Report for Cruise ES033

Second ACES-FOCAS cruise to the southern Weddell Sea

RRS Ernest Shackleton

22 January to 7 March 2009

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Introduction

Overview

Various projects were involved in the cruise: SASSI (Synoptic Antarctic Shelf-Slope Interactions), an AFI-funded project whose PI is Professor Karen Heywood, UEA; the BAS core project ACES-FOCAS; the BAS LTMS-P programme, in collaboration with University of Bergen and Lamont-Doherty Earth Observatory; and BIAC (Bipolar Atlantic thermohaline Circulation), the Norwegian IPY programme. Additional projects were incorporated when HMS Endurance’s Weddell Sea cruise was cancelled. These were primarily concerned with aerosol and air chemistry, and will not be discussed in this report.

The SASSI project involved the deployment of a current meter array across the continental shelf, shelfbreak and slope at around 17° West. The FOCAS element of the cruise aimed to recover moorings deployed two years previously, carry out a set of CTD sections repeating and complementing those of the previous cruise, and to deploy ten CTD tags on Weddell seals. The LTMS work was to turn around the Orkney Passage mooring array and the northern Weddell Sea M2 and M3 moorings, to recover mooring S2 at Filchner Sill, and to deploy a new style, bottom-mounted mooring at that same site. Additional LTMS-P work was the re-occupation of the Marguerite Bay CTD section, a task undertaken after the main cruise, during the last call to Rothera. Work for BIAC involved deployment of moorings over the continental slope west of Filchner Sill to monitor the Ice Shelf Water plume present in that location, and the use of a VMP microstructure profiler to study mixing processes in the plume.

Heavy sea ice, together with problems with some of the acoustic releases, prevented the recovery of several of the moorings, and the sea ice conditions prevented the BIAC plume study from going ahead at the preferred location. However, the BIAC team had been forewarned of this possibility and were able to switch to an alternate plan, which was carried out successfully. The CTD profiling work went smoothly, with full-depth LADCP profiles being recovered from 148 of the 175 casts. With one exception, the SASSI mooring array was successfully deployed, and a CTD/LADCP section recovered from along the array. All ten seal tags were successfully deployed on Weddell seals in the vicinity of Helmert Bank, at the eastern Filchner Sill. An additional activity was a multi-day yo-yo VMP sequence while the ship was moored at Brunt Ice Shelf during the final Halley call.

Personnel

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<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Project</th>
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<tr>
<td>Helen Atkinson</td>
<td>BAS</td>
<td>Air chemistry</td>
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<td>John Beaton</td>
<td>SAMS</td>
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<td>Patrick Robinson</td>
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<td>ACES-FOCAS (seals)</td>
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Cruise narrative

The ship departed Stanley 22 January 2009, arriving at Signy on the 25th (see Figure Map). Three pax were dropped at Signy Base, and the ship departed for the location of mooring M2, a mooring deployed in early 2007. The mooring was recovered and a CTD cast was made at the site before sailing to M3. Nothing was heard from either of the paired releases at M3. We then sailed to the location for the deployment of the SASSI mooring array, arriving 29 January. A glut of sea ice was covering much of the area, but four of the six moorings could be deployed to make up the inshore part of the array at a longitude of ~018°W. CTD/LADCP profiles were obtained at each mooring site.
The ship then sailed for Coast mooring, one of the FOCAS moorings, arriving 2 February. The mooring was released, but did not surface; it was finally recovered by dragging a wire across the mooring's location, which was determined precisely by triangulation.

CTD section A was occupied during January 3rd, and the ship then arrived at Mooring S2. Triangulation showed that the mooring was in an open pool within otherwise heavy sea ice, and the release was triggered. As in the case of the Coast Mooring, S2 did not ascend. The ice drift then caused the pack to cover the location and nothing more could be done. The new S2 mooring was then deployed, and the acoustic modem successfully tested. After checking to ensure that the old S2 mooring was still at the sea bed, the ship headed east and occupied CTD section B.

From this point onwards, the ship stopped to tag Weddell seals when appropriate candidates were identified. Ice cores were recovered during some of these opportunities as part of the air chemistry project. The ship visited mooring sites S4 and S4E during the occupation of Section B. The acoustic transponders on both moorings responded appropriately, but because of the difficult sea ice conditions they were not released. Sections C, D, E, F and G were then occupied over the next three and a half days, by which time all but 1 of the 10 seal tags had also been deployed. Also during this time the FOCAS mooring sites Slope North and Slope South were visited. Neither acoustic release responded. The sites were revisited later in the cruise, and, again, no response was received.

The next week of the cruise was dedicated to BIAC, the Norwegian IPY programme. An attempt was made to reach the area of primary BIAC interest, but this was abandoned when it became apparent that conditions within the pack ice further to the west had worsened. The alternate plan involved deploying five instrument moorings on the Crary Fan (Figure 2), and undertaking a series of CTD/LADCP and VMP sections that complemented the CTD sections obtained to date.

Section H was occupied on Crary Fan, and two of the five BIAC moorings were

Figure 2. Map showing activity in the vicinity of Brunt Ice Shelf. CTD stations (red cross), BIAC moorings (grey circles), VMP sections (black lines) and VMP/CTD yo-yo sites (green squares). The S2 mooring is the grey circle at the west side of the sill.
deployed (BIACM1 and M2). A medivac to Halley delayed proceedings for 24 hr, after which Section I was occupied and the remaining three moorings deployed (BIACM5, BIACM4 and BIACM3). The ship was then mobilized for microstructure profiling (VMP). Over the following four and a half days, Sections J, K and L were occupied. Each section consisted of interleaved CTD/LADCP and VMP profiles. Sections J and L included 12-hour yo-yo stations in a water depth of around 600 m.

The ship again visited the locations of the FOCAS slope moorings to listen again for the acoustic releases, but to no avail. We then returned to Halley for the station’s final call. A VMP yo-yo station was occupied for most of the period moored up at Brunt Ice Shelf, approximately three days in total. This was also an opportunity for Helen Atkinson to carry out an air chemistry experiment from a site near the ship, on the ice shelf itself.

After departing from Halley, the ship returned to the location of the SASSI section, from where the sea ice had cleared. The deep portion of the CTD/LADCP section was completed, and the final mooring deployed. A PIES (pressure inverted echo-sounder) was not deployed, as a result of a spurious diagnostic that erroneously suggested that the instrument had developed a fault.

The ship then returned to the location of the M3 mooring in the northern Weddell Sea, and a grid of listening points occupied in an attempt to communicate with either of the mooring’s acoustic releases. Again, nothing was heard. A new M3 mooring was deployed and a CTD/LADCP profile obtained. The M2 site was then visited, and new M2 mooring deployed and CTD/LADCP profile obtained.

We sailed to Orkney Passage to service the BAS/LDEO mooring array. Mooring OP3 and OP2 were successfully released, but there was no response from the short but deep OP1. The OP CTD/LADCP section was occupied, and the two moorings OP2 and OP3 re-deployed. The SASSI project’s PIES was deployed near the site of OP2.

With the Weddell science cruise now complete, the ship visited Signy, closing down the base and embarking the personnel. Ernest Shackleton arrived back at Stanley on 7th March 2009. Keith Nicholls and Colin Griffiths remained on board for the final call to Rothera, in order to repeat the LTMS-P CTD section in Marguerite Bay.

**CTD Operations**

**Winch**

*Description and installation*

The CTD winch had originally been built for BAS in 1997. It was first used on *HMS Endurance* during the 1998 ROPEX cruise to the Weddell Sea. Maintenance and storage was arranged by BAS until the equipment was given to what was then known as UKORS, based at SOC (now NMF-SS at NOC). The winch was next used by BAS during the 2007 *Ernest Shackleton* cruise (ES031) to the Weddell Sea. This present cruise (ES033) is the winch’s third outing.

The winch is hydraulically-powered, and has a built-in hydraulic power pack. It has a 10-foot container footprint. There is a built-in hydraulically-powered A-frame. The winch presently holds around 6000 metres of coaxial, electromechanical cable, and has been used for full-depth casts in 4700 metres of water. The winch was mounted amidships, on the starboard side, and CTD operations were not overly susceptible to poor weather conditions.
Various recommendations were made to improve the winch after its first season, some of which were acted upon. The biggest unresolved problem was the scrolling system, which, on one occasion during the second season, broke down entirely. The scrolling system was completely overhauled during 2008, and worked flawlessly during the entire ES033 cruise.

**Comments, and problems encountered**

*Winch drum:* The winch drum appeared to rotate perfectly true during the first shallow test cast. After the second cast, which was a deep cast, the drum was visible out of true, such that an interior guard fouled the left hand cheek (looking outboard) during part of the revolution. The guard had to be unbolted to remove the source of the abrasion. The scrolling was unaffected, and the alignment did not appear to worsen during the remainder of the cruise.

*Hydraulic oil heater:* The heater did not come on, even during very cold conditions. The fault was traced to the thermostat, which had to be bypassed. For the rest of the cruise the heater was switched on by hand when it was needed.

*Drum rotation:* As on previous cruises, the drum appears to rotate jerkily at slow speeds, between 15 and 60 m/min. This is most noticeable when the winch is cold, and while paying out.

*Line-out and speed gauges:* Towards the end of the cruise the line-out gauge on the remote control failed. The gauge on the main panel continued to work for a time, as did both wire speed gauges. The line-out gauge on the main panel then failed also. Later, both speed gauges stopped working. When the remote unit was opened up it became clear that sea water had got inside.

*Responsiveness of remote control:* A curious effect was that the remote payout/heave lever would initially not allow heave at the full speed allowed by the lever at the winch. After a few minutes the rate of heave did increase on the remote lever. This became particularly bad late in the cruise. It is possible that it is connected with water ingress.

**Recommendations**

*Detachable main control panel:* The winch is usually mounted in advance of the CTD work, and is likely to take a great deal of heavy weather. Even though the panel’s cover is in place during transit to the work area, it is suffering a great deal of corrosion, and a detachable unit would increase the reliability of the winch as a whole.

*Heated sheave wheel cheeks:* As in the previous two seasons, the sheave suffered from icing, causing the wheel to bind occasionally. This can be dangerous, as it occurs during heaving, and the line-out gauge becomes inaccurate. The result can be that the CTD frame is nearer to the surface than the winch driver expects. Either heating the cheeks, or re-engineering the sheave arrangement to increase the gap between cheeks and wheel would resolve the problem.

*Re-engineering remote box:* The remote unit is crucial to the operation of the winch. Its enclosure should, however, be made watertight. The two very large cables connecting the remote control to the winch main panel are particularly ungainly, which makes it difficult to keep the unit out of the weather. It would be very beneficial for the link to be made either wireless, or with less bulky cabling so that the remote unit can be more easily unplugged and brought inside when not in use.
Containerised wet lab

Description and configuration for the cruise

A 10-foot shipping container had been modified for use as a water bottle annex, or wet lab, for use on RRS Ernest Shackleton during the 2006-07 FOCAS cruise to the Weddell Sea. The same wet lab, dubbed the “CTD Shack”, was used during the present cruise. Rather than two container doors, the shack has a container-style cargo door and a personnel door. Along one wall there is a line of 12 pairs of clips to take Niskin bottles. The other wall is fitted with a bench. There is fluorescent lighting, a small convector heater, and a 240 V ship’s power supply point. A cable gland allows cable access to the Shack.

The shack was used to house the deck unit for the CTD and the CTD computer, for decanting water samples from the Niskin bottles (which had to be removed from the CTD rosette and carried inside), and to house the computer used to configure and download data from the LADCPs.

A telephone connected to the ship’s telephone system was installed, together with signal cabling to the EA600 precision echo-sounder on the bridge. Cabling was also installed to bring the CTD signal to the deck unit, and to connect the LADCP computer to the LADCP instruments between casts. Additional cabling was needed to connect a CCTV camera mounted on the exterior of the Shack to the camera controller and monitor inside.

The EA600 on the bridge combined a GPS feed and the picked depths from the echo sounder itself to form an NMEA output stream. That stream was converted to RS422 using an RS232 to RS422 converter, and then sent to the Shack using Cat5 cabling. In the Shack, another converter transformed the signal back to RS232, which was then presented to the CTD computer. The navigation program SeaClear II was installed on the CTD computer, and used to take and display the ship’s location and the water depth on a bathymetric chart. SeaClear echoed the NMEA data strings to the NMEA input on the CTD deck unit. This was necessary as the precision of the GPS position strings from the EA600 was too high for the deck unit: it appeared to reject them as erroneous data. Once echoed from SeaClear, however, the position data were correctly interpreted by the deck unit.

Comments and suggestions for improvements

The arrangement worked as well as could be expected, bearing in mind the need to dismount bottles from the rosette and carry them to the shack for drawing samples. To make the procedure safer and less onerous new 2.5 litre Niskins were purchased for this cruise. Ten-litre Niskins had been the smallest available for previous cruises.

Having a CCTV system was highly beneficial, giving confidence to the operator inside the (windowless) Shack that the winch is functioning properly, and providing a means of visual communication from the winch operator to the CTD operator. It also meant that, when space had been made available by the removal of the LADCP computer, the winch remote control could be brought into the shack, routing the cables through the cable gland. This arrangement removed the need for personnel on deck during the cast and worked well for the Marguerite Bay LTMS section.

Useful improvements would be:
1. Installation of shelving above the bench: this would help clear the bench of water sampling consumables, such as caps, labels etc. and could be easily achieved using Unistrut components.

2. Installation of an additional heater, or the replacement of the present one with a more powerful unit. During the colder nights, the present heater struggled to keep the shack at an acceptable temperature.

3. Installation of a suitable door arrestor. The one supplied with the shack never worked properly.

**CTD equipment**

*Description*

NMF-SS supplied the CTD fit for the cruise. The fit consisted of:

- stainless steel CTD frame;
- 24-way General Oceanics water bottle carousel, with the necessary battery pack;
- Seabird SBE 9 plus CTD, including 2x pumped CT channels and pressure sensor;
- Benthos altimeter;
- Seabird SBE 11 plus deck unit, plus CTD computer and UPS.

The BIAC team supplemented the CTD system with a pair of 300kHz RDI LADCPs, which the ship’s engineering department mounted on the CTD frame.

*Performance*

NMF-SS were unable to supply any spare sensors or pumps. Fortunately, both TC sensor pairs performed well, although the derived salinity from both showed a large offset from the salinometry (see salinity section below). The initial SASSI CTD section showed very noisy CT data from the primary channel. This was traced to a damaged pump rotor, but the pump worked flawlessly once the shards of rotor had been removed.

With the exception of its reluctance to process the GPS data direct from the EA600 NMEA stream, the deck unit worked perfectly throughout the cruise, the UPS was of great value, and the performance of the NMF-SS-supplied computer was impressive, certainly compared with the PC that had been taken along as a backup.

The Benthos altimeter worked reasonably well: the worst case was a first bed return at a range of 27 m. When the CTD was stripped down at the end of the cruise, the pins on the altimeter plug showed evidence that there had been leaking during the cruise.

For work in cold climates the General Oceanics carousel should be avoided. In fact, if there is a likelihood of encountering freezing conditions the GO carousel is not a practical option. Many delays were caused by freezing up of the pins that need to be depressed to engage the lanyards when cocking bottles. A hair-drier had to be brought out on deck routinely to defrost the top of the carousel. On the other hand, the alkaline battery pack needed to power the GO rosette gave no trouble throughout the cruise, despite the cold conditions.

*Water sampling*

The particular Niskins that BAS purchased for the cruise had internal neoprene elastic to close the caps. A particular problem found using these bottles was that if they remained cocked for a few hours in cold conditions the neoprene did not return to its original length. At one point the lower cap on some of the bottles was hanging loosely. Clearly metal
springs would have been more satisfactory. Poor closure accounted for several bad water samples until the problem was identified.

To obtain samples, the Niskins needed to be removed from the rosette and brought into the shack. The biggest problem encountered was ice in the samples. Once ice had formed, it is not possible to get a good sample for salinometry. In some cases, the problem was only icing in the spigots, in which case a good sample could be obtained once the spigot had thawed out.

Samples were drawn for salinity determination and/or $\delta^{18}$O measurements. When full, crates of salinity samples were moved from the shack to the Wet Lab, where the NMF-SS Autosal had been installed. After a minimum of a day of acclimatizing, the salinity samples were run using standard procedures. The Autosal worked well, except for the failure of the cabinet cooling fan in the back panel. The panel was removed, and the salinometer temperature stabilized at a satisfactory level.

Salinities derived from the CTD system showed large offsets (~0.01) from the results of the salinometry. The large scatter seen in the comparison with salinometry (Figure B1) initially suggested that sampling technique was at fault. However, the scatter was later ascribed to difficulty with sampling in icing conditions, and faulty Niskin cap closures. Comparison with historical data supported the theory that there was a real offset in the conductivity sensors, despite the good agreement between the sensors themselves. Post-cruise calibrations showed no significant change since the calibrations undertaken during the summer prior to the cruise (2008). A similar effect was seen with different sensors, though the same models, during the 2006-07 cruise to the southern Weddell Sea.

**LADCP**

LADCPs were installed on the water bottle rosette on 25/01/2009. The Slave was upward-looking (SN 10012), the Master was downward-looking (SN 10151). They were connected using a co-axial cable fitted for two ADCPs. Filenames for the data were named ES033_XXX_LADCPS.000 for slave, where XXX is the CTD station number.

The LADCPs were connected using a star-cable. The upward-looking Slave did not record during the first cast as a result of a software error, but worked properly from the second cast until one of its beams broke during cast 049. It was deployed until cast 059 when this malfunction was detected. Upon inspection of SN10012, after cast 59, corrosion due to leakage through transducer 1 was detected and photographed prior to cleaning.

At this point the master ADCP was also removed from the rosette, reserved for deployment at the BIAC sites. The master ADCP was re-installed prior to cast 087 and used for the remainder of the cruise.

For data processing, the NMEA latitude/longitude stream was recorded with each scan of the accompanying CTD profiles, which were later 1-s bin-averaged to match the LADCP data.

Following cast 025, at the same station location, seal-tags were attached to the rosette and 4 yo-yo casts were conducted, recorded in cast 026. For processing purposes, the original file was divided into subsections, one file for each down-up cast of the yo-yo cycle, using BBSub.exe from the RDI Tools. The new files, in raw format, are saved as 2601, 2602, 2603, and 2604, with the last figure corresponding to the cast number.
The setup files for the LADCPs are given in Appendix A

**Microstructure profiling**

The microstructure profiling was part of the Norwegian BIAC project. The equipment was the Vertical Microstructure Profiler (VMP-2000, SN 009) from Rockland Scientific International, which comprises the profiler itself, a winch, and a line puller mounted at the stern railings. In a normal configuration, a sheave is mounted between winch and line puller. During this cruise, because of the low headroom beneath the helideck, a sheave was arranged outboard of the line puller (see cover picture for configuration). This worked fine, with no evidence of signal contamination that would have resulted from a taut suspension tether.

The instrument is rated for 2000 m depth. It is a free-falling tethered instrument with power supplied to the instrument via the tether cable. Data are transmitted in real-time up the tether cable. From the slip rings on the winch, the signal/power cable ran via a cable gland into an interface and computer in the Wet Lab and displayed and logged on a Dell XPS M1330 laptop PC (winXP) with a UTRANS (Universal Serial Bus Transceiver) attached to the USB port and ODAS4-RT data acquisition software.

The VMP consists of a main pressure case machined for mounting accessories and sensors, a nose cone for fitting the microstructure sensors, and a fin attached at the rear. Fully assembled, its length is about 2.3 m, and its weight approximately 45 kg in air and 6 kg in water. VMP SN009 has a nominal fall rate of about 60 cm s\(^{-1}\) (about 10 cm s\(^{-1}\) slower than standard VMPs). The drag brushes, flotation, cable termination and a Sea-Bird SBE5 pump are mounted on the fin.

The main pressure case contains a set of three orthogonally mounted accelerometers for measuring profiler attitude (tilt) and profiler vibration levels in x/y/z coordinates and a pressure transducer (Kelley). Also housed in the pressure case is the electronics for signal conditioning, A/D conversion, data transmission and anti-aliasing filters. Up to six turbulence sensors can be mounted on the nose cone, protected by a probe guard. For this cruise the VMP was fitted with two air-foil shear probes, one FP07 fast-thermistor and a Sea-Bird SBE7 micro-conductivity probe.

A pair of Sea-Bird SBE-3 temperature and SBE-4 conductivity sensors provided precision CTD measurements, and are mounted on the pressure tube about 40 cm from the microstructure sensors. Signal-plus-signal-derivative were sampled on thermistors, micro-conductivity and pressure transducer (Mudge-Lueck technique), and the signal derivative from the shear probes. The set up file for the VMP is listed in Appendix F.

The VMP was deployed using a winch system manufactured by Sytech Research, Canada consisting of a winch that is directly driven by a hydraulic motor, a line-puller that continuously feeds the tether into the water and an electrically driven hydraulic pump that supplies hydraulic fluid to run the winch and line puller. The winch and line-puller system was specifically designed to operate the VMP and ensures that enough tether is fed into the ocean to maintain free-fall. The drum is fitted with 2500 m of 0.27" diameter cable.

Three personnel were required to run the system: one to run the PC and pass instructions to the winch operator, the winch operator himself and an additional person to watch the tether over the stern.
Profiling in sea ice was challenging. For most casts the ship was positioned in a pool of open water, the azimuthal thruster lowered and the propeller declutched, and the vessel moved slowly forwards. This removed any danger of the VMP tether becoming entwined in the propeller. However, the procedure became awkward if the ice was moving rapidly. The low temperatures caused icing of the outboard sheave and the sheaves in the line puller. The line puller sheaves in particular needed to be mechanically de-iced between each cast.

**Mooring activities**

Mooring activities were a major part of the cruise, with most discrete projects having significant mooring components. The SASSI mooring array was prepared in the main cargo hold; the Norwegian BIAC array was prepared mainly on the helideck, with instruments being prepared in the dry lab; the CORC-ARCHES/BAS LTMS moorings were assembled on the afterdeck, with instruments being prepared in the wet lab. Mooring diagrams are given in Appendix D.

**M2 and M3**

Moorings M2 and M3 in the northern Weddell Sea (see Figure Map) are the two remaining moorings from the CORC-ARCHES northern Weddell array. These were last recovered and redeployed during ES031, in 2007. Unfortunately, only M2 was recovered this year; neither of the two paired releases on M3 responded to the acoustic command unit. M2 was recovered on the southbound leg of the cruise. This gave BH the opportunity to service the instruments and download the memory modules. On the northbound leg, towards the end of the cruise, a new M3 mooring was constructed and deployed, together with a much reduced version of M2.

**SASSI moorings**

The shallowest SASSI moorings, SASSI1, 2, 3 and 4, were deployed on the southbound leg of the cruise. SASSI 5 was deployed on the way north. The location of the mooring line is shown in the map in Figure 1.

**Coast Mooring**

Coast Mooring was deployed off the Luitpold Coast (south west of Brunt Ice Shelf) during ES031 in 2007. The acoustic release on the mooring responded to the command unit but did not arrive at the surface after the release was triggered. The mooring was only 10 m or so in height, but was in only about 200 m of water. Following CG’s advice, a line was rigged in a U shape, from the stern of the ship to the bow with 50-ton shackles used as weights to maintain the shape of the U. The ship was then slowly thrust over the site of the mooring, which then popped to the surface. We assume the acoustic release’s hook had jammed in the release ring.

**S2 and New S2**

At the location of S2 the ice was moving relatively quickly, although there was an open pool available for the recovery of the mooring. Again, the release responded to the acoustic command unit and the release command was sent. But, again, the mooring failed to surface. We assume that the hook has again jammed in the release ring. The mooring was too deep to dredge with the line that was available and had to be left.
The new S2 bottom frame consisted of RDCP 600 SN 240, RCM-9, SN 1437 and Argos SN/id 266/46244, and was released on 04/02/2009 1400 UTC, at 74° 39.05' S, 033° 32.97' W where ship’s echo sounder read 602 m. The host modem communication set-up is

Baud rate 57600
Data bit 8
Parity None
Stop bit 1
Flow control None

The frame was lowered attached with an acoustic release to ~550 m wire, and was released about 20 m above the bottom. Diagnostics of the frame release confirmed that the release was in upright orientation. Communication with the remote modem was established and the first data files were retrieved from the RDCP600. The frame release is an Ixsea Oceano type, SN 982 with codes:

Arm/range: 18C5
Diagnostic: Arm + 1849
Release: Arm + 1855

**S4 and S4 East**

S4 and S4E were deployed during ES031. They were visited during this cruise, and the acoustic releases responded appropriately. Heavy sea ice meant that we did not attempt to recover the moorings.

**BIAC moorings**

The BIAC moorings could not be deployed in the planned plume location as a result of the difficult sea ice conditions. Instead they were installed on the central Crary Fan and further to the east.

**BIAC M1**

M1 is deployed anchor first, on 10022009 1739UTC, at 74° 13.681’ S, 032° 19.194’ W. Echo depth was 1096 m, corrected 1070 m and 1081 dbar. Release is AR261 SN:50 with codes, INT: 9636, REL: 9635.

The knot attaching a gash nylon rope to the top of the mooing for the final part of the deployment came undone, which meant that the final part of the release was not fully controlled.

**BIAC M2**

Anchor-first deployment of the original M2 was not successful. Halfway through the deployment a 100 m Kevlar line broke in the middle. The line was loaded with about 660 kg anchor weight and parted on 11/02/2009 at 0140 UTC, at 73° 58.9’ S, 032° 24.5’ W (echo depth 1887 m) before any flotation elements were attached to the line. The following instruments were lost: AR191 SN006 Acoustic release; SBE37s SN 5399 / 5450 / 5407; SBE39s SN 3567 / 3568; RCM7 SN 3651; Aquadopp 1.2kHz SN 0649.

Using the remaining instruments and mooring material, a shortened mooring was designed and deployed successfully. M2 was deployed, anchor last, on 11/02/2009 at 1806 UTC, at
73° 58.678′S 032° 16.682′W. Echo depth was 1960 m, corrected to 1913 m and 1940 dbar. Release used is AR661 SN:264 (INT: 9170; REL: 9179).

The Kevlar line that parted on M2 had been used on an unknown number of moorings in the past, and might have suffered damage. The suspicion therefore fell on the line itself. However, anchor-first deployments with reused Kevlar line are routine on Norwegian ships, and free of incidents. It is therefore possible that some responsibility might lie with the methods used in the deployment: the lack of equipment on the Shackleton makes anchor-first an awkward technique.

**BIAC M3**

Deployed anchor last. 13/02/2009 1627 UTC, 74° 30.633′S 030° 09.906′W, Echo depth 753 m, corrected 728 m, 735 dbar.


**BIAC M4**

Deployed anchor last. 13/02/2009 at 1237 UTC, 74° 26.278′S 030° 02.639′W, Echo depth 1092 m, corrected 1059 m, 1071 dbar.


**BIAC M5**

Deployed anchor last. 12/02/2009 2242 UTC, 74° 10.15′S 029° 32.60′W, Echo depth 1976 m, corrected 1928 m, 1956 dbar.


**Slope North and Slope South**

The ship visited the locations of these moorings on two occasions, but nothing was heard from either acoustic release.

**Orkney Passage moorings**

OP3 and OP2 were recovered from Orkney Passage. Unfortunately, there was no response from OP1, the shortest and deepest of the OP moorings. Several hours were spent gridding the area, attempting to contact the acoustic release, but to no avail. OP2 and 3 were redeployed. OP3, the furthest up the slope, was reset at its original location. Based on a detailed CTD/LADCP section, OP2 was reset a little further down the slope.

**Seal tagging**

**Introduction**

Four Weddell seals were tagged during ES031. The tags were SMRU SRDLs, with a CTD head of manufactured by Valeport. The success of the deployments in 2007 prompted a further campaign during ES033.

Six new tags were supplied by BAS, and a further four, rebatteried tags were supplied by Dan Costa’s group from UC Santa Cruz. PR, from UC Santa Cruz, managed the tagging work. All ten tags were successfully attached to seals of a variety of age and size, male and female.
**Calibration check**

A board was constructed on which all ten tags could be mounted and attached to the CTD frame for CTD cast 026. The sea floor pressure was 538 dbar. The water column was profiled five times, with the frame not being brought out of the water between casts.

Inspection of the data from the tags showed that the C and T sensors on one of the rebatteried devices had failed. This tag was finally deployed with a behavioural program, and not the program generally used for CTD tags.

**Method**

The capture methods used by PR were slightly different to those used on ES031. Once the candidate seal had been sighted, the ship manoeuvred up to the floe and the team were deposited on the ice using a Wor Geordie. Guided by radio from the bridge, the team found the seal, and two personnel worked their way around to distract the animal while PR prepared an intramuscular dose of Zoletil. Once injected, the drug took around 20 minutes to take effect, when the animal could be approached and, if necessary, a netting head bag applied. An intravenous needle was set, in case more drugs were needed to keep the animal sedated during the procedure. Ketamine was administered as required.

Girth and length measurements were made and the tag was attached using Araldite. Most tags were attached to the upper neck of their host seal (Figure 3a). A particular problem encountered this season was that most of the seals had not completed their moult. They moult first on the top of the head, the moult continuing in a line down the back and spreading sideways across their shoulders and back. The tags could therefore be attached quite early in the moult process. However, the early loss of some of the tags suggested that they had detached, presumably as a result of the state of moult, the positioning of the tags, or some problem with the gluing procedure. The one tag (10613) positioned to the top of the head of a particularly poorly moulted animal (Figure 3b) remained attached throughout the winter.

![Figure 3.](Image) (a) Upper picture – tag 10858, positioned on upper neck. (b) Lower picture – tag 10613, positioned on top of head.
Deployment of sea ice drifters

While in the south western Weddell Sea three sea ice drifters were deployed for a SAMS study. The drifters were deployed between 1100 and 1400, 18th February 2009, on three neighbouring ice floes at about 75° 36’.2S, 029° 52’.0W (in the vicinity of CTD station ES033-137). Two drifters were still operational as of 29 October 2009.

The drifters each had a temperature sensor chain. Chain J was deployed in ice 103.5 cm thick, covered by 8 cm snow. Sensor 29 was at the top of the snow, with sensors 31 to 40 on the ice. Chain I was deployed on ice 159.5 cm thick, with no snow covering, with sensors 22 to 29 on the ice. Chain H was deployed in ice 138.5 cm thick, with a 6 cm covering of snow. Sensor 23 was at the snow surface, with sensors 25 to 32 on the ice.

Acknowledgements

The science team are deeply indebted to the officers and crew of RRS Ernest Shackleton for their enthusiastic support throughout the cruise. Particular thanks go to the engineering department, which expended a lot of effort on various projects connected with the science work. Excellent food from the cooking staff helped maintain spirits; support and professionalism from Captain Harper’s bridge team meant a great deal was accomplished; and the deck personnel demonstrated great ingenuity in utilising the ship’s equipment to perform some unaccustomed mooring tasks.
Appendix A. Setup files for LADCPs

**Master LADCP setup file:**

```plaintext
; Append command to the log file: "C:\Fer\ES033\ladcp\Mladcp.log"
$1C:\Fer\ES033\ladcp\Mladcp.log
SP ;
SP $P
SP ******* LADCP Master. Looking down************
SP * Master and Slave will ping at the same time
SP **********************************************
; Send ADCP a BREAK
$B
; Wait for command prompt (sent after each command)
$W62 ;**Start**
; Display real time clock setting
tt?
$W62 ; Set to factory defaults
CR1 $W62
; use WM15 for firmware 16.3
WM15 $W62
; Save settings as User defaults
CK $W62
; Name data file
RN MLADCP $W62
; Set transducer depth to zero
ED0000 $W62
; Set salinity to 35ppt
ES35 $W62
; System coordinate.
ex11111 $W62
; Set as MASTER ADCP
SM1 $W62
; TRANSMITS SYNCHRONIZING PULSE BEFORE EACH WATER PING
SA0001 $W62
; SYNCHRONIZING PULSE SENT ON EVERY PING
SI0 $W62
; WAIT 75 MILLISECONDS
ST75 $W62
; Set one ensemble/sec
TE00000010 $W62
; Set one second between pings
TP000010 $W62
; Set LADCP to output Velocity, Correlations, Amplitude, and Percent Good
LD111100000 $W62
; Set one ping per ensemble. Use WP if LADCP option is not enabled.
LP1 $W62
; Set to record 25 bins. Use WN if LADCP option is not enabled.
LN25 $W62
; Set bin size to 400 cm. Use WS if LADCP option is not enabled.
LS400 $W62
; Set blank to 176 cm (default value) Use WF if LADCP option is not enabled.
LF0176 $W62
; Set max radial (along the axis of the beam) water velocity to 170 cm/sec.
; Use WY if LADCP option is not enabled.
LY170 $W62
; Set ADCP to narrow bandwidth and extend range by 10%
LW1 $W62
; Set to use a fixed speed of the sound
EZ0111111 $W62
; Set speed of sound value. 1500 m/sec is default.
EC1500 $W62
; Heading alignment set to 0 degrees
EA00000 $W62
; Recording adjustment to 0 degrees
EB00000 $W62
; Record data internally
CF11111 $W62
; Save set up
CK $W62
; Start pinging
CS $W62
; Delay 3 seconds
$D3 $p
; Please disconnect the ADCP from the computer.
$P
; Close the log file
$1
; Exit BBTalk
$X

**Slave LADCP setup file:**

```plaintext
; Append command to the log file: "C:\Fer\ES033\ladcp\Sladcp.log"
$1C:\Fer\ES033\ladcp\Sladcp.log
SP ;
SP $P
SP ******* LADCP Slave. looking up ************
SP ; Send ADCP a BREAK
$B
; Wait for command prompt (sent after each command)
$W62 ;**Start**
; Display real time clock setting
tt?
$W62 ; Set to factory defaults
CR1 $W62
; use WM15 for firmware 16.3
WM15 $W62
; Save settings as User defaults
CK $W62
; Name data file
RN SLADCP $W62
; Set transducer depth to zero
ED0000 $W62
; Set salinity to 35ppt
ES35 $W62
; System coordinate.
ex11111 $W62
; LISTENS FOR SYNCHRONIZING PULSE BEFORE EACH WATER PING
SA0001 $W62
; WAIT UP TO 300 SECONDS FOR SYNCHRONIZING PULSE
ST300 $W62
; Set ADCP to narrow bandwidth and extend range by 10%
LW1 $W62
; Set to use a fixed speed of the sound
EZ0111111 $W62
; Set speed of sound value. 1500 m/sec is default.
EC1500 $W62
; Heading alignment set to 0 degrees
EA00000 $W62
; Recording adjustment to 0 degrees
EB00000 $W62
; Record data internally
CF11111 $W62
; Save set up
CK $W62
; Start pinging
CS $W62
; Delay 3 seconds
$D3 $p
; Please disconnect the ADCP from the computer.
$P
; Close the log file
$1
; Exit BBTalk
$X
```
; Set one ensemble/sec
TE00000100
$W62
; Set one second between pings
TP000100
$W62
; Set LADCP to output Velocity, Correlations, Amplitude, and Percent Good
LD111100000
$W62
; Set one ping per ensemble. Use WF if LADCP option is not enabled.
LP1
$W62
; Set to record 25 bins. Use WN if LADCP option is not enabled.
LN025
$W62
; Set bin size to 400 cm. Use WS if LADCP option is not enabled.
LS400
$W62
; Set blank to 176 cm (default value) Use WF if LADCP option is not enabled.
LF0176
$W62
; Set max radial (along the axis of the beam) water velocity to 170 cm/sec.
; Use WV if LADCP option is not enabled.
LV170
$W62
; Set ADCP to narrow bandwidth and extend range by 10%
LM1
$W62
; Set to use a fixed speed of the sound
EZ0111111
$W62
; Set speed of sound value. 1500 m/sec is default.
EC1500
$W62
; Heading alignment set to 0 degrees
EA00000
$W62
; Heading bias set to 0 degrees
EB00000
$W62
; Record data internally
CF11101
$W62
; Save set up
CK
$W62
; Start pinging
CS
; Delay 3 seconds
SD3
$P
***********************************************
$P Please disconnect the ADCP from the computer.
$P ***********************************************
; Close the log file
$X
; Exit BBTalk
;X

Single LADCP setup file

; Append command to the log file:
"C:\Per\ES033\adcp\Oneladcp_log.txt"
$2C:\Per\ES033\adcp\Oneladcp_log.txt
; $P
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
$P Please, disconnect the ADCP from the computer.
$P %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
; Close the log file
$X
; Exit BBTalk
;X

; Set to factory defaults
CR1
$W62
; use WW15 for firmware 16.3
WW15
$W62
; Save settings as User defaults
CK
$W62
; Name data file
RN MLADCP
$W62
; Set transducer depth to zero
ED0000
$W62
; Set salinity to 35ppt
ES35
$W62
; Set system coordinate.
EX11111
$W62
; Set one ensemble/sec
TE00000100
$W62
; Set one second between pings
TP000100
$W62
; Set LADCP to output Velocity, Correlations, Amplitude, and Percent Good
LD111100000
$W62
; Set one ping per ensemble. Use WP if LADCP option is not enabled.
LP1
$W62
; Set to record 25 bins. Use WN if LADCP option is not enabled.
LN025
$W62
; Set bin size to 400 cm. Use WS if LADCP option is not enabled.
LS400
$W62
; Set blank to 176 cm (default value) Use WF if LADCP option is not enabled.
LF0176
$W62
; Set max radial (along the axis of the beam) water velocity to 170 cm/sec.
; Use WV if LADCP option is not enabled.
LV170
$W62
; Set ADCP to narrow bandwidth and extend range by 10%
LM1
$W62
; Set to use a fixed speed of the sound
EZ0111111
$W62
; Set speed of sound value. 1500 m/sec is default.
EC1500
$W62
; Heading alignment set to 0 degrees
EA00000
$W62
; Heading bias set to 0 degrees
EB00000
$W62
; Record data internally
CF11101
$W62
; Save set up
CK
$W62
; Start pinging
CS
; Delay 3 seconds
SD3
$P
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
$P Please disconnect the ADCP from the computer.
$P %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
; Close the log file
$X
; Exit BBTalk
;X
Table of CTD stations, showing station number, date, latitude and longitude, corrected EA600 depth (m), and the maximum depth and pressure of the cast (m and db respectively).

<table>
<thead>
<tr>
<th>Station</th>
<th>Date</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Corrected EA600 Depth (m)</th>
<th>Maximum Depth (m)</th>
<th>Maximum Pressure (db)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>03 Feb 2009</td>
<td>57.47</td>
<td>19.82</td>
<td>34.43</td>
<td>44.18</td>
<td>27.48</td>
</tr>
<tr>
<td>02</td>
<td>02 Feb 2009</td>
<td>57.50</td>
<td>19.85</td>
<td>34.43</td>
<td>44.18</td>
<td>27.48</td>
</tr>
<tr>
<td>03</td>
<td>03 Feb 2009</td>
<td>57.47</td>
<td>19.82</td>
<td>34.43</td>
<td>44.18</td>
<td>27.48</td>
</tr>
<tr>
<td>04</td>
<td>02 Feb 2009</td>
<td>57.50</td>
<td>19.85</td>
<td>34.43</td>
<td>44.18</td>
<td>27.48</td>
</tr>
<tr>
<td>05</td>
<td>03 Feb 2009</td>
<td>57.47</td>
<td>19.82</td>
<td>34.43</td>
<td>44.18</td>
<td>27.48</td>
</tr>
<tr>
<td>06</td>
<td>02 Feb 2009</td>
<td>57.50</td>
<td>19.85</td>
<td>34.43</td>
<td>44.18</td>
<td>27.48</td>
</tr>
</tbody>
</table>

Appendix B. CTD stations, bottle data and CTD configuration.
<table>
<thead>
<tr>
<th>Station</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Time (UTC)</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Wind Speed</th>
<th>Wind Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>39.347</td>
<td>-76.941</td>
<td>01 March 2009 11:30:39</td>
<td>10.5</td>
<td>84%</td>
<td>12</td>
<td>245</td>
</tr>
<tr>
<td>002</td>
<td>39.347</td>
<td>-76.941</td>
<td>01 March 2009 11:30:39</td>
<td>10.5</td>
<td>84%</td>
<td>12</td>
<td>245</td>
</tr>
<tr>
<td>003</td>
<td>39.347</td>
<td>-76.941</td>
<td>01 March 2009 11:30:39</td>
<td>10.5</td>
<td>84%</td>
<td>12</td>
<td>245</td>
</tr>
<tr>
<td>004</td>
<td>39.347</td>
<td>-76.941</td>
<td>01 March 2009 11:30:39</td>
<td>10.5</td>
<td>84%</td>
<td>12</td>
<td>245</td>
</tr>
<tr>
<td>005</td>
<td>39.347</td>
<td>-76.941</td>
<td>01 March 2009 11:30:39</td>
<td>10.5</td>
<td>84%</td>
<td>12</td>
<td>245</td>
</tr>
<tr>
<td>006</td>
<td>39.347</td>
<td>-76.941</td>
<td>01 March 2009 11:30:39</td>
<td>10.5</td>
<td>84%</td>
<td>12</td>
<td>245</td>
</tr>
<tr>
<td>007</td>
<td>39.347</td>
<td>-76.941</td>
<td>01 March 2009 11:30:39</td>
<td>10.5</td>
<td>84%</td>
<td>12</td>
<td>245</td>
</tr>
<tr>
<td>008</td>
<td>39.347</td>
<td>-76.941</td>
<td>01 March 2009 11:30:39</td>
<td>10.5</td>
<td>84%</td>
<td>12</td>
<td>245</td>
</tr>
<tr>
<td>009</td>
<td>39.347</td>
<td>-76.941</td>
<td>01 March 2009 11:30:39</td>
<td>10.5</td>
<td>84%</td>
<td>12</td>
<td>245</td>
</tr>
<tr>
<td>010</td>
<td>39.347</td>
<td>-76.941</td>
<td>01 March 2009 11:30:39</td>
<td>10.5</td>
<td>84%</td>
<td>12</td>
<td>245</td>
</tr>
</tbody>
</table>

Table of station number, rosette position, pressure and differences from salinometry for primary and secondary CTD channels.
Figure B1. Discrepancies from salinometry for primary (black) and secondary (grey) CTD channels, outliers excluded. Note lower scatter later in cruise when conditions were warmer.
Station number, Bottle number, pressure, calibrated salinity and in situ temperature for each delta-18O sample.
Table showing the CTD configuration, which remained constant throughout the cruise.

<table>
<thead>
<tr>
<th>Channel</th>
<th>Sensor</th>
<th>Serial number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (F)</td>
<td>Temperature (primary)</td>
<td>4593</td>
</tr>
<tr>
<td>2 (F)</td>
<td>Conductivity (primary)</td>
<td>2165</td>
</tr>
<tr>
<td>3 (F)</td>
<td>Digiquartz pressure with TC</td>
<td>100898</td>
</tr>
<tr>
<td>4 (F)</td>
<td>Temperature (secondary)</td>
<td>4383</td>
</tr>
<tr>
<td>5 (F)</td>
<td>Conductivity (secondary)</td>
<td>2164</td>
</tr>
<tr>
<td>6 (A/D)</td>
<td>Free</td>
<td></td>
</tr>
<tr>
<td>7 (A/D)</td>
<td>Altimeter</td>
<td>874</td>
</tr>
</tbody>
</table>
Appendix C. Selected preliminary sections

*CTD stations for moorings and CTD sections*

(The positions of Sections A to L are shown in Figure 2)

<table>
<thead>
<tr>
<th>Section/mooring</th>
<th>Station numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2 (recover)</td>
<td>1</td>
</tr>
<tr>
<td>SASSI section 1</td>
<td>2 – 5</td>
</tr>
<tr>
<td>SASSI 1600</td>
<td>2</td>
</tr>
<tr>
<td>SASSI 973</td>
<td>3</td>
</tr>
<tr>
<td>SASSI 487</td>
<td>4</td>
</tr>
<tr>
<td>SASSI 273</td>
<td>5</td>
</tr>
<tr>
<td>SASSI section 2</td>
<td>138 – 144</td>
</tr>
<tr>
<td>SASSI 2600</td>
<td>142</td>
</tr>
<tr>
<td>A Filchner</td>
<td>6 – 31</td>
</tr>
<tr>
<td>B Southern ridge</td>
<td>32 – 40, (50)</td>
</tr>
<tr>
<td>C Northern ridge</td>
<td>41 – 46</td>
</tr>
<tr>
<td>D Slope 1 (shallow)</td>
<td>47 – 58</td>
</tr>
<tr>
<td>E Slope 3</td>
<td>59 – 67</td>
</tr>
<tr>
<td>F Slope 6</td>
<td>68 – 78</td>
</tr>
<tr>
<td>G Slope 4</td>
<td>79 – 86</td>
</tr>
<tr>
<td>H Mid fan</td>
<td>90, 91, 89, 92, 93, 87, 88</td>
</tr>
<tr>
<td>I Slope 1 (deep)</td>
<td>94 – 101</td>
</tr>
<tr>
<td>J Slope 7</td>
<td>102 – 107</td>
</tr>
<tr>
<td>K Slope 5</td>
<td>116 – 123</td>
</tr>
<tr>
<td>L Slope 2</td>
<td>124 – 126, 135 – 137, 127, 128, 129</td>
</tr>
<tr>
<td>M3 (deploy)</td>
<td>145</td>
</tr>
<tr>
<td>M2 (deploy)</td>
<td>146</td>
</tr>
<tr>
<td>Orkney Passage</td>
<td>162 – 147, 163 – 166</td>
</tr>
<tr>
<td>Marguerite Trough</td>
<td>167 - 175</td>
</tr>
</tbody>
</table>
Section A
Section B

Section C
Section D

SASSI sections
Orkney Passage Section
Appendix D. Instrument notes and mooring diagrams

M2 (as deployed)

ES033  Mooring M209xx  Deployed

Target Depth
2818 m  McLane Float
2828 m  McLane Float-2
2834 m  SBE39 T 0084
2955 m  SBE39 T 0113
3075 m  Microcat T,C 0753
3081 m  RCM8 9924
3083 m  McLane Float-3
3087 m  8242 release 25181
3096 m  anchor 250 kg

Date/Time (GMT) 28 Feb 09 0303  Actual Depth 3092 m (uncorr)
Anchor drop:  Lat S 62 37.116’  Lon W 043 15.006’
### M3 (as deployed)

ES033  Mooring M309xx  Deployed

<table>
<thead>
<tr>
<th>Depth</th>
<th>Element</th>
<th>Serial Number</th>
<th>Distance between elements</th>
<th>Wire marker</th>
<th>Line length/ type</th>
</tr>
</thead>
<tbody>
<tr>
<td>4023 m</td>
<td>McLane Top w/ radio ch 71</td>
<td>J05-055</td>
<td></td>
<td>srs</td>
<td>poly rope, 10 m</td>
</tr>
<tr>
<td></td>
<td>156.575 MHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4034 m</td>
<td>17” glass x 2 on 2 m 3/8” chain</td>
<td></td>
<td></td>
<td>srs</td>
<td>poly rope, 10 m</td>
</tr>
<tr>
<td>4041 m</td>
<td>Aquadopp 6k</td>
<td>2317</td>
<td></td>
<td>srs</td>
<td>poly rope, 10 m</td>
</tr>
<tr>
<td>4087 m</td>
<td>Microcat T,C,P</td>
<td>1351</td>
<td></td>
<td>srs</td>
<td>poly rope, 10 m</td>
</tr>
<tr>
<td>4213 m</td>
<td>SBE39 Trec</td>
<td>0083</td>
<td></td>
<td>srs</td>
<td>poly rope, 10 m</td>
</tr>
<tr>
<td>4288 m</td>
<td>17” glass x 2 on 2 m 3/8” chain</td>
<td></td>
<td></td>
<td>srs</td>
<td>poly rope, 10 m</td>
</tr>
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<td>4315 m</td>
<td>SBE39 T,P</td>
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<td>Aquadopp 6k</td>
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<tr>
<td>4545 m</td>
<td>17” glass x 5 on 4.7 m 1/2” chain</td>
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<td>4551 m</td>
<td>8242 release(2)</td>
<td>33147</td>
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<td>Srs</td>
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<td>4560 m</td>
<td>anchor 250 kg</td>
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<td></td>
<td>Srs</td>
<td>1/2” chain</td>
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</tbody>
</table>

Date/Time (GMT)  27 Feb 09 1804  Depth  4583 m (uncorr)

Anchor drop:  Lat S  63 31.449’  Lon W 041 46.115’  (48.115’?)

Notes:  radio duty cycle: 2 s on, 4 off
BIAC Moorings (as deployed)

M1 1100m BIAC Weddell

Chain 11mm 4m

170m a.b. SBE39 no.: 3261 (3m below flotation)
Kevlar 20m (2x10)

150m a.b. Microcat no.: 5448

8x17" Glass spheres (SAMS)

Kevlar 40m

110m a.b. Uploading ADCP no.: 10146

100m a.b. SBE39 no.: 3566

75m a.b. Microcat no.: 5398

Kevlar 35m

Aquadopp no.: AQD 0646

50 m.a.b. Kevlar 25m

25m a.b. RCM-7 no.: 1686

Kevlar 15m

10 m.a.b. Microcat no.: 5397

Kevlar 5m

OCEANO (AR281, 14 Alg, C-cells, 2 lithium 9v)

Nylon 20mm 3m

Chain 11mm 2m

Anchor 700kg (2 wheels)

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Geophysical Institute

Project: BIAC Weddell sea/R.R.S. E.Shackleton
Area: M1
Position: 74°13.661’S 032°19.194’W
Time for deployment: 10. Feb 2009 17:39 UTC
Echo depth: 1096m, corrected 1070m, corrected pressure 10816dbar
Comment: Deployed with anchor first, 20 m. 10mm nylon at top flotation.
M2S 1900m BIAC Weddell

Chain 11mm 3m

170 m.a.b. Downlooking ADCP sn.: 11434

120 m.a.b. Microcel no.: 5452

Kevlar 150m

70 m.a.b. SBE59 sn.: 3571

20 m.a.b. 2x17" Glass spheres weddygrip

ROM-7 sn.: 12313

Kevlar 15m

IXSEA OCEANO (AR661; 18D-cell alkaline)

sn.: 264

Recharge: 9170

Nylon 20mm 2m

Chain 11mm 3m

Anchor 350kg (one wheel)

Project: BIAC Weddell sea 2009/R.R S.E. Shackleton

Area: M2S (shortened), Weddell sea

Position: 73°58.678'S 93°22'16.682''W

Time for deployment: 11 Feb 2009 18:00 UTC

Echo depth: 1960m, corrected 1913m corrected pressure 1940dB

Comment: Shortened version of the original (partly lost) M2 mooring. Release (from S. Østerhus), serviced with alkaline D-cells (10pcs) and 9v batt. Deployed with anchor last.
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Project: BIAC Weddell seas 2009/R.R.S. E. Shackleton
Area: M3
Position: 74°30.633's 030°09.906'w
Echo depth: 753m, corrected 729m, pressure 735dbar
Comment: Anchor last deployment, 5m nylon for recovery. Parts of rotation borrowed from SAMS/NERC.

M3 750m BIAC Weddell

Chain 13mm 3m
350 m.a.b.
Microcat sn.: 5448

Kevlar 50m
300 m.a.b.
Continental sn.: 6103

Kevlar 100m
250 m.a.b.
SBE39 sn.: 3576

Kevlar 50m
200 m.a.b.
Down locking ADCP sn.: 10149

Kevlar 50m (2x25m)
150 m.a.b.
Microcat sn.: 5447

Kevlar 75m
125 m.a.b.
SBE39 sn.: 3569

Kevlar 75m
100 m.a.b.
SBE39 sn.: 3570

Microcat sn.: 5446

Kevlar 50m
75 m.a.b.

Kevlar 15m
3 x 17' Glass spheres
25 m.a.b.
RCM-7 sn.: 6798

Kevlar 5m
10 m.a.b.
Microcat sn.: 5408

Nylon 20mm 3m
5 m.a.b.
IXSEA OCEANO 2500 (18 lithium D-cells)

Chain 13mm 3m
Anchor 660kg (2 wheels)
M4 1100m BIAC Weddell

Longranger sn.: 8648
45° buoy

Kevlar 100m
300 m.a.b.
Microcat sn.: 8097

Kevlar 50m
250 m.a.b.
SBE39 sn.: 3252
2x17” Glass flotation

200 m.a.b.
Downloading ADCP sn.: 10150

175 m.a.b.
SBE39 sn.: 3683

Kevlar 50m
150 m.a.b.
Microcat sn.: 6106

100 m.a.b.
SBE39 sn.: 3572

Kevlar 75m
75 m.a.b.
Microcat sn.: 5401

Kevlar 25m

2x17” Glass flotation

25 m.a.b.
RCM-8 sn.: 9907

10 m.a.b.
Microcat sn.: 6018

Kevlar 20m
5 m.a.b.

IXSEA OCEANO 2500 (18 lithium D-cells)
No. 949
ARM/Range 1813
RELEASE. ARM+1855

Nylon 20mm 3m
Chain 13mm 3m

Anchor 66kg (two wheels)
M5 1900m BIAC Weddell

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Project: BIAC Weddell sea 2009/R.S. E Shackleton
Area: M5
Position: 74°10.15'S 029°32.60'W
Time for deployment: 12 Feb 2009 22:43 UTC (Start 21:41 UTC)
Echo depth: 1976m, corrected 1928m
Comment: Deployed with anchor last in open water.

3 x 17" with eddygrip

Anchor 660kg (two wheels)
The SASSI PIES (Inverted Echo Sounder with Paroscientific pressure sensor) was deployed near OP2 in Orkney Passage. The instrument was let go at 2146 on 2 March 2009 at 60°39'.2S, 042°06'.5W, in 3138 m water (corrected).

The following pages give mooring diagrams for the SASSI moorings, as deployed.
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Component</th>
<th>S/N</th>
<th>Rope # (Length)</th>
<th>Distance from lower rope end</th>
<th>In/out of water</th>
<th>Comment</th>
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<td>272</td>
<td>Anchor</td>
<td>500</td>
<td>3/4 Shoc</td>
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M/L5
Depth (m)
1083 246
1080 224
1086 202
1087 180
5594 (T/0) 158
1618 136
1617 114
1616 92
1615 70
1614 48
4993 (S/0) 26

ADCP 300 10689

RAS 12239-02
SBE 37 1125
A/R 254

EC57(W) EC85(D)
EC87 (R)
<table>
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<th>SN</th>
<th>Rope # &amp; Length</th>
<th>Distance from Lower Rope End</th>
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<td>AT 360 14FØ(W)</td>
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<td>1025 kg (dry weight)</td>
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<td>1449 (D) 1455 (R)</td>
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</table>
ES083 - Deployed 31/1/2009

SASSI 1600m 31/01/2009

(41 16S) 8 72° 25' W018° 01.1'

<table>
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<tr>
<th>Depth (m)</th>
<th>Component</th>
<th>S/N</th>
<th>3# &amp; Length</th>
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<td>1449 (O) 1455 (R)</td>
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<td>1590</td>
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ES033 - Deployed 24/2/2009

sassi 2660m (actual depth 2600m) 24-02-2009 v01

<table>
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<th>Distance from sewer rope end</th>
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<td>987 m</td>
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<td>987 m</td>
<td>NORTEK</td>
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<td>1941 m</td>
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<td>2599 m</td>
<td>Anchor</td>
<td>1600 kg (dry weight)</td>
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</table>

Argos 23833 + Light + Radio
LR-A025 5599
SBE37 4549 (485m)

SBE37 31145
Nortek 1415

SBE37 3362
Nortek 1420

SBE37 3081
Nortek 1481

AIR 369 14F9(W)
1449(0) 1455(R)
S2 mooring, as deployed

Project: Weddell sea 2009/R.R.S. E. Shackleton
Area: S2
Position: 74°39.05'S 033°32.97'W
Time for deployment: 4. Feb. 2009 14:00 UTC
Echo depth: 600m


RDCP 600  sn:  249
RCM-9  sn:  1437
Argos  sn/id:  26946244

IXSEA OCEANO
sn:  682
Arm/range:  1805
Diagnostic:  Arm=1649
Finger off:  Arm=1648
Release:  Arm=1855
**FOCAS Coast mooring recovery**

The Coast mooring consisted of a single upward-looking 300kHz RDI Workhorse ADCP. The data files recovered were badly fragmented, and one of the memory cards was unreadable/empty. The result was an intact times series from 11 August 2007 to 20 March 2008. Typically 40 of the 2-m bins contained useful data.

**Orkney Passage Moorings**

*OP2 recovery 28/2/2009*

1742  Release code sent
1759  First buoy spotted at surface
1829  Top float grappled
1830  Top floats on deck
1838  SBE39 s/n 1586 recovered
1849  SBE39 s/n 1311 recovered
1854  Buoy package recovered
1903  SBE39 s/n 1310 recovered
1918  Six-buoy package recovered
1921  RCM s/n 592 recovered
1933  SBE39 s/n 1247 recovered, bundled with two-buoy package
1951  RCM s/n 532 recovered, bundled with four-buoy package
1954  SBE38 s/n 0110 recovered
1957  Release recovered, with two buoys.

*OP3 recovery 28/2/2009*

1600  First buoy grappled
1606  First buoy package recovered
1609  SBE37 s/n 2956 recovered
1628  RCM8 s/n 12677 recovered, tangled with buoys
1645  RCM8 s/n 12669 recovered, tangled with buoys
1654  SBE37 s/n 2678 recovered
1657  Releases recovered
OP3: 60° 39.917 S
042° 11.800W
1951.8 m (uncorr)

Beacon: Channel B

OP2: 60° 39.32 S
042° 06.3W
3410 m (uncorr)

Beacon: Channel A

OP moorings as deployed during ES033. Note that the diagrams do not show beacons mounted on masts in 17-inch CRP buoys. The masts are connected to half-inch chain to ballast the buoy, and the chain is connected via a length of rope to the uppermost buoy on the moorings. The beacons consist of a flasher and a VHF beacon.

An improved location for OP3 was found by triangulation, shown below.
Triangulation for OP3 location

3D mooring position 60°S 39.958° 42°W 11.646°
mooring depth: 2107 [m]
slant error: 0 [m] horizontal error: 0 [m] vertical error: 0 [m]

2D mooring position 60°S 39.927° 42°W 11.643°
horizontal error: 25 [m]

anchor release position 60°S 39.917° 42°W 11.800° depth: 2075 [m]
drift: 159 [m] heading: 118 [°]
sound speed at site 1466 [m/s]

#1 pos: 60°S 39.825° 42°W 10.797° range: 2243 [m] range soundspeed 1500
#2 pos: 60°S 40.392° 42°W 11.157° range: 2285 [m] range soundspeed 1500
#3 pos: 60°S 39.909° 42°W 13.018° range: 2436 [m] range soundspeed 1500
Appendix E. Seal capture data, and calibration data from tags

**Weddell Seal tagging protocol**

Team member responsibilities:

1. **Note-taker**
   a. Ensure all fields of datasheet are completed and all samples are collected
   b. When recording data, always repeat the measurement value aloud

2. **Morphometrics**
   a. Measure girth at pre-defined locations
   b. Measure length at each pre-defined location (starting at tip of tail)
   c. Measure total curvilinear length and total straight line length

3. **Breathing/condition**
   a. Continuously monitor breathing and state of alertness. At any point during the procedure I may ask how long it has been since the last breath
   b. Continuously monitor the overall procedure for general safety concerns

4. **Tag attachment**
   a. Wash fur with acetone and mark attachment location
   b. Dispense epoxy on fur and on bottom of tag
   c. Surround tag with heat packs and hold in place until epoxy is firm
   d. Remove plastic CTD covering and check saltwater switch contacts

5. **Drugger / Ultrasound**
   a. Oversee entire procedure
   b. Initiate and maintain sedation
   c. Collect ultrasound measurements at predefined locations

**Order of events:**

1. Assess condition/health of seal and the safety of the ice
2. Dart / inject initial dose of drug. Wait 10-20 minutes to take effect.
3. Set spinal needle and assess level of sedation
4. Mark morphometric locations and begin measurements (starting at ears)
5. Begin tag attachment
6. Begin ultrasound measurements
7. Take photo
8. Ensure all data have been collected
9. Allow seal to recover and monitor until normal behaviour resumes

**General guidelines:**

1. Always assess the seal before approaching the head and minimize time there.
2. If the seal becomes mobile, ready the net and head bag and await instructions.
3. If you hear the ice crack, tell everyone immediately.
4. Please exercise extreme caution when walking on ice.
5. Please do not distribute photographs or allow them to become publicly available.
6. If you have any questions or are uncomfortable, please let me [PR] know.
Lessons learned from seal tagging activities
Weddell seal tagging in the Weddell Sea, February 2009

1. How to differentiate Weddell seals from crabeater seals (at a distance)
   a. Shape of face (flatter)
   b. Movement style (undulation rather than slithering)
   c. Reaction to ship (docile)
   d. Coloration (darker and spotted on the belly)
   e. Shape and posture of fore-flipper

2. How to find Weddell seals during late summer in the Weddell sea
   a. Thick pack ice generally away from expanses of open water
   b. 350 to 650m bottom depth
   c. Most dense west of 29-degrees, especially near Helmert Bank
   d. Seals typically haul out for several hours in the middle of the day (and feed during the “night”)
   e. Weddell seals are not remarkably dense (crabeater seals are much more abundant)

3. Animal handling
   a. Sea lion net with hoop and block worked perfectly to control the animal and as a head bag
   b. Seals have almost no desire to bite, but need to minimize opportunities
   c. Common to find seal holes close to seals... need to inspect area for holes and cracks prior to drugging
   d. Check moult status... moult on head and along spine first (dark stripe). Possible to pluck old fur.

4. Sedation notes/recommendations
   a. Dart gun is not necessary.
   b. Remarkable variation in response to drugs. Recommend conservative dosing; physical restraint is relatively easy when necessary.
   c. 2.7cc Zoletil worked well as a standard dose.
   d. Traditional elephant seal approach works well (Zoletil and Ketamine)
   e. Diazepam was never used, although it would have been helpful for a couple of seals
   f. Attach heat pack to spinal needle with Velcro ring to prevent freezing
   g. Need to bring drugs in vials appropriate for drawing in the field (e.g. rubber stoppered bottles instead of ‘ampoules’)
   h. Seals respired remarkably well and breaths were easily prompted.
   i. Need to bring 4.5” 18G needles. 3.5” needles were often not long enough and 20G spinal needles bent easily.

5. How to improve overall efficiency
   a. Bring a backpack for gear (instead of a plastic bin)
   b. Bring a larger cooler to store saline, drugs, oil,
   c. Need to find ultrasound oil that remains liquid at cold temperatures
   d. Draw up all drugs (except Zoletil) prior to leaving the ship
   e. Use microwave to heat saline and oil prior to departing ship
   f. Need to find better heat packs to keep epoxy warm and perhaps a ‘hat’ for the tag to block wind.
   g. Essential to have (and use!) probing poles to find cracks/holes in ice
   h. Perhaps consider bringing an emergency clothing kit?
   i. Perhaps bring ‘kneeling pads’
   j. Take photos of animals and tags
   k. Bring Zip-top plastic bags
   l. Glue gun worked well. Pre-warm epoxy on ship.
**Tag calibration check**

The following histograms show the difference between the tag data and data from the calibration yo-yo sequence of four casts (CTD 026).

**Mismatch between tag temperature data and CTD 026**

![Histograms showing mismatch between tag temperature data and CTD 026](image)

**Mismatch between tag pressure data and CTD 026 (dbar)**

![Histograms showing mismatch between tag pressure data and CTD 026 (dbar)](image)
Mismatch between tag conductivity data and CTD 026 (mS cm⁻¹)

Seal capture data

<table>
<thead>
<tr>
<th>Date</th>
<th>Seal I/D</th>
<th>Tag Body #</th>
<th>PTT #</th>
<th>Length (cm)</th>
<th>Girth (cm)</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/2/2009</td>
<td>WED200901</td>
<td>10866</td>
<td>43839</td>
<td>240</td>
<td>181</td>
<td>Female</td>
</tr>
<tr>
<td>4/2/2009</td>
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<td>10858</td>
<td>48929</td>
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<td>171</td>
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</tr>
<tr>
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<td>10862</td>
<td>43844</td>
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<td>169</td>
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<td>10865</td>
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<tr>
<td>5/2/2009</td>
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<td>10860</td>
<td>48928</td>
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<tr>
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<td>10864</td>
<td>43841</td>
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<tr>
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<td>10613</td>
<td>92136</td>
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<tr>
<td>7/2/2009</td>
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<td>92144</td>
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<tr>
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<tr>
<td>13/2/2009</td>
<td>WED200910</td>
<td>10059</td>
<td>92137</td>
<td>159</td>
<td>166</td>
<td>Female</td>
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</tbody>
</table>
The following text is the description for the program used in the six BAS tags. The tags from UC Santa Cruz used different programs.

Software specification for CTD_BAS_07A deployment  
(BAS Weddell seal CTD)

Transmitting via ARGOS
Page transmission sequences:

Until day 1464:  0 1 2 3 1 2 3 2 3 using 1 PTT numbers

Satellite availability (UTC):

<table>
<thead>
<tr>
<th>Time</th>
<th>Availability</th>
</tr>
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<td>00</td>
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</tr>
<tr>
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<tr>
<td>22</td>
<td>-- on --</td>
</tr>
<tr>
<td>23</td>
<td>-- on --</td>
</tr>
</tbody>
</table>

Transmission targets:

- 20000 transmissions after 100 days
- 50000 transmissions after 280 days

In Haulouts: ON (one tx every 1 min 20 secs) for first 5 hours then cycling OFF for 6 hours, ON for 1 hour

Check sensors every 4 secs
When near surface (shallower than 10m), check wet/dry every 1 sec
Consider wet/dry sensor failed if wet for 7 days or dry for 99 days
Dives start when wet and below 6m for 8 secs and end when above 6m for 0, or dry at any time
No separation of 'Deep' dives
A cruise begins if there has been no dive for 9 mins
A haulout begins when dry for 10 mins and ends when wet for 40 secs

Dive shape (normal dives): 4 points per dive using broken-stick algorithm
Dive shape (deep dives): none

CTD upcasts: max 1000 dbar up to 8 dbar in 1 dbar bins.
- 20 cut points per profile
- Send the deepest 1 upcasts in each 2-hour period.
- Minimum depth to trigger collection of cast:
  - 400m in hour 1
  - 50m in hour 2
  - 0 or 20% greater than current maximum.

Sample CTD sensor every 1 seconds.
Temperature: Collected, Stored. Valid range: -2.75 to 2.25 degC
Conductivity: Collected, Not stored.
Salinity: Calculated, Stored. Valid range: 32.8 to 35.4

TRANSMISSION BUFFERS (in RAM):
Dive in groups of 3 (.625 days @ 10mins/dive): 300 = 1200 bytes
No 'deep' dives
Haulout: 30 = 120 bytes
4-hour summaries in groups of 3 (8 days): 16 = 64 bytes
No berniegrams
No timelines
Cruise: 30 = 120 bytes
No diving periods
No spot depths
No emergence records
No Duration histograms
No Max depth histograms
CTD casts (6.66667 days): 80 = 320 bytes
No 'deep' dives
No GPS fixes
TOTAL 1824 bytes (of about 21000 available)

MAIN BUFFERS (in 6.2 Mb Flash):
Dive in groups of 3 (416.667 days @ 10mins/dive): 20000 x 100 bytes = 2000000 bytes
No 'deep' dives
Haulout: 3000 x 16 bytes = 48000 bytes
4-hour summaries in groups of 3 (500 days): 1000 x 68 bytes = 68000 bytes
No berniegrams
No timelines
No diving periods
No spot depths
No emergence records
No Duration histograms
No Max depth histograms
CTD casts (500 days): 6000 x 188 bytes = 1128000 bytes
No GPS fixes
TOTAL 3214 kb (from 6333 kb available)

PAGE CONTENTS (256 bits - 9 overhead):

PAGE 0:
PTT NUMBER OVERHEAD (28-bit code)
-----------[8 bits: 0 - 7]
PAGE NUMBER
-----------[2 bits: 8 - 9]
DIAGNOSTICS in format 0:
TX number: wraparound 11 bits in units of 32 (range: 0 to 65504)
Number of resets: wraparound 1 bits in units of 1 (range: 0 to 1)
-----------[12 bits: 10 - 21]
DIVE group in format 0:
Normal dives transmitted in groups of 3
Time of start of last dive: max 5 days 12 hours @ 30 secs= 15840
as raw 14 bits in units of 1 (range: 0 to 16383)
(recommended sell-by 5 days 11 hours)
Sell-by range: 5 days
Number of records: raw 2 bits in units of 1 (range: 0 to 3)
Reason for end: -- not transmitted --
Group number: wraparound 8 bits in units of 1 (range: 0 to 255)
Max depth: -- not transmitted --
Dive duration: odlog 1/6 in units of 30 s (range: 0 to 5715 s)
Mean speed: -- not transmitted --
Profile data (4 depths/times, 0 speeds):
Depth profile: odlog 2/6 in units of 25 dm (range: 0 to 23887.5 dm)
Profile times: raw 5 bits in units of 32.2581 permille (range: 0 to 1000 permille)
Speed profile: -- not transmitted --
Residual: raw 2 bits in units of 60 (range: 0 to 180)
Calculation time: -- not transmitted --
Surface duration: odlog 2/4 in units of 2.5 s (range: 0 to 588.75 s)
Dive area: -- not transmitted --
-----------[225 bits: 22 - 246]
Available bits used exactly

=== End of page 0 ===

PAGE 1:
PTT NUMBER OVERHEAD (28-bit code)
-----------[8 bits: 0 - 7]
PAGE NUMBER
-----------[2 bits: 8 - 9]
CRUISE group in format 0:
Number of records: raw 1 bits in units of 1 (range: 0 to 1)
Cruise number: wraparound 6 bits in units of 1 (range: 0 to 63)
Start time: -- not transmitted --
End time: max 5 days 12 hours @ 2 mins= 3968
as raw 12 bits in units of 1 (range: 0 to 4095)
(recommended sell-by 5 days 11 hours)
Sell-by range: 5 days 4 hours
Duration: raw 9 bits in units of 120 s (range: 0 to 61320 s)
cf. Max duration is 16 hours

53
Speed: -- not transmitted --
Reason for end: -- not transmitted --
-------------------[28 bits: 10 - 37]

HAULOUT in format 0:
Number of records: raw 1 bits in units of 1 (range: 0 to 1)
Haulout number: wraparound 6 bits in units of 1 (range: 0 to 63)
Start time: -- not transmitted --
End time: max 5 days 12 hours @ 2 mins= 3960
  tx as raw 12 bits in units of 1 (range: 0 to 4095)
  (recommended sell-by 5 days 11 hours)
Sell-by range: 5 days 4 hours
Duration: raw 9 bits in units of 120 s (range: 0 to 6120 s)
cf. Max duration is 16 hours
Reason for end: -- not transmitted --
Contiguous: -- not transmitted --
-------------------[28 bits: 38 - 65]

SUMMARY group in format 0:
Transmitted in groups of 3
Record could be in buffer for 8 days
End time: max 7 days @ 4 hours= 42
  tx as raw 6 bits in units of 1 (range: 0 to 63)
  (recommended sell-by 6 days 19 hours)
Sell-by range: 7 days
Number of records: raw 1 bits in units of 1 (range: 0 to 1)
Cruising time: -- not transmitted --
Haulout time: raw 6 bits in units of 15.873 permille (range: 0 to 1000 permille)
Dive time: raw 6 bits in units of 15.873 permille (range: 0 to 1000 permille)
Deep Dive time: -- not transmitted --
Normal dives:
  Avg max dive depth: odlog 2/6 in units of 25 dm (range: 0 to 23887.5 dm)
  SD max dive depth: odlog 2/4 in units of 50 dm (range: 0 to 11775 dm)
  Max max dive depth: odlog 2/6 in units of 25 dm (range: 0 to 23887.5 dm)
  Average dive duration: odlog 1/6 in units of 30 s (range: 0 to 5715 s)
  SD dive duration: odlog 1/4 in units of 60 s (range: 0 to 2790 s)
  Max dive duration: odlog 1/6 in units of 30 s (range: 0 to 5715 s)
  Avg speed in dive: -- not transmitted --
  Number of dives: odlog 1/4 in units of 2 (range: 0 to 93)
Deep dives:
  Avg max dive depth: -- not transmitted --
  SD max dive depth: -- not transmitted --
  Max max dive depth: -- not transmitted --
  Avg dive duration: -- not transmitted --
  SD dive duration: -- not transmitted --
  Max dive duration: -- not transmitted --
  Avg speed in dive: -- not transmitted --
  Number of dives: -- not transmitted --
Avg SST: -- not transmitted --
-------------------[181 bits: 66 - 246]

Available bits used exactly

--- End of page 1 ---

PAGE 2:

PTT NUMBER OVERHEAD (28-bit code)
-------------------[8 bits: 0 - 7]

PAGE NUMBER
-------------------[2 bits: 8 - 9]

CTD in format 0:
End time: max 5 days 12 hours @ 2 mins= 3960
  tx as raw 12 bits in units of 1 (range: 0 to 4095)
  (recommended sell-by 5 days 11 hours)
Sell-by range: 5 days
CTD cast number: -- not transmitted --
Max pressure: -- not transmitted --
Min temperature: -- not transmitted --
Max temperature: raw 10 bits in units of 1 dbar (range: 8 to 1031 dbar)
Min temperature: raw 13 bits in units of 1 (range: 1800 to 9991 = -3.2 to 4.991 °C in steps of 0.001 °C)
Max temperature: raw 13 bits in units of 1 (range: 1800 to 9991 = -3.2 to 4.991 °C in steps of 0.001 °C)
cf. Valid temperatures: -2.75 to 2.25 degC
Number of samples: -- not transmitted --
20 profile points 0 to 19 (from total of 20 cut points):
  First 18 pressures are fixed
  Min pressure is fixed
  Max pressure is sent separately
Temperature: raw 9 bits in units of 1.95695 permille (range: 0 to 1000 permille)
Temperature residual: raw 7 bits in units of 5 mdegC per sample (range: 0 to 635 mdegC per sample)
Temperature bounds: raw 2 bits in units of 1 lo/his (range: 0 to 3 lo/his)
Conductivity bounds: -- not transmitted --
Salinity bounds: -- not transmitted --
--- Available bits used exactly ---

--- End of page 3 ---
Appendix F. Setup files for Vertical Microstructure Profiler (VMP)

# This is the setup file for VMP SN009 made for the University of Bergen
# Any line that begins with "#", pound symbol, is a comment and is ignored by all programs
# that read this file. Use it to explain what the various items mean.
# Programs such as ODAS and plot_VMP will parse this file and look for key line identifiers.
# an identifier is a word followed by a colon and then a number of parameter values. The identifier is
# the first item on a line.
# For example, the line "prefix: ESR_122_" indicates the prefix or base name of the data
# files created by ODAS will be "ESR_122_XXX.p" where XXX starts from 000 and
# is automatically incremented for subsequent files created by ODAS. The extension ".p"
# is historical and indicates data collected with a parallel interface. Nowadays, most
# data will be collected with a USB interface but the extension ".p" remains.
# this setup file was created on 2005-04-08
# Modified by RSI on 2007-09-11
# When entering parameters values please note that you can use tabs and spaces
# freely for visual effects. You can also use commas to separate values but, if you do use commas,
# you CANNOT use spaces or tabs.
##########################################################
# This is a list of channels (addresses) and their signals
# 0  Reference ground
# 1  Ax or tilt - horizontal acceleration in the direction of the pressure port
# 2  Ay or roll - horizontal acceleration orthogonal to the direction of the pressure port
# 3  Az vertical acceleration
# 4  T1 - Temperature from Thermistor 1 without pre-emphasis
# 5  T1_dT1 - Temperature from Thermistor 1 with pre-emphasis
# 6  T2 - Temperature from Thermistor 2 without pre-emphasis
# 7  T2_dT2 - Temperature from Thermistor 2 with pre-emphasis
# 8  Sh1 - velocity derivative from shear probe 1
# 9  Sh2 - velocity derivative from shear probe 2
#10  P - pressure signal without pre-emphasis
#11  P_dP - pressure signal with pre-emphasis
#12  C_dC - micro-conductivity with pre-emphasis from SBE7
#16  SBT1E - The even address of the SBE3 thermometer that returns the least significant
# half of the 32-bit data word
#17  SBT1O - The odd address of the SBE3 thermometer that returns the most significant
# half of the 32-bit data word
#18  SBC1E - The even address of the SBE4 conductivity sensor that returns the least significant
# half of the 32-bit data word
#19  SBC1O - The odd address of the SBE4 conductivity sensor that returns the most significant
# half of the 32-bit data word
#255 Special Character that always returns 32753 (Decimal) or 7FF0 (Hex) and is used to test the
# integrity of communication.
###########################################################
# Here we identify certain channels for which ODAS calculates record average values and converts
# them to physical units. We identify the channel and give its calibration coefficients.
# Do not enter a channel if its is not available on your instrument or if you
# have chosen not to sample it by excluding it from the address matrix.
# SBE3
channel: 16,SBT1E,4.39844087e-3,6.43402974e-4,2.21488141e-5,1.90305867e-6,1000.0,24e6,128
channel: 17,SBT1O,4.39844087e-3,6.43402974e-4,2.21488141e-5,1.90305867e-6,1000.0,24e6,128
# For the SBE3 SN-4788. We give the g-h-i-j-f0 calibration coefficients (ITS-90). calibrated 2007-06-05
# These values are followed by the reference frequency of the SCCH (usually 24e6) and
# the number of periods for the averaging. Repeat the values for both channels.
\# SBE4
channel: 18, SBC1E, -1.01101980e1, 0, 1.56625229e0, -2.19478852e-3, 2.60910995e-4, 24e6, 128
\# For the SBE4 SN-3340. We give the g-zero-h-i-j calibration coefficients. Calibrated 2007-06-01
\# These values are followed by the reference frequency of the SCOUNT (usually 24e6) and
\# the number of periods for the averaging. Repeat the values for both channels
channel: 0, Gnd1, 0, 0, 0, 0, 0, 0, 0, 0, 0
\# No conversion to physical units for reference ground channel number 1 (up to 2 allowed)
channel: 1, Pitch, 297, 12953, 0, 0, 0, 0, 0, 0, 0
channel: 2, Roll, -123, -13084, 0, 0, 0, 0, 0, 0, 0
\# Linear coefficients for computing the angle in degrees
channel: 10, Pres, -2.3, 0.10381, -3.432e-8, 0, 0, 0, 0, 0, 0, 0
\# Convert pressure to dBars
channel: 32, Mz, -27.5, 60.14, 0, 0, 0, 0, 0, 0, 0
channel: 33, My, -151.5, 62.72, 0, 0, 0, 0, 0, 0, 0
channel: 34, Mx, 12.5, -55.42, 0, 0, 0, 0, 0, 0, 0
\# For PNI MicroMag3, 3-axis magnetometer

#################################################################
\# This is the address matrix and shows the order of sampling proceeding across the rows and
\# then down the columns.
\# Use tabs only to separate the entries otherwise funny things happen. Something to do with
\# the way C++ reads values.
\# The first 2 columns are slow channels the remaining 8 columns are fast channels
\# There are 8 rows, so the slow channels are sampled 8 time slower than the fast channels
\# Warning, only use "tabs" to separate the channels. Do not use spaces or commas.
matrix: 255 0 1 2 3 5 7 8 9 12
matrix: 4 6 1 2 3 5 7 8 9 12
matrix: 16 17 1 2 3 5 7 8 9 12
matrix: 18 19 1 2 3 5 7 8 9 12
matrix: 32 33 1 2 3 5 7 8 9 12
matrix: 34 0 1 2 3 5 7 8 9 12

##########################################
\# Parameters for real-time plotting
#################################################################
\# Plotting parameters for plot_tomi
\# Keywords:
\#   plotting: list of channels to be plotted (should be in order, list both channels of even/odd pairs)
\#   plotaverages: list of channels used to calculate average, calibrated values (as with plotaverages)
\#   plotnames: names of the channels being plotted (can be different from those used above,
\#   but even/odd channel pairs must be identified by E/O suffix
\#   averagenames: names of the channels used to calculate average, calibrated values (routines
\# look for the following names: SBT2(E/O), U1(E/O), U2(E/O), Pres, Cref, Ccos, Csin)
plotting: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 16, 17, 18, 19
plotaverages: 16, 17, 10
plotnames: Ax, Ay, Az, T1, T2, Sh1, Sh2, F, P, do, C, dC, SBT2E, SBT2O, SBC2E, SBC2O
averagenames: SBT2E, SBT2O, Pres

###############################################################