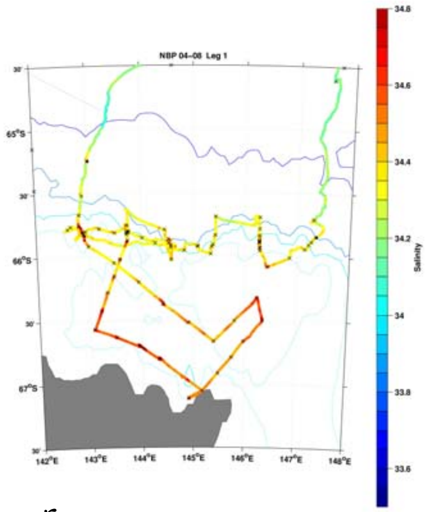
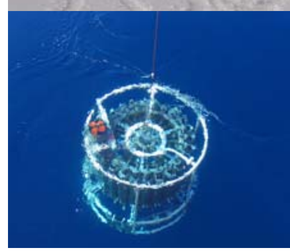
AnSlope-3 Cruise Report

There and back….

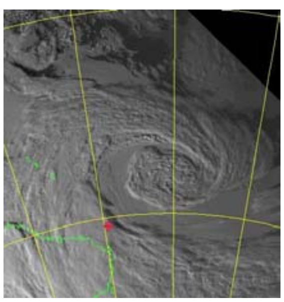


The Journey – Leg 1

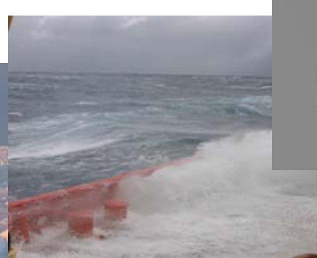
The "Fellowship"

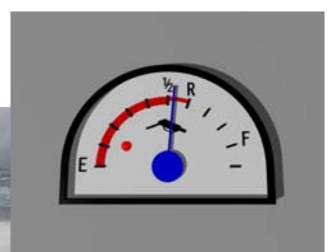


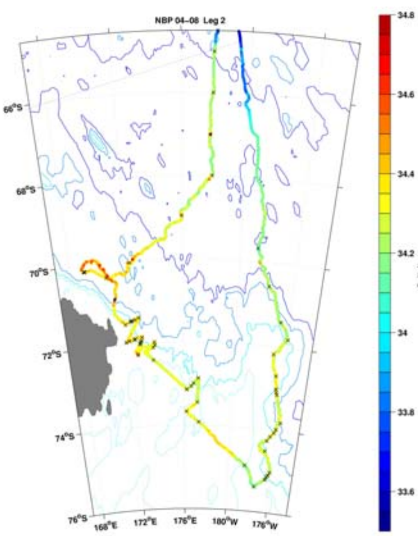
…and there and back again:
The Scientists' Tale



The evil eye and its cohorts







The Journey – Leg 2

NBP0408: Lyttelton (Oct 13) to Timaru (Nov 6-7) to Lyttelton (Dec 7)

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1 Introduction and Overview

1.1 The AnSlope Project

The primary goal of the AnSlope project is to better understand the physical processes that govern the transfer of dense shelf waters into the intermediate to bottom layers of the adjacent deep ocean, and the compensatory poleward flow of waters from the oceanic regime. Assuming that the upper continental slope and its typically associated Antarctic Slope Front (ASF) are the primary gateways for the exchange of shelf and deep ocean waters, four specific objectives have been identified: [1] Determine the mean ASF structure, its principal scales of variability (from ~1 km to ~100 km, and from tidal to seasonal), and its role in cross-slope exchanges and water mass mixing; [2] Determine the influence of slope topography (canyons, proximity to a continental boundary, isobath divergence/convergence) on frontal location and outflow of shelf water; [3] Establish the role of frontal instabilities, benthic boundary layer transport, tides and other oscillatory processes on cross-slope advection and fluxes; [4] Assess the effect of diapycnal mixing (shear-driven and double-diffusive), intrusive lateral mixing, and non-linearities in the seawater equation of state (thermobaricity and cabbeling) on the rate of descent and fate of outflowing, near-freezing shelf water.

The core field elements of AnSlope consist of CTD-O/rosette casts, bottom-moored current/temperature/salinity arrays, ship- and CTD-mounted Acoustic Doppler Current Profilers (ADCPs), microstructure profiling systems mounted on the CTD or operated independently in free-fall mode, geochemical analyses of water samples for chlorofluorocarbons (CFCs), helium, tritium and oxygen isotopes, and basic tidal modeling. On this cruise, no mooring work was done, the microstructure studies were accomplished independent of the CTD with a 'VMP,' and two ship-mounted ADCPs were operated in addition to dual LADCPs. Water samples were taken and processed aboard ship by representatives of the collaborating Italian CLIMA program, frequent sea ice observations were made according to AsPect protocols, and observers routinely logged marine mammals and seabirds along the ship's track.

The fieldwork phase of AnSlope has consisted of three dedicated cruises, two of which were completed earlier, in Feb-Apr of 2003 and 2004. On those cruises, bottom-moored arrays were set near the mouth of Drygalski Trough, recovered, and some reset for recovery in January 2005. In addition, a pre-AnSlope site survey was carried out from the NBP during December 2002 to better define the slope and shelf break area in the western Ross.

1.2 A Brief History of AnSlope

AnSlope 3 has had a rather checkered history. At the proposal stage, it was conceived as a complement to the summer A-1 and A-2 cruises, an opportunity to assess the ASF environment at its winter extreme. It was realized that the NBP would have some difficulty carrying out station work near Cape Adare in midwinter, but that end-of-winter conditions could as well be accessed in October and November, at which time the high salinity shelf water (HSSW) reservoir could be expected to be near its maximum volume. The work was anticipated to be difficult, nonetheless, so 65 days of ship time were requested, at a time between the two summer cruises when bottom-moored current, temperature, salinity arrays would be deployed and operating. The project was approved on the second round, but since then the 'late winter' component has been repeatedly altered by ship scheduling and related constraints.

First the requested Oct-Nov 2003 period was found to be committed to another project. In lieu of that time frame, a shorter, early-summer period was offered and accepted, partly on the rationale that more ground could be covered at that time of year, providing access to the ASF well beyond the Cape Adare region where the A-1 and A-2 would be tied down with mooring work. Indeed, earlier observations had suggested that the ASF might well be stronger in the eastern Ross. Planning for a Dec 2003 - Jan 2004 cruise was thus initiated, personnel committed and substantial time expended on organization and communications. Fairly late in this process, the issue of refueling the NBP in the Ross Sea was raised, and it was realized that the only viable option would be to draw >100K gallons from a USCG icebreaker midway during the cruise, at which time the Polar Sea/Star would be enroute to its channel work. The numbers looked reasonable, if tight, but a decision was made that it would not work, and shorter biology and geophysics cruises then assumed the available ship time. At this remove we do not have access to the notes and considerations that led to the revised schedule, but recall that USCG reluctance to lighten its load prior to working the thick, fast ice in McMurdo Sound was a deciding factor.

AnSlope-3 was then postponed to the Oct - early Dec 2004 period, a year later than originally requested, but consistent with a decision to redeploy some of the moorings for a second year during A-2. At that point in the game, A-3 could have been started earlier, due to an apparent weakness in the NBP schedule in September. However, we were still wary of being unable to work successfully in the NW Ross at that time, and eventually shortened the cruise by five days after analyzing available fuel usage information for past cruises in winter/spring. It did appear that 60 days could be managed, given a full load at the start and a conservative average burn rate of ~6250 gal/d. However, one day before flying south to begin a 60-day NBP04-08, we were informed by RPSC that the ship could only use 220K gallons of fuel between pit stops. That constraint, subsequently revised to 200K gallons in our sailing orders, reportedly resulted from a series of inclining tests and stability calculations that appeared to show the NBP could not meet 'damage stability' criteria under which she was chartered, without retaining about half of her fuel load as ballast. After initially thinking that it made little sense to attempt in ~30 days what was expected to be difficult in 60, we 'bit the bullet' and decided to try and make the best of being dealt another bad hand.

Since A-3 was to be a two-act opera, and satellite imagery showed that ice conditions in the Ross in early October were forbidding, we opted to try and work initially in a more accessible area of the continental margin, south of Tasmania. We had obtained summer data in that region in December 2000 - January 2001, and so knew something about its hydrography, both oceanographic and bathymetric. The ASF is not limited to the Ross Sea, but occurs at other locations along the Antarctic continental margin, where similar processes are believed to occur. In retrospect, this worked out reasonably well, as we were able to gain access to both the shelf break and interior shelf polynyas in a relatively short time. Meanwhile, we kept a satellite eye on the Ross Sea, and eventually decided to attempt work in that sector on the second A-3 leg, following a refueling in Timaru, NZ. Additional time was allowed for the Ross Sea work by departing the George V Coast area a few days early, and assuming that a longer period could be accommodated in the Ross by very conservative fuel use. In the end, that may have been a bad gamble, as we were caught by a major storm enroute to the Cape Adare region. This set us back by several days at the outset, as the NBP was advected NW and then had to cross compact, heavily ridged ice at great fuel expense in order to reach the study area. Otherwise, we found the late November Ross Sea ice to be workable, with plentiful leads, and more could have been accomplished with another 20,000 gallon of fuel. But as this report is being assembled, we are enroute to Lyttelton NZ, and expecting to arrive ~ five (science) days early.

Many already know that we have questioned the decision to hamstring the NBP prior to 04-08, knowing that she is no less safe at present than on numerous prior cruises. We have also argued against costly alterations to the vessel that appear to have worsened an initial problem, primarily to benefit a project that could most likely have been accomplished on other ships. We are concerned that proposed solutions to the existing 'damage stability' problem will cut further into the endurance that is so essential to effective use of a research vessel in remote polar regions. And we are weary of seeing a capable research ship spending more time on transit, in port and on 'hazmat' duty than doing the science for which it was ostensibly chartered, at considerable expense. But our responsibility is only to complain when we end up suffering for such decisions, however desirable or necessary, they may be judged by others. With that said, on to the achievements of this nearly completed cruise.

1.3 A Rough Outline of Anslope-3 Operations and Science

This cruise report is one of three primary documents resulting from A-3. Another is the set of DVDs that contain all of the relevant cruise data, and a third is the RPSC Data Report that includes more technical details about data acquisition, sensor calibration, etc. An appendix to the Cruise Report includes the weekly science reports that we are required to send to 'mo-sciweekly@usap.gov', and the Data Report includes the Marine Project Coordinator's daily 'sitrep' reports. The Cruise and Data Reports will be on the DVDs, which are distributed to AnSlope PIs and the CLIMA and Whale Observation programs, with copies to RPSC aboard ship and in Denver.

More than half of the A-3 CTD/rosette stations and VMP profiles were taken on leg 1, where the belt of pack between the ice edge and shelf break was narrow (~100 km), numerous grounded icebergs east of 150^{o} E continue to hinder the westward movement of thick multiyear sea ice, and the coastal polynyas east of the Mertz Glacier Tongue were readily accessible. The work began with several cross-slope sections between ~149^{o}E and 142^{o}E (sample shown in Figure 1), shorter than occupied during NBP00-08, but sufficient to span the broad frontal region in that sector. This was followed by along-slope CTD and VMP work, a quick tour of open water areas deep on the shelf, and a final cross-slope transect.

New bottom water is clearly being formed, and deep water modified, along this part of the continental margin, and it is primarily a fresh variety that does not reflect much influence of the higher salinity water deep in the shelf troughs. Only our westernmost section showed a thin bottom layer on the upper slope with higher salinity, and that outflow was not pursued westward. Initially a large iceberg blocked further access to the slope region, and in the end a decision had by then been made to save time for use in the

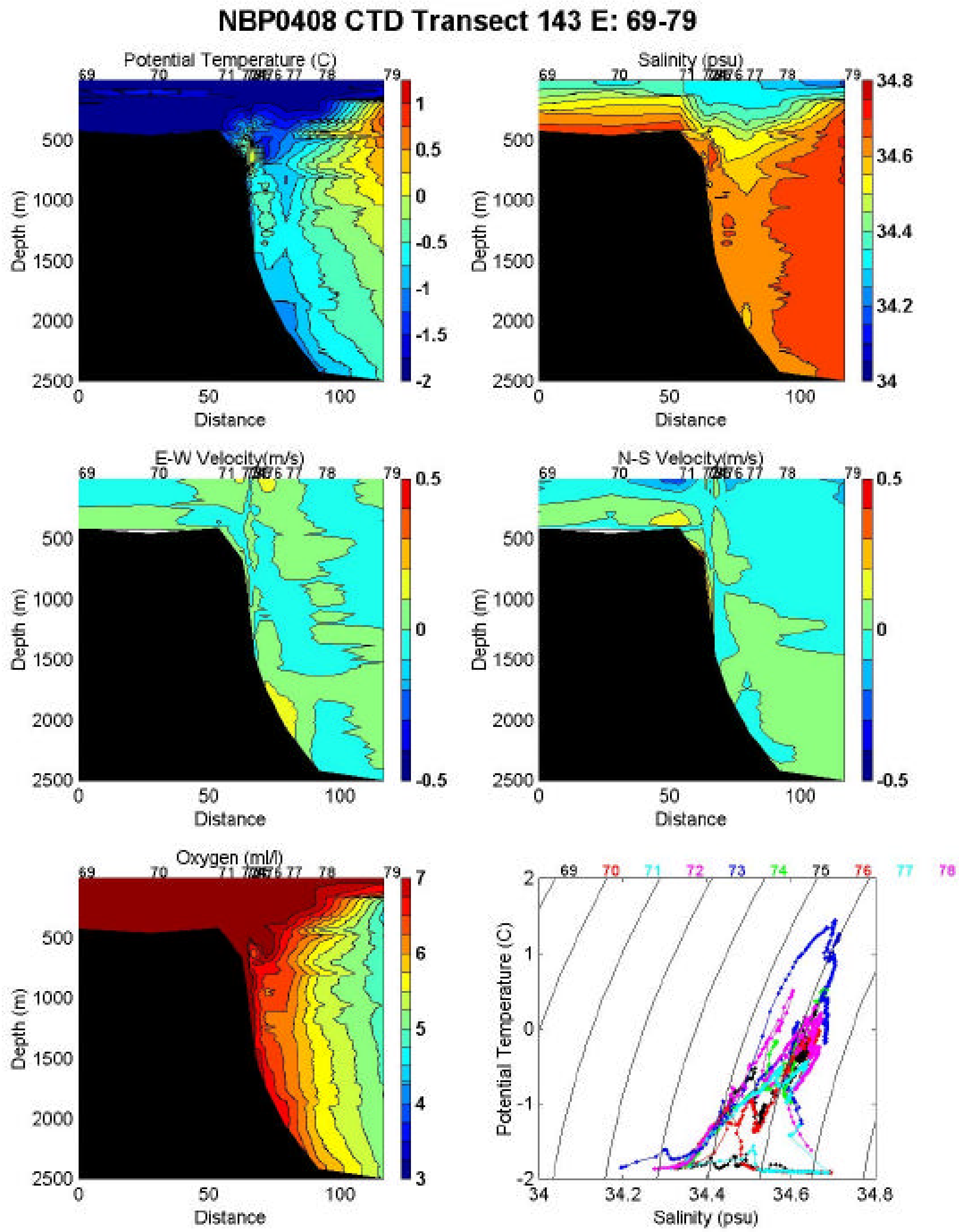

Figure 1. Transect across the outer shelf and slope near 143° E (Figure A.1). Panels show potential temperature, salinity, zonal velocity, meridional velocity, and dissolved oxygen and a *?-S* diagram. Zonal and meridional velocities have had their vertical means removed. Dissolved oxygen has been corrected according to the onboard calibration.

Ross Sea. But given the general properties of bottom water in the Australian-Antarctic Basin, HSSW may not be a significant contributor in this sector, much less to the global ocean. Deep water modification in this region is classic Carmack/Killworth large-scale interleaving, as has been noted previously, a process not often reported in the Ross sector. Waters over the upper slope were remarkably fresh, even in comparison to summer measurements. Modified Circumpolar Deep Water (MCDW) intrusions onto the shelf seemed relatively weak and shallow, and a tendency is noted for deep water and shelf water to enter/exit the shelf across or near the same sills. Of course that traffic keeps appropriately to the left, this being the southern hemisphere, and may also be evidenced by bottom temperature distributions on the slope. Shelf water formation was ongoing, albeit intermittently (see VMP section below), and we are increasingly convinced, as others may already know, that the smaller, less-heralded coastal polynyas, initially neglected in favor of the storied Mertz, are where the saltiest shelf water is formed. Ice Shelf Water (ISW) was also observed, but must compete with the effects of strong surface forcing in winter, and may be less apparent thereby.

On A-3 Leg 2, we began by occupying shallow, widely-spaced reference CTD stations across the eastern Ross Gyre, while moving southward through the pack near the prime meridian. Just prior to that time, satellite data suggested lower ice concentrations might be encountered across the eastern end of the Gyre, but that seemed like a long and potentially risky route to reach the AnSlope mooring sites. A substantial flaw lead north and slightly west of Cape Adare had beckoned for weeks, and appeared to be located near the shelf break, so we diverted SW toward it, across the Adare Trough. At that point we began to encounter much thicker, more compact ice, and had barely reached the downslope end of a planned transect when a large storm halted the proceedings. Persistent easterlies closed off the flaw lead and then strong SE winds moved us much farther NW than desired. Much fuel was consumed backing and ramming toward the SE before we were finally able to accomplish a transect across the 'Visbeck' mooring (Figure 2).

Ice and weather conditions then improved and remained good for the rest of our Ross Sea survey. Several sections were completed in the vicinity of the Drygalski Trough sill, one near the AnSlope moorings. VMP profiling near the Drygalski sill was followed by a section downstream and across the outer Joides Trough, and along the outer western axis of the Challenger Trough. By then it was time to begin heading north, and along that route short sections were occupied across the slope and outer Iselin Bank, ending with a deep cast at the northern side of a passage north of the Bank. On both legs of the cruise, XBT casts were utilized along some transects to guide station work, add detail to the lateral thermal structure, and save time.

The Ross sector was also found to be fresher than anticipated at this time of year, with the ASF more than a spring tidal excursion south of the continental shelf break. Both east and west of Iselin Bank, bottom water on the continental slopes indicated a fresh shelf water/surface water component, quite likely derived from the E-W flow that tracks the ASF. ISW continues to elude us on the slope, implying that little of it leaves the shelf in undiluted form, most of it recirculates back under the Ross Ice Shelf, or we have yet to stumble on its primary exit time/location during brief surveys. The apparent weak roles of

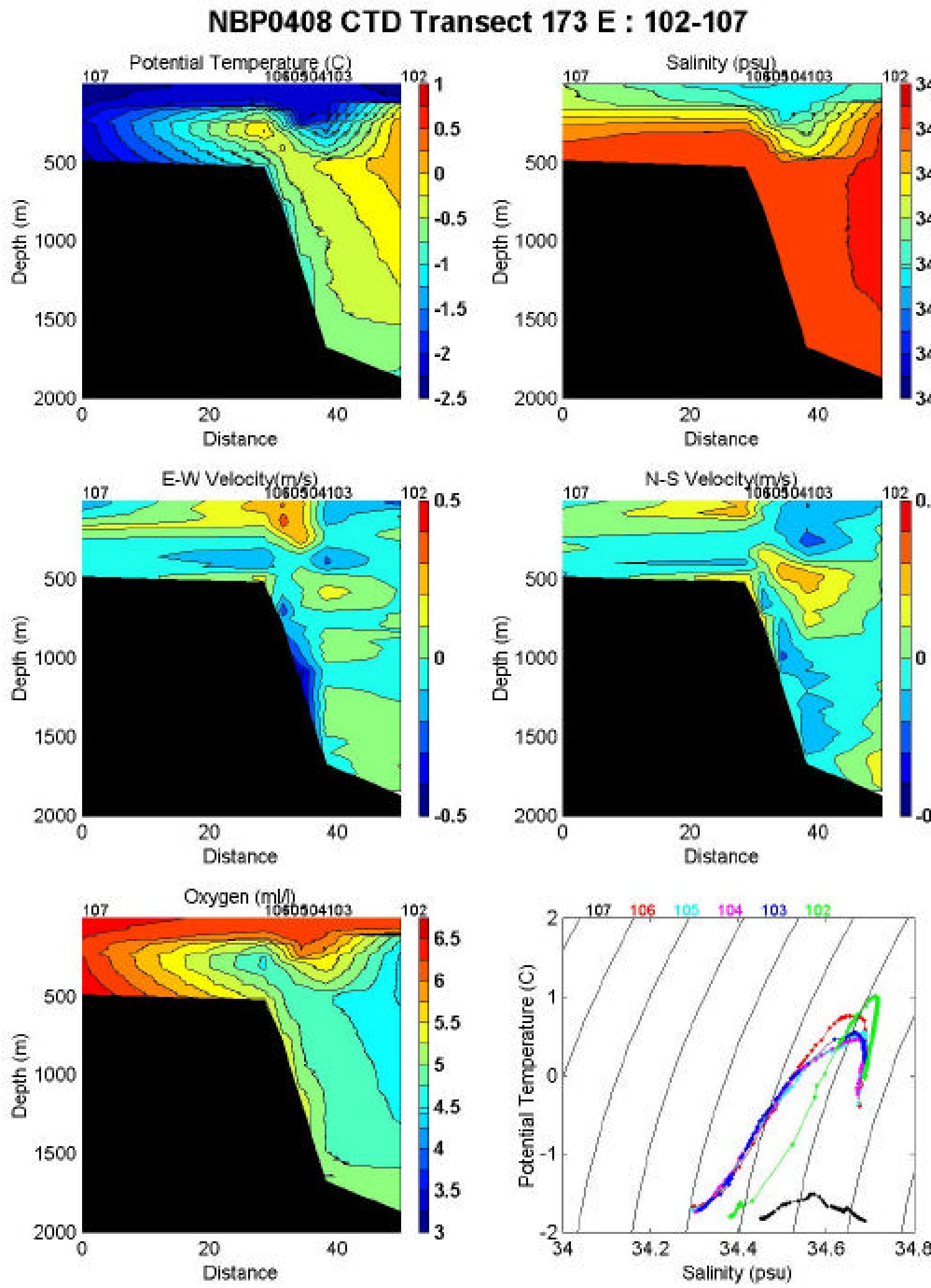

Figure 2. Transect across the outer shelf and slope near 173°E (Figure A-2). Panels show potential temperature, salinity, zonal velocity, meridional velocity, and dissolved oxygen and a ?-*S* diagram. Zonal and meridional velocities have had their means removed. Dissolved oxygen has been corrected according to the onboard calibration.

both ISW and HSSW near the shelf break at this time of year present an interesting puzzle, one that may require more than the narrowly-focused AnSlope data sets to solve.

Conversely, deep water and its derivative intrusions onto the shelf were alive and well, dominating much of the subsurface water column and often extending to the sea floor. Has the HSSW reservoir shrunk to a point where it can no longer keep the MCDW/CDW at bay? Are we witnessing a response to the anomalous sea ice and glacial ice conditions over the shelf during recent summers? Were the A-3 measurements obtained at a time when the forcing was weak and the ocean regime was relaxing after a more active period caused by the large storm? We trust that the moorings, when recovered in January 2005 and analyzed in conjunction with the meteorological and sea ice data, will shed additional light on these issues.

The following sections in this report provide more detail about the profiling, water sampling and underway observations made on A-3. Most all CTD stations were sampled for CFC, dissolved oxygen and salinity, vs. 58% and 44% on A-1 and A-2, respectively. Relatively few helium, tritium and oxygen isotope samples were taken on station, but many more nutrient samples in order to accommodate onboard processing by the CLIMA group. Many more XBT casts were also made on A-3, mostly enroute to and from the study areas, and the accompanying underway sampling was not done on prior AnSlope cruises (see Section 2.9). As the station table (Table A-1) in the appendix demonstrates, about 12 days were spent in each of the two study areas, out of about 55 days at sea and another 5 days in port. Future inspection of RPSC records will show the NBP 'sailing for science' more than 90% of the time during A-3. However, when actual time on site is closer to 40%, it may be time for another rubric to monitor NBP performance.

1.4 Acknowledgements

We thank the many people who have contributed in many ways to the AnSlope 3 adventure, aka NBP04-08. From the responsive and responsible ECO/RPS hands, to the conscientious and congenial science party, all have persevered with talent, care and good humor. We also thank OPP O125172, for which we have tried to give good weight in return. We may have spurned Hobart and ranted at Holik, but from Denver to Palisades, Seattle to Suitland, McMurdo to Timaru, many others have helped to see us through. From a perfect storm off Cape Adare to a perfect finish across the ACC, from here to there and back again, we now have some icy tales to tell.

1.5 AnSlope-3, Personnel

Science Staff		
Stan Jacobs	Chief Scientist	LDEO
Gerd Krahmann	LADCP/CTD/tracer sampling	LDEO
Robin Robertson	CTD/XBT/underway sampling	LDEO
Deb LeBel	CFC sampling/analysis	LDEO
Guy Mathieu	CFC sampling/analysis	LDEO
Raul Guerrero	CTD/autosal/sample analysis	LDEO/INIDEP
Sarah Searson	CTD/XBT/underway sampling	LDEO
Alison Criscitiello	Oxygen/tracer sampling	LDEO
Basil Stanton	Oxygen/sampling analysis	LDEO/NIWA
Laurie Padman	VMP/ AnSlope PI/	Earth & Space Research
Loren Mueller	VMP/CTD/XBT	Earth & Space Research
Denis Franklin	Sea ice observations	LDEO
Ian Southey	Sea ice/ sea bird observations	LDEO
Sarah Dolman	Marine mammal observations	IWC/ WDCS
Kelly Asmus	Marine mammal observations	IWC/ Deacon University
Alessandra Campanelli	nutrient sampling/analysis	CLIMA/ ISMAR-CNR
Serena Massolo	nutrient sampling/analysis	CLIMA/ Universitá di Genova
RSPC Support Staff		
Karl Newyear	Marine Projects Coordinator	
Annie Coward	Marine Technician	
Amy West	Marine Technician	
Jeff Morin	Marine Science Technician	
Sheldon Blackman	Electronics Technician	
Kevin Pedigo	Electronics Technician	
Rob Hodnet	Information Technician	
Dean Klein	Information Technician	

LDEO = Lamont-Doherty Earth Observatory
CLIMA = Climate Long-term Interaction of the Mass balance of Antarctica (Italy)
INIDEP = National Institute for Fishery Research (Argentina)
IWC = International Whaling Commission
NIWA = National Institute for Water and Atmospheric Research (New Zealand)
WDCS = Whale and Dolphin Conservation Society

2 Program Reports

2.1 CTD

Temperature, salinity, and dissolved oxygen profiles were obtained with a SeaBird Electronics SBE 911+ CTD system fitted with 2 sets of ducted conductivity-temperature sensors, dual pumps, and one/two SBE 43 dissolved oxygen sensors. The sensor suite was mounted vertically on a flat surface just inboard of the lower CTD/rosette frame supports. As the sensor pairs gave slightly different values and drifted slightly with time (sea section 2.4.), post-cruise calibration plus intercomparisons with bottle data will be required during data reduction. A transmissometer and fluorometer were also installed, both with 6000 m-depth capability. One Hertz GPS data from the vessel's Ashtech GPS was merged with the CTD data stream and recorded at every CTD scan. Data were acquired using a PC running Windows 98 and SeaBird's Seasave software, version 5.30b. Raw data were copied over the network to a separate drive immediately after station completion. Processed data were copied to a network disk drive and were generally available within minutes after station completion.

Spiking and modulo error counts were of increasing concern during the first leg of the cruise, and led to analyses suggesting a conducting cable fault in the vicinity of 600 m. After considerable discussion, the outer 700 m of cable was lopped off after station 79, enroute to Timaru, followed by a new end termination and test cast near the end of XBT transect #2 (station 80). These measures did not totally eliminate either the spikes or modulo errors, but reduced them to insignificant levels during the 2nd leg. Station 57 needed to be restarted due to pump tubing problems. At station 98, the pump hose for the primary sensors was dislodged when bottles were fired. Consequently, data values for station 98 subsequent to 47 db are suspect. The pump for the secondary sensors was found to be operating incorrectly at the start of station 132 and was replaced.

Most profiles reached within 10 m of the sea floor, with bottom approach guided by a 12 kHz pinger (OSI) mounted on the frame, along with an SBE bottom contact switch fitted with a 10 m lanyard and weight. The pinger and bottom contact switch generally worked well, except for a few stations where the ship drifted rapidly and/or the bottom current was strong, or where the ship's thrusters complicated the bottom approach. (See section 2.11 below.) Transmissometer readings were nearly constant for all casts except # 85, which is puzzling, since early data in this region indicated significant suspended material near the bottom. In an attempt to determine whether the instruments might be at fault, transmissometers were switched in and out before various casts (20, 29, and 81) and the transmissometer cable was changed (cast 9). The surface reference marker on the CTD cable indicated the depth of the CTD beneath the surface was changed before casts 5 and 80.

Water samples were taken with a 24-position SBE 32 Carousel sampler with 10 liter 'Bullister' bottles. Water was collected for onboard analyses of salinity, dissolved oxygen, chlorofluorocarbons (CFCs) and nutrients (silicate, phosphate and nitrate). Salinity and oxygen analyses are primarily for standardizing the CTD conductivity and O_2 sensors. Additional samples were drawn on some stations for later analysis at LDEO and in Italy of helium, tritium, oxygen isotopes and nutrients. The rosette was generally trouble free except for minor problems such as trip failure due to sticky latches, open vents and dislodged O-rings, as noted on the bottle cop sheets. Most bottles were closed on most stations, but usually two or more were fired at each chosen depth, as the water columns encountered rarely required more detailed sampling. Sample depths emphasized water column extrema in T and S, regions with homogeneous layers for salt and O_2 control, and layers near the sea surface and sea floor. Several experiments were conducted with tripping procedures, such as cycling already closed bottles to greater depths on yo-yo stations, and tripping during the upcast without stopping. The fish was typically raised and lowered near 50m/min, but slower near the air and sediment interfaces.

Station setup was more problematic than we encountered on prior NBP cruises, often requiring more than 30 minutes from the time a decision was made to stop for station until the ship was ready for the CTD to be launched. This complicated related preparations, such as starting the LADCP system, and on one occasion an LADCP connector was deep fried as the package went over minus its dummy plug. Time required to get the CTD out of the water and back into the relative warmth of the Baltic room was also of concern, given -20^{o}C air temperatures at some stations. While the CTD sensors seemed to withstand such thermal shock without incident, we cannot easily account for all jumps that occurred, e.g. between sensor output and bottle oxygen values. On the other hand, some time was saved by limiting the O_2 sensor equilibration time at 4 m depth to 1-2 minutes prior to each station. We do not believe this negatively impacted O_2 sensor performance, which was less good overall than expected from these new instruments. After rather large offsets and jumps during leg 1, a second O_2 sensor was added, beginning at station 88, with some improvement. Hysteresis also continues to plague these sensors, although much less so that the earlier Beckmann oxygen units. See section 2.5 for more details on the bottle-CTD oxygen comparisons.

Against some prior advice, and after a full round-house discussion, the Baltic room was made available for VMP casts rather than undertaking that operation on deck and in the wet lab. To protect the CTD during the 12-24 hr VMP stations, during which time the Baltic room door was open, the CTD/rosette was shunted aside, but not disconnected from the conducting cable. It was covered with a tarp, kept warm by a small heater and the sensors were drained. This procedure worked reasonably well, although water was left on the sensors during the last VMP cycle, and a heater may have failed, perhaps accounting for a coincident shift in the secondary conductivity sensor output (see section 2.4.). As noted above, all the CTD temperature, salinity and oxygen data will be reprocessed after post-cruise sensor calibration data are available. At that time it will be determined whether the primary or secondary sensor outputs, or some combination of the two, will be used for the final data set. **[Stan Jacobs]**

2.2 Lowered Acoustic Doppler Current Profiler (LADCP)

A dual head (one up and one downward looking) lowered ADCP (LADCP) system was attached to the CTD/rosette for the entire cruise. Three different heads were used. All units were versions of the 300kHz "workhorse" type. During leg one to the George V Coast, the upward looking system (SN 5254) was a loan from RDI, the ADCP manufacturer manufacturer, while the downward looking was the most reliable unit owned by Lamont (SN 149). SN 5254 is a newly developed head with a stronger output power. RDI thereby hopes to extend the range of the workhorses under difficult conditions such as the low amount of scatterers in parts of the deep ocean.

During test station 1 the battery case developed a leak through which sea water came in contact with the battery pack. This was not noticed directly after the cast. A few days later (there was a 5 day gap between the test and the second station) it was found that one endcaps of the battery case had been blown off. It was not clear whether the alkaline batteries exploded themselves or whether electrolysis caused the failure of the endcap assembly. As the battery case was heavily corroded a spare battery housing was prepared and installed.

During the first few stations unit SN 5254 developed one bad beam. As the RDI workhorse systems each have four transducers they can still operate with one failing transducer. Only the error estimate of the velocities is lost in this case. Unfortunately this system developed a second failing transducer, which rendered it inoperable. Also, we did not find that 5254 provided a significantly longer range. After cast 12, when the second transducer failed, we removed both systems from the rosette.

The data gathered until then was of reasonable acoustic quality at most stations. All profiles in the George V Coast region were, however, plagued by the close proximity to the south magnetic pole. In this region the flux gate compass from which the ADCPs derive their heading does not work reliably. During the first leg of the cruise an attempt was made to derive ADCP heading from other data. So far we have not been able to create a method of recovering the heading over the full length of a profile. Under some circumstances the developed algorithm, which is based on the assumption that the current measured by the ADCP does not change much over the 1.5 second ping interval, is able to recover parts of the rotation. In these cases it is possible to compare the flux gate measured heading with the independently derived rotation and evaluate the quality of the measured heading. In a few cases this evaluation indicated that the measured heading was reliable in spite of the proximity to the south magnetic pole.

After e-mail consultation with colleagues at LDEO we resumed LADCP operations at station 49 with SN 150 as the upward looking unit. Except for the unusable compass data both profilers worked well.

Before station 58, the dummy plug was not placed on the CTD/rosette side of the connection between ADCPs and computer. One of the power holding pins of the plug corroded away during the cast. This rendered unusable the second quintopus cable, which connects the battery with the two ADCPs and the deck cable. The first had been found early during the cruise to be unreliable. ET Sheldon Blackman cut the corroded part off the second cable and replaced it by the same part of the uncorroded, but unreliable, first cable. He built a high pressure safe connection between the two salvaged pieces. A replacement cable ordered from the manufacturer did not reach the ship in time for our mid-cruise port call in Timaru, NZ. A new battery housing was received but has not been used.

During the second leg of the cruise no serious problems were encountered. SN 149 developed one broken beam but remained otherwise fully functional.

Previous experience with LADCP systems in the Southern Ocean indicated that profiles going deeper than about 1500m give unreliable results as the amount of scatterers at these depths is too low for the RDI workhorses. Several such profiles lead to suspicious looking results.

All in all, about 50 out of 100 LADCP profiles were located far enough from the magnetic south pole and shallow enough for a sufficient amount of scatterers. Table A-2 in the appendix lists the LADCP profiles taken and whether they are deemed reliable

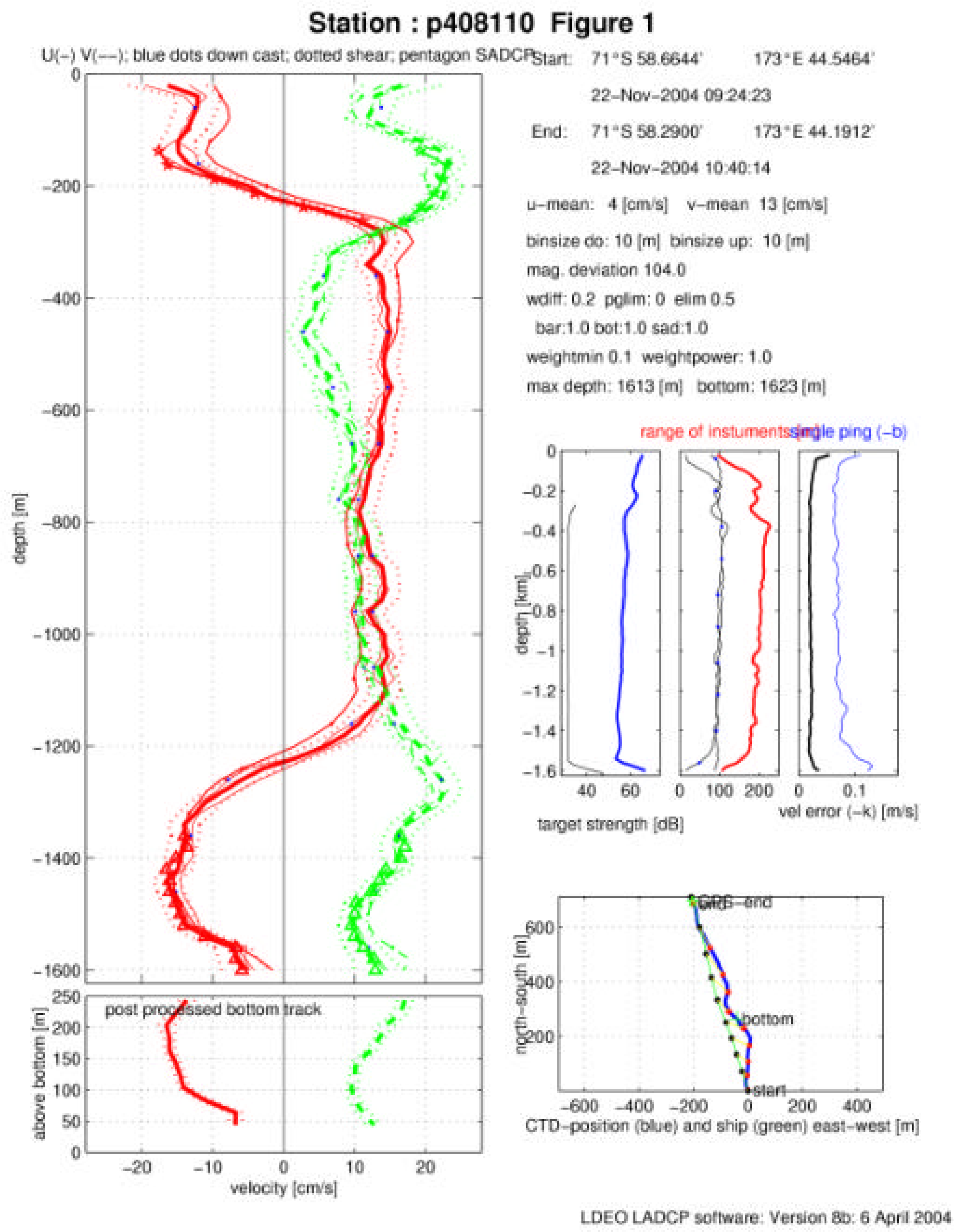

Figure 3: Example LADCP profile showing a three layered current structure.

after being processed with the current version of the processing routines (see Figure 3 for a profile deemed reliable). As the processing routines are under continuous development, we always hope that future advances will result in additional reliable results. **[Gerd Krahmann]**

2.3 Turbulence Measurements with "Vampire"

Operations Summary

The Vertical Microstructure Profiler (VMP, a.k.a. "Vampire"; see photo on Figure 4) is a tethered, free-fall profiler measuring microscale (order 1 cm) temperature and conductivity (*T* and *C*), and velocity shears ?*u*/?*z* and ?*v*/?*z*. Vampire also carries pumped calibrated CTD-quality *T* and *C* sensors (SeaBird SBE-3 and SBE-4), for providing simultaneous high-accuracy (but lower vertical resolution) scalar data. Instrument depth and motion (speed and tilt) are monitored by a pressure sensor and 3-axis accelerometer. The latter data provide a means for removing instrument-induced "noise" from the shear sensors. The instrument fall speed *w* is ~0.6 m/s, the rate determined by a balance by syntactic foam buoyancy elements and a "chimney sweep" drag brush. The chosen fall speed is a compromise between sensitivity of the shear probes (? w^2: i.e., better at higher *w*) and the vertical resolution of the microscale scalar sensors (better at lower *w*). Vampire is ~2.2 m long when fully assembled.

The primary goal of deploying Vampire on AnSlope-3 was to obtain higher-quality measurements of turbulent mixing rates than we obtained on AnSlope-1 using the CTD-mounted Microstructure Profiling System (CMiPS). In particular, we hoped to obtain turbulence data through the upper interface of the bottom-trapped plumes of outflowing dense shelf water, as seen in AnSlope 1 CTD/LADCP/CMiPS data.

Vampire was deployed from the Baltic Room, replacing the CTD there for periods of a few hours to a day. Once the technique for converting the Baltic Room was sorted out, turnover took about 2 hours to set up for Vampire, and 1.5 hours to return to CTD operations.

Maximum deployment depth was ~800 m. We had ~1300 m of cable available on the winch drum, and could have deployed deeper if there had been a good scientific justification. However, because Vampire "kites" with the drag on the cable due to the lateral motion of the ship (generally tied to wind-driven ice motion) relative to the deep ocean currents, the amount of line that must be unspooled from the winch is generally greater than the instrument's final depth. Thus, we tentatively estimate a maximum profiling depth of ~1000 m for the present winch cable.

Mechanical Issues

The main technical problem we encountered with Vampire deployment was with the winch drum. This drum was re-engineered from a standard commercial model in order to accommodate more cable (for deeper profiling). However, the drum flanges were not strong enough to support the pressure exerted by the cable during retrieval: as a result, the drum flanges were warped, and subsequently rubbed against the supporting winch frame.

Data Storage

Vampire data are included on the Cruise CD. The data are provided in Matlab format, and are listed as "raw_data" and "processed_level_1". The raw-data files are in counts (digitized voltages and frequencies) as originally recorded directly off Vampire. The process-level_1 files are a quick-look version of data in engineering units. These data require further post-processing, but contain versions of all the signals that are useful to look at. Setup files (*.setup; ASCII text), list basic information about configuration for each deployment.

Each file contains header and data structure arrays (HDR and DATA). See Matlab documentation for how to access contents of structure arrays. HDR data are profile start time, time base (always UTC here) and the limits used for trimming bad data off the start and end of the original data files (using "trim_files.m"). DATA arrays are in two forms, "fast data" and "slow data". For the first two deployments in AnSlope 3, the fast and slow sampling rates were 512 Hz and 64 Hz, respectively. For reasons explained below, these rates were reduced to 256 Hz and 32 Hz for the third deployment. Table 1 shows signals in the DATA structure array. Information in structure arrays is accessed as follows:

```
load A3_001_030.mat;   % load process_level_1 file, giving HDR and DATA
                       %   structure arrays
Pf = DATA.P_fast;      % etc.
```

Variable	**Units**	**Sample rate**	**Description**
Ax, Ay, Az	$m\ s^{-2}$	Fast	3-axis accelerometer
tilt	degrees	Fast	Derived from Ax, Ay, Az
P_fast	Dbar	Fast	Pressure record for fast channels
P_slow	Dbar	Slow	Pressure record for slow channels
W	$m\ s^{-1}$	Fast	Fall speed
Sh1, Sh2	s^{-1}	Fast	Velocity shear from airfoil probes
T_SBE	^{o}C	Slow	SBE-3 temperature
C_SBE		Slow	SBE-4 conductivity
S_SBE	psu	Slow	Salinity from T_SBE and C_SBE
t_f	s	Fast	Time (seconds) for fast channels
t_s	s	Slow	Time (seconds) for slow channels
T1_lo	^{o}C	Fast	FP07 T1 low-resolution
T1_hi	^{o}C	Fast	FP07 T1 pre-emphasized (high-res)
dT1dz	$^{o}C\ m^{-1}$	Fast	FP07 T1 gradient
T2_lo	^{o}C	Fast	FP07 T2 low-resolution
T2_hi	^{o}C	Fast	FP07 T2 pre-emphasized (high-res)
dT2dz	$^{o}C\ m^{-1}$	Fast	FP07 T2 gradient
C_raw [1]		Fast	Raw output for C_dC

[1] Microconductivity not available on AnSlope 3.

Table 1: Parameters sampled by Vampire, and their sampling rate categories.

Results

A total of 60 good profiles were obtained in 3 sessions as described below (see also Table 2, below). One profile is shown in Figure 4. Graphical summaries of all processed_level_1 profiles are on the cruise CD/DVD as *.PNG graphics files.

Deployment 1: Intrusions along the George V Land Coast shelf break

Vampire was deployed for a period of ~20 hours in sea ice over the upper slope in the George V Land region (AnSlope 3, first leg). 22 profiles were obtained in this period. The ship generally drifted with the ice, with one repositioning (after profile A3_001_012) to move the ship up the slope closer to the shelf break. The data set provides information on the turbulence associated with interleaving intrusions of cold shelf water and warm offshore water of CDW origin.

The number of intrusive layers frequently corresponded to the number of high-backscatter layers visible in the 38 kHz Ocean Surveyor vessel-mounted ADCP. There are a few potential explanations for this observation, ranging from the two water types ("shelf" and "offshore") having distinct scatterer populations, to the higher backscatter that is expected theoretically, associated with high variance of high-wavenumber thermal (and hence sound speed) gradients.

Deployment 2: Upper-ocean response after katabatic winds in the Mertz Polynya

Vampire was deployed for a period of ~6 hours in the open water of the coastal polynya along the edge of the Mertz Glacier Tongue. 10 profiles were obtained in this period. The ship used dynamic positioning ("DP") to stay in an exact location and with a consistent orientation to the wind. Deployment was initiated during a period of intense offshore katabatic winds, with speeds of 50-60 knots, and clear visual evidence of rapid surface cooling and ice formation. Unfortunately for our science interests, the wind dropped to ~10 knots during the ~2-h taken to convert the Baltic Room to Vampire use. However, the air temperature remained cold, below -10^{o}C. The data set provides some information on the turbulence energetics of the surface mixed layer under moderate convective conditions, but we were frustrated at being so close to a "katabatic" data set and missing it. Nevertheless, from preceding CTD operations in the harsh conditions, it is clear that the ship is capable of operating (with CTD or Vampire from the Baltic Room) in high-wind, ice-free, high-convection conditions using DP rather than free drift.

Deployment 3: Mixing over the Drygalski Trough sill

Vampire was deployed for a period of ~24 hours in sea ice over the sill at the northern end of the Drygalski Trough. 28 profiles were obtained in this period. Winds were light, and the ship drifted in a rough ellipse presumably driven by ocean tidal currents and perhaps some near-inertial (wind-forced) variability. The data provide information about mixing between an intrusion of Modified Circumpolar Deep Water (MCDW) and the cold surface layer and cold, dense bottom layer. A sample profile from this deployment (A3_002_023) is shown below (Figure 4).

We experienced two problems during this station. First, upon original setup, the data acquisition system reported many "Bad Buffers", symptomatic of noisy or erratic communication with the instrument. After consulting the manufacturer over Iridium phone, we lowered the communication baud rate and instrument sampling rate (the latter from 512 Hz to 256 Hz). This did not solve the problem, and the cause of the signal noise was ultimately determined to be the deck cable leading to the winch. The entire data set was acquired, however, at the lower sampling rate. The second problem was that we accidentally bottom-crashed Vampire after drop A3_002_012, breaking the microstructure sensors. The crash occurred because of the way Vampire is deployed: in order to obtain good data, cable is let out faster than the instrument falls, so that the real-time displayed pressure at Vampire is not a good indication of how deep the instrument will ultimately fall. We need to mark the wire accurately, and also monitor ship-recorded water depth more carefully. Displays of depth from the Bathy-2000 ("BAT") system are in “uncorrected meters”, i.e., based on a sound speed of 1500 m s^{-1}. For accurate approaches towards the seabed, we also need to account for the ~1% difference between depth (in m) and pressure (in dbar).

The data from this deployment show a strong modulation of mixing rates in the MCDW intrusion during the day. Data were collected just after neap tides for this region; nevertheless, it is likely that mixing rates are influenced by variations of the predominantly diurnal tidal currents during the course of a day. We were not able to test the variability in mixing between spring and neap tides, but we take the present data set as indicating that tides are an important contributor to mixing of MCDW intrusions and dense shelf water in the northern trough and over the sill. This is a potentially significant preconditioning mechanism for determining the average volume and density of shelf water exiting the NW Ross Sea troughs.

Acknowledgments

A large number of people contributed to Vampire operations on AnSlope 3. We thank Annie Coward and Jeff Morin (RPSC) for working out the mechanics of how to deploy Vampire from the Baltic Room, and helping to implement the solution. Amy West and Karl Newyear (RPSC) also contributed to converting the Baltic Room between CTD and Vampire use. Alison Criscitiello, Raul Guerrero, Robin Robertson, Sarah Searson and Basil Stanton all helped with Baltic Room Vampire operations. The ship crew’s ability to keep workable space around the Baltic Room is gratefully acknowledged. The name “Vampire” was coined by Robin Robertson just before Halloween.

[L. Padman and L. Mueller]

Table 2: Details of Vampire profiles during AnSlope 3

Profile ID	Date	Time (UTC)	Lat	Lon	File size (bytes)	
Deployment 1: George V Land Shelf Break						
A3_001_010.mat	25-Oct-2004	13:18:34	-65.922	144.602	19289784	
A3_001_011.mat	25-Oct-2004	13:44:52	-65.921	144.606	53301784	
A3_001_012.mat	25-Oct-2004	14:47:58	-65.918	144.616	78382784	
A3_001_013.mat	25-Oct-2004	15:41:20	-65.916	144.624	79766784	
A3_001_014.mat	25-Oct-2004	16:51:04	-65.913	144.635	84837784	
A3_001_015.mat	25-Oct-2004	17:51:54	-65.911	144.643	82993784	
						Moved South 2.5 km,
A3_001_016.mat	25-Oct-2004	21:27:52	-65.935	144.654	66272784	**up-slope towards**
A3_001_017.mat	25-Oct-2004	22:24:42	-65.936	144.659	74017784	**shelf break**
A3_001_018.mat	25-Oct-2004	23:43:30	-65.937	144.661	76313784	
A3_001_019.mat	26-Oct-2004	00:19:38	-65.937	144.661	74017784	
A3_001_020.mat	26-Oct-2004	01:12:54	-65.937	144.660	53792784	
A3_001_022.mat	26-Oct-2004	01:18:34	-65.938	144.660	19161784	
A3_001_023.mat	26-Oct-2004	02:18:48	-65.938	144.656	68280784	
A3_001_025.mat	26-Oct-2004	03:20:46	-65.937	144.650	69509784	
A3_001_027.mat	26-Oct-2004	05:07:34	-65.937	144.614	61323784	
A3_001_028.mat	26-Oct-2004	06:11:34	-65.936	144.599	59888784	
A3_001_029.mat	26-Oct-2004	07:08:18	-65.936	144.582	60821784	
A3_001_030.mat	26-Oct-2004	07:38:44	-65.936	144.573	10981784	
A3_001_031.mat	26-Oct-2004	07:45:16	-65.936	144.570	14427784	
A3_001_032.mat	26-Oct-2004	08:03:46	-65.937	144.564	47645784	
A3_001_033.mat	26-Oct-2004	08:34:52	-65.937	144.553	53362784	
A3_001_034.mat	26-Oct-2004	09:08:28	-65.937	144.539	47901784	
Deployment 2: Mertz Polynya						
A3_001_035.mat	29-Oct-2004	03:44:58	-67.056	145.178	76785032	
A3_001_036.mat	29-Oct-2004	04:21:40	-67.056	145.178	56528024	
A3_001_037.mat	29-Oct-2004	04:51:22	-67.056	145.178	53153888	
A3_001_038.mat	29-Oct-2004	05:22:44	-67.056	145.178	44035288	
A3_001_041.mat	29-Oct-2004	06:36:34	-67.056	145.178	44087104	
A3_001_042.mat	29-Oct-2004	06:58:48	-67.056	145.178	44867392	
A3_001_043.mat	29-Oct-2004	07:29:44	-67.056	145.178	41162040	
A3_001_044.mat	29-Oct-2004	07:52:14	-67.056	145.178	39350512	
A3_001_045.mat	29-Oct-2004	08:14:08	-67.056	145.178	33438408	
A3_001_046.mat	29-Oct-2004	08:44:00	-67.056	145.178	79168568	
Deployment 3: Drygalski Trough Sill						
A3_002_002.mat	22-Nov-2004	19:32:08	-72.216	172.960	15928664	
A3_002_003.mat	22-Nov-2004	20:19:56	-72.222	172.967	27171720	
A3_002_004.mat	22-Nov-2004	21:06:08	-72.229	172.976	22909704	
A3_002_010.mat	22-Nov-2004	22:13:44	-72.234	172.993	27233696	
A3_002_011.mat	22-Nov-2004	23:11:44	-72.238	173.006	27171720	
A3_002_012.mat	22-Nov-2004	23:59:30	-72.240	173.018	26078504	**Bottom-crash**
A3_002_014.mat	23-Nov-2004	01:33:38	-72.248	173.040	26421912	
A3_002_015.mat	23-Nov-2004	02:18:56	-72.251	173.051	29440448	
A3_002_016.mat	23-Nov-2004	03:20:24	-72.255	173.067	29441464	
A3_002_017.mat	23-Nov-2004	04:06:08	-72.255	173.082	25953536	
A3_002_018.mat	23-Nov-2004	04:50:08	-72.255	173.095	27015256	
A3_002_019.mat	23-Nov-2004	05:38:06	-72.257	173.110	28514872	
A3_002_020.mat	23-Nov-2004	06:24:50	-72.257	173.128	26016528	
A3_002_021.mat	23-Nov-2004	07:15:16	-72.255	173.147	32428504	
A3_002_022.mat	23-Nov-2004	08:05:56	-72.254	173.167	28483376	
A3_002_023.mat	23-Nov-2004	08:49:56	-72.251	173.183	26859808	
A3_002_024.mat	23-Nov-2004	09:33:32	-72.248	173.196	25828568	
A3_002_026.mat	23-Nov-2004	10:50:10	-72.240	173.205	27952008	
A3_002_028.mat	23-Nov-2004	11:38:48	-72.236	173.205	27889472	
A3_002_029.mat	23-Nov-2004	12:29:08	-72.231	173.199	28763144	
A3_002_030.mat	23-Nov-2004	13:16:20	-72.228	173.191	29766280	
A3_002_031.mat	23-Nov-2004	14:06:16	-72.227	173.181	28170448	
A3_002_032.mat	23-Nov-2004	14:43:20	-72.227	173.174	27358664	
A3_002_033.mat	23-Nov-2004	15:28:58	-72.228	173.164	26640352	
A3_002_034.mat	23-Nov-2004	16:14:06	-72.230	173.155	26140480	
A3_002_036.mat	23-Nov-2004	17:01:40	-72.235	173.148	26140480	
A3_002_037.mat	23-Nov-2004	17:58:50	-72.241	173.143	28295416	
A3_002_038.mat	23-Nov-2004	19:02:16	-72.248	173.143	29357136	

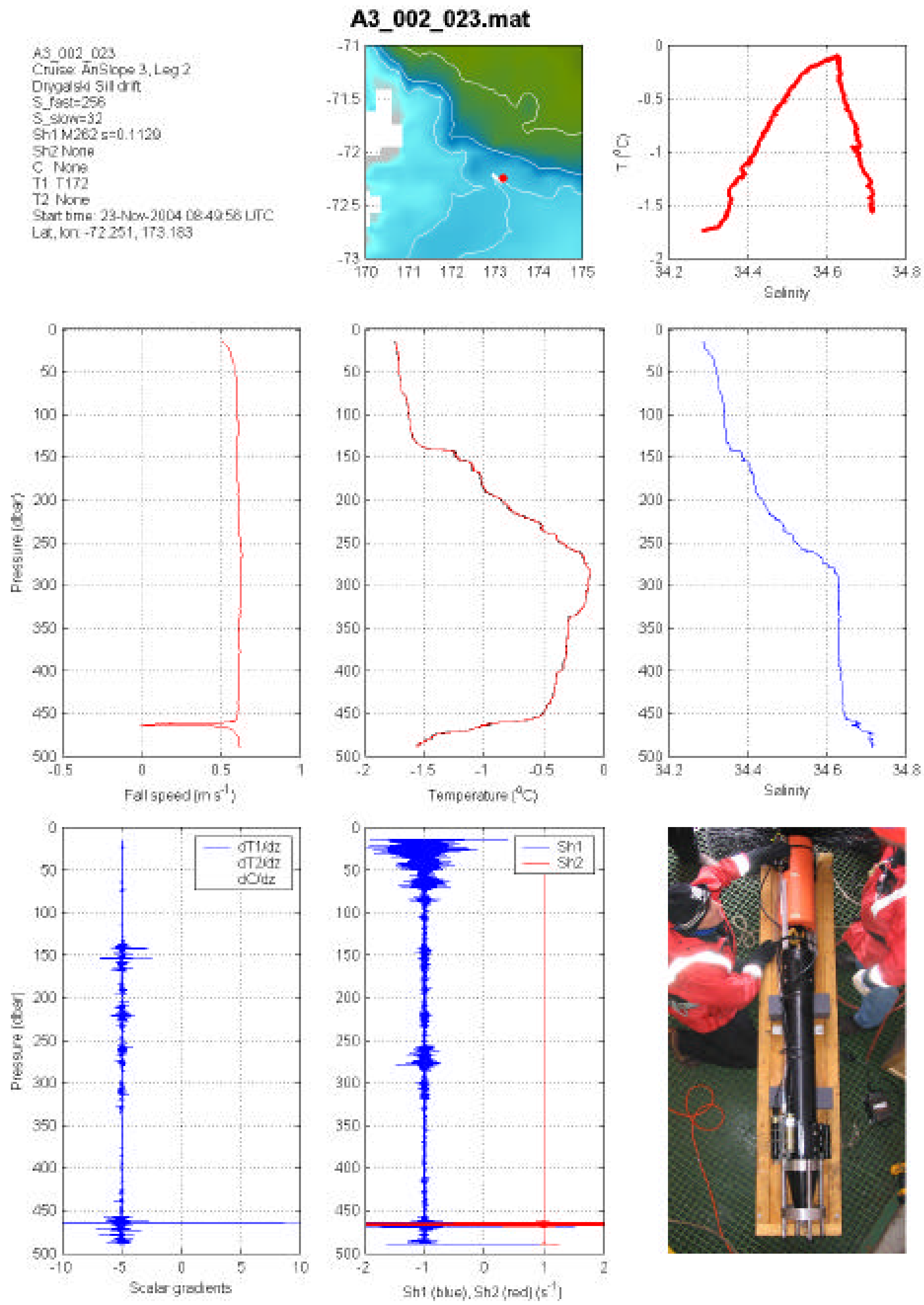

Figure 4: Example Vampire profile from Deployment 3 over the sill at the northern end of the Drygalski Trough. Location is shown as a red dot on the map (upper center). Upper right: T-S relationship from Seabird (CTD-quality) sensors. Middle left: profile of fall speed (m s^{-1}). Middle center: profiles of temperature from SeaBird SBE-3 (blue) and FP07 microstructure sensor (red), which is calibrated against the SBE-3. Middle right: profile of salinity derived from Seabird sensors. Lower left: profile of microscale gradient, ?T/?z, from FP07 thermistor. Lower center: profile of velocity shear, ?u/?z, from airfoil shear probe (only shear-1 installed for this profile). Lower right: photo of Vampire being prepared in the Baltic Room.

2.4 Salinity (Autosal) and T/C Sensor Behavior

In order to monitor the performance of the CTD conductivity sensors, 818 salinity samples were analyzed using the on-board autosals. Autosal SN 59-213 was used for stations 1 to 88 (518 samples), while stations 91 to 142 were measured on Autosal SN 61-670 (300 samples). Both instruments performed within factory specifications, although instrument 59-213 required lowering the flow rate to obtain adequate repeatability. Laboratory temperature control was excellent, remaining 1 to 2ºC below the setting temperature (24ºC). The fan set up on top of one of the salinometers kept the lab temperature vertically homogeneous. Data from the Autosals were captured using the ACI 2000 hard/software package. The connection failed on 3 occasions, but without a clear pattern, we were unable determine the cause. This occurred with both autosals, using the ACI and a home made box (probably from SCRIPP's), and two 50 way ribbon cables. ACI did not reply to email inquiries concerning this problem.

An average of two boxes (48 samples) was measured on each "run" with standardization performed at the beginning and end of each. The standards for calibration came primarily from batch P140 (OSI) from November 2000 (approx. 44 vials) plus three P141 vials from June 2002 and two P143 vials from February 2003, for inter-calibration. On three occasions (Runs 3, 16 & 19), vials from two different batches were used consecutively without finding differences between them. As seen in Table 3, little or no re-standardizing was required between runs. The Standby reading for instrument 213 ranged from 6135 to 6141 while instrument 670 varied from 6067 to 6072. For reference, 5 units change in the Standby readings is equivalent to .00005 CR units or about 0.001 psu.

Errors in salinity resulting from the primary and secondary conductivity sensors were tracked throughout the 142 stations (Figure 5). Salinity errors, denoted DeltaS, are reported as rosette salinity minus CTD salinity. The primary conductivity sensor showed a stable bias from station 1 throughout station 133. Mean Delta S was -0.0015 with a standard deviation of 0.0022. For the estimation of this error, 655 points out of 761 (86 %) were used. Points excluded were greater than 1.5 times the standard deviation of the mean error. The secondary sensor started with a DeltaS ? +0.0075 and decreased down to near 0 around station 50. As this sensor's DeltaS is neither constant nor linear, it may not be as suitable as the primary for final calibration. Both sensors appear to drift from station 134 to 138 and from station 139 to 142 the offsets are constant at much higher DeltaS values (+0.010 for the Primary and +0.0044 for the Secondary).

Run	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
213	6139	6139	6138	6138	6141	6137	6138	6135	6140	6141	6137	6138
Run	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**				
670	6069	6072	6071	6071	6071	6069	6068	6067				

Table 3: Salinometer Standby readings throughout the cruise. Good stability was observed between runs as little or no re-standardizing was needed.

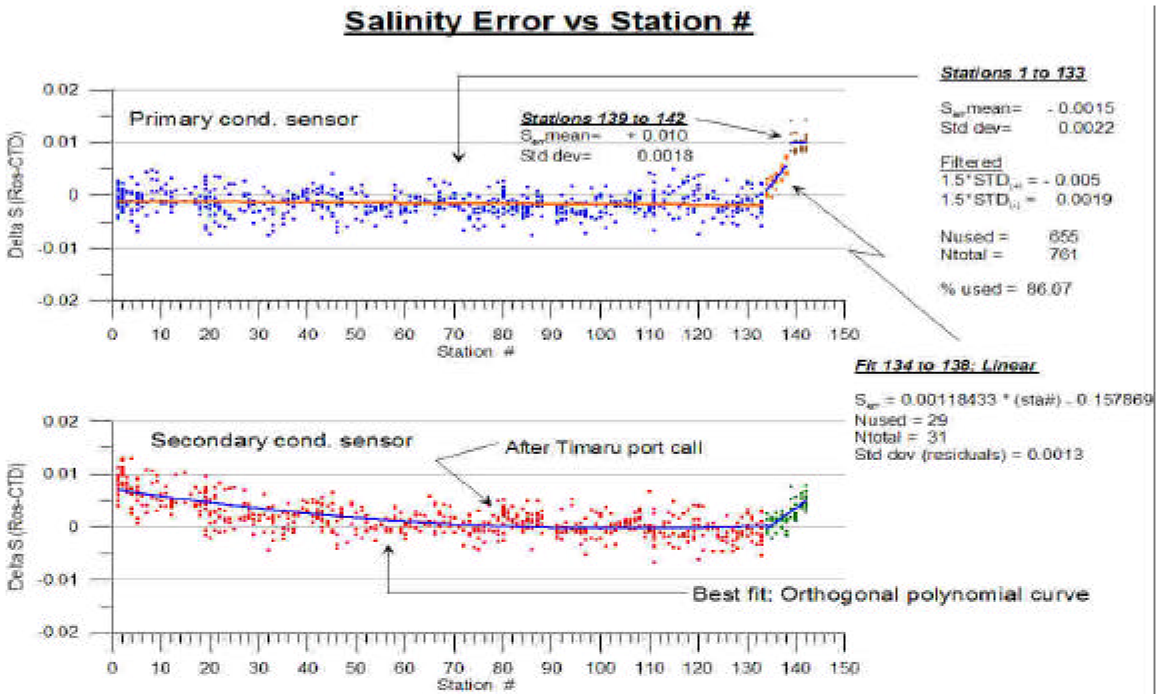

Figure 5: Salinity difference, DeltaS (Rosette-CTD), vs. Station # for primary and secondary conductivity sensors. Curves fit to the primary DeltaS give allow a preliminary estimation of the residuals.

Although the drift in DeltaS values coincided with Autosal run # 19, no problems were observed in the pre- and post-standarizations of the salinometer. Standby readings also showed no significant change relative to prior or subsequent runs. Finally, the rate of change in DeltaS is larger for the primary sensor (change in DeltaS of +0.0115) than for the secondary sensor (where change was less than +0.005), as shown in Figure 5. This differential behavior was also observed in the salinity difference between the primary and secondary sensors (see below). After station 140, the primary conductivity sensor was soaked (for 15 min.) and flushed with a 1% solution of Triton X 100. No subsequent changes in the offset were observed.

Applying a linear correction as a function of 'Sta#' for 134-138 and a constant offset +0.010 for 139-142, the residual has a standard deviation of 0.0022.

Comparison among Primary and Secondary CTD sensors

Differences between the T sensors (Pri-Sec) are constant around -0.001 throughout the cruise. Differences in S between the conductivity sensors are more complicated, and include the following features:

- A gradual drift toward near zero on the secondary sensor from station 1 to 52 (Figure 6).
- A jump (probably in the secondary sensor) between stations 80 and 81, coincident with the Timaru port call, in spite of the fact that both sensors were flushed and kept filled with DI water at that time. The aft dry lab distiller, that provided DI water for the sensors, was out of service. Sensors were flushed after each station only with filtered water.

- The anomalies at station 98 were caused when the primary hose was knocked off when a bottle was fired at 47 db.
- A jump between stations 110 and 111 (not obvious in DeltaS from the bottles) occurred at the time of a VMP station staged from the Baltic room. With the door open, the CTD package was covered and TC sensors were warmed by a heater. However, on this occasion, the TC plumbing was left with filtered water on, the heater was found off and water in the plumbing was slushy.
- Station 111 shows a larger S0-S1 than typical, and a result from tripping bottles while the CTD was underway.

  From station 134 to 138 the difference between primary and secondary drifts, as observed in both sensors when compared against bottle salinities. However, the primary sensor showed a steeper drift than the primary. The cause of this drift is unknown, but could be oil or biological coating/stain on the electrodes that may change their geometry. It could also be a problem within the CTD. SBE technical services might be consulted to check out, which could require factory service.
- From station 139 to 142 the difference between primary and secondary sensors returned to a constant value, but much higher than before. Both sensors then differed from the bottle data by +0.010 and +0.0044, primary and secondary, respectively.

Along XBT sections, thermosalinograph (TSG) salinities were companies with samples drawn from the sea surface water system and analyzed with the Autosal. Out of 111 samples, 109 were used to estimate the preliminary error of the TSG. The error was constant throughout the cruise with a mean value of –0.005 psu and a standard deviation of 0.011 psu. **[Raul Guerrero]**

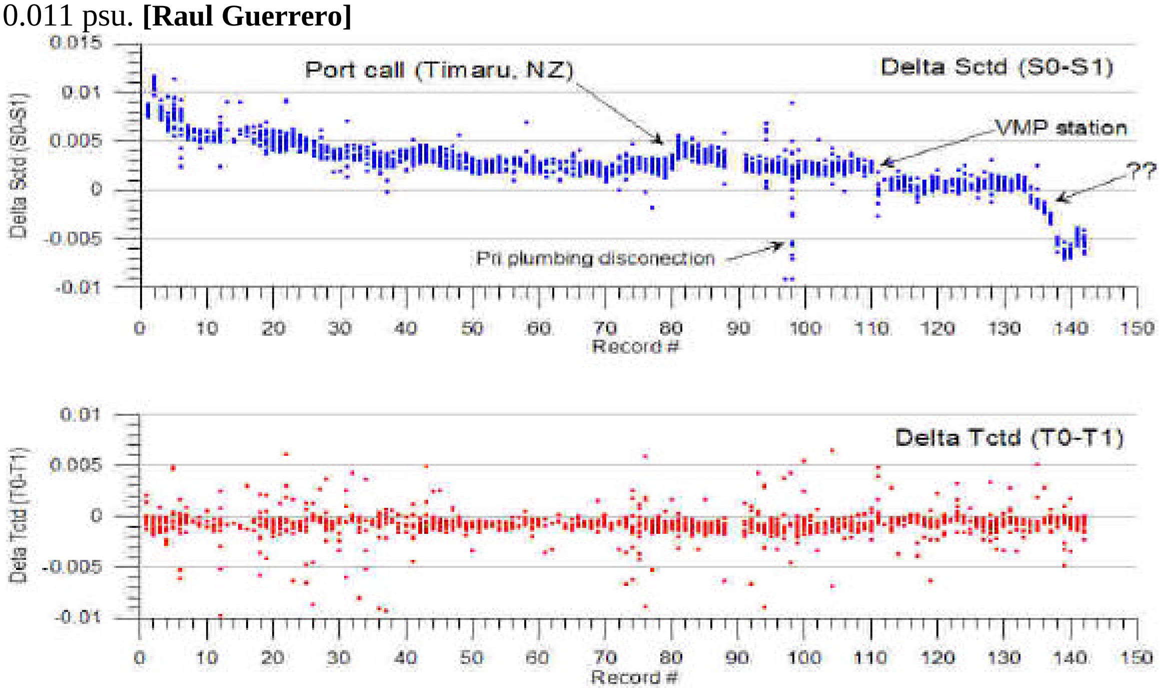

Figure 6: Difference in salinity (S) and temperature (T) between primary and secondary sensors at the time of bottle closing

2.5 Dissolved Oxygen Titration

A SBE43 dissolved oxygen sensor was incorporated in the CTD sensor array. At CTD stations water samples were drawn from selected rosette bottles for dissolved oxygen analysis using the modified Winkler method. Whole bottle samples were titrated using an amperometric titrator designed by Dr. C. Langdon. An RPSC titration unit was used while other laboratory equipment, sample flasks and chemicals were supplied by LDEO.

Titrations were done on 865 CTD samples and 181 surface samples from the 4 Transects between New Zealand and Antarctica. No major problems were encountered with the oxygen analyses. The usual minor problems such as bubbles in the micro burette or sticking of bottle top dispensers occurred occasionally. Initially some difficulty was experienced in getting stable blank determinations and this may have been due to inconsistent performance of the 1 ml standard dispenser. However this eventually settled down and is not thought to have affected O_2 results. Sensitivity analysis of the WHP O_2 equation shows that final accuracy is only very weakly affected by the blank value. Standard determinations showed some variation but these were within the usual accepted range.

Comparison of the rosette O_2 and the primary CTD O_2 sensor data showed that the sensor was reading consistently low. The Delta O_2 (rosette – CTD) at each station (color coded for in situ temperature) are shown in Figure 7. Note that the 3 panels in this figure are plotted with some overlap to show the changes over time. Delta O_2 values were typically in the range 04 - 1.2 ml/l, and the temperature dependence is evident with the largest Delta O_2 values at low temperatures. The figure also shows there were variations with time throughout the cruise. These variations were a slow drift over time interspersed with periods of apparent stability. On occasions there was an apparent abrupt change in O_2 sensor calibration while on station. This occurred at Stations #52 and #98 and accounts for the outliers at these stations. The problems at Station # 98 are covered in the CTD section of the report. Another outlier at Station #124 has been checked and remains unexplained.

Plotting Delta O_2 against CTD Temperature for all data showed the clear decrease in Delta O_2 with increasing temperature up to a temperature of 2.0, with a generally flat response at higher temperatures. The All Data plot showed a large spread but suggested that a simple temperature correction could be found by taking stations in similar groups suggested by Figure 7. Figure 8 are plots of Delta O_2 against temperature for all 142 Stations in 8 groups. For each plot a least squares straight line has been fitted for the data at temperatures below 2^o C. The straight line parameters and Root Mean Square deviations of Delta O_2 from the straight line are given for each panel. We believe these parameters should be used in the final post processing of the CTD O_2 data.

An additional SBE43 sensor was installed on the CTD at Station #88, as a secondary while retaining the original primary sensor. Comparison of these sensors showed a mean difference of 0.336 ml/l, with the secondary sensor reading higher than the primary sensor. Consequently the secondary sensor values were closer to the rosette data. The standard deviation between the primary and secondary sensors was 0.094 ml/l. The Delta O_2 (rosette-secondary sensor) exhibited a similar tendency to the primary sensor with higher values of Delta O_2 at the low temperatures. These Delta O_2 data are shown in Figure 9a with a fitted straight line as was done for the primary sensor. After removal of the temperature effect, Figure 9b shows a quadratic curve fitted to the residuals to remove the pressure dependence, while Figure 9c shows the residual Delta O2 after removal of both temperature and pressure trends. It can be seen that the remaining variation is very small with a standard deviation of 0.039 ml/l.

The surface water samples on the four transects (see Figure 10) between New Zealand and Antarctica were drawn from the thermosalinograph sea water system in the wet lab. Some problems were experienced with fine air bubbles in the water flow and as a result extra care was needed in taking these samples. Even then on occasion, fine air bubbles could form (presumably from out gassing) within the flask during the interval between sampling and titration. When this occurred appropriate comments were added to the log sheets. **[Basil Stanton]**

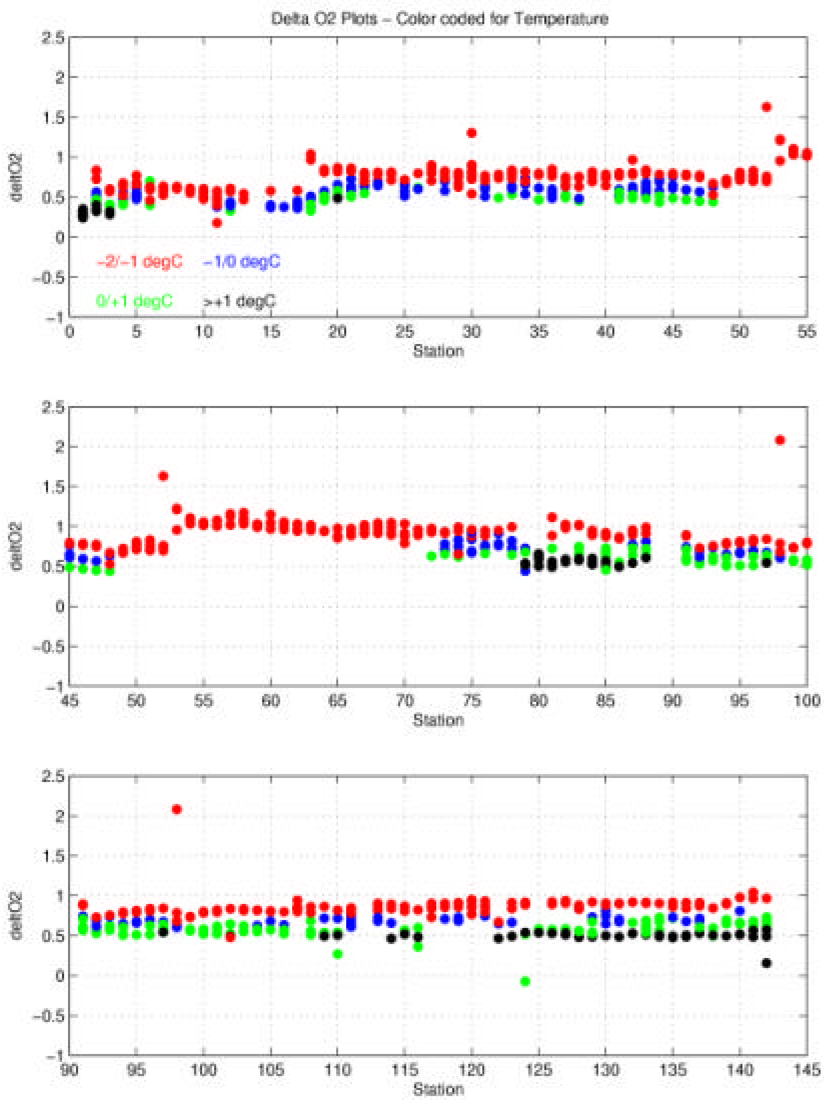

Figure 7: Difference between titrated and CTD-measured dissolved oxygen. The color of the dots indicates the temperature.

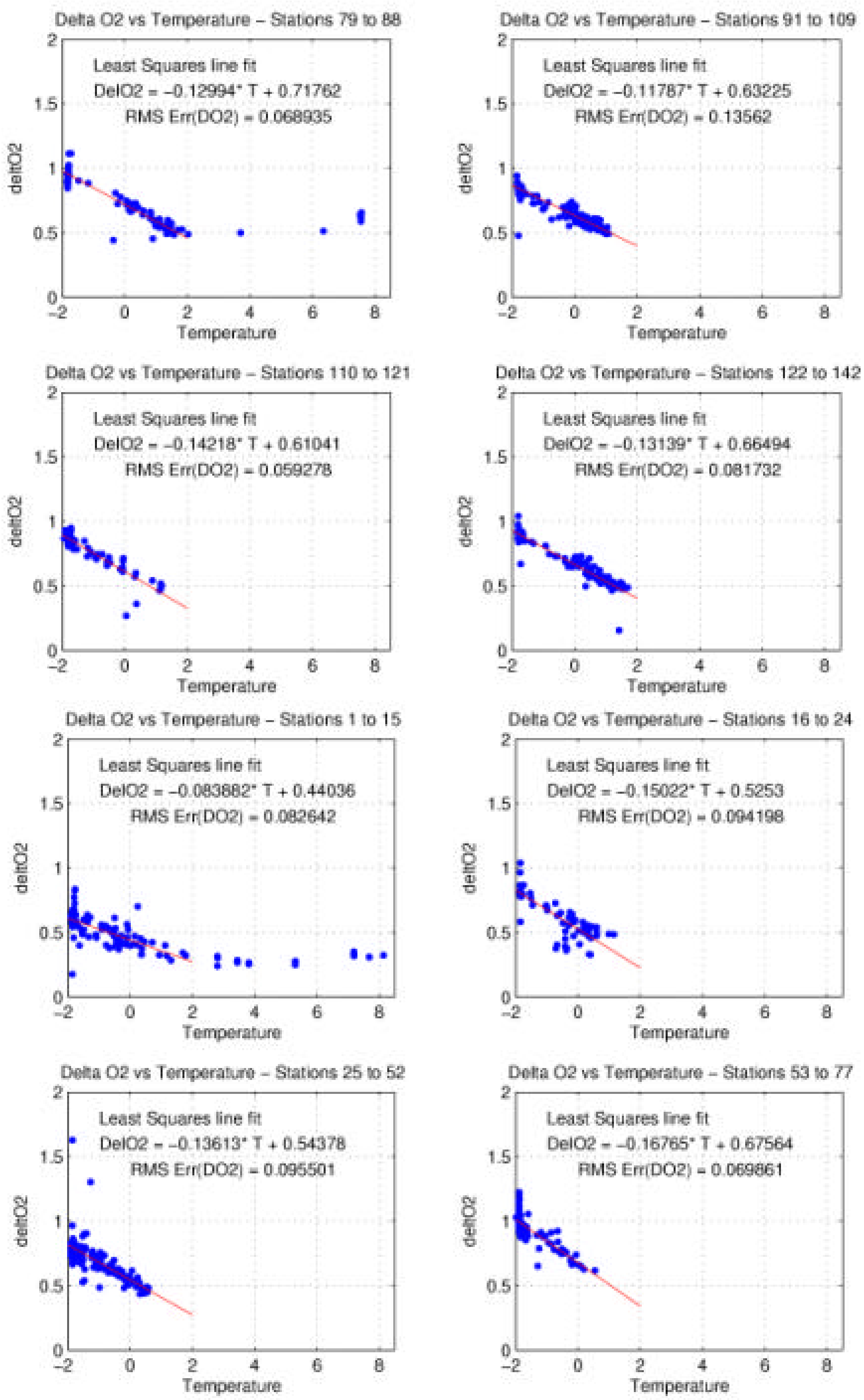

Figure 8: Temperature dependency of the dissolved oxygen deviation between CTD sensor and titrated measurements.

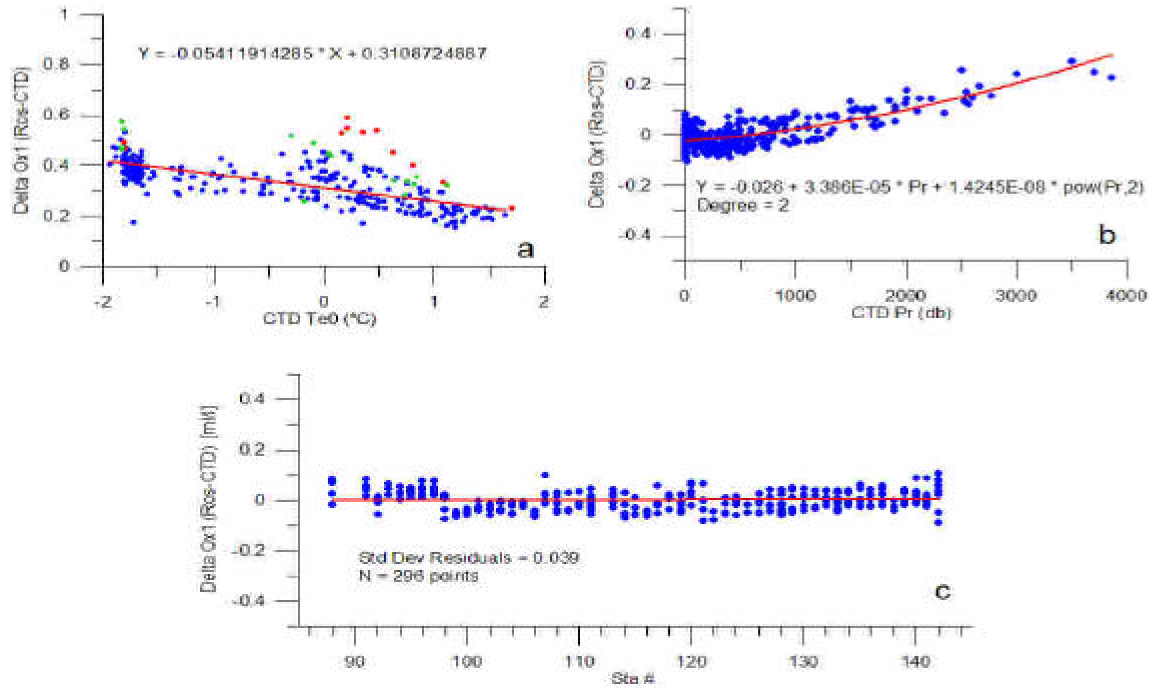

Figure 9: Delta O2 variation for the secondary O_2 sensor.

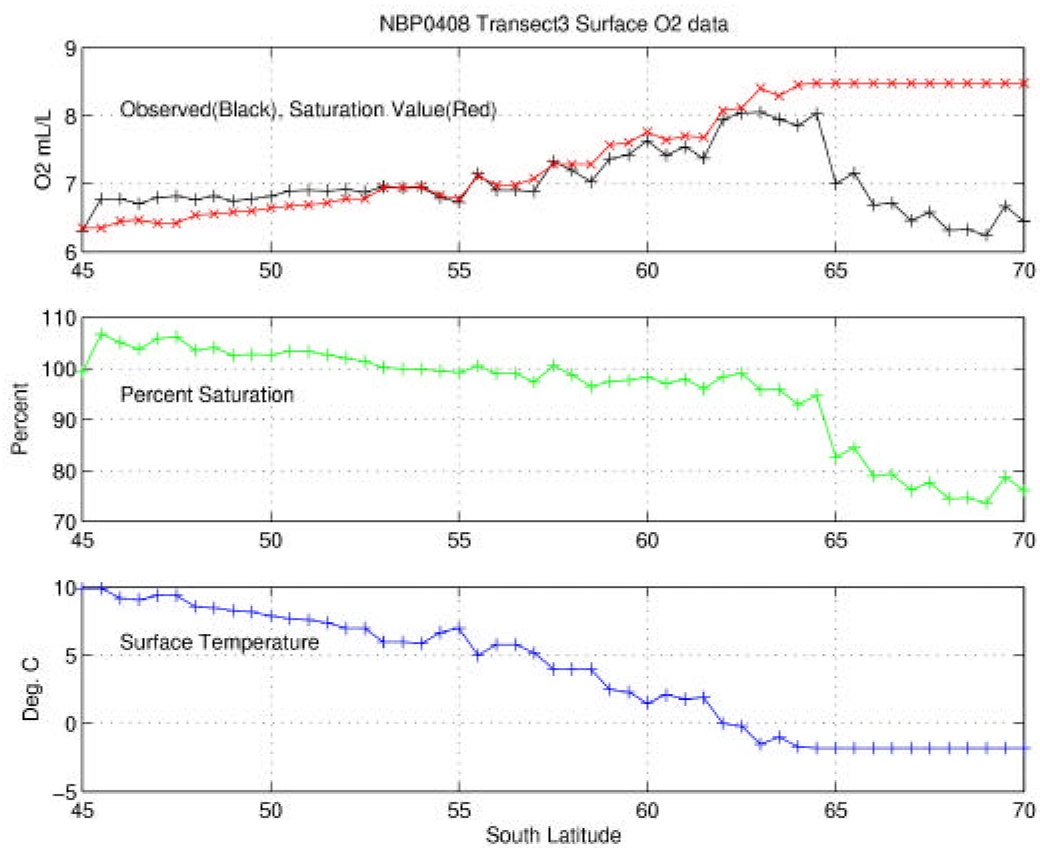

Figure 10: Titrated dissolved oxygen content on XBT transect 3.

2.6 CFC-Sampling

Water sampling

Water samples were collected using 10-l Niskin-type bottles with coated internal springs and baked o-rings. CFC samples were the first samples taken and were drawn into 100-ml precision ground glass syringes. The syringes were capped with stainless steel Luerlock caps and stored in a sink filled with uncontaminated surface seawater. Tension was maintained on the syringe plunger with rubber bands and the samples were analyzed within 12 hours of collection, typically less. For most of the cruise, the water bath temperatures were less than -1.0C, which ameliorated any potential degassing during sample storage.

Sampling from the uncontaminated seawater line

Water samples were collected on all four transits between New Zealand and the ice. On the first two transits, samples were collected every two hours; on the second two transits every 30^o of latitude. Sampling was simply a matter of inserting the tip of the syringe into the length of Tygon tubing providing flow to the syringe water bath and following standard rinse and storage procedures. Data quality statistics (see Data Quality section) were not significantly different from samples drawn from the rosette.

Water sample analysis

From the syringes, the water samples were injected through a three-way valve into a calibrated glass volume (approximately 35 cc, calibrated to better than 0.1%). The three-way valve and the calibrated volume were flushed with sample water prior to taking the aliquot for analysis.

The water in the calibrated volume was subsequently transferred to a glass stripper chamber where the dissolved gases were purged with ultra high purity nitrogen, which was also used as the gas chromatograph carrier gas. The released CFCs were concentrated by adsorption on a unibeads 2S cold trap at –70°C. Subsequently the trap was isolated and heated to 100°C. The desorbed gases were then backflushed into the chromatographic columns using ultra pure nitrogen. Cooling was accomplished with liquid CO_2 and heating was done electronically. The entire stripping, trapping and GC analysis procedure was automated with a Shimadzu Chromatopac C-R8A used to control the sequential steps of the procedure.

Air sample collection and analysis

Air samples were drawn from an interface with the ship's on-board pCO2 measurement system. Aliquots of air taken from this line for CFC analysis were passed through magnesium perchlorate to remove water vapor, isolated in a calibrated sample loop, and then analyzed in the same way as standard gases (see section on calibration). Samples were only collected when the wind direction was from the bow to avoid contamination with the ship’s atmosphere.

Gas chromatography

The CFC analysis system consisted of a Lamont-built purge and trap system interfaced to a HP 6890 gas chromatograph which contained a precolumn (stainless steel, 3 foot length, 0.085 inch ID packed with 80-100 mesh Porasil B) and a main column (stainless steel 5 foot length, 0.085 inch ID packed with 60-80 mesh Carbograph 1AC) mounted in the GC oven and maintained at a constant temperature of 90°C. The main column was followed by a 0.085 inch ID, 4 inch long stainless steel column packed with 80-100 mesh mol sieve 5A. This was mounted outside the GC oven and maintained at 50°C. Its purpose was to separate CFC-12 from N_2O and it was valved out of the gas stream after CFC-12 eluted. The detector was operated at 260°C. The chromatographic run required 8 minutes and the total analysis time was 10 minutes per sample.

CALIBRATION

Procedure

The response of the electron capture detector to different amounts of CFCs was calibrated by filling 10 different sized calibrated loops attached to a multiport valve with a gas mixture (CFCs in nitrogen) of known CFC content. Loops were filled individually and after relaxation to ambient temperature and pressure, the standard gas was concentrated onto the cold trap and subsequently injected into the gas chromatograph by the same procedure used for water samples. Calibration curves were run approximately once a week during the course of the cruise and one of the standard volume loops was run frequently (at least every other hour) to check for drifts in the detector's response between calibration curves.

Standard

Lamont standard 842 was used on this cruise. It was calibrated before and after the cruise against an air standard (Lamont standard 35078) that had been analyzed at R. Weiss' laboratory. The CFC concentrations on the SIO98 scale for this standard are:

CFC-11:	387.83 pptv
CFC-12:	200.49 pptv
CFC-113:	105.82 pptv

PROBLEMS

A high CFC-11 stripper blank (-0.078 t 0.369 pmol/kg, averaging 0.003 pmol/kg) persisted for most of the cruise. We believe this is due to a small secondary peak overlapping with the CFC-11 peak, and post-cruise corrections will be made on shore.

DATA QUALITY

Stripping efficiency

Stripping efficiencies were measured approximately every day throughout the cruise. The overall averages were 99.8% for CFC-11, 99.7% for CFC-12 and 99.3% for CFC-113. The efficiencies for CFC-12 and CFC-113 would be expected to be higher than CFC-11 because of their lower solubility. However, the CFC-12 and CFC-113 concentrations were lower than the CFC-11 concentration for the samples used in these determinations and thus are more sensitive to small uncertainties in blanks. We do not believe the stripping efficiency is less for CFCs 12 and 113 than for CFC-11 and a correction has not been made for stripping efficiency for any of the CFCs.

Blanks

System and stripper blanks were measured for every 6-8 water samples that were run and are presented in Tables 4 and 5. The stripper blanks averaged about 0.003, 0.007, and 0.010 pmol/kg for CFCs 11, 12, and 113 respectively. Blank corrections were made by interpolating between blank determinations made before and after a given analysis, and variability in blanks had little effect on the data quality.

Rosette bottle/sampling blanks could not be determined for this cruise because CFC-free water was not sampled. In cruises where we have been able to determine such blanks, they have been in the range of 0.002 to 0.005 pmol/kg. We have not applied a correction for bottle/sampling blank to this data set.

Precision

The precision of the measurements was monitored throughout the cruise by making replicate measurements. For atmospheric measurements, 3-6 replicates were measured at each location. For water measurements duplicate samples were collected at most stations.

The average precisions of the atmospheric measurements were 1.26%, 1.42%, and 2.44% for CFCs 11, 12 and 113 respectively. Mean mole fractions were 251.7 ppt, 537.66, and 79.88 ppt.

The average differences between duplicates with CFC-11 concentrations greater than 1 pmol/kg were 1.2% for CFC-11, 0.5% for CFC-12, and 1.7% for CFC-113. The average differences for concentrations less than 1 pmol/kg were 0.007 pmol/kg for CFC-11, 0.003 pmol/kg for CFC-12, and 0.003 pmol/kg for CFC-113.

Duplicates were drawn on approximately 80% of the samples taken from the uncontaminated seawater line. The average reproducibility was 1.1%, 0.7%, and 1.7% for CFC-11, CFC-12, and CFC-13, respectively.

RESULTS

Underway Measurements

We compared samples drawn from the surface bottle (~3 m) from six stations with water drawn from the uncontaminated seawater supply (~7 m) when the CTD was at the surface at the end of the cast (Table 4). The average difference was 2.23%, 1.26%, and 1.01% for CFC-11, CFC-12, and CFC-113, respectively. These differences are only slightly larger than the average precisions for Leg I, during which the comparisons were made. This suggests that underway measurements for CFCs can provide useful information, assuming an uncontaminated seawater supply of the same quality as the Palmer's.

We completed four transects between New Zealand and 65-70^{o}S. The four transects reflect a change from late winter to early spring conditions, with the southern ends of

	CFC-11 (pmol/kg)	CFC-12 (pmol/kg)	CFC-113 (pmol/kg)	CFC-11 Difference (pmol/kg)	CFC-12 Difference (pmol/kg)	CFC-113 Difference (pmol/kg)
Underway	5.492	2.994	0.540	-	-	-
Station 2	5.402	2.923	0.527	1.67	2.43	2.47
Underway	4.997	2.709	0.490	-	-	-
Station 3	4.885	2.687	0.489	2.29	0.82	0.20
Underway	4.469	2.522	0.418	-	-	-
Station 30	4.348	2.468	0.415	2.78	2.19	0.72
Underway	4.675	2.542	0.445	-	-	-
Station 46	4.492	2.504	0.441	4.07	1.52	0.91
Underway	4.600	2.548	0.444	-	-	-
Station 47	4.667	2.557	0.452	1.44	0.35	1.77
Underway	4.662	2.566	0.439	-	-	-
Station 57	4.611	2.572	0.439	1.11	0.23	0

Table 4 CFC concentrations for six pairs of stations where both surface rosette and underway samples were collected together and the differences in concentrations between the samples

Transects 1 and 2 occurring off George V Land and those of Transects 3 and 4 in the Ross Sea.

Concentrations at 7 m (Figure 11) typically reflect the thermal structure. Variations are more weakly correlated with salinity variations, as expected from the solubility function for CFCs (Warner and Weiss, 1985). This initially confirmed the plausibility of the measurements. Highest concentrations were observed between 60^{o}S and 65^{o}S (Figure 11), reflecting a balance between decreasing surface temperatures and ice cover slowing gas exchange.

On all four transects, saturations decline essentially monotonically between 57^{o}S and 65^{o}S (Figure 11). Supersaturations were observed north of about 47^{o}S and are probably due to warming of the surface waters. On Transects 1 and 2 saturations rose to a maximum at the thermal front at 57^{o}S and decreased again to the south. On Transect 3, no thermal front was observed, with no associated increase in saturations. Saturations also dropped markedly south of 65^{o}S on the last two transects, where we observed heavy ice cover.

Saturations of CFC-12 are typically about 3% higher than CFC-11 and about 9% higher than CFC-113 (Figure 11). This likely reflects differences in gas exchange rates, which depend on the molecular weight of the species. **[Deborah LeBel]**

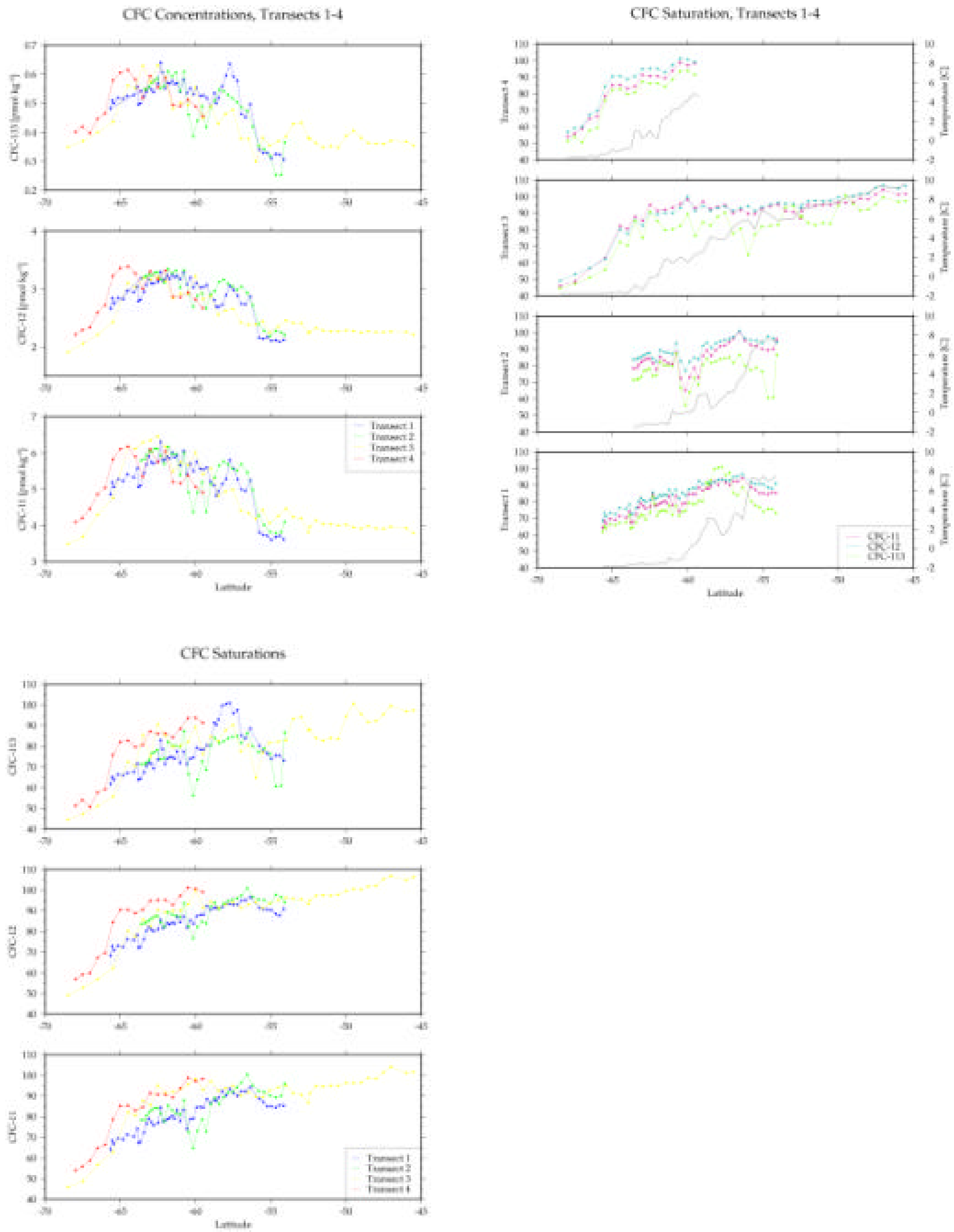

Figure 11. CFC concentrations and saturations for the three species along the XBT transects.

2.7 Transient Tracers (He, Tritium, O-18)

Stations with indications of possible meltwater were sampled for He, Tritium and ^{18}O. On some other stations, only ^{18}O was sampled, mainly near the surface and seafloor. Samples were drawn by A. Criscitiello and G. Krahmann according to the sampling procedures provided. 48 He channels, 48 Tritium bottles and 147 ^{18}O bottles were filled from CTD/rosette casts and 162 ^{18}O samples were taken underway near the sea surface from the onboard sea water lines. The tracer samples will be analyzed at LDEO. **[Alison Criscitiello]**

2.8 Nutrient Sampling and Analysis

Approximately 1400 nutrient samples were drawn and processed aboard the ship. About 1150 seawater samples were taken from Niskin bottles on all CTD/rosette stations, the remainder were taken from the ship underway system during the four XBT transects between Antarctica and New Zealand (Table 6).

	No. Samples	**Date**
Underway 1	108	15-20 October 04
Underway 2	67	1-4 November 04
Underway 3	45	7-15 November 04
Underway 4	72	30 November – 5 December 04
CTD George C Land area	595	20-31 October 04
CTD Ross Sea	572	12-30 November 04
Tot.	1459	**57 days**

Table 6. Number of nutrient samples collected during AnSlope-3.

Material and methods:

Seawater samples were filtered using GF/F Whatman filters (0.7 ?m) and immediately stored at -80°C until analysis. Samples were unfrozen using a warm water bath (35-40°C) in order to bring them to room temperature immediately prior to analysis.

Analyses were carried out using an Autoanalyzer TRAACS 800, according to the colorimetric method suggested by Strickland & Parsons (1972).

The determination of nitrate and nitrite uses the procedure whereby nitrate is reduced in nitrite at pH 8 in a copper-cadmium redactor. The nitrite then reacts under acidic conditions with sulphanilamide to form a diazo compound that then couples with naftileliendiamina hydrochloride (NEDD) to form a reddish-purple azo dye that is measured at 550 nm.

The determination of soluble silicate is based on the reduction of a silico molybdate compound in acid solution to molybdenum blue by ascorbic acid. Oxalic acid is introduced to the sample to minimize interferences of phosphate. The absorbance is measured at 660 nm.

The determination of phosphate is based on the colorimetric method in which a blue compound is formed by the reaction of phosphate, molybdate and antimony followed by reduction with ascorbic acid. The reduced blue-phospho- molybdenum complex is read at 880 nm.

Data processing software AACE, designed by Bran and Luebbe, was used during analysis and allowed us to check standard quality.

Duplicate analyses, involving samples stored with different methods (described below), were taken at some stations in order to check whether nutrients (in particular, silicate) were adversely impacted by freezing. In fact, it is well known that a correct sample storage is particularly important for silicate determination when silicate content is higher than 50 ?M, as in the case of Southern Ocean water masses. Silicon tends to polymerize when stored frozen and samples must be allowed to stand at room temperature before analysis. Tests carried on 55 samples showed that there is not any significant difference among concentrations found in samples analyzed just after sampling and after frozen storage (differences are < 5%, so very close to method precision), showing that no systematic error was made. In addition, a small set of samples (15) were stored in dark, cold conditions (+4°C) for 5 days before analysis. The concentrations for these samples are very similar to the ones obtained for those stored in the two previously described ways.

Furthermore, we checked our standard solutions with some other standards made up for intercomparison purposes.

During the cruise a quality problem with one of the Nanopure systems was detected in the nitrite and phosphate analyses. The use of Low Nutrient Sea Water (LNSW), brought on board at the refuelling stop in Timaru, allowed us to run nitrite samples on board. But problems in phosphate analysis persisted even using LNSW. Reagent tests and standard intercomparison did not reveal any analytical faults and in addition, phosphate analysis results were very sensitive to the ship movements. Since this kind of problem persisted during the whole cruise, it was decided to process these samples in Italy. Samples of the standard solutions prepared on board will be shipped to Italy together with the phosphate samples in order to control the data quality. Furthermore, about 70 samples were collected from CTD stations at different depths and from the underway system and they were frozen (-80°C) just after sampling. These samples, together with standard solutions run on board, will be processed in Italy using a five-channel Autoanalyzer Technicon II. Results will be compared with the ones obtained on board for intercomparison purposes and will be used for more sample storage tests.

Analysis of the last samples taken from underway system during the 4th XBT transect will be finish on board at the end of the transect if sea conditions permit, otherwise samples will be analysed in Italy.

Results:

Leg I – George V Land Coast

Measurements in the George V Land Coast area were carried out in early spring (2nd half of October). During this period in the shelf area, the water column exhibited only small ranges of temperature, salinity and nutrients, suggesting that the water column was well mixed. In fact no vertical trend can be identified in nutrient concentrations, which range from 70 to 90 ?M and from 25 to 29 ?M for silicate and nitrate respectively.

In the surface layer low temperature and relatively high salinity indicate that the melting process is not pronounced, and as a result nutrient concentrations are relatively high at 69.1 ±10.5 ?M for silicate and 26.8±2.2 ?M for nitrate.

At the slope area we can observe the CDW intrusion on to the shelf at depths greater than 200 m. This water mass can be identified not only from its physical characteristics,

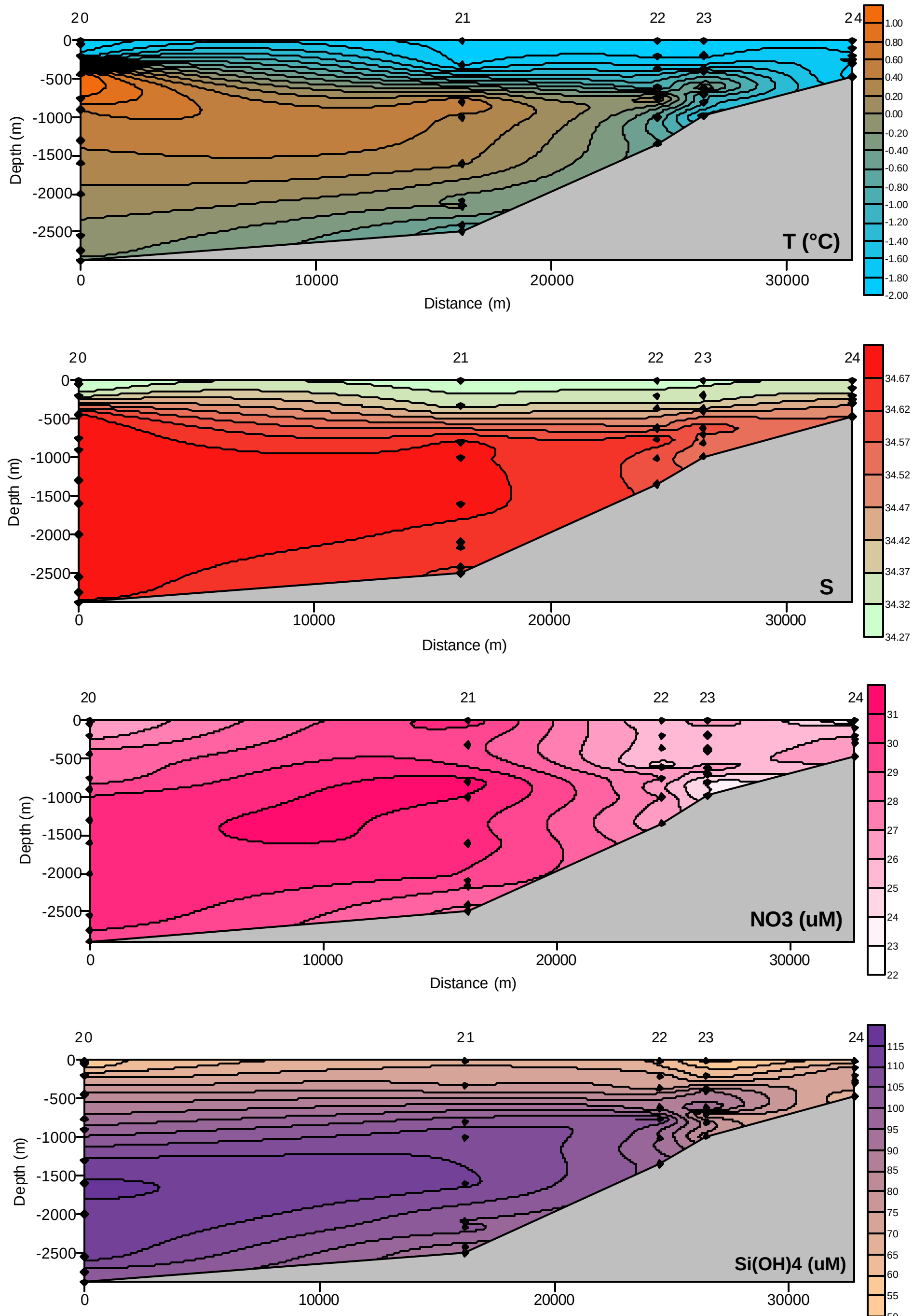

Figure 12. Temperature, salinity, nitrate and silicate vertical profile in section 20-24 (George V Land coast).

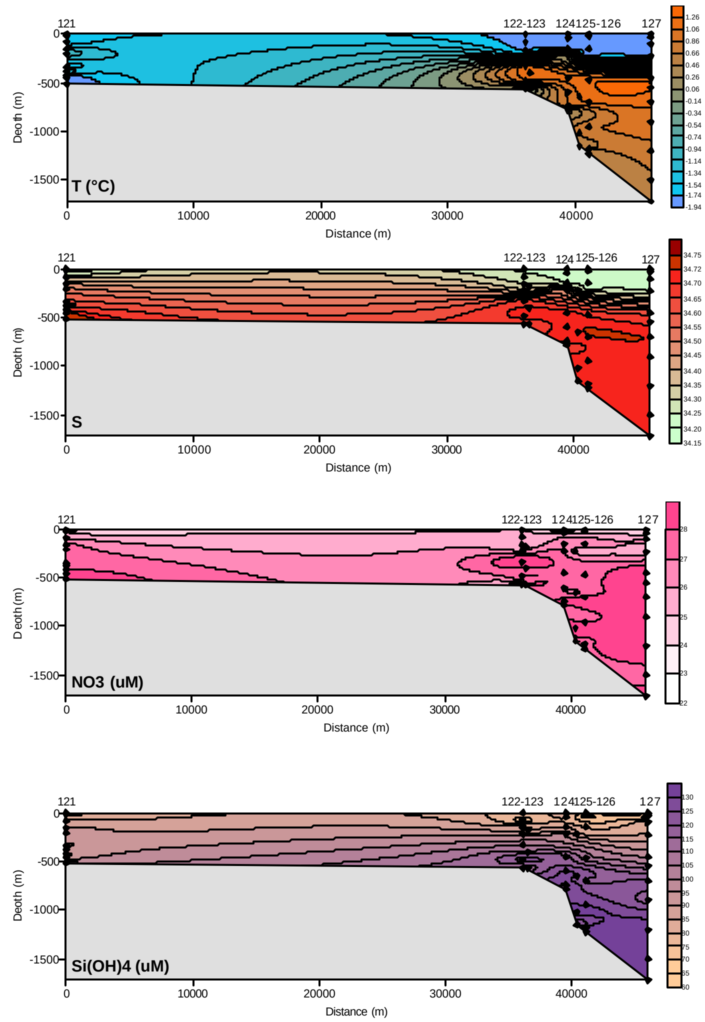

Figure 13. Vertical profiles of temperature (°C), salinity, nitrate (?M) and silicate (?M) in casts 121-127 (Ross Sea).

but it can be traced also by high nutrient concentrations. In particular, silicate is a good tracer for this water mass ,which is characterized by concentrations ranging between 80 ?M and 127 ?M (99.3±11.3 ?M as mean value), but the silicate maximum can often be found a few hundred meters below the temperature maximum, as already observed by other authors (Gordon *et al.*, 2000). Nitrate shows a distribution more homogeneous than silicate also in the slope area, with the highest values (about 30 ?M) coincident with the temperature maximum. “NO“ mean level of 473±22 ?M was calculated for CDW at the temperature maximum; this value falls in the same range as those calculated for the Weddell Sea (Lindegren&Anderson, 1991)

As an example, Figure 12 shows vertical profiles of temperature (°C), salinity, nitrate (?M) and silicate (?M) in section 20-24, across the slope. Bottom concentrations, both for nitrate and silicate, are slightly lower than those found at the temperature maximum, showing a possible influence of shelf water overflow, which agrees with the temperatures below 0°C.

Comparing our data with results obtained during a previous cruise carried out in the same area in austral summer (end December 2000- mid January 2001) (Jacobs et al., 2005), we can see that, as a consequence of the heating and melting processes and the biological activity, surface nutrient concentrations in summer are lower than concentration found during this survey. Moreover, during the previous survey nitrate concentrations found in the MCDW core are a little higher than our data.

<u>Leg II - Ross Sea</u>

Measurements in the Ross Sea area were carried out in the spring period (second half of November), about 20 days later than the previous measurements in the George V Land area.

The shelf area surface layer was a little warmer and fresher, suggesting the beginning of an increase in solar radiation and dilution by melting of sea ice. In this condition nutrient concentrations were still high in the surface layer (77.1±9.3 ?M for silicate and 25.8±2.7?M for nitrate) and nearly constant with depth. At some stations the nutrient minimum was not associated with the surface layer but it could be found around 40-80 m depth (e.g. stations 94, 99, 103, 109, 126, 127). Moreover, results showed that surface nutrient minima could be found in correspondence with fresher water (for example, in station 124, 126 and 127, shown in Figure 13).

In the slope area, we observed the intrusion of CDW on to the shelf and its mixing with shelf waters, more intense in the area off Cape Adare and along 175°W.

As an example, Figure 13 displays vertical profiles of temperature (°C), salinity, nitrate (?M) and silicate (?M) found in section 121-127.

CDW intrusion can be traced by nutrient high concentrations, which are around 29 ?M for nitrate and around 110 ?M for silicate. As already observed in the George V region, silicate traces better than nitrate the intrusion of CDW. In fact, nitrate is characterized by a more homogeneous vertical profile. In many cases silicate maxima were observed near the bottom (concentration increase toward the bottom by 10-15 ?M), indicating dissolution of silica at the interface water-sediments. “NO” levels found at the temperature maximum (460±27?M) are very close to the ones reported for the same area (Rivaro et al., 2003).

At some stations on the shelf (i.e. station 121) the presence of ISW, was indicated by a temperature minimum near the bottom (about 500 m depth). This water mass is characterized by nitrate concentrations of 29-31 ?M and silicate concentrations around 80-90 ?M.

Comparing our results with data collected in the same area during the austral summer (February 2003) by CLIMA project, we can observe some significant differences concerning the surface layer.

During summer meltwater dilution and warming of surface waters are at their maximum. In fact, temperature and salinity (-1.43°C; 33.88) are significantly lower than the spring values. Moreover, summer surface nutrient concentrations were lower (21 ?M for nitrate and 60 ?M for silicate, as mean values) than spring data obtained during this cruise and the nutrient vertical profile is characterized by a stronger vertical stratification.

XBT transects- underway sampling

Surface samples were collected from the underway system during 4 XBT transects from New Zealand to Antarctica and vice versa.

Underway samples revealed a sharp increase in nutrient concentrations, in particular for silicate, from 58°S to 60°S, coincident with a strong decrease in temperature. Nitrite concentrations were undetectable (< 0.02 ?M) in nearly all samples, but when they are detectable they show an inverse trend compared to the other nutrients, decreasing from north to south.

As an example, Figure 14 displays the XBT 1 section (15th to 20th October), in which the sharp increasing in silicate concentrations (from 10-15 ?M to 50-55 ?M) and the strong decreasing in temperature can be observed from 58° S to 60° S. Nitrate instead increased more regularly moving from north to south, with concentrations ranging from 10-12 ?M at 54° S to 25-30 ?M at 66° S, as shown in Figure 15. The same trend was observed in the XBT 2 (1st to 3rd November) and XBT 3 (7th to 15th November) transects. During the XBT 3 transect the increasing in silicate concentrations were particularly sharp from 60° S to 64° S. These results fall in the same ranges as those measured by other authors (Brzezinski et al., 2003). XBT 4 transect sample analyses are still in progress. In order to obtain a more robust dataset about seasonal evolution of surface nutrient concentration from New Zealand to Antarctica, we plan to analyze nutrients in seawater samples collected during XBT transects which will be made during the Italian-Antarctic survey at the beginning of January 2005 and at the end of February 2005.

[Serena Massolo and Alessandra Campanelli]

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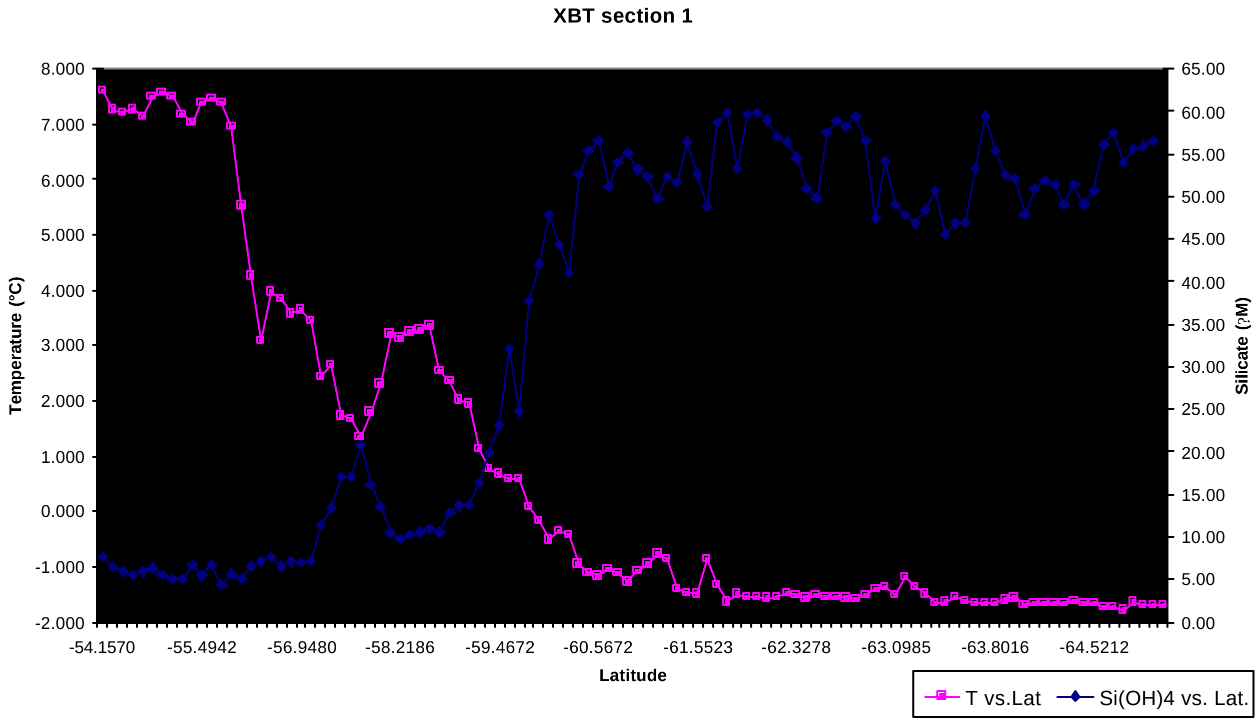

Figure 14. Temperature and silicate concentration versus latitude in XBT section 1 (15-20 October).

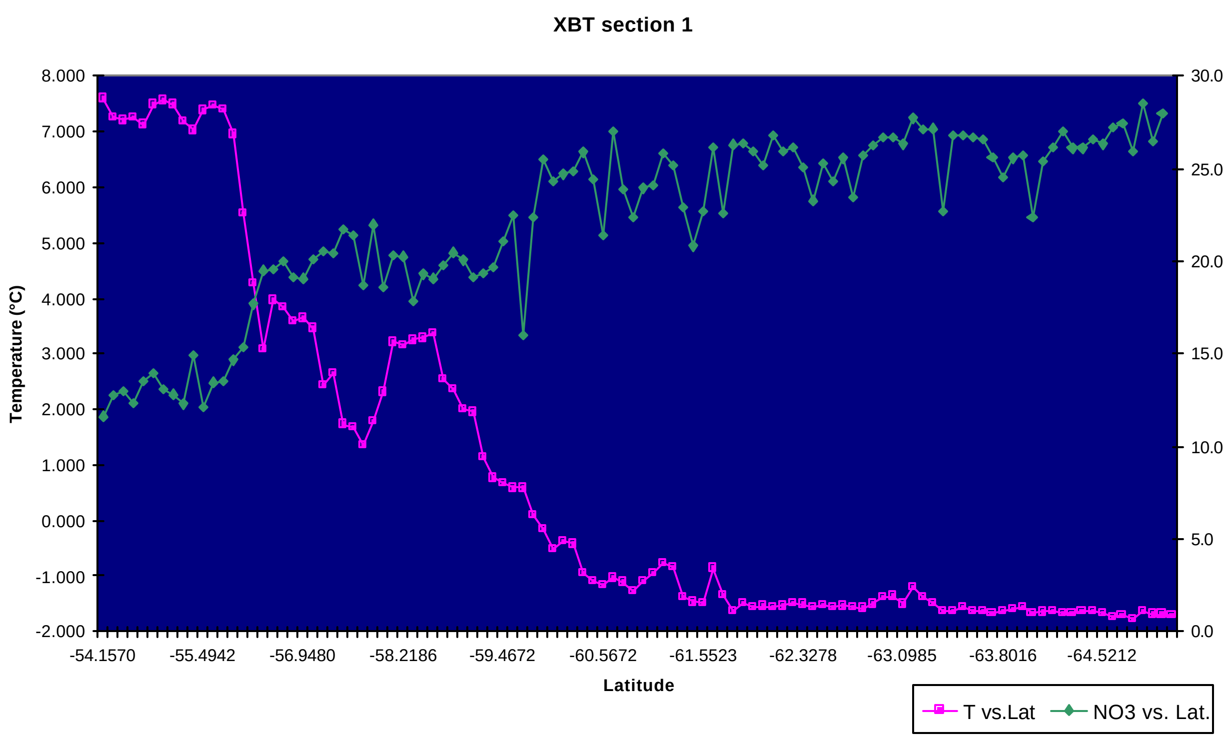

Figure 15. Temperature and nitrate concentration versus latitude in XBT section 1 (15-20 October).

2.9 XBT Transit and Underway Measurements

Since A-3 was ordained to make four crossings of the Antarctic Circumpolar Current in order to obtain a few weeks time over the continental slope and shelf, we utilized the otherwise idle time to conduct an enhanced underway sampling program. While some of our transits were along routes that have been profiled since the IGY, such work has less commonly been done this early in 'the season'. XBTs extend the surface temperature record to depths of several hundred meters and reveal the positions and structures of the Polar, Subantarctic and other frontal features. It is also of interest to know whether the properties of near-surface waters are changing over time, since they help to set the characteristics of Antarctic Intermediate Water, which spreads far northward into more temperate latitudes. In addition Antarctic surface waters are presumably exchanged, if typically ignored, across the ASF.

The underway work consisted of dropping XBTs at regular intervals on each transit south of the Campbell Plateau. Transects to and from the George V Coast stopped at the ice edge; those in the Ross sector were continued southward into the sea ice. The XBT casts were supplemented on NBP04-08 by periodic underway sampling for dissolved oxygen, nutrients, CFCs, TCO2 and oxygen isotopes, some continued well onto the Plateau. A representative XBT section appears in Figure 16, and examples of the underway chemical data are shown in Figures 10, 11, 14-15 and 17. In addition, other underway data are routinely recorded aboard the NBP, as illustrated by the daily plots in Figures 18-20, along with ADCP measurements as shown in Section 2.10 (Figures 21-22). Trackline bathymetry (not shown) was also logged along most of the ship's track, but as much time was anticipated to be in heavy ice, multibeam data was not recorded.

Comments about the underway data are included in some of the Program Reports. We have noted earlier that undersaturations are significant in CFC and dissolved oxygen south of the Polar Front, probably due to the entrainment of deep water, and particularly under the sea ice where surface equilibration is damped. Larger temperature and salinity changes are associated with the Subantarctic Front than the Polar Front, and eddies are common between these features, but they are not the only contributors to mesoscale variability in the ACC. Two examples of that variability from NBP04-08 are the strong oscillating currents at near-inertial frequencies observed with the NBP's new 38 kHz Ocean Surveyor ADCP (Weekly Report #5), and perturbations in several near-surface parameters caused by a large field of melting icebergs north of the polar Front (Section 2.12).**[Stan Jacobs]**

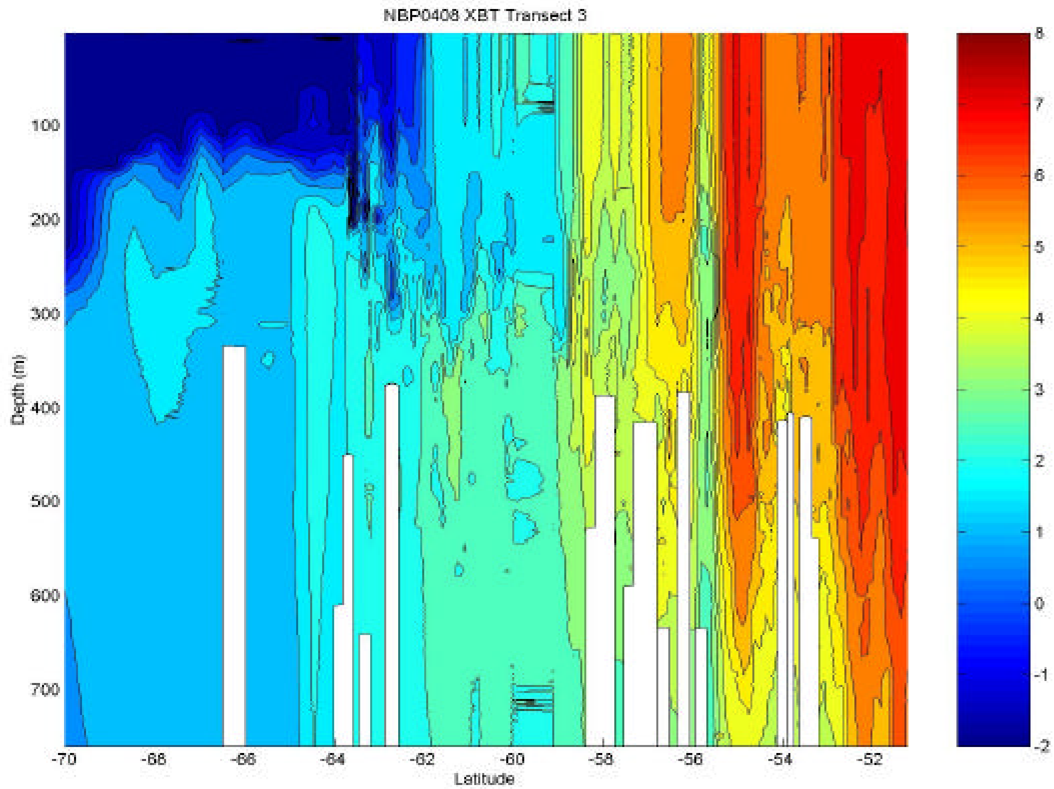

Figure 16. XBT transect across the polar front between the Campbell Plateau (right) and the northwestern Ross Sea.

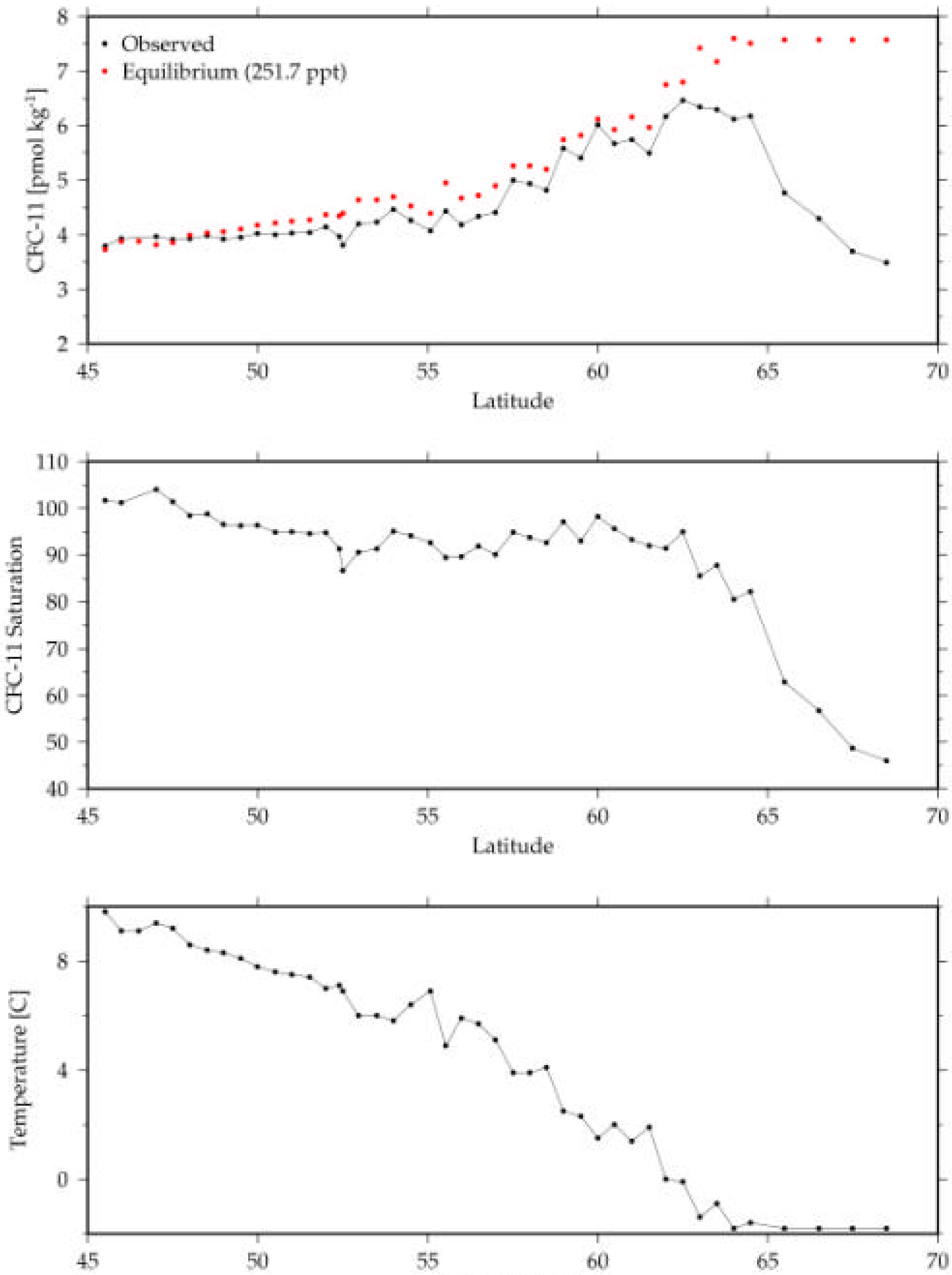

Figure 17. Transect of CFC-11, -12, and –13 concentrations for the third XBT transect – caption to be supplied by Deb along with the figure.

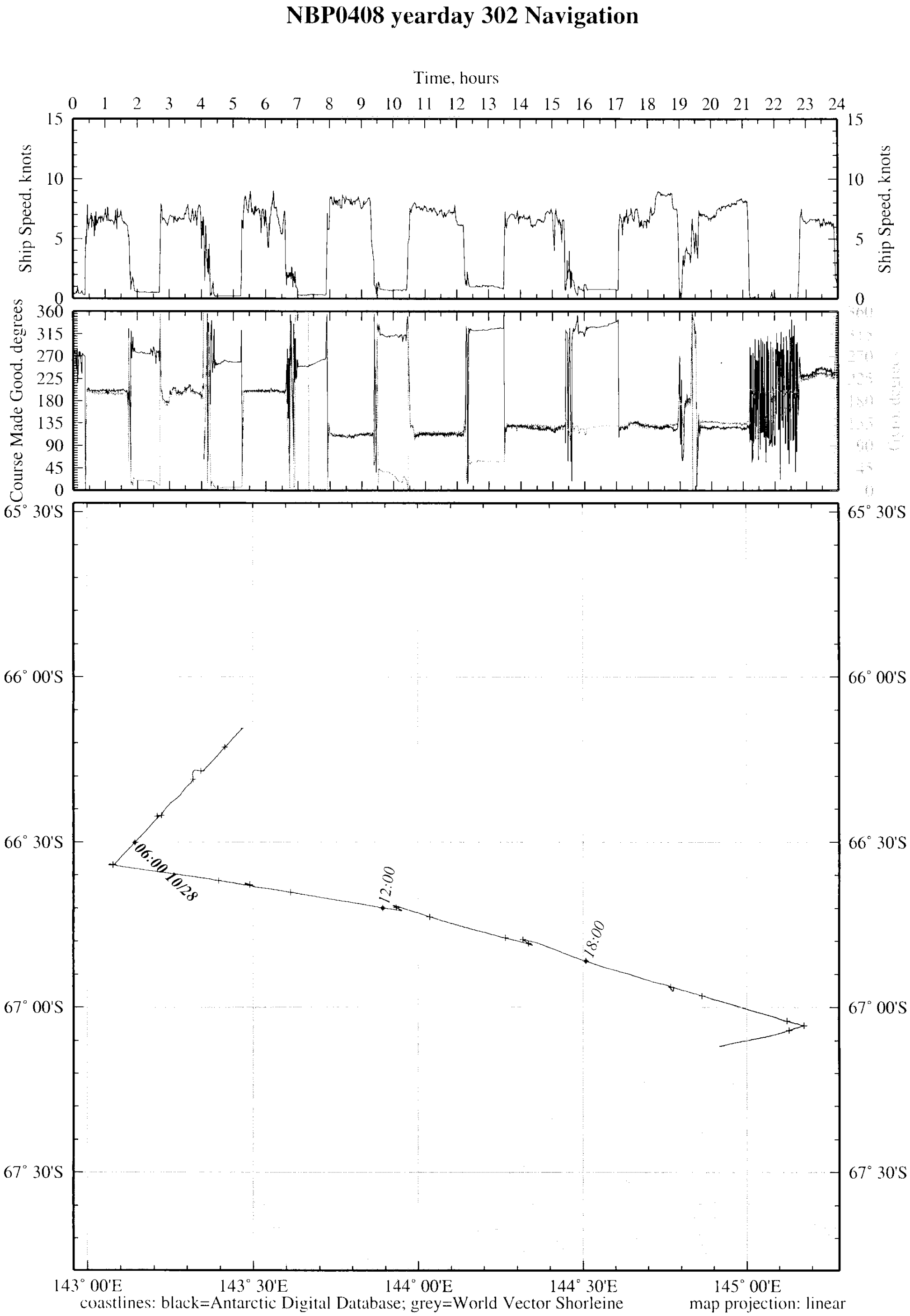

Figure 18. Sample navigational data supplied by RPSC, see RPSC Data Report for further information.

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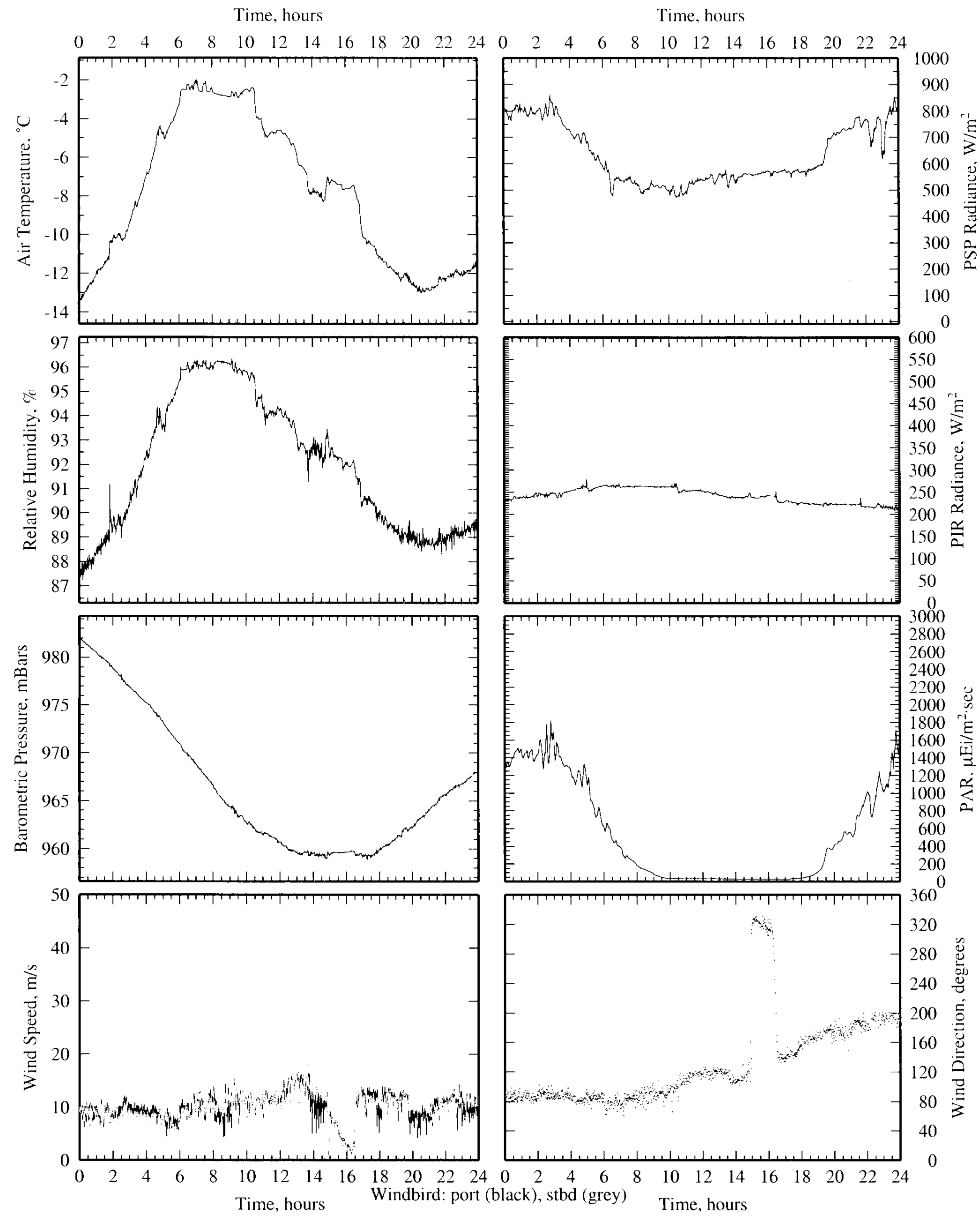


Figure 19. Sample meteorological data supplied by RPSC, see RPSC Data Report for further information.

NBP0408 yearday 308 Ocean

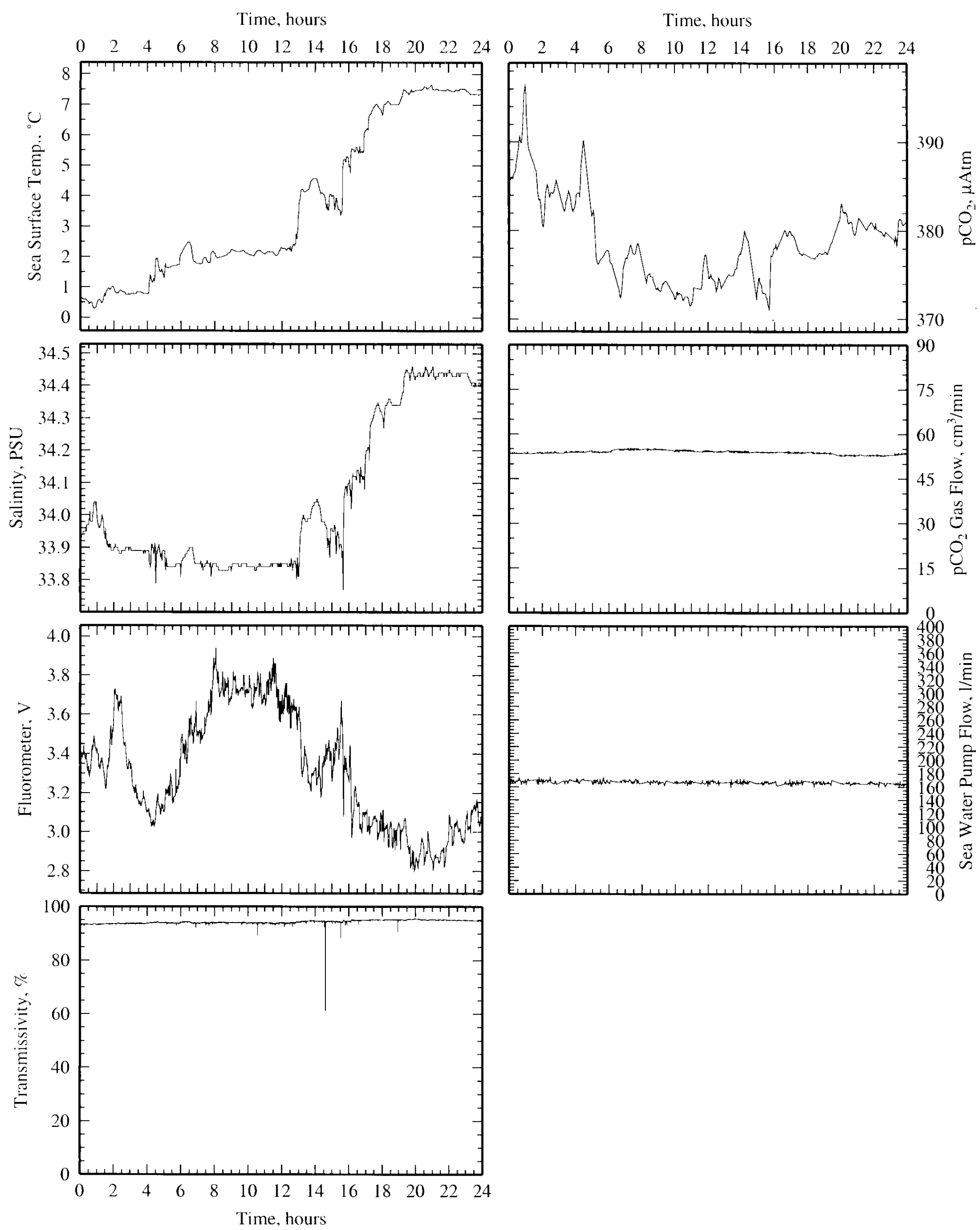


Figure 20. Sample surface water data supplied by RPSC, see RPSC Data Report for further information.

2.10 Ship-mounted ADCP Measurements (SADCP)

Ship-mounted Acoustic Doppler Current Profilers (SADCP) were used during both cruise legs to observe ocean currents. Two systems were used, one for the first time after its installation a few weeks prior to the cruise. In comparison to the older 150kHz system, which has a range of up to 400m, the new 38kHz profiler is able to measure ocean velocities at depths of up to 1500m.

After a small problem at the beginning of the cruise when the shipboard processing of the ADCP data was not functional (data was however recorded during that time), the two systems worked reliably in most open water conditions. As had been found on many previous cruises, the collection of ADCP data on RVIB Nathaniel B. Palmer is severely limited under ice breaking conditions probably because of broken ice floes covering the ADCP well at the bottom of the ship. We found that this problem is the same for the new 38kHz system.

Both working areas had ice cover near 100% for most of the cruise. Thus little useful SADCP data was collected during transits between stations. On a number CTD and VMP stations, when the ship was not breaking ice, good data was collected. Unfortunately we found that the usage of bow and stern thrusters also created unfavorable conditions for the ADCPs. At stations of particular interest we thus let the ship drift with wind and ice for several more minutes after the CTD/rosette had been taken on board. Thereby we were able to obtain a few reliable current profiles at these locations. A more permanent solution that prevents ice floes from covering the ADCP transducer well would, however, be much preferable.

Figure 21 and 22 show the SADCP data collected by the two systems during transects 1 and 2. The top three panels display the zonal velocity component as measured by the old 150kHz system, the 38kHz system in broadband mode, and the 38kHz system in narrowband mode. The 38kHz system operates interleaved in a narrow and a broadband mode. The narrowband mode has, at the cost of lower resolution, a deeper range than the broadband mode. We found that data collected with both modes agrees within their limitations. Data collected with the 38kHz system also agreed well with data collected by the 150kHz system. The 38kHz broadband mode appeared to have a lower tolerance to adverse environmental conditions than the narrowband data. And both 38kHz modes were in turn less reliable than the 150kHz system.

Analysis of the times when the 38kHz system provided fewer reliable current measurements showed high correlations with wind speed and pitch and roll movements of the ship (Figures 21 and 22, lower two panels). This finding is likely being caused by the ship's motion misaligning the transducer heads from the direction in which they had sent out their signal. We found that the data quality degraded strongly at pitch-roll angles of more than about 7 degrees. Such movements are encountered rather frequently in the Southern Ocean, but RVIB Nathaniel B. Palmer appears to be stable enough for us to expect the 38kHz system to provide reliable data under most conditions. The relatively small angle of 7 degrees beyond which the data quality degrades might, however, mean that on a ship more prone to rolling motions or operating in adverse conditions like Drake Passage, such as the ARSV Laurence M. Gould, only less reliable data could be collected. **[Gerd Krahmann]**

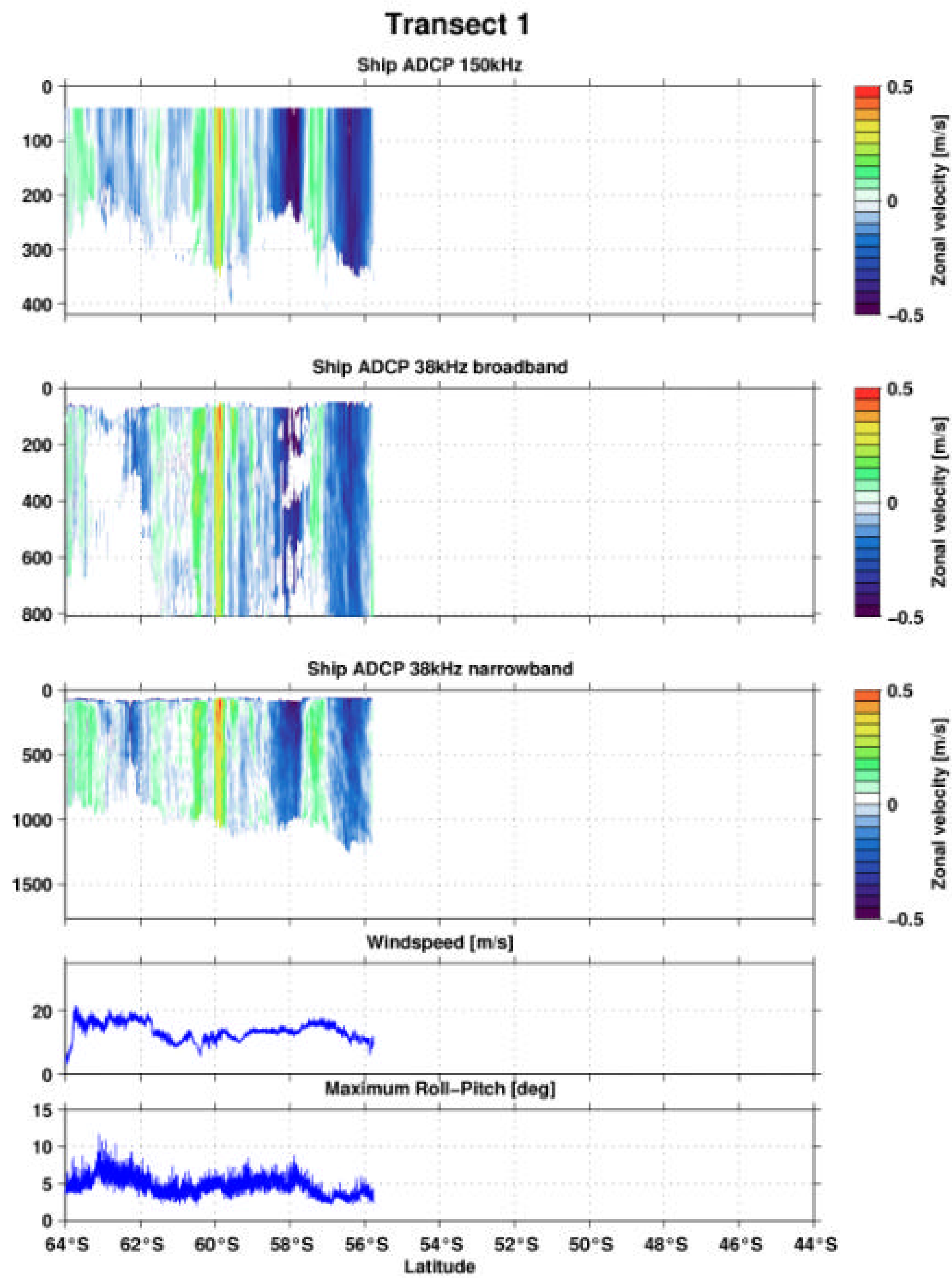


Figure 21. Zonal currents measured by the two SADCP systems during the first transect from New Zealand to the George V Coast region. The lower two panels show the measured windspeed and the maximum pitch-roll angle within one minute intervals.

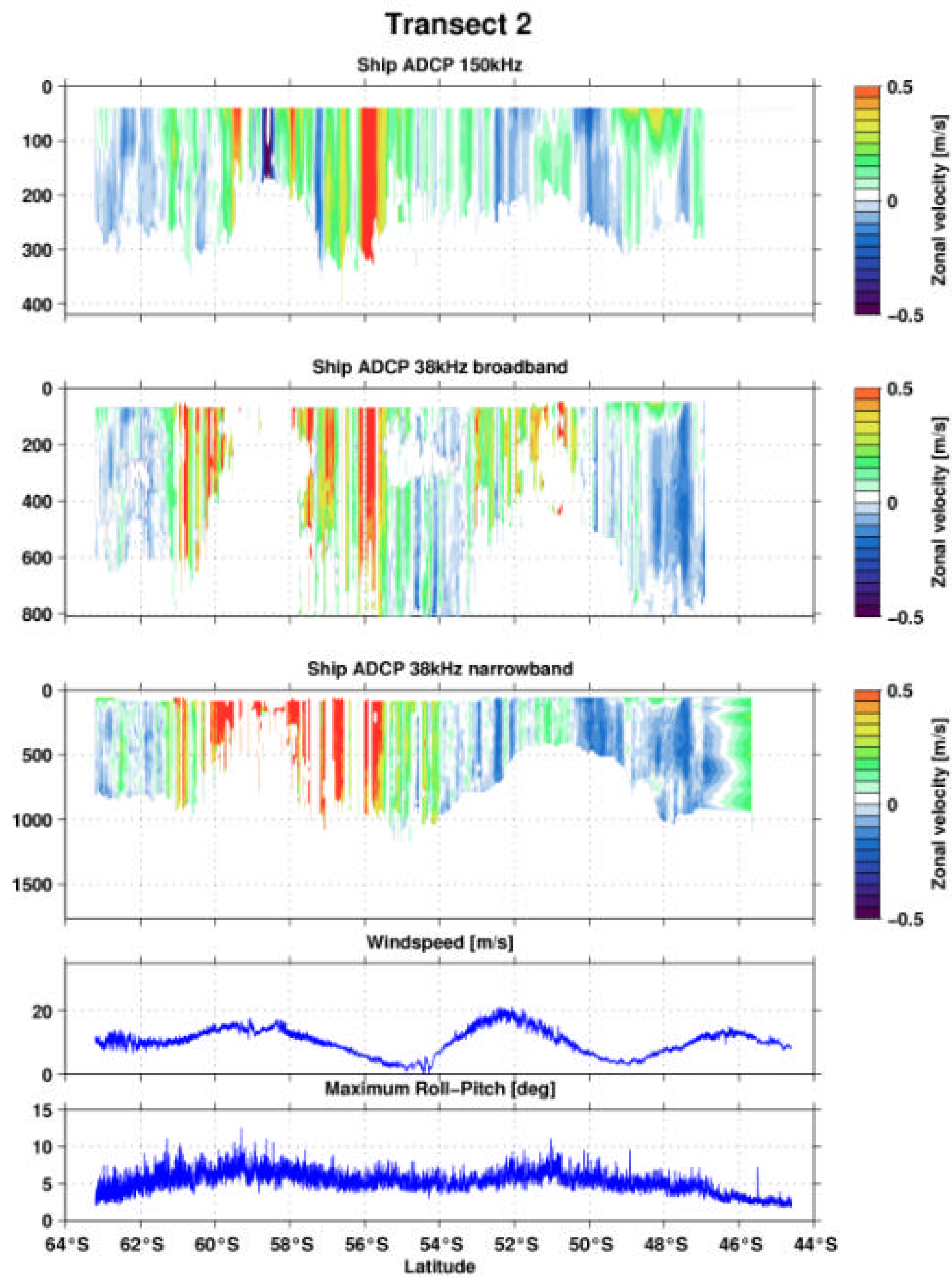


Figure 22. Zonal currents measured by the two SADCP systems during the second transect from the George V Coast region to New Zealand. The lower two panels show the measured wind speed and the maximum pitch-roll angle within one minute intervals.

2.11 Ship acoustic systems: influence of thrusters on on-station data quality

The quality of data from the ship's Bathy-2000 ("BAT") depth recorder and acoustic Doppler current profiler (ADCP) systems (both the old 150 kHz and new 38 kHz) is strongly influenced by ship operational conditions. Underway in ice, no useful signals are received from either BAT or ADCP: there is no obvious way around that, although future icebreaker designs should consider whether maintaining an ice-free area under the hull around the transducers is feasible. The current lack of underway-in-ice data, however, places a premium on obtaining good data from both systems while on station; e.g., while doing CTD and water sampling profiles. Choices made by the bridge watch profoundly affect data quality for both systems.

During AnSlope 3 we noted the following specific problems:

1. During one station (CTD 130) in about 1000 m of water, we found that BAT was reporting a rapidly shoaling bottom (by about 150 m in several minutes), even though ship drift and known bathymetry suggested that water depth should be increasing. While the entire screen of the BAT was noisy (typical of underway-in-ice and many on-station records), the apparent bottom return was extremely clear. Since the CTD was approaching the seabed, we asked the bridge to turn off the thrusters long enough to get a clean BAT record. The BAT depth immediately returned to the value expected from our drift and charts.

2. On some occasions we were unable to get a clean signal from the CTD pinger, which is used to judge when the CTD is approaching the seabed. As with BAT, the solution was to request that the thrusters be turned off while bottom approach was completed and until the CTD was headed up, safely clear of the seabed.

3. The ADCP systems are capable of ranges of ~300 m (150 kHz) and ~1000-1400 m (38 kHz) while the ship is underway in open water and low sea states. The new 38 kHz unit is a great addition to the Palmer, allowing deep currents to be measured over the entire Antarctic continental shelf and the dynamically important upper slope. However, while on station in the ice, we frequently obtained little or no information from either system. As with the BAT, the key to getting good on-station data is to have significant time periods with no or low thruster activity.

In talking with the First Mate, Scott Dunaway, it appears that the forward thruster is likely the principal source of noise on the science acoustic systems, since it is closest to the transducer windows in the hull. Both the forward and aft thrusters are used to keep the port (usually leeward) side against an ice floe while equipment is deployed from the Baltic Room on the starboard side aft. However, at times when we have requested the thrusters be turned off or at least reduced, we have been able to get a significant time interval (>30 minutes) of quiet acoustic data before the bridge watch determined a need to re-power the thrusters. That is, it appears the amount of thruster power used to maintain contact with the port-side floe is frequently more than is needed. For science data return, the optimum conditions are to use the thrusters the minimum amount needed to maintain the ice-free space around the Baltic Room (mainly achieved with the stern thruster and main engine wash), and maintain an acceptable CTD wire angle. Holding the ship firm against the ice on the port side is unnecessary provided the right conditions are met on the starboard (working) side.

Thrusters are essential to expedite ship set-up in the right location and orientation at the start of a CTD or other science station. They are frequently needed for washing ice chunks clear of the operating hole around the Baltic Room. There will also be conditions, possibly frequent, when ship handling requires significant thruster work on-station in ice. Weak winds, where ice motion can be driven by ocean currents (e.g., tides) acting against the windage on the ship, is one example of conditions where maintaining position relative to the port-side ice could be difficult. In open water, dynamic positioning ("DP") as we used in the Mertz Polynya, requires continuous thruster work. As a general rule, however, thrusters (especially the bow thruster) should be at the minimum setting (preferably even off) required to carry out CTD operations from the Baltic Room once the ship is positioned on-station.

Influence of thrusters and main engine wash on upper-ocean turbulence

The influence of thrusters on surface turbulence is apparent when watching the water around the Baltic Room door while on-station for CTD and other operations. Under high thruster power, the wash extends at least several tens of meters away from the ship. To what depth does this ship-driven turbulence penetrate? And: How important is this turbulence to upper-ocean data quality?

During AnSlope 3 we deployed a new instrument, the Vertical Microstructure Profiler (VMP; a.k.a. "Vampire"). Vampire measures temperature, conductivity and ocean velocity fluctuations at very fine scales (~1-3 cm), and is used to calculate profiles of ocean turbulence. Backscatter intensity on the ship's acoustic systems (ADCP, and EK-500 on previous cruises) is also found to be high over depth ranges where we expect turbulence. Vampire and acoustic measurements both indicate that thrusters create significant mixing in the upper ocean. If there is no near-surface stratification, i.e., a pre-existing deep mixed layer, the thruster-driven mixing extends to 50-100 m below the surface. This distance is estimated from turbulence measurements where there is no obvious geophysical source of upper-ocean turbulence such as wind stress, or convection due to surface cooling and ice formation.

Physical oceanographic process studies focusing on upper-ocean mixing have previously been carried out from *Palmer* by ship-supported "mini-ice-camps", placing science huts over hydroholes cut through the ice some distance (~100 m) from the ship (the "AnzFlux" program in the eastern Weddell Sea in austral winter 1994). However, the goal in AnzFlux was primarily to get away from more subtle wake effects due to flow under and around the hull, which might be expected to reach to about 20 m (roughly twice the draft). It is clear from AnSlope 3 measurements that the thrusters extend the apparent ocean turbulence well below this depth. One unresolved question is whether this on-station ship-induced mixing influences the data obtained from the CTD and water samples from the CTD rosette. On a short station, deep thruster-induced mixing might only be found when the surface layer is well mixed already, i.e., where there is no pre-ship stratification to damp out turbulence. On stations where ice/ship drift is rapid compared with the underlying water, the thruster wash mixing downwards might not be seen since the water immediately below the ship is replenished by lateral relative motion. However, on longer stations with little ice/ship drift relative to the ocean, continual use of thrusters may create upper ocean mixing and stratification conditions, which are not typical of the pre-ship environment. This is especially important for near-surface bottle sampling from the CTD rosette, which takes place as the CTD is retrieved, i.e., after the ship has been on station for some time.

As with performance of the ship acoustic systems, the general conclusion of these studies is that, after station set-up and while the ship is on-station, thrusters should be at the minimum setting (preferably even off) required to maintain satisfactory ship motion and safety for the science taking place, whether CTD, Vampire, or other sampling. **[Laurie Padman]**

2.12 Oceanographic conditions in northern iceberg field near 57.5^{o}S

On the final transit of AnSlope 3, north from the Ross Sea towards Lyttelton NZ, we passed a field of icebergs centered near 57.5^{o}S, 176.9^{o}E. This was about 500 miles north of the sea-ice edge at this time. The field included two large tabular bergs as well as many smaller, less regular-shaped bergs (Figure 23). Sea surface temperature (SST) and salinity (SSSal) both declined within the field (Figure 24), being significantly lower (by ~3^o and 0.8 psu) than the surrounding values for about 0.5 h (~5 nautical miles at 10 knots). A sonobuoy deployed within the field by Sarah Dolman will be analyzed for evidence of anomalous marine life concentration, and the sounds of iceberg melt and fracturing.

XBT profiles taken through the field (Figure 25) confirm the reduction in SST seen in the underway data. These profiles show the icebergs to be located in an irregular transition zone between cooler upper-ocean (above ~300 m depth) water to the south and warmer water north. In the profile taken within the iceberg field (T-7#347; green), the layer of cooled, fresh water (presumably a result of iceberg melting), is only ~20 m thick. The deeper portion of this profile shows 3 cold intrusions, near 210, 390, and 450 m. While the origin of these intrusions is unknown, at least the ~210 m intrusion may be the result of lateral spreading of melt-water from the icebergs' base.

From underway "Ocean Surveyor" ADCP currents (Figure 24), the iceberg field is coincident with a strong (~0.4 m/s) eastward-flowing current. Sea surface fluorometer readings (SSFluoro; Figure 24d) were low in a latitude band about 200 km wide, encompassing the "jet". The complexity of upper-ocean temperature and currents suggests that frontal meanders or eddies may play a role in the advection of this iceberg field (and perhaps in keeping the group together). **[Laurie Padman]**

Figure 23: Examples of icebergs seen near 57.5^{o}S, 176.9^{o}E. There were many tabular bergs (bottom) in the cluster. small, irregular bergs (top), and 2 large tabular bergs (bottom) in the cluster.

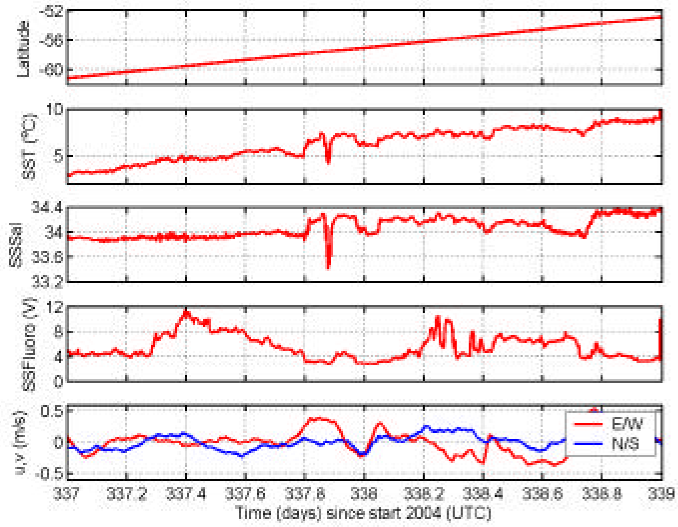


Figure 24 Time series of (a) latitude, (b) sea surface temperature (SST), (b) sea surface salinity (SSSal), (d) sea surface fluorometry (in volts), and (e) E/W (red) and N/S (blue) currents averaged over the top 300 m from the Ocean Surveyor 38 kHz narrow-band ADCP system. The center of the iceberg field is near t=337.9 days.

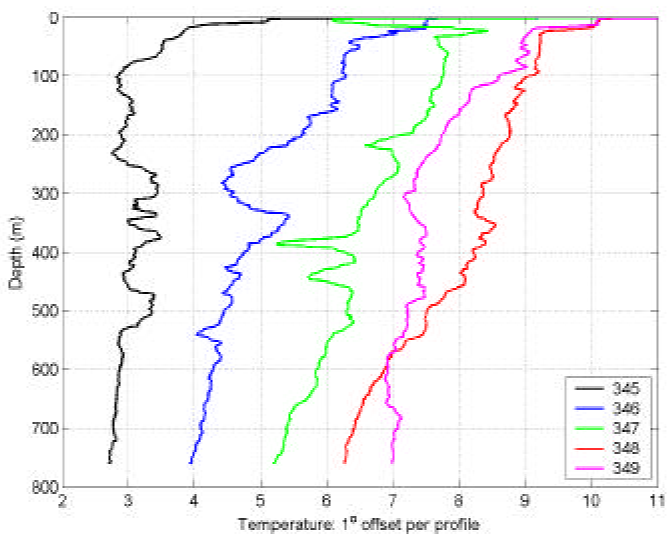


Figure 25 Profiles of temperature from T-7 XBTs south (profiles 345 and 346) of, within (347) and north (348, 349) of the iceberg field. Each profile is offset from the previous one by 1°C. There are strong lateral gradients of T below the mixed layer, especially above 300 m between #345 and #346. The SST anomaly is confined to the upper 20 m. The surface layer in the iceberg field is cooler (and fresher) than the deeper water, while the surface layer north and south of the field is warmer than the underlying water.

3 Station Maps and Tables

3.1 Station Maps

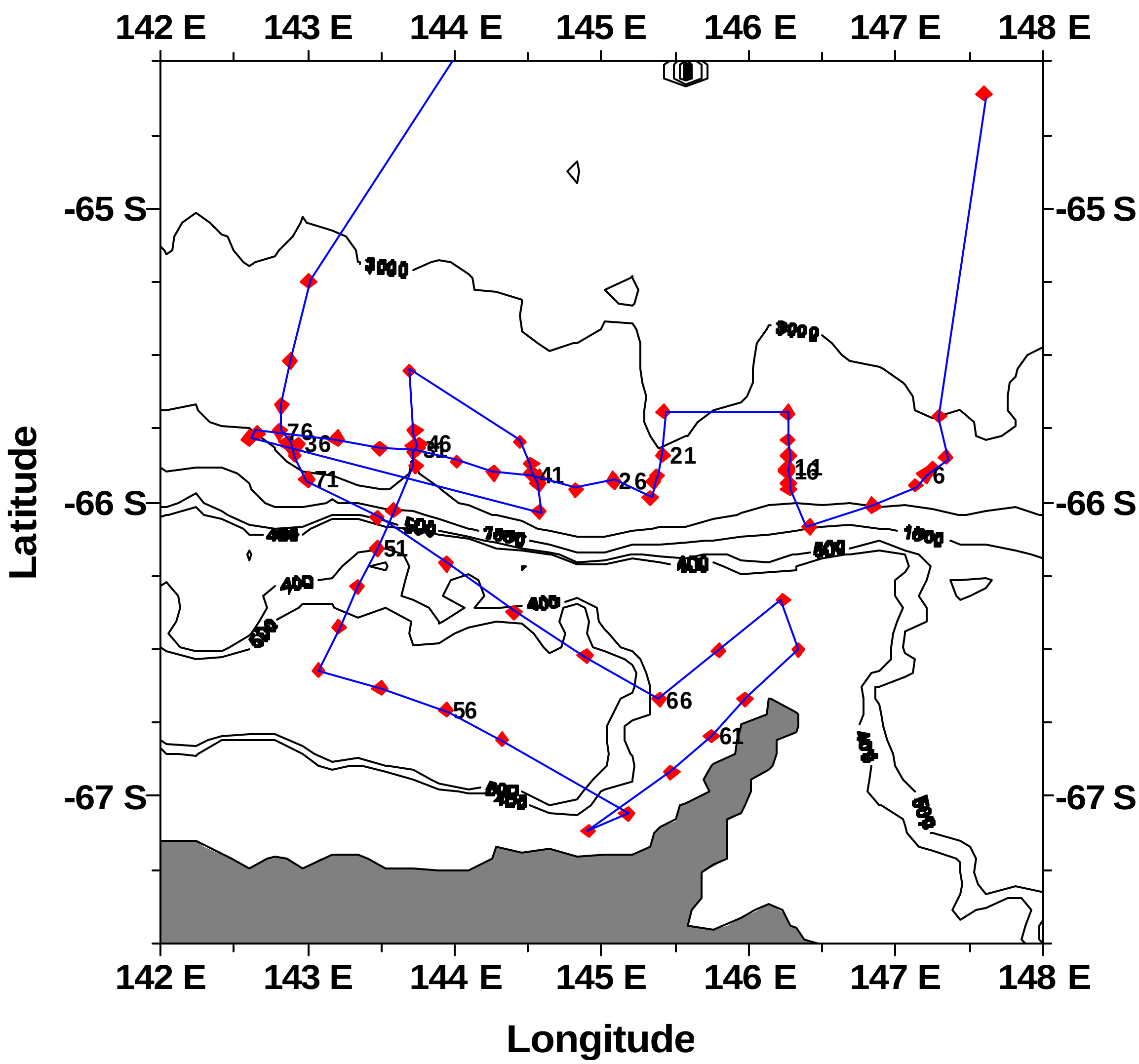


Figure A.1. CTD station locations for the first leg of Anslope-3 off the George V Coast Bathymetry from BEDMAP [Lythe et al., 2000], which is inaccurate in many locations, coastline approximate.

Lythe, M.B., Vaughan, D.G. and the BEDMAP CONSORTIUM, 2000, BEDMAP - bed topography of the Antarctic. 1:10,000,000 scale map. *BAS (Misc)* 9. Cambridge, British Antarctic Survey.

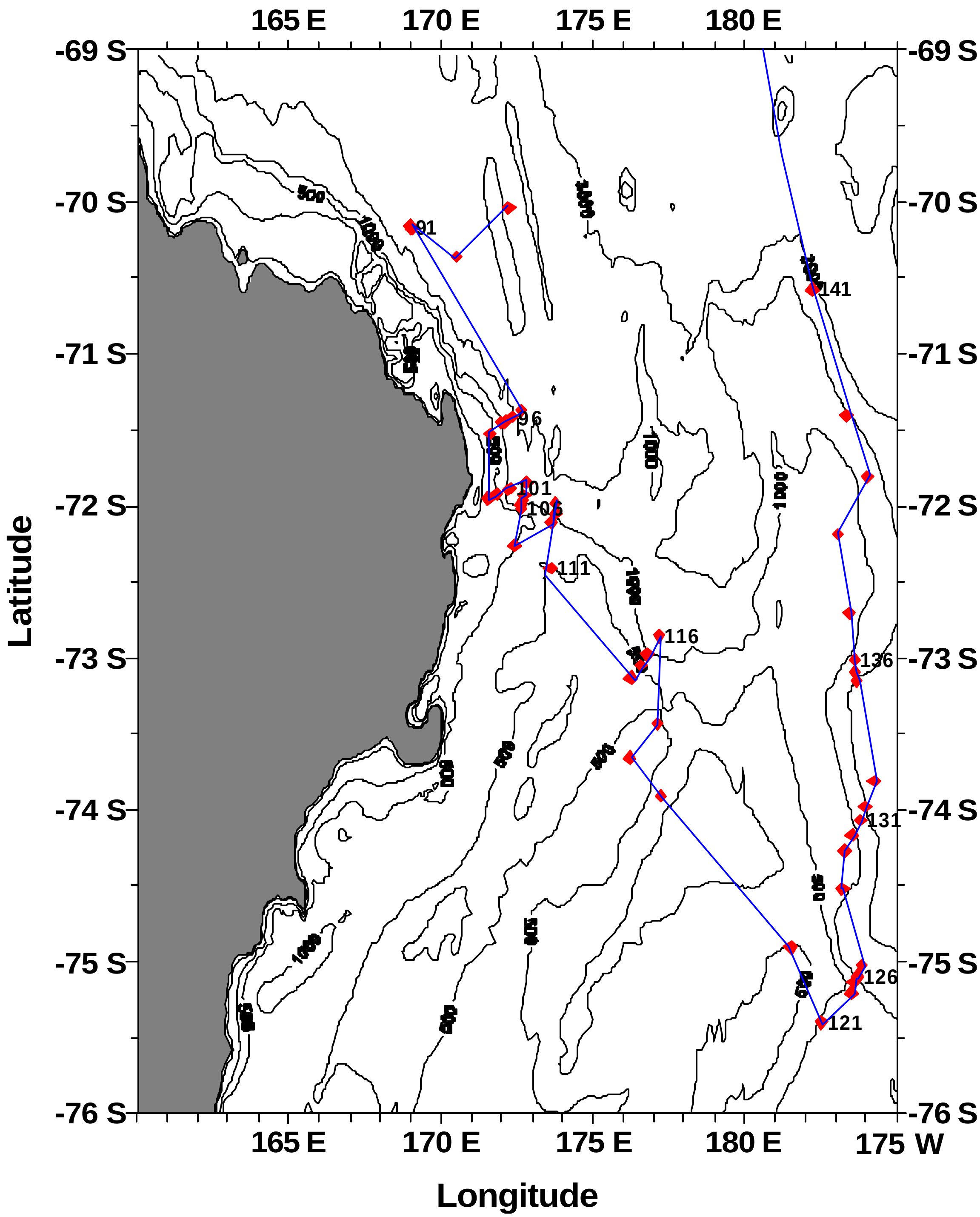


Figure A.2. CTD station locations for the second leg of Anslope-3 in the Ross Sea. Bathymetry from F. Davey compilations (2004), Institute of Geological and Nuclear Sciences.

3.2 CTD/LADCP Stations

CTD	Latitude		Longitude			Date	Time	Max. Pres	Water Samples (No. of Rossette bottles sampled)						
	Deg	Min	Deg	Min		M / D / Y	(GMT)	(db)	CFC	He	O_2	^3H	^{18}O	Sal	Nut
1	46	2.057	171	55.641	E	10/13/04	06:19	1350	18	-	22	-	-	23	23
2	64	36.414	147	36.276	E	10/20/04	00:54	3620	22	-	12	-	6	23	22
3	65	42.295	147	17.88	E	10/20/04	18:25	2777	21	4	10	4	4	9	21
4	65	50.575	147	20.557	E	10/20/04	23:47	1997	16	3	14	4	3	15	17
5	65	52.908	147	15.508	E	10/21/04	03:17	1398	12	-	12	-	-	12	12
6	65	54.288	147	12.388	E	10/21/04	05:29	951	12	4	8	4	4	8	12
7	65	56.401	147	8.168	E	10/21/04	08:21	464	8	-	9	-	-	5	9
8	66	0.528	146	51.064	E	10/21/04	11:17	300	4	2	4	2	2	4	4
9	66	4.891	146	24.949	E	10/21/04	13:59	268	4	-	4	-	2	4	5
10	65	57.18	146	16.685	E	10/21/04	16:11	512	6	-	7	-	3	6	7
11	65	52.639	146	16.169	E	10/21/04	18:15	1040	7	-	7	-	-	5	7
12	65	50.298	146	16.511	E	10/21/04	19:57	1700	12	-	12	-	-	9	12
13	65	56.008	146	16.572	E	10/21/04	23:21	557	2	-	2	-	-	2	2
14	65	55.807	146	16.384	E	10/21/04	23:54	559	-	-	-	-	-	-	-
15	65	53.497	146	15.989	E	10/22/04	01:26	852	3	-	3	-	-	3	3
16	65	53.308	146	15.83	E	10/22/04	02:10	896	2	-	2	-	-	2	2
17	65	53.122	146	15.756	E	10/22/04	02:56	936	2	-	4	-	-	4	4
18	65	47.016	146	16.273	E	10/22/04	05:14	2215	12	-	8	-	4	6	12
19	65	41.611	146	16.336	E	10/22/04	09:05	2412	12	-	12	-	1	12	12
20	65	41.393	145	25.644	E	10/22/04	18:05	2886	12	-	12	-	-	9	12
21	65	50.144	145	25.343	E	10/22/04	22:47	2497	12	-	8	-	-	8	9
22	65	54.58	145	22.669	E	10/23/04	01:60	1347	7	-	8	-	-	5	8
23	65	55.591	145	21.288	E	10/23/04	03:56	986	8	-	6	-	-	6	8
24	65	58.973	145	20.048	E	10/23/04	06:04	408	6	-	6	-	-	6	6
25	65	55.549	145	5.342	E	10/23/04	08:47	1119	5	-	5	-	-	2	5
26	65	55.307	145	4.722	E	10/23/04	09:49	1281	4	-	4	-	-	3	4
27	65	57.421	144	49.566	E	10/23/04	13:22	797	7	-	7	-	-	5	7
28	65	54.889	144	34.328	E	10/23/04	16:12	1059	9	-	9	-	-	7	9
29	65	53.788	144	16.271	E	10/23/04	19:22	808	6	-	6	-	-	4	6
30	65	51.4	144	1.13	E	10/23/04	21:28	1051	8	-	8	-	-	4	8
31	65	48.866	143	44.225	E	10/23/04	23:48	1067	6	-	6	-	-	4	7
32	65	48.61	143	43.661	E	10/24/04	00:44	1136	3	-	3	-	-	2	3
33	65	48.427	143	43.151	E	10/24/04	01:39	1195	8	-	8	-	-	8	8
34	65	48.854	143	29.803	E	10/24/04	05:03	809	6	-	6	-	-	4	6
35	65	46.89	143	12.274	E	10/24/04	08:07	1095	5	-	5	-	-	5	5
36	65	48.094	142	56.454	E	10/24/04	11:38	1142	8	-	8	-	-	6	8
37	65	45.732	142	39.633	E	10/24/04	15:12	1233	8	-	7	-	-	5	8
38	65	46.938	142	36.205	E	10/24/04	18:06	835	5	-	5	-	-	4	5
39	66	1.75	144	34.526	E	10/26/04	12:04	316	4	-	4	-	-	3	4
40	65	56.012	144	34.33	E	10/26/04	14:36	710	5	-	5	-	-	4	5
41	65	53.931	144	31.722	E	10/26/04	16:47	1352	8	-	8	-	-	5	8
42	65	51.99	144	31.389	E	10/26/04	20:12	2039	13	-	8	-	-	6	13
43	65	47.52	144	26.764	E	10/26/04	23:25	2530	13	-	13	-	-	13	13
44	65	33.017	143	41.569	E	10/27/04	05:17	2140	9	3	6	3	1	4	10
45	65	45.295	143	43.888	E	10/27/04	09:45	1876	10	-	6	-	-	5	10
46	65	48.05	143	45.85	E	10/27/04	12:32	1406	9	-	5	-	-	5	9
47	65	48.691	143	45.244	E	10/27/04	14:39	1124	8	-	5	-	-	4	8
48	65	49.638	143	43.296	E	10/27/04	17:35	737	6	-	5	-	-	2	6
49	65	52.522	143	44.298	E	10/27/04	19:07	389	5	-	4	-	-	4	5
50	66	1.415	143	35.318	E	10/27/04	21:42	420	6	-	4	-	-	4	6
51	66	9.299	143	28.437	E	10/27/04	23:47	511	6	-	6	-	-	5	6
52	66	17.062	143	20.446	E	10/28/04	02:06	639	6	-	6	-	-	6	6

53	66	25.292	143	12.914	E	10/28/04	04:29	736	6	-	3	-	-	3	6
54	66	34.148	143	4.546	E	10/28/04	07:07	838	4	-	4	-	-	4	4
55	66	37.85	143	29.846	E	10/28/04	09:41	780	4	-	3	-	-	4	4
56	66	42.2	143	56.614	E	10/28/04	12:38	874	4	-	3	-	-	3	4
57	66	48.245	144	19.862	E	10/28/04	16:10	967	5	-	4	-	5	5	5
58	67	3.341	145	10.562	E	10/28/04	21:34	1305	8	3	5	3	5	5	8
59	67	6.882	144	54.608	E	10/29/04	00:26	510	8	5	7	5	5	7	7
60	66	54.979	145	28.859	E	10/29/04	10:58	662	6	-	4	-	-	-	6
61	66	47.45	145	44.881	E	10/29/04	13:07	454	6	-	4	-	-	5	6
62	66	39.895	145	58.989	E	10/29/04	15:37	302	5	-	4	-	-	4	5
63	66	29.987	146	20.67	E	10/29/04	18:13	233	3	-	3	-	-	3	3
64	66	19.745	146	14.252	E	10/29/04	20:17	241	4	-	4	-	-	3	4
65	66	30.09	145	48.125	E	10/29/04	23:09	222	4	-	4	-	-	4	4
66	66	40.013	145	23.83	E	10/30/04	01:34	465	12	-	6	-	-	6	6
67	66	31.253	144	53.706	E	10/30/04	04:39	441	6	-	6	-	-	6	6
68	66	22.282	144	24.396	E	10/30/04	07:46	456	6	-	6	-	-	6	6
69	66	12.373	143	56.926	E	10/30/04	10:33	427	7	-	5	-	-	5	7
70	66	3.011	143	28.51	E	10/30/04	13:44	462	6	-	4	-	-	4	6
71	65	55.156	142	59.827	E	10/30/04	17:09	422	5	-	4	-	-	4	5
72	65	50.08	142	54.991	E	10/30/04	19:19	668	6	3	4	3	2	3	6
73	65	49.243	142	54.245	E	10/30/04	20:58	902	9	2	7	2	2	5	9
74	65	48.403	142	52.903	E	10/30/04	22:47	1212	12	2	8	2	2	7	12
75	65	47.44	142	52.018	E	10/31/04	00:44	1494	10	-	6	-	-	6	10
76	65	45.452	142	48.845	E	10/31/04	02:56	1773	8	2	7	2	2	6	8
77	65	40.136	142	49.555	E	10/31/04	05:39	2105	8	1	5	1	1	5	8
78	65	31.004	142	53.285	E	10/31/04	09:17	2459	9	1	5	1	1	1	9
79	65	14.656	143	0.652	E	10/31/04	14:32	3083	11	-	6	-	-	6	11
80	54	17.735	166	20.334	E	11/4/04	01:15	1204	8	-	8	-	-	12	8
81	64	1.746	178	12.214	E	11/12/04	21:54	1051	12	-	8	-	1	8	12
82	65	0.124	177	53.435	E	11/13/04	07:51	1025	12	-	6	-	1	6	12
83	65	59.935	177	53.038	E	11/13/04	18:29	3561	12	1	7	1	1	7	12
84	67	0.332	177	44.509	E	11/14/04	08:31	1158	12	-	10	-	1	10	12
85	67	59.322	177	54.97	E	11/14/04	21:53	3538	24	-	14	-	1	13	24
86	68	56.935	175	56.412	E	11/15/04	14:42	1000	8	-	5	-	2	5	8
87	70	2.492	172	14.776	E	11/16/04	18:32	2606	12	-	7	-	2	7	12
88	70	21.709	170	30.428	E	11/17/04	10:05	2670	12	-	6	-	3	6	12
89	70	10.468	169	2.221	E	11/18/04	05:17	1009	-	-	-	-	-	-	-
90	70	9.992	168	59.93	E	11/18/04	06:08	1000	-	-	-	-	-	-	-
91	70	9.523	168	57.854	E	11/18/04	06:56	2546	12	-	8	-	-	8	12
92	71	31.441	171	36.887	E	11/20/04	09:32	475	12	-	8	-	2	8	12
93	71	27.125	172	0.206	E	11/20/04	11:36	776	8	-	5	-	2	5	8
94	71	27.08	172	4.985	E	11/20/04	13:09	1356	10	-	6	-	5	6	10
95	71	26.405	172	9.085	E	11/20/04	15:10	1647	8	-	5	-	3	5	8
96	71	25.073	172	21.139	E	11/20/04	17:44	1896	11	-	6	-	3	7	11
97	71	22.277	172	38.822	E	11/20/04	20:52	2229	12	-	7	-	3	7	12
98	71	57.004	171	34.315	E	11/21/04	03:48	373	6	-	6	-	-	4	5
99	71	55.36	171	50.033	E	11/21/04	05:16	533	6	-	5	-	-	4	6
100	71	53.639	172	12.732	E	11/21/04	07:32	1115	8	-	6	-	-	6	9
101	71	52.99	172	16.762	E	11/21/04	09:06	1337	9	-	6	-	-	6	9
102	71	50.741	172	49.291	E	11/21/04	12:17	1900	9	-	6	-	-	6	9
103	71	55.921	172	44.584	E	11/21/04	15:23	1699	6	-	4	-	-	4	6
104	71	57.82	172	42.51	E	11/21/04	17:19	1180	8	-	5	-	3	5	8
105	71	59.214	172	37.528	E	11/21/04	18:58	791	5	-	4	-	-	4	5
106	72	1.024	172	38.6	E	11/21/04	20:17	531	6	-	4	-	-	4	6
107	72	15.82	172	25.895	E	11/22/04	00:15	493	8	-	6	-	-	6	8
108	72	6.342	173	38.437	E	11/22/04	05:28	760	6	-	6	-	-	6	6
109	72	2.903	173	46.52	E	11/22/04	07:18	1206	6	-	5	-	-	5	6
110	71	58.681	173	44.564	E	11/22/04	09:22	1636	12	-	6	-	-	7	12
111	72	24.488	173	36.505	E	11/23/04	23:57	477	23	-	17	-	2	17	23

112	73	7.682	176	14.502	E	11/24/04	10:31	376	1	-	1	-	-	1	1
113	73	7.822	176	14.686	E	11/24/04	10:55	377	8	-	5	-	2	4	8
114	73	2.88	176	36.233	E	11/24/04	12:58	598	7	-	4	-	-	4	7
115	72	58.757	176	48.097	E	11/24/04	14:45	947	6	-	4	-	-	4	6
116	72	51.341	177	10.774	E	11/24/04	17:42	1302	7	-	4	-	-	4	7
117	73	25.998	177	7.294	E	11/25/04	01:26	549	9	-	6	-	-	6	9
118	73	39.376	176	12.5	E	11/25/04	05:28	597	10	-	5	-	-	7	10
119	73	54.523	177	15.536	E	11/25/04	10:07	408	9	-	7	-	-	7	9
120	74	54.379	179	30.350	W	11/26/04	01:37	491	8	-	6	-	-	6	8
121	75	23.881	178	32.116	W	11/26/04	07:26	512	11	3	6	3	5	6	11
122	75	12.254	177	29.962	W	11/26/04	10:57	568	3	1	3	1	1	3	3
123	75	12.302	177	30.731	W	11/26/04	11:33	567	7	2	4	2	5	4	7
124	75	8.178	177	36.007	W	11/26/04	12:58	783	8	2	5	2	6	5	8
125	75	6.082	177	43.228	W	11/26/04	14:31	1155	4	-	3	-	2	3	4
126	75	5.591	177	43.238	W	11/26/04	15:31	1230	8	-	5	-	2	5	8
127	75	1.342	177	51.795	W	11/26/04	17:21	1720	11	-	6	-	3	6	11
128	74	31.327	177	12.509	W	11/27/04	00:16	897	10	3	8	3	4	6	10
129	74	16.267	177	16.936	W	11/27/04	08:56	824	9	-	6	-	3	6	9
130	74	9.786	177	32.365	W	11/27/04	11:10	960	9	-	6	-	4	6	9
131	74	3.96	177	49.202	W	11/27/04	13:28	1529	9	-	5	-	3	5	9
132	73	58.816	177	57.864	W	11/27/04	16:58	2115	8	-	5	-	4	4	8
133	73	48.539	176	16.484	W	11/27/04	20:08	2568	20	-	11	-	4	11	20
134	73	9.01	177	41.595	W	11/28/04	04:26	2123	9	-	6	-	-	6	9
135	73	5.604	177	37.551	W	11/28/04	07:06	1545	9	-	6	-	-	6	9
136	73	0.802	177	37.519	W	11/28/04	09:32	1095	11	-	6	-	-	6	11
137	72	42.082	177	26.729	W	11/28/04	14:14	842	9	-	7	-	3	7	11
138	72	11.221	177	4.357	W	11/28/04	20:05	720	6	-	4	-	3	4	6
139	71	48.436	176	2.557	W	11/29/04	02:43	1116	11	-	6	-	-	6	11
140	71	24.476	179	21.339	W	11/29/04	08:22	1719	8	-	6	-	-	6	8
141	70	34.481	178	13.801	W	11/29/04	19:18	2772	10	-	7	-	1	6	10
142	69	40.916	178	9.530	W	11/30/04	07:20	3856	19	-	11	-	2	11	19
Total									1175	48	861	48	147	814	1181

Table A-1 CTD station locations and samples collected.

3.3 NBP04-08 LADCP Profile Quality

CTD/ LADCP	Reliability Of results	Problem
1	High	
2	Low	Magn. Pole, bad beam
3	Medium	Magn. Pole, broken beam
4	Medium	Magn. Pole, broken beam
5	Medium	Magn. Pole, broken beam
6	Medium	Magn. Pole, broken beam
7	Medium	Magn. Pole, broken beam
8	Medium	Magn. Pole, broken beam
9	Low	Magn. Pole, broken beam
10	Medium	Magn. Pole, broken beam
11	Medium	Magn. Pole, broken beam
12	Low	Magn. Pole, broken beam
49	Low	Magn. Pole, 1 ADCP
50	Low	Magn. Pole
51	Low	Magn. Pole
52	Low	Magn. Pole
53	Low	Magn. Pole
54	Low	Magn. Pole
55	Low	Magn. Pole
56	Low	Magn. Pole
57	Low	Magn. Pole
58	Medium	Magn. Pole
65	Low	Magn. Pole
66	Low	Magn. Pole
67	Low	Magn. Pole
68	Low	Magn. Pole
69	Low	Magn. Pole
70	Low	Magn. Pole
71	Low	Magn. Pole
72	Low	Magn. Pole
73	Low	Magn. Pole
74	Low	Magn. Pole
75	Low	Magn. Pole
76	Low	Magn. Pole
77	Low	Magn. Pole
78	Low	Magn. Pole
79	Low	Magn. Pole
80	Medium	Large tilt & swell
81	High	Large swell
82	High	
83	Medium	Low scatterers
84	High	
85	Medium	Low scatterers
86	High	
87	Medium	Low scatterers
88	Medium	Low scatterers, large tilt
89	Medium	Large tilt
90	Medium	Large tilt
91	Low	Large tilt
92	High	

CTD/ LADCP	Reliability Of results	Problem
93	High	
94	High	
95	High	
96	High	
97	High	
98	High	
99	High	
100	High	
101	High	
102	High	
103	High	
104	High	
105	High	
106	High	
107	High	
108	High	
109	High	
110	High	
111	High	
112	High	
113	High	
114	High	
115	High	
116	High	
117	High	
118	High	
119	High	
120	High	
121	High	
122	High	
123	High	
124	High	
125	High	
126	High	
127	High	
128	High	
129	High	
130	High	
131	High	
132	Medium	Low scatterers
133	Medium	Low scatterers
134	High	
135	High	
136	High	
137	High	
138	High	
139	High	
140	High	
141	Medium	Low scatterers
142	Medium	Low scatterers

Table A-2 NBP04-08 LADCP Profile Quality during AnSlope-3.

4 Other Project Reports

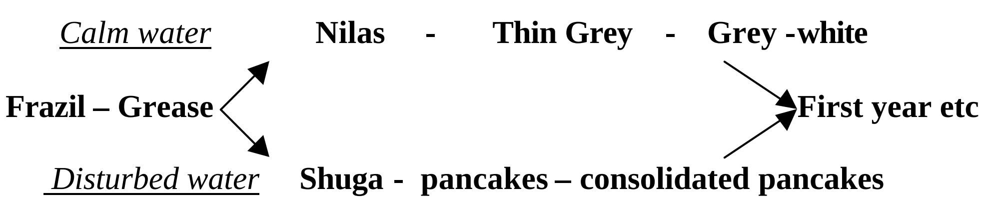
4.1 Sea Ice Observations

Underway sea ice observations were logged at hourly intervals following the protocols defined by the Antarctic Sea Ice Processes and Climate (ASPeCT) program, developed within the Scientific Committee on Antarctic Research (SCAR) to address global change issues related to the Antarctic sea ice zone (Worley and Ackley, 2000). Observations were made on the hour, except when the ship was on station for oceanographic work. A total of 647 ice observations were made while we were in the ice, 261 in the GeorgeV Coast area and the remainder in the Ross Sea. Similar observations were made on the previous AnSlope cruises, and on the pre-AnSLope site survey cruise. The resulting data will reside in the ASPeCT archive maintained at the University of Tasmania. A parallel sea ice data set was obtained by the marine mammal program (Section 4.2) and eventual comparison of these data sets should prove interesting.

Aspect Sea Ice Program

We found the version of the sea ice program we were using to have options that were tightly constrained. An advantage of its inflexibility is that it forces different users to give a fairly uniform data set. The Aspect software emphasizes ice thickness and, perhaps, topography. We were not able to combine the available options to describe some of the phenomena we saw such as melting snow on first year ice, or snow on brash ice while “consolidated pancakes” was not allowed in any combination at all.

Interpretations of sea ice from the resources on board - experienced personnel and literature, were quite variable. We found the pictures on the disc to give a clear idea of how to characterize nilas ice, for instance, but there was much debate about other types e.g. frazil and shuga. Improved pictures and descriptions would both help novice observers and standardize definitions used by observers who have learned their ice under other contexts. We found that forming the categories into a sequence of stages of ice formation to be helpful:



Ice that is breaking up also may resemble these types. For instance, fine brash ice may look like shuga, and small pieces of thin sheet ice such as nilas may develop upturned edges like pancakes. Maybe this could be specified, but it might be inferred from other data that show whether the ice is forming or breaking up.

Trying to estimate the height of ridging from the ship is also difficult. The elevation of the bridge makes it difficult to appreciate the true height and estimates may be 2 – 4 times lower than they actually were.

Snow falling or drifting into the water is clearly not sea ice but it may closely resemble frazil or grease and it may then freeze to look like nilas or young grey ice. It also seems to help cement brash ice back into sheets. It is also difficult to describe as some of the choices available in this program cannot be combined.

Observations

Early in the cruise we had the opportunity to witness early spring conditions with sea ice still being actively formed in the Mertz Glacier Tongue area. This was most dramatic in the Mertz Polynya, where ice was forming as nilas or pancakes and thickening into sheets of first year ice before being broken up by the very strong katabatic winds and blown across the polynya as cake or pancake ice where it re-froze as sheets of first year ice.

By the time we reached the Ross Sea, air temperatures were substantially warmer and new ice formation was limited to a small amount of nilas, which usually melted during the day. The storm near Cape Adare broke up the floes, also leaving a lot of new ridging and brash ice. As we proceeded in the Ross Sea we encountered ice much thinner (10 to 20 cm) than the one to two meters we had bludgeoned our way through to get down there.

[Ian Southey and Denis Franklin]

4.2 Marine Mammal Passive Acoustic Monitoring and Cetacean and Wildlife Diversity

INTRODUCTION

Commencing in 1999/2000 austral summer, cetacean research programs have been conducted aboard multidisciplinary research cruises of many nations in Antarctic waters (e.g. CCAMLR 2000, and Southern Ocean GLOBEC 12001-3, UK, Australia, USA Germany). These programs have been facilitated by the International Whaling Commission (IWC) Scientific Committee (Thiele & Glasgow, 2004 Anslope2). This summary report focuses on participation in the Anslope 3 voyage NBP 0408 on the Nathaniel B. Palmer during austral spring and summer 2004. This voyage allowed the collection of visual and acoustic data on cetacean and other wildlife distribution and habitat information as well as sea ice data collection. The IWC funded research provides a non-lethal approach to the integration of cetacean distribution and the ecology and dynamics of the Southern Ocean ecosystem. This region is an IWC sanctuary for whales (The IWC Southern Ocean Sanctuary, SOS). Non-lethal research that will improve our understanding of whale populations at local, regional and circum-Antarctic scales is an important means of contributing to the objectives of the SOS. This voyage was primarily focused on oceanographic measurements in the Ross Sea.

The main objective of this research is to determine the relationships between cetacean species, especially minke whales, with sea ice habitat. Sea ice in the Antarctic is a 'dynamic and complex region of the Antarctic marine ecosystem in both physical and biological terms' (Thiele & Glasgow 2004 Anslope 2). Few voyages into sea ice conducting whale surveys have attempted to determine the extent to which sea ice can be categorized in an ecologically meaningful way, particularly relating the patchiness of cetacean distribution in ice to the heterogeneity of ice formation.

Voyage NBP 0408 (Anslope3) provided the platform for IWC observers to conduct visual surveys for wildlife in conjunction with sea ice data collection using a relatively new logging and photographic system in the Ross Sea area (between 132? 0'00"E and 178?0'00"E). A range of habitat was surveyed including shelf, shelf slope, and off slope deep waters through a vast range of sea ice types. The data from this and several other similar cruises conducted in this area, Weddell Sea, Antarctic Peninsula and East Antarctica will be used to test the relationship between cetaceans and sea ice, including determining the level of complexity of sea ice that is ecologically important as habitat (for example, Thiele *et al.* 2004).

METHODS

Visual monitoring

Visual surveys for cetaceans and other wildlife were conducted by one to two observers during daylight hours from the bridge (height, 65 feet from sea level) of the RVIB Nathaniel B. Palmer throughout the voyage from Lyttelton, New Zealand to Ross Sea to Timaru, New Zealand, and the second leg from Timaru to Ross Sea to Lyttelton (13th October to 12th December 2004). Sightings of birds and marine mammals were recorded on a laptop-based version of the logging program (LOGGER[1]) specially adapted for use in the Antarctic. This program allows for the entry of Antarctic cetacean, seal,

[1] These data were collected using software (Logger 2000 and Sea Ice Logger) developed by the International Fund for Animal Welfare (IFAW) to promote benign and non-invasive research (http://www.ifaw.org).

penguin and flying bird species and a full suite of Aspect Sea Ice Data Fields, downloading the information directly into a Microsoft Access database.

Sea ice observations

Sea ice images were collected every 10 minutes while steaming and every 30 minutes while slowed, photos were discontinued while at station. All images were taken from the same point on the bridge and were classified at the time of capture. Sea ice was classified out to 1 kilometer on the port side of the vessel (the same side of the vessel was used throughout each survey) as per ASPeCt protocols. A single observer classified photos. Whale habitat was captured on digital video tape (x2) and digital images where possible and sea ice observations were conducted at the time of sighting when in ice. Nikon Coolpix camera was used to photographically record sea ice.

Passive acoustic monitoring

Passive acoustic monitoring was undertaken using expired US Navy Sonobuoys. Sonobuoys were not deployed in New Zealand domestic waters due to permit restrictions. They were opportunistically deployed to monitor biological sounds, particularly those of marine mammals.

Sonobuoys are expendable underwater listening devices that have four main components: a float, a radio transmitter, a saltwater battery and a hydrophone. Sonobuoy Type AN/SSQ 53D, which are directional and 57B, which are omni-directional, were used. A 160 MHz omni-directional Cushcraft Ringo Ranger ARX-2B was used during the voyage. Software controlled ICOM IC-PCR 1000 scanner radio receivers were used for reception of sonobuoy signal. Data were recorded as 30 minute WAV files using *Ishmael* software, which was also used for real time review.

Photo-identification

Opportunistic photo-identification was undertaken both from the bridge of the ship and from the zodiac that was available for small boat work. Nikon D100 Digital SLR camera was used to photographically record wildlife.

SUMMARY OF RESULTS

Cetacean species sighted during this voyage included killer, *Orcinus orca*, minke, *Balaenoptera bonaerensis sp.*, humpback, *Megaptera novaengliae* and sperm whales, *Physeter macrocephalus* (see Table 7 below). Total sightings of cetacean species up to the 3rd December are shown in Table 7. Minke whales showed a patchy distribution with a distinct preference for areas over the slope (refer to Figure A-4). One band of interest was on the first leg near the Mertz Glacier where a straight line of minke and like minke sightings was recorded even though the ship track was quite erratic. These sightings correspond to an area just inshore of the shelf break as did the sightings inside the Ross Sea. The clusters of sightings off Cape Adare correspond to water depths of 2700 to 3500 meters. Orcas were identified to Type B on 3 of the 4 occasions that they were sighted, according to Pitman and Ensor (2003). Type B orcas are most commonly sighted amongst loose sea ice (Pitman and Ensor, 2003) and this was reflected in our observations. Type B orcas regularly take pinnipeds, but may also take whales and penguins. The highest densities of minke whales occurred in the same areas as the highest densities of other whales with the exception of the area towards the continent of New Zealand where only 1 minke sighting was recorded. The majority of the sightings in the study area are minke whales, orcas or unidentified species. Outside of the study area, sightings of humpback, sperm, pilot and beaked whales and 2 sightings of probably dusky dolphins near the New Zealand continent were made.

The main wildlife species encountered, other than whales, were crabeater seals (*Lobodon carcinophaga*), Weddell seals (*Leptonychotes weddellii*), leopard seals (*Hydrurga leptonyx*), Ross seals (*Ommatophoca rossii*) and phocids, where species could not be determined; and adelie and emperor penguins. During the first leg of the voyage, only crabeater seals and a leopard seal were seen in the ice; the crabeater seals were frequently accompanied by pups. The second leg revealed a more productive area for seal species with the addition of Weddell and Ross seals to the tally and higher numbers crabeater and leopard seals. The highest concentrations of seals was evident along the shelf edge of the Mertz Glacier area and along the whole ship track of the second leg from around 63? down through the Ross Sea study area and up to 66? on the return leg of the voyage.

The maps of seals (Figure A.4), minke whales (Figure A.5) and other whales (Figure A.6) show a band of absence between 52? and 63? S along the ship tracks. This could be due at least in part to observer coverage, rougher sea conditions in the open ocean or to a reduction in productivity in this area. Acoustic deployments were made along the track of the ship, throughout the voyage, outside of New Zealand waters. Once deployed, each sonobuoy transmitted to the

Cetacean species	No. sightings	No. individuals
Minke whale	47	81-84
Like minke whale	13	17
Pilot whale	2	24-34
Killer whale	4	37-42
Sperm whale	2	5-6
Humpback whale	2	4
Like humpback	1	1
Bottlenose dolphin	1	3
Grey's beaked whale	1	4
Like sei	2	9-11
Unid large baleen whale	3	7
Unid large whale	2	2-3
Unid dolphin	2	4-6
Unid whale	10	14-16
Unid whale/dolphin	1	2
Total	*93*	*214-240*

Table 7: Cetacean species sighted for the voyage NBP04-08 to 3rd December 2004.

Species	No. sightings	No. individuals
Crabeater seal	222	290
Weddell seal	14	24
Ross seal	3	3
Leopard seal	5	7
Fur seal	11	12
Phocid	48	74
Total	*303*	*410*

Table 8: Seals sighted during the voyage NBP04-08 to 3rd December 2004.

ship for an average of 3 hours. A total of 82 sonobuoys were deployed, totalling over 200 hours of acoustic recordings (Figure 10).

Continuous monitoring was not possible due to visual observations and so continuous recordings were made. Whilst monitoring was undertaken, seals were heard almost continuously within the ice. Crabeater seals were the most commonly heard species (Figure A-8) and this is consistent with the visual observations made. Weddell seals (Figure A-8) and other unidentified seals were heard during the second leg of the voyage when seal species being seen were more varied. Minke whales were heard on at least one occasion in the ice, as well as killer whales and possibly humpback whales. Figure A.8 shows unidentified calls. Whilst transiting through open water a sperm whale was heard on one occasion.

Sonobuoys were deployed within a mile of large ice bergs on 2 occasions. Once within the ice edge and once in open water, in order to record any bergy sounds.

Further analysis of the recordings is needed to check for calls that were not detected. Verification of sources of unidentified calls is also required.

Small boat work was undertaken with the intention of obtaining photo-identification on one occasion. A pod of 20-25 orcas were sighted from the bridge in loose ice and were travelling at a slow pace. Due to the time taken to launch the zodiac the whales had moved into thicker ice that the zodiac could not navigate through, and photo-identifications were not possible. **[Kelly Asmus and Sarah Dolman]**

ACKNOWLEDGEMENTS

We would like to acknowledge the assistance of Ian Southey on the bridge and in the zodiac with photography and bird identifications. Ian, Scott, Rachelle, and Jay ("No Jay, that's a penguin, not a whale") for their wildlife spotting skills and Captain Rob for his 'whale vibe'. Kevin and Sheldon offered invaluable support with acoustic work. Our thanks to the Captain and crew of Edison Chouest, and the Raytheon Marine Support Team who made our work on the bridge possible and enjoyable. We would like to thank the ANSLOPE team for providing berths on their science cruise, and NSF for permission and support in participation. This work was funded by the IWC Scientific Committee and participation of S. Dolman by WDCS.

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Thiele, D. Chester, E. D. and Asmus, K. 2004. Antarctic Sea Ice: measuring complexity as it relates to habitat for minke whales. *J. Cetacean Res. Manage*. SC/56/E23.

Thiele, D. and Glasgow, D. 2004. Cetacean and Wildlife Diversity Cruise Summary. NBP04-08, AnSlope 2.

Figure A.3 Minke whale in ice (Photo by Ian Southey 2004).

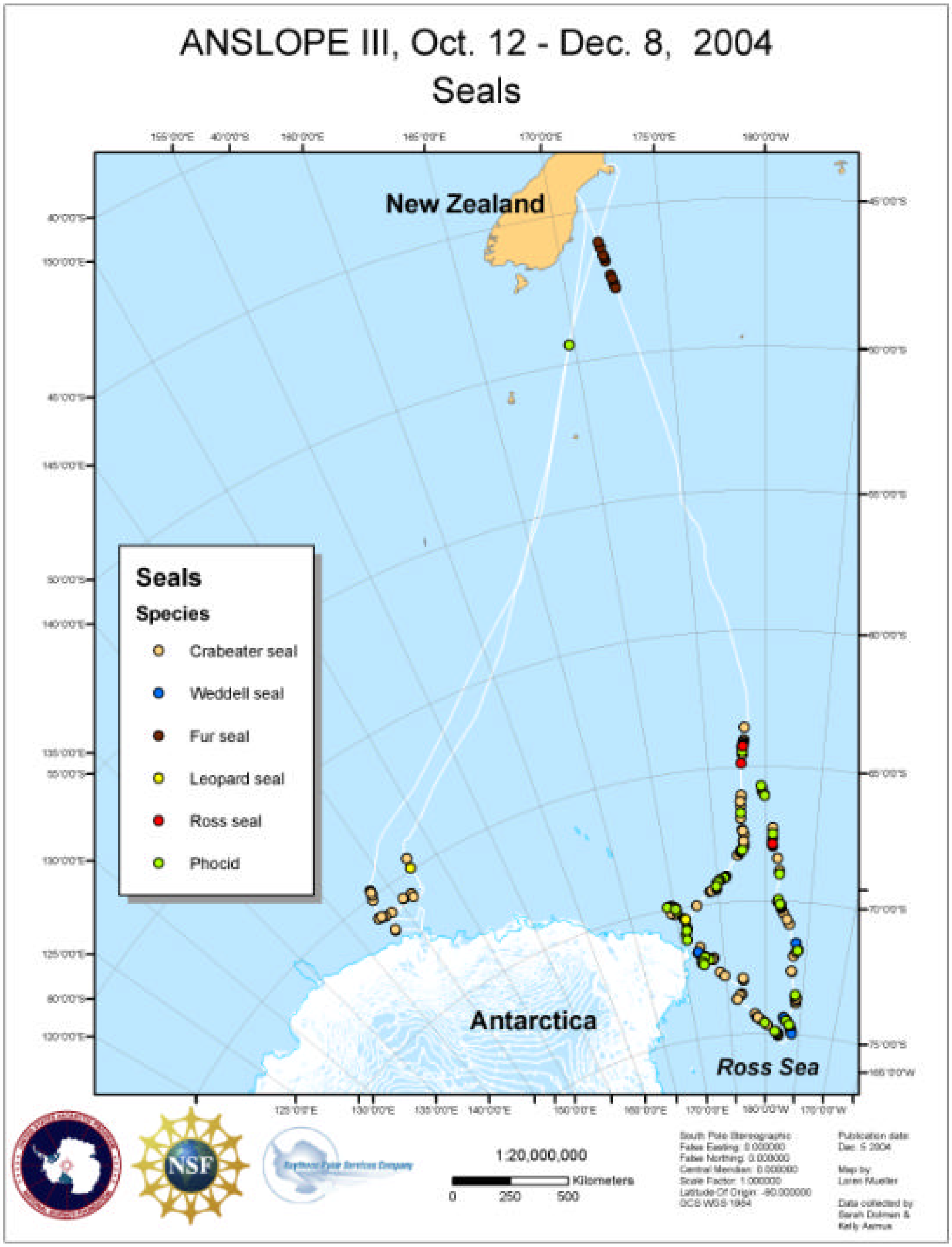


Figure A.4. Sightings of seals.

Figure A.5. Sightings of Minke whales.

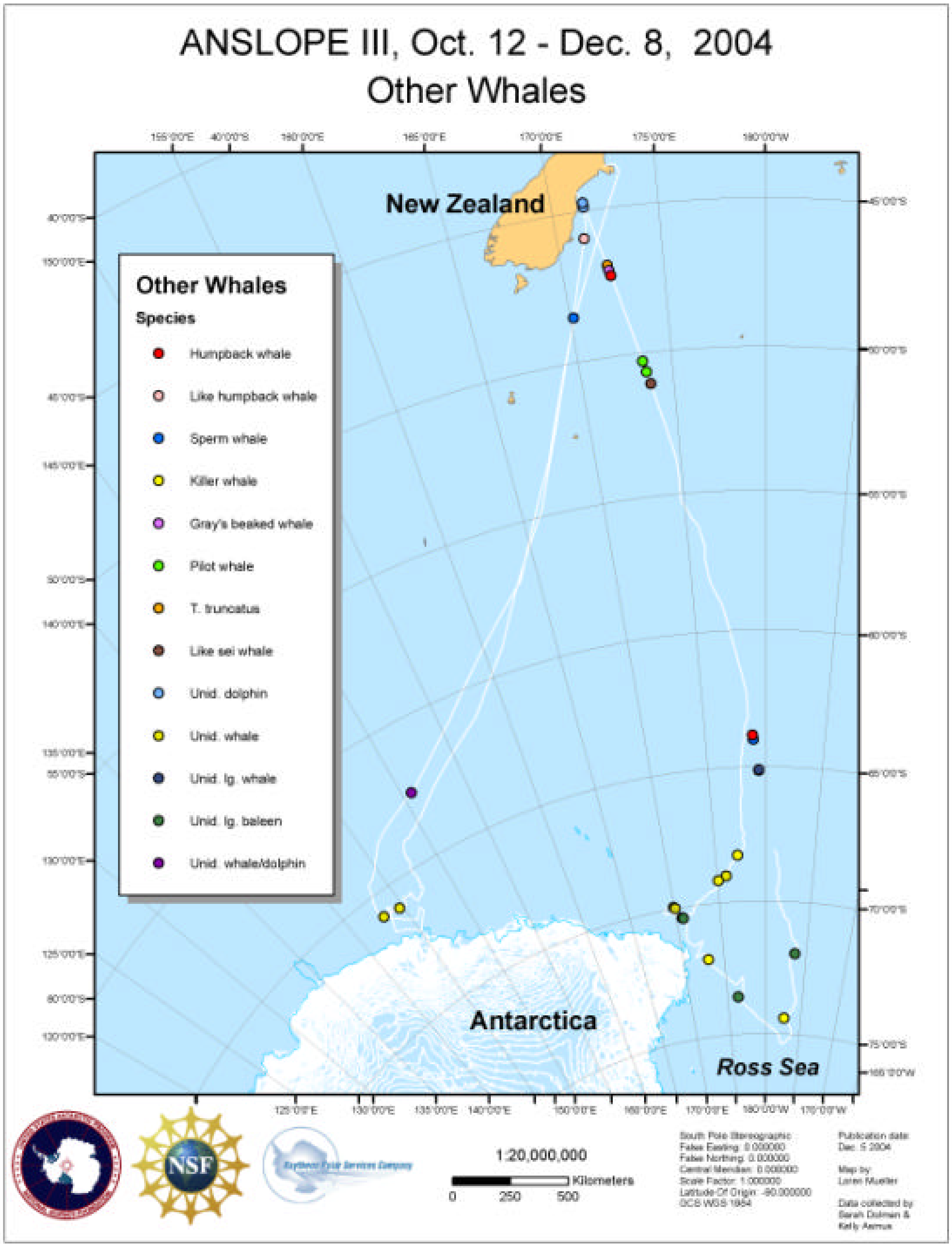


Figure A.6. Sightings of other whales than Minke whales.

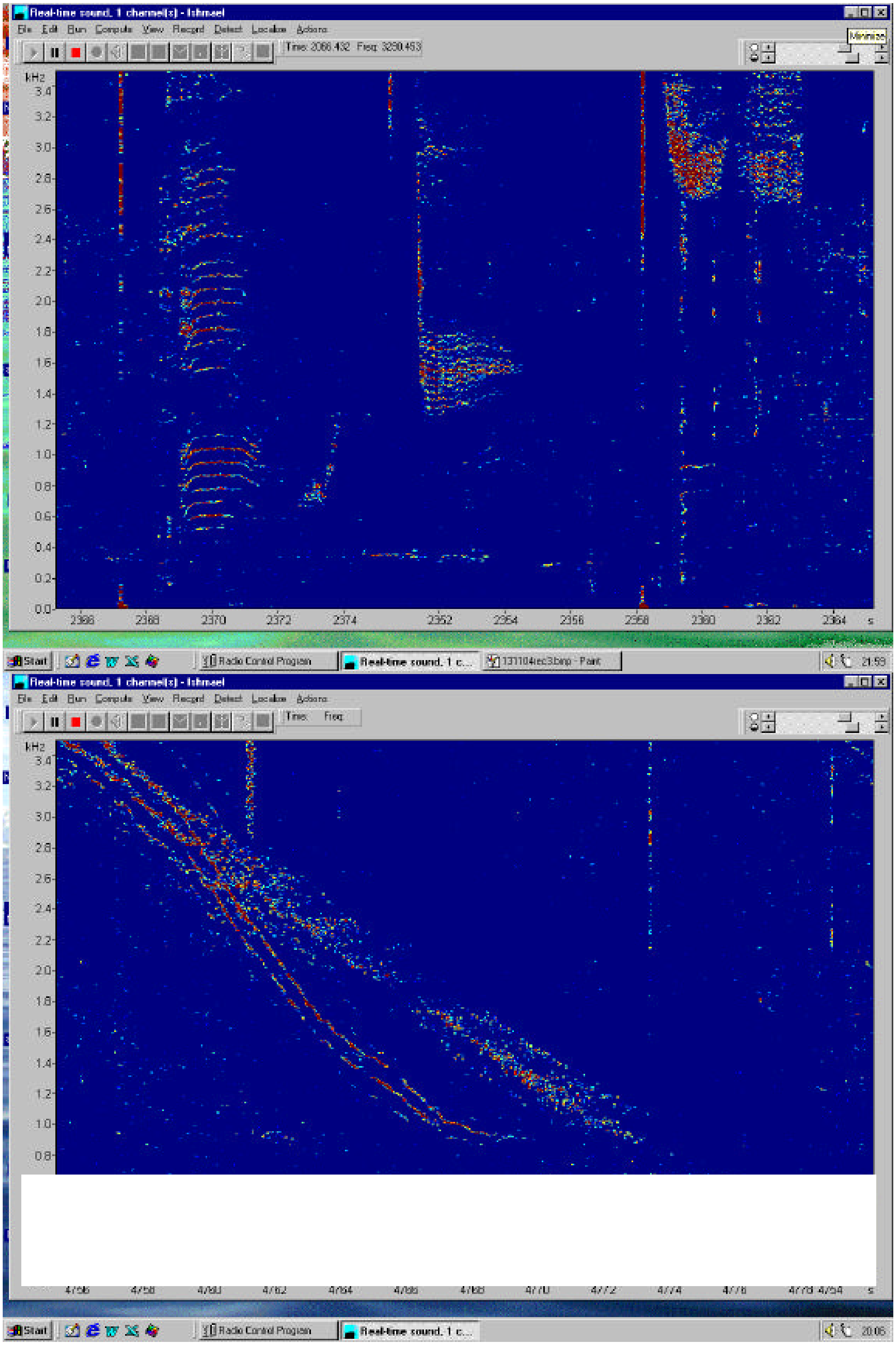


Figure A.7 Marine mammal sounds

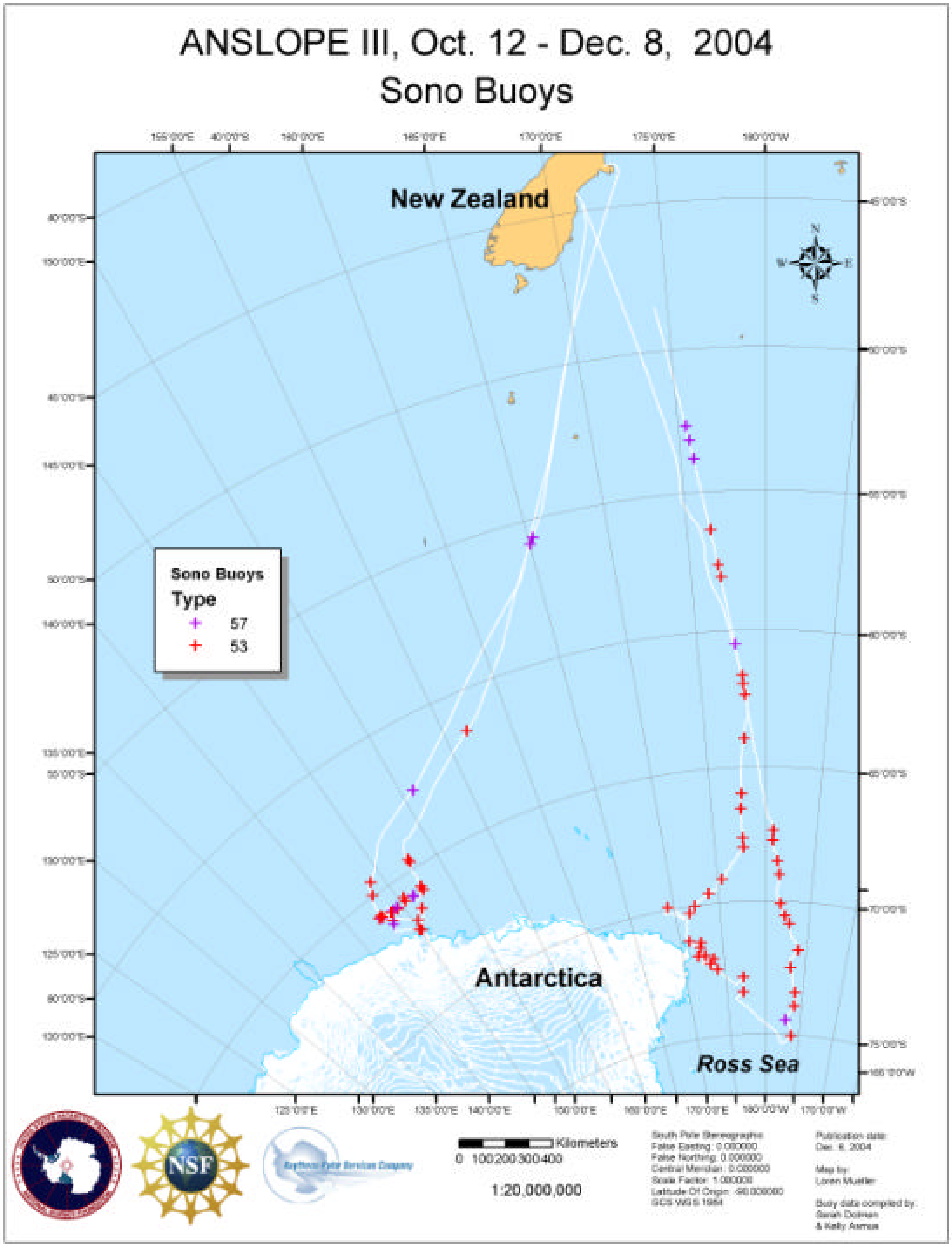


Figure A.8 Sonobuoy deployment locations.

4.3 Ornithological Observations

Birds were counted while in transit between New Zealand and the ice, and also between stations at the Mertz and Ross study sites. Numbers were assessed using point counts covering a 90^{o} arc out to 500m from whichever side of the bridge offered the best visibility. Counts were also made between these points to allow comparison with transect counts made in the 1970s. More than 5000 counts were made and these have been matched to the ship data to give positions for the observations and to allow the relationship between bird distribution and oceanographic characteristics to be examined.

The time this trip covers is an interesting period of seasonal change. Kerguelen Petrels and Blue Petrels were fairly common south of Macquarie Island on the first leg of the voyage, but rare on the others, perhaps moving closer to their breeding sites. There were also a number of returning migrants. On the first leg there were no Wilson's Storm Petrels or Arctic Terns and few South Polar Skuas in the Mertz area. The Storm Petrels and terns were in the subantarctic during the middle legs of the voyage and only seen within the ice on the homeward leg. A similarly gradual southward spread was seen in the subantarctic with Mottled Petrels and Sooty Shearwaters.

Although basically similar the Mertz study area differed from the Ross site in that Cape Pigeons and Antarctic Fulmars were found well into the ice, even to the Mertz Polynya. There were also fewer skuas there but it is possible that not all of the returning migrants had arrived.

The seas to the south of New Zealand have a rich sea bird fauna and there are definite limits the ranges of most species as well as peaks and troughs in abundance. Preliminary maps for species on the AnSlope site, for example, show some interesting patterns (Figures A.9-10). The two species of penguins, for example, seem to have complementary peaks of abundance. Emperors are concentrated in shallower water along the edge of the shelf, especially on Pennell Bank, but also on Mawson and Ross Banks. Peak densities of Adelies are in slightly different places, mainly around the upper edges of the slopes between these banks and the adjacent basins. This may related to their different feeding requirements as Emperor Penguins are known to be deep divers and can easily reach the bottom in this shallower water whereas Adelie Penguins seem adapted to hunt under the ice so depth is less important and their prey respond to other factors.

In addition to this, skuas tend to be found close to land while Wilson's Storm Petrels are along the shelf break. Snow Petrels seem to be fairly evenly distributed in comparison to the Antarctic Petrels and this may reflect a fundamental difference in the patchiness of their food sources.

Several times we saw Antarctic Petrels scavenging dead fish, most spectacularly in flocks of hundreds along the face of the Mertz Glacier. In the Ross Sea, on November 27th, six groups of birds, mainly Antarctic Petrels, were seen feeding on fairly large dead fish. Later, at 74^{o} 41'S 177^{o} 35' one of these fish was retrieved. It proved to be an obvious deepwater species, a Rat-tail (*Macrourus sp.*). How such a deepwater species became available to a surface feeder has given rise to some speculation, but it is may be of greater interest to how important these dead fish are as a food source. Large numbers of Antarctic Petrels were also noted feeding close to icebergs at times. Certainly this species was often seen roosting on bergs, but there may also be a food related connection. Unfortunately the data gathered on this cruise is not suited to addressing this question.

Thanks are due to Loren Mueller for preparing the penguin count maps. [**Ian Southey]**

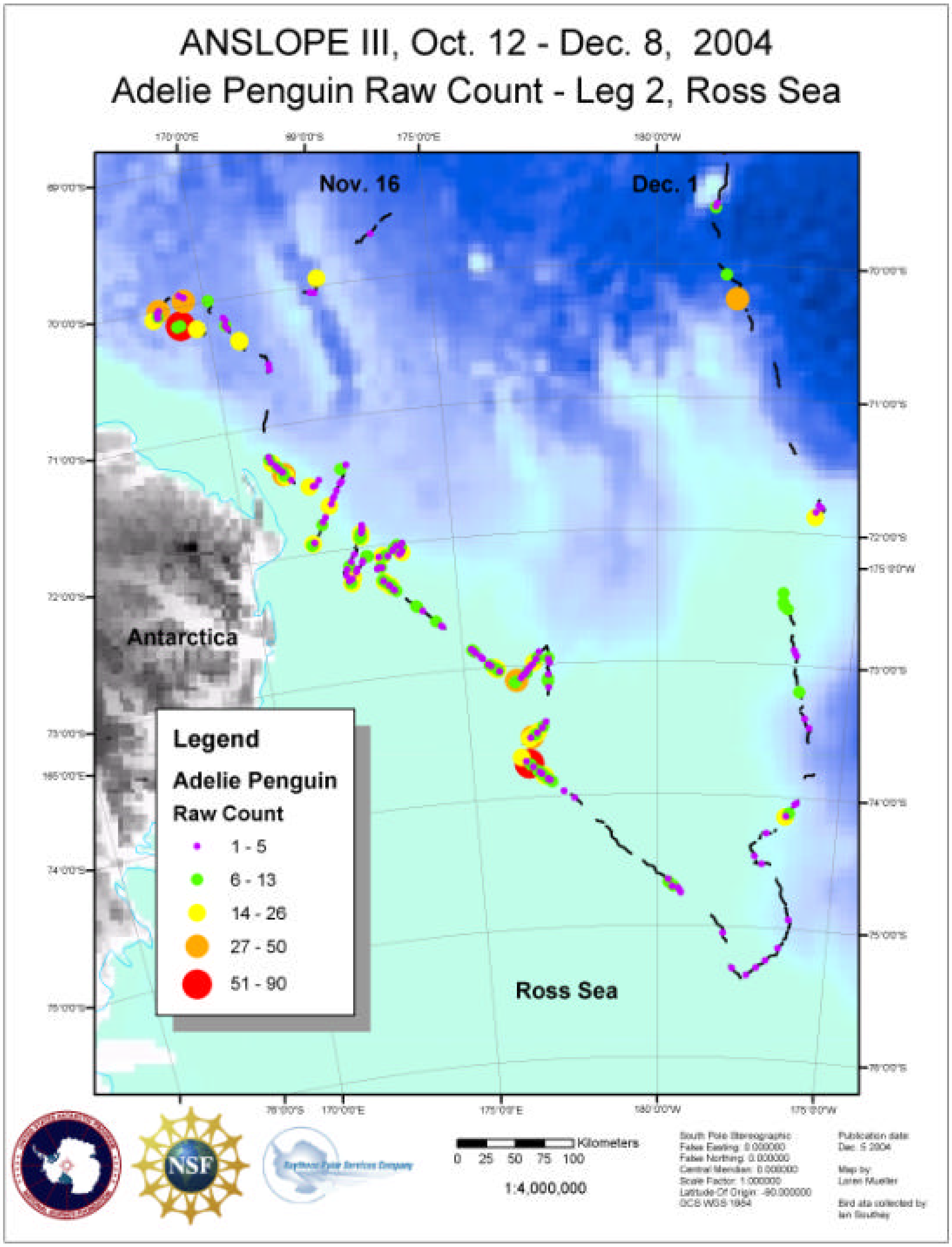


Figure A.9. Sightings of Adelie penguins.

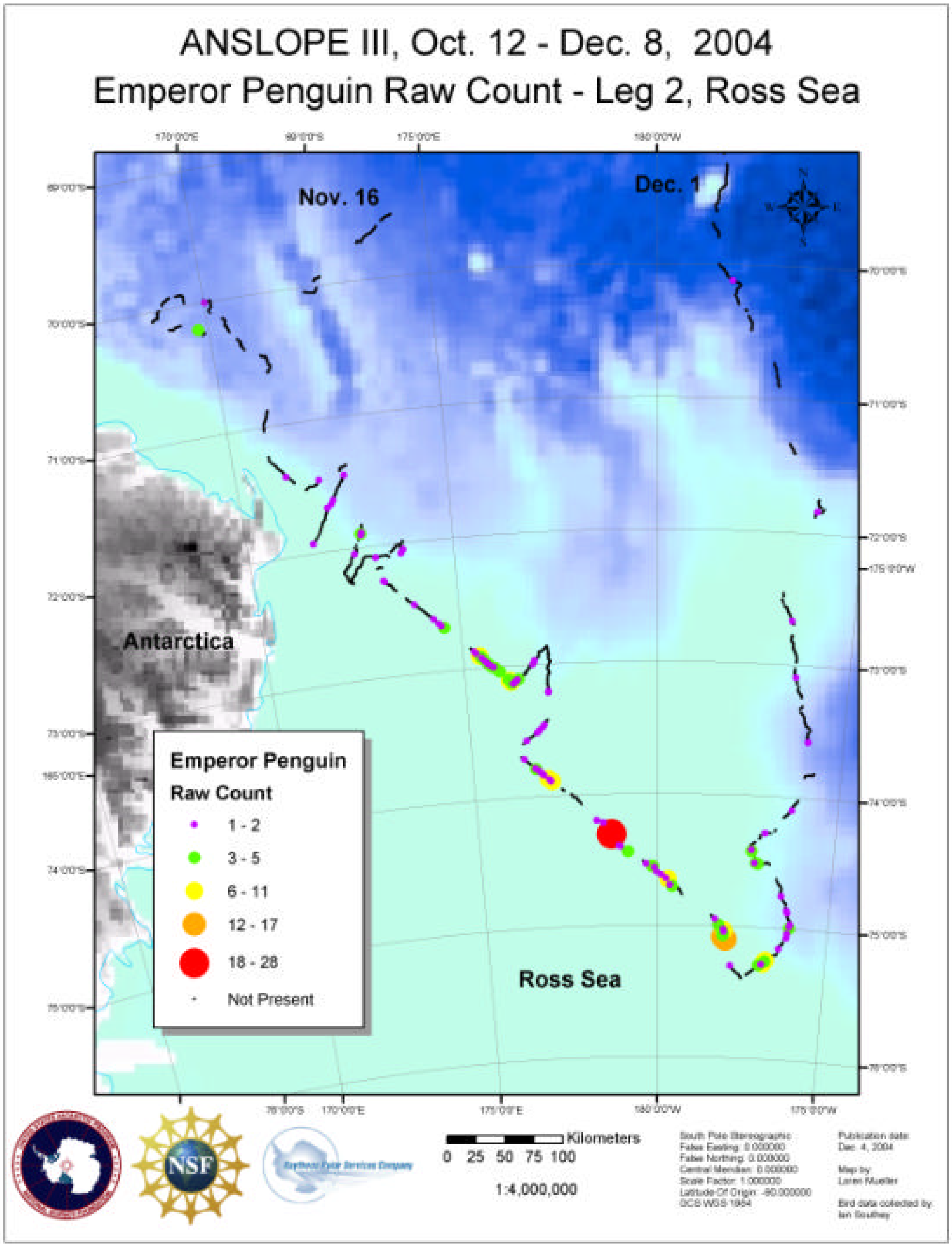


Figure A.10. Sightings of Emperor penguins.

4.4 Educational/Public Outreach

Three separate education/public outreach programs were associated with AnSlope-3 and performed by G. Krahmann, S. Dolman, and R. Robertson. G. Krahmann sent biweekly “Reports from the Field” for LDEO’s website, which described the scientific activities. Education is a key part of S. Dolman’s role at WDCS (Whale and Dolphin Conservation Society). During the voyage, she kept a daily web diary of sightings and items of interest to WDCS supporters. This diary is published on the WDCS website along with an Antarctic gallery of photographs and short video clips, as well as some examples of the marine mammal calls we have recorded.

As educational outreach, R. Robertson is collaborating with Mrs. Geoghan (principal), Mrs. Voss (6th grade), and Mrs. Tartaglione (5th grade) of George Grant Mason elementary school in Tuxedo, NY. The classes were emailed daily with the time, position, and air and water temperatures. The school is following the path of the NB Palmer during the cruise and plotting the daily temperatures. Weekly "reports" were sent to the classroom, which cover topics such as life at sea, ice, CTD, topography, water masses, or a simplified version of the science and AnSlope objectives. The class also receives a picture once a week. And a class email account has been established for the students to ask questions and interact during the cruise.

A CD is being assembled for distribution to the students and Girl Scout Troop 554. This CD will include photos of the ship, scientific instruments, computers, ice, wildlife, and life at sea, and some data, a few downsampled CTD profiles, navigation and meterological data. In addition, several contests/exercises for the students were devised. These exercises review basic vocabulary (wordfind and crossword puzzles) or the basic science (an easy step-by-step lab to investigate a couple CTD profiles and introduce concepts such as graphing, contouring, salinity, density, and water masses).

R. Robertson visited the class prior to the cruise and gave a presentation on Antarctica, salinity, and density, and a demonstration on dense plume overflow. After the cruise, she will again visit the class, reviewing the basic science concepts, answering questions, and giving a simple physical oceanography demonstration. According to Mrs. Voss, "This is NOT getting in the way of our regular teaching, it is enhancing it." (Robertson and Mrs. Voss met during the summer to go over basic concepts covered in the curricula that could be introduced or reinforced through this program.) **[Robin Robertson, with Gerd Krahmann and Sarah Dolman]**

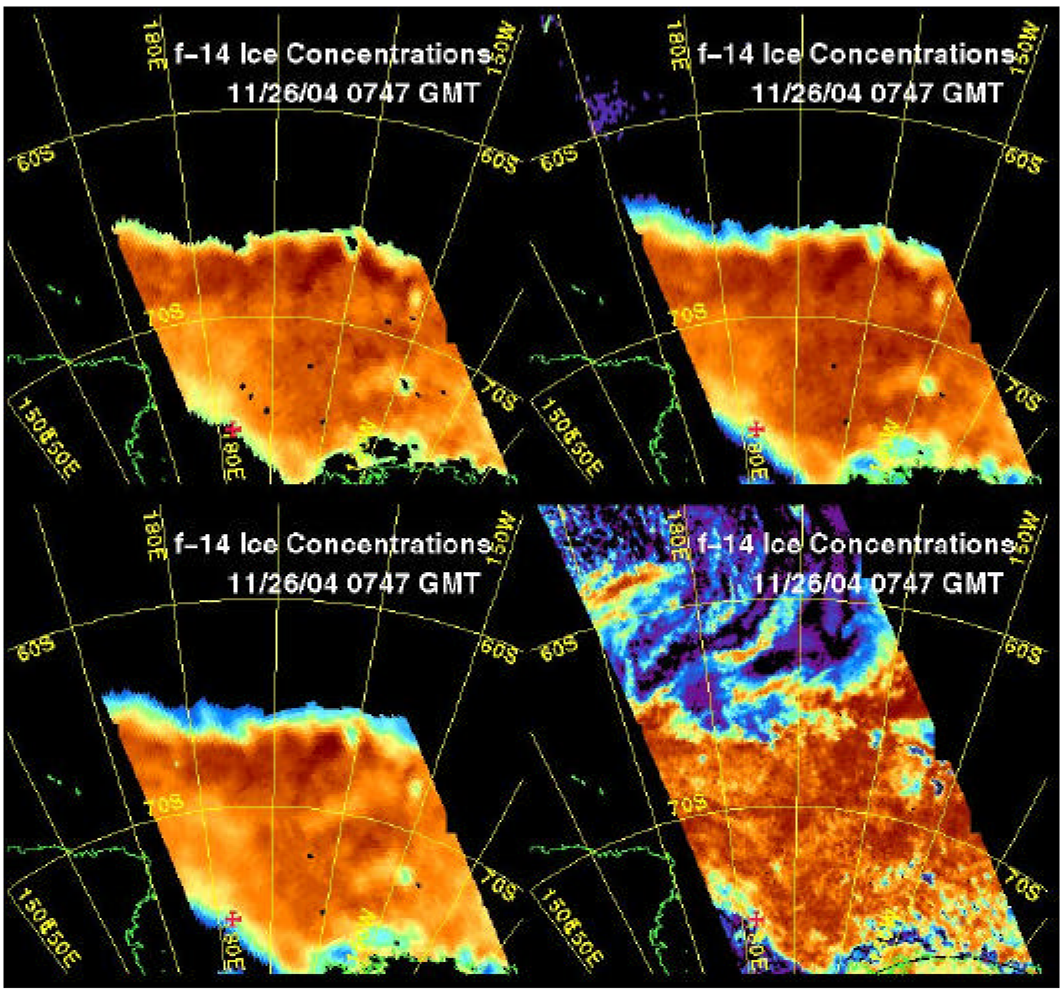
4.5 Satellite Imagery

Satellite imagery, primarily ice concentration and weather data products, were made available from a number of sources, including AMSR images emailed to the vessel by Susan Howard at ESR, various products from the National Ice Center including RadarSat, SSM/I products, and visual imagery, SSM/I and visual imagery from McMurdo Station, and locally produced imagery generated by the TeraScan equipment on board the Nathaniel B Palmer.

While AMSR and RadarSat imagery produced the highest level of detail and posses the greatest resolution, the delay in receipt of these images made them of limited value as navigation aids, however they were outstanding as planning aids. McMurdo Station provided imagery during the period when the TeraScan antenna on board the vessel was malfunctioning. The assistance of the McMurdo staff, in particular Jeff Otten, was instrumental in the success of the final portion of the first leg of the cruise. Upon receipt of parts at the refueling stop, repairs were affected to the antenna, and onboard production of imagery resumed.

Data products produced on board included visual images of weather systems and ice from both NOAA and DMSP satellites, and ice concentration images derived from DMSP SSM/I data by a variety of algorithms. At the request of the science party RPSC personnel located information on the NASA Team sea ice algorithm and forwarded it to SeaSpace for implementation. They also tracked down and generated on board an implementation of the Basic Bootstrap Algorithm for sea ice concentration.

***Air Force Algorithm*[1]**	***NASA Team Algorithm*[2]**



***Bootstrap Algorithm*[3]**	***Ice85 Algorithm*[4]**

Figure A.11: Ice concentrations processed with 4 different algorithms

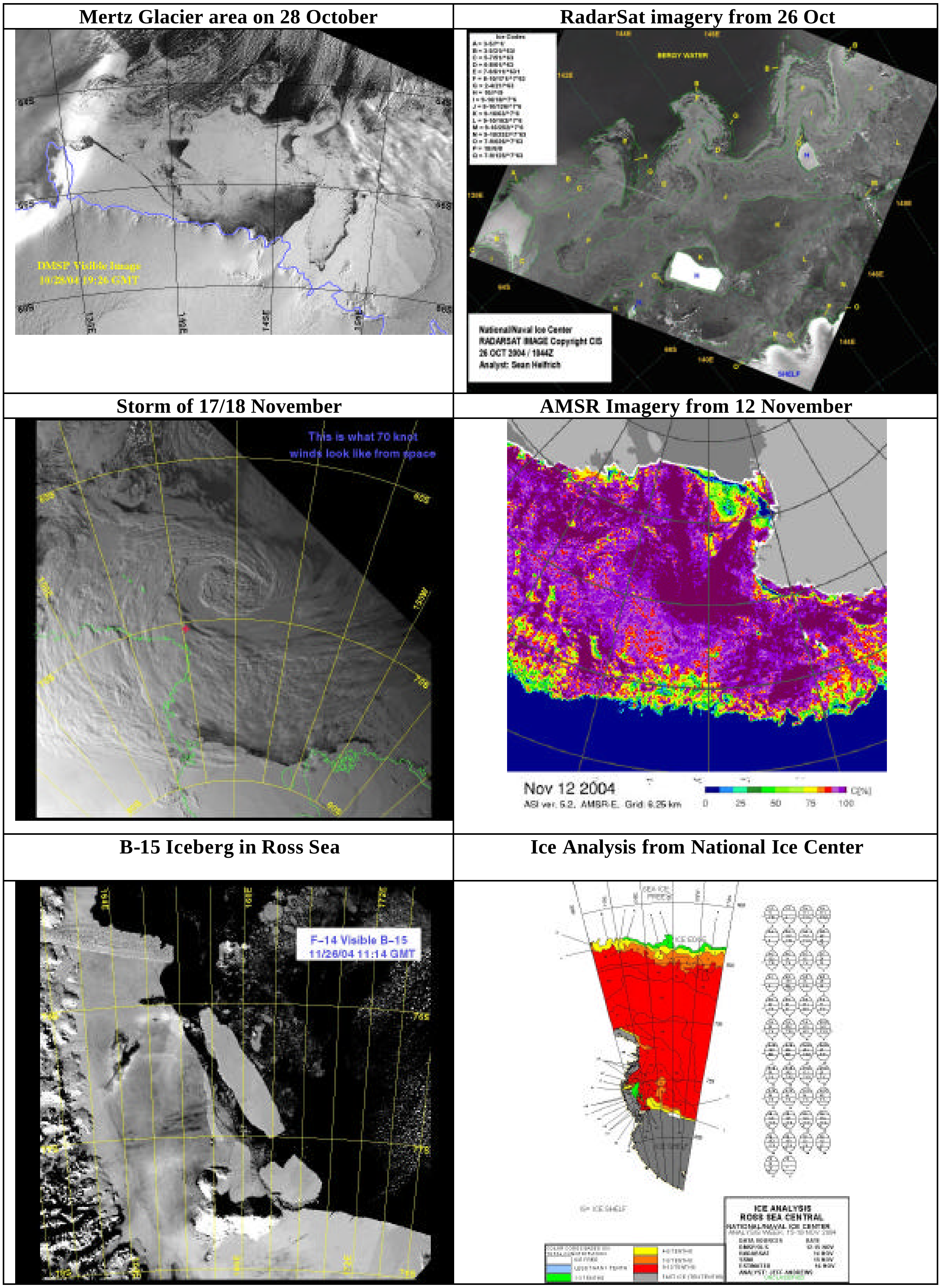


Figure A.12: Examples of other images and products

References:

1) Air Force Global Weather Center (AFGWC) D-matrix. *SSM/I Program Maintenance Manual, Manual for FNOC, (Rev B), Volume III, CDRL Item No. 013A1, March 1991.*

2) Nasa Team Algorithm: *Sea Ice Concentration Cavalieri, et al., 1991, Jour. Geoph. Res., V96, No. C12, pg. 21989*.

3) Bootstrap Algorithm: *Comiso (1986) and Comiso and Sullivan (1986). Implementation developed on board the Nathaniel B Palmer during Anslope III based on documentation from NSIDC website.*

4) Ice85 Algorithm: *Lomax (no other reference available on board Nathaniel B Palmer)*

[Kevin Pedigo]

4.6 Weekly Reports

Week 1

The NB Palmer departed Lyttelton, NZ, early on 13 October and struck a course toward 65S, 150E. That course did not take it into the Ross Sea, as long planned for this AnSlope cruise, as a severe fuel usage constraint imposed by RPSC at the outset made it impractical to try and reach the official AnSlope study area at this time of year. In the roughly 30 days we may be able to squeeze out of the allotted 200,000 gallons, travel time estimates showed that we would be lucky to reach the planned study area much before it was time to turn around and head north.

In an attempt to salvage some generic AnSlope work from the remnants of this crippled cruise, we opted to try and access the Antarctic continental margin in the vicinity of 145E, where a much narrower band of pack lies between the ice edge and continental shelf break. We obtained comparative oceanographic data in that sector nearly four years ago on NBP00-08. While its slope front is not as sharply defined as that in the Ross Sea, it is a known region of bottom water formation, modified deep water intrusion onto the continental shelf, and strong interleaving and bottom boundary layers over the continental slope.

During the first week of 04-08, the NBP reached the vicinity of the ice edge near 150E. Forward progress was a bit slower than anticipated, in part because of a fuel-saving pace (6100 gpd avg), but also because of two storms and the usual strong westerlies and eastward currents. Enroute we have completed an XBT transect extending from the southern end of the Campbell Plateau to the ice edge. That upper ocean thermal section followed a successful test station with the CTD/rosette, and was supplemented by underway sampling for nutrients, dissolved oxygen, CFCs, oxygen isotopes, salinity and total CO_2, in turn complemented by the continuous recording of sea surface temperature, salinity, fluorescence, pCO_2, the usual meteorological parameters, currents via ADCPs and trackline bathymetry.

Meetings were held to outline the science that can likely be accomplished on the reconfigured NBP04-08, to organize the XBT transect and underway sampling project, and to brief involved and other interested individuals on the recording of sea ice parameters via Aspect protocols. Communications have been established pursuant to selecting an appropriate refueling port at the end of the current mini-cruise.

<u>Lowered and Ship-mounted ADCP</u>: After attaching the lowered ADCP package to the CTD rosette as on the
previous two ANSLOPE cruises, a test cast that included one modified RDI workhorse ADCP delivered good data. A small leak in the battery housing led to installation of the spare battery system after the cast. Since the recent Auckland drydock, the ship-mounted ADCP now includes the standard 150kHZ system and a newly installed 38kHz system. Both have been recording data continuously, and processed velocities are now available in near real time after initial problems with the software. For the first few days the 38kHz system recorded data down to 1200m depth, but that range later dropped to 800m and

occasionally to 600m. Whether this lower range is caused by the lately rougher sea state or by fewer scatterers in the water column is not yet clear.
Nutrients in Seawater: The instrumentation for nutrient analysis was assembled and firmly attached to the working table in the after dry lab, where all the utilities for survey activity were arranged. The sampling system was tested during a CTD cast (46°03.06'S; 171°55.01'E) during which seawater samples were collected at the bottom, 1000m and surface from 6 Niskin bottles in order to verify the reproducibility of analysis method and sampling procedure. Starting on October 15th, at 19.00 GMT at 54°09.417'S; 166°43.267'E, and coincident with XBT casts at nominal intervals of ~10 nautical miles, underway seawater samples were collected, filtered (using glass microfibre filters) and stored at -80°C until analysis. Nutrient determination will begin on board as soon as a sufficient number of samples have been accumulated.

Whale Observations: No cetaceans have been observed from the bridge so far in 89 hours of visual observation since departure. This is at least in part due to poor sighting conditions. After resolving technical difficulties with the acoustic equipment, the first successful sonobuoy deployment has occurred. Analysis of acoustic data will occur after the voyage.

G. Krahmann, S. Massolo, A. Campanelli and S. Dolman have contributed to this report. Please let us know if you receive more than one copy (we do not yet know who is on the 'mo-sciweekly@usap.gov' distribution list), or prefer not to receive future reports.

RPSC and ECO shipboard support has been commendable for the week that was.

SS Jacobs
At sea on the NBP; ~64S, 148E
20 OCT 2004

Week 2

From 20-26 October, the NB Palmer worked in the sea ice over the Antarctic continental rise, slope and outer shelf, between 142 and 148E. Thirty seven CTD/rosette casts were completed, most in cross-slope and along-slope transects, plus several XBT casts across the western sill of this shelf sector. Dedicated work with the ESR vertical microstructure profiler (VMP) focused on the upper slope near 143 34E.
The sea ice cover has rarely dropped below 9/10-10/10, and with air temperatures usually between -5 and -15C, new ice is still forming in open water areas. Most of the ice encountered is 1st-year, and its thickness has been manageable at 30-50 cm. That is fortunate, as the ship's TerasScan receiver failed within a day of our arrival on site. We are hopeful that a replacement spare part will be available at our next port call. With the ship taking advantage of leads that often parallel the shelf break, only at the western end of this region did heavily ridged ice seriously hamper forward progress. This may have resulted from the blocking effect of an iceberg with rough dimensions of 40x15 miles. From satellite visible imagery taken on 22 and 25 October, obtained from McMurdo, one corner of that berg appears to have caught on the shoal directly west of the above sill, inducing a CCW rotation.

The CTD/rosette equipment has performed well, albeit with a few spikes of undiagnosed origin and a puzzling lack of any apparent scattering according to the two deep transmissometers. We are basically seeing a 'late-winter' regime that is qualitatively similar to the summer conditions observed on NBP00-08. Below the deep mixed layer, a broad frontal region is characterized by extensive lateral interleaving between cold, fresh shelf and slope waters and the 'warm' deep water. Substantial differences appear between vertical profiles several kilometers apart, and on successive cycles of yo-yo casts. Water with thermohaline and chemical properties strongly influenced by shelf waters is found near bottom at many stations on the slope, and attenuated deep water intrusions are reaching at least the outer continental shelf.

Previous seafloor mapping efforts, primarily on NBP00-08, suggest a rougher bottom on the slope here than in the western Ross, but available bathymetry is barely adequate to guide our sampling efforts. Indeed, when traveling through the pack, the ship must typically be stopped to obtain reliable depth and ADCP data. The ship's ADCPs have been performing very well in open water and on-station. The new 38 kHz Ocean Surveyor has provided good data to 800-1000 m, or 80% of the water depth. The most significant flow is a bottom-trapped westward current of 20-30 cm/s on the upper slope. The VMP has made 22 profiles from the sea surface to ~800 m depth in that depth range, revealing strong intrusions and energetic vertical mixing between the deep and shelf water.

On all 37 CTD stations, nutrient seawater samples (302) were collected from Niskin bottles at depths determined by the CTD vertical profiles, filtered, and stored at -80°C until analysis. Silicate and phosphate analyses have been completed, and nitrate plus nitrite for the first 21 stations. Preliminary evidence shows the highest nutrient concentrations at the Tmax and O2min of the CDW core. Underway samples (108) taken the previous week reveal a sharp increase in nutrient concentrations, in particular for silicate, from 58°S to 60°S, coincident with a strong decrease in temperature. Nitrite concentrations were undetectable (< 0.02 ºM) in all samples.

As one of our educational outreach efforts, R Robertson is collaborating with teachers at the GG Mason elementary school in Tuxedo, NY, by sending two classes the daily time, position, and air and water temperatures, which they are plotting. Weekly reports sent to the classroom include a picture and cover topics such as life at sea, ice, CTD work, bathymetry, water masses, or a simplified version of the science objectives. An email account has been established for the students to ask questions and interact with us during the cruise. A CD ROM is being assembled showing photos of the ship, scientific instruments, computers, ice, wildlife, etc, along with a few ocean profiles and some meterological data. Several contests/exercises are being developed to review basic vocabulary and science, including concepts such as graphing, contouring, and water properties. Dr. Robertson visited the school prior to the cruise and gave a presentation on Antarctica, salinity and density, and a demonstration of dense plume overflow. She also conferred with one of the teachers, going over basic concepts in the curricula that could be introduced or reinforced through this program.

L Padman, S Massolo, A Campanelli, and R Robertson have contributed to this report.

The sturdy RPSC and ECO shipboard support makes all the difference down here. We also thank J Otten, A Archer, S Howard, B Huber and R Kwok for assistance in

obtaining satellite imagery of the sea ice cover. Fuel usage during the 2nd week of this cruise has averaged 6100 gpd (range 3800-8500 gpd).

SS Jacobs
In the ice on the NBP; ~65 50S, 144 30E
27OCT04

Week 3

From 27 October through 02 November, the NB Palmer completed AnSlope project work along the Antarctic continental margin off George V Coast, including a circuit of the Adelie Trough and downwind (western) side of the Mertz Glacier Tongue. Forty one CTD-O/rosette stations were occupied over the slope and shelf region, along with VMP profiling near the MGT. Late in the week the NBP emerged from the ice and set course for a required pit stop, in Timaru NZ, resuming XBT casts and underway sampling of geochemical parameters.

CFC-11, CFC-12, and CFC-13 contents have been measured on 667 water samples from 77 stations since the beginning of the cruise. Reproducibility was 1.2% for CFC-11, 0.6% for CFC-12, and 1.7% for CFC-113. During the southbound transit, the ship's uncontaminated seawater line was sampled every two hours, coincident with XBT deployments. Underway samples and water drawn from the surface water bottle on several CTD stations agree within 2%, and suggest increasing entrainment of deep water toward the southern end of the section. Measurements of the CFC content in air have been made using the intake from the underway pCO2 system, and that sampling will continue as wind conditions allow.

The sea ice cover, logged hourly via AsPect protocols, was again mostly 9/10-10/10 concentration, but thinned southward to mostly open water near the coastline. New ice formation was occurring in that environment, with most of the standard forms represented, from frazil to grease ice, shuga, nilas, thin finger-rafted sheets with small frost flowers and pancakes. Winds gusting around 50 kts cost us one station, and with air temperatures as low as -20C, dense 'sea smoke' initially obscured the lower end of the MGT. Katabatic outflow from the ice sheet produced some interesting small-scale structure down to ~400m in the water column, but ceased about as soon as the ship was set up for VMP profiling. According to satellite visible imagery provided from McMurdo and RPSC Denver, the Mertz and related polynyas extended over a wide area at the time, nearly reaching the continental shelf break along the usual line of grounded icebergs NE of the MGT, with implications for direct input of shelf water to the slope regime.

The sea ice observers, aided by the AsPect background materials if not by more experienced hands aboard, would have preferred to have started out with new ice in the polynya, followed by a progression northward into the thicker, multiyear floes. Nonetheless, they have benefited from the wide range of ice types presented, and have also recorded ice thickness and type, floe size, rafting, ridging and snow cover. The thickness information, in combination with satellite-derived areal drift, will allow estimates of freshwater transport off the shelf via the snow and ice. The observers find the AsPect nomenclature to be more logically formatted than the WMO 'Egg Code,' typically applied to analyses of satellite passive microwave data. That code is also being applied to the Radarsat images we receive periodically from the NIC, including a very good 26 Oct picture of this study area, forwarded only two days after being taken.

Our excursion deep onto the narrow shelf in this sector was designed to sample the dense shelf water end member involved in mixing near the Antarctic Slope Front, including its Ice Shelf Water (glacial melt) component. In addition, it provided comparative data for summer observations obtained in this region in early 2001, and a quick look at late winter Modified Circumpolar Deep Water penetration onto the shelf. The latter was weak, judging by the stations occupied, with the Tmax/O2min relatively shallow vs summer measurements. Whether this results from weak or intermittent inflow or from strong vertical mixing remains to be determined, but the latter is consistent with slightly increasing CFC concentrations with depth in the shelf water columns.

There have been 31 whale observations, of 62 animals, so far during the voyage and over 500 hours of acoustic recordings have been made. Although almost exclusively minke whales were encountered in the ice, sightings include a probable Gray's beaked whale. Twenty sightings of crabeater seals were recorded on our way out of the ice, the majority of which were female and pup pairs, many with a male escort Seabird observations are also being made along the ship's track, with the highest Emperor and Adelie penguin densities over or near the continental slope, as expected from earlier work. Somewhat more surprising was a concentration of many hundreds of Antarctic Petrels in a narrow band close to the MGT, and their near absence in the rest of the polynya. The petrels appeared to be feeding on material embedded in the (light) nilas and grease ice.

D Lebel, D Franklin, I Southey and S Dolman have contributed to this report. We thank the galley staff for the (over)abundance of good food, and RPSC MTs A Coward and A West for their careful work during long hours on the repetitive CTD stations. Fuel usage for the days that included ice operations averaged 6277 gpd, a potentially useful statistic for future work in this area at this time of year.

SS Jacobs
On the route to Timaru; ~58 44S, 160 19E
03NOV04

Week 4

From 03 through 09 November, the NB Palmer returned to NZ for refueling (169,222 gal), accomplished during a 28 hr layover at Timaru on 06/07 Nov, and then headed south for the Ross Sea. This saved about a day's transit time relative to Lyttelton, less than would have been the case at Bluff (Invercargill), where sufficient fuel was unavailable, or (Port Chalmers (Dunedin), where channel depth was a problem. While in port, the ship's TeraScan receiver was repaired by ETs K Pedigo and S Blackman, using a replacement part acquired from SeaSpace. We are also obtaining helpful sea ice imagery from the NIC, ESR and McMurdo, the current objective being to identify alternative routes through close pack to the continental slope.

On the northbound transect, hourly XBT casts were made between the ice edge and the southwest end of the Campbell Plateau, accompanied by underway sampling for CFCs, dissolved oxygen, nutrients, salinity total CO2 and oxygen isotopes. At the end of that line, a CTD station was occupied to test a new cable end termination, along with leak testing of bottles closed near the surface and cycled to depth. The underway sampling was resumed shortly after leaving Timaru, and an XBT transect started near 51S.

Preliminary results along the transects are so far unremarkable for the season, an exception being some interesting gas undersaturations.

S Dolman reports that marine mammal encounters have been more diverse during the ship's open ocean transects than previously observed in the ice. A total of 10 cetacean sightings, of 44 animals, included sperm, humpback and minke whales, pilot whales, bottlenose dolphins, dusky dolphins and Gray's beaked whales. There were also 11 sightings of fur seals after leaving port as we ran parallel to the NZ coast. As we have been transecting through NZ waters, no acoustic recordings have been made in the last 7 days.

During the first leg of NBP04-08, which lasted about 25 days, about half of our time was spent in transit to the ice edge, and roughly 1/3 of the 'in ice' time on station, i.e., with the CTD or VMP in the water. In retrospect, the increase in transit time on 04-08 would have provided opportunities for multibeam work, support for which was not requested due to the anticipated 50 days in the ice. Aside from the time in port, fuel usage during the past week has varied from 12,200 to 5,700 gpd for SOGs of ~13.3 to 9.8 kts, both in good weather.

We thank the RPSC personnel and ship's agent who went out of their way to accommodate the brief but first NBP port call at Timaru.

SS Jacobs
Pitching and Rolling southward at 8 kts
10 NOV 04

Week 5

From 10 through 16 November, the NB Palmer tracked southward from New Zealand toward the AnSlope study area in the western Ross Sea, entering the outer fringe of sea ice early on 13 Nov. Progress since then has been negatively correlated with latitude, but by taking advantage of a fair distribution of leads the ship has been able to avoid many of the harder, more heavily ridged floes. Of course this makes the track resemble a drunken walk and will bias the Aspect sea ice observations, but that is well understood by the principals, and we hope by all who may subsequently try to utilize that data set. In addition, the satellite imagery has drawn us in a SW direction toward a persistent flaw lead along the fast ice edge NW of Cape Adare. The betting now is on whether that lead will close before we get there, in response to the recently persistent easterlies, apparently associated with a low pressure system that has lingered to the west for several days, and now seems to be moving in on us.

The third cross-ACC XBT transect was continued into the ice on this leg, with the ship stopping briefly for deep T-5 deployments and less briefly for shallow/deep CTD casts at half-degree latitude intervals. T & S results are consistent with the long-term trends we have reported for the upper water column of the Ross Gyre. Underway surface sampling was likewise continued into the pack, where late-winter conditions still prevail, including some parameters as much as 50% below saturation. Fortunately the surface mixed layers are deep, usually >100m, as we have found evidence for ship-generated turbulence extending more than 40m into the water column. This raises some question about the representativeness of 'surface' samples taken on typical CTD/rosette stations, including their use for inferences about ocean- sea ice interactions.

The ship's ADCP systems have continued to perform well when the vessel has been in open water, although data loss was significant during the high sea state accompanying last week's storm. At other times before the ice edge was reached, the 38 kHz Ocean Surveyor system has reported currents to depths exceeding 1200 m, i.e., roughly 4 times the penetration of the original (and still active) 150 kHz system. For some days following the storm, oscillating currents at near-inertial frequencies were observed, with amplitudes of 20-40 cm/s. We note that these significant currents complicate the process of assessing current strengths associated with Southern Ocean and ice edge frontal features.

At ~2:28 AM (local ship time) on 16 Nov two of the science party observed a "green flash" accompanying sunrise. The flash lasted several seconds, and was confined to a fairly small region of the horizon around the rising sun. Unfortunately, we must take them at their word for this, along with the contention that they were even awake at that hour, given the dearth of ongoing station ops and other science tasks. Indeed, some folks have taken to giving slide shows and knitting classes in an attempt to ward off the boredom of our turtle-like transit. Others have taken advantage of the lull in station work to test different nutrient sample storage techniques, particularly for silicate, to intercompare standard solutions, experiment with filters prepared in different ways, and to analyze CTD vs rosette results in dissolved oxygen and salinity.

Fourteen minke and six killer whales have been sighted since entering the ice, most in the last day or two. In one seemingly unproductive area, 5 orcas were observed, including a male with a large triangular dorsal fin and 4 female/juveniles with smaller fins. The male approached the ship and was at one point bow riding while the females/juveniles remained at least 150 meters away. We also encountered a Ross seal and numerous crabeaters, including a dead pup. Acoustic recordings have provided a great variety of interesting marine mammal calls.

For the potential benefit of those who may in the future also be sentenced to sisyphian transits on this lobster boat, in order to reach their divined destinations, a few more words about fuel usage. Given reasonable weather (only one storm), two engines and props at 75% pitch, one can expect to reach the mid-Nov ice edge in five days from NZ, consuming 6040 gpd of fuel in the process. Allowing four more days for travel through the pack, frequently with 4 engines and variable pitch (including reverse) should bring the nbp to at least 70S, on an average of 7425 gpd. At that point it will be located roughly 200 nm north of the mouth of a continental shelf trough, curiously misnamed Joides Basin, and about 500 nm from McMurdo, as the skua flies. And since drm7 has so far been unable to persuade those big bergs to kedge northward out of the increasingly congested area near Ross Island, one can wonder whether more than seabirds will make it all the way to Hut Pt this year, or next.

We thank the several individuals and agencies who continue to supply us with tempting satellite imagery, and the ETs who have repaired the XBT cable and Terascan software, and are again keeping a weather eye on the intermittently re-spiking CTD data stream.

L Padman, S Massolo, D LeBel, A Campanelli, S Dolman and K Asmus have contributed to this report, but neither they nor our sponsors should be held liable for its loosely edited content.

SS Jacobs
Over the Adare Trough
17 NOV 04

Week 6

At the end of the prior week, we had crossed the east wall of Adare Trough, and at that point the sea ice conditions and weather rapidly deteriorated. Many hours were consumed setting up and completing a CTD cast into the Trough, which was found to be more hydrologically interesting than we had been led to believe. The water column below wall height is distinctly colder and fresher than outside the Trough, an indication that this feature may serve as a conduit for northward bottom water flow. Working slowly westward, only one station was completed at the deep end of an intended cross-slope transect before a major storm shut down operations and caused substantial northward drift of the NBP. The storm also closed off a persistent flaw lead that had been our objective, and led to more than two days of slow SE progress through heavily ridged ice to regain the AnSlope working area.

Following that episode, the weather ameliorated substantially, and we have completed several cross-slope transects near and downstream of the Drygalski Trough. The results are somewhat surprising, in that little if any high salinity shelf water was observed on the slope, currents were not particularly strong, and the ASF was well south of the continental shelf break. Indeed, ocean conditions are not markedly different than what was recorded during the earlier late-summer AnSlope cruises in this area. While there are several possible explanations for this situation, including our timing vs the tidal cycle, a more complete understanding will await analysis of the full AnSlope data sets. It seems increasingly likely however, that these data will challenge received wisdom on the hoary topic of bottom water formation. This week ended with a 24-hr VMP station in progress near the mouth of the Drygalski Trough

The sea ice encountered in this Ross Sea study area has been much different from that observed during our colder, late October leg along George V Coast. Air temperatures during recent days have mostly remained above -5°C, near which sea ice undergoes important structural changes. The seawater has often been above freezing, sometimes > -1.3 degrees, probably due to the predominance of upwelled deep water in the near-surface layers. This may also contribute to typically lower ice concentrations observed in satellite imagery over banks on the outer shelf. Nilas formed when the sun was at it's lowest, but melted during the day, and melting snow and slush ponds were widespread. Strong winds earlier in the week caused differential movement of the floes, giving rise to more brash ice and ridging than may be usual for the Ross sector.

Although our working area this week has been close to large colonies of Emperor Penguins, relatively few have been seen from the NBP. Adelie Penguins have been widespread, however, especially along the slope. Snow Petrels have also been widespread, and often common, but in contrast to the Mertz study area, fewer Antarctic Petrels and no Antarctic Fulmars have been seen. Giant Petrels, on the other hand, seem more common and their plumage suggests young, presumably non-breeding birds.

Wilson's Storm Petrels and South Polar Skuas have appeared or become more common but, as returning migrants, it is hard to say if this difference is related to the change in site or season. Marine mammal sightings over the last week have included a probable Fin Whale, 22 Minkes, 9 unidentified whales, a pod of 6 Killer Whales as well as Weddell, Leopard and Crabeater seals. Acoustic monitoring has produced a variety of sounds that have not been recorded previously on this voyage, including probable Weddell seals and odontocetes (toothed whales).

For those who may be interested in the continuing fuel follies saga, a brief update. From 17 through 23 November we consumed 48,400 gallons of the precious shiply fluids, ranging from a low of 4,000 while drifting on station to a high of 10,100 while backing and ramming through heavily ridged ice. One likely impact of such heavy net consumption will be a reduction in the remaining number of days that can be devoted to science, prior to our transit back to an oil pier. An informal request for an additional 10% allowance over the official 200k gallon fuel restriction was denied by NSF. Plans are thus being hatched to drift for a few weeks, make offerings of excess desserts to the weather gods, and/or to expend more NBP time than necessary in LYT harbor.

I Southey and S Dolman contributed to this report. Special thanks to K Pedigo, who bit the bullet that SeaSpace had not, tracked down the elusive Comiso Bootstrap algorithm, wrote the script necessary to convert passive microwave brightness temperatures to ice concentrations, and implemented same on the ship's TeraScan. In the process, he demonstrated that one must be careful what one asks for, since the resulting images are, for operational purposes, inferior to Ice 85 and not substantially different from the more commonly used 'NASA Team.'

SS Jacobs
Adrift on the NBP
24 NOV 04

Week 7

During the final week of November we worked eastward along the continental slope and outer shelf of the Ross Sea, and northward along the east side of Iselin Bank. Sections into and across the Joides Trough revealed conditions similar to those encountered to the west near the Drygalski sill, albeit with slightly higher near-bottom salinities. Areas of open water within the pack appeared to be more common over the slope and outer banks than directly to their north and south, consistent with model results and satellite imagery. Ice Shelf Water was found in its usual location south of the shelf break in Challenger Trough, and was not located on the adjacent continental slope. Deep ocean conditions prevailed east of the Iselin, with relatively weak indications of local bottom water formation at most sites. Except for CFC work, the geochemical tracer sampling was reduced accordingly.

The severely limited NBP endurance shortened the 6-7 weeks anticipated in the Ross study area to less than 2 weeks. This only allowed time for a quick survey in lieu of the more detailed measurements that had been planned. In particular, our observations were made at whatever portion of the tidal cycle happened to coincide with our track. Results may thus not represent mean conditons, nor the short term extremes, as the tides in this area have a strong influence on frontal location, as well as flows on and off the continental shelf. In addition, the regional near-surface environment may again have been anomalous, this time resulting in part from the large storm noted in last week's report. While both AnSlope 1 and 2 encountered heavier than usual ice for late summer, our spring work has taken place directly seaward of the rapidly expanding Ross Polynya, in one of its larger manifestations during this season in many years. Nonetheless, the overall impression gained is one of an ASF dominated by the interplay between 'warm' deep water and 'fresh' shelf water.

As the week drew to a close under the midnight sun, petrels alighted in a small polynya near the ship as the last CTD/rosette cast of the cruise, #142, was completed. It was the deepest station we occupied, and resembled A-2-192 on the other side of the deep passage south of Julia Seamount. A few hundred meters above bottom, even fresher layers of lower salinity water than observed in March disrupted an otherwise monotonic profile. Considerably more CTD casts had been anticipated on the initially scheduled 65-day cruise, but, in combination with 60 VMP profiles, the number accomplished is not unreasonable for the time available in the study areas at this time of year. In the process, we demonstrated the feasibility of carrying out process studies in both the shelf break region and in coastal polynyas during the austral spring. What remains to be determined for largescale studies is how much advantage that confers over summer measurements of the resulting end products.

This week S. Dolman and I. Southey reported 4 sightings of 6 Minke whales, a group of 8 - 10 large unidentified baleen whales (probably Sei) and a pod of 20-25 Orcas, including at least two mothers with calves. Weddell, Leopard and Crabeater seals have all been recorded. Almost continuous seal calls have been heard during acoustic monitoring, including some calls not previously recorded on this voyage. Relatively high numbers of birds during transits across the shelf tapered off rapidly as we crossed the slope into deeper water. Emperor Penguins were particularly notable in one outer shelf area, as were grounded icebergs, and high densities of Antarctic Petrels were also seen locally. In contrast, few Skuas have been encountered now we have moved away from land. A 3hr sortie in one of the ship's zodiacs in pursuit of Orca photo IDs was not successful, but returned a 50cm specimen of *Macrouras sp*, a Rat tail. This reminded us of earlier observations of several small groups of petrels - Antarctic, Wilson's Storm and Snow, hovering over a single dead fish, and of similar scavenging noted earlier near the Mertz Glacier Tongue. How such deepwater fish become available to these surface feeding birds, and whether they constitute an important diet component are questions for our readers.

SS Jacobs
Enroute to Middle Earth
30 NOV 04

Week 8
TBA