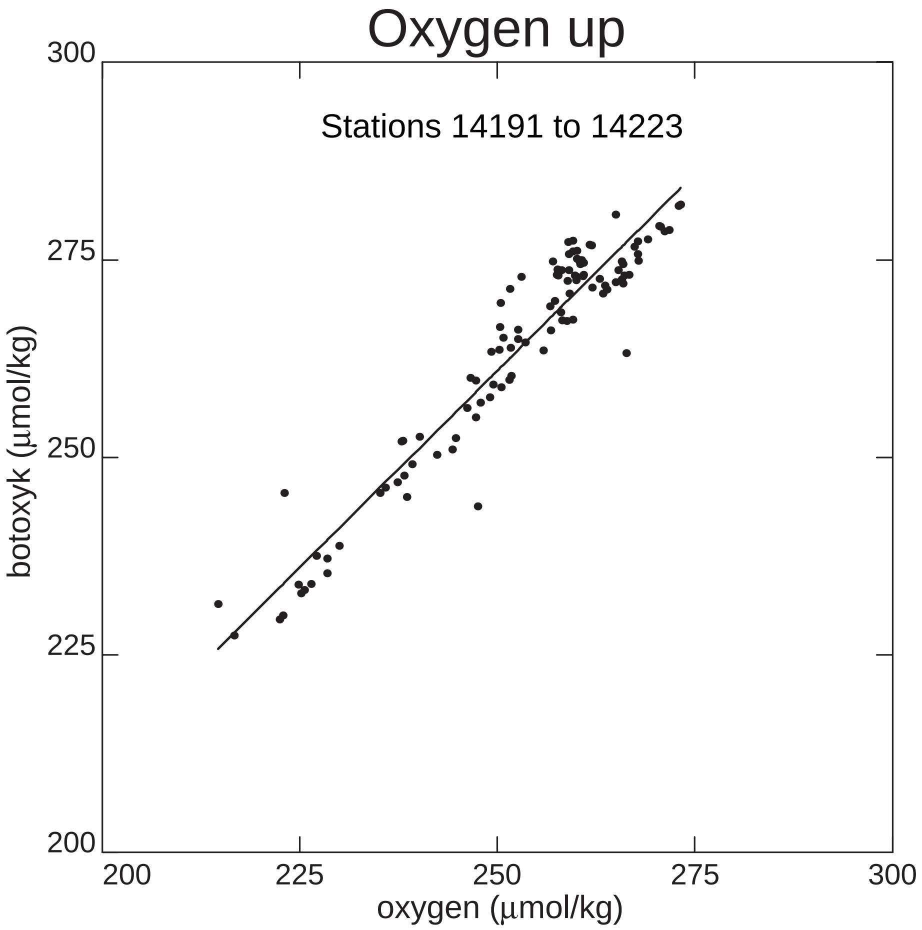


Fig. 10. Oxygen calibration for CTD casts 14191 to 14223: scatterplot of the oxygen concentration in µmol/kg measured on water samples (botoxyk) versus oxygen measured by the Sea-Bird oxygen sensor. (Text section 2.3).

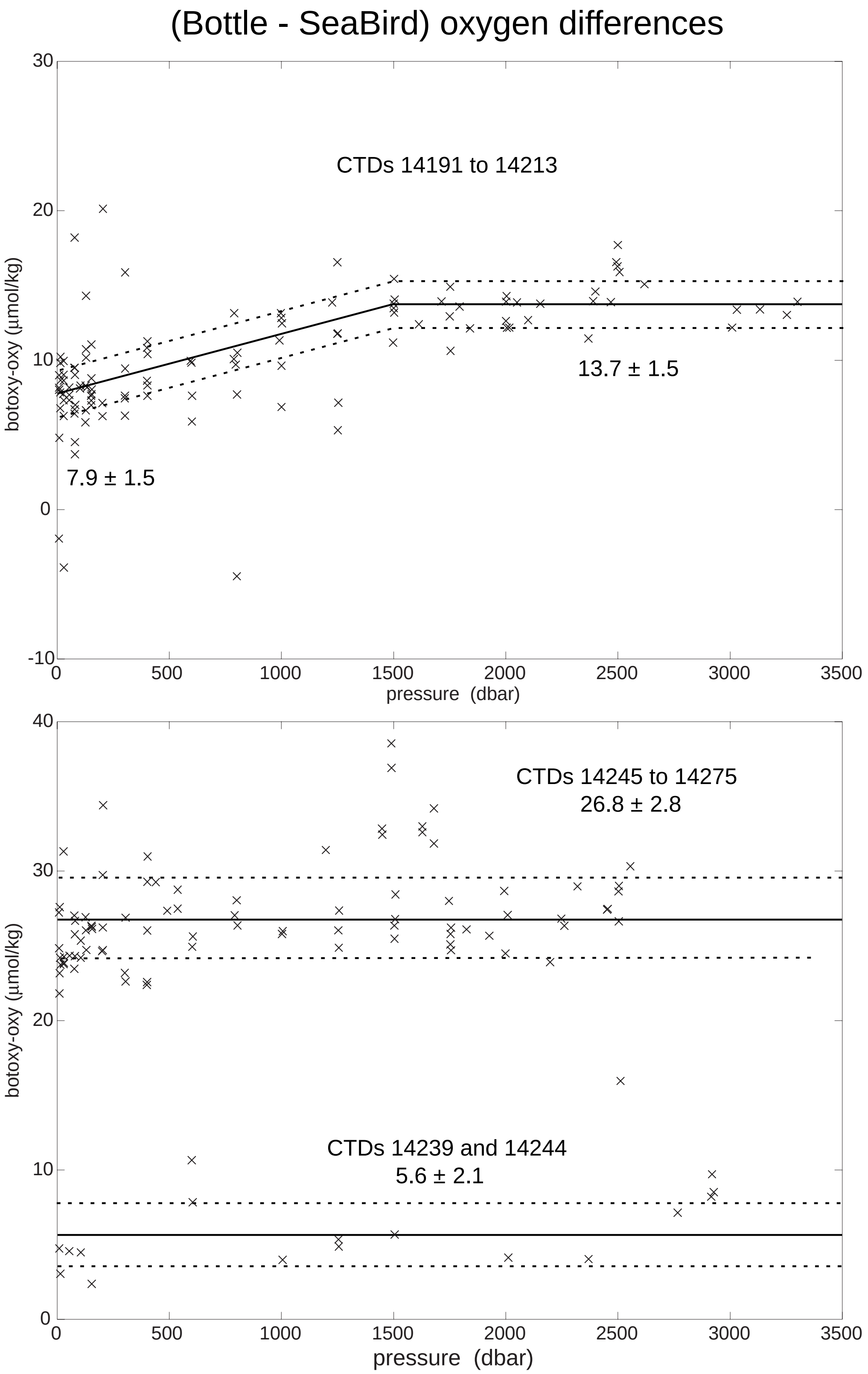


Fig. 11. Difference in oxygen concentration between bottle samples (botoxy) and CTD sensors for SBE43_0086 (casts 14191-14231, upper plot) and for SBE43-0076 (casts 14239-14275, lower plot) plotted against pressure. (Text section 2.4).

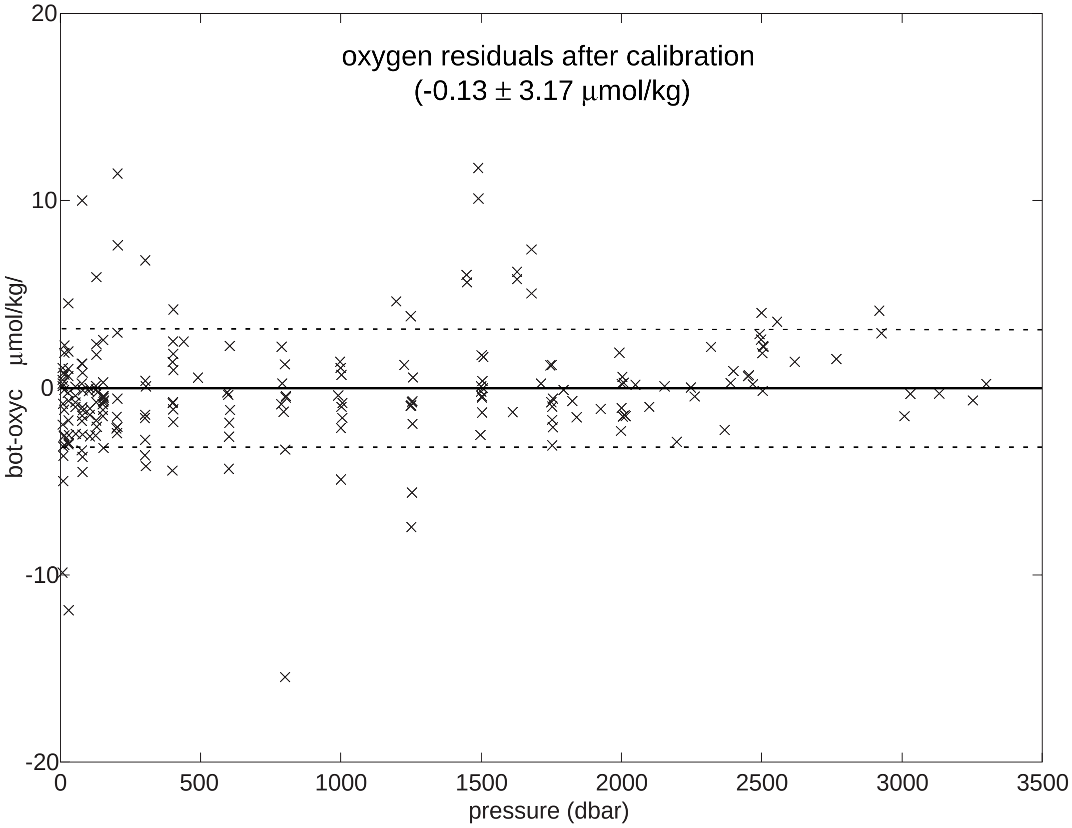


Fig. 12. Oxygen residuals after calibration of the Sea-Bird oxygen sensor (oxyc) against pressure. (Text section 2.4).

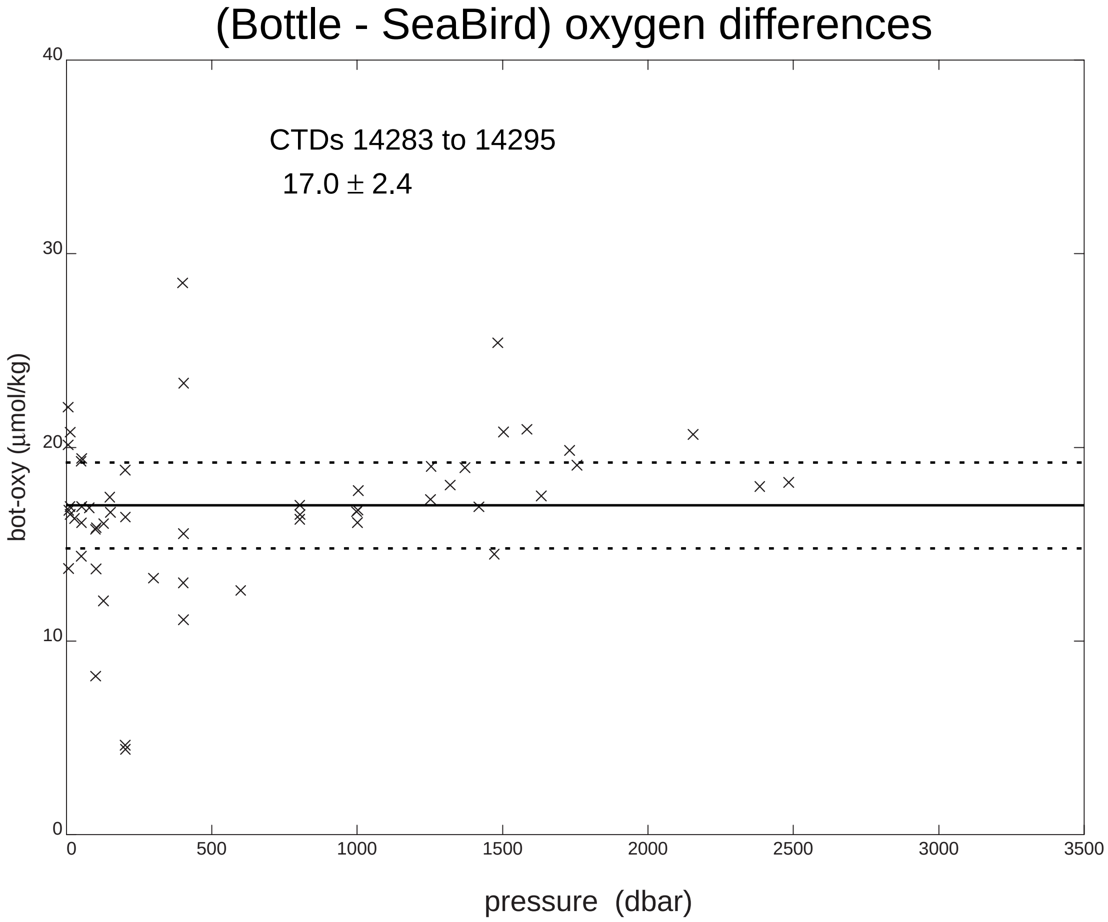


Fig. 13. Difference in oxygen concentration between bottle samples and CTD sensor (bot-oxy) against pressure for casts 14283-14295 (CTD SBE43-0076), following down-time period during the second leg of the cruise. (Text section 2.4).

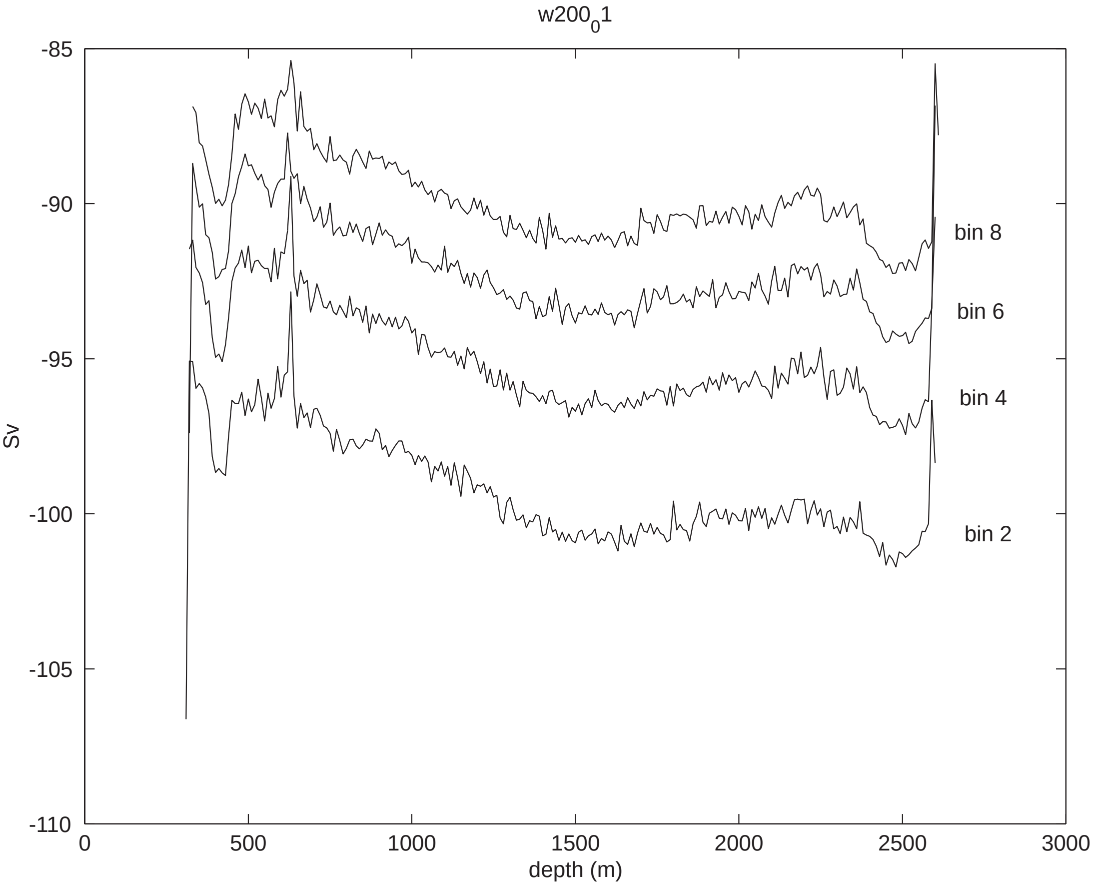


Fig. 14. Backscatter in dB plotted for four separate bins (position relative to the instrument) sorted on depth and then averaged over 10-metre depth ranges. Example from CTD station 14200. (Text section 2.6.1).

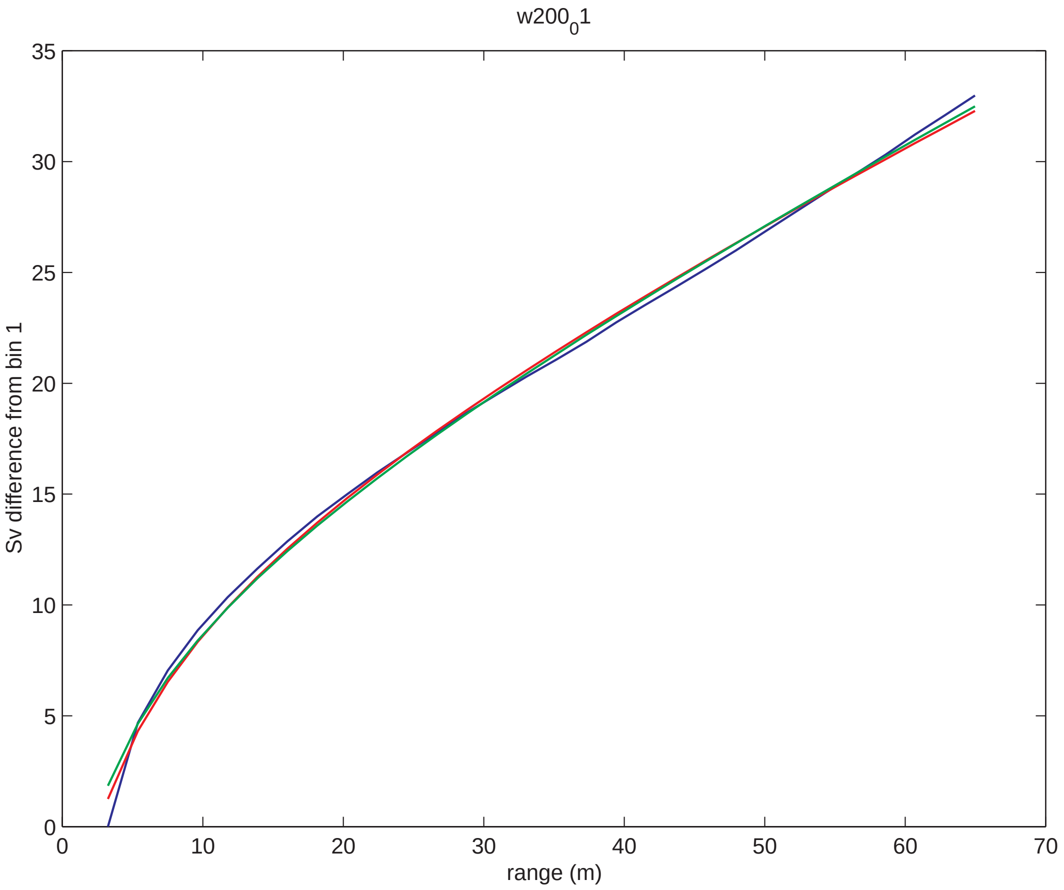


Fig. 15. Backscatter difference in dB between beam 1 and each of the other bins, averaged over the whole cast. In this case the horizontal axis represents the depths of each bin beneath bin 1. The blue curve represents the original data error; the red curve the correction calculated from the full model; the green curve the correction from the partial model (see text for more details). (Text section 2.6.2).

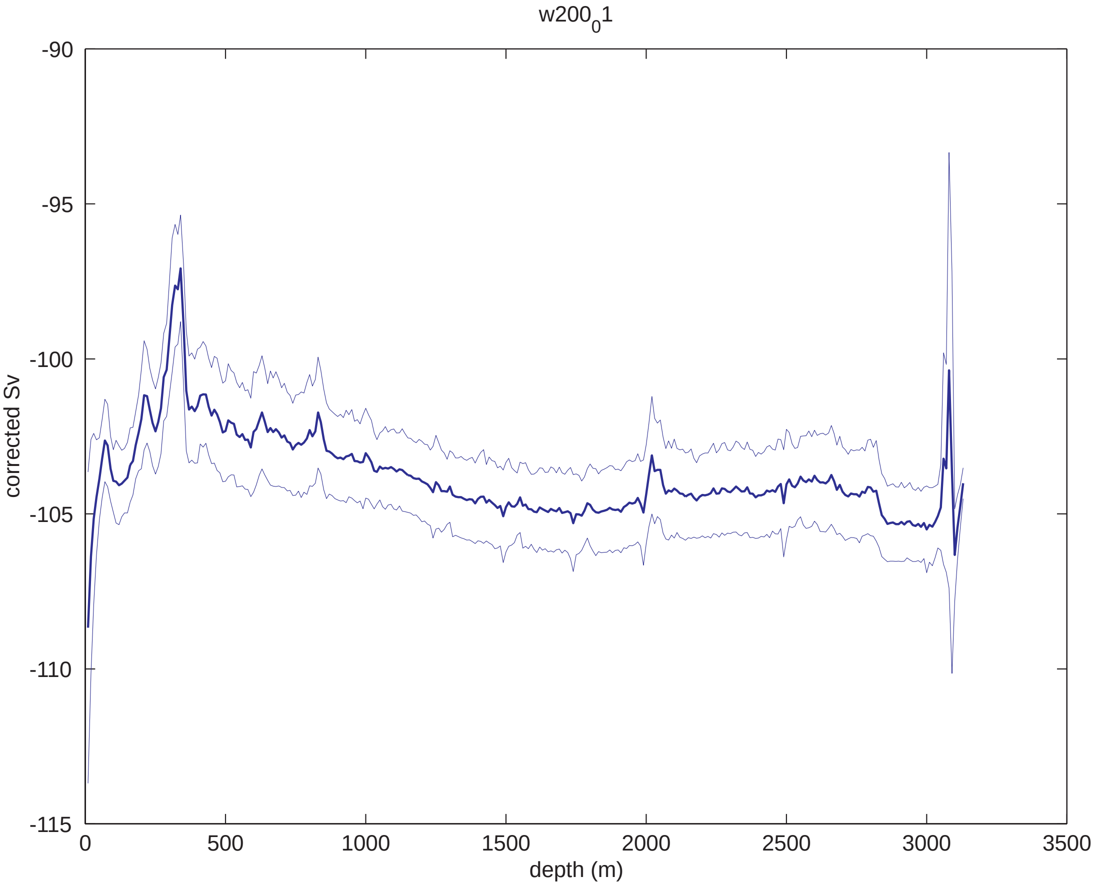


Fig. 16. Profile of backscatter in dB from station 14200 after correction by the partial model (central line). Data is averaged into 10-metre depth ranges. The upper and lower lines represent one standard deviation difference from the profile. (Text section 2.6.2).

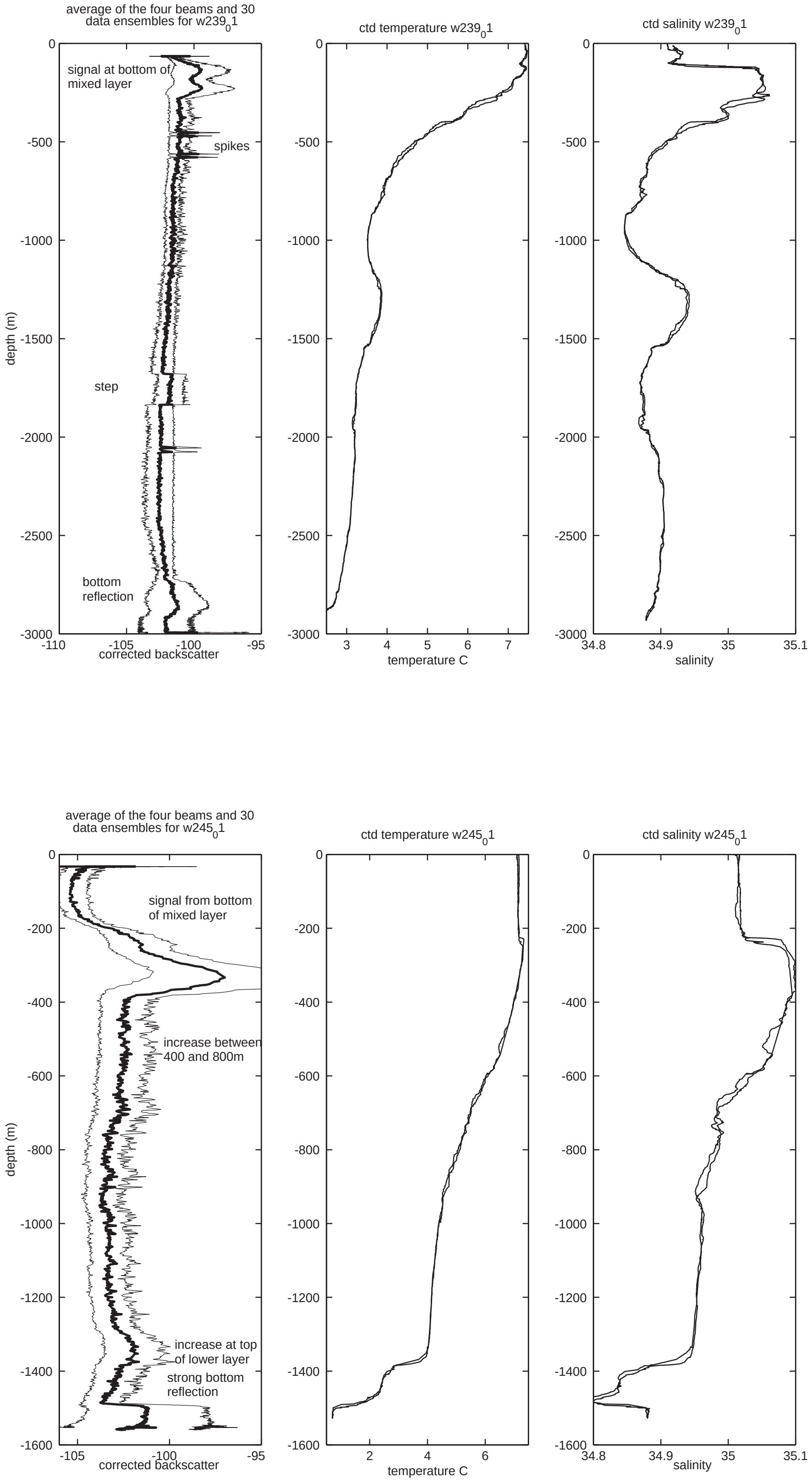


Fig. 17. Backscatter, temperature and salinity profiles for CTD14239 (upper plots) and for CTD14245 (lower plots). (Text section 2.6.2).

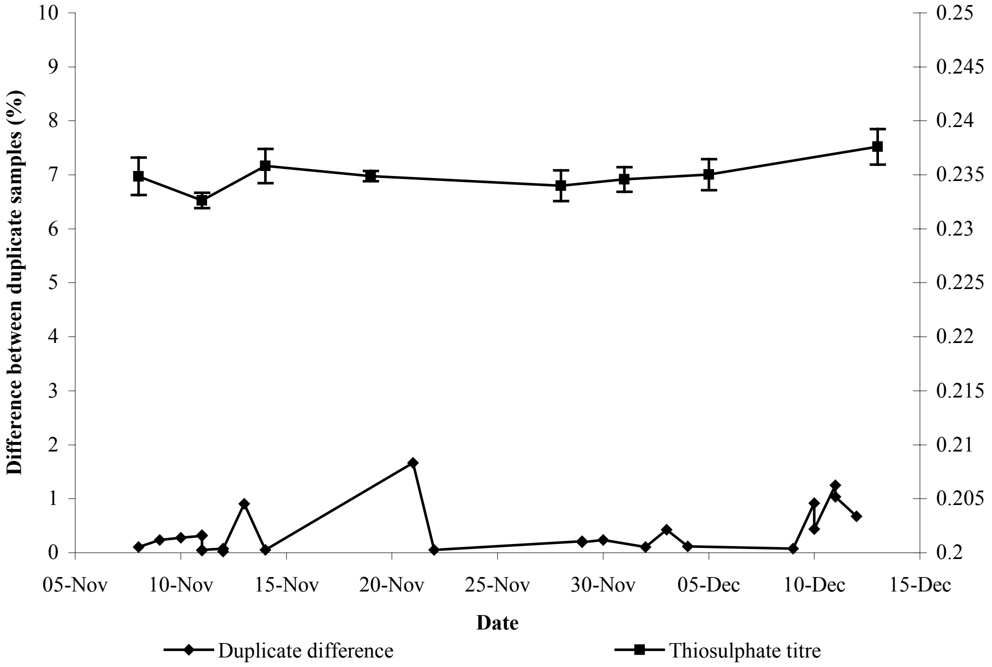
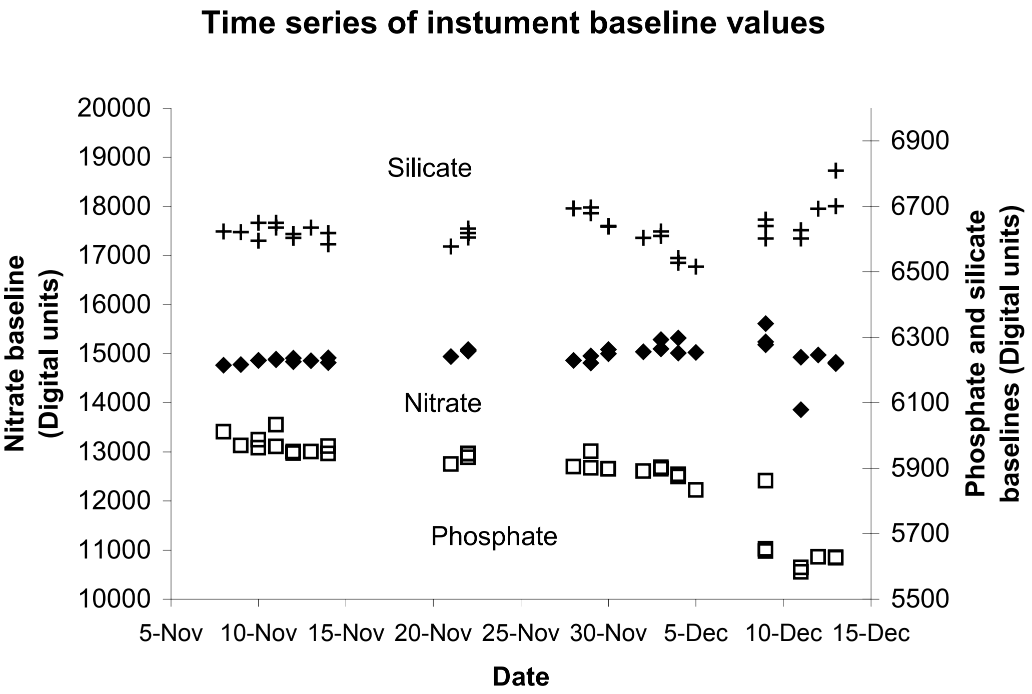


Fig. 18. Time series of the volume of thiosulphate required to titrate 5ml of the in-house prepared iodate standard and of the difference between duplicate oxygen samples over the course of the cruise. Titre volumes are the mean of five determinations and the error bars are one standard deviation from the mean value. (Text section 7.1).


Time series of instument baseline values

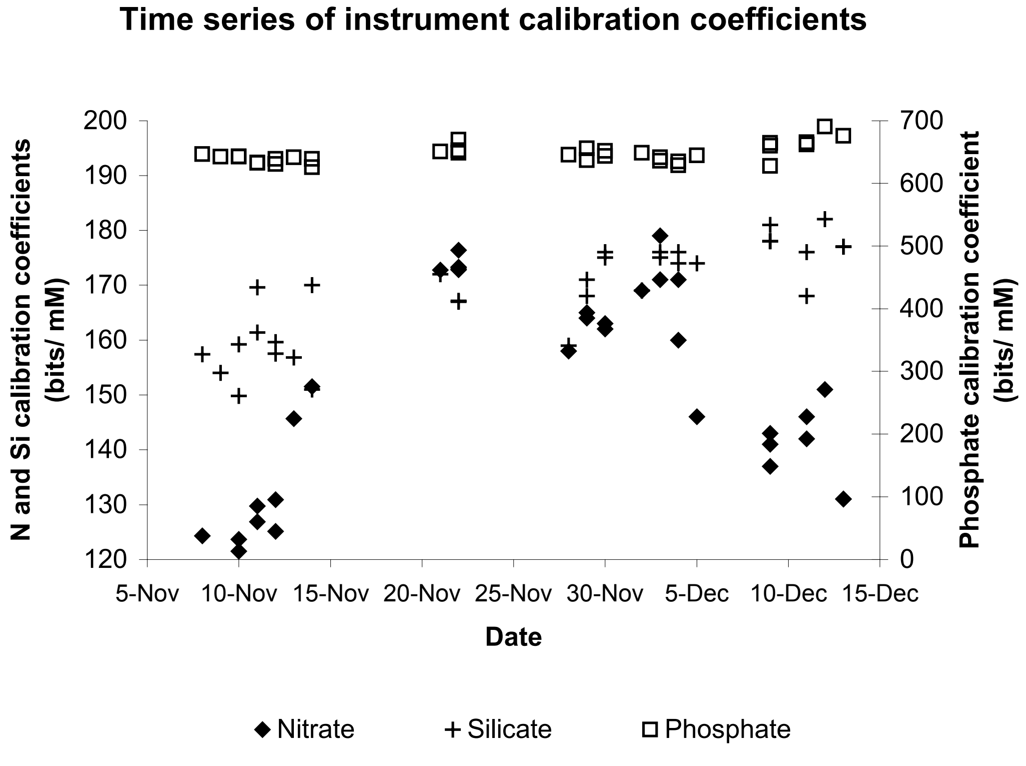
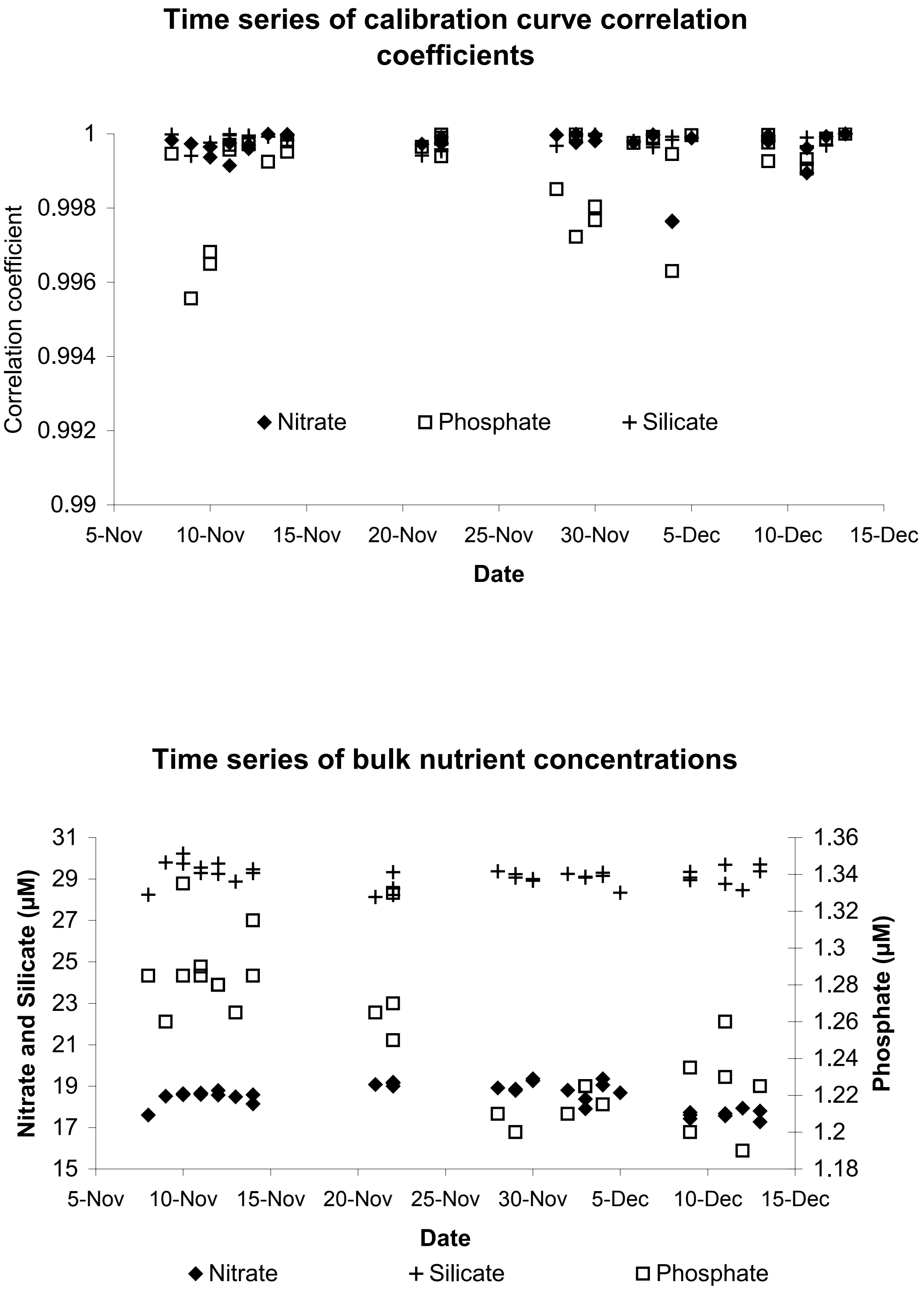

Time series of instrument calibration coefficients

Fig. 19. Time series of the nutrient auto-analyser baseline values and calibration coefficients for nitrate, silicate and phosphate. (Text section 7.2.2).



Time series of calibration curve correlation coefficients

Time series of bulk nutrient concentrations

Fig. 20. Time series of the calibration curve correlation coefficients of the auto-analyser (upper plot) and of bulk nutrient concentrations (lower plot). (Text sections 7.2.2 and 7.2.3).

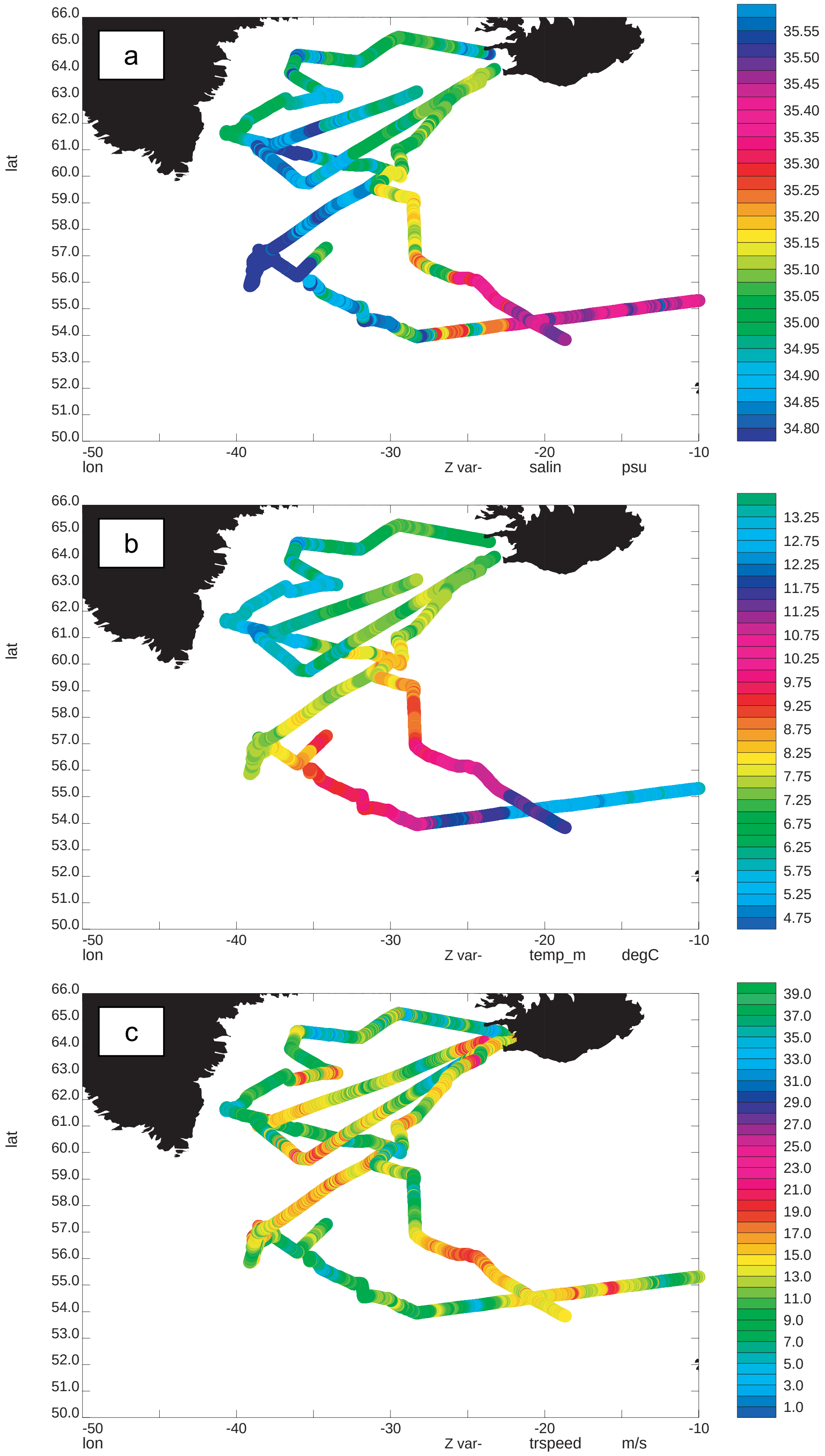
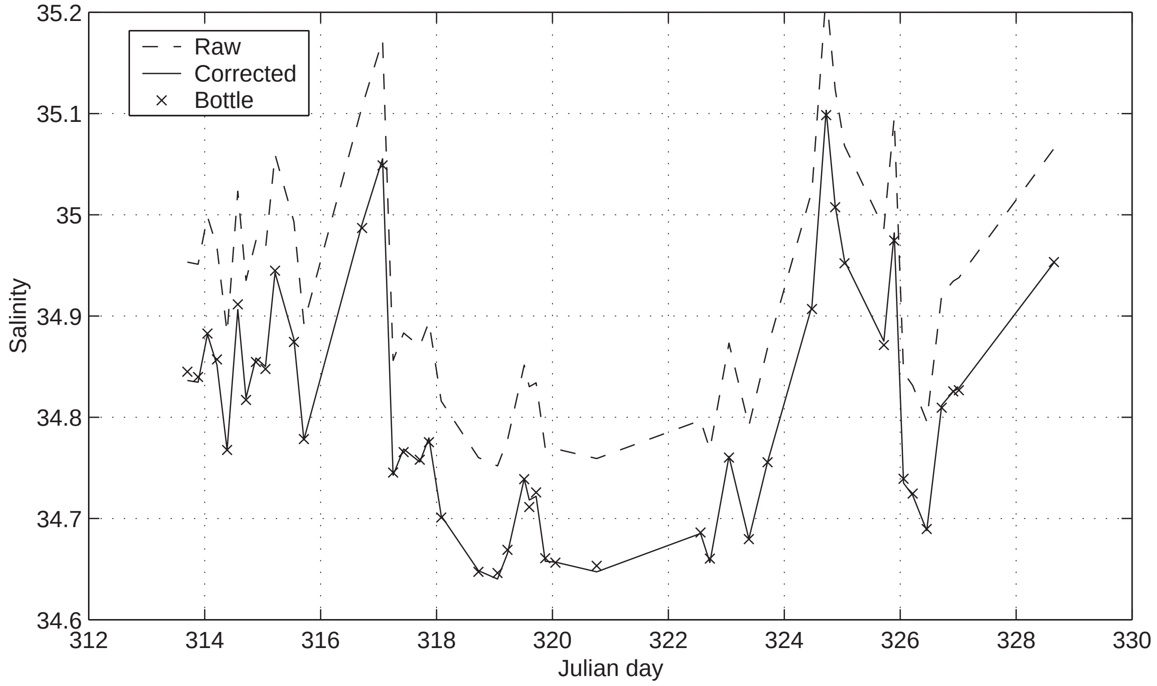


Fig. 21. Spatial plots of a) underway sea surface salinity and b) temperature from the ship's thermosalinograph, and c) underway absolute wind speed measurements from the ship's anemometer. (Text section 9.1.2).

(a) TSG salinities for Discovery 258 Leg 1



(b) TSG salinities for Discovery 258 Leg 2

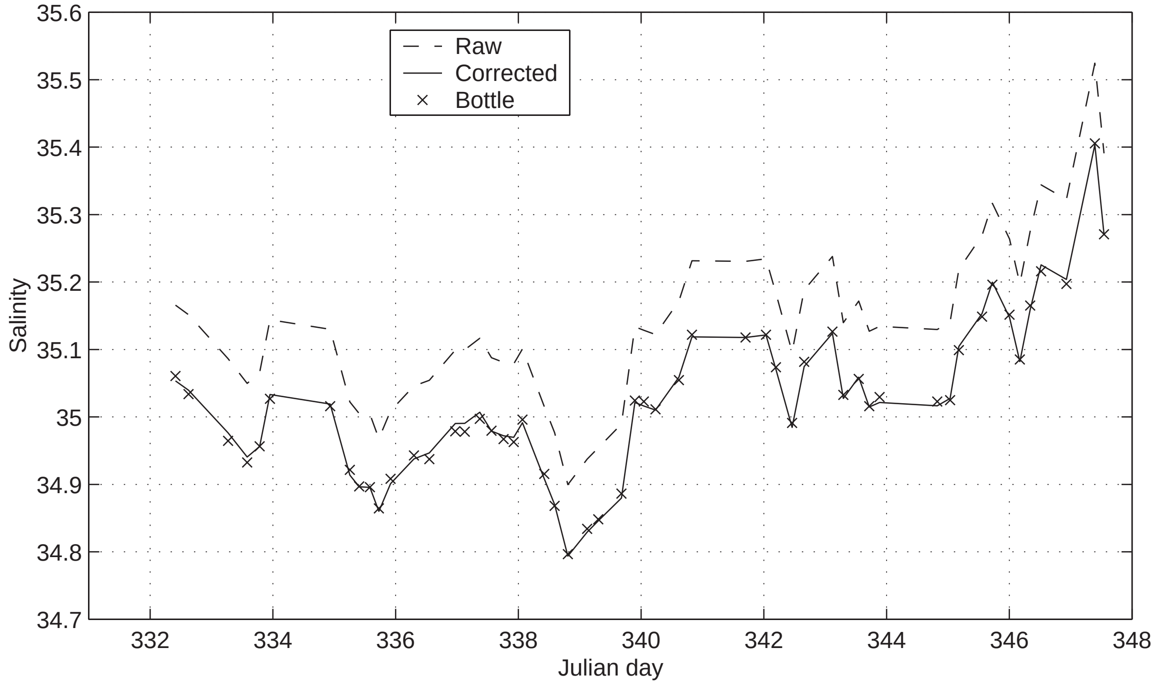
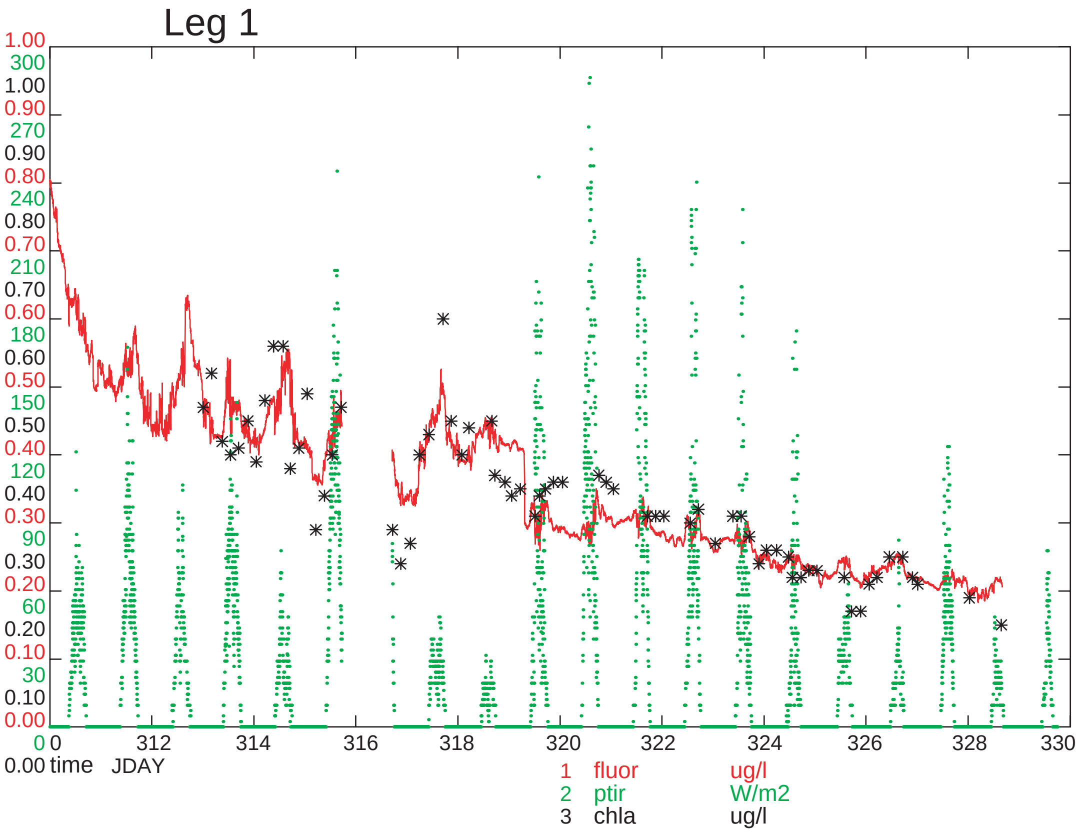


Fig. 22. Calibration of thermosalinograph (TSG) salinity, for leg 1 (upper graph) and leg 2 (lower graph). (Text section 9.1.3).



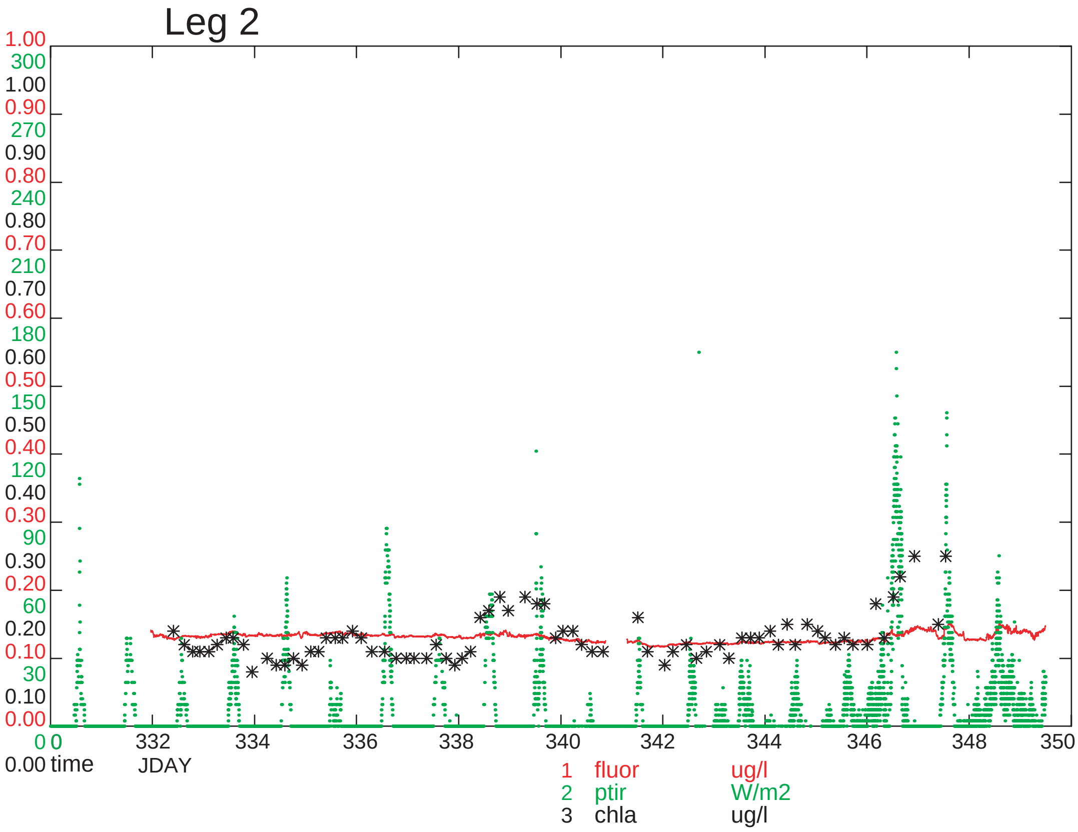


Fig. 23. Underway time series of total solar irradiance (ptir), surface fluorescence (fluor), and chlorophyll concentration measured on samples collected from the ship's non-toxic water supply (chla). Leg 1 (upper graph) and leg 2 (lower graph). (Text section 9.1.3).

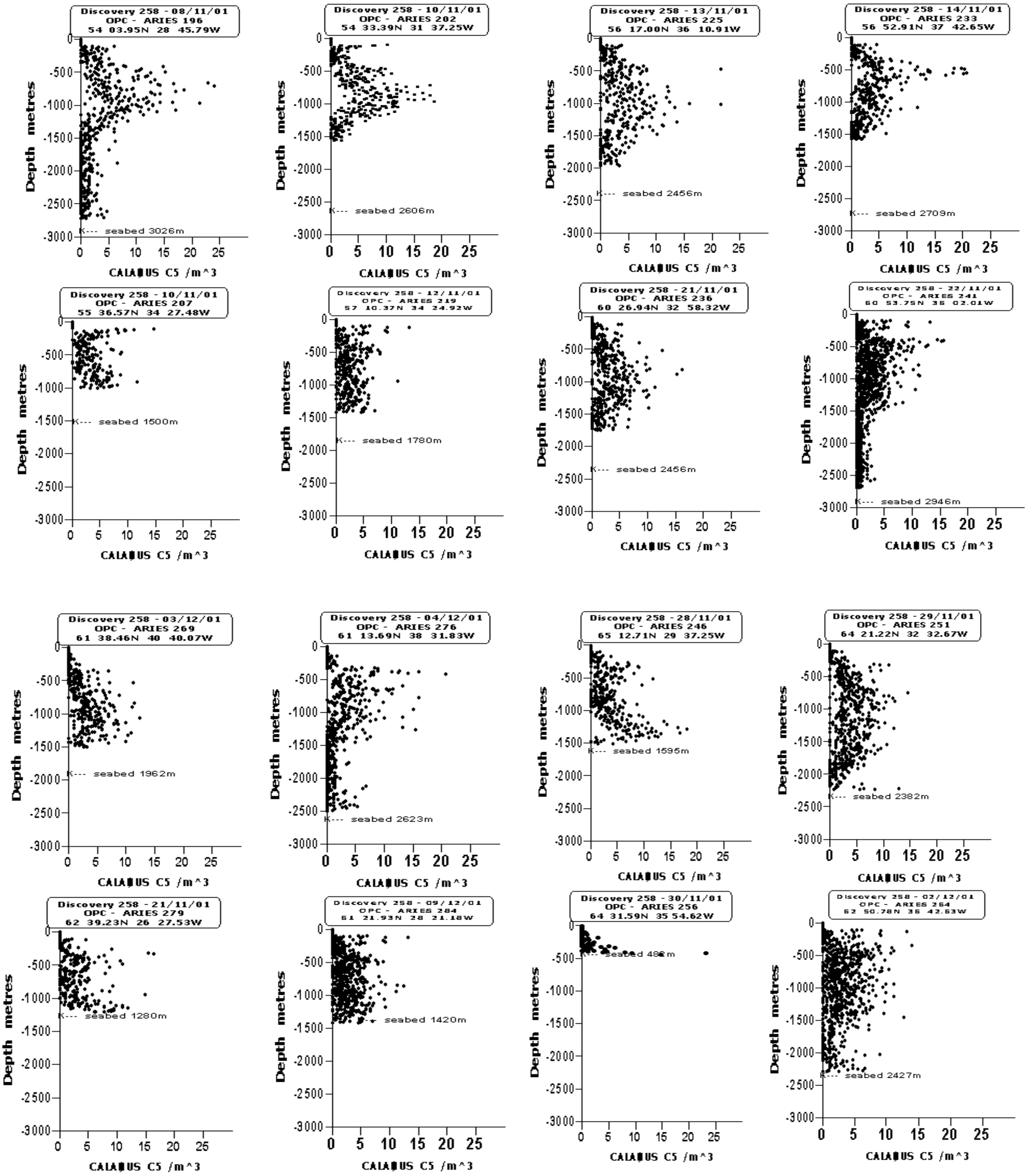
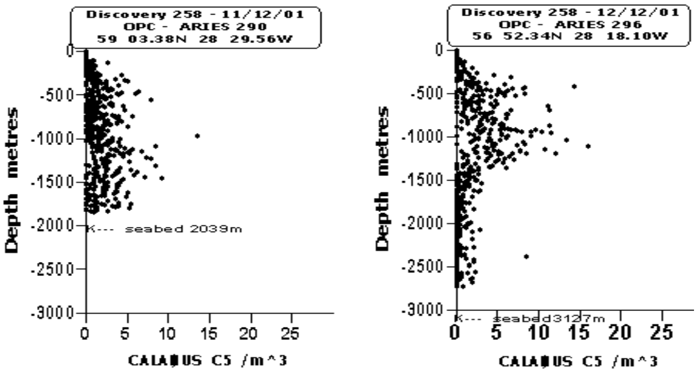


Fig. 24. OPC (Optical Plankton Counter) estimates of *Calanus*-sized particles as a function of depth, from *Discovery* 258 ARIES data (calibration subject to confirmation). (Text section 10.3).



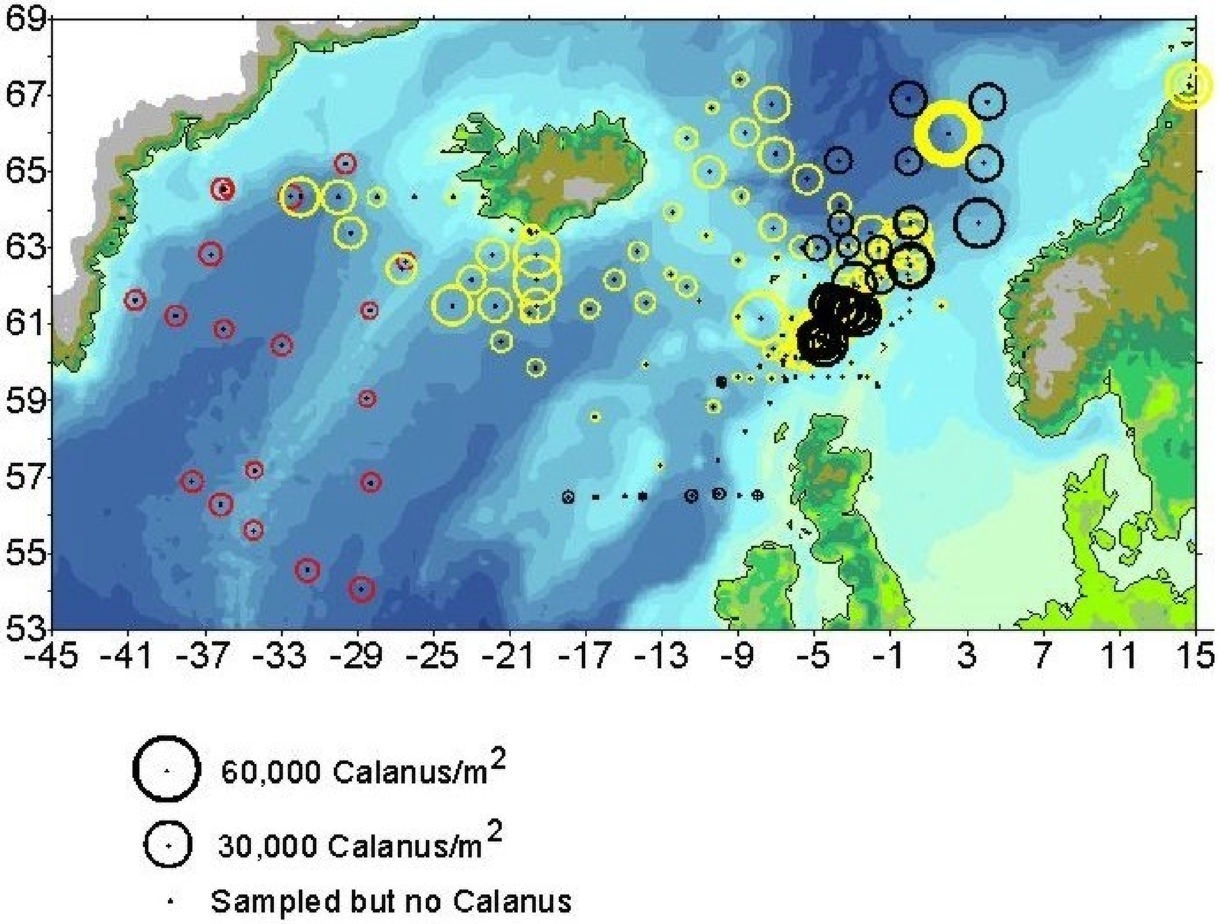


Fig. 25. Winter abundance of *Calanus finmarchicus* stages C4 and C5 in the eastern North Atlantic. Combined data 1991-2001, from ICOS, TASC and other net samples (yellow circles), FRS Marine Laboratory Aberdeen (black circles, calibrated OPC), and *Discovery* 258 (red circles, preliminary OPC data). Note that definitive MarProd data will not be available until summer 2002, after samples have been sorted and actual counts made. (Text section 10.3).

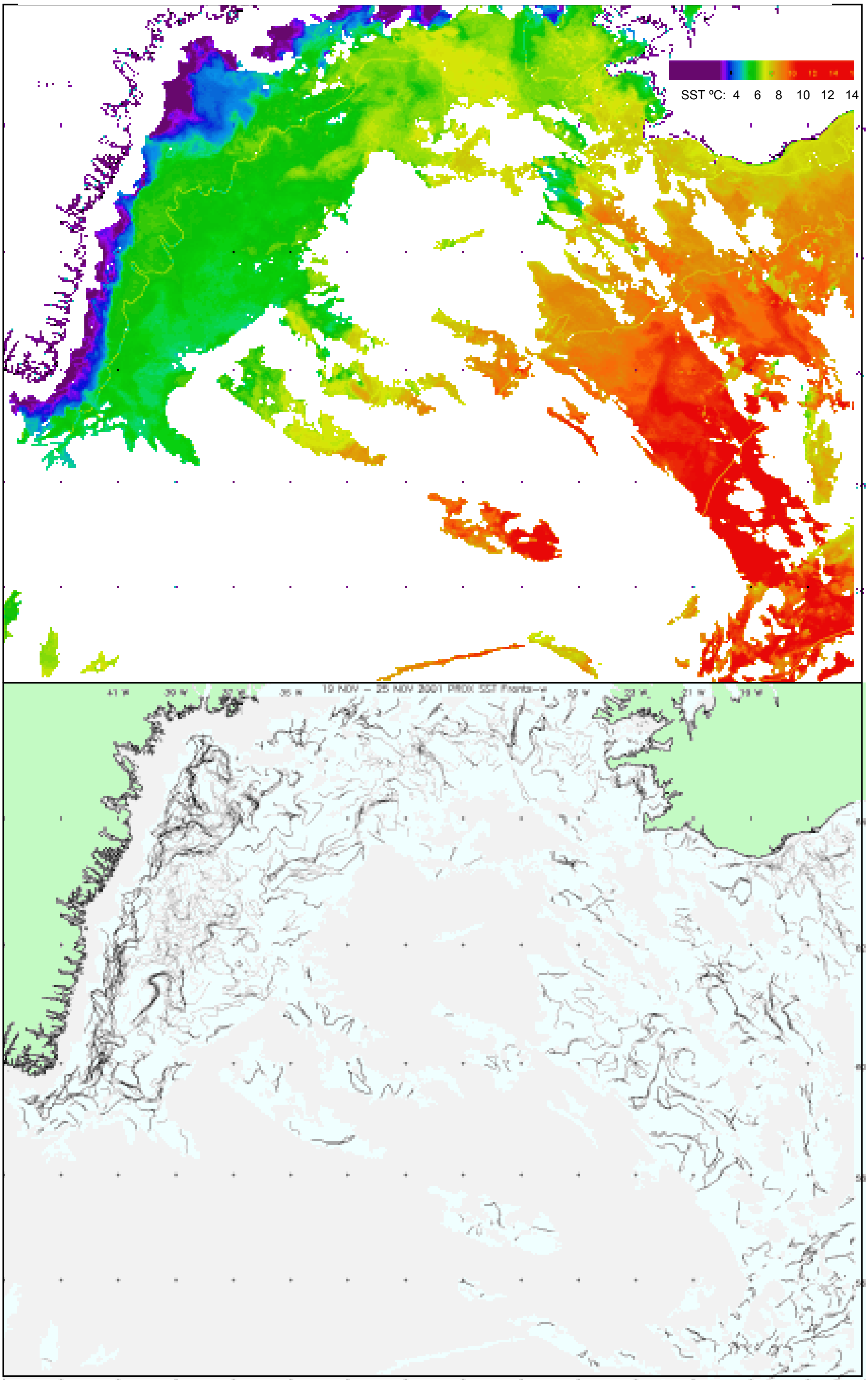


Fig. 26. Sea surface temperature composite image for 19-25 November 2001 (upper) with associated analysis of frontal features (lower). (Text section 13).

Fig. 27. Examples of the photographic record of the cruise: ARIES recovery (above) and zooplankton sorting (right). (Text section 14).