BAS Marine Life Sciences - Cruise JR17

Briefing documents for pre-cruise meeting 9 August 1996

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60/39/3211
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BAS Marine Life Sciences - Cruise JR17

INTRODUCTION

MLSD Cruise JR17 is the second in the Core Programme, a five year series of repeat cruises which is focussed on year-to-year variability around South Georgia. Because of the need to have data which enable comparisons between different cruises, the design is standardised and, with a very few minor differences, the Core Programme is identical to the early part of Leg 1 of Cruise JR11 (January-February 1996).

SCHEDULE AND ACTIVITIES

A **draft** schedule for the cruise activities is attached to this document. The major components are discussed in the following section of this background document:

Mobilization

On the basis of arrival in Stanley on 10 December, I have allowed one and a half days alongside at Fipass for unpacking and installing gear. This is shorter than the provisional itinerary which has the vessel sailing on the 13th, but I believe that this time should be adequate given the fact that we will not need to be using much of the equipment until late on the 16th. I assume that the period from the vessel's arrival in Stanley on 8th will be adequate for any maintenance and shore-leave.

The only activity which is planned for the cruise which is not a formal part of the Core Programme is further testing of the undulator and acoustic transducer tow-fish. Forty-eight hours have been added to passage time to the study site to allow for this. Clearly, the sailing time must be dependent on these two items of gear being installed and operational. For this purpose, the starboard PES fish and its cable will need to be removed to make way for the MLSD transducer fish, and the undulator winch and block will need to be installed on the after deck.

A 'shakedown' CTD cast is planned for a suitable time and location in deep water,approximately one day prior to the start of the transect.

Maurice Ewing Bank Transect

The oceanographic transect from north of the Maurice Ewing Bank duplicates that in JR11 (except the weather, I hope). There are 22 hydrographic stations, each separated by 35 km transects (see attached map from JR11). The transect legs will be steamed at 10 knots, and will pass through the way point at either end. The undulator will not be deployed routinely, but we hope to use it to profile through the Polar Front at around station 12.

Equipment in use on the stations will be the CTD-rosette, vertical haul net (ZNET) and a small,

self-contained instrument package (Aquapak) which will be used on one of the small winches on the midships gantry to profile over the top 200 m. At five of the stations, additional net hauls and CTD casts are timetabled.

Observations of birds and seals will be made during parts of this transect and later in the cruise. This will mean having at least two members of the science group on the bridge.

Navigation data for the MEB transect from JR11 should already be saved in the VMS.

Acoustic survey boxes

The two acoustic survey boxes are essentially identical in location to the JR11 studies - one is located at the eastern end of the island, east of Cumberland Bay, whilst the second is north of Bird Island. Although the activities are identical, there have been changes in timetabling to enable us to undertake net hauls during daylight. Each box contains 5 pairs of 80 km transects, with associated net hauls and hydrographic stations carried out mainly at night.

Daytime activities will comprise a transect pair plus a haul with the redesigned multinet to characterise acoustic targets. Daytime fishing is a new approach, which offers specific advantages in relating the net haul and target data, but does involve a more flexible timetable. In particular, if net sampling in the middle of the transect is required, then the second transect will have to be completed in its entirety later. In order to accommodate this, the morning start of the transect pair has been brought forward to 0500 so that the transects are completed in daylight. Transects are steamed at 10 knots, passing through the waypoint at either end. If the two transects are to be steamed consecutively, the undulator will be left in the water for the turn, whereas if fishing is planned along the second the undulator will be recovered and passage to the fishing site carried out at 12 knots.

Night-time activities will be centred on two hydrographic stations, one on the shelf region of the transect and one at the oceanic end. Multinet tows will be carried out at some of these stations, and the foredeck net (FNET) will be deployed at the same time.

Navigation data for the boxes available on the VMS will not be used for JR17, because we intend to use a new randomised survey design for each cruise. The transect pairs start alternately nearshore and offshore, and both boxes will be worked from west to east.

Acoustic calibration

If time allows, we plan to carry out three calibrations in Stromness - one before the first (eastern) acoustic survey box, one after the second (western) box, and a third between the two.

Under favourable circumstances, we believe that each calibration can be carried out in twelve hours. The ship will need to be anchored and attached to the mooring buoy as in previous years.

Return to Stanley and demobilization

If time allows, we plan to return to Stanley along the Scotia Ridge as far as Shag Rocks Passage, using XBT deployments to build up a temperature section. A few CTD profiles between South Georgia and Shag Rocks would be included if possible.

I have included a visit to Mare Harbour to refuel on the return leg. On this basis, equipment packing should be more or less completed on arrival at Fipass, and I consider that a day to pack containers should be adequate.

EQUIPMENT

Nearly all of the equipment in use on Cruise JR17 will have been in use at least once before. The only new pieces of gear are a rebuilt multinet, and the Aquapak.

Undulator
The winch, block and the towed body have been refurbished, hopefully correcting the defects apparent during JR11.
CTD-rosette
No new requirements
Aquapak
This is a small self-contained instrument package which will be lowered on a wire from the midships gantry.
Vertical 'bongo' net
This will again be deployed from the midships gantry. It has had minor modification from JR11, but this makes no difference to its operation.
Multinet
Following the demise of the previous net, this has been re-built as a smaller and more rugged system. Deployment details should be identical to the previous net.
RMT 8
This will be carried as a back-up for the multinet only.
Foredeck net
No modifications
Transducer towfish
Deployment of the towfish during the cruise will depend on the results of trials at the start of JR17.

PERSONNEL

A list of personnel is attached. The majority of the group comes from BAS. At present, the group is small enough to obviate the need to share cabins, and this will also ease the pressure on the catering.

Round the clock working will be needed. About half of the group will require meals at night. At a first estimate, there are about eight vegetarians in the group as a whole.

Accommodation on ship will be problematic on return to Stanley with the exchange of ship's personnel as well as the incoming Geophysics group.

BRITISH ANTARCTIC SURVEY - MARINE LIFE SCIENCES DIVISION

Cruise JR17 - Core Programme 2

First Report: Maurice Ewing Bank Transect

This report describes the results obtained on the large-scale transect running from the northwest towards South Georgia and crossing the Maurice Ewing Bank. This transect forms a major component of the MLSD *Core Programme*, and is designed to provide a description of environmental and biological variability in the area adjacent to South Georgia.

The science group joined the ship in Stanley on 10 December, after a mercifully uneventful flight down from the UK. Unpacking and installing gear was undertaken rapidly, allowing us to leave on the afternoon of the 12th. Almost as soon as we left, we carried out a calibration of the ADCP, and commenced an XBT section up to the head of the Maurice Ewing Bank (MEB) transect. Whilst en route to the transect, we carried out trials of the undulator and acoustic towfish. It was particularly pleasing to find that problems encountered with the undulator on the last cruise (JR11) appeared to have been solved for the most part. We carried out a 'shakedown' CTD cast and a deployment of the new Aquapack sensor package, and again all appeared to work successfully. In order to carry out further trials with the undulator before starting the MEB transect, we steamed from the first waypoint on the reciprocal bearing, deploying further XBTs on the northwesterly leg and then towing the undulator on the return. This effectively added a distance equivalent to five extra stations to the length of the transect.

We started work on the MEB transect at the first station at 2100 (local) on 15 December. Weather was calm, and we were able to watch a varied assortment of animals attracted to the surface by the ship's lights - a wide range of fish, squid (probably *Martialia*) and dense swarms of the amphipod *Themisto*. Work on the transect began to intensify as we approached the bank, where shallow stations meant very short intervals between samples. The work was helped by calm weather, and often brilliant sunshine. On 18 December we reached the southern flank of the MEB, where we expected to find the Polar Front and had planned an undulator section. The location was correct, and coincided with the unfortunately labelled Station 13. During JR11, we had run into bad weather and had spent a day hove to at this point, and had had to abandon the undulator tow. On this occasion, the weather was good, but we had a series of equipment problems which compromized the study. Most serious was a fault with the undulator, but this was traced to a loose screw jamming the alternator, and the unit was repaired in time for an abbreviated survey after the next station. The undulator survey was carried out under deteriorating weather conditions, but was completed successfully on arrival at Station 15. We then continued on schedule, and completed the MEB transect at 0230 on 20 December. Despite some equipment problems, and the failure to deploy some gear during the one period of bad weather, the transect can be considered a total success, as the results presented below demonstrate.

After the MEB transect, we carried out a second ADCP calibration and then further trials with the acoustic towfish en route to Stromness. Prior to arrival, we also undertook a further run with the undulator, to test new software provided by the manufacturers. We moored to the Stromness buoy at 1600 on 21 December, and started the calibration of the hull-mounted echosounders that night, continuing on until the afternoon of the following day.

The results presented in this report are all preliminary, and given the fairly frantic schedule there has been little opportunity for exhaustive analysis of data at this stage. No part of the report is attributed to individuals, and all have worked with equal effort to make the first part of the cruise go so well. Support from all departments on the ship has been superb.

Physical oceanography

CTD and XBT data. Temperature and salinity data were obtained at all twenty-two stations along the MEB transect using the CTD. XBTs were deployed half-way along each inter-station transect leg, and the MEB transect had also been extended northwestwards by and XBT and undulator section.

The northwards extension of the transect showed interesting structure. A core of cooler water was observed, sandwiched between warmer Subantarctic Zone (SAZ) water (Fig. 1). This SAZ water was closer to the northern edge of the Maurice Ewing Bank than had been observed during cruise JR11 in January 1996 (Fig. 2a). Then the northern flank of the bank had been marked by a cold core which appeared to be a retroflection of Polar Frontal water from the main eastwards flow at the eastern end of the bank. This core was not detected during the present cruise, but temperatures in the upper 300 m tended to be colder than on JR11, with a very strong surface temperature gradient marking the northern edge of the MEB.

The Polar Front (PF) was encountered at the southern side of the MEB, in the same location as on cruises JR06 and JR11. South of this, the character of the sections in JR11 and JR17 were similar, although surface water temperatures were about 0.5 K cooler on this cruise (Fig. 2).

All CTD data have been calibrated, and a validated dataset is already available. This represents a considerable advance on previous cruises.

Data from the undulator. Immediately prior to the occupation of the MEB transect a deployment was made of the Chelsea Instruments NvShuttle undulator. The deployment (cruise event 039, transect T02) was made in a north-south direction from 46°30′S, 44°18′W to 48°00′S, 43°17′ W, and covered a distance of almost 220 km. During the tow, undulations covered the surface waters between 14 m and 135 m, with each undulation lasting approximately 6 minutes and covering a distance of 2.2 km.

Fig. 1. Temperature section for the MEB transect, based on XBT data and including the additional transect run to the northwest of Station 1 (left hand side of the figure). Large tick marks on the distance axis denote latitude (at 30' intervals), whilst the shorter ticks are XBT positions. [file xbt_ps.gz]

Fig. 2. Potential temperature sections for the MEB transect derived from CTD data for: A, January 1996 (cruise JR11), and B, December 1996 (cruise JR17). Note that these sections do not extend as far to the northwest as does the XBT section in Fig. 1. Short tick marks on the distance axis are station positions. [file comp_ps.gz]

Fig. 3. Undulator sections along the northwest extension of the MEB transect. A, temperature (compare with XBT data in Fig. 1); B, salinity, and C, potential density. [file t02_pst.gz]

Fig. 4. Undulator sections on the MEB transect in the region of the Polar Front. A, temperature; B, salinity, and C, potential density. [file t19_pst.gz]

At the northern end of the tow, warm saline water with a strong SAZ character was sampled. Just south of this, at approximately 47°00′S a strong temperature and salinity gradient marked the Subantarctic Front (SAF) (Fig. 3). At this point surface temperatures fell by more than 2.5°C over a distance of 12 km, while salinities decreasing by approximately 0.5 psu over a similar distance. Further south, at about 48°00′S an isolated packet of warm, saline water coincided with the beginning of the MEB transect. This feature had a similar character to the water sampled north of the SAF; it was also sampled later on by the northern casts of the CTD section.

Midway along the MEB transect a second deployment of the NvShuttle was made. The deployment covered a distance of approximately 95 km in a north-south direction, with undulations of similar pattern to those describd above. This deployment (cruise event 121, transect T19) crossed the Polar Front, previously identified from the CTD section. The PF occurred at approximately 51°20′S. As expected the PF showed strong gradients, with higher surface temperatures in the Polar Frontal Zone (PFZ - above 4.5°C) and cooler temperatures in the Antarctic Zone (AAZ - less than 3.0°C) (Fig. 4). In addition in the AAZ, the temperature minimum associated with Antarctic Surface Waters was apparent at about 120 m depth, with temperatures of about 0.5°C. A clear difference in salinity was also apparent, with surface water in the AAZ being fresher.

Nutrient chemistry and phytoplankton biomass

Samples for nutrient chemistry and chlorophyll *a* were taken from all CTD-rosette casts along the MEB transect. In addition, *in vivo* chlorophyll fluorescence was sampled continuously from the ship's non-toxic seaawater supply, and surface water samples for nutrient chemistry and extracted chlorophyll were taken to coincide with the XBT deployments midway between stations.

Nutrient chemistry data await analysis in the UK. Decreased nutrient concentrations south of the Polar Front coincided with increased phytoplankton biomass, although the very high levels of chlorophyll concentration at some stations between the PF and South Georgia suggest that nutrient depletion should have been greater than was observed. Explanation may be sought in major systematic changes in C:chl ratio, but this will need further study. Certainly, the biomass of phytoplankton was higher overall south of the PF than was observed on cruise JR11 in January 1996, suggesting that grazing pressure is probably lower at present. This is consistent with preliminary acoustic observations (see below).

The Aquapack sensor package has been deployed at most stations along the MEB transect, and looks likely to produce greatly improved capacity for producing vertical profiles of chlorophyll biomass. Data analysis will be based on the algorithms already developed for the underway *in vivo* fluorescence, by modelling the effects of light on fluorescence yield. The same technique can then be extended to calibrate data from similar sensors on the undulator.

Zooplankton studies

The MEB transect provided some interesting contrasts in zooplankton species composition during this cruise, reflecting the major changes in physical structure found along its length. At the first five stations located within the cell of warm water *Calanus tonsus/australis* and to a much lesser extent *Calanus simillimus* dominated the population. Between stations 5 and 6 the surface temperature dropped by approximately 3°C, the former species disappeared completely and the population was then dominated for a short period by *C. simillimus* and *Rhincalanus gigas*. A Polar Frontal Zone community was then apparent until near the PF when *Calanoides acutus* appeared in low numbers and *R. gigas* was dominant. Up to this point all species apart from *C. simillimus* were largely represented by overwintering stages. From station 9 onwards quantities of the diatom *Thallasiothrix* and the colonial prymnesiophyte *Phaeocystis* appeared in the nets, although the population response to this increase in food was not marked. South of the Polar Front the fauna became increasingly more Antarctic in character and changes in phytoplankton composition occurred, *Thalassiothrix* giving way to *Corethron* and other species until at the last station over the South Georgia shelf much smaller diatoms were present. Ripe females and young copepodite stages representing the summer generation of the dominant species, *R. gigas* and *C. acutus*, were present at the majority of these southernmost stations.

As part of a study to look at the influence of zooplankton on nutrient flux, preliminary data have been gathered for two of the major copepod species present (*Rhincalanus gigas* and *Calanoides acutus*). Copepods taken from bongo net tows were incubated in whole sea-water for 12 hours and their faecal pellets collected and put onto filters for later analysis of silica content. As expected, faecal pellet production appears to vary with food availability, with production rates ranging from 0.1 - 3 pellets per individual over 12 hours.

Carotenoid and chloropigment analysis was undertaken on particulate matter in seawater from bottles cast to 30 m and 200 m at Stations 1, 5,11,19, 22 and from non-toxic inlet at stations 14 and 16. All samples were partitioned at 0.7 and 20 µm on glass fibre and nylon membranes respectively. There was very little material in the water column at Station 1 but amounts increased steadily to Station 19. Generally, there was little material at 200 m for all stations - consequently some analyses were unviable.

The composition of the algal community can be summarised from the pigment profiles:
Station 1 - Prymnesiophyte signal from both depths - very little material and none above 20 µm.
Station 5 - Strong Prymnesiophyte signal in 0.7 µm fraction and lesser signal from diatoms in 20 µm fraction. No material at 200 m.
Station 9- Strong Prymnesiophyte signal in 0.7 µm fraction with some chrysophytes and dinoflagellates. Large diatom colonies in 20 µm fraction (*Thalassiosithrix*).
Station 11 - Strong Prymnesiophyte signal with some diatoms in 0.7 µm fraction, and all diatoms in 20 µm fraction. All material from both size fractions at 200 m was diatom-derived.

Station 14 - *Corethron* 'bloom' (see above). Diatoms dominating both size fractions in surface water.
Station 16 - Diatoms dominating both size fractions in surface water.
Station 19 - Diatoms dominating both size fractions at 30 m. Material at 200 m mostly small diatoms and a signal for Cryptomonads in 0.7 μm fraction at 200 m.
Station 22 - Mixture of diatoms, Chrysophytes, Prymnesiophytes and some Cryptomonads at 30 m. Similar signal at 150 m but very little material.

Phaeopigment analysis was used to follow the effects of grazing. Diatoms were grazed heavily at Stations 14, 16 and 19, resulting in a strong phaeophorbide signal in the surface water. This was probably attributable to copepod faecal pellets remaining suspended in the upper water column - as opposed to krill faeces which would drop out relatively rapidly. There were also traces of phaeophorbides and phaeophytin at Stations 5 and 11 in the 0.7 μm fraction and phaeophorbides at stations 11, 22 in the 20 μm fraction at 30 m but not at 200 m. This again suggests grazing by copepods rather than by krill or other larger zooplankton.

Acoustic observations

The standard acoustic settings used for deep water on cruise JR11 have again been used while steaming the Maurice Ewing Bank transect. Good acoustic conditions prevailed for much of the transect and it has been possible to observe the characteristic deep scattering layers at around depths of 300 and 600-700 m. Changes in the depth of these layers have been observed due to nocturnal upward migration and also due to interactions of watermasses within the frontal regions. While most of the scattering layers appear to be diffuse, we have observed occasional strong but small targets within the layers.

During cruise JR11, in a season of good krill abundance, we observed surface krill swarms on a number of occasions as we traversed the transect. This year, no obvious patches were noted and a daily inspection of the filters on the pumped seawater intakes produced only one or two krill a day at the southern end of the transect. First signs, therefore, would indicate that there was less krill this season than last.

Higher predator studies

The objective along the MEB transect has been to examine the determinants of the at-sea distribution of seabirds and other predators. Higher predator observations had not been included in the first Core programme cruise (JR11). Species identities, numbers and behaviours of predators (seabirds, seals and whales) were recorded by a pair of observers during nine transects along the MEB line. One observer continuously scanned a 100 metre square "box" projected 100 m directly in front of the ship. When a predator was sighted, data were entered directly to a portable computer. This methodology gave each record a time-stamp so that observations will later be able to be linked to other environmental parameters

being logged (e.g., acoustics, water chemistry, chlorophyll, etc.) Duties switched at half-hour intervals to avoid observer fatigue.

As part of an ongoing research study investigating olfactory cues used by seabirds to locate krill, we carried out an experiment to test birds' ability to detect 2-methyl pyrazine, which is a primary aromatic derived from krill. At nine locations we presented birds with vegetable oil slicks which were either unscented (control), krill-scented or scented with herring oil, a known olfactory attractant to procellariiforms. We will examine the relative attractiveness of these slicks by comparison of total numbers of birds attracted, onset of responses and behavioural retention.

Our initial examination of distribution data for three seabird species (Fig. 5) indicates that Great Shearwater *Puffinus gravis* is primarily associated with warm water to the north of the Polar Front. This was in marked contrast to the Wilson's storm-petrel *Oceanites oceanicus,* the abundance of which increased in colder water south of the APF. The Wandering Albatross *Diomedea exulans*, a species known to have a very large (e.g., thousands of miles) foraging range, occurred equally frequently in both water masses. Interestingly, at one station close to the PF (Station 13) , three Wandering Albatrosses from the Bird Island study population were recorded resting on the water near to the ship.

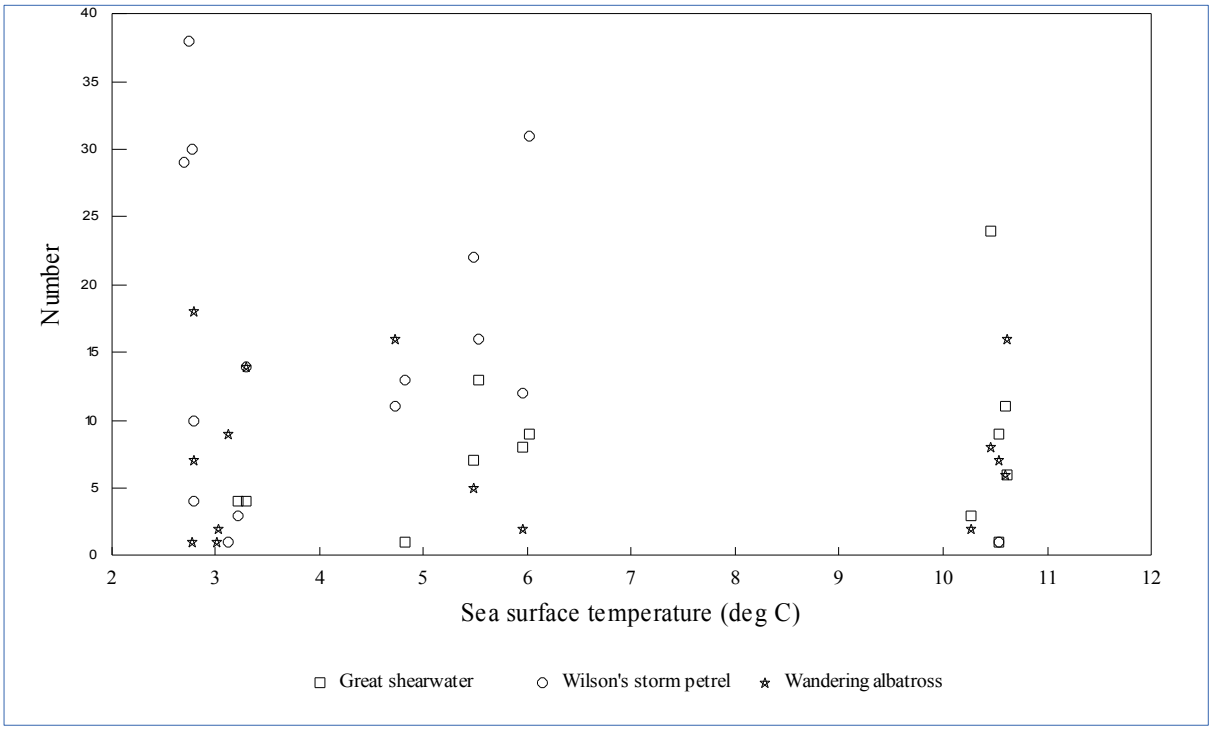

Fig. 5. The relationship between sea surface temperature and distribution of three species of procellariiform seabirds along the Maurice Ewing Bank transect of JR17.

BRITISH ANTARCTIC SURVEY - MARINE LIFE SCIENCES DIVISION

Cruise JR17 - Core Programme 2

Second Report: Acoustic Box Surveys

This report describes the preliminary results from the two acoustic box surveys which, together with the large scale hydrographic transect across the Maurice Ewing Bank, form the MLSD *Core Programme*. Each survey comprises five pairs of transects, running across the shelf break, and associated night-time station work. Cruise JR17 was the second in the *Core Programme* series, and the first execution of the surveys in January 1996 (cruise JR11) had been beset both by bad weather and equipment problems. The present cruise provided the opportunity to carry out the surveys in their entirety to the original design, and this was accomplished.

After the MEB transect, the ship had moored in Stromness for the first of three calibrations of the scientific echosounders. The ship departed in the evening of 22 December, and headed for the western offshore corner of the Eastern Survey Box (Fig. 1). Various net deployments and trials were accomplished en route. On the following morning, we started the first transect pair at 0500. Each transect pair consists of two 80 km runs with the undulator, with collection of underway acoustic and other datasets. Because the transects went over the same tracks as the previous cruise, bathymetric data for each were available and allowed precise control of the undulator altitude with respect to the seabed. Further transect pairs were carried out on the succeeding days. Problems with the multinet meant that we had to fall back on the RMT for target- and station-fishing. Weather conditions were generally very good, and the night-shift were treated to some spectacular sunsets over the eastern end of South Georgia. Christmas Day was spent at sea, with people making the best they could of the occasion whilst keeping the work running. Although the weather threatened to intervene two or three times, it never had any serious effect on the programme, and the Eastern Survey Box was completed on the afternoon of 27 December. We then undertook a deep-water CTD cast, and also made a second cast with heavy weights on the end of the cable in an attempt to rectify twisting. Following this work, we steamed on an acoustic transect running diagonally across the survey box, and fished the RMT once. We arrived at Stromness for the second acoustic calibration in the morning of 28 December, leaving the same evening.

We steamed for the western end of the Western Survey Box, again arriving for a 0500 start. Along the northwestern coast of South Georgia, we encountered very dense algal blooms. Bad weather on the first night curtailed activities slightly, but we were back in business the following day. Net hauls on

Fig. 1. Track plots for the two survey boxes [following page]

succeeding nights brought a variety of species, including good quantities of fish, mysids and cephalopods, in addition to krill. A call into Bird Island planned for 31 December, at the end of the third transect pair, had to be abandoned due to bad weather. The undulator suffered some damage during these transects, and a conductor in the cable was severed just before the finish of the transect. The Bird Island call was carried out successfully on New Year's Day in much calmer weather. Although this was carried out quickly and efficiently, time was lost from the following night-time fishing. The weather deteriorated once again overnight, however conditions ameliorated and the undulator was deployed for the final transect pair on 2 January. A small amount of excitement on the first transect was provided by a squid jigger, whose lights we had seen on the previous night, 'parking' about ten miles along the track. A minor detour was made. On completeion of the final pair of transects, we had achieved our goal of using the undulator on every one of the twenty acoustic transects in the two survey boxes, a vast imporvement on our first attempt in cruise JR11.

The ship then called into Grytviken before mooring at Stromness in the evening of 2 January for the final acoustic calibration. We departed in the afternoon of 3 January, and carried out a further brief trial with the undulator before undertaking an XBT section along the northern Scotia Ridge before heading directly for Stanley.

Description of the survey boxes - undulator data

In each of the two Core Boxes, all transects were surveyed with the Chelsea Instruments NvShuttle. Of the 20 transects, all were completed apart from approximately 7.5 km on the inshore end of transect W.3.2 in the Western Box. This small section was lost as a result of an unplanned recoverey of the NvShuttle following a sudden and complete loss of communications due to a cable failure caused by mechanical damage. All transects were surveyed with undulations that covered the surface waters between 14 m and 135 m, with each undulation lasting approximately 6 minutes and covering a distance of 2.2 km. Where water depth was restricted by bathymetry, undulations were carried out so that a conservative bottom clearance (75 m) was achieved (Fig. 2). This clearance was judged necessary due to the rugged bathymetry in the region.

In the Eastern Core Box the surface waters were warmer onshore than offshore, with temperatures more than 2.5°C at the surface onshelf and below 2.0°C offshelf. Over the shelf the water was much also much fresher, with salinity values less than 33.85 psu compared to offshore values of approximately 33.90 psu. On transect E.3.1 off Calf Head near St. Andrews Bay, very fresh water was encountered with salinity values of less than 33.70 psu. In contrast in the Western Core Box water was generally warmer offshelf than onshelf, with temperatures of more than 3.0°C off shelf and less than 3.0°C onshelf (Fig. 3). However, surface salinity in the Western Core Box followed a similar pattern to that found in the Eastern Box, with fresher water (33.80 psu) over the shelf and more saline water off shore (33.90 psu).

Fig. 2. Trajectory for the NvShuttle undulator along transect W.3.1 (first transect of the third pair in the Western Core Box).

Fig. 3. Temperature, salinity and potential density sections along the same transect.

Fig. 4. In vivo chlorophyll fluorescence, downwelling photosynthetically active radiation (PAR) and raw transmissometer data for the same transect. The chlorophyll fluorescence is uncalibrated, and has not been corrected for light quenching. The transmissometer provides a measure of particle concentration in the water, and the broad resemblance between the distribution of chlorophyll, itself a measure of phytoplankton abundance, and particle concentration is clear.

Fig. 5. Data from the optical plankton counter (OPC) along the same transect. The data are presented for three size bins. It is possible that some of the particles in the smallest bin (< 0.5 mm) are phytoplankton - compare with the previous figure.

In addition to temperature and conductivity sensors, the NvShuttle carries a fluorometer that enables a detailed description of the phytoplankton biomass distribution in the two Core Boxes to be made (Fig. 4). In the Eastern Core Box fluorescence values were low with maximum values always towards the inshore end of the transects. However, even over the shelf chlorophyll fluorescence values rarely exceeded 1.2 $\mu g\ l^{-1}$ and offshore remained very low at approximately 0.2 $\mu g\ l^{-1}$. In comparison in the Western Core Box fluorescence values were much higher, with values over 6.0 $\mu g\ l^{-1}$ over the shelf to the west of the Willis Islands and values of approximately 3.0 $\mu g\ l^{-1}$ at the northern end of all transects over deep water. These observations accord with data collected from the ship's pumped seawater supply, and from stations worked within the two survey areas. Intercalibration of the datasets will be undertaken in due course.

The NvShuttle also carries an optical plankton counter (OPC) which provides a description of the particles encountered by the undulator as it travels through the water (Fig. 5). Although the particles recorded by the OPC may include feacal pellets, phytoplankton cells and small zooplankton, the data provide a broad description of the biological activity in the area. The pattern revealed by the OPC was broadly similar to the pattern of fluorescence, with low particle counts in the Eeastern Core Box, and much higher counts in the west. In the Western Box particle counts were generally high over the entire length of the transect, but were higher over deep water offshelf.

Core-box acoustic surveys

The acoustic survey of the Eastern Core Box began at the offshore, western end of the grid on 23 December, immediately after a full echo sounder calibration. There is evidence that krill swarms are associated with major bathymetric features such as sea-mounts. Consequently, to prevent any genuine interannual abundance variation from being confounded with and possibly masked by the influence of otherwise varying bottom topography on krill distribution, the same transects surveyed during CP1 were again studied here (this conveyed the additional advantage of providing known bathymetry for the undulator to be flown over). Transects within the Eastern Box were surveyed sequentially from west to east, beginning each daily pair alternately on- and off-shelf, and the survey was completed without loss to bad weather. Krill swarms were detected periodically throughout the survey, most frequently towards the on-shelf ends of the transects.

The acoustic survey of the Western Core Box began on 29 December after the second calibration. The survey commenced on-shelf at the western end of the grid and, as with the eastern survey, daily transect pairs were begun alternately on- and off-shelf. Despite deteriorating weather on days 3 and 5, data were gathered successfully from each of the 10 planned transects within the Western Box, data being lost only from the end of transect 3.2 which was abruptly curtailed because of an undulator failure. Krill swarms were detected throughout the survey, notably in the vicinity of the continental shelf break.

A final series of echo sounder calibrations were conducted after completion of the western box, and a calibrated data set was produced in light of this. The AVS-based data editor (much modified by Patrick Craig) was then used to estimate biomasses for each core-box from the calibrated data set in a single step, without recourse to the complex, multi-staged data processing path required after CP1 (JR11). The total acoustic signal was partitioned into that attributable to krill, smaller zooplankton, and larger nekton on the basis of the difference in mean volume backscattering strength between the 38 and 120 kHz channels (δmvbs = mvbs 120 kHz - mvbs 38 kHz). Krill were defined as targets with a δmvbs difference between 2 and 12 dB, other zooplankton > 12 dB and nekton < 2 dB. The CP2 (JR17) krill biomass estimates indicate a greater abundance of krill than that detected 12 months earlier during CP1 (Table 1, Fig. 6). As in CP1, the krill biomass in the Eastern Box during CP2 was greater than that detected in the Western Box. The observation in the Western Box that the majority of acoustic targets were concentrated around the shelf-break corresponds well with the observations of increased numbers of krill predators in these regions.

Table 1. Estimates of krill biomass, with associated variance, for the two survey boxes in three different years. Note that the survey design in cruises JR11 and JR17 was identical, but that the survey undertaken during JR06 used a different transect pattern.

	Mean krill biomass per core box, g m^{-2} (variance)	
Cruise	West	East
JR06 (1994)	7.43 (1.33)	1.87 (0.14)
JR11 (1996)	26.48 (54.30)	40.57 (13.37)
JR17 (1997)	25.17 (18.44)	58.28 (56.31)

The AVS-based acoustic data editor has enabled all acoustic data from each of the core boxes to be formatted to provide biomass-by-position for use in collaboration with the higher predators study group for comparison with patterns of bird and seal distribution, and for further analysis using geostatistical techniques. The data are also available in a fully calibrated format for comparison with, for example, underway oceanographic data from the UOR.

During the cruise Paul Woodroffe was able to produce a preliminary programme to extract ping-by-ping data from our recorded data stream. This is a considerable achievement and, with further development, will provide the potential for high resolution analysis of our data, with applications in many aspects of our research.

Fig. 6. Comparison of krill biomass in the two survey areas for three years [following page]

Nutrient chemistry and phytoplankton biomass

Concentrations of nutrients (silicate, nitrate, nitrite, ammonium and phosphate) were logged continuously at 5 s intervals along the full length of most of the transects in the two survey boxes, and were also collected at other times when the vessel was underway. Additional data were obtained from CTD-rosette casts at night. There were relatively low ammonium concentrations in the surface water compared with those found during JR11, although pycnocline levels were still relatively high (>1.5 mmol m^{-3} in places). The "South Georgia Shelf Front" not as well defined by its nutrient signal in the Eastern Box as it was during JR11, and had no obviously high silicate levels (Weddell Sea influenced) in the NE corner of the box - at least not in the surface waters as there was on JR11 (there may be some at depth).

At the "South Georgia Shelf Front" in the Western Box, an abrupt change in concentrations was evident with on-shelf concentrations being far higher than those off-shelf. Indeed silicate levels were barely detectable in some areas. Off-shore nitrate and phosphate levels were also lower than those measured in the Western Box during JR11.

Raw fluorescence from the Turner through-flow fluorometer was processed by Pstar exec flocean0 and program pfiltr to give despiked and smoothed fluorescence data. Pstar exec flocean1 was used to subset the data corresponding to extracted chlorophyll samples. Fluorescence yield per mg chlorophyll extracted was calculated. As in previous years this showed a strong quenching effect with increasing PAR. An exponential model with four curves was fitted by maximum likelihood to the data from the South Georgia Core Boxes. This model has a common nonlinear parameter and separate linear parameters for on-shelf and off-shelf regions of each box. The model accounts for 74% of the variance in the data. Using this model adjustments were caclulated tostandardize the observed fluorescence data to notional “dark” values. These “dark” fluorescences were then used to recalculate the fluorescence yields.

Preliminary geostatistical analysis of the PAR-adjusted fluorescence yields shows strong spatial dependence of the variance of yield. This year there is some suggestion of more continuity in yield at small spatial scales than for JR11. There is also strong evidence for anisotropy with variance along shelf increasing to a plateau at a scale of about 60 km in the Eastern Box and about 50 km in the Western Box but variance in the across-shelf direction was unbounded in both boxes. The next step in the analysis is to model these variograms in order that kriging weights may be calculated and yields interpolated for all locations in the boxes.

The final step in estimation of chlorophyll will be to apply the PAR-adjustment model and the interpolated yields to calculate chlorophyll concentrations from the underway data. The same approach will be used to model and calibrate the data from the *in vivo* fluorometer on the undulator.

Zooplankton studies

In addition to collecting bongo net samples for community composition analysis, material was also used for experimental determinations of copepod moulting rates and egg production. Moulting rates of a range of copepodite stages of the biomass dominant copepods *Rhincalanus gigas* and *Calanoides acutus* were measured in both the Eastern (EB) and Western Core Boxes (WB). Comparisons were made between boxes and on and off shelf stations.

Moulting rate studies. Biomass of both species was generally lower in the Eastern Box which lacked the range of copepodite stages present in the western box where the majority of the copepod biomass was located offshelf. In the EB stage durations were generally much shorter on shelf. Durations of stages CI and CII *R. .gigas* were up to four times quicker on shelf than off, CIs having durations of 5 vs 21 days and CIIs 16 vs 53 days on- and off-shelf respectively. Stages CIII and CV were not observed moulting. Stage durations of CIV *C. acutus* on and off shelf were 14 and 30 days respectively.

In the WB a lack of younger copepodite stages on shelf precluded comparisons between rates on- and off-shelf. However, generally faster rates were measured off shelf in the WB than in the EB. *R.. gigas* stages CI and CIII gave 10 and 17 days duration respectively, stage CII gave a relatively long duration of 31 days and CIV and CV were again not observed to be moulting; *C. acutus* stages CII,CIII and CIV gave durations of 4,8 and 11 days respectively. All individuals from the moulting rate experiments have been preserved for dry weight and carbon analysis in the UK.

Egg production studies. To an extent egg production mirrored the patterns found in the above experiments. Although showing inter-station variability, production rates of both of the above species were higher in the WB. Onshelf/offshelf comparisons in production were made difficult in many cases by the scarcity of females at some stations but generally speaking in the EB the shelf was marginally more productive than offshore. Copepods appeared to be responding to the increased amounts of food in the WB, ripe females were present and egg production was considerably higher than in the EB. Of the three species examined *Calanus simillimus* had higher production rates (up to 41 eggs female $^{-1}$ day^{-1}) than either *C. acutus* (up to 37 eggs female $^{-1}$ day^{-1}) or *R. gigas* (up to 21 eggs female $^{-1}$ day^{-1}). Interestingly whilst at many stations egg production by the latter two species was apparently food limited this was not the case for *C. simillimus*, which, even in the EB, consistently produced eggs at vanishingly low chlorophyll concentrations perhaps indicating its ability to exploit other food resources.

Biochemical studies of grazing interactions. Carotenoid and chloropigment profiles were obtained for phytoplankton and from faecal material from captive krill fed by the ships non-toxic seawater supply. Phytoplankton were sampled by filtration at 0.7 and 20 µm from CTD casts to 30 and 200 m.In the Eastern Box phytoplankton at 30 m depth was dominated by the 0.7 - 20 µm size fraction

which was primarily a mixture of prymnesiophytes and small diatoms. Chrysophytes were also present on the first transect pair and a cryptomonad signal was observed on the second transect pair. The only evidence of grazing was on the second transect pair. Very little material was found at 200 m, but what was present was derived from small diatoms and prymnesiophytes.

In the Western Box at 30 m depth large diatoms (> 20 μm) were predominant at most stations and the small size fraction, 0.7 - 20 μm, comprised mainly small diatoms. Some prymnesiophytes and chrysophytes were present at all stations. Prymnesiophytes were most abundant in the smaller size fraction at the offshore station of the second transect pair. Except for the first transect there was a grazing signal from phaeopigments throughout the Western Box. This appeared to be related to the diatom population. As in the Eastern Box, very little material was found at 200 m and phaeopigments were only detected on the third transect pair.

The general absence of phaeopigments in material at 200 m suggests that there was substantial recycling of faecal material in the upper water column and grazing was mainly by copepods.

Krill caught by FNET at the beginning of the Western Box were kept in an aquarium constantly replenished by seawater flow from the non-toxic supply. Faecal pellets were collected regularly and analysed for carotenoids and phaeopigments. For both box studies the carotenoid profiles reflected those of the water column - there was no indication of selectivity by krill. Phaeopigments were generally only produced when diatoms were part of the diet. In the Eastern Box phaeopigments were largely absent in faecal pellets except for one station when there was an increased proportion of small diatoms. In the Western Box the highest levels of phaeopigments corresponded to the largest populations of diatoms.

Three sets of thirty krill were held in aquaria and fed on (a) large diatoms (> 20 μm), (b) small phytoplankton 0.7 - 20 μm and (c) nothing. The krill were frozen after 14 days for fatty acid analysis in the U.K.

Krill and macrozooplankton population structure in the core boxes

The net sampling strategy for the core boxes consisted of a series of 8 fixed stations per box plus a series of daytime net hauls targetted at dominant acoustic targets. A complex protocol was required to allow for responsive target fishing either at the shelf break or at the ends of the transects (depending on where targets were seen earlier in the day) without compromising the daytime acoustic and UOR transects.

Fig. 7. Length-frequency distributions for krill sampled in the two box surveys during JR17.

A total of 6 station hauls and 3 targetted net hauls were carried out during the Wastern Core Box and a total of 4 station hauls and 3 targetted net hauls were carried out in the Western Core Box. Surface tows using the FNET were undertaken with all the station hauls. Due to problems with the multinet, all but the first tow station hauls were undertaken with the RMT8. Subsamples from all net hauls were formalin preserved for archival storage in Cambridge. Identification and enumeration of each catch was also carried out during the cruise.

Over 1600 krill were analysed from 13 separate net hauls in the two boxes. In addition, some hauls krill samples from up to 3 nets were analysed. A krill length frequency distribution for each core box has been derived from a random sample of 100 krill from each haul (Fig. 7). The most notable feature of the plots is the large size difference between the East and West Core Boxes. The mean size of krill in West Core Box is approximately 10 mm larger than the mean size in the East Core Box. The dominant krill size in the East Core Box is about 39-40 mm, this is probably krill of age 2+ years and is linked with the strong 1+ year class seen last year on cruise JR11. In addition, there was evidence of new recruitment in the East Core Box with krill as small as 18 mm being found in the area. Large krill were not particularly abundant in the first hauls in the East Core Box, however, samples collected on 27 December from the middle of the box while on transist to Stromness contained large (40-50 mm) adults that were starting to become sexually mature.

Krill in the West Core Box were dominated by size classes around 45-50 mm. Many of the krill were sexually mature and krill ready to spawn were frequently detected. A much smaller proportion of the krill in the West Core Box were new recruits (1+) or had recruited into the population last year ie were now 2+ years. So where have these large krill come from? Krill of 45-50 mm length are likely to be at least 4 years old and so the implication is that the West Core Box contains krill that may have been spawned just prior to the relatively poor krill years around 1994 (JR06). Further light will be shed on this discussion once the population structure from other areas and other years is combined together back in Cambridge. However, at this stage such results demonstrate firstly the great benefits that are occurring from having annual sampling from the core boxes and secondly the importance of having selected two contrasting study areas along the north coast of South Georgia.

Higher predator observations

Thanks to remarkable weather, the predator team was able to collect an unprecedented amount of high quality data. Predator observations were completed on nine of the ten transects in the East Core Box and on eight of the ten transects comprising the West Core Box.

Predator observations were made using the same rigorous experimental design employed on the MEB transect. Observations were restricted to a 100 meter square “box” positioned 100 meters directly in front of the ship. To ensure inter-observer reliability, this box was outlined on the window with masking tape. The person observing stood at arms length from the window to further restrict the viewing area to the specified region. During transects, one observer continuously scanned the

viewing area. When a predator was cited, species identities of predators, numbers and behaviours were entered directly into a HP 100 palmtop computer by the second person. This methodology gave each record a time-stamp to link observations accurately to other ongoing environmental parameters being logged (e.g., acoustics, water chemistry, chlorophyll, etc.). Observations were always made by the same pair of observers, and duties promptly switched at half-hour intervals to avoid observer or recorder fatigue. In addition, the predator observers remained "blind" to physical or other biological factors that might have otherwise biased observations. For example, while observations were being conducted during the Core Box Surveys, observers were not informed as to when a shelf break might occur; nor were they told when krill was being spotted by the echosounders.

An example of the data that were collected is shown in Fig. 8. This figure shows the distribution of Wilson's storm-petrels (*Oceanites oceanicus*) as observed during the East Core Box survey. Data for the five primary transect lines have been included in this plot. The plot clearly indicates a dramatic increase in the numbers of Wilson's storm-petrels observed inshore as opposed to offshore, and this pattern is remarkably consistent for each transect line. Data for the West Core Box have not yet been plotted, but preliminary analysis indicates that predator activity increased dramatically in association with the shelf break in this area.

XBT observations along the north Scotia Ridge

The temperature structure of the waters flowing along and across the north Scotia Riage was studied using expendable bathythermographs (XBTs). T5 and T7 probes were used, giving maximum depths of 1500 and 750 m respectively, and launch intervals were varied from 1-1.5 h to accommodate changes in ship speed as well as to reflect anticipated gradients in temperature. The section was continued from the western end of South Georgia on the afternoon of 3 January until late afternoon of 5 January, covering about 80% of the return leg to the Falkland Islands. The section had also been undertaken at bout the same time of year during cruise JR11 in 1996. This indicated a location for the Polar Front flowing through a a relatively shallow gap in the Scotia Ridge, to the east of the deeper gap shown as the location of the PF on the charts. For the present section, the location of the PF appears to be in the expected, more westerly location (Fig. 9). The section forms a useful addition to the MEB transect, and should be undertaken where possible at the end of a Core Programme cruise.

Fig. 8. Distribution of Wilson's storm-petrel along five primary transects (A1 = E.1.1, A2 = E.2.1, etc) in the Eastern Core Box.

Fig. 9. Temperature section along the north Scotia Ridge, derived from XBT data.

CTD report JR17

M.A. Brandon, P. Woodroffe, T. Marwood

Summary

In this report we first give details of problems encountered and then the calibration route in detail. The route for the calibration process is detailed in figure 1. In all CTD stations the 2 dbar averages of the downcast data are reported as the final product. In some cases the 1 db and 3 db level are missing from the final file. In these cases the shallowest level with data present was copied to these pressure levels.

The CTD equipment

The CTD unit used for the measurement program was the BAS Neil Brown Mk IIIb (serial number 01 - 3868 - 2086). The most recent calibration had been carried out by Chelsea Instruments on 12 September 1996. The CTD was mounted in a purpose built frame with a General Oceanics 12 position bottle mulitsampler rosette. On each position on the rosette was a 10 litre General Oceanics sampling bottle. For the near bottom CTD stations the package was fitted with a 10 kHz pinger to enable accurate near bottom approach. On three of the 10 L bottles were SIS Temperature Sensors. These were in two pairs, serial numbers T711 and T713, and serial numbers T715 and T716, and serial number T717 alone.

Deployment of the CTD underwater package was from the midships gantry and A-frame on a single conductor, torque balanced cable. This CTD cable was made by Rochester Cables and was hauled on the 10T traction winch. There were no significant problems deploying the CTD package as close control was maintained with the gib arm and two hand lines whilst the package was suspended above the surface. On one occasion (station 078) the CTD wire came off of the roller at the top of the gib arm at the start of a cast. The package was lowered to the deck, the problem cured and the package successfully deployed.

CTD data were logged via a Neil Brown Instrument Systems deck unit, model 1150, to a 386 Viglen PC running E.G. and G. Marine Instruments CTD data acquisition module version 2.02
control software, and also to the RVS ABC system through a dedicated microcomputer. The CTD level A, mainly through historical reasons, averages the data at this point to 1 second values and passes the data through a simple editing procedure. During this editing procedure

pressure jumps of greater than 100 raw units (eg for the pressure transducer equivalent to 10 db) are removed along with spikes in individual channels through a median sorting routine. The rate of change of temperature change over 1 second is also calculated. These one second data are then passed to the ship's UNIX system and archived. Calibration routines are then applied to the data and are described below.

Bottle problems

On coming onto the ship in November it was noted that one handle on the CTD package was broken, this handle was changed before the cruise. During the cruise one more handle broke and was changed. Unfortunately the changing of this handle led to bottle 5 being out of action for a three CTD stations as Brandon lost a crucial spring whilst changing the handle. P. Woodroffe inspected the other bottle handles and replaced a further four. Whilst completing this task it was noted that he failed to drop any crucial springs. On a few occasions the bottles did not seal properly and leaked when the package was brought on deck. When this occurred the leaking bottle was noted on the logsheet and the sample treated as suspect. At stations 150, 155 and 157, the reversing thermometers on bottle 5 (711 and 713) did not trigger properly. This problem was cured for subsequent stations.

Bottle Pylon misfires

The bottle rosette was controlled via a General Oceanics RMS MKVI 1015 - PM controlling unit. There were several misfires indicated on this unit that were indicative of the coming failure of the termination. The full list of bottle misfires is in table 1.

Reterminations

There were four reterminations on the CTD package. These are listed in table 2 and are of two types. An electrical retermination was when the electrical part of the connection was remade, the mechanical termination was left intact. Some concern was expressed at what was felt was a high number of reterminations being required and rotation of the package during deployment was thought to be straining the electrical connection. In a bid to remove this rotation, after station 237 the conducting cable was sent down to 3000 m with a weight attached to try and remove some turns from the wire. On the final electrical retermination a potting compound was used to try and make the electrical termination more robust.

10 kHz Pinger

The 10 KHz pinger was not fitted until station 17ctd157 (MEB 22) as this was the first near bottom station. It worked well throughout the rest of the cruise.

The calibration of the CTD

As stated, the BAS Neil Brown MK IIIb serial number 01 - 3868 - 2086 was used for all CTD stations. This unit was calibrated on 12 September 1996 by Chelsea Instruments and we use values from this calibration for the pressure and temperature. The conductivity sensor was calibrated against *in-situ* salinity samples from the GO water bottles. We report three sets of coefficients for the conductivity and this is described in greater detail below.

Temperature calibration

The temperature calibration was derived by Chelsea instruments using eight temperatures on the ITS-68 scale between 2° and 30°C and was applied to the data was through the following equation

To convert from the ITS-68 scale to T90 following Saunders (1990) we multiplied all temperatures by 0.999760057, so

To allow for the mismatch in response times between the temperature sensor and conductivity sensor, following the standard procedure, the temperature was lagged for the salinity calculation. This lag was achieved by adding a fraction Δ of the rate of change of temperature that is output from the level A (dT) to the temperature. The temperature is then

From experiment the spiking in the derived salinity was minimized with $\Delta = 0.15$.

Pressure calibration

A pressure calibration derived by Chelsea Instruments from 11 pressures between 0 and 6000 m was applied through the following equation

Following King and Alderson (1994) the pressures were then modified by the addition of a factor ΔP, to take into account the effect of temperature on the pressure sensor so that

And ΔP is calculated from

Here T_{lag} is a lagged temperature in °C and is constructed from the CTD temperatures. We use a time constant for the lagged temperature of 400 seconds and update the temperature following the method put forward in King (1996). If T is the CTD temperature and t_{del} the time interval in seconds over which the temperature is being updated, and T_{const} our time constant of 400 seconds then the factor W is

and now

We finally make an adjustment to the upcast pressure to take into account hysteresis in the sensor. The extent of the hysteresis was calculated using a series of laboratory measurements. The hysteresis after a cast to 5500 m (which we denote by *dp5500(p)*) is given in table 3. These values were derived from a laboratory calibration at IOSDL in 1994. Intermediate values are found by linear interpolation. If the pressure of the cast is outside the values in table 1 then *dp5500(p)* is set to zero. For a cast in which the maximum pressure reached is p_{max} dbar, the correction to the upcast CTD pressure (p_i) is

Salinity (conductivity) calibration

We first describe the principal of our method and then detail the steps. For this cruise we calibrated the conductivity against *in-situ* samples collected with the GO multisampler rosette. Once the conductivity of the CTD was calibrated we derived salinity. A full data processing route is detailed at the end of this report. In brief, first we applied a nominal calibration of the form

From the salinity samples, once successfully matched, we calculated the bottle sample conductivity using *in-situ* temperature and pressure from the CTD. From this *in-situ* conductivity we calculated the difference of the bottle conductivity ($cond_b$) and CTD conductivity ($cond_{ctd}$) to derive a value ΔC. We now plot bottle conductivity (*x variable*) against deltaC (*y variable*). This should give a straight line where from

We get

After rejecting suspect bottles we use the pstar programme plreg2 to derive *m* and *c* for ΔC. Now, as

the calibration coefficients for the CTD conductivity are derived through substituting equation (13) into (12), the CTD conductivities are now

and from the *m* and *c* in equation (12)

and

These values for *a* and *b* are entered into the calibration files for both the pstar and RVS system. The processing route is then repeated and the new graph of ΔC against $cond_b$ gives the conductivity residuals, the residuals should now be random with a mean of zero. This calibration procedure does have a feature in that as we moved south along the section and moved into waters where the entire water column was of lower conductivity than the station used for the initial calibration the validity of the original m and c are called into question because of extrapolation. Accordingly we used three sets of coefficients for *a* and *b* that are detailed in table 4. After applying these calibration coefficients to the relevant stations there is still a residual drift within the conductivity signal with time. For each station this drift is

From substitution into our original equations we can now remove this residual drift.

Salinity Samples

Salinity samples were taken for all of the CTD casts made for the physical oceanographic program. For the 22 stations of the Maurice Ewing Bank section 18 samples were taken from the GO 10 L bottles , This gave one sample for each bottle plus six duplicates. For the core boxes around South Georgia this was reduced to nine samples for each station. This gave a total of 420 samples with 148 duplicates (568 in total). The samples were taken in 300 ml medicine bottles. Each bottle being rinsed twice before being filled to just below the neck. The rim of the bottle was then wiped with tissue, a plastic lid inserted and the crew cap replaced. The salinity samples were placed near to a salinometer to allow the sample temperatures to equalise with the salinometer. The samples were then analysed on the BAS Guildline Autosal model 8400 S/N 45363. This salinometer was serviced and electronically aligned by Ocean Scientific International in June 1996. For each CTD stations worth of salinity samples (18 samples) one vial of OSIL standard seawater (batch P130, 1996) was run

through the salinometer to enable an calibration offset to be derived. Once analysed the conductivity ratios were entered by hand into an Apple Macintosh based EXCEL spreadsheet using software written by Dr Brian King (S.O.C.) before being transferred to the UNIX system as described below. For the 148 duplicate samples the mean difference was 0.000 and the standard deviation 0.001.

The quality of the conductivity calibration procedure

After applying the calibration coefficients and adjusting for the residual offset ΔC, the salinity of the bottle sample was differenced with the derived CTD salinity. After rejecting samples detailed in table 5 the mean of the remaining samples was 0.0000 with a standard deviation of 0.0018 psu. In table 5 we list the conductivity calibration file number used for each station along with the residual offsets applied to the cast after calibration (ΔC). We can see in table 5 that the drift of the sensor is small. In figure 2 we show the residual salinity offset against time (station).

The CTD processing route for JR17

Step 1: ctdexec0
Purpose: To read in the CTD data from the RVS stream.
The programmes are

datapup - in the data from an RVS stream (bas_ctd) into a pstar file.
pcopya - reset the raw data flag in the pstar file.
pheadr - set the header of the pstar file.

The output is 17 ctd $num .raw

Step 2: ctdexec1
Purpose: To calibrate the ctd data.
The programmes are

ctdcal - to apply a nominal calibration to the ctd data.
pcalib - convert from T68 to T90 by multiplying T by 0.999760057
peos83 - derive a sigma0.

The output file is 17 ctd $num
Also output is the data cycle at the end of the downcast. Record this value for step 8.

Step 3: sal.exec
Purpose: To read in the sample file from the mac to the UNIX system.
The programmes are

getexel.exec - reads data file from the mac

There are two files output. An ascii file called sam $num.txt,
and a pstar file sam $num.bot.
The file has eight variables. These are bottle number, the salinity of the bottle, the salinity of the duplicate and the five thermometer values.

Step 4: ctdexec2
Purpose: To merge the bottle firing data to the sample data.
The programmes are

mrkcal - create an ascii file containing 10 s averages of the data *before* bottle firing.
sed - here we use a sed script to clear unwanted information from the ascii file.
pascin - read the ascii bottle firing data into a pstar file.
pcopya - copy in eight extra variables to the firing file.
ppaste - paste the eight variables from sam$num.bot into the firing file.
peos83 - calculate *in-situ* conductivities of the salinity samples.
parith - calculate conductivity residuals (ΔC above).
mlist - get a quick and dirty plot of ΔC vs $cond_b$.

The output file is in the form 17 sam $num .cond
There are problems with this exec in that it requires 12 bottle firing levels to run successfully. For some of the CTD stations - in particular the shallow stations in the core boxes more than one bottle was closed at each level. Therefore we end up with an ascii file from mrkcal with less than twelve levels. This will crash the exec. To cure the problem we must manually edit the ascii file from mrkcal (cal_output) and copy the missing levels in. For example if we fired five bottles at 150 m we copy the 150 m level in cal_output four times to give five lines in cal_output for the 150 m level. You must then run "ctdexec2_fix" to run the exec from the point at which the sed operates on the ascii file.

Step 5: Determine the individual ctd offset
Use phisto to calculate residual ΔC for the station. This value of ΔC is the input for ctdexec3.

Step 6: ctdexec3
Purpose: To add the ΔC offset for the station.
The programmes are

pcalib - add the ΔC offset to 17 ctd $num
peos83 - derive a salinity from the new conductivity.
The output of the exec is in the form 17 ctd $num.cal

Step 7: Find the start of the downcast

Here we use mlist on the file 17 ctd $num.cal to list the variables pressure, temperature and salinity to find the start of the downcast. In the standard operating procedure (see appendix N) the package should enter the water and descend to approximately 10 db. After a couple of minutes the package will be brought to the surface (pressure will decrease) before descending. The data cycle at which the pressure is a minimum (but > 0) and salinity does not go to zero is recorded as the start data cycle.

Step8: ctdexec4

Purpose: To get the final output from the ctd data
The programmes are

pcopya - use the data cycles from step 2 and step 7 to copy out the downcast.
peos83 - derive a potential temperature (θ) and potential density (σ_0).
pmdian - remove large spikes from individual data streams.
pintrp - interpolate missing data removed by pintrip.
psort - sort the down cast into a file containing only increasing pressure (17 ctd $num.1hz).
pavrge - create 2 dbar averages of the .1hz file.
pintrp - remove missing data from the 2dbar file (usually none).

The output files from the exec are 17 ctd $num .1hz for the sorted 1 second down cast
and 17 ctd $num .2db for the 2dbar averaged file.

Step 9: samexec0

Purpose: To create a sample file with the corrected CTD data and calculate residuals. This step is similar to step 4, ctdexec2
Programmes

mrkcal - create an ascii file containing 10 s averages of the data before bottle firing.
sed - use a sed script to clear unwanted information from the ascii file.
pascin - read the ascii bottle firing data into a pstar file.
pcopya - copy in eight extra variables to the firing file.
ppaste - paste the eight variables from sam$num.bot into the firing file.
parith - calculate salinity residuals (ΔS).

There are two output files 17 sam $num .final
and 17 sam $num .offsets
The same problem that exists with ctdexec2 when there are less than 12 bottle levels exists for samexec0. You must edit the ascii file (cal_output) in the manner described above and run "samexec0_fix" to successfully run the exec.

Step 10: add_position

Purpose: To add the latitude and longitude as variables to the two sample files.
The programmes are

pcopya - copy in two extra variables in the .final file.
pheadr - change the two extra variable names to lat and lon.

pcalib - make the two extra variables equal to latitude and longitude
pcopya - copy in two extra variables in the .offsets file.
pheadr - change the two extra variable names to lat and lon.
pcalib - make the two extra variables equal to latitude and longitude

Step 11: plot the data
We use a programme such as plotxy to plot the temperature, salinity and potential density of the CTD data. A hardcopy of the data is not required at this stage. What we are looking for is to see if there are any unrealistic density inversions in the regions of high temperature and salinity gradients at the surface. If there are such inversions move onto step 12.

Step 12: plxyed
Here we use the pstar interactive editor to remove the spikes identified in step 11. This editor replaces the bad data points with missing data.

Step 13: ctdexec5
Purpose: To remove the missing data from step 12
The programmes are
pintrp - interpolate across the bad temperature and salinity data.
peos83 - re-derive potential temperature (θ) and potential density (σ_0).

The output file is again called 17 ctd $num .2db

TABLES

Table 1: Misfires on the General Oceanics MK IV 1015 - PM

Cast	misfire position	number of misfires
045	12	1
110	All	numerous
125	12	1
	11	1
	10	1
237	12	3
	11	2

Table 2: Reterminations of the CTD conducting cable

After Station	Type of retermination
110	Full
125	Electrical
210	Full
261	Electrical

Table 3: The table of hysteresis corrections in the pressure sensor

p (dp)	dp5500(p) db
0.0	0.0
100	2.7
200	3.9
1000	5.9
1500	6.3
2000	5.8
2500	5.7
3000	5.1
3500	4.5
4000	3.7
4500	2.4
5000	1.5
5500	0.0

Table 4: Calibration coefficients used for the conductivity calibration

calibration number	a	b	from station
1	0.0146667	0.916304	17 ctd 061
2	-0.0326956	0.917617	17 ctd 093
3	-0.080606	0.919089	17 ctd 237

Table 5: Calibration summary for CTD stations on JR17

Station event number	Identifier	Offset	Rejected bottles	Calibration file
026	test cast	0.0000	11	1
043	GC 1	-0.0024		1
045	MEB 1	-0.0024	10, 11	1
050	MEB 2	-0.0015	3	1
054	MEB 3	0.0005	3	1
061	MEB 4	0.0000	3	1
066	GC 2	-0.0011		1
068	MEB 5	-0.0011	3, 7	1
073	MEB 6	-0.0035	5, 10	1
078	MEB 7	-0.0037		1
083	MEB 8	-0.0032		1
088	MEB 9	-0.0045	6	1
093	MEB 10	0.0000	9	2
098	GC 3	0.0014		2
100	MEB 11	0.0014		2
105	MEB 12	0.0002		2
110	MEB 13 (1)	0.0008		2
113	MEB 13 (2)	0.0008	1	2
118	MEB 14	-0.0004		2
122	MEB 15	-0.0019	6	2
125	MEB 16	-0.0015		2
130	MEB 17	-0.0015		2
133	MEB 18	0.0013	1	2
140	MEB 19	-0.0009	3, 8	2
145	MEB 20	0.0001		2
150	MEB 21	-0.0009	10	2
155	GC 4	-0.0007		2
157	MEB 22	-0.0007	9	2
163	AC 1	-0.0005		2
164	AC 2	-0.0005		2

172	E1.2.N	-0.0004		2
174	E1.2.N	-0.0004	9	2
180	GC 5	-0.0004		2
182	E1.2.S	-0.0004		2
189	E2.2.S	-0.0004		2
192	GC 6	-0.0004		2
200	E2.2.N	0.0000	7	2
210	GC 7	-0.0003		2
212	E3.2.N	-0.0003		2
218	E3.2.S	-0.0016		2
223	GC 8	-0.00012		2
225	E4.2.S	-0.00012		2
231	E.4.2.N	-0.0001		2
237	E.5.2.N	0.0000		3
247	AC 3	0.0000		2
252	GC 9	-0.0008		2
254	W1.2.S	-0.0008	11	2
261	W1.2.N	0.0000	10	2
270	GC 10	0.0001		2
272	W2.2.N	0.0001		2
277	W2.2.S	-0.0002	8	2
284	GC 11			2
286	W3.2.N			2
295	AC4			2
296	AC5			2

Appendix A:

A Standard operating procedure for the BAS Neil Brown Mk III CTD unit

Mark Brandon, MLSD.

1) Check the package is ready for deployment - i.e all the rosette bottles are both empty and cocked. Ensure protective cap is removed from temp/salinity probe. Note the positions of any reversing thermometers and set them to sample.

2) When the station is reached, set up and check that the PC and Level A data stream is logging.

3) Deploy the CTD to 10-15 m depth depending on conditions.

4) Wait 2 minutes.

5) Depending on conditions bring the CTD as close to the surface as is safe.

6) With no pause start lowering the CTD increasing to a maximum rate of 60 m/min.

7) If going close to the bottom try not to bounce the package down, just slow the rate of descent to 30 m/min and then 15m/min - this extends the "thinking time" and should enable the bottom approach to be both close and smooth.

8) Look at the approach towards the bottom on the PES screen. Stay off the bottom- it's bad style to do anything else and 10 m off is perfectly satisfactory.

10) If the CTD is close to the sea floor, the time at bottom is to be *not greater than 1 minute.* Once at the maximum depth note the relevant information on the log sheet. As soon as this is done (approximately 30 seconds) switch of the Level A (this prevents spikes in the CTD data when the bottles are fired) fire one rosette bottle and bring the package to a level 50 m above the bottom depth and hold it there for 1 minute, then fire another rosette bottle.

11) If not a full depth CTD wait 1 minutes at the bottom before firing a rosette bottle.

12) At each of the chosen levels for water samples, stop the package at that level and let it sit for 1 minute, turn off the level A and fire a bottle. If the bottle has a reversing thermometer attached, the package is to sit for 30 seconds *after* the bottle has been closed. Switch the level A back on and bring the package up to the next level.

13) Do not bring the package out of the water without firing all the rosette bottles.

14) Once the package is on deck and secured, stop the PC and level A logging, inform the bridge to proceed to the next station and fill out the rest of the CTD logsheet.

At The CTD package

1) Read reversing thermometers.

2) Using *one sample crate* per CTD cast, take one 300 ml sample of water from each bottle with six duplicates from each cast. Note carefully the sample and bottle numbers on the logsheet.

3) Place the sample crate in the prep lab and stow next to the salinometer for analysis.

Appendix B

MLSD Core Program 2. MEB transect bottle levels

Station	Water depth	Cast depth	Bottle Levels
WP1	5757	4500	**4500**, 2500, 1000, 600, **200**, 150, 125, 100, 80, 60, **40**, 20
WP2	5942	1000	**1000**, 800, 600, 400, **200**, 150, 125, 100, 80, 60, **40**, 20
WP3	5712	4500	**4500**, 2500, 1000, 600, **200**, 150, 125, 100, 80, 60, **40**, 20
WP4	5894	2000	**2000**, 1500, 1000, 600, **200**, 150, 125, 100, 80, 60, **40**, 20
WP5	4503	2000	**2000**, 1500, 1000, 600, **200**, 150, 125, 100, 80, 60, **40**, 20
WP6	4821	1000	**1000**, 800, 600, 400, **200**, 150, 125, 100, 80, 60, **40**, 20
WP7	1901	1000	**1000**, 800, 600, 400, **200**, 150, 125, 100, 80, 60, **40**, 20
WP8	1684	1000	**1000**, 800, 600, 400, **200**, 150, 125, 100, 80, 60, **40**, 20
WP9	1362	1000	**1000**, 800, 600, 400, **200**, 150, 125, 100, 80, 60, **40**, 20
WP10	1767	1000	**1000**, 800, 600, 400, **200**, 150, 125, 100, 80, 60, **40**, 20
WP11	2254	2000	**2000**, 1500, 1000, 600, **200**, 150, 125, 100, 80, 60, **40**, 20
WP12	2918	2000	**2000**, 1500, 1000, 600, **200**, 150, 125, 100, 80, 60, **40**, 20
WP13	3578	3000	**3000**, 2000, 1000, 600, **200**, 150, 125, 100, 80, 60, **40**, 20
WP14	3694	3000	**3000**, 2000, 1000, 600, **200**, 150, 125, 100, 80, 60, **40**, 20
WP15	3689	1000	**1000**, 800, 600, 400, **200**, 150, 125, 100, 80, 60, **40**, 20
WP16	3710	3000	**3000**, 2000, 1000, 600, **200**, 150, 125, 100, 80, 60, **40**, 20
WP17	3715	1000	**1000**, 800, 600, 400, **200**, 150, 125, 100, 80, 60, **40**, 20
WP18	3712	3000	**3000**, 2000, 1000, 600, **200**, 150, 125, 100, 80, 60, **40**, 20
WP19	3730	1000	**1000**, 800, 600, 400, **200**, 150, 125, 100, 80, 60, **40**, 20
WP20	3498	3000	**3000**, 2000, 1000, 600, **200**, 150, 125, 100, 80, 60, **40**, 20
WP21	1236	1000	**1000**, 800, 600, 400, **200**, 150, 125, 100, 80, 60, **40**, 20
WP22	170	160	**160**, 150, 150, 125, **125**, 100, 100, 80, 60, 40, **20**, 20

Bottle levels in **bold** have reversing thermometers on them

Appendix C: Core Box CTD sampling strategy

M. Brandon

There are three types of CTD stations
1) shallow
2) deep
3) Geoff Cripps specials.

Type 1: SHALLOW
These are at the inshore end of a UOR leg. The water depths will typically be around 200 m. The cast is to go to 10 m off the bottom. Bottles are to be closed at

bottom, 5 at 150, 125, 100, 80, 60, 40, 20

There should be **Eight** salt samples taken. One from each bottle level (i.e no duplicates).

Type 2: DEEP
These are at the offshore end of the UOR leg. Water depths will typically be over 2500 m. The cast is to go to 1000. Bottles are to be closed at

1000, **800**, **600**, **400**, **200**, **150**, 125, **100**, 80, **60**, 40, **20**

samples are to be taken from the levels in bold - that is 9 samples.

Type 3: GEOFF CRIPPS SPECIAL
These are wherever Geoff needs them but are only to 200 m. Typically he needs six bottles closing at 200 m and six bottles at 30 .We **do not** take salt samples from these stations.
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Navigation notes JR17

Mark Brandon

The Marine Life Sciences Division of the BAS now have a total of six instruments to use on the RRS *James Clark Ross* that are connected with navigation and listed in table 1. Although the six instruments seem in some cases similar, they are all unique. The collection and use of all of the navigation data are linked.

Table 1: Navigation instruments on the RRS James Clark Ross.

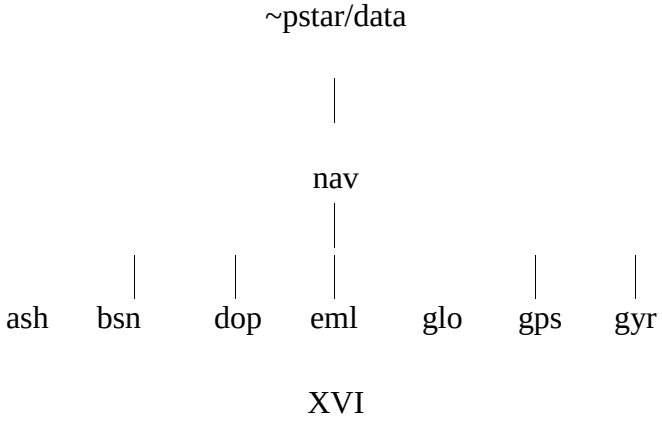
Instrument	Type	Code	Use
Ashtec GG24	GLONASS receiver	glo	Primary positional information
Trimble 4000	GPS receiver	gps	Secondary positional information
Ashtec GPS3DF	GPS receiver	ash	Attitude information
Gyrocompass	Sperry Mk 37 model D	gyr	Heading information
Electromagnetic Log	????????????	eml	Velocity information
Doppler Log	????????????	dop	Velocity information

In this short document I am going to very briefly describe each instrument and explain the processing, as I see it should be done on cruise JR17. I will first deal with the directory structure, then describe the instruments and their individual processing. In appendix A we list the commands for completing one days navigational data processing.

1.Directory structure

The directory containing the navigation data is in ~pstar/data and is called “nav”. Beneath this are six directories for the six instruments listed in table 1. These directories are shown in figure 1. The directory structure is fixed as some of the execs for other instruments reference them.

Figure 1: The directory structure of the navigation data



2.Ashtec GLONASS (GG24)

The *James Clark Ross* is the only British research ship installed with a GG24 receiver and this will be "its" second cruise. It is to be our primary source of positional information and velocity information for the cruise. The GG24 works by accepting data from both American GPS and the Russian GLONASS satellites. This extends the constellation of available satellites to 48, but we expect that including the GPS cluster will decrease the accuracy of the data. There is consequently excellent data coverage. It is however an instrument in development and will need careful observation. The GG24 was observed to hang once or twice on JR16 so it should become a watch duty to check it is working. As the RVS Level A for the instrument has only just been installed by Bruce Lamden I have written a new exec called ggexec0.

ggexec0: This exec reads in data from the GG24 into pstar format, It also does some primary editing.

datapup - transfers the data from RVS binary files to pstar binary files.
pcopya - resets the raw data flag on the binary file.
pheadr - sets up the header and dataname of the file.
datpik - rejects data with on the following criteria
If there are less than 4 or greater than 24 space vehicles
If the positional dilution of precision is greater than 10
If the time dilution of precision is greater than 4
If the horizontal dilution of precision is greater than 4
If the vertical dilution of precision is greater than 4

Two files are output from this exec. The first the raw data 17glo{jday}.raw, and the edited data 17glo{jday}. We will then edit this file a little more using the pstar program plxyed and manually remove spikes. This edited data stream will then be put through bestnav as described below.

3.Trimble 4000

Until the previous cruise (JR16) the Trimble was the primary source of positional information for the ship and it has the facility to record the coded signal for post processing differential data. This facility is no longer required because of the GLONASS system. We will however log the data at 1 second intervals as a back up and use this as our secondary data stream in the bestnav programme. On JR16 the Trimble 4000 inexplicably sent a large period of data with poor information and so on JR17 it should become a watch duty to check the receiver is working. The Trimble 4000 data is to be read into pstar format using gpsexec0.

gpsexec0: This exec reads Trimble data into the pstar format. It retrieves the daily files with a .raw extension and appends the data to a master file.

datapup - transfers the data from RVS binary files to pstar binary files.
pcopya - resets the raw data flag on the binary file.
pheadr - sets up the header and dataname of the file.
datpik - removes data with a dilution of precision (pdop) greater than 5.

Two files are formed by this exec.
One is just before the datpik (editing stage) and is called 17gps{jday}.raw
the other is after the datpik, this is 17gps{jday}.
The file 17gps is appended to a master gps file called 17gps01.

4.Ashtec GPS3DF

The Ashtec GPS3DF system performed well on JR16 with excellent data coverage. We will use the instrument to correct the gyrocompass data and update the ADCP data. The handling of the data stream is however complex and there are many steps in the procedure. In appendix B we show the settings on the sub-menus of the Ashtec receiver for JR16 and how they will be set for JR17. There are three execs involved in the processing these are ashexec0, ashexec1 and ashexec2. These three may be appended into one large exec once we have evaluated the procedure.

ashexec0: This exec reads in data from the GPS3DF into pstar format.
datapup - transfers the data from RVS binary files to pstar binary files.
pcopya - resets the raw data flag on the binary file.
pheadr - sets up the header and dataname of the file.
The output file is in the form 17ash{jday}.raw

ashexec1: This exec merges the ashtec data to the master gyro file from gyroexec0
pmerg2 - merge the ashtec file to the master gyro file.
parith - calculate the differences in the ashtec and gyro headings (delta heading).
prange - force delta heading to lie around zero.
The output file is in the form 17ash{jday}.mrg

ashexec2: This exec is complicated as it edits the merged data file.
datpik - reject all data outside the following limits
heading outside 0° and 360°
pitch outside -5° to 5°
roll outside -7° to 7°
attf outside -0.5 to 0.5
mrms outside 0.00001 to 0.01
brms outside 0.00001 to 0.1
delta heading outside -5° to 5°
pmdian - we remove flyers in delta heading of greater than 1° from a 5 point mean.
pavrge - set the data file to be on a 2 minute time base.
phisto - calculate the pitch limits.
datpik - further selection of bad data outside the following limits

pitch outside the limits created
mrms outside the range 0 - 0.004

pavrge - again set the data file to be on a 2 minute time base.
pmerge - merge back in the heading data from the gyro from the master gyro file.
pcopya - change the order of the variables.

The output files are 17ash{jday}.edit
and 17ash{jday}.ave.
We now follow an elaborate manual editing procedure following the suggestions and written notes of Raymond Pollard (S.O.C.).

5.Gyrocompass

The gyrocompass is used by the RVS program bestnav to create a ships heading variable. It has been BAS MLSD policy to avoid the use of bestnav in past cruises, for JR17 I will use this data stream and will explain this more below. The other significant use of the gyro compass is that it provides heading information to the acoustic Doppler current profiler (ADCP). This data needs correcting from the Ashtec GPS3DF. For the cruise JR17 we will use the exec gyroexec0.

gyroexec0: The purpose of this exec is to read in the gyrocompass data and take the inevitable bad data. The exec runs a series of pstar and RVS programmes that are as follows.

datapup - transfers the data from RVS binary files to pstar binary files.
pcopya - resets the raw data flag on the binary file.
pheadr - sets up the header and dataname of the file.
datpik - forces all data from the gyro to be between 0 and 360°.

The output file is in the form 17gyr{jday}.raw, but the script also runs one more programme that appends the day file to a master file. This file is called 17gyr01.

6.Electromagnetic Log

The electromagnetic log has not really been looked at from JR11 except by Alistair Murray. On this cruise we shall read in the data using an a very basic exec called emexec0.

emexec0: This exec reads in data from the electromagnetic log into pstar format.
datapup - transfers the data from RVS binary files to pstar binary files.
pcopya - resets the raw data flag on the binary file.
pheadr - sets up the header and data name of the file.
The output file is in the form 17eml{jday}.raw

7.Doppler Log

The Doppler log is another speed measuring device only looked at by Alistair. We shall read

the data in 24 hour chunks the using the very simple exec dopexec0.

dopexec0: This exec reads in data from the Doppler log into pstar format.
- *datapup* - transfers the data from RVS binary files to pstar binary files.
- *pcopya* - resets the raw data flag on the binary file.
- *pheadr* - sets up the header and data name of the file.

The output file is in the form 17dop{jday}.raw

8.Bestnav

We have not used this route in the past but will use it for JR17. Basically we want to use the bestnav routine to easily fill the gaps in the GG24 so that we can derive absolute velocities from the acoustic Doppler current profiler. We shall set bestnav to replace gaps of greater than 300 seconds with first data from the edited Trimble 4000, and then failing the Trimble with data from the electromagnetic log. We shall use the pstar exec navexec0 to read in this data in 24 chunks, but append it to a master file.

navexec0: This exec reads in data from the bestnav stream into pstar format.
- *datapup* - transfers the data from RVS binary files to pstar binary files.
- *pcopya* - resets the raw data flag on the binary file.
- *pheadr* - sets up the header and data name of the file.
- *posspd* - here we calculate the east and north velocities from position and time.
- *papend* - the output file is added to the master file.
- *pdist* - we now recalculate the distance run variable.
- *pcopya* - and take out the RVS calculated distance run.

Appendix A: The daily processing of the navigation data.

The data will be read in in periods of 24 hours. The order of the processing is important as some of the execs reference other streams. The suggested order is. Each exec will find the correct directory and so the starting point is not critical

1. gyroexec0 - *read in gyrocompass data.*
2. ggexec0 - *read in the GG24 data.*
3. gpsexec0 - *read in the trimble data*.
4. ashexec0 - *read in the ashtec data.*
5. ashexec1 - *merge the ashtec and gyrocompass.*
6. ashexec2 - *edit the ashtec data.*
7. dopexec0 - *read in the Doppler log data.*
8. emexec0 - *read in the electromagnetic log data.*

After the output from ggexec0 has been edited, and the bestnav file updated by Bruce step 9 can be completed

9. navexec0 - *read in bestnav data.*

Appendix B: Ashtec GPS3DF receiver settings (menu 4 and sub-menus)

POS	54:17.0S, 35:40,W,+0.0m
Alt known	N
Ranger	0
Unhealthy SV	N
Rec. Intv	20
Min no. Sv	4
Elev mask	10
Pdop mask	40

PORT A (not used)	
nmea	off
real time	off
VTS	off
baud	9600
PORT B (Level A logging)	
nmea	on
real time	off
VTS	off
baud	4800
OPTIONS	PAT ON
	1 s rate

Attitude Control Menu				
max rms	8			
search ratio	0.5			
1 s update	Y			
3 Sv search	N			
	TAU	TO	Q	R
Hdg	999	000	1.0e-2	1.0e-2
Pitch	020	000	4.0e-2	1.0e-2
Roll	020	000	4.0e-2	1.0e-2
Kalmann filter reset	N			

The coordinates in the following table are from a survey using the Ashtec software in Grimsby in September 1996. The port-aft antenna is designated number 1, port-fwd is 2, stdb-fwd is 3 and stbd-aft is 4. The XYZ vectors have been adjusted so that heading is defined by the direction normal to the 1-4 baseline (i.e. that baseline has Y = 0)

Vector	X(R)	Y(F)	Z(U)
1-2	2.955	4.751	0.0
1-3	11.499	4.754	0.0
1-4	13.227	0.0	0.0
offset	0(H)	0(P)	0(R)
Max cycle	0.2 cyc	smoothing	N
Max mag	0.08	Max angle	10