RRS *James Clark Ross* Cruise 40
15th March – 22nd April 1999

ALBATROSS

Antarctic Large-scale Box Analysis and The Role Of the Scotia Sea

A Hydrographic Survey of the Scotia Sea

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1. ALBATROSS Cruise Narrative

1.1 Cruise Summary

This cruise (JR40) formed the basis of the ALBATROSS project. It took place on the RRS *James Clark Ross*, an ice strengthened vessel operated by the British Antarctic Survey. We left Port Stanley, Falkland Islands (Malvinas) on 15th March 1999 and returned there on 22nd April 1999 (Figure 1). A total of 170 $CTDO_2$ small volume stations were occupied (Figure 2 and Table 1).

1.2 Cruise participants

1.2.1 Scientific party

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1.2.2 Principal Investigators

Chief Scientists	David Stevens and Karen Heywood
$CTDO_2$, Hydrography	David Stevens and Karen Heywood
XBT	David Stevens
VMADCP	Elaine McDonagh
LADCP	Elaine McDonagh
Chlorofluorocarbons	Michael Meredith
SF_6	Fiona Carse
Nutrients & dissolved oxygen	Richard Sanders
Helium/Tritium	Uli Fleischmann and Oliver Huhn
Oxygen isotopes	Michael Meredith

1.2.3 Ship's Officers and Crew

Mr. Christopher Elliott	Master
Mr. Robert C. Paterson,	Chief Officer
Mr. Robin Kilroy	2nd Officer
Mr. Andrew R. Liddle	3rd Officer
Mr. John Summers	Deck Officer
Mr. Thomas Haigh	Cadet
Mr. Charles A. Waddicor	Radio Officer
Mr. David J. Cutting	Chief Engineer
Mr. William J. Kerswell	2nd Engineer
Mr. Roger S. Jones	3rd Engineer
Mr. Steven J. Eadie	4th Engineer
Mr. Simon A. Wright	Deck Engineer
Mr. Norman E. Thomas	Electrical Engineer
Mr. Kenneth R. Olley	Catering Officer
Mr. Martin Brookes	Bosun
Mr. Jonathon M. Dodd	Bosun's Mate
Mr. Peter A. Cossey	Sg1a
Mr. Roderick A. Graham	Sg1a
Mr. Neil Sullivan	Sg1a
Mr. Raymond A. Davis	Sg1a
Mr. David N. Watson	Sg1a
Mr. Sidney F. Smith	Mg1
Mr. Mark A. Robinshaw	Mg1
Mr. Roy W. Fox	Chief Cook
Mr. David R. Bailey	2nd Cook
Mr. John A. Clancy	Steward
Mr. Tony N. Dixon	Steward
Mr. Lawrence Baldwin-White	Steward
Mr. Derek W. Lee	Steward

1.3 Cruise Diary

Shiptime throughout the cruise was 3 hours behind GMT.

Monday 15th March (day 074)

We set sail at 4pm from Port Stanley, Falkland Islands, and steamed south towards our test station.

Tuesday 16th March (075)

We arrived at our test station (001) mid afternoon. Conditions were ideal, sunny and calm. This was a full depth station. All bottles were fired at 3200 m for CFC bottle blanks. The first XBT was launched. After the station we steamed westwards towards Cape Horn to start the Drake Passage section. During the night the sea got rougher and there was a large swell.

Wednesday 17th March (day 076)

We were pitching into a large swell, although it was sunny with a cloudless sky. We steamed all day towards the first station on our Drake Passage section. Cape Horn was seen in the distance.

Thursday 18th March (day 077)

Our section across Drake Passage (stations 2-46) began in the early hours of the morning in shallow water not far from Cape Horn. Stations were closely spaced on every 500 m depth contour. We were now beam on to the swell so the ship was rolling badly. After only a couple of stations we had to reterminate the CTD cable which had kinked. By the end of this first day, we had completed our section over the continental shelf and very steep slope.

Friday 19th March (day 078)

Another retermination was necessary due to a bird's nesting of the CTD cable. We also replaced the LADCP unit which would no longer communicate. We continued deep (4000 m) stations southwards, repeating the stations occupied by the WOCE A21 cruise in 1990, and additional stations in between. It was still sunny but with a big swell.

Saturday 20th March (day 079)

The CTD cable was streamed with a heavy weight due to recurring problems with kinks and reterminations. After several sunny and relatively calm days (although with a big beam-on swell), the wind began to get up and it rained. We were about halfway across Drake Passage. Pilot whales were seen around the ship.

Sunday 21st March (day 080)

We were hove to from about midnight until midday due to poor weather. This was the first day without any reterminations being necessary since the section began! Pilot whales were seen spy-hopping. Crispin Day gave a fascinating talk about Antarctica.

Monday 22nd March (day 081)

Stations continued in heavy seas. The CTD cable required reterminating. We crossed the Polar Front during Sunday and Monday. We were now halfway across Drake Passage. It was a grey day and we had some snow. In the late evening there were 2 more kinks in the cable and it was decided to restream the cable to the sea bed, and to remove the fin (which prevented the package from spinning).

Tuesday 23rd March (day 082)

The first station without the fin was completed in the early hours. The swell and wind had abated by daybreak, and it was a pleasant sunny day with small waves. The cable was streamed again in the evening.

Wednesday 24th March (day 083)

Today we had snow, saw our first iceberg and some Gentoo penguins porpoising along beside the ship. A humpback whale investigated us for about half an hour. We also saw another ship in the distance. We had calm seas and it was foggy at times. We had to cut 1000m off the CTD cable. There have been 7 terminations necessary so far. The fin was replaced. ADCP signal penetration dramatically increased today. We spent some time trying to unfreeze the liquid nitrogen plant.

Thursday 25th March (day 084)

The liquid nitrogen plant began working, much to our relief, otherwise no CFC measurements would have been possible thereafter. We began closely spaced stations up the continental slope of Antarctica. Land was sighted. ADCP signal penetration decreased again.

Friday 26th March (day 085)

We completed the Drake Passage section, with our last station (046) in shallow water close to the Antarctic Peninsula. Since the CTD cable had been nothing but trouble, and was wasting a good deal of time with reterminations and deploying the weights, it was agreed that we would spool off the old cable by hand, and rewind the replacement one on during our visit to Rothera, when we would be moored alongside a jetty. Accordingly we spent the afternoon helping to walk the CTD cable off the drum. There was snow during the morning and the weather gradually deteriorated during the day. Snowmen were made on the aft deck. By late afternoon the snow had turned to rain and the wind and waves got up. We were disappointed to have to take the outside route along the Peninsula, instead of the scenic inside route, but the weather conditions were too poor. It became very rough overnight during our steam to Rothera.

Saturday 27th March (day 086)

We arrived in Rothera at lunchtime. It was a calm and sunny day and the scenery was spectacular. We went ashore while the unloading of the aircraft fuel began. Then the spooling of the new CTD cable began, while the scientific party enjoyed the generous hospitality of the winterers, including trips on snocats and walks to see the seals and penguins.

Sunday 28th March (day 087)

We awoke to find that the spooling of the new CTD cable onto the winch had not gone smoothly and there were some turns misaligned. This meant that the cable had to be unwound again, by hand, and put onto the storage reel again (like a giant cotton reel). The scientific party, together with a number of volunteers from Rothera, spent the morning turning the drum manually, helping the crew to unwind the cable. By lunchtime this was accomplished and the winding onto the winch could begin again. Finally by 9pm the new CTD cable was safely spooled onto the winch, and we were able to leave Rothera at 10pm. We did a shallow CTD station just off the wharf for comparison with a similar station done last year, primarily for Richard Sanders. We began steaming north towards the tip of the Antarctic Peninsula.

Monday 29th March (day 088)

We woke to find fog and poor visibility. We continued north past Adelaide Island. Roy organised a Race Night and good fun was had by all.

Tuesday 30th March (day 089)

We had a short visit to Deception Island during the morning, where the ship's officers were able to deploy and test both lifeboats.

Wednesday 31st March (day 090)

We began our southern section, eastward from the tip of the Peninsula, just after midnight. Seven stations were completed today, many of which were shallow ones (500 m) across the continental shelf. It was the calmest day yet, almost glassy.

Thursday 1st April (day 091)

The intensive southern section of closely spaced stations continued.

Friday 2nd April (day 092)

Good Friday. We finished our section to the South Orkneys. Due to a happy coincidence the Bransfield was just leaving Signy on her way back to the UK, so we were able to meet up and steam together for a few miles. It was good weather and we saw fur seals porpoising. There were many icebergs, one with penguins on. In the evening we began stations eastwards. After much trial and tribulation since the beginning of the cruise, the SF6 kit appeared to be working. To allow the tracer chemists time to prepare for the important Orkney Passage section, we did a 12 hour echo sounder survey across the Passage. This enabled us to accurately locate the sill of the Passage and deduce the number of stations required.

Saturday 3rd April (day 093)

The wind got up during the early morning, and we made slow progress back to the 500 m station, arriving about 10 am. We occupied closely spaced stations across the Passage in rough weather. In the evening the SF6 kit suffered 'melt-down'.

Sunday 4th April (day 094)

It was still fairly rough. We completed our section across the Orkney Passage. The CFC kit was unfortunately playing up.

Monday 5th April (day 095)

Stations continued eastward sampling the deep gaps in the South Scota Ridge. The CFC team battled to achieve good CFC data.

Tuesday 6th April (day 096)

We woke to find heavy seas and strong winds. We were hove to for 4 hours after station 089. We returned to the section at 9 am and then continued.

Wednesday 7th April (day 097)

Stations continued across the last deep passage of our southern section. It was calm and sunny.

Thursday 8th April (day 098)

At the eastern end of our southern section, we set off to recover a bottom pressure recorder (BPR) deployed a year previously by colleagues at the Proudman Oceanographic Laboratory.

Friday 9th April (day 099)

Heading north towards South Georgia. The weather was incredible – glassy calm and sunny. We saw a green iceberg. We found ourselves repeating A23 station 42 as ALBATROSS station 109 exactly 4 years later, to the day.

Saturday 10th April (day 100)

We continued occupying stations northward, repeating the A23 locations.

Sunday 11th April (day 101)

Our biggest storm yet, Force 9. We were hove to from 2 am to 9 pm.

Monday 12th April (day 102)

In the evening we completed our repeat of the A23 stations on the continental shelf of South Georgia. There was rough weather overnight as we steamed to Grytviken.

Tuesday 13th April (day 103)

We arrived at Grytviken at breakfast-time. Unusually for South Georgia, we had spectacularly clear weather and Mount Paget was out of cloud against a deep blue sky. During the morning the scientific party explored the old whaling station and encountered large numbers of elephant seals and fur seals. A CTD station was occupied in the bay as we left at lunchtime. Stations began on the Maurice Ewing Bank Section in the late evening.

Wednesday 14th April (day 104)

We continued stations along the Maurice Ewing Bank Section. It was foggy so we had to reduce speed. It became windy and rough.

Thursday 15th April (day 105)

Much rain and still rough. Now that the CFC and SF6 kits were working reasonably well, we did another bottle blank station. We also retested the original LADCP unit, but it was found still to produce

X profiles so we reverted to the proven one.

Friday 16th April (day 106)

Rough weather again, 50 knot wind. We were hove to for about 6 hours during the morning but by the afternoon it was sunny and we were lurching along again. Cattle egrets have been landing on the ship, presumably blown off course by the recent storms. During the evening another storm hit us.

Saturday 17th April (day 107)

We finally went round the bend (in the cruise track, of course!) and headed west towards Stanley.

Sunday 18th April (day 108)

On station 151, the rosette returned to the surface with 2 bottles missing, one broken in half, and two cracked. We guessed that a bottle had closed prematurely on the descent, and imploded at depth.

Monday 19th April (day 109)

Only one cattle egret was left alive despite the best efforts of the crew to feed them.

Tuesday 20th April (day 110)

The end-of-cruise dinner was enjoyed during the evening during a brief break from stations.

Wednesday 21st April (day 111)

The last station was completed at 9 pm. We held an RPC (Requests the Pleasure of your Company) to thank all the officers, crew and scientists for making the cruise such a success.

Thursday 22nd April (day 112)

Arrived in Stanley at dawn.

1.4 Cruise Newsletters

During the cruise weekly newsletters were sent back by email to be displayed on the ALBATROSS web site http://www.mth.uea.ac.uk/ocean/ALBATROSS.

ALBATROSS Newsletter Week 0
Monday 15th March

We have just set sail, so we thought it would be a nice to send a newsletter to keep you up to date with how we are, after a week away. We left RAF Brize Norton on Monday evening and had no significant delays during the journey. Our only anxious moments were when Mike, Lucy and Alison only just arrived in the nick of time to check in for the flights, and we were already worrying about how we might have to manage without them ! We were very pleased to meet up with our French participant Michel and our German participants Uli and Oliver. Karen nearly made off with the hire car keys in her luggage to the Falklands. The enormous mound of luggage was shared out amongst everybody, and off we went. We enjoyed the brief spell in the morning sunshine at Ascension during refuelling. We had a slight technical delay but the captain said that ground engineers had given the plane the once over and thought it was OK. He added 'The ground engineer seemed to know what he was talking about' ! We finally arrived in the Falklands Tuesday afternoon.

The James Clark Ross was not due in until Thursday so we had 2 days to be tourists. We stayed at the Ross Complex (aka the Inferiority Complex), basically like a youth hostel. Various expeditions were organised. Some of us took a day trip to Volunteer Point, several bumpy hours in a landrover off road to see a colony of King Penguins. They were remarkably relaxed when we approached to take (millions of) photos. The Gentoo and Magellanic penguins were more nervous. Nick was the most enterprising, and arranged a 24 hour trip by air to Sealion Island, where he saw elephant seals and huge penguin colonies. The fittest amongst us went to some nearby hills on long walks. Unfortunately the weather was not good – some days showery, other days just drizzly, but always windy. We were exciting to see the ship coming in Thursday lunchtime. First impressions of some people as she sailed past the headland were that she was awfully small to be going south in. However they were reassured when they went on board on Friday and realised how big she is. Kate reckons she is like a Tardis, looks small on the outside but is much bigger on the inside.

Our containers were craned on board on Friday afternoon, and in the evening we started to unload and unpack. The chemists have decided to all be one happy family in the main lab, CFCs, SF6, nutrients and dissolved oxygens all together. Soon they were surrounded by a huge pile of crates and boxes. The CTD, LADCP and data processing side is all in the UIC lab, one deck up. On Saturday morning the unpacking began in earnest. The liquid nitrogen generator was craned aboard and installed by Simon down in the scientific hold. We were greatly impressed and very grateful for his expertise when he announced after lunch that the beast was running. All we now have to do is wait 40 hours to see if it produces any liquid nitrogen. As an interim measure, to take some of the pressure off, Lucy made an expedition to Mount Pleasant, the air base, to fill a couple of dewars with liquid nitrogen. The RAF produce it as a byproduct and were happy to let us have some.

The mobilisation days were hectic but most of us still found time to visit the Seamen's Mission, near the port, for tea and cakes. This is run by a Danish woman and is universally agreed to have the best home made cakes in the Falklands. Lizzy flabbergasted us all by going for incredibly long runs and still looking perky. Evenings were spent either in the ship's bar, or some took the shuttle bus into Stanley to the pubs.

Our first major headache was the discovery that the Ashtech 3dgps is dead. This is a clever piece of navigational equipment which tracks GPS satellites and tells us a very accurate heading for the ship, essential for the shipborne acoustic Doppler current profiler (ADCP). There is no spare on board and despite Pat Cooper's best efforts it cannot be made to work. However a replacement had been ordered some weeks ago, and its delivery date was Monday 15th March in Cambridge. Since accurate current measurements are vital for many of the cruise's objectives, we decided that it was worth exploring all possible avenues for getting a replacement to the ship. We lined up a UEA PhD student, Tim Marwood, to be on standby to fly out to the Falklands on the Monday night flight from Brize Norton. This would entail a day's delay in sailing, which we deemed worthwhile for the advantages of the Ashtech. Monday morning found us anxiously awaiting news from Cambridge whether the crucial parcel had been delivered. Our spirits sank when we heard that it had not, and would not arrive for several more days. We have had to resign ourselves to less accurate ADCP currents. We are so pleased that we have the lowered ADCP, which will now be our salvation.
Our other disappointment is that the XBT system is not working. This measures the temperature of the water in the top 1000 m, and can be launched from the ship while it is steaming along. We use it to fill in the gaps between stations, to get a more accurate picture of where changes occur. The XBT was hand carried out from BAS as a replacement for one which had broken. We are hoping that it may be coaxed into life. Oh yes, and we shouldn't forget that Matlab didn't work on our computer because of a bad

license file, and the only exabyte (tape reading/writing device) on board caused Nick Crisp's hard disk to be completed wiped, setting him back by 24 hours (he has remained remarkably cheerful !). The good news is that the nutrient/oxygen team are ready to go, the CFC and SF6 team are making good progress, the CTD and LADCP are ready to go, and the technicians and engineers on board have been superb in sorting out problems of all kinds.

On Monday morning Prince Charles visited the Falklands fishery protection vessel, tied alongside the JCR. The JCR looked lovely all decked out in flags. Karen, and the Master, Chris, went to a reception at the Seamen's Mission, and got to shake HRH's hand, but were disappointed he didn't have time to come on board the JCR.

We set sail from Stanley at 4 pm, resigned to the lack of the Ashtech. It was a relief to be started on our project. The first hour or so was devoted to Boat drill and safety procedures. We don't arrive at our test station until midday Tuesday, so watches have not yet started, and only limited data sets are being collected. We sail on into the night, luckily with reasonable weather. ALBATROSS is airborne!

ALBATROSS Newsletter Week 1
Sunday 21st March

We have spent nearly a week at sea now and there is a lot to tell you. Our first whales, our first storm and our first data churning through the computers.

The first few days at sea were sunny with very little wind, as good as one could hope for in the Southern Ocean. Tuesday was spent getting equipment to work, and organising data processing. The test station was south of the Falklands, its location chosen to be in deep water outside Argentinian jurisdiction. It went suspiciously smoothly, and soon we were heading west to Cape Horn. Cape Horn was clearly visible, steep blue mountains rising out of the sea. Later as darkness fell we could make out the beam from the lighthouse.

We began our section across Drake Passage in the early hours of Thursday, on the continental shelf just south of Chile. We are repeating a set of oceanographic (CTD) stations done by German oceanographers 10 years ago, and one of our goals is to see if there have been changes in the ocean physics and chemistry. So every other station is a 'Roether station' and is sampled fully for trace gases. We are putting extra stations in between to get a more detailed picture of the currents. We really threw everyone in at the deep end, because the first few stations were extremely close together as we crossed the continental slope into deep water. This meant that barely had the water been taken from the bottles from one station, when it was time to deploy the CTD again.

We have now been doing stations for 4 days and are halfway across Drake Passage. After only 2 days everyone felt that they had been doing stations for weeks. Overall things are going well, although we've had our share of hassles. The CTD wire has had problems and John had to reterminate the CTD every morning for 3 consecutive days. After yesterday's retermination it was decided to let the CTD wire unwind itself by spooling it into the water with a heavy weight on the bottom and a swivel at the top. Fingers crossed, this may have eliminated the tendency to get kinks in the wire. Nick has had to replace the Lowered ADCP unit. Pat is rebuilding an XBT processing unit from scratch.
Team Chemistry have been working very hard. Alison has the unenviable task of coaxing temperamental gas chromatographs to work, measuring CFCs. This has been very stressful and she deserves a medal, and at the very least a Mention in Dispatches. There have been a series of problems which she has solved carefully, and today she has at last looked more relaxed and less exhausted. Fiona has put her own SF6 work to one side for a while to support Alison, Sally has been learning CFC analysis 'on the job', and Uli and Oliver have been helping with sampling and trouble shooting. The

nutrients/oxygen team are busy but seem to have everything under control. Well that's what they tell us anyway.

We have had a few sightings of schools of pilot whales near the ship, causing great excitement. We saw them spyhopping – this is when they lift their heads out of the water using their flippers to balance, to have a look around, presumably out of curiosity. There have been large numbers of birds, mostly various types of albatrosses (Black browed and the big Wandering ones), and also a pretty delicate pied bird called a Cape Petrel.

As we turned south across Drake Passage we found ourselves beam on to a large swell. During Saturday conditions worsened, it began to rain and the wind got up. The last station of Saturday night was sampled in mountainous seas, and Sally was at one stage drenched to her waist. Sunday morning found us hove to, sitting out the storm into wind. The wind during the night was up to force 11 but had abated to 9 by morning. Everyone was groggy with lack of sleep, as the ship had rolled and corkscrewed all night. Dave L was found curled on the floor of the main lab claiming it was the most comfortable place. He has struggled on stoically despite suffering the worst seasickness of all of us.

By lunchtime Sunday the wind was decreasing but the seas were still confused. A number of us were in the bar for 'tabnabs', pre-lunch snacks, when the ship gave an almighty roll (measured at 39 degrees). All the tabnabs went flying. There was mayonnaise over the Mate, tartar sauce all over Lucy. John was thrown from his chair, somersaulted over Sally, hurtled out of the door and back in again, all without spilling a drop of his gin ! Down in the lab even more devastation had occurred. Nick's computer had, lemming like, decided to throw itself off the bench to which it was screwed down. Kate showed incredible presence of mind. She threw down the can of coke in her hand, launched herself at the computer and managed to catch the hard disks, while the monitor dangled on its lead an inch off the deck. Seconds later she was attacked by a flying metal waste bin which has given her a very nasty bruise on her knee. We have given her stick for the mess caused by the coke can as there were 2 other waste bins within reach which she managed to miss, but she definitely wins this week's prize for heroism beyond the call of duty.

Stations began again on Sunday afternoon when the waves had abated somewhat. We hear rumours that another low pressure system is on its way. We are just crossing the Polar Front. Today our passenger, Crispin Day, whom we are dropping off at Rothera, gave us a slide show about Antarctica, which has certainly whetted our appetites for the ice and scenery to come. Something to look forward to this week.

ALBATROSS Newsletter Week 2
Sunday 28th March

We are writing this week's newsletter moored alongside the BAS base at Rothera, on the western side of the Antarctic Peninsula, surrounded by the most spectacular scenery and wildlife. It has been an eventful week.

Science-wise, the week has been very successful. We have completed our section across Drake Passage, 45 stations from continent to continent. These are closely spaced, and have excellent lowered ADCP data to give us in situ current profiles. Team Nuts (Richard, Lucy and Dave) have measured every bottle for nitrates, phosphates, silicates and dissolved oxygen. Team CFCs (Alison, Fiona and Sally) are now achieving high quality data and have a good section across the southern Drake Passage where this data set will be most interesting. The CTD data have been calibrated and the quality of the data looks good. We have made initial comparisons with the Roether data from the same section 10 years ago. Hopefully within the next few days we'll be able to send back some preliminary results to put on the Web.

One major success of the week has been getting the liquid nitrogen generator to release its supply. We knew it was working (well the flashing lights indicated so) but the outlet appeared to be frozen up. Alison spearheaded a thankless campaign of aiming a hot air gun at the outlet for hours on end. She then announced that she'd sleep on it (rather uncomfortable we thought …) and it would work in the morning. It didn't, but the following day Simon, our deck engineer, tried again and practically fell over in astonishment because the outlet siphon just slid out effortlessly ! Since then the generator dragon has been behaving, much to our relief, because that would have been the end of our CFC measurements. We still thank our lucky stars that Lucy got the two dewars filled in the Falklands, which gave us enough to complete Drake Passage.

Socially, the high spot of the week has been "These Rough Notes", a collection of slides and readings from diaries, to document Scott's disasterous expedition to the South Pole. This was organised by Mark, who showed slides of various people and their original drawings. John read Cherry-Garrard, the Mate Rob was Bowers, Crispin read Wilson, Elaine was Kathleen Scott and Richard read Scott. It was very moving, and particularly apt as we pitched and rolled our way towards Antarctica. Other entertainment on board tends to revolve around the bar, and frequently involves noisy games of Trivial Pursuit. We also get a daily news bulletin printed out by the radio officer. We have followed the Pinochet trial with close interest, not least because Oli and Uli were planning to fly home via Lan Chile to Punta Arenas but will now probably have to return with us via Brize Norton. We were most relieved to have safely left Chilean waters before this week's ruling, since it would have been too late to rescind their permission for us to work in their waters.

However the high spot for all of us this week has been Antarctica itself. It is almost impossible to find words for how spectacular the scenery is. We left off the section on Friday morning and arrived in Rothera on Saturday after lunch, a welcome break from the hard work of the last week. The weather deteriorated during Friday, and we had snow, several inches. We enjoyed making substantial snowmen and snow penguins, and having snowball fights, on the aft deck. Visibility was poor, so we took a route outside of the islands which dot the coastline, and steamed quickly south. It was windy overnight, and the sea was rough - one of the worst nights so far for sleeping, as the ship was pitching and lurching. However we woke on Saturday to a clearing sky and the wind was dropping. Soon we saw our first glimpses of mountains in the distance. Then we could make out snow covered peaks, glaciers, crags, ice bergs. Science, data analysis and sample preparation were soon forgotten as the scientists excitedly went out on deck, up to the bridge or the monkey island, to absorb the views. Cameras were clicking incessantly. The mountains are so steep and high, it feels as though we are sailing through the Alps, but the valleys are filled with sea. There are no trees, but the beauty is in the crags and rocks, the colours of the ice, the sharp pinnacles. Sorry, but you'll just have to wait until you see the photographs, to get an inkling of how amazing it is.

The main source of angst this week has been the CTD cable. During our deep stations across Drake Passage, the cable kept getting turns in it, and becoming kinked. We had to stop every few stations, and deploy the cable with just a set of weights on it, lowered down to the sea bed to let the cable de-stress itself. This was getting time consuming, so the decision was taken to replace the cable with a new one. There are two main parts to this - getting the old cable off, and putting the new one on. All the scientists were roped in to help with the former job, by keeping the wire under tension as we walked it off the winch drum and into the hold where it was coiled in a figure of eight by the crew. When you realise that the cable is some 5 km long, you can see how much walking up and down the ship this involved. This task was completed during our steam south to Rothera on Friday.

The purpose of the trip to Rothera was to drop off aircraft fuel there, to be used next spring. On arrival the de-fuelling began, together with the longer task of winding the new CTD cable onto the winch drum. This was done by the winch, so there was nothing the scientists could help with. We were welcomed onto the base and allowed to explore. There are 22 BAS people overwintering at Rothera, a few scientists but mostly support personnel. They were extremely helpful and went to great efforts to show us their home. They took us up Reptile Ridge on Snocats or skidoos, where we had fantastic views over the bays. We were extremely lucky with the weather, which was windless and sunny. The wildlife at Rothera was the other marvel. We walked round the nearby headland along the rocky shore, and saw Crabeater seals, Weddell seals, Fur seals, and dozens of Adelie penguins. They were all so fearless. Uli sat still and wiggled his fingers in the snow, and one penguin came to peck his fingers out of curiosity! The Skuas were also fearless but in a nasty way - one or two people were attacked by them - they dive-bomb people's heads which is frightening.

By Saturday evening the CTD cable was well on the way to being spooled on, but there was bad news when we woke on Sunday morning expecting to be sailing at 9 am. The cable spooling had become uneven after 3.6 km (due to a slightly greater wire thickness), and it was necessary to unspool it and start again. All of the scientists were required again, and many base members came to help too. Our task was to turn by hand the drum onto which the cable was being wound. This was like a giant cotton reel, suspended on the aft deck. With 4 or more people at a time, we just managed to keep it turning, taking turns of a few minutes each from 8.30 until 11.30, to the strains of a range of music from the 'chain gang song' to the teletubbies ! It was exhausting, and our arms and backs ached. The drum weighed 5 tonnes. There were rumours that the wire change had been concocted by Karen as a team building exercise … entirely unfounded!

At lunchtime the cable was off again, and the painstaking task of winding it back on began again. This time the ship's side managed to avoid the uneven lie of the cable, and they succeeded in getting the cable on smoothly (we hope). Our unexpected extra day at Rothera was spent in a variety of ways. Many people walked, photographed and enjoyed the scenery and the wildlife. Some went for boats trips in the bay to collect water samples for oxygen isotope analysis. In the evening we learnt that the cable was on again, and we sailed at 10 pm. The base people gave us a spectacular send-off, with flares and fireworks. Hard to believe that they will be there for 5 months with no means of getting out. Lizzy was very envious of them, and indeed there were rumours that she had hidden in a cupboard on Rothera as a stowaway ! Finishing this week's newsletter, we are now steaming northwards from Rothera, to rejoin our section at the tip of the Antarctic Peninsula.

ALBATROSS Newsletter Week 3
Monday 5th April

Happy Easter from the James Clark Ross, just east of the South Orkney islands. Since leaving Rothera a week ago, we have had a week of hard work and are now progressing well round our cruise track. We should accomplish our hundredth CTD station within the next 3 days.

The social highlight of the week has been 'race night', organised by Roy, one of the catering staff. This took place in the officers' bar on Monday night. Six small wooden horses moved along a mat laid out along the floor, with some fences and a water jump. We shook dice to determine which horse moved and how many spaces. If your horse landed on a jump, it had to go back a few spaces, rather like snakes and ladders. Horses cost £1, and the names chosen were inventive! We also bet on the outcome of the races. It was hilarious and very noisy! About £100 was raised for charity, and a good time had by all, even if most of us did lose our money.

On leaving Rothera, we were hopeful of a scenic steam through the 'inside route', between various islands and the peninsula. However we were beset with bad weather, first fog and then rougher seas, which meant that the inside route was not feasible. As a consolation, we visited Deception Island for a few hours on Tuesday morning. (The Captain announced at Race Night that he would not allow a visit to Deception unless there was a good showing at breakfast. Accordingly there were more than the usual number of bleary eyed scientists munching cereal at 7.30 am. Strangely however the Captain was not to be seen …). Deception is a caldera, a volcano with sea in the middle. Apparently the water is warm enough to swim in, although we didn't have time for such an in depth exploration. Slowly the JCR slipped through the very narrow gap through the rock cliffs to get inside, crew standing by on the foredeck in case we began to drift onto the rocks and had to drop anchor. Most others were on Monkey Island or on the Bridge taking photos. It was a lovely calm and bright morning. Inside there is an old whaling station, rusty hulks of the containers they used to store the whale oil in. On the beach were dozens of fur seals gambolling about. They look like bears, because they stand on their hind flippers. Very furry and appealing but definitely rather nasty. We stayed at Deception for about an hour, while the ship took advantage of the calm seas to test the launching of both life boats.

There has been a good range of wildlife this week. Fur seals leaping through the water alongside the ship, hourglass dolphins and sei whales. Dozens of chinstrap penguins frequently arrive when we're on station or sampling, and porpoise along. They look so small and vulnerable to be so far from land. We are often followed by various kind of albatross and petrel, including an attractive light-mantled sooty albatross, and some Antarctic petrels.

Tuesday brought us the bad news from Myriam in Stanley that we will not be flying home to the UK on Saturday 24th April as planned, because the RAF have cancelled that flight. Instead we have a prolonged visit to the Falklands and return to the UK on Thursday 29th. This created a subdued atmosphere for several days (and emergency chocolate rations were broken into), now replaced by a mixture of resignation and determination to get out of Stanley and make the most of the enforced stay. A number of us are still hoping that we might be able to escape through South America, if any air links to the Falklands resume. As of 1st April there is no longer an air link with Chile because of the Pinochet situation.

CTD stations began again on Wednesday at the tip of the Antarctic Peninsula. It was our calmest day yet, with almost glassy seas. The stations were shallow, only about 500 m, so progress was fast. By Friday we had arrived at the South Orkneys. By coincidence, the other BAS ship, the Bransfield, had just relieved their base on Signy, and was leaving to return to the UK. We were able to meet up with her, and the 2 ships steamed side by side for a few miles, each ship crawling with people waving and taking photos. Some fur seals came and porpoised along in between us. Finally the JCR sounded her horn, brash and loud, and there came from the Brannie a deep throaty response. The 2 ships 'talked' for a few minutes and then we swung away to turn east again. It was strangely emotional meeting the other ship, and she seemed too small to be going all that way on her own!

The weather on Friday was excellent and we enjoyed seeing all the icebergs grounded around the South Orkneys. One was covered with penguins, so many that from a distance it looked like the whole iceberg was covered in a black smudge. In the evening we did a survey of the ocean depth in the Orkney Passage east of the South Orkneys, so that we could decide where best to place our stations, and also to give Fiona some extra time to fix some problems with her SF_6 kit. By Saturday morning the wind had got up and we were struggling through heavy seas. Stations began again and proceeded eastwards. Unfortunately Fiona's kit suffered what she described as 'meltdown' and she is back to square one. She is remarkably sanguine about it.

The chemists have discovered a new chemical compound, ^{137}Tedium. They are measuring its concentration daily and have a plot showing its variations. There is a positive correlation between the number of CTD stations per day, and the concentration of Tedium determined by their sensitive equipment. Very little Tedium was observed at Rothera or during Fiona's meltdown.

Much excitement this week when we saw 2 ships nearby, their lights clearly visible. They were Polish fishing vessels. It is strange to see other ships and realise that there are other people in the world. Easter day was celebrated with turkey and Christmas pudding. Don't ask us why. For the last couple of weeks there has been a dire shortage of chocolate, but suddenly the ship was awash with chocolate as people brought out their hidden supplies. Bill the engineer has started bribing Karen and Dave with Mars bars to allow a visit to South Georgia. Easter Day was Sally's birthday and a party spontaneously erupted during the small hours in the crew bar.

We are now past the halfway point and will soon be turning north to repeat the A23 stations we did almost exactly 4 years ago from the same ship. If all goes well and we are lucky with the weather, we should be writing next week's newsletter from the vicinity of South Georgia. In the mean time we are looking forward to a break from the CTD stations, to recover a bottom pressure recorder for our colleagues at the Proudman Oceanographic Lab in Birkenhead. This has been moored for the last year just east of our first A23 repeat station.

ALBATROSS Newsletter Week 4
Tuesday 13th April

We have delayed sending this email out until today so that we could tell you about our visit to South Georgia. It has been another week of hard work for all of us, and we have had some rough weather to contend with, so the short break was very welcome. Science wise all continues to go well. We have now chalked up 122 CTD stations and have completed almost three sides round our box. After the test station, we have 45 stations in Drake Passage, one at Rothera, then 55 along our southern section, and 20 along the short repeat of A23, the WOCE section we occupied in 1995. We now head northwest repeating stations occupied annually by BAS, the Maurice Ewing Bank section (or as Lucy calls it, the Bobby Ewing Bank!). Then west along the Falkland Plateau, back to Port Stanley. Due in lunchtime Thursday next week.

At the end of the southern section, as we went into triple figures with the CTD stations, we had a short detour to recover a bottom pressure recorder (BPR) for Chris Hughes at the Proudman Oceanographic Lab. This has been sitting on the sea bed for the last year, recording the pressure due to the amount of water above it - this tells us how variable the currents are. We arrived at its location soon after daybreak on Thursday, and were astonished when it responded immediately to the acoustic signal we sent it, to tell it to wake up. Happy that we were talking to it, we sent the signal to release, then waited for it to begin coming up. As it rose we could track its progress as it sent back its pressure reading (this was a bit of a black art since it sent back about 6 different numbers and you had to choose which one was most realistic). At a depth of 300 m, we lost track of it - no more response. We all went up onto Monkey Island or the Bridge, to search for it on the surface. No sign. The BPR should have a radio transmitter to allow us to get a bearing on its location. There was silence on the receivers on the Bridge. The ship began to do a box around the supposed location, and we discussed whether it could have drifted out of sight or perhaps was never released in the first place. Suddenly, good news spread round the ship, Charlie had spotted it! There has since been some debate over which Charlie saw it first, since both Charlie the radio officer and Charlie the Motorman claim the right to the prize. We were extremely lucky that the weather was so calm with no wind or waves to speak of, otherwise we would never have seen the BPR on the surface. Its radio transmitter was not working, although it did start working belatedly when safely on deck. We were expecting a large BPR rig and had the crane standing by to haul it out of the water, so were surprised when the rig turned out to be a small capsule only about as big as Karen.

After the BPR recovery we had several more days of unbelievable seas, glassy calm with barely any wind, and plenty of sunshine, which lifted people's spirits considerably. It was hard to believe that this was the Southern Ocean. On Friday we were excited to find that we were repeating A23 station 42, which we had occupied on the same day, 9th April, exactly 4 years ago. Conditions could scarcely have been more different. In 1995 we had our big storm immediately after that station, and were 'hove to' for 24 hours. In 1999 we completed the station in flat seas and sun.

One of the unusual sights of the week has been a green iceberg. Most icebergs are white or grey, and some older ones are vivid blue or black. This one however was green. We decided that it was worth a closer look, for scientific purposes of course. According to Mark, it was green because it had chlorophyll growing inside it. As the glaciers flow seawards, they pick up soil and, presumably, plant life, from the rock beneath. Then the iceberg calves, eventually rolls over, and the chlorophyll is exposed to light and begins to grow. We knew the iceberg was something special when even the Chief Engineer and the Captain were getting their cameras out for the first time this trip. The green iceberg was covered with hundreds of penguins, and a small whale was spotted cavorting about in the surf beside the berg. Other wildlife this week has included fur seals and chinstrap penguins swimming round the ship, and krill swarms - big brown streaks on the sea. Plus the usual birds accompanying the ship from time to time, including petrels and shags. The different types of albatross we usually see are Wandering, Black-browed, Grey-headed and Light-mantled sooty albatrosses; the latter look rather like chocolate point Siamese cats. One night around the CTD there were dozens of long stringy things drifting about in the water. Some people caught them in nets. They were up to about a metre long and a couple of centimetres in diameter, translucent and jelly like. Apparently they are salps, a kind of zooplankton.

After the glorious weather early this week, the ocean returned to its more usual state on Saturday evening and we were hove to for much of Sunday, about 24 hours in all. Force 9 winds, together with snow, rain and just about anything else the atmosphere could hurl at us. Lots of ship rolls so furniture falling over, luckily no kami kaze computers this time. This caused a 24 hour delay in our visit to South Georgia, planned for Monday. There were suggestions that this had been deliberately arranged by Mikey so that he could spend his 30th birthday on South Georgia. By Monday we were back doing stations and completed the A23 repeat in the evening. Our last station was a shallow one on the shelf of South Georgia. Overnight it got very windy again and there was some concern that we would not make it to the harbour at Grytviken by morning.

However early Tuesday found us steaming past spectacular mountains, turned pink in the dawn, as we approached Grytviken. Glorious sunshine again, and the high mountains were sheltering us from the strong wind. Glaciers came down to the sea and had jagged edges where bergs had calved. There was much more bare rock than there had been in Antarctica, giving a greater contrast between glaciers and mountains. Strangest of all, there was a green colour on the lower slopes - rough grass. It was noticeably warmer out on deck than it had been in Antarctica - we had forgotten how much further north we are now. Furry hats and gloves are now optional rather than essential.

Grytviken was a Norwegian whaling station until the 1960's, then it was used as a BAS base, and now it houses a small contingent from the British army. There is also a museum and a post office. We had hoped to lie the ship alongside the jetty but the wind was strong onshore and the idea was abandoned. Instead the cargo tender was launched. The ship's officers refer to this as the floating skip, but it also looks rather like a child's drawing of a boat. We had to climb down a ladder over the side of the ship, and stand in the boat as it chugged to land. All the scientists went ashore to explore Grytviken for a couple of hours. The whaling station is deserted and eerie, derelict buildings, rusty machinery and half sunken ships. It had a macabre atmosphere. Some retail therapy was liberally applied in the post office and museum shop. The museum was fascinating. High spots included a huge stuffed albatross, wings extended, hanging from the ceiling, and a fur seal's whisker, very long and wiry. There were big displays on Shackleton's Antarctic expedition which ended in South Georgia, and on the life and times of the Norwegian whalers. A short walk from the whaling station was the cemetery where Shackleton is buried. To get there we had to run the gauntlet of the fur seals, who were getting cross at the number of visitors so decided to run after a few to frighten them. There were fur seals everywhere, and we managed to get close to some of the least aggressive ones (and some people got closer to the aggressive ones than they intended - fur seals can run remarkably fast!). Also there were elephant seals all over the place. These are frankly not one of nature's most attractive inventions. They smell, and their throaty snores could be heard reverberating across the bay. They paid us no attention but continued basking in the sun, all piled on top of one another. A lone Gentoo penguin seemed to enjoy being the centre of attention and would happily let people get within a metre to take pictures.

We left Grytviken after lunch, and after a quick CTD station in the bay for Richard, continued our steam west across the South Georgia shelf, towards our first Maurice Ewing Bank station, due late this evening.

ALBATROSS Newsletter Week 5
Thursday 22nd April

Our final newsletter from the ship. We arrived in Stanley at dawn this morning and already people can be found singing 'we're coming home' in unguarded moments. Overall it has been a more successful cruise than we would have dared to hope for, so we are very pleased. We have had our share of good fortune, but primarily the success is owed to everyone's hard work. The dataset will keep us out of mischief for several years to come. After leaving South Georgia, we completed a set of CTD stations to the Maurice Ewing Bank, repeats of the ones done by BAS for several years. It will be interesting to see how the ocean properties vary from year to year. This will be the first time that the section has been done with tracer chemistry, and measuring the whole water column from surface to sea bed. Our final section was westward along the top of the Falkland Plateau, where we sampled again the Antarctic Circumpolar Current that flows through Drake Passage and then turns north. Our last station, number 170, was completed on Wednesday evening, close to the Falklands.

For several days we were visited by cattle egrets, large white birds on impossibly spindly legs. They ought not to be found here, so have presumably been blown off course by recent storms. Sadly they all seem to die on the ship. Otherwise there has been very little wildlife this week - no whales or penguins, just the usual albatrosses. One of the most dramatic events of the week has been the loss of 5 of the sampling bottles on the CTD rosette frame. The CTD came inboard with 2 of its 24 bottles completely missing, a 3rd broken in two and a further 2 cracked. These are huge bottles more than a metre tall and made of thick plastic so one can only imagine the force needed to break them apart. There are 2 possible explanations in circulation. First, Dave suggests a giant squid attack. Second, a bottle may have closed at the surface, and descended with air inside, so imploded at depth, taking out the bottles either side as well. Both explanations are something most of us have heard about but never seen. We leave it to our readers to decide which story they prefer.

The early part of the week brought us bad weather, and we were hove to for several hours on Friday and Saturday, unable to steam anywhere or do stations. However the weather improved for the last few days as we neared the Falklands, and we had some lovely mild days with plenty of sunshine. Visibility has been good and we had excellent sightings of Mars and Venus. The red planet was amazingly clear and definitely reddish orange in colour. We have enjoyed some beautiful sunrises and sunsets. They seem more spectacular at sea, because of the large expanse of sky, and the lack of light pollution.

It being the last week of the cruise, we have managed to fit in some socialising amidst the science, although the end-of cruise celebrations were muted by the fact that the last stations were so close to our arrival in port so there was a good deal of packing to do. On Tuesday we had the formal end of cruise dinner, when the officers wear their full uniforms. The catering staff did us proud with an excellent meal. On Wednesday after the last stations we held an RPC (Requests the Pleasure of your Company), a party to thank everyone on board for their hard work. The table tennis tournament reached its closing stages and Mikey beat Uli in the grand final.

On Tuesday we heard that the southbound Tristar from Brize Norton has been delayed at Ascension. We emailed to enquire whether its northbound journey was likely to be delayed sufficiently for us to get it. We found out that it would be returning north early Thursday morning, and that 6 places were available. Sadly most of us were unable to take up this opportunity since we have a huge amount of equipment to dismantle, the last salinity samples to analyse, and final data to archive. Five fortunate souls, Michel, John, Alberto, Mikey and Uli, were able to go. We arrived at our berth in Stanley at 6 am today, and they were whisked off in a bus straight to the airport. The rest of us are most envious. We leave the ship tomorrow, and have various expeditions planned until our homeward flight scheduled to depart on Wednesday.

Karen and Dave, Chief scientists, RRS James Clark Ross cruise 40, ALBATROSS
Antarctic Largescale Box Analysis and The Role Of the Scotia Sea
or as the chemists have renamed it, *A Long Boring And Tedious Round Of Silly Stations*

2. CTDO$_2$ Measurements

2.1 CTD and Rosette Multisampler
John Smithers

In total 170 stations were occupied ranging in depths from 100 – 4700 metres. The equipment used during cruise JR40 was as follows.

CTD MKIIIc	S/N Deep04.
Chelsea Transmissometer.	S/N
Simrad 200 metre Altimeter.	S/N
FSI 24 Bottle Rosette Pylon.	S/N FSI No 2.
LADCP	S/N

The raw data were logged both on the DAPS and on the CTD data/display systems. Throughout the cruise both the CTD deck and underwater units worked without fault. There were few misfires when firing bottles and most faults were due to lanyards not being set properly. The 10 litre water bottles were gradually replaced or serviced during the cruise. Typical faults were leaking or stiff taps and leaking bottom ‘O’ ring seals. One bottle was found to have no bottom seal even though it had sealed for most of the cruise.

During station 151 five bottles were damaged. There was no obvious cause but speculation suggests that one of the bottles may have closed at the surface and then imploded at depth, damaging the bottles either side of it.

Throughout the first part of the cruise the CTD cable presented problems. The down cast was generally fine but as the load increased on the up cast the package would spin and wind the cable. The number of turns could be determined from the LADCP. This resulted in kinks forming once the package was recovered and the load was removed from the cable. The termination had to be remade on an almost daily basis. It was not initially clear which was causing the spin, the CTD package or the cable. A fin was fitted to the CTD frame. This stopped any rotation of the package but the problem persisted. The

CTD cable was replaced with a new one once the ship reached Rothera. There were no further problems from then on.

2.2 Ship's Winch Operation
Simon Wright

After cast 003 the wire kinked and required reterminating, this was after a test cast and a shallow one to only a few hundred metres. It was decided to control this spinning by fitting a vane on one side to resist the rotations. Although the spinning was no longer a problem being indicated by the LADCP, the wire did need reterminating on casts 011 & 016. This was because the wire kinked on recovery either on deck or in the winch room damaging it beyond use. At this point, considering the fact that turns were already in the wire, it was deployed to full depth (3900m) connected to a swivel and some weights with the aim of letting the twists come out. After this operation no further twisting was registered by the LADCP in the water, but some evidence of twisting still existed on deck. This led to a policy of unshackling the package and allowing the twists to come out. The wire kinked again on casts 022 & 025 resulting in reterminations, after 025 the wire was deployed with weights and the vane was removed from the CTD to study its effects. The package appeared to be behaving with only one deployment with weights on cast 030 being required. However on cast 033 the wire was twisted so much that once the weight was removed it kinked inside the winch and had to be cut out of the system. At this point 1000 m of wire was removed with the aim of using newer cable and the vane reattached to the CTD. The package was now spinning in the water with the vane on, particularly on the down cast. The wire was also having to be disconnected nearly every time it came on deck to remove the twists and occasionally deployed with weights to relax it.

Due to the continuing problems the decision was then made to use the visit to Rothera to replace the cable with the spare being carried at that time. This operation went reasonable smoothly as wire winding goes with only one major removal of cable (~4000m) being required. The operation took about 26 working hours and resulted in extending the time taken for the resupply by about four hours over the BAS allocated period. I would like to thank all the ship, base and scientific personnel who assisted when required for all their help and patience.

The winch system was then operated with a policy of veering at 50 m/min and hauling at 60 m/min as one possible theory was that the wire was over speeding the package particularly in the rough weather we had been experiencing in Drake Passage. This would have the possible effect of trying to kink and twist the wire as the weight was applied and removed, but this cannot be proven at this point. The policy also allowed the wire some gentler operations as a single deep cast could not be carried out and allowed the wire to bed into the system.

The system has however worked with only minimal attention since then. The only problems being experienced was a lack of traction due to grease coming out and coating the wheels causing some slight delays on deeper casts, this has improved as the wire is worked and is a fact of life with a new cable. Some adjusting of the wire during spooling on was required until the ends became worked in due to the new cable being marginally larger than the old one.

In the period from this no major problems have been experienced to date with the remaining 120+ CTDs and it is the hope of the Deck Engineer that the earlier problems have not detracted from or hindered to a detrimental effect the science being done.

2.3 CTDO$_2$ Calibrations
Alberto Naveira-Garabato

Temperature calibration

The calibration of temperature consisted of, firstly, a conversion from temperature in engineering units (T_{raw}) to temperature in deg C on the ITS-90 scale (T):

$T = 4.9966928 \times 10^{-4} * T_{raw} + 0.13094213.$

A correction was applied in order to allow for the mismatch between the time constants of the temperature and conductivity sensors and in accordance with the procedure described in the SCOR WG 51 report (Crease *et al.*, 1988). This involved computing a time rate of change of temperature (δT) from 16 Hz data in the level A, for each 1 s ensemble. The correction then consisted of

$T = T + \alpha * \delta T$

where α is a time constant chosen as 0.25 s after the trial of a range of values made obvious that the selected figure minimised the spikiness of the temperature profile.

Though the ITS-90 scale was used for all the temperature data reported from this cruise, temperatures were converted to the 1968 scale for the purpose of computing derived oceanographic variables:

T68 = 1.00024 T (Saunders, 1990)

Pressure calibration

The calibration of pressure involved a number of steps. Following a conversion from pressure in engineering units (P_{raw}) to pressure in dbar (P)

$P = 0.107378894 * P_{raw} - 38.2847318$

a correction was made for the effect of temperature on the pressure offset.
This correction required the construction of a lagged temperature (T_{lag}) from the time series of temperature at each CTD cast:

$T_{lag}(t=t0+tdel) = W * T_{lag}(t=t0) + (1-W) * T(t=t0+tdel)$

where W = exp(-tdel/tconst), tdel (= 1 s) is the time interval over which T_{lag} is being updated, and tconst is a time constant estimated as 400 s in laboratory experiments (King, 1996). Then

$P = P - 0.55 * (T_{lag} - 12)$
The values of 0.55 and 12 were determined by inspection of on-deck CTD temperatures and pressures.

An additional adjustment to upcast pressures was conducted to account for hysteresis in the CTD pressure sensor. This was resolved after it became apparent that nominally calibrated salinity profiles at depth were systematically offset to lower values — by O(0.002) — in the downcast with respect to the upcast, and that pressure hysteresis appeared to be the only remaining factor that could explain such discrepancy. Through trial and error, the following table of pressure hysteresis corrections was derived that forced the downcast and upcast salinity profiles to converge:

P [dbar]	δP [dbar]
6500	0

5000	0
3500	0.5
3000	2
2500	3
2000	3
1500	3
1000	2
500	2
350	2
200	1.5
0	0
-10000	0

with the correction equation for upcast pressures expressed as

$$P = P + (\delta P(P) - P)*\delta P(P_{max})/P_{max}$$

where P_{max} is the pressure at the bottom of the cast.

Salinity calibration

Salinity (S) was calibrated by comparison with upcast Niskin bottle salinities on a station by station basis. By logging the bottle firing events in the level A, simultaneous CTD data required for the calculation of salinity (T, P and conductivity C) were merged in time with bottle sample salinities. Initially, a conversion of C from engineering to physical units was performed in an analogous fashion to T and P:

$$C = 7.7913034 \times 10^{-3} + 0.96424172 \times 10^{-3} * C_{raw} + 3.325916 \times 10^{-11} * C_{raw}^2$$

This was followed by the correction to conductivity ratio:

$$C = C\ (1 - 6.5 \times 10^{-6} * (T-15) + 1.5 \times 10^{-8} * P)$$

A nominally calibrated salinity was then computed from P, T and C using the UNESCO 1983 algorithm (Fofonoff and Millard, 1983). Least-squares linear regression with reference to bottle salinities followed to derive a small correction (as a function of P, T and C) for the nominally calibrated CTD salinity. Poorly-fitting samples, which generally occurred in regions of strong vertical salinity gradients, were excluded from the linear regression. To provide a measure of the final uncertainty associated with the calibrated salinities, Figure 3 shows a scatter diagram of the deviations between CTD and bottle salinities for all stations and depths. Only stations 016 and 017 (where data quality was bad, see section on stations with special treatment) and 046, where the fit to near-surface salinities was poor, deviate significantly from the cluster of points below 0.001. The root-mean-square deviation of bottle and CTD salinities for 1298 good samples deeper than 1000 m was 8×10^{-4}.

Though the agreement between upcast and downcast T/S relations was adequate, it was decided to extract the upcast data for the subsequent construction of the master 2 dbar-gridded files. This was due to the fact that, for some reason, downcast profiles were considerably noisier than the upcasts (Figure 4).

Oxygen calibration

CTD dissolved oxygen concentration was calibrated by fitting to bottle values using the expression

$$[O2] = sat(T,S) * \rho * (oxyc + c) * \exp(a * (w*T + (1-w)*T_{oxy}) + b*P)$$

where ρ, a, b, c and w ($0<w<1$) are the coefficients of the fit. oxyc and T_{oxy} are output in the CTD data stream and relate, respectively, to the amplitude of the signal from the oxygen sensor and its temperature. Due to the strong hysteretic behaviour of the oxygen sensor, only downcast CTD data were considered in the calibration. Accordingly, the merging with the bottle samples was conducted in pressure rather than time, which, in light of the generally close resemblance between downcast and upcast hydrographic properties, should not be critical for the accuracy of the calibration. The fit coefficients were computed separately at each station by a least-squares minimisation algorithm. Figure 5 shows a scatter diagram of the dissolved oxygen concentration residuals for all stations and depths. The root-mean-square deviation of bottle and CTD oxygens for 1299 good samples deeper than 1000 m was 2.18 μmol kg^{-1}.

Gridded master files

Once this series of calibrations had been applied, the upcast data for each CTD cast (downcast in the case of oxygen) was despiked and gridded into 2 dbar pressure bins with linear interpolation used in regions of absent data (see the guide to the CTD processing algorithm below).

CTD stations with special treatment

A few CTD stations were processed in a manner which differed in some aspect from the general procedure described above.

Bottle oxygen data from station 011 were bad and no direct computation of the CTD oxygen calibration coefficients was possible. As a result, those from station 010 were used in the calibration.

The data from stations 016 and 017 were strongly affected by high-frequency noise due to rough weather. In order to bring noise down to acceptable levels, the data were reprocessed through DAPS while applying a despiking routine at the 25 Hz level. Since time had been lost during reprocessing, it had to be reconstructed manually. A rate of change of temperature with time was also computed explicitly for use in place of δT, which was very noisy.

In station 021, the signal from the oxygen sensor was useless (possibly due to leaving the sensor cap on during the cast) and a new oxyc was constructed by calculating the mean of the oxyc values at stations 020 and 022 at each pressure level.

The hysteresis table that was used in the other stations did not perform well for cast 037, the deepest of the cruise. Adopting a practical approach to optimise the quality of the CTD salinity calibration, the following table was employed instead:

P [dbar]	δP [dbar]
6500	0
5000	0
4500	0.2
3500	0.5
3000	1.2

1000	1.2
500	0.8
350	0.8
200	0.5
0	0
-10000	0

During station 085, DAPS was started late when the CTD was at a depth of 800 m during the downcast. The downcast data from the top 800 m then had to be reacquired and pasted into the remaining segment of the cast. Special manipulation of the data was needed to match the times of both fragments of the cast.

In station 095, DAPS was never activated. As a result, no record of the firing of bottles was available and a bottle file had to be created manually. The times in the bottle file and the CTD data were matched by reference to a time series of pressure during the cast.

Being bottle blank stations, casts 134, 153 and 154 offered no possibility of a local salinity or oxygen calibration, so the coefficients from a neighbouring station (133, 152 and 155, respectively) were used instead.

References

Crease, J. *et al.*, 1988: The acquisition, calibration and analysis of CTD data. *Unesco Technical Papers in Marine Science*, No. 54, 96 pp.

Fofonoff, P. and R. C. Millard Jr., 1983: Algorithms for computation of fundamental properties of seawater. *Unesco Technical Papers in Marine Science*, No. 44, 53 pp.

King, B. A., 1996: CTDO2 data collection and processing. In WOCE Section A23 Cruise Report, *UEA Cruise Report Series No. 1.*

Saunders, P. M., 1990: The International Temperature Scale 1990, ITS-90. *WOCE Newsletter No. 10*, p. 10. (Unpublished manuscript)

2.4 CTDO$_2$ Data Processing

Alberto Naveira-Garabato

Instructions for CTD processing during ALBATROSS were as follows:

nnn refers to the 3 digit station number e.g. 001.

Log on to a suitable Sun workstation (either jrue or albatross).

cd ~/ctd
ls

If a directory for the station to be processed does not exist, create it (**mkdir *nnn***) and copy the calibration file (cal.*nnn*) from the station 001 directory.

cp 001/cal.001 nnn/cal.nnn

cd ~/ctd/nnn
ftp wodaps
Name daps
Password jr40jr40

cd /local/daps_data/jr40
get ctdfile and bottlefile indicated on daps logsheet.
exit from ftp (type **bye**)

cp ctdfile **ctdnnn.raw**
cp bottlefile **botnnn.asc**

matlab
ctdcal(*nnn*)

This uses the calibration information in cal.*nnn* to convert all variables in ctd*nnn*.raw from engineering to physical units. In addition, it changes the time unit from Julian day to seconds and applies the deltat correction to temperature, the lagged temperature and hysteresis corrections to pressure, and the correction to conductivity ratio.
The output file is ctd*nnn*.1hz .

This program will also produce a hardcopy of the time series of all the variables in the input file.

Now add to (or if necessary create) the README file in the directory and document what you have done (look at previous stations for examples). Keep adding to the README as you go through each of the remaining procedures.

Next correct for a possible offset in pressure. Type **offpress**
enter station number *nnn*

A plot will appear on the screen showing time series of pressure and conductivity as read from the ctd*nnn*.1hz file.
You will then be prompted to enter the desired pressure offset (in dbar).

The program will apply the specified offset, produce a new time series of the resulting pressure and use this to extract the part of the input file in which the CTD was in the water. The offset pressure (along with the other input variables) is output to ctd*nnn*.wat. If the pressure offset applied does not appear satisfactory, run offpress again.

If by any chance you have to recreate ctd*nnn*.wat and you already know the pressure offset to apply, you can run **offpress2(*nnn*,off)**
where 'off' is the pressured offset of your choice.

Now check for high frequency noise in the temperature and conductivity data in ctd*nnn*.wat. Type **spike(*nnn*)**

Spikes in temperature and conductivity are automatically set to absent data. In addition, a nominal calculation of salinity is performed within the program in order to detect any spikes possibly resulting from the combination of smooth temperature and conductivity data. If any such spikes are observed, the corresponding data cycles in conductivity are also set to absent data.

The output file is ctd*nnn*.spk .

Creating the bottle file

Running **ctd10s(*nnn*)** produces a 10 second average of all variables in ctd*nnn*.spk . This is saved to ctd*nnn*.10s .

Outside matlab, edit the bot*nnn*.asc file using your favourite editor. This is a text file containing the times of the bottle firings.
From the CTD logsheet, enter the sample number as a 3^{rd} column into the bot*nnn*.asc file. The sample number is the station number followed by the bottle number. e.g. 01801 for bottle 01 in station 018. Take particular care to enter the sample numbers in the right order, if the bottles were not fired in numerical order.

matlab
readbot
enter station number *nnn*

This will produce the basic matlab bottle file bot*nnn*.mat, into which other variables can be read. It also sorts into sample number order.

Typing **readsal**
enter station number *nnn*

will put salinity values from the ascii file sal*nnn*.txt into the bottle file. It will also create a salinity flag variable called salflag, set it to 1 and append it to the bottle file. In future stages of the processing, samples can be excluded from the salinity calibration algorithm by setting salflag to 0.

Now we want to merge values from the upcast CTD profile into the bottle file:
mergctdt(*nnn*) merges ctd*nnn*.10s into bot*nnn*.mat . Variables from the ctd*nnn*.10s file are renamed with the prefix *ctd.*

Calibrating salinity

The program **salcal2(*nnn*)** reads in data from bot*nnn*.mat and calculates the salinity calibration coefficients, which it writes to the file salcoef.mat along with the root-mean-square deviation and individual point-to-point differences of the fit. A flagging facility is included through the variable salflag in the bot*nnn*.mat file.

salcal(*nnn*) reads in the salinity calibration coefficients in salcoef.mat and calculates salinity from conductivity, temperature and pressure in ctd*nnn*.spk . Output file is ctd*nnn*.sal . This program also calculates salinity from the CTD conductivity, temperature and pressure data merged into bot*nnn*.mat and appends it to this file.

Now run **interpol(*nnn*)** which interpolates across absent data in temperature and salinity in ctd*nnn*.sal writing the results to ctd*nnn*.int .

This should be followed by **dervar(*nnn*)** which derives T_{68}, potential temperature, σ_0, σ_2 and σ_4 from the variables in ctd*nnn*.int . Output is ctd*nnn*.var . This program also calculates the above variables for the CTD data previously merged with bot*nnn*.mat, appending them to this file.

Executing **splitcast(*nnn*)** splits the CTD cast in ctd*nnn*.var into a downcast (saved to ctd*nnn*.var.dn) and an upcast (saved to ctd*nnn*.var.up).

Then **ctd2dbup(*nnn*)** grids the ctd*nnn*.var.up file into 2 dbar pressure bins, producing ctd*nnn*.2db

interp2db(*nnn*) interpolates across gaps of absent data in every variable in ctd*nnn*.2db

ctdbottom(*nnn*) can be run once ctd*nnn*.var exists. It appends latitude, longitude and depth information to the ascii file ctdbottom.asc. It should be run normally only once for each station, and in numerical order of stations.

Calibrating dissolved oxygen concentration

loadoxynuts(*nnn*) reads in oxygen and nutrient data from the ascii file JR40*nnn*.TXT in the oxynuts directory and appends them to the bot*nnn*.mat file. It also creates an oxygen flag variable called oxyflag, sets it to 1 and appends it to the bottle file. In future stages of the processing, samples can be excluded from the oxygen calibration algorithm by setting oxyflag to 0.

ctdpav(*nnn*) then grids the ctd*nnn*.var.dn file into 2 dbar pressure bins, producing ctd*nnn*.pav

Run **mergctdp(*nnn*)** to merge variables from the gridded CTD downcast data file, ctd*nnn*.pav, into bot*nnn*.mat, renaming them with the prefix *d*.

oxycal2(*nnn*) reads in data from bot*nnn*.mat and calculates the oxygen calibration coefficients, which it writes to the file oxycoef.mat along with the root-mean-square deviation of the fit. A flagging facility is included through the variable oxyflag in the bot*nnn*.mat file.

oxycal(*nnn*) reads in the oxygen calibration coefficients written to oxycoef.mat and calculates dissolved oxygen concentration from oxyc, oxyt, temperature, salinity and pressure in ctd*nnn*.int . Output file is ctd*nnn*.oxy . This program also calculates dissolved oxygen concentration from the downcast CTD oxyc, oxyt, temperature, salinity and pressure data previously merged into bot*nnn*.mat and appends it to this file. In addition, it performs the conversion of oxygen and nutrients in the latter file from $\mu mol\ l^{-1}$ to $\mu mol\ kg^{-1}$, creating new variables oxykg, nitkg, phoskg and silckg and outputting them to bot*nnn*.mat.

Finally, **splot(*nnn*)** extracts the downcast data from the ctd*nnn*.oxy file, grids it into 2dbar bins and appends it to the existing ctd*nnn*.2db .

interpoxy2db(*nnn*) interpolates across gaps of absent data in oxygen in ctd*nnn*.2db

3. Rosette Water Sample Analysis

3.1 Salinity Sample Analysis

Kate White, Michel Arhan, Liz Hawker, Mark Brandon.

At the start of the cruise two salinometers were set up for use in the Radiation lab. These were a British Antarctic Survey Guildline 8400b serial number SN 63360, and a Southampton Oceanography Centre Guildline 8400b serial number SN 60839. Both salinometers were fitted with peristaltic pumps purchased from Ocean Scientific Ltd. The BAS unit was designated as the primary salinometer, being purchased in the Autumn of 1998 it was significantly newer. The laboratory was set at 19ºC, and a thermometer attached to the wall showed no significant deviations from this throughout the cruise. The salinometers were set to 21ºC. After thermal equilibrium was reached in the salinometers (i.e the internal heating lamps were flashing), the BAS unit was aligned against OSIL standard seawater batch P134. The BAS salinometer functioned perfectly and was used throughout.

Samples were taken from every Niskin bottle throughout the cruise. The only exceptions were on casts where duplicate bottles were fired for CFC sampling (stations 011, 013, 015, 117, 119 and 154). In total 2572 samples were taken. The salinity samples were taken in 200 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 seal inserted and the screw cap replaced. The salinity samples were then placed near to the salinometer and left for at least 24 hours before measuring. This allowed the sample temperatures to equalize with the laboratory (19ºC). In addition samples were taken from the non-toxic supply to underway calibrate the oceanlogger system approximately every 4 hours throughout the cruise. These samples were taken and analysed in the same way as the CTD samples.

The samples were then analysed on the salinometer S/N 63360 and calibrated against standard seawater supplied by Ocean Scientific International Ltd. The salinity samples were analysed in batches of two crates, one vial of standard seawater was used at the beginning and end of each crate to enable a calibration offset to be derived and check the stability of the salinometer. Once analysed the conductivity ratios were entered by hand into a using an Excel based spreadsheet written by Sheldon Bacon (S.O.C.). The derived salinities were then transferred to the UNIX system and integrated into the CTD calibration process.

Throughout the cruise two batches of standard seawater were used: P133 and P134. As two bottles were closed at the deepest level of each CTD station we can use these duplicates as a measure of the accuracy of the method. For 177 duplicate pairs the mean difference between all pairs was 0.000, the standard deviation was 0.001.

3.2 Dissolved Oxygen Measurements

Lucinda Spokes, Dave Leah and Richard Sanders.

The concentration of dissolved oxygen was determined in seawater samples taken from individual Niskin bottles using the same analytical equipment as that used on WOCE section A23 (March to April 1995) and the repeat occupation of SR1b (JR27 - December 1997 to January 1998). The method uses the whole bottle Winkler procedure coupled to an automatic titration system with spectrophotometric end-point detection (Williams and Jenkinson, 1982).

The Winkler Method

The initial step of the reaction involves the reaction of Mn^{2+} ions (a 1 ml addition of 3 mol L^{-1} $MnCl_2$) with hydroxide ions added from an alkaline iodide solution (a 1 ml addition of a mixed solution of 8 mol L^{-1} NaOH and 4 mol L^{-1} NaI) to form the $Mn(OH)_2$ precipitate. Reagents were both prepared according to the methods in Dickson (1994). Once formed the precipitate scavenges oxygen from the water and is itself oxidised to Mn(III).

$$\downarrow 2Mn(OH)_2 + \tfrac{1}{2} O_2 + H_2O \rightarrow \downarrow 2Mn(OH)_3$$

Samples were shaken twice, once just after fixing and again once the $Mn(OH)_3$ precipitate had settled to approximately half the bottle volume. Samples were then left until the precipitate had again settled to approximately half the bottle volume. Just before analysis, the samples were acidified with 1 ml of 5 mol L^{-1} sulphuric acid. The acidification step causes the precipitate to dissolve and liberates Mn^{3+} ions. Under acidic conditions, these are strong oxidising agents reacting with the iodide added initially to form iodine.

$\downarrow 2Mn(OH)_3 + 2I^- + 6H^+ \rightarrow 2Mn^{2+} + I_2 + 6H_2O$

The iodine liberated then reacts with the remaining iodide ions to form the orange-yellow coloured triiodide species.

$I_2 + I^- \rightarrow I_3^-$

The triiodide species is then titrated against thiosulphate and the reaction end point determined photometrically once all the triiodide has been converted to the colourless iodide ion.

$I_3^- + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 3I^-$

The amount of thiosulphate used is therefore proportional to the I_3^- concentration which is proportional to the amount of Mn^{3+} produced, which is itself proportional to the initial dissolved oxygen concentration. The amount of thiosulphate required was therefore converted to an equivalent oxygen concentration (in μmol L^{-1}) at the fixing temperature using equations taken from Dickson (1994).

Sampling

Oxygen was sampled on all casts. On approximately half the stations, Helium, CFC's and SF_6 were also sampled. On these occasions, oxygen sampling followed that for these gases otherwise it was the first analyte to be sampled. Samples were drawn through Tygon tubes into the oxygen bottles directly from the Niskin and the bottle allowed to overflow with approximately three times its own volume (ca 360 ml). The temperature of the water at the time of fixing was measured using a Testo thermometer accurate to ± 0.1°C. The sample was then fixed using manganous chloride and alkaline iodide solutions. Injections were made using two BCL 8000 repetitive pipettes (Boehringer Mannheim) calibrated before the cruise by Biological Instrumentation Services Ltd. Syringes were changed frequently and greased to ensure accurate volumes of reagents were dispensed. In all but one case (the station at Marguerite Bay), samples were titrated within four hours of collection.

The oxygen bottles used were approximately 120 ml and were obtained from SOC as being surplus to their requirements and are in less than perfect condition. They are nominally calibrated to 0.01 ml. Usage has resulted in chipping of the lids which has reduced the accuracy of these calibrations leading to an increase in the effective bottle volume. No assessment of the possible impact of this factor on the final results has been undertaken.

Instrumentation

The various sub-units of the automatic titration system are a Metrohm 665 Dosimat 1 ml burette and a custom built end point detector purchased from the School of Ocean Sciences, University of Bangor, which are coupled to a PC and printer. Further details are available in Heywood and King (1996). The instrument is controlled by a QuickBasic program (LOXYBOT.BAS). At the beginning of this cruise a new version of this programme was created (JR40.BAS) which has been archived. Several of the default values differ from those in the original programme. The photocell readings was set at 100 (since a 286 computer was used), 4 endpoint checks were employed, 3 for the number of decrease points and the tolerance read was set at 0.35%.

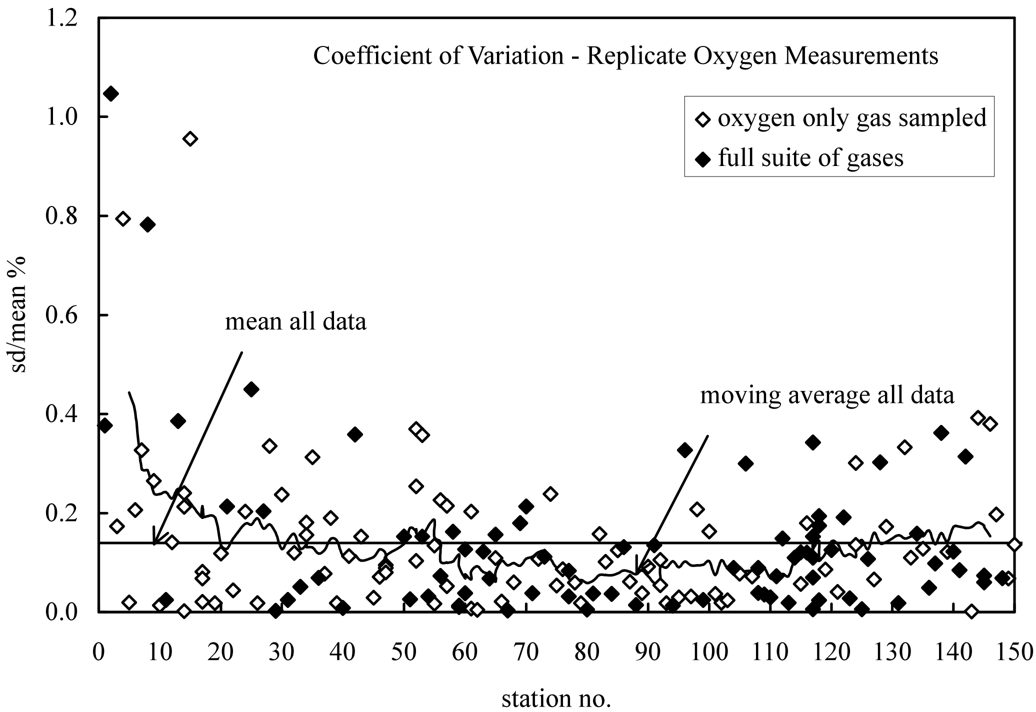
Standardisation

Two batches of thiosulphate were used through the cruise with the second batch being introduced on April 4th. Since thiosulphate is not a primary standard (i.e. its concentration decreases with time), the degradation of each batch was monitored by titrating it against two iodate standards. These standards both had a nominal concentration of 0.0017 mol L^{-1}. In addition we used a Sagami standard of concentration 0.0017 mol L^{-1} (0.01N). These were titrated in 5ml aliquots against the thiosulphate at intervals throughout the cruise to monitor deterioration of the thiosulphate solution. Initial checks on the thiosulphate solutions (once problems with lamp deterioration had been corrected for, see below) indicate that the concentrations of both batches changed only slightly during the cruise. Reagent blanks were determined during standardisation. Results indicate an average reagent blank equivalent to an oxygen concentration of 1.14 μmol L^{-1}.

Precision of Replicate Measurements

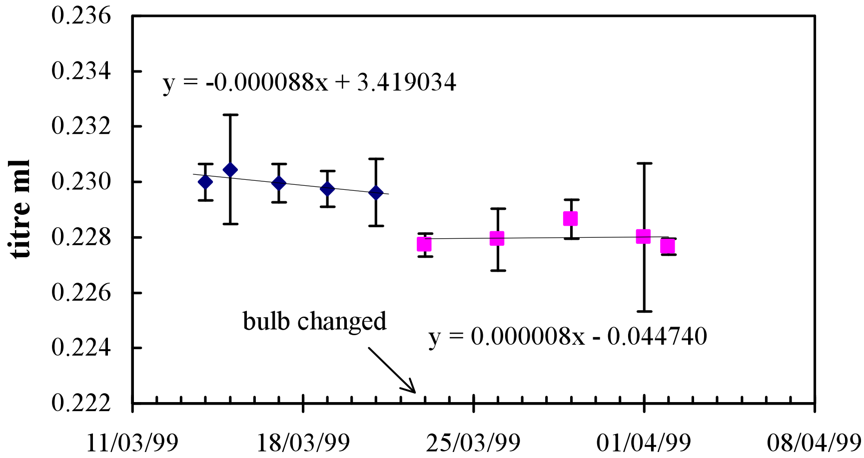
On all casts, two bottles were fired at the bottom. Comparison of the oxygen concentrations recorded in these two bottles, replicate samples taken from the same bottle and full bottle blank casts enables an assessment of the precision of the analysis. Since oxygen values differ in different water masses, the coefficient of variation (CV = standard deviation/mean value * 100) has been used. Over the first 150 stations, an average CV value of 0.14 % was obtained.

Precision of replicate measurements improved dramatically after the first few days. Thereafter, values for CV appear correlated with sea-state, with lowest values (< 0.1%) during calm weather (~ Stations 64 to 95). Under rough sea-state conditions, precision is worse as the titration equipment has problems finding the endpoint as the equipment moves around. Even under these conditions, the value for CV is better than ~ 0.4%.



Problems Experienced

The analytical system for dissolved oxygen analyses worked well throughout the cruise with only a few minor problems. As a result of instability in the light source, the lamp was changed on March 23rd 1999 immediately before titrating the samples from Station 29. During standardisation it was noted that the amount of thiosulphate needed to titrate a fixed amount of iodate was decreasing. This is contrary to expected results (the thiosulphate is not stable over time so the amount required to titrate a fixed amount of iodate should increase). After the bulb was changed, little change in the thiosulphate titre was seen..



On previous cruises bubbles in the burette have also caused problems. This was largely eliminated during JR40 by the use of Metrohm grease on the burette during assembly.

In addition:

Station 11.	Values not reported as the accuracy of replicate measurements was, for an unknown reason, very poor.
Station 108.	Problems experienced with the thermometer and an average fixing temperature of 0.2 used throughout.

Preliminary Results

Since the cruise, all data has been recalibrated to correct for the instability in the light source and slight changes in the thiosulphate concentrations over time.

Preliminary interpretation of the data has been carried out. Along the Southern Section from the Peninsula to the start of the A23 repeat there is evidence for recently ventilated water with oxygen levels around 240 μmol L^{-1} entering the Scotia Sea from the Weddell Sea. The eddy feature encountered on the A23 repeat also shows up especially well in the oxygen data.

References

Dickson, A. G. (1994) Determination of dissolved oxygen in seawater by Winkler titration. *WHP Operations and Methods-November 1994*.

Heywood, K. J. and King, B. A (1996) WOCE Section A23 Cruise Report. *UEA Cruise Report Series No.1.*

Williams, P.J.L. and Jenkinson, N. W. (1982) A transportable microprocessor-controlled precise Winkler titration suitable for field station and shipboard use. *Limnology and Oceanography* **27** 576-584.

3.3 Nutrient Measurements

Richard Sanders, David Leah and Lucinda Spokes

Methods

Dissolved inorganic nutrients (phosphorus, silicon and nitrate+nitrite) were analysed using a Skalar San Plus autoanalyser as on cruises JR10 (WOCE section A23) and JR27 (WOCE section SR1b); the reader is referred to reports detailing the results obtained on these cruises for further details of instrumentation and methods. The autoanalyser generally worked satisfactorily throughout the cruise with the following points noted.

1) Dilutions On both JR10 and JR27 we operated a ten fold dilution loop for silicate analyses in order to bring the high concentrations encountered within the linear range of the method. On JR10 we did not dilute nitrate samples however we diluted nitrate samples three fold on JR27 as we were unable to obtain linear calibrations for undiluted nitrate samples for unknown reasons. On JR40 we diluted both nitrate and silicate samples ten fold.

2) Baseline jumps. The phosphate line has developed an electrical fault which results in sudden jumps in the baseline within an hour of start up. We solved this problem initially (in the early part of the cruise) by running standards at the end of runs if a jump occurred and towards the end of the cruise by leaving the electronics switched on continuously.

3) Sample and wash times were both 150 seconds. These are longer than those used on JR10 and JR27, allowed a better resolution of peaks and was made possible by having three experienced analytical chemists on board to undertake the nutrient and dissolved oxygen analyses. In addition the oxygen and nutrients systems were set up on adjacent benches in the main lab which allowed simultaneous operation of the two systems to a greater degree than we have been able to undertake in the past. Data work up was undertaken using a UEA lap top also situated in the main lab as the shipboard computer facilities in the main lab were found to be inadequate. The new purified water system on the JCR is excellent.

4) Cleaning, retubing and cadmium columns. The entire cruise was run on a single cadmium column purchased new before the cruise began. All lines were cleaned at the start of the cruise. All pump tubes were replaced at the start of the cruise.
5) Logging and software. All analytical runs were logged and results calculated using the Skalar supplied software Version 5.1. This is in common with the results from A23 and JR27. The logging system failed towards the end of one of the analytical runs (stations 104-6) resulting in the loss of one stations worth of data (106).

6) Rerun salinity samples. On one station (137) we reran the samples that had been stored for 24 hours in salinity bottles to establish the potential for using these samples to settle disputes about anomalous results or if samples were lost. The average concentrations determined after this storage, expressed as a percentage of the initial concentration determined were 105, 89 and 98 for N, P and Si respectively. This suggests that the usage of stored salinity samples is only suitable for silicate.

Precision

1. Short term: We repeated one or two samples from each station. The mean coefficients of variations (standard deviation of the replicate analyses expressed as a percentage of the mean) were 1.16, 1.37 and 1.01% for nitrate, phosphate and silicate respectively. The short term precision of the data obtained on JR27 were Nitrate 0.46%, Phosphate 0.56% and Silicate 0.72%. These are approximately the same as A23 short term precisions which were Nitrate 0.4%, Phosphate 0.65% and Silicate 0.35%. Clearly the dataset collected on Albatross whilst of high quality is not as good as those collected on A23 and JR27. This is probably because the Albatross data was not as extensively quality controlled post cruise as the data from the other two cruises was.

2. Longterm: To check for day to day variations in calibrations and blanks, we also analysed each day a bulk (25l) seawater sample collected on the A23 cruise. The results obtained, together with those found on A23 and JR27 are shown below. If we assume that the bulk nutrient concentration is unlikely to vary significantly over the course of ALBATROSS (when it has been approximately

constant for 4 years) then the cruise wide precisions of our analyses are given in the table above as the standard deviations of the replicate analyses of the bulk sample (i.e. Nitrate 2.85%, Phosphate 3.4%, Silicate 1.52%).

	Mean (µM)	Stdev (µM)	s/mean (%)	Mean (µM)	stdev (µM)	s/mean (%)	Mean (µM)	stdev (µM)	s/mean (%)
Nitrate	33.83	0.5	1.24	34.18	0.75	2.19	34.75	0.99	2.85
Phosphate	2.35	0.07	2.48	2.32	0.053	2.30	2.31	0.08	3.4
Silicate	126.8	2.07	1.30	129.6	2.39	1.84	131.6	2	1.52

Clearly the precisions for nitrate and phosphate obtained on Albatross not as good as those obtained on A23 or JR27. On the other hand the silicate data is of a better quality than that obtained on JR27.

Conclusions

The dataset from Albatross is slightly worse than that from A23 and JR27 in its current state. It would probably benefit from the thorough scrutiny that the datasets from these other two cruises received.

References

Heywood, K. J. and King, B. A (1996) WOCE Section A23 Cruise Report. *UEA Cruise Report Series No.1.*
King, B. A. Drake Passage JR27 cruise report.

3.4 Chlorofluorocarbons and Carbon Tetrachloride

Alison Bateman, Sally Thorpe, Uli Fleischmann, Fiona Carse, Mike Meredith

Four transient tracer halocarbons were measured during ALBATROSS using a Shimadzu GC8A gas chromatograph equipped with an electron capture detector (ECD). These were trichlorofluoromethane (CCl_3F; CFC-11), dichlorodifluoromethane (CCl_2F_2; CFC-12), trichlorotrifluoroethane (CCl_2FCClF_2; CFC-113), and carbon tetrachloride (CCl_4).

Procedure

Samples were drawn directly from the Niskins into glass syringes (100 ml) with metal stopcocks. Sampling was performed immediately after the CTD package had been secured when possible, or immediately after sampling for Helium had been completed. Samples were stored under cold seawater until analysis, which was usually possible within 12 hours of sample collection.

The analysis system used was largely the same as that used for the WOCE A23 section (Watson *et al.,* 1996), itself a modification of that described by Haine *et al.* (1995). It comprised a sample stripping board, a Shimadzu GC8A (operated isothermally at 50°C), an electronics system controlling timing of valve throwing, and a data acquistion system. The SpectraPhysics software used previously with this system was replaced for ALBATROSS with the Unicam 4880 chromatography software package, with a stand-alone single channel data capture unit (DCU) interfacing with the output of the GC-ECD.

During operation, volatiles were extracted from seawater by purging a known volume of sample with 1%H in N_2 as stripper gas. These were then concentrated on an unpacked stainless steel trap at temperatures between -145 and -160°C. The trap was situated in the headspace above liquid nitrogen and the temperature of the headspace controlled by a heater in the liquid nitrogen. The compounds were separated using a DB-624 column. This comprised approximately 2.5m of precolumn and 20-25m of main column. CP grade He was used as carrier gas, and zero-grade N_2 as make-up gas. Flowrates of 5 ml/minute and 27 ml/minute were used for the carrier and make-up gases respectively.

Blanks

During previous cruises (e.g. the WOCE A23 section), the bottle blanks have been determined by closing all the Niskins at a depth presumed to be tracer-free. In the case of the A23 section, this was at the core depth of North Atlantic Deep Water in the Argentine Basin of the South Atlantic. However, the ALBATROSS cruise track was not well-suited to this technique, since it did not cross any water masses which could be known for certain to be devoid of CFCs. In particular, the Lower Circumpolar Deep Water (LCDW) shown by Roether *et al.* (1993) to be tracer-free in 1990 can now reasonably be expected to contain small but measurable quantities of tracer. Nonetheless, all the Niskins were closed at the core depth of the LCDW at stations 1, 134 and 154, with multiple samplings also occurring at the LCDW level at stations 11 and 13. These will be used to place constraints of the range of possible bottle blanks. For example, it is known that the final tracer concentrations in Drake Passage must be higher than those reported by Roether *et al.*, and those on the A23 section must be higher than those shown in Meredith *et al.* (1999), whilst simultaneously the tracer ratios must be reasonable upon comparison to the published Southern Hemisphere atmospheric histories (Walker *et al.,* 1999) and solubilities (Warner and Weiss, 1985; Bu and Warner, 1995; Bullister and Wisegarver, 1998). Thus, once the necessary rigorous quality control on the data has been performed, the bottle blanks should be able to be determined to a reasonable degree of accuracy.

Calibration

As with A23, the samping frequency precluded full calibrations prior to each cast. Consequently, multi-point (low-end) calibrations were performed when time permitted (18/3/99, 26/3/99, 7/4/99, 17/4/99), with full calibrations being performed on 7/4/99 and 16/4/99. The calibration was performed by analysing various volumes of the NOAA gas standard used on ALBATROSS, with combinations of the small loop (0.3776 cm^3), large loop (2.1261 cm^3) and extra-large loop (10 ml) being implemented to cover the full range of concentrations encountered in seawater. Fourth-order polynomials were then fitted to the points to form the base calibration curves, with residuals being examined to ensure no systematic lack of fit. Blanks and NOAA standards were run approximately every 6 samples; the variation of standard was smoothed with a 1-day filter, and used to determine "stretch factors", whereby the system response at the time of analysing the samples was made appropriate to that at the time of the calibration.

Problems

Numerous technical difficulties were encountered during the cruise, many of which were due to the long period since the last use of the system, and the very short time available with which to reconstruct it prior to ALBATROSS. Full details of the difficulties and suggestions for improvements to the system are described in Bateman (1999). The impact of the problems experienced on the data quality is not yet fully ascertained, though the quantity of high-quality measurements available will certainly be less than desired. Extensive rigorous quality control of the data is now needed, after which the precisions of the measurements can be derived.

References

Bateman, A., 1999. CFC and CCl_4 measurements during JR40 (ALBATROSS). UEA internal document, 28pp.

Bu, X. and M.J.Warner, 1995. Solubility of chlorofluorocarbon 113 in water and seawater. *Deep-Sea Research,* 42, 1151-1161.
Bullister, J.L. and D.P.Wisegarver, 1998. The solubility of carbon tetrachloride in water and seawater. *Deep-Sea Research,* 45, 1285-1302.
Haine, T.W.N., A.J.Watson and M.I.Liddicoat, 1995. Chlorofluorocarbon-113 in the northeast Atlantic. *Journal of Geophysical Research*, 100(C6), 10745-10753.
Roether, W., R.Schlitzer, A.Putzka, P.Beining, K.Bulsiewicz, G.Rohardt and F.Delahoyde, 1993. A Chlorofluoromethane and Hydrographic Section Across Drake Passage: Deep Water Ventilation and Meridional Property Transport. *Journal of Geophysical Research,* 98(C8), 14,423-14,435.
Meredith, M. P., R. A. Locarnini, K. A. Van Scoy, A. J. Watson, K. J. Heywood and B. A. King (2000) On the sources of Weddell Gyre Antarctic Bottom Water, *Journal of Geophysical Research*, *105(C1)*, 1093-1104.
Walker, S.J., R.F.Weiss and P.K.Salameh, 2000. Reconstructed histories of the annual mean atmospheric mole fractions for the halocarbons CFC-11, CFC-12, CFC-113 and carbon tetrachloride. *Journal of Geophysical Research*, submitted.
Warner, M.J. and R.F.Weiss, 1985. Solubilities of chlorofluorocarbons 11 and 12 in water and seawater. *Deep-Sea Research,* 32, 1485-1497.
Watson, A.J., K.A.Van Scoy and J.Kleinot, 1996. CFCs and Carbon Tetrachloride Transient Tracers. pp.33-34 in *WOCE Section A23 Cruise Report, UEA Cruise Report Series No.1, May 1996* (ed. K.Heywood and B.King).

3.5 SF_6 Measurements

Fiona Carse

Water column dissolved sulphur hexafluoride (SF_6) concentrations were determined using vacuum-sparge and ECD gas chromatography. Sampling commenced at the southern end of the repeat A23 section, running approximately every other station. Around 450 samples were analysed in total.

Analysis

The system was the same as that described in Law *et al.* (1994). SF_6 is separated from oxygen and other gases by a 3 metre column (at room temperature, outside the oven) of molecular seive (5A, 100-120 micron), and detected by the electron-capture detector in the GC. The SF6 was extracted from approx. 350ml seawater sample under vacuum and by purging with oxygen-free nitrogen. The extracted gas stream is dried and cryotrapped at < -70°C in a 30 centimetre loop of porapak QS in 1/8" steel tubing. The SF_6 is released from this trap by electro-heating to about +70°C, and is injected onto the chromatographic column. Each sample takes 10 minutes to run.

Calibration

One gas standard (47.8 parts per trillion v/v SF_6 in nitrogen) was used for calibration, using two gas sample loops (0.297 and 0.850 ml) to produce a relationship between peak area and SF6 concentration in water samples. The ECD response to SF_6 is highly linear at low concentrations, and early data work-up shows regression lines for calibration have $R^2 > 0.999$. The blank for this procedure is zero, thus the calibration relationship takes the form $[SF_6]$ = slope * peak area.

A calibration took about 2 hours to run and was performed approximately every two days.

Air Sampling

On four occasions, triplicate air samples (~ 2 ml) were run after calibration. These were collected in 100 ml ground glass syringes into the wind, to avoid contamination from the ship, and injected into the system via a tube of magnesium perchlorate (to remove water vapour). The atmospheric concentration of SF_6 was found to be above 4 pptv, as predicted by measurements reported by Maiss *et al.* (1998) for Cape Grim, Tasmania.

Sample Handling

Samples were collected in 500 ml ground glass stoppered BOD bottles, using Tygon tubing, and were overfilled at least 3 times to eliminate all bubbles. One person from each watch was trained to take SF6 samples, in order that I could analyse as many samples as possible, and keep the system maintained. Samples were stored (for as short a time as possible) in coolboxes topped up with cold Niskin bottle water. It was found that if the samples were stored for more than about 6-8 hours, they developed bubbles and therefore had to be thrown away.

Precision

Standard injections were generally measured to within 1 %, however on the smaller loop size the precision was occasionally around 2 %. Duplicate water samples were taken from at least one niskin on almost every cast. Average co-variance was 0.8 %, with a maximum of 1.4 %.

Sampling Blank

Two bottle blank stations were analysed (casts 134 and 154). Both stations gave a mean signal of about 0.4 fmol/l. There was some uncertainty about whether the system was capable of measuring 'zero-SF6' water. In order to test this, niskin 24 was removed from the CTD rosette and set up in the Wet Lab, filled with spare niskin water and purged with oxygen-free nitrogen for 12 hours. An SF6 signal was still found in this water. Attempts are on-going to determine the size and cause of this problem, however data quality may be seriously impaired.

References

Law, C.S., Watson, A.J., and Liddicoat, M.I. (1994) Automated vacuum analysis of SF6 in seawater: derivation of the atmospheric trend (1970-1993) and potential as a transient tracer, *Marine Chemistry*, 48, 57-69.

Maiss, M. and Brenninkmeijer, C.A.M. (1998) Atmospheric SF6: Trends, sources and prospects *Environ. Sci. Technol.*, 32, 3077-3086.

3.6 Helium and Tritium Measurements

Uli Fleischmann and Oliver Huhn

In total we took 576 helium and 528 tritium samples at 70 stations: 176 helium and 146 tritium samples at 19 stations in Drake Passage, 169 helium and 161 tritium stations at 24 stations along the southern west/east section. On the eastern south/north section we collected 89 helium and 77 tritium samples at 10 stations south of South Georgia and 77 helium and 79 tritium samples at 8 stations north of South Georgia. Finally we collected 65 helium and 65 tritium samples at 9 stations on the northern east/west section on the way back to the Falkland Islands.

At all chosen stations both helium and tritium were sampled, and were also sampled on equivalent depth with CFCs for further comparisons. The main interest was focused on connections between basins, so that sampling was more dense close to slopes and gaps. Further more we repeated most of the stations that have been sampled for helium and tritium on cruises A21 (Drake Passage) and A23 (i.e. eastern south/north track) to allow intercalibration of these data sets.

The 40 ml helium samples are stored in 1 m long copper tubes, with both ends pinched off, to prevent degassing. Air bubbles along the inner side of the copper tubes were removed prior to the pinching by banging along the guides. The tritium samples are stored in 1 litre glass bottles, sealed with a screw cap. Both samples are to be carried home for analysis in the Institut fuer Umweltphysik (Institute of Environmental Physics), University Bremen, Germany as soon as possible. The helium samples have to be degassed into vacuum to extract the dissolved gas. The He isotopic ratio, as well as ^{4}He and Ne concentrations, will then be measured in a He-isotopic mass spectrometric system.

The tritium samples will be degassed to remove all the helium dissolved in the water. The degassed water is then stored for about 6 month. After this time, ^{3}He from the tritium decay is measured with a mass spectrometer. Knowing the storage time, the date of sampling and the half-life time of tritium, it is possible to derive the tritium concentration in the water when it was sampled.

3.7 Oxygen Isotope Measurements
Michael Meredith

Sampling for oxygen isotope analysis was performed at 24 of the CTD casts made during the cruise. Samples were drawn directly from the Niskins into 150 ml winchesters which had rubber seals in the caps, and which were further sealed with Nescofilm® to prevent equilibration of the sample with the atmosphere. The sampling programme concentrated predominantly on the deep stations of the South Scotia Ridge section (in particular the Orkney Deep), and the A23 repeat stations for which oxygen isotope data already exist. Additionally, two ice samples were obtained from icebergs in Marguerite Bay (Adelaide Island) to better enable quantification of the glacial endmember. These samples were allowed to melt slowly in the ship's cold store before being sealed in 150 ml winchesters as per the seawater samples. Two surface water samples were obtained from near the icebergs for comparison. All samples will be analysed at the UEA Stable Isotope Laboratory to determine the ratios of stable oxygen isotopes.

4. Lowered Acoustic Doppler Current Profiler (LADCP)
Elaine McDonagh, Nick Crisp, Michel Arhan and Kate White

Description

The LADCP package at SOC consists of a RDI 150kHz BroadBand ADCP (Phase III) with a pressure case rated to 6000 meters and 4 downward facing transducers mounted at 20 degrees from the vertical. An instrument with transducers mounted at 30º was also available for use. Fitted centrally in the CTD rosette frame, the LADCP is powered during casts by a 48 volt lead-acid rechargeable battery pack housed in a second pressure case horizontally mounted near the bottom of the frame. As well as a permanent connection to the ADCP, the battery pack pressure case is fitted with a recharge plug and a screw at the end cap which can be used to release any gas build-up as a result of charging. The communications connector of the ADCP is brought to the outside edge of the frame with a short extension cable, enabling easier access for the unit to be connected pre- and post-deployment.

Two 15 metre communications and power leads were connected to a dedicated PC and to a Wynall purpose made 48v charging unit located in the UIC Lab. Unlike the CTD sensors which are sending a continuous flow of data to the computer onboard, the LADCP unit is set for recording internally prior to deployment then sealed off with two socket blank plugs for the deployment.

Prior to each cast the instrument was subjected to a checklist and sent a configuration command-file (Table 1), which determines the mode of operation. The pre-cast checks include setting the ADCP time to GMT, and running internal diagnostic tests. The test results and pre-deployment files were recorded for each cast. After cast 008 BD, the number of pings for which the instrument pauses before attempting bottom tracking again, was changed from 50 to 25. After cast 023 BA, Bottom-tracking minimum evaluation amplitude was changed from 30 to 25. The success of changing BD was masked by the instrument change after cast 011. The change of BA was based on the data from the 30-degree instrument, it had little effect on data retrieval from the 20-degree instrument which generally had more and higher amplitude returns from the bottom. The instrument was set to Water and Bottom Tracking Mode with 10-bin ensembles of 16-meter bins for the whole cruise. The rechargeable battery pack was connected for recharge at the end of each cast, and remained on charge until the next deployment. Keeping the batteries well charged both minimises the charging period and minimises any gassing of the batteries. Experience gained from this cruise has shown that there is no significant gassing of the batteries when used in this way. The pressure release screw on the end-cap was loosened at weekly intervals, with no, or very little, audible evidence of gas being released.

Two instruments were available for use during the cruise. One of these (the 30º instrument) had suffered a leakage and beam-failures on a previous cruise (*RRS Discovery* cruise 232) and had just been refurbished by the manufacturers. It was, therefore, necessary for us to install this instrument at the beginning of the cruise in order to confirm it's operation. On the first station (the deep test station), the resulting current profile was what has become known in LADCP-speak as an 'X-profile' (c.f. http://www.ldeo.columbia.edu/~visbeck/ladcp/example/example.html). The first few casts in shallow water south of the Cape, however, showed good data with closely matching up and down shear-profiles. The instrument was replaced with the 2nd unit just prior to cast 012 when we were unable to communicate with it. Later inspection of the instrument identified some blown communications fuses in the main electronics, and a shorted filter in the end-cap. This failure was most likely the result of an accidental shorting of pins in the communication connector on the CTD frame which occurred just prior to cast 008.

It has been noticed during this cruise that due to the relatively high voltage of the battery packs that if the plugs and sockets of the connectors and dummy-plugs are not completely dry when mated that severe corrosion of the pins/sockets occurs. The problem occurs because seawater is usually dripping from the CTD frame when people are connecting the communications and battery leads. It is therefore necessary to keep a close eye on the state of these connectors and to check that they are dry before mating them.

Towards the end of the cruise, the number of errors occurring during data recovery was found to be increasing (these are noted on the logsheets). Data were being recovered using RDI's **BBSC** software. However, a read-through of the manual for the terminal software **BBTALK** revealed that the more recent version (which we were now using) was capable of data recovery from the instrument using the 'Y' Modem protocol. This facility was consequently tried and found to recover data without errors (and, therefore, loss of ensembles). The Microsoft Windows terminal program **HyperTerminal** also has the 'Y' Modem facility, and so this program was also tried. Again, data recovery was 100% successful, and the user interface to **HyperTerminal** is better than **BBTALK**. In addition, the user is provided with useful information whilst the download is taking place (e.g. estimated time remaining, no. of retries, etc.). Due to the better user interface, we used **HyperTerminal** for the download of LADCP data for the remainder of the cruise.

Data processing

The LADCP measures relative instantaneous velocities of scatterers in the water column which can be converted into profiles of absolute currents by an elaborate processing path. The scatterer velocities are calculated by measuring the doppler shift in the return signal from each of the 4 transducers. Given the geometry of the transducer set, the orientation of the package, and the magnetic declination, the along-beam velocities are then transformed into magnetic co-ordinates to give East and North current motion relative to the CTD package. Later in the processing, the velocity data are scaled by taking into account the in-situ sound velocity, as estimated from CTD data. The instrument depth is first calculated by integrating the measured vertical velocity and later fine-tuned by matching CTD pressure and time data.

In order to remove relative velocities introduced by the motion of the package during the cast, shear profiles are computed by differentiating the velocities within each of the ensemble 16-bins. Then, the data are integrated up over the cast to produce a shear profile with a zero net velocity. This process also removes the barotropic component of the velocities, which must be reinstated either from the ship displacement (recorded from differential GPS data) or from the relative motion of the package over the sea floor (from Bottom Track data). The final velocity profile is therefore the sum of the baroclinic and barotropic components.
The processing of LADCP data is achieved using software developed by Eric Firing at the University of Hawaii. The software uses a combination of *perl* scripts and MATLAB *m* files to process the data:

1) Extract binary ADCP files from instrument,

2) Load the ADCP data into a database, including nominal cast position. Raw data files (with extension 000) and deployment log and test files were copied to the SUN workstation.

3) The perl script *domerge* calculated mean shear profiles (the baroclinic component of the current) and applied corrections and editing options which were kept constant throughout the cruise. The MATLAB script *do_abs* calculated absolute velocities and produced a standard set of profiles. In this step the uncorrected data (down, up and mean profiles) were viewed and plotted as unreferenced shear profiles with the depth-averaged set to zero.

4) Next the calibrated CTD data were interactively matched to the ADCP vertical velocities within MATLAB (*fd.m*), and the true depth information for the cast merged into the database together with sound speed data corrected for temperature and salinity (add_ctd and re-run domerge and do_abs).

5) In order to restore the depth-averaged (barotropic) velocity component (equivalent to the ship's displacement) which was removed when first calculating the shear, the cast GPS data was used.

An additional correction to the GPS-derived barotropic component of the flow was made for the time when the package was near the sea floor and no good water-tracked data were recorded. The depth-averaged (barotropic) velocity component was also estimated using bottom-tracked data (where available) to remove package motion from the water-tracked data. This was achieved using a MATLAB script (bottomexec.m) written at UEA. On return to UEA a comparison of the GPS-derived and the bottom-track-derived barotropic velocity will be undertaken. An estimate of the of the contribution of tidal velocities to the velocities measured by the LADCP was made using version 3.1 of the OSU tidal model (Egbert *et al*., 1994). This was achieved using a perl script (tide.prl) written by Eric Firing.

Data collection

The LADCP was deployed on a total of one test station and 169 CTD stations, in depths ranging from 170 to 4500m.The instrument with the 20-degree beam angle was used for all stations apart from the test station and the first ten stations in Drake Passage. The 30º instrument was installed once more at station 134 in the Maurice Ewing Bank section for the purposes of a comparison with the 20º instrument, deployed at the same location. The data from the 30-degree instrument (station 134) were again in the form of an X-profile. This is in contrast to the data from the 20-degree instrument (station 133) which gave well matched shear profiles for the upcast and the downcast.

1st July 1999 – On return from the ship further analysis of the LADCP data has shown that the 30-degree instrument suffered from an unacceptably high noise floor, which has reduced data quality to the extent that the data from this instrument are unlikely to be useful. The high level of noise observed in this instrument has not been explicitly linked with the large and spurious shears that characterise an X profile. This instrument has been returned to the manufacturers for investigation.

The CTD was again deployed in the same place along the Falkland plateau section. The 20-degree instrument was installed for each of these casts (stations 153 and 154). For each cast the up and down shear profiles matched one another very closely. The data from the two casts also matched one another closely. This reinforced our confidence that the 20-degree instrument was working well.
Table 1. LADCP command file.

CR1	Restore factory defaults
PS0	
CY	Clear Error status word
CT0	
EZ 0011101	
EC 1500	Speed of sound in m/s-1
EX 11101	
WD 111100000	
WL 0,4	
WP 00001	One water track ping
WN 010	10 bins
WS 1600	Bin size 16 metres
WF 1600	Blanking distance 16 metres
WM 1	Profiling mode 1
WB 1	
WV 400	
WE 0150	
WC 056	
CP 255	Max transmit power
CL 0	
BP 001	One Bottom track ping
BD 25	
BX 2500	Max bottom track distance 250 metres
BL 0,200,600	
BM 4	
TP 000100	
TE 00000200	Ensemble every 2 seconds
&R20	
CF11101	

&?

Reference

Egbert, G.D., A.F. Bennett, and M.G.G. Foreman, TOPEX/POSEIDON tides estimated using a global inverse model, Journal of Geophysical Research, 99 (C12), 24821-24852, 1994.

5. *Expendable Bathythermographs (XBTs)*

Pat Cooper

The cruise started badly with the demise of the Ashtec 3DF GPS receiver and new Sippican Mk12 XBT system. The Ashtec was beyond local repair and attempts to revive the old Mk9 XBT system were not successful. Detailed documentation for the Mk9 XBT was available and I constructed a very basic system from this information (PXBT).

An XBT probe consists of a temperature sensor (thermistor) mounted in a bomb shaped housing. The thermistor is connected to the ship via a fine 2 core copper cable. Part of the cable is contained within the probe and the rest is wound round a former in the launch tube. A probe is launched by releasing it from the launch tube. When the thermistor reaches the sea surface it completes an electrical ground path to the ship via the sea water. This connection can be detected and used to trigger the digital recording system. The probe is spin-stabilised to fall at a guaranteed rate. The end of a deployment is signalled by an abrupt change in recorded temperature caused by a preset weak point in the cable.

It took a number of weeks to produce a working system that produced temperature profiles similar to the CTD information. The final circuit used a simple potential divider with the thermistor as the second resistor. Two other resistors were connected in place of the thermistor to act as calibration sources. The potential divider output was connected to a low pass filter. The filter was created by trial and error but gave good step response and removed a significant amount of induced noise. The analogue voltage from the LP filter is connected to a 10bit analogue-to-digital converter. The A/D plugs into a PC printer port.

The whole system has to be isolated from ship ground to prevent noise (mains & radio) from swamping the XBT signal. This caused problems but eventually I used an isolated precision voltage generator to supply the potential divider and a portable PC (Toshiba T2110) as the data logger. Two programs were written to collect and partially process the data.

Data Collection

The PC automatically booted into PXBT1.exe and requested various parameters from the operator. Automatic calibration was carried out and the system readied for deployment. The probe/sea signalling system could not be made to function so the logger was started manually. A 10 second delay between starting logging and probe deployment ensured that the moment of water impact would be visible on the recorded data. XBT progress was monitored using the PC screen and the operator ended the cast when the sensor wire signal was visible, the wire broke or 30 seconds had passed. This covered all eventualities during moving & stationary deployments. The following files were then transferred to floppy disk:

Filenames are created from PC date, day, hour & minute.

01042345.raw   Raw data from A/D converter. The first line contains a header containing start and stop times. These times are the number of seconds since midnight so by subtracting start from stop the cast time can be determined.

01042345.bak as above

01042345.cal Calibration results from “HI” and “LO” resistors. 50 samples of each resistor. If all values are within 2 or 3 counts then calibration is considered valid.

Data Processing

The above files were transferred to a Viglen desktop PC for further processing. Data from the A/D is sampled using a software timing loop. This allowed the Toshiba to over-sample at high speed to produce smooth data profiles. A typical file would contain 25,000 samples. An equivalent Sippican file would only have 2,500 samples. The first task was to calculate cast time and divide this by the number of samples. This produced an accurate column of timed data points. The sample time was generally 0.012 mS. ie 80/second.

The operator is presented with the first 6000 records of the cast in graphical format and asked to chose a 200 record gap which bracketed the water entry point. The 200 record gap was then expanded to allow a more accurate water entry point (+/- 5m) to be determined. The data file was now truncated to contain a record of samples when the probe was in the water - not in the air. A new column of depths is added to the file using time and depth coefficients for the appropriate probe type.

Drop equation: Depth (m) = $B*T - A*T^2$ (T=Time in seconds)

For a T5 probe - A=0.00182 , B=6.828
For a T7 probe - A=0.00216 , B=6.472

A graph of the complete cast is displayed and the operator is asked to select the end of cast point. This simplifies post processing as the data file now contains only information of interest to the scientist. A number of files are transferred to the network drive for archiving and further transfer to the UNIX system.

Final Files:

01042345.raw Original data file (untouched)
01042345.txt New data file containing 3 columns :

Time(S)	Data	Depth(m)
0.171	1047	1.170
0.343	1042	2.339
0.514	1039	3.509
0.685	1036	4.678
0.857	1033	5.847
1.028	1030	7.017
1.199	1027	8.186
1.371	1025	9.355
1.542	1022	10.523
1.713	1021	11.692

01042345.bak As above
01042345.cal Calibration data
01042345.inf Information file, details below

PXBT System, pjc, ets, 1999
Information file for 01042345.xxx

Filename consists of day(2) month(2) hour(2) min(2)
Each PXBT drop creates 6 files -

01042345.raw = raw data from A/D converter (in mV)
01042345.bak = raw data backup file
01042345.int = semi-processed data before trimming
01042345.txt = fully processed - correct time stamp & depth
01042345.cal = calibration file
01042345.inf = this information file

Calibration file contains 50 samples of two resistors alternately switched in place of the thermistor. The values can be averaged to give offset (low) and scale (high) readings and applied to the resulting trace.

Data columns are | Elapsed Time (mS) | Data (mV) | Calculated Depth (m) |

Station Number	26
Operator	pjc
Probe type	5
Start log time (Seconds)	29995.03
End log time (Seconds)	30322.17
Number of samples	29416
Duration of cast (before trim) (Seconds)	327
Samples in final file	28001
Frequency of sampling (Hz)	89.95718
Sampling period (Seconds)	0.0111164
Water entry lower range	500
Water entry upper range	700
Water entry sample number	630
End of cast sample number (x 1000)	28
Comments	stn 84

A number of attempts were made to calibrate the XBTs using simultaneous CTD casts. Unfortunately the fit was at best variable and generally poor so the data are not meaningful.

6. Navigation

Kate White

A series of daily navigation files were maintained throughout the cruise. These included the output from the gps, glonass and gyro. The script get_data is used initially on all the navigation data to produce the ascii files to be read into Matlab and requires the instrument required to be selected and the Jday as input.

Best Nav File

Two daily files were produced during the cruise, the first was the output from the get_data script which produced a ascii file containing the RVS 'bestnav' position data at 30 second intervals. The input into this file is primarily the gps data, with the addition of the gyro data to cover any missing time intervals.

The second file was a standard matlab file, produced by the script loadbnav.m. The daily matlab files were appended to a master file every 24 hours (bestnav.all.mat).

No modifications have been made to the data contained in bestnav.all.mat, although this file has been used to produce bathymetry files, which were binned into 10 or 30 minute time intervals.

Best Drift Data

Ascii and matlab versions of the RVS 'bestdrf' data were produced daily. These data give estimates of the current velocities derived from differences between dead-reckoning calculations (based on EM_LOG velocities) and the actual position fixes from GPS at 30 second intervals. The script get_data produced the ascii file and loadbdrf.m will then produce bestdrf.nnn.mat where nnn is an incrementing time counter.

7. Ship-mounted Acoustic Doppler Current Profiler (ADCP)

Elaine McDonagh, Kate White and Mark Brandon

The *RRS James Clark Ross* is fitted with a 153.6 kHz RDI hull-mounted ADCP. To protect the unit from damage by ice it is mounted in a chest which is recessed into the hull. The chest is enclosed by a 33mm sheet of low density polyethylene and is filled with an unknown silicone oil. The transducer is mounted in a direction offset from fore-aft by 45°. Firmware version 17.07 and Data Acquisition Software (DAS) version 2.48 were used. Primarily the instrument was operated in water-tracking mode. When the water depth was less than ~500 m the instrument was switched to bottom-tracking mode where one in four pings being bottom tracking. In each mode data was collected in two-minute ensembles of sixty-four 8-m depth bins. The depth of the transducer is approximately 6 m and the 'blank before transmit' distance is 4 m. This means that the first bin is at 14 m.

Data quality was generally good to about 250 m, but was degraded in rough weather. The lack of an operational three dimensional GPS system meant that errors in the ship's gyrocompass could not be corrected. Bottom-tracked data were used to calibrate the adcp. The six main areas where bottom-tracked data were collected were,
1) On the Falklands shelf at the start and end of the cruise.
2) Across the Birdwood Bank.
3) On the shelf just south of Cape Horn.
4) Along the Antarctic Peninsula on the voyage to Rothera station.
5) South of Coronation Island.
6) At South Georgia.

It was felt that the easiest way to access data from the ADCP was to use the established pexec data route. A Unix script "get_adp" extract data from the RVS level C in 24 hour chunks, and then divided each days data into two files: these were a file containing water track data, and a file containing bottom track data. When the ADCP was configured in water track mode, the bottom track file, although still created had zeros in the velocity data.
The variables stored in each file were as follows:

Water track file: adp.nnn

year day HH:MM:SS bindepth heading toll pitch temp velew velns velvert velerr ampl good

Bottom track file: bot.nnn

year	day	HH:MM:SS	heading	bottomew	bottomns	depth	temp

Further data processing consisted of three main steps, and was achieved using MATLAB scripts.

1. Effect of Oil on Sound Speed

A correction was applied to account for the change in sound speed caused by the transducers being surrounded by oil (loadadp, loadbot). This correction is a scaling factor (F) for the velocities measured by the adcp and takes the form

$$F = 1.0 - 0.004785\ T + 0.0000355\ T^2$$

where T is the temperature measured at the transducer head. This correction is based on work described by King and Alderson in the cruise report for the Drake Passage repeat section SR1 (Observations on the R.R.S. *James Clark Ross* across Drake Passage in November 1993, King, B.A. and S.G. Alderson, Unpublished Cruise Report, Southampton Oceanography Centre)

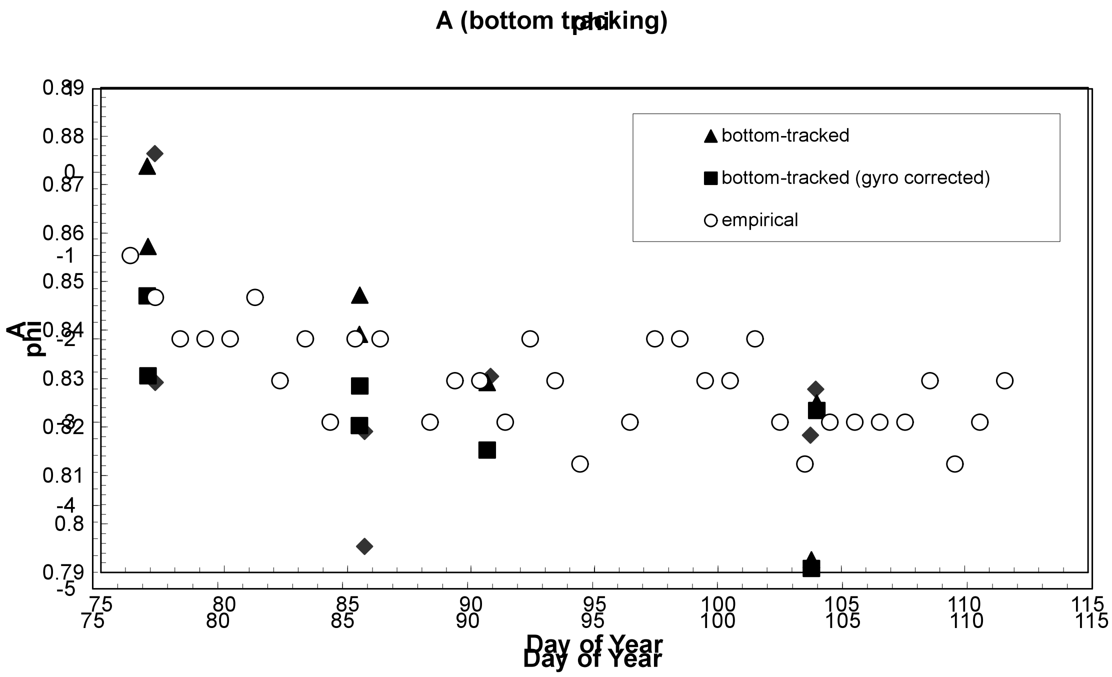
2. Clock Correction

The pc which logs the adcp data has a clock which drifts at a rate of around one second per hour. A log of the difference between the adcp clock and the ship's master clock is used to derive a correction for this drift (clock_correction). Subsequent to this data were merged with navigation and velocity components converted to speed (merge_bestnav, con2speed)

3. Misalignment angle, phi and scaling factor, A.

The misalignment angle, phi, represents the offset of the transducers from the fore-aft direction and should be constant. Recent evidence from cruises on the James Clark Ross (Brian King, pers. comm.) has suggested that phi has in fact a variation that can be linked to horizontal scale. This is most likely due to incorrect paramertization of the effects of the oil bath around the transducers. The failure of the 3D GPS system on ALBATROSS meant that our estimates of phi were contaminated by errors in the gyrocompass. The scaling factor, A, represents the fractional overestimation of velocities by the adcp. These calibration parameters were determined from a comparison of the bottom velocities measured by the adcp and the ship's velocity from navigation (bottomtxt, Aphicalc). The ten-minute blocks of bottom-tracked data used in this comparison were selected based on the following criteria:
i) gyrocompass heading varied by no more than 1.5°,
ii) ship's speed varied by no more than 20 cm s^{-1} and
iii) ship's direction over the ground from navigation did not vary by more than 2°.

In the first instance, the ADCP data were calibrated using A = 0.82 and phi = -2.3°. Using the bridge's measurements of gyrocompass error an estimate of phi corrected for gyrocompass uncertainty was also made. An empirical estimate of phi was also made on a daily basis. The results of these exercises are shown below.



Subsequent to this the data were calibrated using A and phi, water-tracked velocities were converted to water velocities by removing the ship's velocity and data with percent good less than 25% were set to absent (correct4Aphi, absvel, maskbad).

8. Underway Observations

8.1 Bathymetry

Kate White

A Simrad EA500 hydrographic echosounder and a hull mounted transducer were used to acquire sea floor depth. Uncorrected depths, assuming a sound speed of 1500 m s^{-1}, were passed via a RVS level A interface to the level C system for processing, and logged every 30 seconds. Pairs of time and uncorrected depths were extracted from the level C system at 30 second intervals, and corrected depths were matched to the corresponding latitude and longitude logged in the navigation file. Sets of merged data were appended to a master file daily. The merged data was used to produce sea floor profiles for each section, and to obtain the water column depth at the location of each station occupied. The corrected depths from the prodep files were merged with the bestnav position fixes. Binning on time intervals of 30 minutes and 10 minutes was done in matlab (using scripts such as dpass30.m for the Drake Passage section). The bathymetry was edited to remove multiple values whilst on station and also any missing values were interpolated across. The 10 minute time binned data file was further smoothed on 0.1° latitude or longitude bins dependent on the orientation of the section. The few obvious anomalies, such as the topography reaching the surface, were removed by hand. It should be noted that the uncorrected depths from the prodep files had not been despiked prior to being merged with navigation.

Towards the end of the cruise, a problem was noticed with the prodep data in that the time index was not regular and monotonic. Further investigation revealed a problem with the merging of the bestnav data and the uncdepth file. This was overcome by only selecting the output data at 30 second intervals using listit. A new directory, bathynew, was made and the daily files rerun and the bathymetry recalculated. Little visible difference resulted, but it was done for completeness.

8.2 Oceanlogger

Mark Brandon

The Oceanlogger system is a BAS designed and built (P. Woodroffe, E.T.S.) PC based logging system. It emulates the function of several RVS level A interfaces, has an input from the ship's master clock and has real time display of data. This system logs sea surface data gathered from the ship's non-toxic pumped sea water supply and some meteorological data to the RVS ABC system with a ship's master clock time stamp on the data. The instruments with an analogue output are connected to self-contained digitising Rhopoint modules located close to the relevant instrument. The modules are then interrogated by the controlling PC using the RS485 protocol. A full list of the sensors used is given in Table 1 below.

Table 1: The instruments connected to the Oceanlogger.

instrument	type	location	Field Name
sea temperature	4 wire PRT	Transducer space	sstemp
flow meter	Liter Meter	prep lab	flow
Thermosalinograph	Sea Bird SBE 21 serial No. 214800-0820	prep lab	tstemp and cond
fluorometer	Turner Systems	prep lab	fluor
Air temperature	vector T351	foremast	atemp
PAR sensor	Kipp & Zonen CM5	foremast	par
TIR sensor	Didcot DRP1	foremast	tir
Barometer	Vaisala PA11	UIC	Press

Calibration and logging

The last calibration of the Seabird SBE 21 was on 23 July 1998 by Seabird Inc, Seattle, U.S.A. The sensor number used was s/n 820. For the duration of cruise JR40 the sampling rate was set to 5 seconds (the maximum the present system is capable of) and the data logged to the level B system.

Routine Processing

The data were read into the UNIX system daily in 24 hour sections using a Unix script, get_data, and then read into matlab using loaduway.m A master file, ocean.all.mat was updated daily using oceancatexec.m. The anomalous readings caused by the ship being docked at Rothera and South Georgia were removed by hand. The routine dspike.m was then run on the remaining data to remove all major spikes and missing data values were replaced by NaN's.

Underway salinity samples

Salinity samples were drawn from the non-toxic supply as it left the thermosalinograph approximately once every four hours. These samples were treated in the exactly the same manner as those taken for the CTD calibration. The 200 ml sample bottle was rinsed twice and the neck of the bottle dried carefully before an air tight plastic seal was inserted and the cap screwed back on. The samples were then stored in the radio lab beside the Guildline Salinometer for at least 24 hours before the conductivity was measured against Ocean Scientific Standard Seawater batch P133 and P134. The sample conductivity values were entered into a Macintosh Excel Spreadsheet and transferred to Unix. In total there were 163 underway salinity samples. The data are in the oceanlogger directory ready for calibration.

Problems

At the start of the cruise the system fell over approximately once every four hours. This was cured by taking the controlling PC out of “Turbo” mode. The second problem is much more serious and is the still unexplained lag between the temperature sensor and the conductivity cell in the thermosalinograph. The problem was first reported during WOCE leg A23 (JR10) when it was noticed that conductivity from the SBE - 21 lagged the temperature of the housing (tstemp). This of course causes a spike in the derived salinity signal. The A23 scientists overcame this by applying a lag through a filter to the stream tstemp. On previous MLS cruises (CF reports for JR16 and JR17) we tried filters of varying length in time to lag the temperature before settling on a length 48 one-way filter with n = 48 successive coefficients given by $W(1 - W)^{n-1}$. W was found by experiment to reduce the salinity spiking best at a value of 0.03 for this data set. With the 5 second sampling rate the 48 point filter has an effect over 4 minutes.

9. Shipboard Computing : DAPS

Nick Crisp

The Data Acquisition and Processing System (DAPS), is a real-time system for the acquisition of ship's/scientific data such as CTD/SeaSoar/GPS - indeed it can currently be coded for anything that outputs an ASCII data stream, and could, if required, cope with other data transmission mediums such as ethernet. The system is coded in C and utilises a single ULTRA-Sparc, SUN workstation with a peripheral unit providing an extra 16 serial ports in addition to the 2 standard ones. This small amount of hardware makes DAPS a very portable system, and it has, to date, been used on Spanish, French and South African vessels in addition to 3 NERC vessels.

When the software is started, two windows appear - a command window, and a status window. Acquisition processes are started, controlled, and killed in the command window, and the status window displays which processes are running, their acquisition status, and any error or warning messages, such as data-time-out messages.

Each 'instrument' which is logged, is configured by parameters in an Instrument Control Parameters (ICP) file. Such a file exists for each instrument and includes parameters for the configuration of the RS232 port, a time-out value, and which variables in the data stream are to be logged, together with polynomial calibration constants if required. One setting in this file determines whether the data are acquired in real-time (e.g. from an RS232 port) or from a file. This feature enables the replaying of certain data streams such as CTD, which proved useful during this cruise - see below and in section 2 regarding CTD processing.

During this cruise, DAPS was used for the logging of CTD and Bottle data. The processes were started just prior to each cast, and killed once the CTD was back on deck. The ASCII files generated were named using the UNIX process number of each acquisition process (e.g. ctd25342.000 where 25342 is the process number). This method ensures unique file names and is currently the method used by DAPS for all acquisition processes. An alternative method would be to allow the operator to specify an identifier such as the cast number on the command line when starting up a process, but this has not yet been coded. In order to keep track of the file names for each cast, a logsheet was maintained with the cast number, start and stop times of logging, time comparison of the workstation's clock with GMT, and ctd and bottle filenames.

CTD Data acquisition

The CTD acquisition process used with DAPS includes a 1-second de-spiking and averaging routine before the data are written out to an ASCII file. Currently the routines used are based on those in the RVS level A,B,C system which were originally written by scientists at the former Institute of Oceanographic Sciences (IOS). The 1 second averaging procedure is described below:

1. For each variable in each second's worth of data…
2. Remove large spikes by comparing each value with previous value. Spike value for each var. is defined in ICP file.
3. Calculate delta-t = last good temp. in frame minus first good temp. Then divided by no. of good samples.
4. (Median despiking)

a) Binary sort good samples in frame. Take absolute value of difference (diff) between value at the mid-point, and the previous value. Also calculate the mean of these 2 values.
b) Set upper and lower limits based on: Av. value +/- (diff * no. good samples)
c) Calculate mean of all samples within these limits

5. Return the 1-second mean values

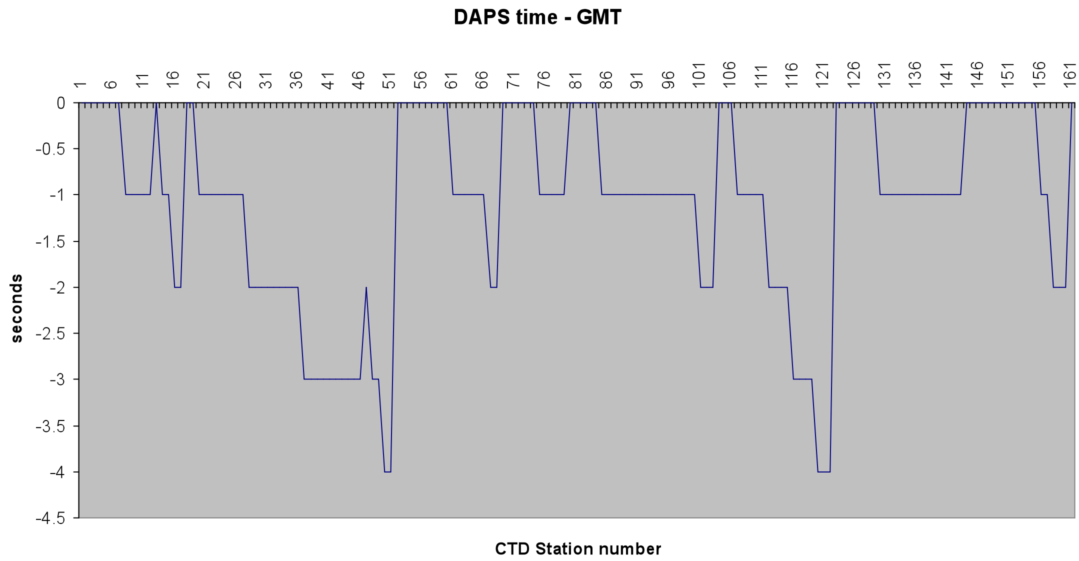
In order to try to de-spike the conductivity data from casts 16 and 17, the casts were re-run through DAPS after tightening the criteria for the median de-spiking routine. Instead of calculating the difference between the two median values as described above, the difference value was chosen by calculating all of the difference values for successive samples in the averaging interval, sorting them, and then taking the median of these. A section of data from the down-cast of station 16 was run through DAPS several times. For each run, the upper and lower limits for the median de-spiking were tightened, and the number of frames over which to calculate the average were adjusted. The most successful averaging interval was found to be 3.2 seconds (equal to 80 frames of raw CTD data) which is approximately half the period of the occurrence of the spikes in the conductivity. Consequently, both casts were run using the above criteria. Further processing and de-spiking was carried out in MATLAB (see section on CTD data processing).

DAPS time-stamping

The DAPS software currently uses the internal clock of the workstation (which has a resolution of microseconds) for it's time-stamp value. However, there is currently no way to precisely synchronise this clock with the ships clock, or with GPS time. The method currently used is to check the current time using the UNIX command 'date -u'. This provides the GMT time which can be visually compared with the ships clock.

The workstation time was always fast compared with the ship's clock, and so when the difference was greater than 2 seconds (typically), the workstation time was adjusted back to ship's time using the command 'date -a *sec*', where *sec* is the number of seconds. This command gradually (over a minute or so) adjusts the workstation time by the required amount. Such adjustments were, of course, only made in between stations, when data acquisition was turned off.

As mentioned above, the DAPS logsheets included the time-difference, and for reference, these values have been plotted (against CTD station number) in the figure below. For standard CTD work, offsets of these magnitudes are unimportant. However, where absolute currents were being calculated for the LADCP, it was important that the CTD data were synchronised to the nearest second with the GPS and LADCP (which were always in line with the ships clock) and so the DAPS logsheets were referred to in these circumstances. In the future, it is intended that GPS data will provide a time-input for DAPS, so that the workstation time can be kept in line with GMT with sub-second accuracy.



10. Liquid Nitrogen Generator

David Stevens and Alison Bateman

Liquid nitrogen (LN_2) was required for the analysis of CFC and SF_6 samples. A day before sailing 40 litres of LN_2 was acquired from the RAF at Mount Pleasant airport. This was used as an interim measure until the LN_2 generator was up and running.

The UEA IWATANI liquid nitrogen generator was installed in the scientific hold (by the entrance). The generator used two power supplies, a 30 amp single phase 240 volt supply to the transformer and a 13 amp single phase 240 volt supply to the circulating water chiller. The generator was installed following the written instructions provided by Sue Turner of ENV UEA. There were no problems with the generation of LN_2. However, an initial and recurring problem was blockages in the siphon tube. In principle this is straightforward to rectify. The siphon tube should be replaced by a spare and unblocked with the aid of a heat air gun. Unfortunately this problem was sometimes compounded by the siphon tube being frozen stuck in the storage dewar. No amount of treatment with the heat gun would loosen the siphon tube sufficiently. A technique we discovered which had a 100% success rate was to press the red stop button and leave the generator for 12 hours! The siphon tube could then be extracted with relative ease. One of the two siphon tubes provided appeared to have a permanent blockage. Thus when blockages occurred the 'good' tube had to be extracted, unblocked with a heat gun and replaced in a short time.

11. Bottom Pressure Recorder Recovery

David Stevens and Mark Brandon

The Proudman Oceanographic Laboratory (POL) deployed a bottom pressure recorder (BPR), code named CH-1, at 59°52.046′S 30°06.044′W in 2843 m of water during the previous year. As the ALBATROSS cruise was occupying stations in this vicinity a request was made to recover the BPR. Following completion of CTD station 102 the ship steamed toward the deployment location arriving at 09:55UTC on day 98 (8^{th} April 1999).

A Benthos TR7000 series deck unit was used to send the release signal. The deck unit was set up in the wet lab with the acoustic transponder deployed over the starboard side close to the lab entrance. The acoustic settings were as follows:
ID=08, Rx=13.5 kHz, Tx=12.0 kHz
Enable=A, Disable=B, Release=C
Direction Finder Radio Beacon - 154.585 MHz (Channel A)

With the acoustic transponder in the water, the deck unit was switched to RANGE mode and a series of pings were sent to the BPR. After a number of positive replies were received, the deck unit was switched to TR70000 mode. At approximately 10:05UTC a release signal was sent to fire the burnwire release mechanism on the BPR. It was anticipated that the release would take approximately 30 minutes. If a further release signal were sent during this time then the release would be aborted. The deck unit was switched back to RANGE mode. Pings were sent to the BPR at frequent intervals to ascertain whether the release signal had been successfully received. A predicted depth was computed based upon a rise rate of 0.5m/s. Unfortunately the majority of responses appeared to be false and so it was difficult to know whether the unit had been successfully released. At approximately 10:45UTC a second release signal was sent 'just in case'. Throughout the following hour a number of pings were received which were close to the predicted depth, although the majority were not. At 12:00UTC the ship began searching for the BPR both visually and with the direction finder. The BPR was eventually sighted at 12:30UTC and recovered at 59°52.05′S 30°06.11′W 12:36UTC. The radio direction finder did not receive a signal until the unit was on deck!

Acknowledgements

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Table 1. ALBATROSS Station List

Station number	Day of year	Date dd mm	Time at bottom GMT	Lat (south)	Long (west)	Max Pressure (db)	Max Depth (m)	Minimum distance off (m)	Water depth (corrected) (m)	No. of samples	Notes
001	75	16 3	16:53	55 22.27	57 58.83	4339.0	4256.4	8.9	4263.8		
002	77	18 3	03:41	56 19.81	67 59.29	96.5	95.6	4.3	101.4	4	2,4,5,6
003	77	18 3	07:33	56 47.81	68 11.51	306.4	303.4	6.7	307.6	7	2
004	77	18 3	09:53	56 50.95	68 12.60	526.4	520.9	7.0	522.7	9	2
005	77	18 3	11:41	56 52.59	68 14.03	1323.2	1306.9	16.6	1280.2	12	2
006	77	18 3	13:53	56 53.64	68 14.28	2012.1	1984.1	10.3	1955.3	15	2,5,6
007	77	18 3	16:57	56 54.52	68 14.70	2638.6	2598.1	8.6	2478.4	16	2
008	77	18 3	19:49	56 55.32	68 14.69	3005.9	2957.3	8.2	2846.4	16	2,4,5,6
009	77	18 3	23:35	56 59.00	68 14.75	3671.0	3606.0	7.4	3611.8	16	2
010	78	19 3	04:20	57 07.82	68 14.90	4452.8	4366.2	10.3	4395.0	20	2
011	78	19 3	09:21	57 19.85	68 14.60	4461.1	4374.2	5.1	4383.7	24	2,4,5,6
012	78	19 3	15:42	57 34.69	68 15.25	3820.7	3751.6	8.0	3738.7	19	2
013	78	19 3	20:15	57 49.78	68 14.41	3809.4	3740.5	4.8	3742.5	24	2,4,5,6
014	79	20 3	01:01	58 04.79	68 14.40	3800.2	3731.5	9.1	3718.7	18	2
015	79	20 3	05:53	58 19.79	68 14.40	3890.9	3819.7	6.0	3782.2	24	2,5,6
016	79	20 3	10:55	58 34.75	68 15.02	4017.3	3942.6	7.8	3855.4	19	2
017	79	20 3	17:38	58 50.40	68 15.62	3902.9	3831.2	234.5	3829.2	19	2,5,6
018	79	20 3	22:07	59 05.46	68 14.81	3578.6	3515.4	5.6	3386.0	18	2
019	80	21 3	02:33	59 19.88	68 14.18	3655.8	3590.5	8.4	3583.8	19	2,5,6
020	80	21 3	18:53	59 35.13	68 14.43	3767.4	3699.1	1.3	3679.4	17	2
021	81	22 3	00:23	59 48.94	68 14.12	3708.6	3641.8	6.4	3560.1	17	2,4,5,6
022	81	22 3	05:17	60 04.24	68 11.06	3553.5	3490.7	5.8	3498.5	18	2
023	81	22 3	11:30	60 19.24	68 07.27	3831.9	3761.7	12.0	3711.7	18	2,4,5,6
024	81	22 3	16:27	60 34.53	68 03.53	4014.2	3938.9	7.7	3865.0	19	2
025	81	22 3	21:20	60 49.71	68 00.05	4025.4	3949.8	8.4	3932.2	19	2,4,5,6
026	82	23 3	05:00	61 01.18	67 40.27	4171.2	4091.4	6.4	4075.1	21	2
027	82	23 3	09:41	61 12.60	67 19.89	3872.2	3800.6	5.2	3801.3	19	2,4,5,6
028	82	23 3	14:18	61 24.59	67 0.02	4127.3	4048.6	2.7	4038.3	20	2
029	82	23 3	18:48	61 36.02	66 40.14	4000.6	3925.4	7.0	3882.5	19	2,4,5,6
030	82	23 3	23:07	61 48.10	66 19.38	3768.9	3699.9	6.7	3708.2	18	2
031	83	24 3	04:39	62 00.16	65 56.72	3632.3	3566.9	6.6	3577.5	18	2,4,5,6
032	83	24 3	08:43	62 08.61	65 34.51	3682.0	3615.3	5.3	3620.8	17	2
033	83	24 3	12:45	62 16.83	65 12.35	4123.7	4044.8	6.5	4054.2	19	2,4,5,6
034	83	24 3	20:40	62 23.30	64 49.75	3868.1	3796.3	5.9	3806.8	18	2
035	84	25 3	00:50	62 30.00	64 27.39	3807.1	3736.9	7.8	3732.3	18	2
036	84	25 3	04:53	62 36.60	64 04.85	3524.8	3462.0	7.9	3473.7	18	2,4,5,6
037	84	25 3	09:21	62 41.67	63 54.11	4558.3	4466.6	9.1	4475.0	20	2,5,6
038	84	25 3	13:46	62 46.59	63 42.27	3372.8	3313.9	3.5	3255.5	18	2
039	84	25 3	18:05	62 48.80	63 37.18	2613.9	2572.7	3.1	2461.4	16	2
040	84	25 3	20:26	62 51.59	63 31.32	1772.5	1748.0	6.0	1740.2	13	2,4,5,6
041	84	25 3	23:00	62 56.29	63 26.72	1028.5	1016.0	4.9	1013.9	10	2
042	85	26 3	00:39	62 58.86	63 23.26	495.1	489.7	5.1	493.3	9	2,4,5,6
043	85	26 3	02:46	63 08.99	63 12.01	470.1	465.0	5.6	473.0	9	2
044	85	26 3	06:01	63 28.99	63 10.01	680.7	673.0	9.3	662.6	9	2
045	85	26 3	09:04	63 48.71	63 07.47	455.5	450.6	5.1	457.9	9	2
046	85	26 3	11:43	64 08.52	63 05.04	608.0	601.1	1.9	599.3	9	2
047	88	29 3	01:39	67 34.60	68 07.93	336.7	333.1	5.4	323.4	12	2,3
048	90	31 3	4:13	62 44.98	55 09.05	185.1	183.3	11.4	199.5	6	2,3,4,5,6
049	90	31 3	7:33	62 24.44	54 43.28	287.3	284.3	7.9	291.4	7	2,4
050	90	31 3	10:45	62 03.56	54 17.18	643.5	636.4	6.1	643.1	8	2,4
051	90	31 3	14:07	61 43.12	53 51.96	321.7	318.4	7.1	323.8	7	2,4,5,6
052	90	31 3	17:02	61 38.70	53 06.44	400.7	396.5	4.3	399.2	8	2
053	90	31 3	20:07	61 33.90	52 20.80	468.3	463.3	6.3	468.1	8	2,3,4,5,6
054	90	31 3	22:22	61 27.39	51 59.35	986.9	975.1	7.3	983.7	10	2,4,5,6
055	91	1 4	01:43	61 16.82	51 21.26	555.5	549.5	6.3	556.1	9	2
056	91	1 4	03:22	61 13.31	51 10.99	1040.1	1027.6	6.2	1020.4	11	2,4,5,6
057	91	1 4	05:22	61 11.51	51 06.80	1557.9	1537.4	6.8	1545.3	12	2
058	91	1 4	07:55	61 05.41	50 50.88	1017.7	1005.5	8.8	1014.3	11	2,4
059	91	1 4	10:46	60 54.64	50 28.20	1010.9	998.9	8.1	1008.8	10	2,4
060	91	1 4	14:01	60 37.80	50 10.20	1586.5	1565.6	5.5	1545.1	13	2,4,5,6
061	91	1 4	18:16	60 35.05	49 29.85	1614.5	1593.0	4.4	1596.9	13	2
062	91	1 4	21:51	60 31.94	48 49.44	1512.1	1492.3	5.0	1498.8	12	2,5,6
063	92	2 4	01:21	60 28.94	48 09.90	1379.0	1361.5	7.4	1367.7	12	2,4
064	92	2 4	05:56	60 30.65	47 51.16	1908.8	1882.1	7.4	1890.0	14	2,3,4,5,6
065	92	2 4	08:56	60 31.50	47 41.40	1610.9	1589.5	13.5	1512.2	13	2,3,4,5,6

066	92	2 4	11:09	60 31.74	47 35.83	979.6	968.0	3.9	973.5	10	2
Station number	**Day of year**	**Date dd mm**	**Time at bottom GMT**	**Lat (south)**	**Long (west)**	**Max Pressure (db)**	**Max Depth (m)**	**Minimum distance off (m)**	**Water depth (corrected) (m)**	**No. of samples**	**Notes**
067	92	2 4	13:14	60 33.86	47 14.17	487.3	482.1	6.6	487.8	9	2,4,5,6
068	92	2 4	14:39	60 35.02	46 59.96	247.2	244.7	3.1	246.8	7	2
069	92	2 4	23:35	60 55.02	43 59.87	250.5	248.0	5.8	253.0	7	2,3,4,5,6
070	93	3 4	13:21	60 45.57	42 57.54	506.8	501.3	6.8	495.4	9	2,4
071	93	3 4	15:01	60 44.24	42 47.23	1362.2	1344.9	6.8	1348.8	12	2,3,4,5,6
072	93	3 4	17:34	60 40.60	42 23.47	1014.6	1002.5	5.8	995.3	11	2
073	93	3 4	19:13	60 39.85	42 18.83	1553.6	1533.2	4.7	1480.1	12	2,3,4,5,6
074	93	3 4	21:37	60 39.12	42 12.52	2066.7	2037.0	5.5	1955.8	15	2
075	94	4 4	01:25	60 38.78	42 11.48	2665.7	2623.8	5.8	2474.2	16	2,3,5,6
076	94	4 4	04:49	60 38.57	42 10.29	3138.2	3085.5	7.6	2862.3	17	2
077	94	4 4	08:15	60 37.95	42 05.27	3721.2	3653.8	7.3	3668.1	18	2,3,4,5,6
078	94	4 4	12:36	60 35.63	41 49.70	2994.7	2945.4	4.0	2949.1	17	2
079	94	4 4	15:44	60 34.31	41 41.62	2490.5	2452.4	3.0	2447.2	16	2,3,5,6
080	94	4 4	18:46	60 31.54	41 22.72	1992.9	1964.7	5.3	1959.5	14	2,4
081	94	4 4	21:38	60 27.95	40 58.85	1472.6	1453.5	6.0	1457.5	12	2,4,5,6
082	95	5 4	01:53	60 26.07	40 04.40	1379.9	1362.3	5.2	1359.1	12	2
083	95	5 4	06:17	60 24.83	39 17.88	1562.0	1541.5	7.3	1526.5	13	2
084	95	5 4	08:50	60 24.53	39 07.27	2121.0	2090.3	10.5	2066.4	15	2,4,5,6
085	95	5 4	12:08	60 25.23	38 42.36	2626.4	2585.4	3.7	2559.7	16	2,3
086	95	5 4	16:30	60 26.68	37 59.98	2945.3	2897.2	4.5	2903.9	18	2,3,4,5,6
087	95	5 4	20:48	60 27.31	37 22.28	2099.2	2069.0	3.8	2077.0	15	2
088	96	6 4	01:34	60 22.87	36 23.84	1905.0	1878.5	5.2	1881.6	14	2,4,5,6
089	96	6 4	07:23	60 18.68	35 27.37	1520.5	1500.6	8.9	1450.8	14	2
090	96	6 4	14:20	60 08.56	34 53.15	382.5	378.5	6.3	385.0	8	2
091	96	6 4	16:44	60 01.56	34 28.36	1023.1	1010.9	5.2	1000.8	11	2,4,5,6
092	96	6 4	20:00	59 55.99	33 50.82	1307.6	1291.2	4.1	1293.5	12	2
093	96	6 4	23:13	59 50.79	33 16.95	1620.2	1598.8	4.9	1605.6	13	2
094	97	7 4	01:23	59 51.53	33 09.85	2073.1	2043.5	2.9	2007.9	15	2,4,5,6
095	97	7 4	03:48	59 51.66	33 04.43	2509.9	2471.5	7.3	2488.9	16	2,3
096	97	7 4	06:59	59 52.69	32 57.14	2933.3	2885.6	5.1	2847.2	17	2,3,4,5,6
097	97	7 4	10:03	59 53.54	32 51.55	2027.4	1998.6	7.9	1966.9	14	2
098	97	7 4	11:60	59 53.86	32 48.65	1528.2	1508.2	5.9	1499.5	13	2
099	97	7 4	13:60	59 54.24	32 43.74	1051.6	1039.1	2.5	1005.7	13	2,4,5,6
100	97	7 4	16:49	59 56.49	32 14.27	1000.2	988.4	4.0	989.0	11	2
101	97	7 4	20:44	59 58.44	31 28.67	2274.4	2240.8	3.5	2141.3	15	2
102	98	8 4	01:42	60 18.92	30 57.53	2790.8	2746.2	4.9	2663.5	16	2
103	98	8 4	06:12	59 59.63	30 55.84	3036.7	2986.6	5.7	2995.3	17	2,3,5,6
104	98	8 4	16:13	59 45.98	30 54.37	3858.6	3787.8	4.4	3799.1	18	2,4
105	98	8 4	20:22	59 40.40	30 53.76	3016.5	2966.9	4.4	2868.2	17	2
106	99	9 4	00:28	59 26.16	30 51.61	3515.5	3453.8	4.1	3429.0	18	2,4,5,6,7
107	99	9 4	05:35	59 03.05	30 49.84	3166.8	3113.8	7.1	3125.3	17	2
108	99	9 4	10:52	58 37.90	30 49.58	3599.4	3535.8	7.3	3528.8	18	2,4,5,6
109	99	9 4	17:08	58 12.85	30 49.32	4065.1	3989.2	4.0	3803.0	19	2,4
110	99	9 4	22:41	57 48.12	30 49.95	3641.3	3576.9	3.7	3489.1	18	2,3,4,5,6,7
111	100	10 4	04:12	57 27.47	31 19.64	3815.4	3746.5	205.3	3753.1	18	2,4
112	100	10 4	09:40	57 07.12	31 48.51	3449.0	3389.6	7.5	3398.8	18	2,4,5,6,7
113	100	10 4	14:53	56 46.54	32 18.24	3280.3	3225.2	4.9	3230.0	17	2,4
114	100	10 4	20:40	56 22.80	32 52.15	3186.1	3133.3	3.3	3145.0	17	2,4,5,6
115	101	11 4	02:58	55 59.42	33 25.19	3099.9	3049.2	3.0	2949.8	17	2,4,5,6
116	102	12 4	00:37	55 43.52	33 47.18	3569.1	3507.1	4.5	3441.1	18	2,4,7
117	102	12 4	07:24	55 40.39	33 51.77	3109.9	3059.1	5.3	3010.1	21	2,4
118	102	12 4	11:52	55 29.10	34 08.05	2490.4	2453.3	4.4	2449.0	20	2,3,4,5,6,7
119	102	12 4	15:30	55 17.30	34 24.25	1999.3	1971.8	4.6	1944.1	14	2
120	102	12 4	17:32	55 15.54	34 26.59	1534.3	1514.9	3.1	1493.4	12	2,4,5,6,7
121	102	12 4	19:43	55 13.71	34 29.22	1095.6	1082.9	9.7	1032.6	11	2
122	102	12 4	20:59	55 12.86	34 30.38	569.6	563.6	4.9	545.0	9	2,4,5,6,7
123	103	13 4	17:30	54 12.96	36 26.59	244.9	242.6	5.4	246.6	8	2,4
124	104	14 4	01:16	53 53.20	38 39.35	170.3	168.7	5.1	177.9	6	2,4
125	104	14 4	03:29	53 41.75	38 49.47	718.3	710.6	13.5	701.2	9	2,4
126	104	14 4	05:10	53 36.66	38 53.52	1240.9	1226.2	6.0	1229.9	11	2,4,5,6
127	104	14 4	07:17	53 32.99	38 56.62	1840.8	1816.4	4.6	1756.2	14	2
128	104	14 4	09:43	53 31.58	38 57.71	2384.5	2350.0	6.8	2348.3	16	2,4,5,6,7
129	104	14 4	13:00	53 29.28	38 59.93	2943.2	2896.8	3.4	2883.9	16	2
130	104	14 4	16:55	53 20.25	39 07.74	3493.7	3434.4	2.5	3431.7	18	2,4,5,6,7
131	104	14 4	21:48	53 02.91	39 21.63	3820.9	3753.2	205.3	3767.1	18	2,4
132	105	15 4	03:06	52 45.98	39 34.73	3797.4	3730.5	205.2	3748.0	18	2,4,5,6,7
133	105	15 4	07:56	52 28.94	39 48.56	3801.7	3734.8	14.1	3750.9	18	2,4
134	105	15 4	12:44	52 28.95	39 48.56	3811.9	3744.7	205.3	3751.1	24	2,4,7
135	105	15 4	18:15	52 12.27	40 02.47	3808.5	3741.5	205.2	3743.4	18	2,4

Station number	Day of year	Date dd mm	Time at bottom GMT	Lat (south)	Long (west)	Max Pressure (db)	Max Depth (m)	Minimum distance off (m)	Water depth (corrected) (m)	No. of samples	Notes
136	105	15 4	23:06	51 55.30	40 15.76	3777.7	3711.6	205.2	3723.5	18	2,4,5,6,7
137	106	16 4	04:11	51 38.21	40 29.16	3783.3	3717.1	8.8	3728.0	18	2,4
138	106	16 4	13:56	51 21.27	40 42.29	3657.2	3594.3	5.9	3599.1	18	2,4,5,6,7
139	106	16 4	18:58	51 04.32	40 55.84	2971.1	2924.7	4.6	2920.4	17	2
140	106	16 4	23:37	50 47.17	41 08.23	2291.4	2259.2	7.6	2269.3	15	2,5,6,7
141	107	17 4	06:20	50 30.55	41 22.55	1779.1	1756.3	5.3	1761.8	13	2
142	107	17 4	09:57	50 13.83	41 35.45	1367.4	1351.2	8.4	1360.1	12	2,5,6,7
143	107	17 4	14:55	50 21.89	42 17.51	1369.5	1353.2	4.0	1356.5	12	2
144	107	17 4	19:31	50 30.02	43 00.02	1352.1	1336.1	4.1	1340.4	12	2
145	107	17 4	23:38	50 31.50	43 41.52	1358.9	1342.8	1.9	1344.2	12	2,5,6,7
146	108	18 4	03:25	50 32.93	44 23.15	1380.6	1364.2	7.1	1373.8	12	2
147	108	18 4	07:21	50 34.46	45 04.62	1444.3	1426.9	8.1	1435.3	13	2
148	108	18 4	11:26	50 35.73	45 46.03	1566.6	1547.3	3.6	1551.5	14	2,5,6,7
149	108	18 4	15:33	50 37.46	46 27.58	1981.0	1954.6	5.1	1959.2	16	2
150	108	18 4	20:07	50 39.07	47 08.77	2711.8	2671.1	5.2	2675.5	13	2,5,6,7
151	109	19 4	01:06	50 40.37	47 50.03	2689.0	2648.9	3.2	2652.1	14	2
152	109	19 4	07:01	50 41.80	48 31.49	2811.1	2768.4	7.5	2776.7	15	2,5,6
153	109	19 4	10:47	50 42.28	48 54.08	2846.4	2802.9	7.4	2808.1	17	2
154	109	19 4	12:60	50 41.88	48 54.79	2817.5	2774.6	44.1	2815.0	24	2,7
155	109	19 4	16:18	50 43.32	49 13.04	2813.7	2770.9	4.2	2768.6	17	2
156	109	19 4	21:02	50 44.74	49 53.03	2652.0	2612.6	4.0	2613.6	16	2,5,6,7
157	110	20 4	01:35	50 46.18	50 33.49	2484.2	2448.3	4.7	2450.8	16	2
158	110	20 4	05:33	50 47.34	51 04.91	2371.8	2338.1	6.7	2315.6	16	2,5,6
159	110	20 4	09:49	50 48.63	51 36.64	2079.1	2051.0	6.6	2060.2	15	2
160	110	20 4	14:07	50 49.68	52 09.54	2058.6	2030.8	4.6	2042.1	14	2
161	110	20 4	18:35	50 50.79	52 42.13	2067.8	2039.9	3.4	2049.2	15	2
162	110	20 4	23:51	50 51.80	53 14.94	1912.3	1887.2	3.1	1891.3	15	2,5,6
163	111	21 4	04:14	50 53.07	53 46.78	1732.3	1710.3	7.4	1717.7	13	2
164	111	21 4	07:37	50 54.26	54 18.98	1530.6	1511.8	9.2	1518.4	13	2
165	111	21 4	11:02	50 55.44	54 50.99	1337.2	1321.4	2.4	1322.1	13	2,5,6
166	111	21 4	14:01	50 56.36	55 17.95	1126.9	1114.1	3.5	1115.2	11	2
167	111	21 4	17:01	50 57.43	55 47.09	876.1	866.7	4.0	867.6	10	2
168	111	21 4	19:32	50 58.54	56 15.69	608.5	602.4	2.8	603.6	9	2,5,6
169	111	21 4	21:55	50 59.40	56 43.82	361.1	357.6	4.6	362.3	7	2
170	111	21 4	23:56	51 00.59	57 11.72	114.3	113.3	4.9	120.1	4	2

Notes:

1. Date, time and position are reported for the time at the bottom of the cast.
2. Salinity, dissolved oxygen, silicate, nitrate+nitrite, and phosphate were sampled for these stations
3. Oxygen isotopes were sampled for these stations.
4. CFC11, CFC12, CFC113, and CCl4 were sampled at these stations.
5. Tritium was sampled for these stations.
6. Helium was sampled for these stations.
7. SF_6 was samples for these stations.

Table 2. ALBATROSS XBT List

Probe	Julian Day	Date dd mm	Time hh:mm	Latitude	Longitude	Depth (Corrected)	Probe Type
001	091	01 04	16:28	60 35.57	49 43.95	1546.1	T-5
002	091	01 04	17:55	60 35.03	49 29.74	1594.9	T-5
003	091	01 04	20:05	60 33.55	49 11.07	1519.3	T-5
004	091	01 04	21:23	60 31.91	48 49.49	1498.5	T-5
005	092	02 04	01:24	60 28.93	48 09.98	1368.4	T-5
006	092	02 04	05:16	60 30.63	47 50.82	1893.5	T-5
007	092	02 04	08:20	60 31.47	47 41.62	1485.9	T-5
008	092	02 04	13:21	60 33.87	47 14.21	487.9	T-7
009	093	03 04	04:36	60 39.85	42 18.52	1512.7	T-7
010	093	03 04	15:11	60 04.25	42 07.30	343.9	T-5
011	093	03 04	17:20	60 40.62	42 23.39	995.3	T-7
012	093	03 04	18:42	60 39.98	42 19.03	1414	T-5
013	094	04 04	00:41	60 08.77	42 01.34	543	T-7
014	094	04 04	00:54	60 38.78	42 11.35	2455.9	T-7
015	094	04 04	03:58	60 38.62	42 10.16	2859	T-5
016	094	04 04	07:31	60 37.99	42 05.32	3674.1	T-5
017	094	04 04	13:02	60 35.63	41 49.68	2947.9	T-5
018	094	04 04	15:09	60 34.33	41 41.75	2453.4	T-5
019	094	04 04	18:23	60 31.57	41 22.92	1969.9	T-5
020	095	05 04	00:00	60 26.69	40 30.27	1408.3	T-5
021	095	05 04	04:26	60 25.27	39 38.24	1536.9	T-7
022	095	05 04	04:33	60 25.21	39 36.33	1451.4	T-5
023	095	05 04	05:47	60 24.86	39 18.05	1518.8	T-5
024	095	05 04	05:55	60 24.89	39 18.04	1520.6	T-7
025	095	05 04	06:00	60 24.87	39 17.97	1523.1	T-5
026	095	05 04	08:18	60 24.56	39 07.34	2061.6	T-5
027	095	05 04	11:40	60 25.24	38 42.29	2569	T-5
028	095	05 04	14:39	60 26.14	38 15.06	2928.3	T-5
029	095	05 04	15:41	60 26.66	38 00.12	2906.3	T-5
030	095	05 04	18:45	60 27.19	37 43.89	2878.6	T-5
031	095	05 04	20:12	60 27.32	37 22.19	2078	T-5
032	095	05 04	23:36	60 24.70	36 46.60	1723.5	T-5
033	096	06 04	00:59	60 22.97	36 23.82	1887.6	T-5
034	096	06 04	16:24	60 01.54	34 28.52	989.5	T-7
035	098	08 04	22:11	59 35.22	30 53.09	2669.2	T-7
036	099	09 04	02:56	59 17.00	30 50.82	2928.4	T-7
037	099	09 04	03:15	59 13.69	30 50.78	3098	T-5
038	099	09 04	03:19	59 13.00	30 50.84	3108.2	T-5
039	099	09 04	04:49	59 03.01	30 49.81	3124.3	T-5
040	099	09 04	14:16	59 14.61	30 49.42	3367.3	T-7
041	099	09 04	20:03	58 00.53	30 49.38	3360.8	T-7
043	100	10 04	01:21	57 38.32	31 04.18	2851.7	T-5
044	100	10 04	07:01	57 17.55	31 34.00	3422.5	T-7
045	100	10 04	12:16	56 58.14	32 01.69	2973.2	T-7
046	100	10 04	17:45	56 35.46	32 33.95	3475.7	T-7
047	105	15 04	20:41	52 04.13	40 08.70	3728.1	T-7
048	106	16 04	01:29	51 48.43	40 21.25	3712.0	T-7
049	106	16 04	16:31	51 13.25	40 48.68	3184.6	T-7
050	106	16 04	21:23	50 56.45	41 01.96	2587.1	T-7
051	107	17 04	01:45	50 44.63	41 09.91	2208.2	T-7
052	107	17 04	08:11	50 22.58	41 29.09	1544.0	T-7
053	107	17 04	13:36	50 20.46	42 10.09	1353.0	T-7
054	107	17 04	17:18	50 26.09	42 39.04	1327.4	T-7
055	107	17 04	21:32	50 30.69	43 19.78	1360.9	T-7
056	108	18 04	01:29	50 32.24	44 01.85	1299.5	T-7
057	111	21 04	05:56	50 53.58	54 02.31	1592.8	T-7
058	111	21 04	09:15	50 54.95	54 33.98	1396.5	T-7
059	111	21 04	12:35	50 55.97	55 04.00	1295.3	T-7
060	111	21 04	15:32	50 56.88	55 30.58	1042.1	T-7

Figure 1 ALBATROSS cruise track and station positions.

Figure 2. Location of bottle samples

Figure 3. Scatter diagram of CTD minus bottle salinity data

Figure 4. Example of upcast and downcast 1 Hz CTD data. Station 012 is plotted. The solid line is the downcast. The dotted line, offset by 0.002, is the upcast.

Figure 5. Scatter diagram of CTD minus bottle oxygen data