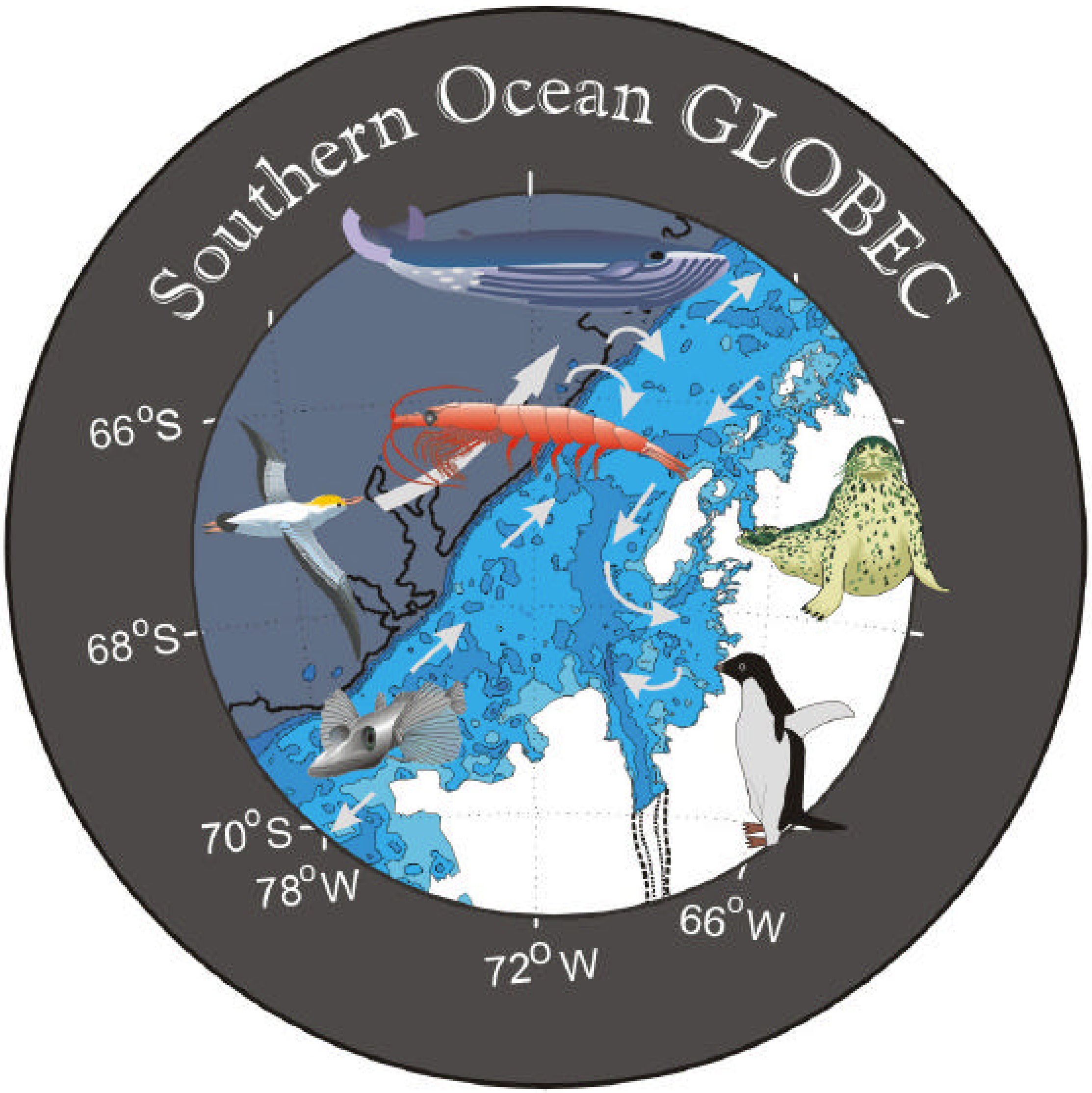
Report of
R/V *Laurence M. Gould* Cruise LMG02-03
to the
Western Antarctic Peninsula
7 April to 21 May 2002



United States Southern Ocean
Global Ocean Ecosystems Dynamics Program
Report Number 5

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to the
Western Antarctic Peninsula
7 April to 21 May 2002

Report was prepared by J. Torres, J. Burns, C. Denker, K. Daly, S.-J. Ju, A. Friedlaender, M. Zhou, J. Morin, with considerable assistance from our colleagues in the science party, our Raytheon Polar Services crew, and the Captain and crew of the R/V *Laurence M. Gould*.

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Acknowledgments

A grateful scientific party would like to extend their sincere thanks to our friends on the *Laurence M. Gould* for making our cruise a successful one. To Steve Ager, Christian McDonald, and Josh Spillane for help on deck, in the Zodiacs, under the ocean, in the shop, with logistics and damn near everything else. To Fred Stuart and Andy Nunn for keeping our MOCNESS nets running, emails flowing, DAS system recording, and CTDs dunking. To Mo Hodgins for keeping our chems straight, our chlorophyll green, and our hazmats out of doors. To Jeff Morin for CTD deployments and nutrient analyses beyond the call of duty, particularly on the ammonia front. To Captain Robert Verret, chief mate Jesse Gans, 2nd mate Jay Bouzigard, and 3rd mate Alan Arrigoni for plain and fancy boat driving, pinnacle avoidance, putting up with our schedule changes, and generally keeping us all safe. To Chief Engineer Mike Murphy, 1st engineer Paul Waters, 2nd engineer Gerry Tompsett, and our two oilers Noli Tamayo, and Donde Dasoy for keeping us afloat and moving, even when declutched on the starboard side. To Mark Stone, Luciano Albornoz, and Marisol Albornoz for 42 days of great meals and great desserts. To Fernando Naraga and Efren Prado for all their help on the winches, and Rafael Sabino and Luis Ojeda for their general help on deck and keeping our boat spotless. We thank you one and all.

LMG02-03 Cruise Participants

(see facing page)

Row 1 (L-R): Jeff Morin, Ester Quintana-Rizzo, Se-Jong Ju, Ryan Dorland

Row 2 (L-R): Mo Hodgins, Ann Petersen, Chris Denker, Yiwu Zhu, Jenn Burns, Susan Klosterhaus, Jose Torres

Row 3 (L-R): Joel Bellucci, Melanie Parker, Fred Stuart, Jason Zimmerman, Kerri Scolardi, Brett Pickering, Kendra Daly, Andy Nunn, Steve Ager, Joe Smith, Gitte McDonald, Mark Hindell, Meng Zhou, Millie Gray, Ari Friedlaender

Missing from picture: Christian McDonald, Josh Spillane

This composite picture of the LMG02-03 science party with the mountains of Port Lockroy in the background was created by Joel Bellucci, also known as "Mr. Wizard".

LMG02-03 Cruise Participants

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1.0 PURPOSE OF THE CRUISE

1.1 Objectives

The overall goal of the Southern Ocean Global Ocean Ecosystems Dynamics (SO GLOBEC) program is to elucidate shelf circulation processes and their effect on sea ice formation and Antarctic krill (*Euphausia superba*) distribution, and to examine the factors that govern krill survivorship and availability to higher trophic levels, including seals, penguins, and whales.

The SOGLOBEC field effort in its second year consisted of a series of five cruises within the fall-winter time frame. The initial cruise during late March-early April (LMG02-01A) was a stand-alone effort to deploy current meter moorings and passive acoustic devices for monitoring marine mammal populations. Moorings were successfully deployed across the mouth of Marguerite Bay on the western Antarctic Peninsula continental shelf. The program quickly followed the mooring cruise with a series of two cruises using two vessels working in tandem, sampling in a survey grid centered on Marguerite Bay. Cruises took place during the austral fall period from early April through May (LMG02-03, NBP02-02), and during the winter from late July through August (LMG02-05, NBP02-04). The two vessels working in tandem had two distinctly different missions. The survey vessel was primarily charged with conducting a broad scale survey to provide a shelf-wide picture of hydrography, circulation, and krill distribution. The process cruise was designed to provide detailed information on selected sites within the survey grid.

This is the report of the third process cruise (LMG02-03), which took place from 7 April to 21 May 2002. We were the sister cruise to the fall survey, NBP02-02. A listing of the scientific activities on LMG02-03 is given in Appendix 1. Our mission was to examine in detail several elements of the biology of the target species, *Euphausia superba*, at a series of approximately five previously chosen process stations nested within the survey grid. Our specific objectives were:

1) **To determine the abundance and distribution of *Euphausia superba* using Multiple Opening and Closing nets (MOC-1 and MOC-10), Acoustic Doppler Current Profiler (ADCP) surveys, acoustic surveys with a towed body, and when sea ice was present, using SCUBA surveys underneath the ice;**
2) **To describe the krill predator field using visual surveys, satellite tags, and diet analysis for sampling whales, penguins and seals, and MOC-10 nets and acoustics for sampling fish;**
3) **To describe the physiological status of *Euphausia superba* at each of the process stations using measurements of respiration, excretion, growth, feeding and egestion rates; and**
4) **To collect hydrographic data, chlorophyll data, and nutrient data to better understand the krill's environment and prey spectrum.**

1.2 The Process Study Sites

The process sites were chosen either because they represented a habitat type, or because they were associated with important elements of bottom topography, or both. Process site 1 was located at the shelf break along the axis of the main across-shelf trough, Marguerite Trough, that runs from the shelf break through the mouth of Marguerite Bay and into George VI Sound, an embayment at the southeastern corner of Marguerite Bay. Process site 1 allowed us to sample a typical oceanic fauna at the oceanic depths seaward of the shelf break, and by moving inshore, at depths more typical of the shelf. As such, it really had two parts: "A and B". Both sampling sites were at the mouth of the Marguerite Trough, a topographic feature that the program considered to be an important potential conduit for bringing oceanic water and fauna deep into the Bay. Process site 2 was located in the mouth of Marguerite Bay over the axis of Marguerite Trough. It allowed access to depths typical of the shelf (500 m) and the greater depths typical of the canyon itself (800-1000 m).

Process sites 4 and 5 were both created to sample habitats deep within the Bay. The location of site 4 gave the program access to the fast ice at the southern end of George VI Sound. At the same time it allowed sampling in the southernmost leg of the Marguerite Trough. Process site 5 allowed access to the deep fjords east of Adelaide Island, areas where both seals and penguins were believed to spend time in the fall and winter. Process site 6 was a mini-station in the vicinity of Neny Fjord, affording our group access to typical shelf depths (400-500 m) deep within the Bay and access to a newly forming ice edge. Process site 7 was the Crystal Sound region north and east of Adelaide Island. It was chosen as part of the suite of process sites because it was a favored location for seals during the last austral winter, as reported by satellite tags. (Note: Process site 3 in Lazarev Bay was not occupied due to sea ice conditions.)

<u>Projects represented on the process cruise</u>

BG-232-0	Dan Costa and Jennifer Burns - Seal ecology
BG-234-0	Bill Fraser - Seabird ecology
BG-236-0	Kendra Daly - Krill ecology and physiology
BG-237-0	Rodger Harvey - Krill biochemistry
OG-238-0	Laurie Padman - Mesoscale circulation and hydrography
OG-240-0	Eileen Hofmann - Circulation, hydrography, modeling
BG-239-0	John Hildebrand-Cetacean biology
BG-245-0	Jose Torres - Krill and fish ecology, krill physiology
BG-248-0	Meng Zhou - Krill ecology, behavior, and modeling

Nutrient Analyses - Jeff Morin

<u>Cruise overview</u>

07 APRIL 02	LMG02-03 departed Punta Arenas, Chile
12 APRIL 02	LMG02-03 arrived Palmer Station
13 APRIL 02	LMG02-03 departed Palmer Station for first study site, process site 7, Crystal Sound and Hanusse Bay on the western Antarctic Peninsula Shelf. Visited Vernadsky Station enroute, dropping off supplies and taking advantage of the available time in quiet water to calibrate our HTI 120/38 acoustic system.
14 APRIL 02	Arrived process site 7, initiated sampling.
17 APRIL 02	Departed process site 7
18 APRIL 02	Arrived at Avian Island, dropped off penguin field party, began process site 5: Laubeuf Fjord.
20 APRIL 02	Dropped off seal field party at Rothera Base, continued with process site 5 operations.
23 APRIL 02	Rendezvoused with RVIB *Palmer*, departed process site 5
24 APRIL 02	Arrived process site 1, initiated sampling
27 APRIL 02	Departed process site 1
28 APRIL 02	Arrived Avian Island, picked up penguin field party. Departed Avian Island, arrived at Rothera Base to pick up seal field party.
29 APRIL 02	Acoustic survey south of Adelaide Island
30 APRIL 02	Transit to process site 4 - arrive at 1500 process site 4A
5 MAY 02	Transit and arrival at process site 4B
6 MAY 02	Transit and arrival at process site 2
7 MAY 02	Depart process site 2
8 MAY 02	Arrive Avian Island - penguin operations, acoustic survey- depart for process site 6
9 MAY 02	Arrive process site 6
11 MAY 02	Depart process site 6 - whale survey
12 MAY 02	Reoccupy process site 7- whale and seal sampling
12 MAY 02	Survey science continues, all other science ended

14 MAY 02	Arrive Palmer Station
16 MAY 02	Depart Palmer Station
20 MAY 02	Arrive Punta Arenas, Chile

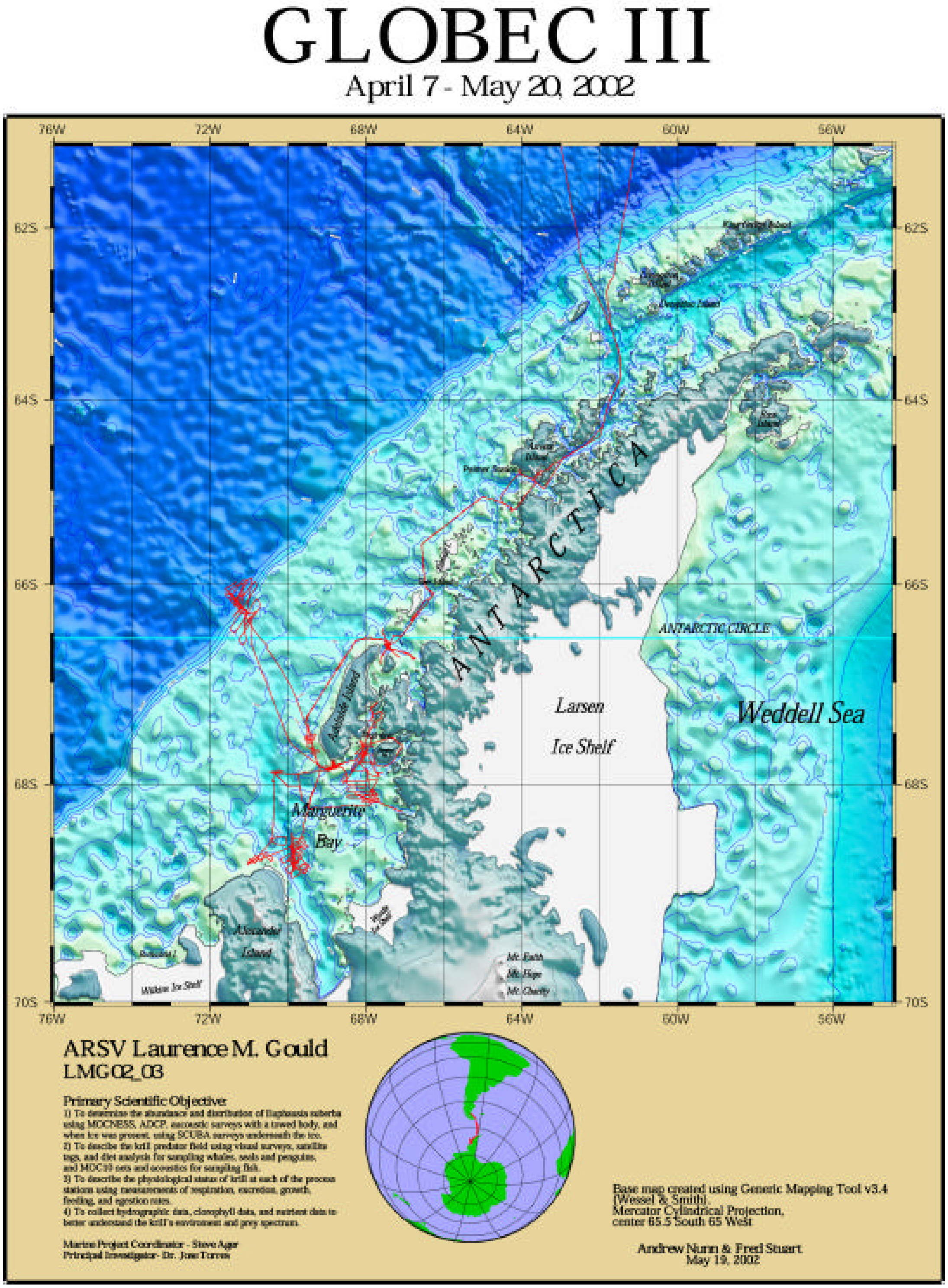


Figure 1. The complete cruise track of LMG02-03. Map by Andy Nunn and Fred Stuart.

2.0 PART I: THE TRANSIT TO THE STUDY SITE (CRUISE DAYS 07 APRIL TO 13 APRIL INCLUSIVE)

Synopsis

The first week of the cruise was entirely taken up with transit from Punta Arenas, Chile to Palmer Station, offloading of cargo, and shore-based cruise preparation. Prior to departure from Punta Arenas, 34,000 pounds of excess cargo had to be offloaded because the *L.M. Gould* (LMG) was sitting too low in the water. This was successfully accomplished causing only a slight delay in our estimated departure time and we were on our way at 1530. Our transit across Drake Passage was blustery with winds varying from 25-45 kts out of the west and southwest, and seas from 4-6 m.

Activities at Palmer Station included cargo offloading, instrument calibration, and a checkout dive for our process cruise dive team. In addition, we took advantage of our stay to finish assembling the MOC-10 and MOC1 nets. Deck space was at a premium during the transit due to the large amounts of cargo going south, which precluded us finishing the net assembly prior to departure.

Overall, our ship's crew and our Raytheon Polar Services Company (RPSC) support have been outstanding. Our scientific gear was waiting for us on the LMG when we arrived so unpacking and setting up the labs went quickly and smoothly. Moreover, the large amounts of materiel we needed to bring south required juggling scientific and cargo shuttle demands. It was a difficult balance and it was handled well. Our scientific party is enthusiastic and morale across the board is high.

3.0 PART II: THE FIRST TWO WEEKS OF SCIENCE (CRUISE DAYS 14 APRIL TO 28 APRIL INCLUSIVE)

Synopsis

During the first two weeks of the cruise, three process sites were completed. Our shipboard operations were complemented by the stand-alone field efforts of our seal and penguin teams during the LMG's offshore sampling.

Process site 7 was created as a mini-station during the last 2 days of LMG01-04, the fall 2001 process cruise (see U.S. SO GLOBEC Report No. 1), when we found it to be an area of high krill abundance. Tagged seals used it extensively as a hunting area during the winter of 2001. It clearly merited further study and was chosen as our first study site for 2002. It is bounded on the north by the northern end of Lavoisier Island, on the south by the southern end of Hanusse Bay, on the west by Matha Strait, and the east by longitude 66° 30'W.

We arrived at site 7 at first light and began our operations with a successful seal survey along the east coast of Lavoisier Island, which set the tone for what was a terrific cruise. We have followed a strategy similar to last year's process cruise which is to devote the lion's share of daylight hours to the projects that are most light dependent, viz. our seal and penguin projects. One very clear difference between this year and last year is the presence of considerable sea ice left over as relic floes from last year's winter cover, and sea surface temperatures over 1ºC colder.

During our stay at site 7, we completed three conductivity-temperature-depth (CTD) casts, two MOC-10 tows, two MOC-1 tows, and two ADCP/HTI surveys, in addition to six Tucker trawls and a large suite of lab experiments. Our seal team instrumented and worked up four seals, and our penguin team sampled diets in two Adélie penguins. At completion of our sampling in the Crystal Sound region we originally planned to move south down the "inside track", staying to the east of Adelaide Island by skirting the west coast of Laird Island down through Hanusse Bay, into Tickle Passage, through The Gullet, and through the Barlas Channel and down into Laubeuf Fjord, our process site 5. Unfortunately, we were stymied by heavy sea ice cover in southern Hanusse Bay, an area that was totally ice free on 29 May 2001. Consequently, we ran around the west coast of Adelaide Island to reach Avian Island, and to enter Laubeuf Fjord from the south.

At site 5, following the drop-off of our penguin team at Avian Island, we began an ADCP/HTI survey covering the mouth of Laubeuf Fjord and running the length of it to Day Island. At the conclusion of the survey, we resumed our day/night division of labor with MOC-10 and MOC-1 tows dominating the hours of darkness and seal/whale operations during the day. At site 5, we introduced diving into our daylight repertoire to look for *Euphausia superba* furcilia under the scattered ice floes in Laubeuf Fjord. We saw no furcilia under the ice on our first dive, in spite of considerable amounts of "brown ice" in the floes around us.

We dropped off our seal team at Rothera Base on 20 April and immediately began an ADCP/HTI survey back and forth across Laubeuf Fjord during the course of a tidal cycle. The purpose of the survey was to allow us to get an idea of the tidal influence on circulation through Laubeuf Fjord, as well as distribution and movement of krill over a well defined area through time.

We towed our MOC-10 and MOC-1 nets intensively during our last two days to get a net's eye view of diel distribution patterns prior to our departure for process site 1. Our rendezvous with the *N.B. Palmer* went seamlessly, with an exchange of chemicals and a brief visit by Captain Robert of the LMG to the *Palmer* Bridge. Directly after our rendezvous we headed out to the treacherous waters at the shelf break to complete our process site 1.

Site 1 was divided into two stations, one at oceanic depths (>3,000 m), which was dubbed station 1A, and one at shelf depths (500 m), which we termed station 1B. We arrived at station 1A in the wee hours of 24 April (0100) and initiated our sampling with an ADCP grid across the shelf break followed by a MOC-1 tow and a CTD cast. Our nighttime sampling included Tucker trawls for live animals and MOC-10/HTI deployments. Winds were moderately high, 25-35 kts, but the sea stayed a workable 2-3 m for our first 12 hours.

Our schedule continued with our days divided between CTD casts, Tucker trawls, and MOC-10's/HTI deployments from noon to midnight and ADCP surveys and MOC-1 tows from midnight to noon. We stayed a total of four days at site 1, losing our third day to weather. We completed five MOC-10 tows, eight Tucker trawls, three CTD casts, six MOC-1 tows, three ADCP surveys, and several deployments of the HTI acoustic system before departing. The weather hovered at the limits of a working sea for the LMG most of the time, with winds running from 25-45 kts and seas from 3-5 m.

Our last day for the present (bi) weekly report, 28 May, included our transit and smooth pickup of our penguin team at Avian Island and the pickup of our seal team at Rothera Base. Process site 1 was the first location where we captured krill larvae in quantity.

Individual group reports

BG 232 - Seal ecology and physiology - Burns/Costa

Week 1: 7-13 April

Our team (Jennifer Burns, Gitte McDonald, Millie Gray, Mark Hindell) arrived in Punta Arenas, Chile on 4 April 2002, and had a easy move onto the ship. RPSC had done a great job with orders and gear sorting, and with few exceptions, everything we needed was available. [two ordering glitches – two cases rather than two bottles of lidocaine-HCL; 15 oz. epoxy bottles rather than 50 ml epoxy cartridges, both easily dealt with]. We unpacked into our lab space, and battened everything down for the transit south. At Palmer Station, we did some work in the radiation van, which was used first by our group and others to weigh chemicals on land (as the bio lab at *Palmer* was under construction). Thanks to Steve Ager and the marine technicians (MTs) who were willing to load the van off and on the ship during a busy port call so that we could do our science preparations. We enjoyed the time at Palmer station, and recorded one tagged and branded (ST 0) southern elephant seal. We are working to track down the 'owner' of the brand so that we can report the sighting appropriately.

Week 2: 14-20 April

On the morning of 14 April, the ship was at the northern tip of Lavoisier Island in Crystal Sound. This area was a hot-spot for seals throughout the winter last year, and we were interested in characterizing the region on this cruise. The eastern coastline of Lavoisier was an ice cliff into the water, and fog lowered visibility considerably. However, as we approached the southern tip of the Island, we entered an area with several large ice floes, three of which had crabeater seals hauled out. We took the Zodiac out, and captured and deployed a satellite tag on the first crabeater seal of the 2002 U.S. SO GLOBEC cruises (Event #20). The seal was a small female, and all procedures (weight, blood sampling, measurements, body condition, blood volume, tissue samples) went well. A good start that was promptly followed on 15 April, when we realized that Crystal Sound was a hotspot for crabeater seals in the fall, as well as the late winter. The ship was in the area around 66° 45.225'W, 66° 46.555'S and we were surrounded by large floes with multiple seals on them. In one day we saw more seals than we had seen during the entire cruise last fall. After a little difficulty with very alert and active seals, and with floes not being stable enough for us to work on safely, we located a floe on which 3 seals were hauled out. We successfully captured and tagged a male on the floe (PTT 13363), and then immediately moved on and captured one of the females that had remained on the floe (PTT 13365, Event #29). All procedures worked well, and we have refined our methods slightly to increase speed and efficiency.

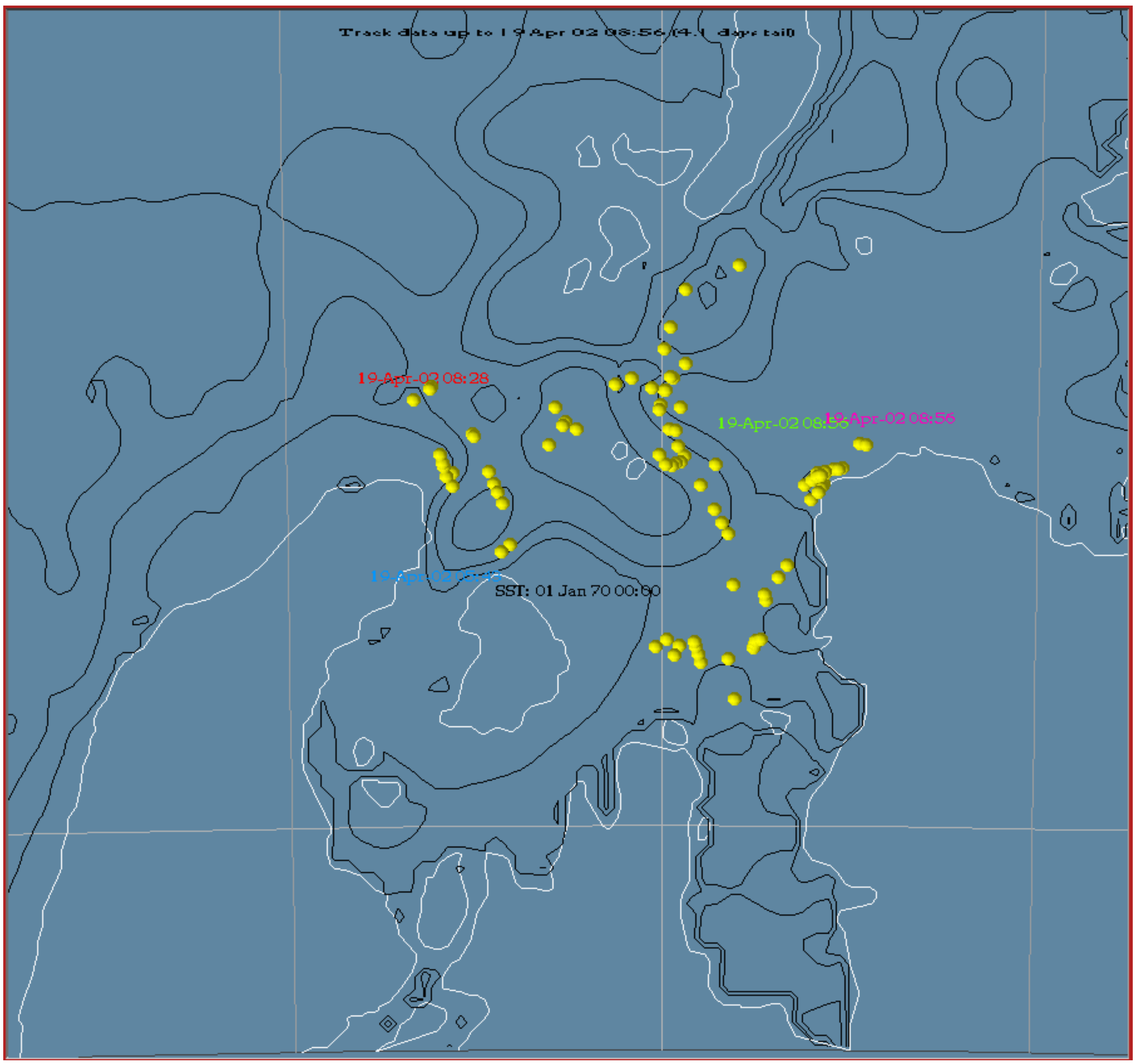


Figure 2. Map showing locations of temperature-depth profile upcasts in Crystal Sound, collected up through 19 April by 4 seals (Lolita – tagged 04/14, Patch and Dexter – tagged 04/15, Bubba – tagged 04/17).

Our luck continued to hold, and on 16 April we were again in an area with abundant seals and large floes. Since we had 3 of our tags deployed already, we decided to hold onto our remaining tags until we captured a larger animal. The single seal we handled on 16 April did not meet the size criteria (was <200 kg), and so we only collected blood and tissue samples from it (event #38). Having the opportunity to be selective is a welcome change from last year. On 17 April, the ship was still in southern Crystal Sound, as the high abundance of krill was of interest to many groups. As the weather held, we were again able to conduct seal searches, and this time we captured a large adult male (Event # 52) and deployed our fourth PTT (14749) on the animal. With half of our tags deployed, we are working well as a team, and have been well supported by Steve Ager (Marine Project Coordinator, MPC), Christian McDonald, and Josh Spillane (MTs). We'd also like to thank Chris Denker, Brett, and Ari Friedlaender for their assistance with the animals. With four PTTs deployed, we were well ahead of schedule, and off to an excellent start. The abundance of seals was possibly due to a large krill swarm that was located at the southern end of Matha Strait, and we were thrilled to have tagged seals out in an area of known krill abundance. The tags are working well (as determined from data sent daily to the ship) and we have already received many temperature-depth profiles from the seals (Figure 2) and dive profiles (Figure 3). One interesting point is that the seals we handled in Crystal Sound were much smaller than the seals we handled last year. Still they have been fat and healthy, so it does not appear that food is a limiting factor, just that the animals are younger.

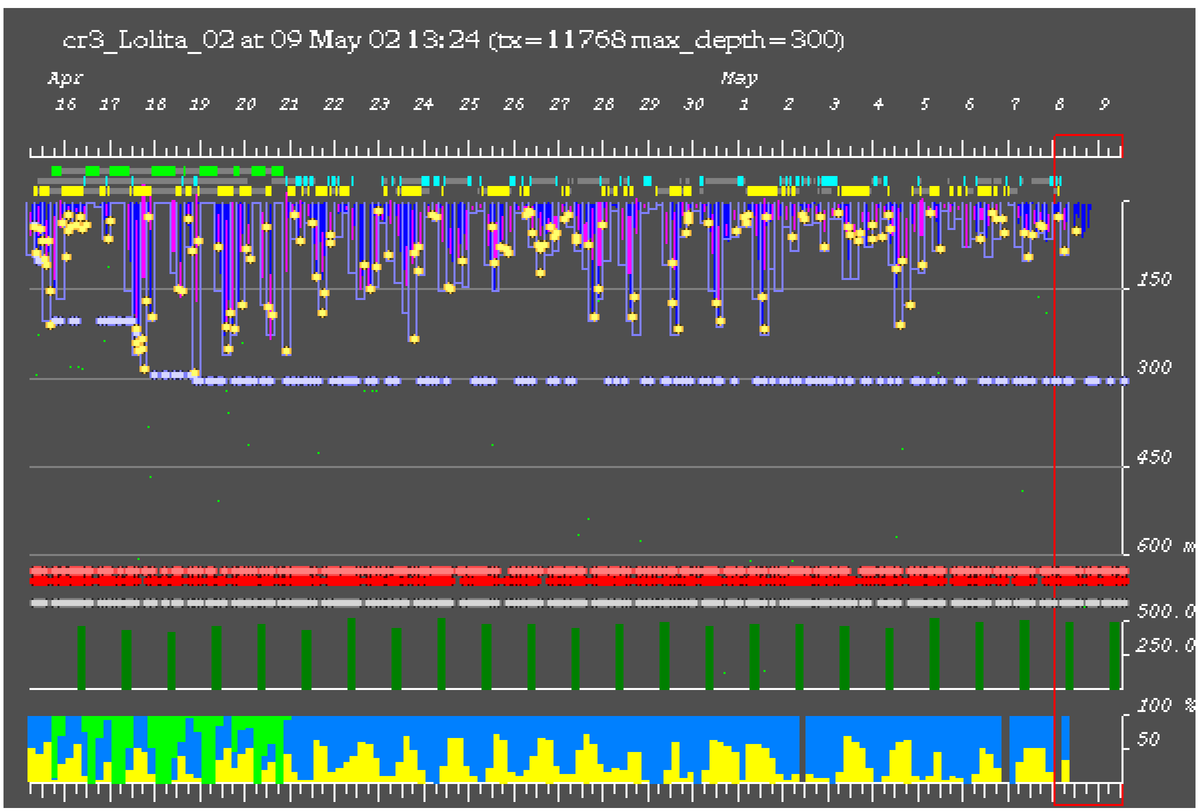


Figure 3. Seal dive depths by day for Lolita, tagged on LMG02-03.

The days of 18 and 19 April were spent getting the penguin team set at Avian Island, and doing a 24-hour ADCP/HTI survey in Laubeuf Fjord. We did not see any crabeater seals on either day, but did sight some Orcas (a predator on seals). On the morning of 20 April, we were off Wyatt Island, where we captured our first 3 seals of last year. This time the area was clear of ice and seals, so we proceeded south down Lawrence Channel searching for seals on suitable ice. At the southern end of the channel (67°27.364'W, 67°38.900'S) we located a single large female hauled out on an ice floe by herself. We took a Zodiac to the seal (Event #87) and attempted to capture the animal. After several technical problems, we succeeded in restraining the animal sufficiently to get her on gas anesthesia (she destroyed one of our capture nets in the process). After that, all went well, and we deployed the fifth satellite tag of the study on this animal. We then returned to the *Gould*, and prepared for our evening transfer to Rothera Base. As of 20 April, three of the tagged seals were within 20 miles of their tagging location, but one had moved 70 miles to the northeast.

<u>Week 3: 21-27 April</u>

We transferred from the *Gould* to Rothera Base in the evening of 20 April. The transfer went smoothly, and took approximately an hour to accomplish. Everyone at base was welcoming, helpful and friendly, and we immediately felt at home. Sunday, 21 April was a rest day on base, and we spent it getting acquainted with our new 'home', and setting up our lab space in the main building. We also went through several safety briefings, and acquainted the base commander, Simon Garrod, Dive Officer Phil Horne, and Boatman John Burleigh, with the details of our research plan. Sunday evening we presented a brief slide show about our project to everyone on base. Our first opportunity to conduct research was on 22 April, but the winds were too high to permit safe Zodiac operations. Instead, we walked to Rothera point, and located one crabeater seal on a floe a bit offshore. This was reassuring, as it meant that the seals were in the area. That point was in no doubt on 23 April, as we awoke to a beautiful still day. The wind overnight had blown sea ice into Ryder Bay, and as we went out in boats to look for seals, we saw dozens on the floes. All in all, we counted ~100 crabeater seals on floes. While the British Antarctic Survey (BAS) boating policy does not normally support operations on floes, the fact that we couldn't reach the haulout beaches due to dense ice, and the abundance of seals on ice led both John Burleigh and Phil Horne to suggest that they ask for an exception to policy. We returned to base and spoke with BAS in Cambridge, and after providing a risk assessment of work on floes, were able to return to Ryder Bay and work on sea ice. We are extremely appreciative of the efforts of Simon, John, and Phil to make this possible.

The effort paid off, and in the afternoon, we captured a large male seal on an ice floe upon which there were 11 other seals hauled out. We deployed PTT 14755 on this animal (Rothera Event #2) and while working on the seal spotted a pod of about a dozen Orcas in the nearby ice. We were able to accomplish all procedures except weighing the animal, as the wind was blowing our floe into the side of a large ice berg, and we felt it prudent to leave the floe before the impending impact. We returned to base, and celebrated our success with those who had been so helpful.

By the morning of 24 April, all the sea ice had blown back out of Ryder Bay, and we searched the shoreline of Lagoon and Anchorage Island for seals from Zodiacs. Unfortunately we did not see any seals there, and we were unable to go out to Leonie Island due to worsening sea conditions. Winds continued to plague our efforts on 25 and 26 April, as we were unable to go out in boats, and shoreline searches did not find any seals. However, conditions broke on 27 April, and we were able to get out in boats. There was little ice in Ryder Bay, and we planned to search the shoreline of Leonie Island. However, on our way to the Island we sighted a large floe with four crabeater seals hauled out on it. We were able to capture two of these animals and deployed our two remaining satellite tags on two large females (Rothera Event #7). While working on the animals we were visited by 3 minke whales, an Antarctic fur seal, and several flocks of penguins. It was a magical day, where everything worked as it was supposed to, and we all enjoyed our time out on the floe (despite being rained on for most of the time). We were happy to get the tags out, and not concerned that the tags were located in the northern part of the study area because seals we had tagged earlier were showing large scale movements. We returned to Base to discover that the *Gould* would arrive the next night. We were sad to think that our time at Rothera was coming to a close so quickly, but thrilled with our success during our visit. We celebrated our success at a fancy dinner Saturday night, and thanked everyone who helped. Sunday (28 April) we packed our gear, and got ready to transfer back to the ship.

At this point, I'd like to reiterate that we received superb support during our stay at Rothera. On each trip in boats we were supported by 4 (or 5) base personnel, and we can't thank Phil, John, Rayner Piper (marine assistant), Pete Martin, Andy Chapman, and Felicity Aston enough for their help in the field. On base, everyone helped ensure that our work was a success, but also that we had a good time while guests. The time ashore was well spent–we accomplished a significant amount of science, gained insight into the research program at Rothera, and made many new friends. We hope to be able to repay their hospitality in the near future.

BG 234 - Seabird Ecology - Fraser - Report by Chris Denker (Dr. Bill Fraser represented by Chris Denker and Brett Pickering)

The period from 14 April to 28 April was a very successful 2 weeks for the Seabird Group. In the Crystal Sound region we collected 4 Adélie penguin stomach samples from two groups of two birds on 15 and 16 April. The depth of the first location was 1200 m with the majority of krill in the 41 to 45 mm size class. Both of these birds (a male and female) appeared very healthy with the female's sample containing fish. The second two birds were found in 200 m of water with krill a bit smaller (36-40 mm). Both of these birds were females with fish found in one. Unlike the birds found in 1200 m of water, these two did not appear nearly as healthy.

The morning of 17 April brought us to Avian Island (Figure 4), where brash ice surrounded the island. After pushing through the ice we landed at the survival hut on the north end of the island. The remainder of the day we spent setting up camp and securing anything and everything. We deployed satellite transmitters on 19, 20, and 22 April. A total of 14 were set out with 4 of them being dive/depth recorders. After 22 April, we spent our time collecting diet samples. From 23 to 27 April, a total of 20 samples were collected with one day taken off due to weather. Krill size classes have varied depending on the day of collection. Adult krill in the 40 mm class were found early in the week, while 25 mm juveniles dominated the end of the sampling period. Fish were present throughout the sampling period. The Avian Island camp allowed us to complete a fair amount of work which otherwise might not have happened. The time allowed for the camp was sufficient to meet our objectives. So ended 14 through 28 April.

Figure 4. Two young elephant seals take a break from practicing their fighting on Avian Island. Photo by Joel Bellucci.

BG 236 - Krill ecology and physiology - Daly

Shortly after leaving the Vernadsky Base and before our planned survey in Crystal Sound, we successfully completed a field calibration of the Hydroacoustic Technology Inc. (HTI) echosounder using a standard target sphere. Unfortunately, the southern end of Crystal Sound had too much sea ice to allow us to safely tow the HTI system. The ADCP system, however, detected a dense layer of *Euphausia superba* (verified by net tows) across Matha Strait. By positioning the *Gould* using the ADCP, we were able to collect over an hour of acoustic data of the layer by drifting through the heavy pack ice. The layer extended from about 35 to 300 m in depth over water 400 m or greater. As the bottom depth shoaled, the layer consolidated between about 50 to 150 m and disappeared when the bottom shoaled to about 100 m. Many of the krill collected in net tows had black-green guts and hepatopancreas indicating feeding on phytoplankton or phytodetritus. A brief assessment indicated that juveniles 17-33 mm in length were the dominant stage and size present as well as immature and mature males and females 39-47 mm. No *Euphausia crystallorophias* of any stage or *E. superba* larvae were found.

At our next station in Laubeuf Fjord, we completed almost 24 hours of a hydroacoustic/ADCP survey of the main fjord basin in collaboration with Meng Zhou, before sea ice conditions forced us to bring the towed fish on deck. Last year we observed dense layers in this outflow region from Crystal Sound. The purpose of this survey was to map the density and distribution of this layer in relation to the bottom bathymetry, circulation and tidal flow to better understand how the zooplankton and fishes maintain themselves in the strong downstream current. The layer was continuously present over the main basin and up onto both sides, but disappeared when the bottom shoaled to about 75 m depth. Although the overall extent of the layer varied, it was generally 20 m to more than 200 m in depth, with one maxima concentrated between 30 m to 120 m and a second maxima centered about 150 m, during late afternoon and evening at the bottom of the fjord. There was some evidence of vertical migration. By 1000, near the top of the fjord, there was little acoustic backscattering in the upper 60 m. The layer was more compact with a maximum concentration about 180 m.

Net tows suggested that different species of zooplankton and fishes were vertically segregated, with *Euphausia superba* and *E. crystallorophias* being shallower than juvenile and adult *Pleuragramma* (fish). The occasional acoustic targets near surface were probably *Themisto* amphipods. Deeper targets included the mysid (*Antarctomysis* sp.) and large amphipods (*Eusirus* spp.). Almost no krill larvae were found in Laubeuf Fjord or the surrounding area. Juvenile *E. superba* appeared to be the dominant size class similar to the krill population in Crystal Sound. Live individuals of all the above species were given to Dezhang Chu during a rendezvous with the Palmer to determine their acoustic material properties (the sound speed contrast and density contrast of an individual relative to the surrounding seawater). These measurements will help interpret the acoustic backscattering data.

Kerri Scolardi participated on one ice dive in Lawrence Channel behind Wyatt Island. No krill or ctenophores, a potential major predator of small krill, were observed at the undersurface of the ice, even though both were collected in net tows in nearby areas. Two samples from the ice-water interface and one piece of golden-colored ice were collected and measured for chlorophyll and particulate organic carbon.

At the off-shelf station, acoustic backscattering layers were generally about 140 m to 280 m deep. High winds and a large swell prevented much acoustic data collection. Larval *E. superba* were collected by some net tows at this station, but they had a very patchy distribution compared to that observed last year. Larval stages included Calyptopis 2 and 3 and Furcilia 1 and 2, whereas last year we found these stages as well as older furcilia. Few large *E. superba* were collected.

To date, we have completed 1 lipid biomarker and an HPLC feeding experiment for krill in collaboration with Se-Jong Ju, three growth and molting rate experiments, three ingestion rate, four egestion rate, and one assimilation efficiency experiment for different stages of *E. superba*. We collected 2-3 samples per day from the flow-through fluorometer to help characterize the along-track surface chlorophyll concentrations. In addition, Maureen Hodgins collected chlorophyll profiles for all the CTD casts.

BG-237 Krill Biochemistry - Harvey - report by Se-Jong Ju

Our field team consisted of Se-Jong Ju and Susan Klosterhaus. The major focus of this project was the biochemical determination of age structure in *E. superba* and lipid biomarkers indicative of its dietary history. A tucker trawl tow on 16 April in Crystal Sound by Dr. Torres's group collected lots of adult krill. Different size classes of adult *E. superba* (n=400) were sorted, providing an adequate number (>300) for statistical analysis. After morphological measurements (length, eye diameter) were taken using a dissection microscope, eye tissues were carefully excised. Age markers (lipofuscins) were extracted from eye tissues and immediately analyzed using the onboard HPLC system to minimize potential problems of preservation and sample handling. Whole bodies were immediately frozen in the deep freezer for lipid analysis. A week later (20 April), the second set of adult krill (n=300) was collected at process site 5 using a Tucker trawl. Morphological measurements and eye tissue collections were conducted immediately as described above. However, age markers (lipofuscins) from the second set of samples could not be analyzed immediately due to the sea conditions at process site 1. After coming back to the near-shore site, those were analyzed.

Additionally, the portable HPLC system for this project presented the opportunity for separation and analysis of algae pigment distributions in the water column. Water samples from CTD casts and brown ice (potentially ice algae) have been collected and will be analyzed on-board for algae pigments to provide information on phytoplankton distributions and communities in the water column and in the ice.

BG 239 - Cetacean ecology - Hildebrand - report by Ari Friedlaender

<u>14 April 2002, Day 8</u>
0805 began observations as we steamed along the east side of Lavoisier Island looking for seals to tag. Patches of fog and snow fog, visibility between 1-2 nm, winds from the south began the day around 20-25 kts and diminished to 10-15 kts later in the morning. Position at beginning of watch: 66º 10'S, 66º 29'W. Stopped at 1000 for seal work and remained in that area for the rest of the day. Position at 1000: 66º 20'S, 66º 46'W. No whales were seen, only 4 seals on scattered floes. Zodiac trip was attempted but stopped due to bad motor.

<u>15 April 2002, Day 9</u>
0800 ship transiting across Crystal Sound from east to west. Skies were mostly cloudy, Beaufort Sea State (BSS) 2, 2/10 ice coverage of brash and bergy bits, and visibility was good. Position 66º 45'S, 66º 44'W. At 0805 four minkes were sighted working a zone of open water between larger areas of ice. Zodiacs were deployed for seal tagging and whale biopsies. No biopsy samples were collected. The whales were seen once from the water and then were not seen again. Stayed out on ice to help with seal tagging and returned to the ship at 1500. When the ship began moving again, the minkes were resighted and the ship soon stopped for penguin capture, finishing off the daylight hours. Position at penguin capture at 1650: 66º 42'S, 66º 57'W.

<u>16 April 2002, Day 10</u>
Position at 0755 66º 30'S, 67º 34'W. Snow fog, 0.75 nm visibility, in 8/10 brash and bergy bits. At beginning of effort, 3 minkes were seen in the open lee of a small berg. Ship stopped at 0845 for seal capture and resumed steaming at 1345. Ice loosened to 5/10. A single humpback whale was sighted at 1400 in 3/10 ice nearing open water. At 1540 the ship stopped for penguin capture at 66º 44'S, 67º 09'W.

<u>17 April 2002, Day 11</u>
0800 towing MOCNESS nets in Crystal Sound. Winds were 15-20 kts, skies partly cloudy, visibility was good. Some bergs and floes in the area. At 0850, 2 minkes were seen at 66º 39'S, 67º 25'W. Ship then stopped for seal capture for the rest of the daylight. However, when leaving the ship, a single minke whale followed the Zodiac at close range and stayed with us to the ice floe with seals. The whale

surfaced several times very close by, spy-hopped, swam under the Zodiac right side up and upside down, and was generally very curious.

<u>18 April 2002, Day 12</u>
0800 ship stationed off Avian Island to drop off penguin team at 67º 46'S, 68º 51'W. We remained off Avian Island, moving the team on until 1425 when we began a slow ADCP/HTI survey across the northern end of Marguerite Bay and headed generally north. Skies were partly cloudy, with excellent visibility. Winds were light in the lee of the island, but increased to 20 kts once into the Bay. No whales were seen at the time that observations ended at 1630 at 67º 57'S, 68º 36'W.

<u>19 April 2002, Day 13</u>
0815 position 67º 41'S, 68º 15'W. Skies were partly cloudy, BSS 1-2, visibility excellent at 3 nm. Ice to the north as small cakes and floes and bergs. Continued throughout the day on a slow (4 kts) acoustic survey of Laubeuf Fjord area weaving east to west and heading from south to north. No animals were seen until 1600. At that time, several crabeater seals were seen, as were a dozen or so Adélies on floes. A group of 12 Orcas was sighted meandering through 6/10 pack ice and bergs. There were two large males in the group, as well as at least two other large animals, and one distinctly small calf. The Orcas passed the beam at 1 km from the ship and some video was taken. They appeared to see the ship, as evidenced by several high surfacings, but did not alter their course of travel. Observations ended soon thereafter due to failing light. A sonobuoy was deployed at 1642 and listened until 1753, but no sounds were heard.

<u>20 April 2002, Day 14</u>
Observations began at 0755 at 67º 17'S, 67º 50'W under cloudy skies, BSS 1, good visibility, and fine sighting conditions. We circled around Day and Wyatt Islands, searching for seals. Some bands of ice were encountered, but mostly there was open water, newly frozen grease ice and glacier rubble in some spots. We stopped at 1005 for seal capture and remained there for the rest of the day, diving afterwards. No whales were seen before stopping.

<u>21 April 2002, Day 15</u>
At 0845, 67º 37'S 67º 57'W, winds were high (30-40 knots), skies were overcast and visibility was 1 nm. The ship was doing an ADCP survey back and forth on the same line at the south end of Laubeuf Fjord. No survey effort due to winds and continuous survey of the same area. Incidentally, nothing sighted.

<u>22 April 2002, Day 16</u>
Survey effort began at 0805 during an ADCP survey at 67º 57'S, 68º 30'W. Skies were overcast, visibility was good and BSS 3-4. No sightings were made by 0945 when we stopped to do a MOCNESS tow.

<u>23 April 2002, Day 17</u>
0925 position 67º 51'S, 67º 58'W after rendezvous with the *N.B. Palmer*, skies were clearing, BSS 2-3, visibility was good, began steaming around Adelaide Island towards the offshore station. Between 67º 36'S 69º 22'W and 67º 32'S 69º 24'W (Johnston Passage) ice was 3/10 brash bits in neat lines, three sightings of humpback whales (two mom/calf pairs and a single animal) and over 300 crabeater seals were seen. The crabeaters were mainly in large groups of 20-50 animals in the water, but at least 50 were hauled out on small floes.

<u>24 April 2002, Day 18</u>
0825 position 66º 08'S, 71º 23'W, BSS 5 skies overcast visibility 1 nm, no ice. Effort continued until 1130 for a deep CTD cast. At this position at 1330 a pair of large humpback whales surfaced near the ship and remained social for 5 minutes before diving and then reappearing near the ship (50 m). Position

of sighting 66º 10.49'S, 71º 19.82'W.

25 April 2002, Day 19
0800 MOCNESS tow in progress, followed by a CTD cast. BSS 5, skies cloudy, visibility 1.5 nm. No observations made today.

26 April 2002, Day 20
0900 position: 66º 12'S, 71º 17'W. Conducting ADCP survey, BSS 6, snow and fog, poor visibility. No observations made until 1345 at 66º 10'S, 71º 03'W, for 2 hours. No sightings were made.

27 April 2002, Day 21
0845 position: 66º 13'S, 71º 18'W. Day spent at station or doing tows. No survey effort and no sightings.

28 April 2002, Day 22
0840 position: 67º 32'S, 70º 00'W. Winds 25-30 kts, overcast and foggy skies, steaming to Avian Island around Adelaide. No survey effort, only incidental watch kept. No sightings made.

Survey Times and Sightings Log, 14-28 April 2002

Date	Start Survey	Finish Survey	Survey Time
11 April	11:50	13:56	2:06
11 April	14:39	18:17	3:38
13 April	17:19	20:47	3:28
14 April	12:02	13:47	1:45
15 April	11:51	13:58	2:07
16 April	17:43	19:35	1:52
17 April	14:36	14:53	0:17
18 April	18:24	20:31	2:07
19 April	12:07	16:23	4:16
19 April	17:33	20:33	3:00
20 April	11:49	14:06	2:17
21 April	12:02	13:43	1:41
22 April	13:21	20:13	6:52
24 April	12:22	15:31	3:09
26 April	17:40	19:27	1:47
28 April	14:22	15:31	1:09
28 April	18:31	20:08	1:37
TOTAL			42 hours 8 minutes
AVERAGE			3 hours/day

sighting #	species	number	date
18	minke	4	15 April
19	minke	3	16 April
20	humpback	1	16 April
21	minke	2	17 April
22	orca	12	19 April
23	humpback	2	23 April
24	humpback	2	23 April
25	humpback	1	23 April

TOTAL 8 sightings of 27 animals
3 sightings of 9 minke whales
4 sightings of 6 humpback whales
1 sighting of 12 orcas

BG 245 - Krill and fish ecology, krill physiology - Torres

Process site 7. The bottom topography at process site 7 was shoal and necessitated our taking very shallow tows to assure the safety of our nets. MOC-10 tows were limited to maximum depths of 300 m and were taken in the Matha Strait. We captured very large quantities (2-3 l) of large (45-50 mm) krill in the upper 100 m. Oceanic fishes, notably *Electrona antarctica* and *Gymnoscopelus nicholsi*, were captured in both MOC-10 and Tucker trawl samples. Sixty individual determinations of metabolism and excretion on a variety of species were completed. Species included: *E. superba, Calanoides acutus, Metridia gerlachei, and Pareuchaeta sp.*

Process site 5. Laubeuf Fjord and its adjoining fjords on the east contain several depressions of 800 m or more. We were able to deploy our MOC-10 with a margin of safety in two depressions that run along the axis of the fjord, and captured a similar fauna in each. Five MOC-10 tows and 10 Tucker trawls were completed at site 5. In addition, two dives looking for krill larvae underneath sea ice were completed in collaboration with the Daly program. Typical catches for the MOC-10 nets were as follows. Species are named in order of abundance. Species lists are incomplete.

Night

0-50 m	*Euphausia superba* juveniles (<30 mm), *Eusirus* spp., *Callianira*, Thimble jellies
50-100 m	*Euphausia superba* adults (>50 mm), *Pleuragramma* year class 2, *Eusirus* spp, *Stygiomedusa gigantea*
100-200 m	*Pleuragramma* year class 2, *E. superba* adults, *Eusirus, Antarctomysis ohlinii*
200-300 m	*Antarctomysis ohlinii*, *Pleuragramma* year class 2, *Paraliparus terraenovae*
300-500 m	*Antarctomysis ohlinii,* thimble jellies , *Electrona antarctica, Melanostigma gelatinosum*

Day

0-50 m	*Themisto gaudichaudi, Eusirus spp, Antarctomysis*
50-85 m	*Euphausia superba* juveniles (<30 mm), *Pleuragramma* year class 2
85-125 m	*Euphausia superba* juveniles and adults*, Callianira, Pleuragramma*
125-200 m	*Euphausia superba* adults, *Callianira, Eusirus*
200-500 m	*Euphausia superba* adults, *Antarctomysis ohlinii, Eusirus, Electrona antarctica, Pleuragramma, Stygiomedusa gigantea*

In addition to the trawling program, 150 individual determinations of metabolism and excretion were successfully completed on *E. superba* and a variety of other species at process site 5. The character of the trawls differed from our 2001 cruise in the presence of large quantities of juvenile krill and *Pleuragramma* year class 2. Very few *Pleuragramma* were captured in 2001, and almost no juvenile krill. The oceanic fish *Electrona antarctica* was present in all trawls.

Process site 1. Site 1 was at the shelf break in the vicinity of survey station 12 which allowed us to complete several tows to 1000 m of depth, giving us a good look at the full complement of oceanic fauna we were able to capture in our nets. We divided the site into two elements, one off the shelf in oceanic depths (station 1A - 3000 m) and one just over the shelf break (1B - 500 m) The western Antarctic Peninsula shelf is atypical of Antarctic coastal regions in the absence of very cold (-2.0ºC) ice shelf water, which is potentially lethal to fishes without antifreezes. Even so, there is the potential for depth limitation of oceanic species with a range over the upper 1000 m of water. Our deep oceanic tows gave us a barometer for what was typically an oceanic species, what species were present only on the shelf, and what species were found in both areas. Typical catches for station 1A are described below with species listed in order of abundance. Species lists are incomplete.

Night

0-50 m	*Salpa thompsoni, Themisto gaudichaudi*
50-100 m	*Salpa thompsoni, Euphausia triacantha, Electrona antarctica, Gymnoscopelus nicholsi*

100-200 m	*Euphausia triacantha, Electrona antarctica, Gymnoscopelus braueri*
200-500 m	*Euphausia triacantha, Thysanoessa macrura, Electrona antarctica, Protomyctophum bolini, Pasiphaea scotiae*
500-1000 m	*Gennadas valens, Atolla atolla, Cyanomacrurus piriei, Cyclothone spp, Euphausia triacantha, Periphylla wyvillei, Parandania boecki, Euphausia superba*

Day

0-50 m	*Themisto gaudichaudi*
50-100 m	*Themisto gaudichaudi*
100-200 m	*Callianira*, Myctophid (unidentified)
200-500 m	*Euphausia triacantha, Protomyctophum bolini, Periphylla wyvillei, Cyclothone spp.*
500-1000 m	*Electrona antarctica, Gennadas valens, Gigantocypris mulleri, Benthalbella elongata*

There is clearly good evidence for diel vertical migration in the fishes at site 1. *Euphausia superba* adults were nearly absent, but our Tucker trawl picked up large numbers of larvae. Ninety individual measurements of metabolism and excretion on a variety of species were completed at site 1. Blood samples were taken from all species of fishes for hematocrit and total hemoglobin determinations.

BG 248 - Krill ecology, behavior, and modeling – Zhou (Ryan D. Dorland, Joe P. Smith, Yiwu Zhu, University of Massachusetts Boston)

Prior to 14 April

Our group was responsible for the 1-m Multiple Opening and Closing Nets and Environmental Sampling System (MOC-1), Optical Plankton Counter (OPC) and Acoustic Doppler Current Profiler (ADCP) during the cruise. Both the MOC-1 and OPC were tested prior to departure using a test cable. The sea cable termination was not done till we arrived at Palmer Station. We had to increase the FSK signal voltage of the OPC when the sea cable was used. The FSK voltage was lowered to 0.5 v during the last winter cruise on the RVIB *Palmer*. The resistance of the sea cable on the R/V *Gould* is much higher. The final voltage setting was 1.5 v (The standard is 3 v.). Both the MOC-1 and OPC were working properly. The ADCP was set by Eric Firing at the University of Hawaii and Theresa Chereskin at Scripps Institution of Oceanography. The current ADCP data can be accessed in real time, which gives us a powerful tool to display the echo intensity measurements at real time.

Crystal Sound (14-17 April 2002)

Our first station was in Crystal Sound (Figure 5). An ADCP survey and 6 CTD casts were conducted crossing Matha Strait, and the two channels between Crystal Sound and Hanusse Bay during the night of 14 April after the seal and penguin operations during the day. The objectives were to understand the circulation patterns and krill distribution in this area. The ADCP measurements showed mesoscale circulation patterns of 5-10 km. We found a clockwise circulation pattern in the southeastern corner of Crystal Sound, east of Laird Island, and a counter-clockwise circulation pattern near Cape Mascart, north of Laird Island (Figure 6). The near surface water was fresher in nearshore regions and in Hanusse Bay. Most krill swarms were concentrated near Cape Mascart, the southern entrance to Crystal Sound, north of Laird Island. The ADCP transect to the east showed that there were still a fair amount of krill swarms inside the Sound. The role of the eddy north of Laird Island in determining krill distribution will be further investigated from net tow samples, acoustic estimates of krill distribution and current measurements.

During the second night, we tried to make our way to Hanusse Bay through the channel between Adelaide and Laird Islands. We had to turn around at 66º 48.5'S due to heavy sea ice. Krill swarms with high abundance were measured by the ADCP during the transit (Figure 7). The study of krill distribution in Hanusse Bay was aborted due to sea ice.

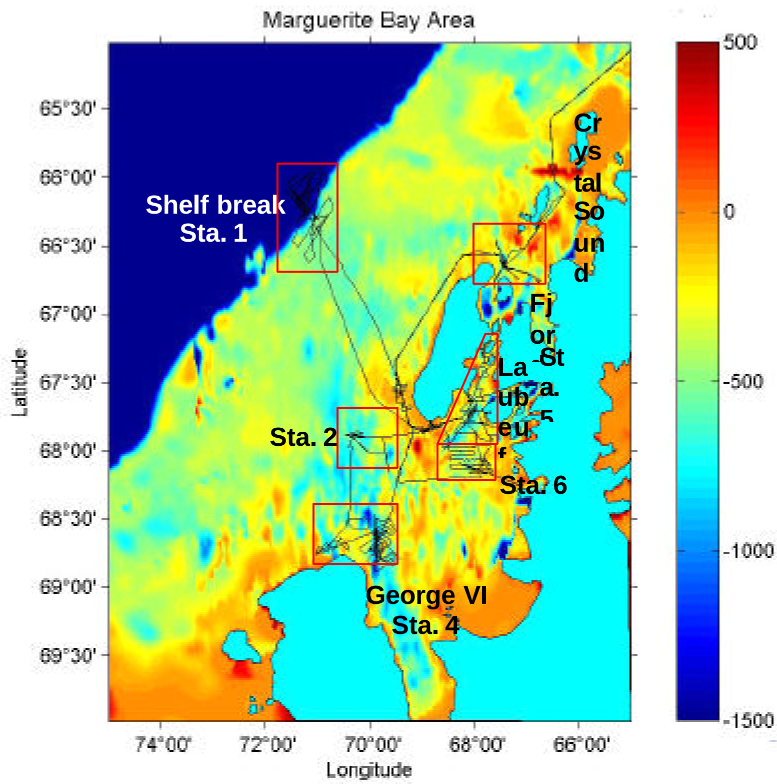


Figure 5. Bathymetry of the study area. Station locations are defined by red boxes. Color coding for depths (m) given on bar to right of figure.

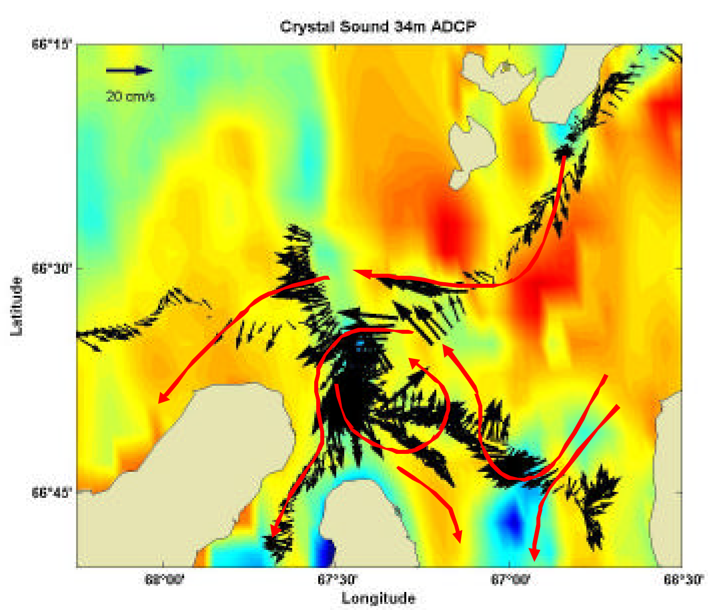


Figure 6. The currents measured by a VM NB ADCP on the R/V *Gould*. The red arrows indicate the circulation patterns.

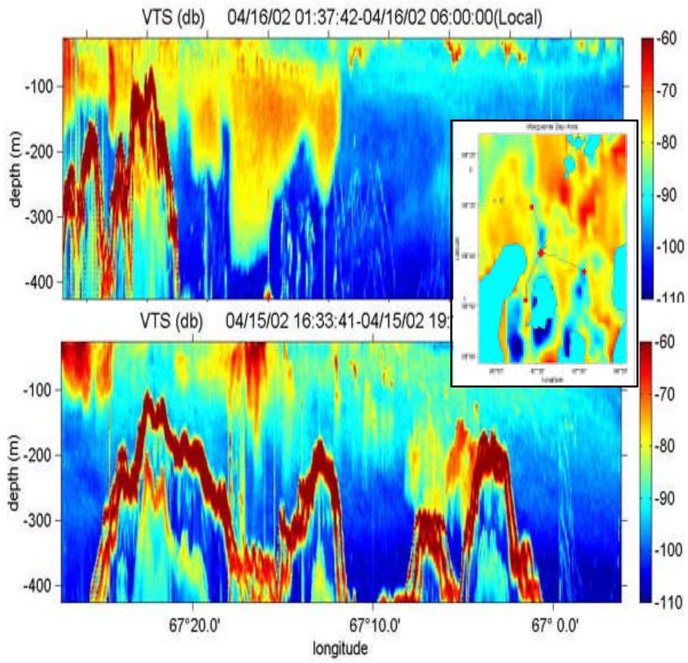


Figure 7. The transects of ADCP backscattering. The locations of transects are indicated in the inserted figure. Upper: the north-south transect between two red round dots; Lower: the east-west transect between two red diamond shaped dots.

Two MOC-1 tows confirmed that our acoustic measurements were detecting krill swarms, composed mostly of *Euphausia superba* adults. The echo intensity at the swarms reached -60 db. If we take the target strength of an adult krill approximately -80 db, the abundance of krill reached 100s individuals m^{-3}.

A study of diel vertical migration was conducted using both the ADCP and MOC-1 tows. A large krill swarm several miles long was found within the top 150 m during the night (Figure 8). A targeted MOCNESS-1 tow clearly showed the highest abundance of adult krill in this red patch. In the morning transition period, they formed smaller dense patches of 100s m and descended to 200-280 m. At daytime depth, they again formed a dense swarm approximately one mile long. A targeted tow was also conducted. We successfully ran the net through the krill swarm at 200-280 m.

The two targeted tows were conducted in the same geographic location and on the same track line within the error of the ship's capability to maintain course. The dramatic difference in bathymetry between the two tows indicates that pinnacles in Crystal Sound can rise hundreds of meters. In Figure 8, the ADCP shows the MOC-1 on the bottom at 380 m while the ship's echosounder showed a water depth of 450 m. Thus, with a change of tens to hundreds of meters in the horizontal, a pinnacle can rise 100-200 m in the vertical. The codend of net 0 from this tow was filled with greenish mud, sea stars and spider crabs.

A drifting experiment using both the ADCP and the HTI (Kendra Daly) was done for calibrating the HTI and for an inter-comparison between the ADCP and HTI. We first used the ADCP to locate the krill swarm in the deep canyon, and then we deployed the HTI and shut off the ship's main engine. The ship drifted for one-half hour. Both the ADCP and HTI obtained very valuable data that can be used for future comparison and calibration.

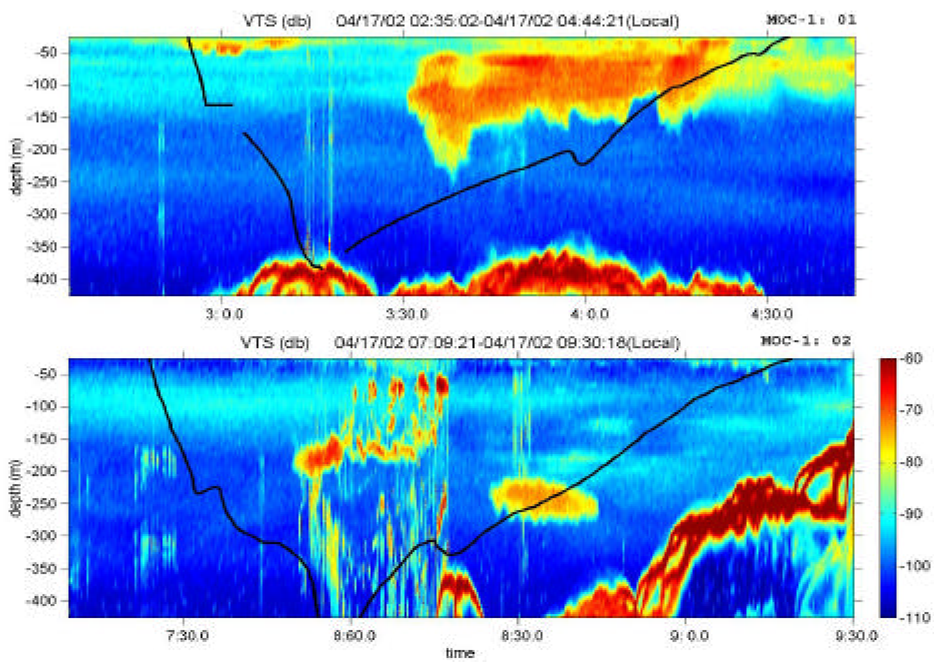


Figure 8. Krill vertical migration study. The upper panel: transect taken at night; and the lower panel: transect taken in the morning. The solid black lines are two MOCNESS tracks.

The zooplankton community can also be examined by their size structure. Because there is a lack of information on the conversion between size and carbon of a zooplankter, we plot the body volume as the *x* axis and normalized biovolume spectrum as the *y* axis (Figure 9). The definition of normalized biovolume spectrum is similar to the definition of biomass spectrum: the total biovolume falling into the size range Δv normalized by Δv. From theoretical work, the slope of the biovolume or biomass spectrum is equal to the ratio of the mortality to individual growth rates. The OPC measurements show that the steepness of the biovolume spectrum, which typically indicates the balance between mortality and growth (Figure 9). Because of the relatively small intake of the instrument (2 by 25 cm^2), adults of *E. superba* would not be sampled quantitatively. The measurements more likely represent small and large copepods and krill larvae and juveniles. One noticeable thing is that the slope in the range less than 1 mm^3 is steeper than that in the range larger than 1 mm^3, which may indicate some kind of excess mortality in the size range less than 1 mm^3 (Figure 9).

Laubeuf Fjord (18-23 April 2002)

We started our acoustic and XCTD survey, working jointly with the HTI deployment (Kendra Daly), as soon as we dropped the penguin group on Avian Island on 18 April. The survey consisted of eight longitudinal transects and nine latitudinal transects covering from lower to upper Laubeuf Fjord. Most of the time the HTI was in the water (See Kendra Daly's report for details), which provides a good data set for inter-comparison and calibration. Three XCTDs were launched during each longitudinal transect, one each at the beginning, middle, and end. The reason XCTDs were used instead of a regular CTD/Rosette was simply to save time. Our operation was scheduled at night. We had to arrive at Hinks Channel in the morning for the seal and whale operation.

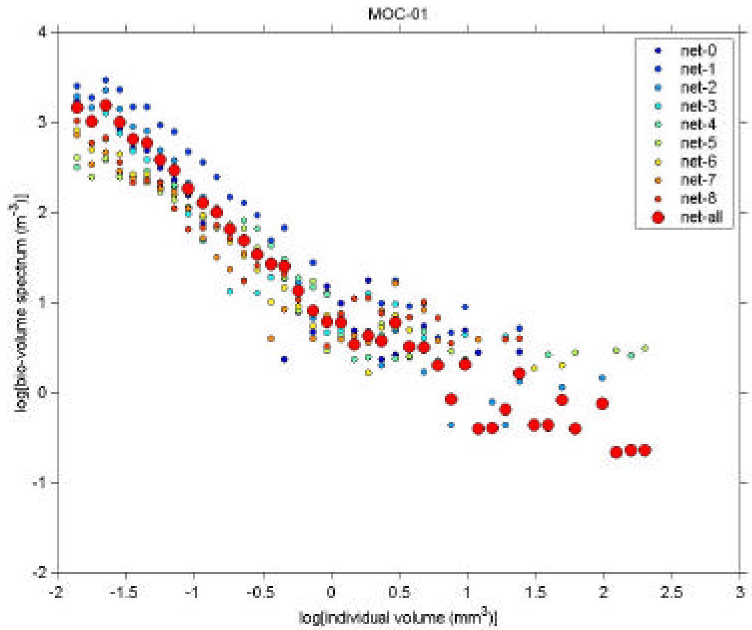


Figure 9. The biovolume spectra measured in Crystal Sound.

The circulation study showed several clockwise and anticlockwise features over Laubeuf Fjord (Figure 10), which seemed to be associated with bottom topographic features. We took a 13-hour time series of velocity measurements over a transect to resolve the tidal period dynamics and vertical migration behavior of krill. The measurements showed the existence of a very weak tidal component up to several cm s^{-1}. The other component was up to 10 cm s^{-1}. Hence, the tidal component can be neglected in most of our study area.

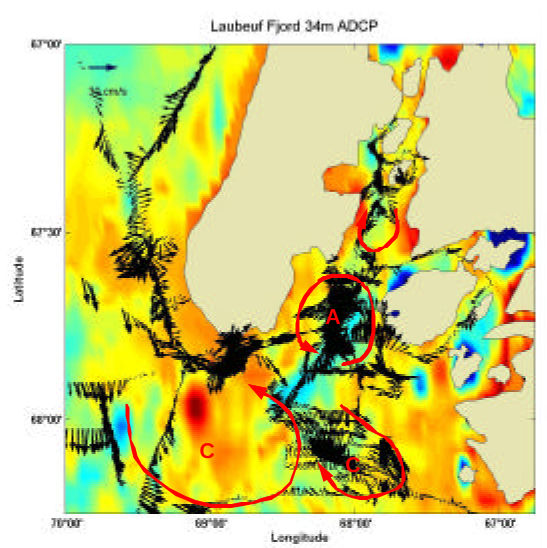


Figure 10. Circulation patterns in Laubeuf Fjord and its vicinity.

The most noticeable feature of the current measurements was the small scale variability over the entire study area. The spatial scale varied from 5 to 10s km, which was much smaller than the external Rossby radius of 54 km assuming an average depth of 300 m. Thus, these small and mesoscale features must be generated by either the internal Rossby radius due to horizontal density gradients or small-mesoscale topographic features, such as deep canyons and seamounts. In our study done last year of circulation in George VI Sound, we found that the contribution of the baroclinic pressure gradients cannot account for the magnitude of currents measured by the ADCP. We conclude that the currents must be topographically controlled barotropic currents. The circulation patterns shown in Figure 10 once more indicate that the circulation patterns are associated with the bathymetry, the canyons, and shallows.

The survey indicated that the zooplankton distribution was very different from that observed last year in this area. We did not find super swarms over the deep canyon in lower Laubeuf Fjord. The distribution was more dispersed and relatively uniform in space (Figure 11). We found two layers at night: one from the surface to 50 m composed mostly of krill, and a second layer between 80 and 120 m composed of fish larvae. The night and day MOC-1 tows indicated that the top layer was composed mostly of intermediate-size krill. They migrated to 150-200 m during the day.

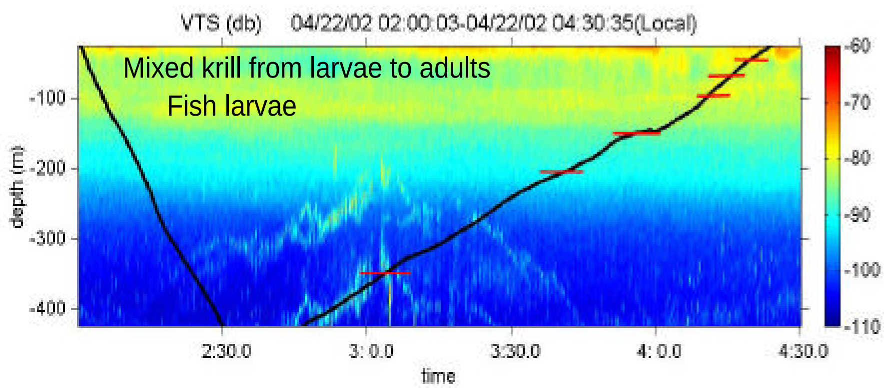


Figure 11. An acoustic transect in Laubeuf Fjord showing two layers of krill and larvae.

One MOC-1 tow was conducted in Cole Channel, and two were conducted in the Laubeuf Fjord deep canyon. *E. superba* did not clearly dominate the samples collected in this year as they did in last year's samples, which showed a dominance of adult *E. superba* in this area. There were mysids, amphipods, copepods, a lot of fish larvae and a lot of jellyfish. The biovolume spectrum in Laubeuf Fjord shows a relatively smooth line from small to large sizes, which implies no excess mortality (Figure 12).

The study of circulation patterns depends greatly on the accuracy of the ADCP because of the barotropic nature of these currents. The reliability of ADCP measurements depends on the mounting of the instrument, bin length, pulse length, ship noise, ship gyro information, ashtech heading and time interval of average. Because there is no other instrument available to calibrate the ADCP, we ran the ship forwards at 6 kts for a short track of 0.5 hour in an open area, and then turned the ship around following the same track. We obtained horizontal velocities (u, east-west; v, north-south) in cm s^{-1} at 34 m along the two tracks of:

	mean (u)	std (u)	mean (v)	std (v)	# of samples
Track 1:	-22.5	4.4	4.5	5.7	8
Track 2:	-23.0	3.4	3.4	6.0	7

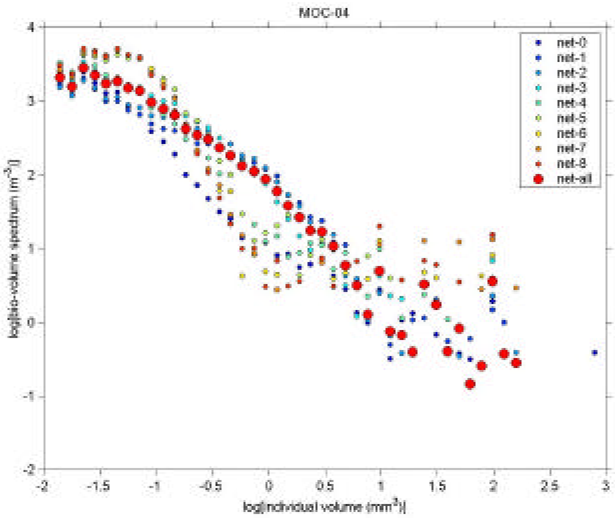


Figure 12. The biovolume spectra measured in Laubeuf Fjord.

The differences between means are approximately 1 cm s^{-1}. The standard deviation (std) also includes the spatial variability of current fields because in 0.5 hour, the ship moved 3 nm at a speed of 6 kts. Hence, we concluded that the ADCP was performing well.

Shelf break Station (24-27 April 2002)

We arrived at the station at 0100. The wind was at 35 kts from north-northeast, occasionally 50 kts. Waves were washing over the main deck. The MOC-1 tow was postponed to 0300 when the wind declined to 15 kts. During this period, a small scale ADCP survey was done to seek hot spots of backscattering. During retrieval, the wind increased to 25 kts with 10 foot swells. Though the MOC-1 was deployed at the side of the A-frame which causes a lot of difficulties during retrieving, it came back safely despite heavy rolling and pitching.

The MOCNESS samples at the off-shelf site revealed that extremely high abundances of krill larvae, phytoplankton and salps were found in the top 50 m, which was consistent with the ADCP backscattering (Figure 13). The high abundance of krill larvae within the surface layer was further confirmed by OPC measurements of body volumes between 0.03 mm^3 and 1 mm^3 which corresponds to a body length between 1.5 and 3 mm assuming a ratio of body length to body width approximately equal to 7:1 (Figure 14). A deep layer was found at 150-300 m. Some small fish were found in the net corresponding to that depth. Different from the samples at the off-shelf site, samples at the on-shelf site showed no or very few krill larvae. Phytoplankton was still found in the top 50 m.

Two ADCP surveys over the off-shelf and on-shelf regions were carried out during the periods when other activities were cancelled due to weather (Figure 15). The circulation shows that our off-shelf site was set in a small counter-clockwise eddy. The nature of the eddy provided longer residence time where higher concentrations of krill and krill larvae were found.

Potential vorticity constraints cause flow in this region to be mainly along isobaths; only a weak component of flow across isobaths is expected. However, weak onshore flow over the deep shelf slope leads to a stronger onshore transport at the shelf break. Our on-shelf site was in a region where the current was thought to cross the shelf break onto the shelf in the vicinity of the deep canyon (Marguerite Trough). We found weak cross-shelf flow over the slope and significant cross-shelf currents over the shelf. Mesoscale variability (meanders and eddies) had a different character on either side of the current core at the shelf break.

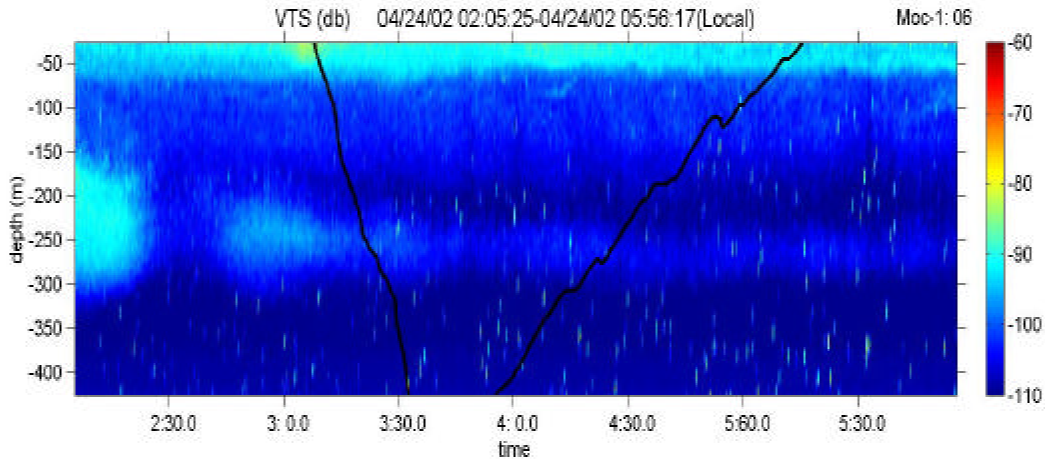


Figure 13. An acoustic transect off the shelf break at station 1. Black solid line indicates the MOCNESS track.

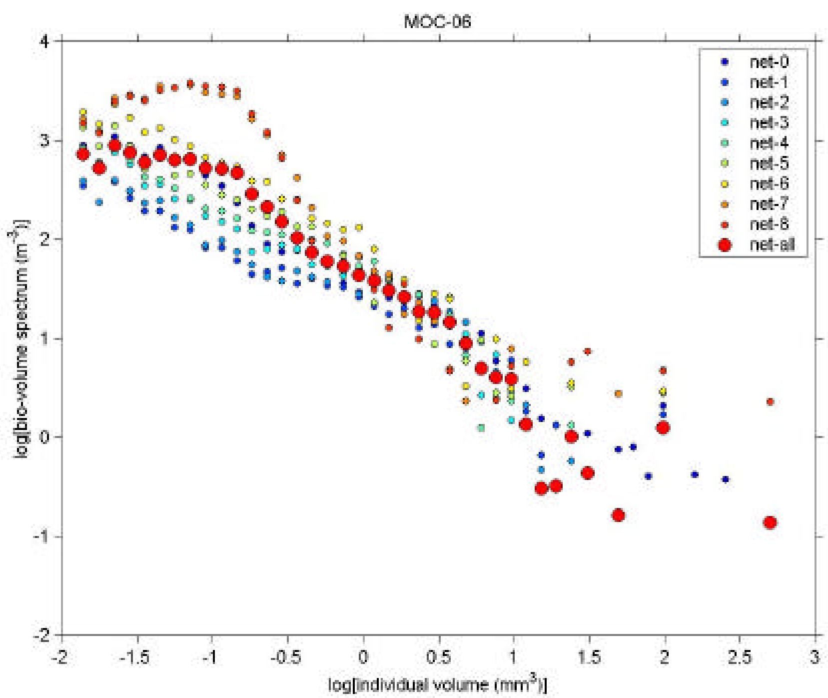


Figure 14. The biovolume spectra measured at the off-shelf station.

The wind-driven currents in this region can be a very important mechanism for transport of larval krill onto the shelf. Large numbers of krill larvae were found in the surface nets prior to the wind storms at the off-shore site. After the storm, krill larvae were not found in either off-shelf or on-shelf sites. If we assume that the wind-driven Ekman layer is down to 50 m, within which krill larvae were found, the transport of krill larvae should be in the on-shore direction because of the predominant north-northeast wind.

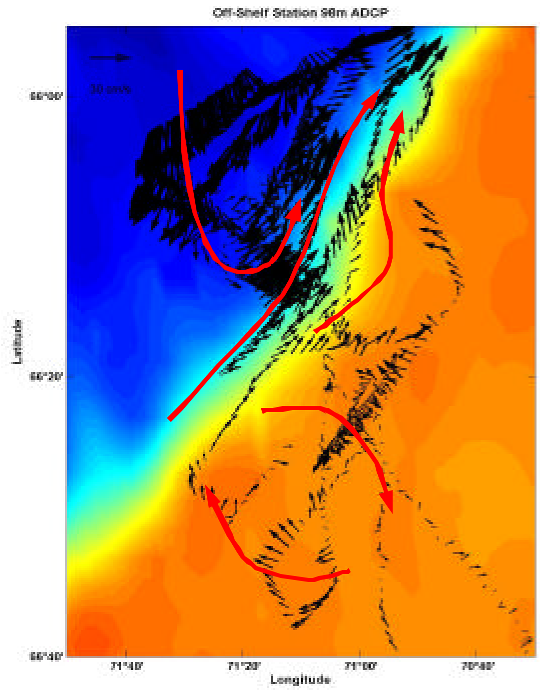


Figure 15. The current field at the shelf break station.

Nutrient analyses - Morin

<u>Nutrient and Oxygen Analysis of CTD Bottle Samples</u>

Oxygen profiles show a distinct reduction from the surface to a depth of between 200 and 300 m. This reduction trend lies below a relatively stable-looking high concentration surface layer (approximately 50 m, 7.8-8.0 ml L^{-1},) that is evident regardless of the existence of an obvious mixed layer defined by the salinity profiles. In the deep water stations the oxygen minimum has concentrations below those of the bottom waters. In many cases the concentration begins to increase at the oxygen minimum and increases consistently to the bottom of the bottle cast.

The nutrient profiles thus far have shown remarkable similarities in trends. Expected surface water depletion trends in nitrate (NO_3^-), silicia ($HSiO_3$), and phosphate ($HPO_4^=$) are evident in almost all profiles. These concentrations do not approach complete depletion, or levels approaching limitation. Ammonium (NH_4^+) and nitrite (NO_2^-) conversely show consistent increases toward the surface starting around the depth of the pycnocline. The depth of the origin of depletion in NO_3^-, $HSiO_3$, and $HPO_4^=$, and the beginning in the increase in NH_4^+ and NO_2^- appear to co-occur with the oxygen minimum. In many cases the depth of the minimum in oxygen concentration corresponds to a peak in both NO_3^- and $HPO_4^=$. A localized subsurface peak in nitrite concentration is also evident in many of the profiles slightly above the oxygen minimum and above the depths of the peaks in NO_3^- and $HPO_4^=$.

Nitrate and phosphate concentrations in the bottom waters of the deepest cast (Station 1, event 112, event 122) show extremely little variation below the pycnocline (NO_3^- – standard deviation is 1.25% of mean for bottom 2500 m, twelve samples, $HPO_4^=$, standard deviation is 1.36%). Silicia displays an increasing trend with depth but does not vary from the trend. This type of observation has been seen in most casts where well developed bottom waters are evident.

4.0 THE FINAL TWO WEEKS OF SCIENCE AND END OF THE CRUISE (CRUISE DAYS 29 APRIL TO 14 MAY INCLUSIVE)

Synopsis: During the final two weeks of the process cruise we completed work at 4 additional sites, 4A, 4B, 2, and 6, and made an additional final visit to Avian Island. At the completion of process site 2, our scientific party elected to move deeper into Marguerite Bay to sample at the then-developing ice edge. Since the ice edge is often a zone of high abundance for all trophic levels it was considered a favorable site for study, particularly in light of the very low quantities of data extant on newly forming ice edges. The fact that the ice edge was forming deep inside Marguerite Bay over waters of typical shelf depths, and the fact that the middle of the Bay had been under-represented in our sampling efforts, both contributed to our decision to move into the Bay after the completion of site 2. Our mid-Bay excursion was considered as process site 6 since it was in the vicinity of Neny Fjord, our site 6 during the 2001 fall process cruise. Directly after completing our work in mid-Bay we began a cetacean survey/biopsy track north until reaching Vernadsky Station and then on to Palmer Station.

29-30 April. Directly following our seal team pick-up and the departure from Rothera Base a 24-hour acoustic survey using both the ADCP and the HTI 120/38 was conducted south of Adelaide Island. The purpose behind the survey was to forge a stronger connection between the data collected on the Avian Island Adélie penguins and the krill populations inhabiting the many depressions in the vicinity of the Island that were major sites for foraging.

Process site 4A. 30 April-5 May. Process site 4A was located in the southeastern corner of Marguerite Bay and included the mouth of George VI Sound. It was bounded roughly by the tip of Alexander Island vic 68.8ºS, 70.6ºW on the northwest, 68.8ºS, 70.0ºW on the northeast and by the ice edge at the mouth of George VI sound on the south. It included the southeastern end of the Marguerite Trough, the large cross-shelf canyon that runs south-southeast through Marguerite Bay. The Marguerite Trough runs right down the middle of George VI Sound. The Sound was completely occluded by sea ice before our arrival at the study site. Ice conditions precluded any sampling in the main body of the Sound (see cruise track line).

After a 10-hour transit we arrived at process site 4A, in the vicinity of survey station 58 on 30 April. Our strategy of leaving the lion's share of daylight hours to the operations that absolutely required daylight continued here. Our days were divided between seal operations, whale operations, and dives, and our nights between MOC-10 tows, Tucker trawls, MOC-1 tows, and ADCP surveys. Details on the results from individual programs are provided in the group reports found below.

Process site 4B. 5 May-6 May. Site 4B was located at the northern end of Alexander Island in the vicinity of survey station 42. After completing work at site 4A, we proceeded north to 4B and completed an ADCP survey of the area vic station 42. Despite a substantial krill signal and reports of high predator activity in the area, both on the survey vessel and in previous cruises, we saw few seals and penguins. As a consequence, the LMG departed for process site 2 by the afternoon of 6 May. It should be noted that a substantial freezing event began to occur at this location on 6 May.

Process site 2. 6 May-7 May. Our stay at site 2 was brief. We did an ADCP survey, MOC-1 and MOC-10 tows and began our transit to Avian Island at about midnight on 7 May.

Avian Island and the southern process site 5 were revisited on 8 May. Our purpose in re-occupying Avian Island and southern site 5 was to allow our penguin team to get the rest of their satellite tags out and to collect additional data on krill presence in the depression adjacent to the Island, where most of the penguins were hunting. An abbreviated ADCP survey and a plummet net series were completed there before we began our transit to process site 6 in the vicinity of Neny Fjord.

Process site 6. 8 May-10 May. The process group completed a series of ADCP surveys, MOC-1 and MOC-10 tows, and SCUBA surveys in the vicinity of Neny Fjord, a station deep in the Bay at typical shelf depths of 400-500 m. Few penguins and seals were found despite the presence of sea ice.

Whale surveys/biopsies and seal surveys were done while transiting 11-13 May. The remainder of the cruise was spent in an extended whale survey/biopsy track around the southern end of Adelaide Island and up its west coast. A stop was made in the Crystal Sound area to work up two additional seals and then the boat headed for Palmer Station, surveying along the way, with two stops at Vernadsky Station and Port Lockroy, respectively.

Individual group reports

BG 232 - Seal ecology and physiology - Burns/Costa

<u>Week 4: 28 April-6 May 2002</u>

With all our satellite tags deployed (Figure 16), this week was dedicated to capturing additional seals to bolster our sample size for diet and physiological studies. We were hopeful that we would be able to do so, since there were frequent sightings of seals in the pack ice. After leaving Rothera Station on the morning of 29 April, we headed towards Johnston Strait, where several of the seals handled during the SO GLOBEC II cruise (August-September 2001) were captured, and where the *Gould* had seen ice, seals, and whales when it had headed towards the open water station after dropping us at Rothera Station. However, we had little luck with weather, and the area was too exposed to work in. Instead we headed south to the ice edge and process site 4 (southern edge of Marguerite Bay). This area had been a hot-spot last fall (see Appendix 2), and two of our tagged seals (Hellion and Ryder) were in the area, suggesting that it was a hot-spot again. The ship arrived at site 4 on 30 April, to find very thick ice, covered with deep snow. The main business of the evening was to exchange some equipment with the *N.B. Palmer*, and we did that near their station 58. The NSF science writer, Kristin Cobb, came aboard briefly, and we were able to tell her what our research was all about.

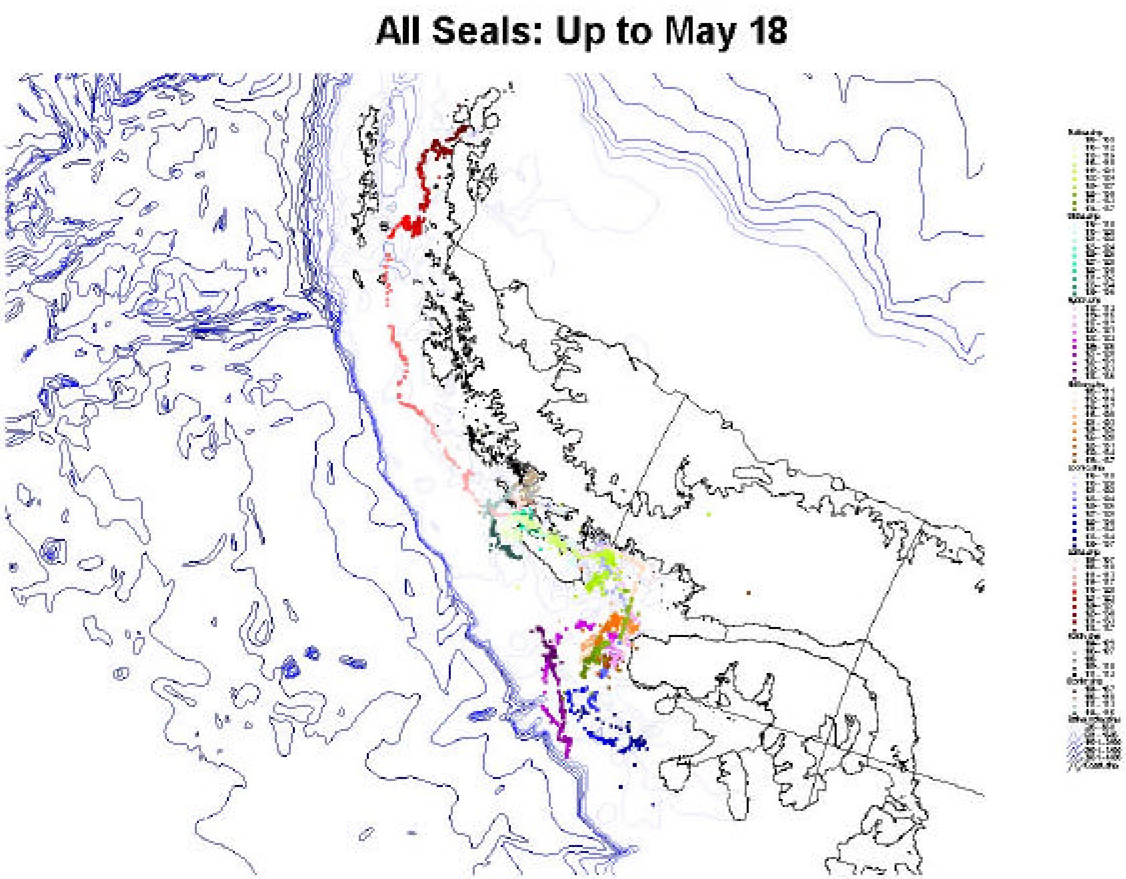


Figure 16. Geographic Information System (GIS) map of all crabeater seal position data up to 18 May 2002; seals tagged on LMG02-03.

On 1 May, we were at the ice edge in the morning (the thick ice of the evening before was not conducive to working, as the floes were too tightly packed to conduct Zodiac operations in, but too small to use a personnel basket on). The plan was to look for seals, whales, and penguins. But right from the beginning, Ari Friedlaender saw many whales, and instead we spent the morning on the bridge helping direct the Zodiac to groups of humpback whales. In the afternoon we headed into the ice to see if we could find seals. We did, but the floes were far too small to work on, and so instead the diving team went in. While not successful, the area clearly abounds with seals, so we are confident that we will be able to work here.

On 2 May, we located crabeater seals from the moment we were up on the bridge. There were lots of seals on floes just inside the ice edge, but the floes were not overly large, and there was a big running swell that made working on floes marginal. We marked our position, and headed deeper into the pack hoping to find more seals on larger floes in an area where the swell wasn't so strong. However, as we moved into the ice, the floes did not get any larger, and the swell did not ease. Instead, we found ourselves in an area of small floes that were closely packed, which made Zodiac operations impossible. And, as we moved away from the edge, we found fewer and fewer seals. So after about an hour, we returned to the spot where we had seen seals in the morning, and again assessed conditions. We decided that it was possible to work on some of the larger floes, and the MTs agreed, providing we wore the full Helly Hansen work suits instead of our mustang suits. We did, and just after lunch headed towards a floe with 4 seals on it. We captured and handled an adult female on the floe (G032, event #153). Everything went well, and we did all procedures except attach a satellite tag (as we have deployed all our tags). We also collected a fresh scat deposited by one of the other seals on the floe. After completing G032, we headed towards another floe with seals, and captured the second seal of the day, G029, a large adult male. Everything went well, with the exception that we were all getting extremely chilled, and the light was quickly diminishing. The *Gould* helped out towards the end by providing their spotlights, and we were able to complete our work successfully. The swell was not as bad once we were on the ice as it appeared from the bridge. But the worksuits were much worse than we expected. In the cold (-5ºC) they became stiff and slick, the boots were not fitted so that it was hard to walk in the deep snow on the floes, and their bulk made it difficult to move around efficiently.

Interestingly, on 3 May, we did not see many seals or whales at all (and penguins have been uniformly scarce), even though we were very close to our position of the previous day. The ADCP data shows that process site 4 is characterized by highly localized krill swarms, and that in the little movement we did overnight, we moved out of an area with krill pockets, and into an area with a thin diffuse layer. Our work on 4 May started at the ice edge, and we moved inside during the morning looking for seals and penguins. We saw a large number of leopard seals on floes, and a few crabeater seals. We were under a bit of a time constraint, as the divers were to dive in the afternoon, and diving and seal operations cannot take place simultaneously (a change from last year due to safety concerns). Again, we had to find the balance between floe size and floe accessibility, and did so closer to the ice edge. While the ice gets thicker as we move inside the edge, we are still not seeing large floes that would allow us to use the personnel basket. We finally sighted a seal on an accessible floe, and headed towards it in the Zodiac. While we were able to jab the animal, it never became sedated, and when we attempted to capture it, it fled into the water. Due to time constraints, we were not able to try for a second seal. We have noticed that the seals are calmer when they are in groups, and that they also appear less willing to go in the water in the afternoon, rather than the morning. While work schedules mean that we must work in the morning, we will change our search strategy and target seals in groups rather than solo seals.

On 5 May, we were still at process site 4, and as it was getting light (sunrise is now at 0940) we spotted seals. We headed off in the boat at 0900 in the hopes of working seals until 1400, when the divers were to dive. We headed towards a floe with 4 seals on board, but just before we reached the floe we had an accident in the Zodiac. A large piece of ice went under the boat, and kicked the motor so high that it broke off the transom and started to sink. Quick thinking on Josh's part, and a strong fuel line, prevented the loss of the motor, but it took quite an effort to get it back on board the Zodiac and remounted on the (now shorter) transom. Since it had been completely submerged in freezing water, we were not surprised when it did not start, and so we called the *Gould* for a rescue. Captain Robert did a fabulous bit of driving, and docked us next to the LMG by moving the ship and not us (we were dead in the water). We quickly transferred gear into the second Zodiac and again headed out to the seals (that were conveniently still asleep). We were able to capture our largest female yet (G028, event #172, mass 314 kg), and despite Mark's attempt to fall off the ice floe (he didn't) everything went well, and we accomplished all procedures. However the delayed start meant that we were unable to attempt a second seal due to time considerations. Instead, we returned to the ship around 1300, and the afternoon was dedicated to penguin searches and diving. Remarkably, Christian was able to get the Zodiac engine running again, so we again have two functional Mark V Zodiacs. Throughout the afternoon and evening we were surrounded by crabeater and leopard seals on floes. This area is clearly a hot-spot for activity, and there continue to be dense aggregations of krill apparent on the ADCP.

On the morning of 6 May, we were in very thick ice at the northern tip of Alexander Island (process site 4B). We were deep into the pack ice, and all leads were frozen over. Despite this, the floe size was small (20 x 20 m at the largest). We could not see the ice edge, but headed northeast to where we thought it would be (the entire ADCP survey conducted overnight was done in thick ice). Even so deep in the ice, we did see some crabeater seals—solos on floes, widely spaced, but couldn't get to them with Zodiacs, and they all fled when we approached with the *Gould*. We didn't reach the ice edge until after lunch, and here the seals were widely scattered and on small floes. Since we have all our tags deployed and have even handled an additional four animals, our work took a back seat to the penguin group, and the LMG moved quickly along the ice edge looking for birds, with little success. This area was not a good one for working on seals, and we will leave tonight to head to process site 2 (open water at the head of the canyon).

<u>Week 5: 7-14 May</u>

Most of this week was spent with the *Gould* supporting other science activities. As we had deployed all our tags, and had handled an additional 4 seals, we were happy to see other groups accomplish their work. On 7 May, we were at the open water station, and did not see any seals. On 8 May, the *Gould* headed to Avian Island so that the penguin group could get their research accomplished, and we searched Avian Island for crabeater seals and tagged elephant seals. This trip we saw two juvenile elephant seals with tags. One carried orange tags N14 (left) N15 (right), while the second carried a single white tag Z51. On 9 May, we conducted a search for seals, whales, and penguins in the middle of Marguerite Bay. The bay was rapidly freezing, and there was sea ice all around. We moved north towards Bourgeois Fjord this morning looking for seals but ran out of sea ice before we ran into any floes or seals, so instead we are heading back west and south to bands of larger ice and floes. It was a gorgeous clear morning, with the sun rimming the mountains with fire right before it rose. The sea was completely calm, with a thin skim of new forming sea ice and lots of bergs and bits. We hunted for the edge until noon, and then turned it over to the divers. Total seal sightings: 2 crabeater seals—1 on a floe and 1 in the water. We did not see whales or seabirds, and seem to have found a predator free zone. This is reflected in the ADCP data which showed a very diffuse layer, but no krill swarms or areas of high abundance. The trawls did not yield high numbers either. The *Gould* remained in this area for an additional day, as other science teams worked to characterize an area where predators weren't. Again, there was little vertebrate fauna seen, and poor returns on all aquatic surveys. On 11 May, the ship turned north, and headed towards Crystal Sound. All of Marguerite Bay was frozen, and sea ice extended north and west around the southern tip of Adelaide Island. This slowed our progress and we did not reach the Johnson Strait area until late afternoon. In the area we sighted several 100 crabeater seals on small ice floes and new forming sea ice. The seals were often so closely packed on the floes that the ice seemed in danger of sinking.

On the morning of 12 May, we were in Crystal Sound for our last day of seal work. As the sky lightened just after 0830, we were located in an area of large ice floes, and seals. As we waited for Josh and Christian to get the Zodiac engines operating (the extremely cold water temperatures were making Zodiac operations extremely difficult) we watched more seals haul out. Repairs took approximately 90 minutes, and then we headed out to capture seals. The sea ice was fairly heavy and mixed with glacier bits and old ice, which slowed our progress. However, we were able to successfully capture a large male on a floe with two other seals. We completed all procedures, and collected a scat sample. The other two seals remained on the floe throughout our work with seal #27, but went into the water once we targeted one for our final seal of the cruise. Instead, we moved off the floe and towards another large group about 1000 m away. The ice had blown around, and our path was too choked to make progress. We called the LMG, and Captain Robert did some skillful driving to free us from the ice without disturbing the seal we had just finished working on, or the seals that we were heading toward. We were able to capture another large male on the second floe. This animal had recently been in an altercation with something, as it was missing part of its lower jaw and seven teeth. The wound looked to be 1-2 weeks old and healing, and the seal was still in good condition. It will be very interesting to see the final veterinary exam results for this animal. Throughout the day, more seals continued to haul out, and as the day progressed, those on floes seemed to become calmer and less active. The ADCP data showed that this area had extremely high krill abundance, and this was nicely correlated with the large number of seals. We are now convinced that it is easier to work with seals on floes that have many seals hauled out. The seals we don't handle generally remain on the floe, and having companions seems to reduce the agitation caused by our initial presence and the drugging activities. Similarly, it is easier to work with animals later in the day than earlier in the morning.

With our science complete, we headed to Vernadsky Station on 13 May and spent that day packing and making sure that all our gear was entered into the Cargo database. With that completed, we enjoyed good weather in the morning of 14 May at Port Lockroy.

Summary of data from tagged seals

Lolita *(subadult female, tagged 14 April 2002 in Crystal Sound).* Lolita moved north from the sound to the tip of the Antarctic Peninsula just south of Deception Island (63.415ºS, 59.847ºW). The movement was made in open water to the west of the Antarctic Peninsula, but east of the shelf break. Her transit lasted from 21 April to 29 April, and since then she has remained just south and west of the tip of the Antarctic Peninsula. She has gradually moved towards the tip of the Peninsula, and we are anxiously waiting to see if she enters the Weddell Sea.

Dexter *(subadult male, tagged 15 April 2002 in Crystal Sound).* He remained in the Sound until 20 April, and then moved west through Matha Strait and south along the coast of Adelaide Island. His tag stopped transmitting on 27 April for unknown reasons.

Patch *(subadult female, tagged 15 April 2002 in Crystal Sound).* She remained in Crystal Sound but moved slightly northeast. Her tag stopped transmitting on 23 April for unknown reasons.

Bubba *(adult male, tagged 17 April 2002 in Crystal Sound).* He remained in Crystal Sound until 25 April, at which point he moved south through Tickle Channel and through Laubeuf Fjord. From 30 April to 3 May, he was in the ice just south Laubeuf Fjord. Moved towards process site 4, and arrived there (where he has remained) on 4 May.

Hellion *(adult female, tagged 20 April 2002 just south of Wyatt Island).* She moved steadily south and on 25 April reached process site 4, where she has remained since.

Ryder *(adult male, tagged 23 April 2002 in Ryder Bay).* He remained near Rothera Station until 26 April, then moved towards process site 4, which he reached on 28 April. He remained in this area until 3 May, when he moved southwest to the shelf break. After spending a few days at the break, he doubled back on his track, and moved northeast. He is offshore but over the shelf, and in waters where there should be fairly thick sea ice.

Stella *(adult female, tagged 27 April 2002 in Ryder Bay).* She remained near Rothera Station until 29 April, at which point she moved north into Crystal Sound through Tickle Channel. She reached Crystal

Sound on 2 May and has remained there since.

Leonie *(adult female, tagged 27 April 2002 in Ryder Bay).* She moved out of Ryder Bay within 24 hours of tagging, paused briefly to the southwest of the entrance to Laubeuf Fjord (30 April-2 May), then headed towards process site 4, which she reached on 3 May. She remained there for a few days then headed southwest toward the shelf break near where Ryder had been. Prior to reaching the break, she headed south, and is now offshore directly west of Lazarev Bay.

Diving patterns show that the seals are diving deeper during the day (to between 100-250 m) and shallower at night (cf. Figure 3, Appendix 2). The seal dive data also provide information on environmental conditions encountered on individual dives (Figure 17). Most haulouts occur at night (although the pattern is extremely variable among and between seals). The maximum depth to date is 365 m. Seven of our scat samples appear to be completely krill, but two are dark brown, and do not look like they contain krill.

We find it extremely interesting that four of our tagged seals traveled to process site 4, near the north tip of Alexander Island, despite the fact that we tagged them in very different locations. This was a region of high krill abundance and good sea ice. However, we do not know how or why seals tagged in Crystal Sound (also an area of high krill abundance) moved so far south. At much the same time, Leonie made a fairly direct movement to north, and has resided in Crystal Sound since. Finally, Lolita's movements are the most extreme that we have recorded, and she has not hauled out since she began her journey to the north.

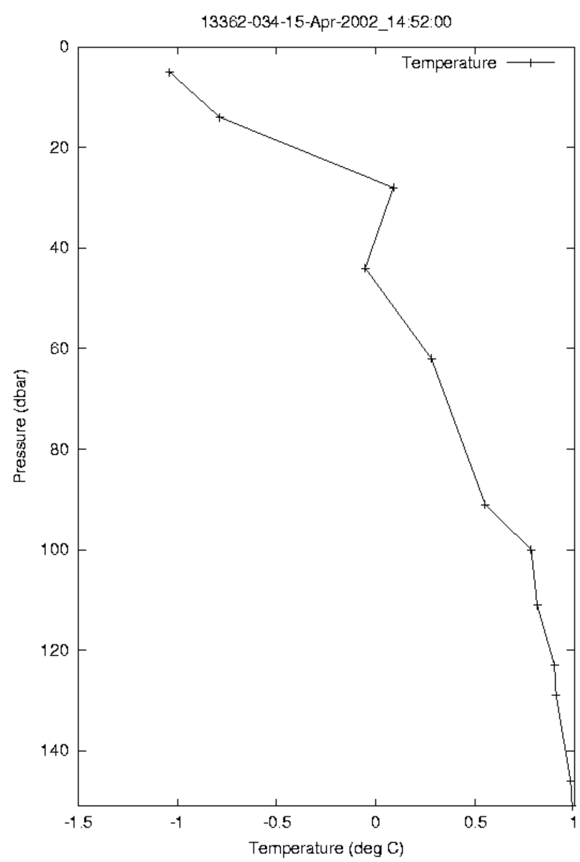


Figure 17. Vertical temperature profile as recorded by a seal-mounted time-depth recorder and relayed back to LMG02-03 via satellite.

BG 234 - Seabird Ecology - Fraser - Report by Chris Denker (Dr. Bill Fraser represented by Chris Denker, and Brett Pickering)

Unfavorable sea ice conditions in the southern half of Marguerite Bay added quite a challenge for the seabird team during the second half of LMG02-03. The ice edge in George VI Sound followed a broken line from the tip of Alexander east to the Antarctic Peninsula. This edge was not uniform and contained multiple leads. Sea ice types ranged from multi-year floes, to brash, to newly formed sea ice. This outer edge, especially over the deep trough of Marguerite Bay, teemed with life. Numerous whales and seals appeared to follow dense patches of krill, but even with this huge food source Adélie penguins were not present on the edge. Two days of observations were unsuccessful in finding any birds in this area.

After communications with Erik Chapman, the seabird observer on the *N.B. Palmer*, we chose to go deeper into the pack. Erik had seen roughly forty Adélies several days before and we hoped to find a few of our own. Six miles in, we started seeing birds. Not many (a whopping four) but it was a start. At this point, sea ice conditions deteriorated and stopped us from penetrating deeper into the pack. The Adélies we observed were traveling over broken floes with snow accumulations of one meter. Due to the ice conditions we could not capture these birds for satellite tag deployment or diet sampling.

Our next attempt came at the northern tip of Alexander Island in the "Iceberg Graveyard". An ADCP grid of the previous night had us situated deep within the pack ice at daybreak. Ice conditions in this location were similar to what we found in George VI Sound except with more multi-year floes. Heavy snow accumulation was still present. Once again we were frustrated by finding Adélie penguins (16), but all in unworkable conditions. Due to time constraints the LMG now had to move away from the southern Marguerite Bay area.

We were now closing in on the end of the cruise. Three satellite tags still needed to be deployed with not many opportunities left. According to recent satellite data, one bird was in the Pourquois Pas area close to an ice edge, but the majority of our satellite birds were still on Avian Island. We chose to access Avian Island first. If weather or sea ice prevented a landing then we would move to Pourquois Pas, try working birds there, and if that failed head back to Avian Island on our way out of the study area. Luckily, weather and sea ice were not part of the day's equation and Avian Island was a go. Three uneventful landings in one cruise has to be a record for that Island! We deployed the last three satellite tags by 1300 and returned to the ship by Zodiac soon thereafter.

Calm, clear, and cold weather still held fast over the Marguerite Bay area at the end of 8 May with sea ice growing very rapidly. We headed east through six inch deep sheets of new ice to Pourquois Pas. Very little in the way of whales or seals were seen here. A group of six Adélies was spotted towards sunset, but accessing them for diet sampling was impossible due to the ice conditions. Steaming out of the Bay for the last time on 11 May we were very surprised to see how far the sea ice had grown just since 8 May. Had we waited to access Avian Island on our way north from Pourquois Pas then we would have been denied. Ice conditions literally went from open water to 10/10 in just a couple of days. Amazing.

We conducted our final day of science in Crystal Sound. The seal team worked two seals while we stood watch for birds from the bridge. Once again, the only birds we saw were past sunset and, of course, on unworkable floes. Rather unfortunate, but you can only do so much before sinking to the bottom of the deep blue sea, and that's just not part of the game plan.

Overall, 90% of our objectives were met. We would have liked to spread the transmitters over a wider area and collect more diet samples, but sea ice conditions either prevented Zodiac operations or stopped us from outright walking on the floes. On a more positive note, we were lucky enough to be in the Marguerite Bay area just as it was re-freezing. The tagged Adélies from Avian Island are now traveling on this new ice and appeared to have abandoned land all together. These tagged birds will shed some interesting light on Marguerite Bay during the winter months and give LMG02-05 a great place to start hunting in July.

BG 236 - Krill ecology and physiology - Daly

We used a Hydroacoustic Technology, Inc. (HTI) echosounder with 38 and 120 kHz frequencies to assess the abundance and distribution of euphausiids and fishes. We collected about 1 hour of acoustic data in Crystal Sound, more than 24 hours in Laubeuf Fjord during a day-night survey and subsequent net tows (process site 5), 3.5 hours at the shelf break (process site 1) coincident with MOCNESS net tows, and 14 hours during a survey from Laubeuf Fjord to Avian Island, where the penguin camp was located, and then to Johnston Passage. All acoustic surveys were done jointly with ADCP data collection (see M. Zhou's report) to assess the distribution of krill in relation to current flow and circulation features. The day-night surveys were designed to investigate diel vertical migration behavior by zooplankton and fishes. A system calibration using a standard tungsten sphere was completed prior to the first survey. A final calibration was not done at the end of the cruise because sea ice conditions prevented deployment of the towed body after the first two weeks of the cruise.

A dense layer of *Euphausia superba* (verified by net tows) was detected across Matha Strait in Crystal Sound, where crabeater seals were abundant. The layer extended from about 35 to 300 m in depth (Figure 18) in water 400 m or greater and persisted for over a month, as evidenced by repeated occupations of this site at the beginning and end of our cruise and later by the *N.B. Palmer* (P. Wiebe, pers. comm.). Many of the *E. superba* collected in net tows had black-green guts and hepatopancreas indicating feeding on phytoplankton or phytodetritus. Juveniles, 17- 33 mm in length, were the dominant stage and sizes, but immature and mature males and females 39-47 mm also were present. No *E. crystallorophias* of any stage or *E. superba* larvae were found.

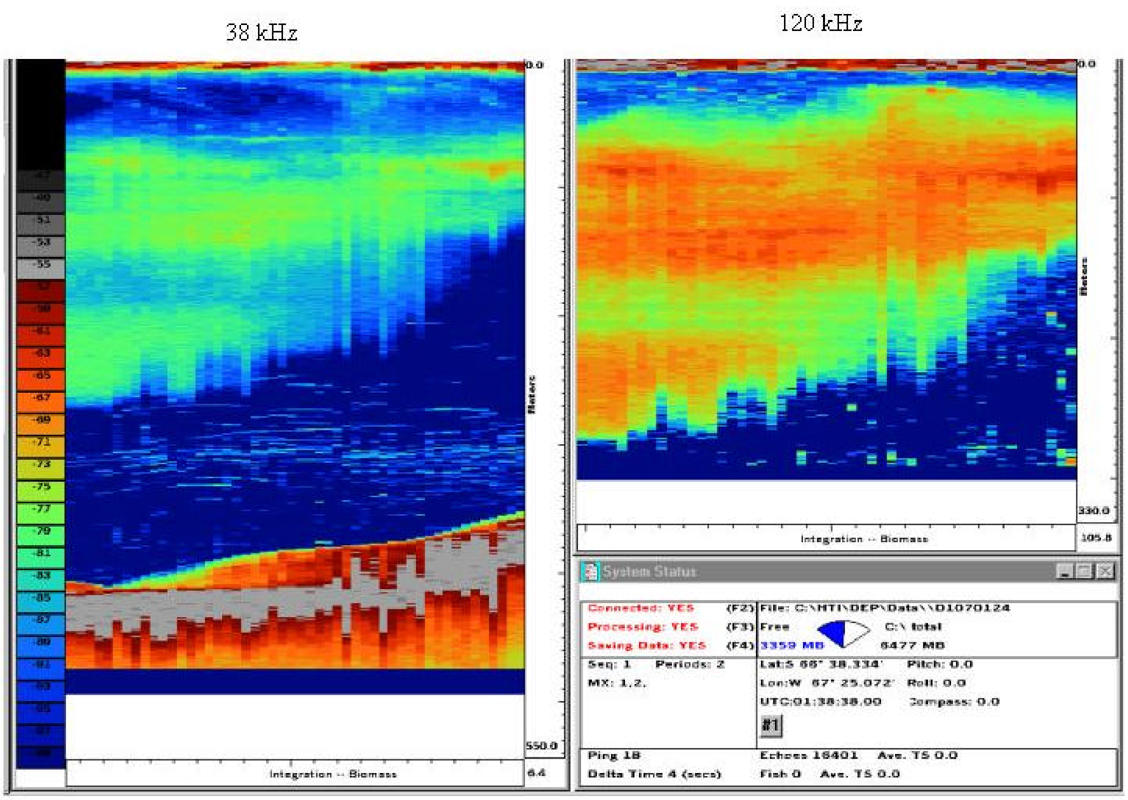


Figure 18. Acoustic echogram from Matha Strait in Crystal Sound showing the distribution of acoustic backscattering (dB) through the upper 300 m for the 120 kHz frequency and the upper 500 m for the 38 kHz frequency. Bottom about 410-350 m on the 38 kHz echogram. The color code bar for the dB scale is shown on the right.

In Laubeuf Fjord, vertically migrating layers of zooplankton and fish were observed across the entire channel (Figure 19). Some areas had acoustic backscattering levels similar to that in Matha Strait, but overall backscattering levels were generally lower. The layers were composed of a mixture of different organisms, including ctenophores, the amphipods, *Eusirus* spp. and *Themisto* sp., copepods, such as *Pareuchaeta and Calanoides acutus*, siphonophores, jellyfish, *E. superba and E. crystallorophias*, another euphausiid, *Thysanoessa*, the mysid, *Antarctomysis*, and several fishes. Juvenile *E. superba* were abundant, but no larvae were observed. Small juvenile (ca. 22 mm) and adult *E. crystallorophias* also were observed, but no larvae. Live zooplankton and fish were painstakingly collected from this area by Torres and McDonald and transferred to the *N.B. Palmer* for measurement of material properties, sound speed contrast and density contrast by Dezang Chu.

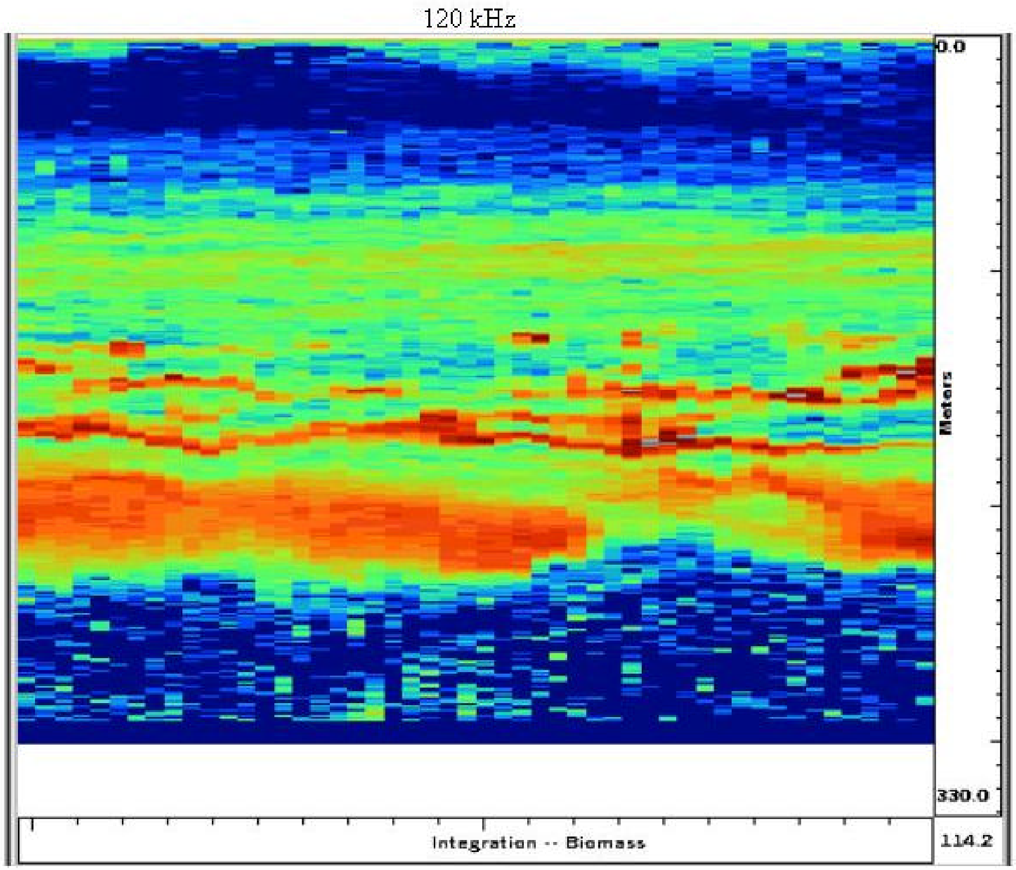


Figure 19. Acoustic echogram for the central Laubeuf Fjord, showing a layer from about 60-240 m in depth for the 120 kHz frequency. dB color scale as in Figure 18.

Offshore (process site 1) acoustic backscattering was the lowest of all regions (Figure 20). Few adult *E. superba* were collected in nets and larvae were patchily distributed in near surface waters. One net tow contained larval stages Calyptopis 2 and 3 and Furcilia stage 1. Another tow was composed primarily of Furcilia stages 1-3. Other tows didn't collect any larvae. The Avian Island–Johnston Passage survey indicated several "hot spots" just south of Avian Island (Figure 21) where penguins were prevalent. These layers had a similar composition to that in Laubeuf Fjord, including juvenile and adult *E. superba*.

At the remaining locations sampled in the Marguerite Bay, George VI Sound, mid-Bay, and in

Neny Fjord, juvenile and adult *E. superba* often dominated net hauls. Larval *E. superba* or *E. crystallorophias* were much more scarce compared to abundances collected last year. Live zooplankton and fishes were collected north of George VI Sound and transferred to the *N.B. Palmer* for measurement of material properties, sound speed contrast and density contrast by Dezang Chu.

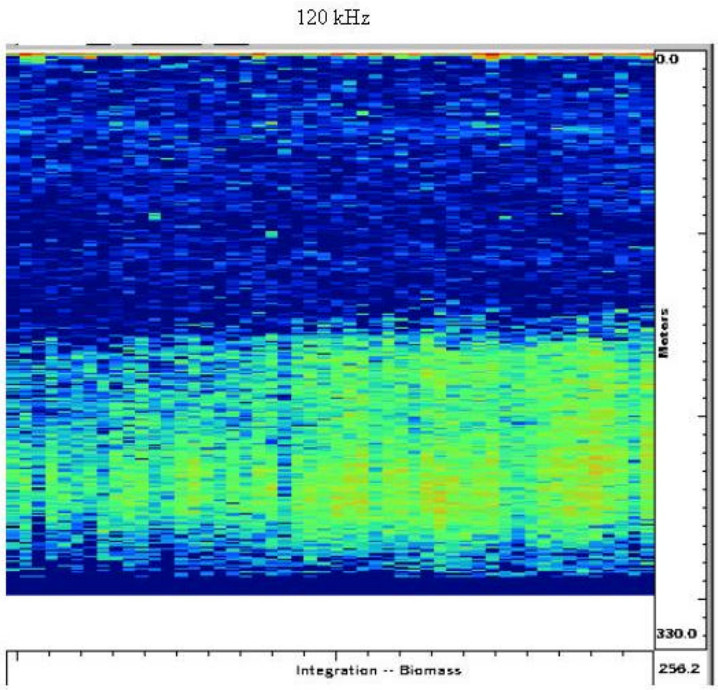


Figure 20. Acoustic echogram for offshore Station 1, showing a reduced level of backscattering at 120 kHz; layer between 150-280 m. dB color scale as in Figure 18.

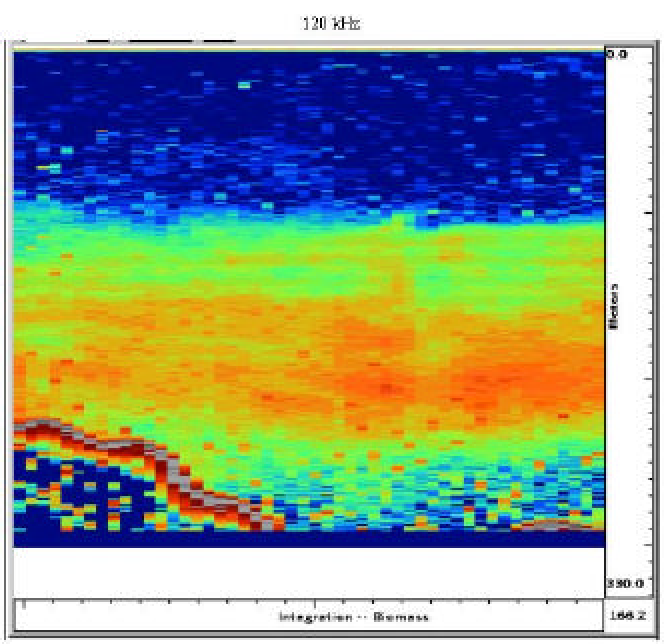


Figure 21. Acoustic echogram south of Avian Island, showing a dense layer at 120 kHz between 100-250 m. Bottom depths are 230-290 m. dB color scale as in Figure 18.

Our group helped the Marine Science Technician, Maureen Hodgins, to collect and analyze chlorophyll profiles at 19 CTD stations. The mean chlorophyll concentration over all depths was 0.189 µg L^{-1} (± 0.242 SD, median = 0.096, range = 0.001-1.49, n = 114). Chlorophyll maxima were usually at the surface (12 of 19 stations). At 5 stations the maxima were elsewhere in the upper 100 m, and at two stations the maxima were near bottom (465 and 753 m, respectively), suggesting that phytoplankton was sinking out of the water column at some sites. On average, 64% of the total pigment (chlorophyll + phaeopigments) was phaeopigments, indicating that grazing processes were important during autumn. The phaeopigment contribution ranged from 5.2–89.8%. Total pigment concentrations ranged from 0.006 –2.84 µg L^{-1}, with a mean of 1.24 µg L^{-1} (± 0.743 SD, median = 0.817). Size fractionations of samples indicated that most of the chlorophyll was associated with cells 5-20 µm, or > 20 µm long. Single centric and pennate cells and chain diatoms frequently were observed under a dissecting microscope at most stations.

We also measured 50 surface chlorophylls from the flow-through seawater system (about twice a day). The flow-through intake is at about 6-7 m depth on the *L.M. Gould*. Values for total pigment were relatively high throughout the study area ranging from 0.062 to 2.40 µg L^{-1}, with a mean of 1.18 µg L^{-1} (± 0.51 SD, median =1.01).

During dive operations, we collected samples from the undersurface of sea ice (ice-water interface), from surface slush and from chunks of older golden-colored sea ice to assess food availability to krill. Total pigment concentrations ranged from 0.55 to 57.17 µg L^{-1}, with most of the biomass being in the > 20 µm and 5-20 µm size fractions. These pigment concentrations are 1-3 orders of magnitude higher than was measured by us last winter. Hence, a significant biomass of sea ice biota accumulated during spring and summer and should be available to overwintering krill. Larval krill, however, only were observed feeding under sea ice just north of George VI Sound (1 out of 6 dives), possibly because there was still sufficient food in the water column.

In addition we completed five Growth and Molting experiments, eight Egestion, four Ingestion, three Assimilation Efficiency, and two Lipid Biomarker experiments (in collaboration with Se-Jong Ju) for *E. superba*. Small larval krill (C2-F3) molted about every 21 days, juveniles molted about every 19-25 days, and adults molted about every 33-36 days. Almost all individuals showed positive growth. Gut fluorescence was 1-2 orders of magnitude higher compared to values measured last year during April/May and July/August, indicating that herbivory was a larger component of the autumn diet in 2002.

<u>Preliminary conclusions for autumn 2002</u>

- Larval krill abundances on the shelf appeared to be lower than last year, indicating a reduced reproductive effort, higher larval mortality, and/or fewer larvae being advected onto the shelf.
- Juvenile krill were abundant, in contrast to last year, suggesting that last year's overwintering larvae successfully recruited to juveniles last spring.
- There appeared to be higher concentrations of food this year. Sea ice biota and late summer/early autumn phytoplankton blooms supported growth in all krill life history stages.
- Large numbers of whales and seals in the vicinity of krill aggregations create a high risk of predation for krill. Mortality of larger stages of krill may have been substantial during autumn. This high risk of predation was likely the driving force behind the diel vertical migration observed throughout the study area.

BG-237 Krill Biochemistry - Harvey - report by Se-Jong Ju

Our field team consisted of Se-Jong Ju and Susan Klosterhaus. The major focus of this project is the biochemical determination of age structure in *E. superba* and lipid biomarkers indicative of its dietary history. Two sets of adult krill (n=400 and n=300, respectively) were collected from Crystal Sound and process site 5. Age pigments and proteins of eyes and eye-stalks from individual animals had been extracted and analyzed using the onboard HPLC system with fluorescence detector. Protein-based age pigment concentration in the eyes and eye-stalks varied positively and were strongly correlated ($p< 0.001$;

r$0.63; n=596) with krill size (total length (mm) - from anterior margin of the eye to the tip of the telson), with sub-adults having much lower values compared to adults. Additionally, the portable HPLC system for this project presented the opportunity for separation and analysis of algae pigment distributions in the water column (Figure 22). Water samples from CTD casts (Events #49 and #100) and brown ice (potentially ice algae) were collected and analyzed for algal pigments to provide information on phytoplankton distributions and communities in the water column and in the ice. More than 12 pigments were identified with dominance of Chl-a, Chl-c, and fucoxanthin. Furthermore, feeding experiments were conducted on adult krill by Dr. Daly's group in order to understand the consumption rate and digestion efficiency of diet (mainly algae) using biomarkers (photosynthetic pigments, fatty acids, and sterols). Based on HPLC analysis, Chl-a levels rapidly dropped with increasing pheopigment concentrations. However, some algal pigments (such as fucoxathin and lutein) were relatively sustainable through the feeding process.

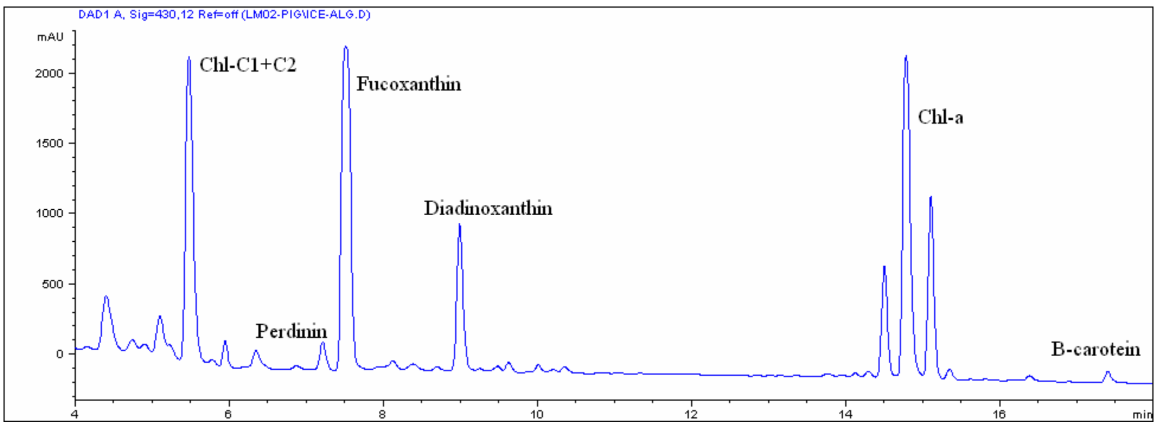


Figure 22. Chromatogram of separated accessory pigments of ice algae collected from brown ice in process site 4. Pigments were separated with Phenomex Luna C18 with multi-solvent gradients and measured at 430 nm for absorbance using onboard HPLC (Agilent 1100 series).

BG 239 - Cetacean ecology - Hildebrand - report by Ari Friedlaender

Recently, the International Whaling Commission (IWC) developed proposals for collaborative work in the Southern Ocean with the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and the International Global Ocean Ecosystem Dynamics (GLOBEC) program under the IWC Southern Ocean Whale Ecosystem Research (SOWER) program. This research program has the long-term aim to "define how spatial and temporal variability in the physical and biological environment influence cetacean species in order to determine those processes in the marine ecosystem which best predict long-term changes in cetacean distribution, abundance, stock structure, extent and timing of migrations and fitness."

This objective is being pursued through collaboration with GLOBEC and CCAMLR using a multidisciplinary ecosystem approach to data collection, analysis, and modeling. The IWC also recognizes that it lacks the data to determine baseline patterns of distribution (and the biological and physical processes responsible for such patterns) of baleen whales from which to judge the potential effects of climate change. Therefore, three further objectives have been defined by the Commission. They are: 1) to characterize foraging behavior and movements of individual baleen whales in relation to prey characteristics and physical environment, 2) to relate distribution, abundance and biomass of baleen whale species to same for krill in a large area in a single season, and 3) to monitor interannual variability in whale distribution and abundance in relation to physical environment and prey characteristics.

SO GLOBEC studies provide the ideal platform for such long-term studies, where scientists from a range of disciplines can conduct intensive focused studies, within the framework of long-term data synthesis and planning. Given the shared objectives among the IWC, GLOBEC and CCAMLR, the IWC has determined that the most effective means of investigating these ecological issues is to focus a considerable body of cetacean research within the framework provided by these programs (taken from D. Thiele).

The first of the "Predator Science Questions" in SO GLOBEC has been formulated as: How does winter distribution and foraging ecology of top predators relate to the distribution and characteristics of the physical environment and prey (krill) (taken from J.A. van Franeker).

Methods

Standard IWC methodology for multidisciplinary studies will be used throughout all GLOBEC collaborative cruises. This will involve experienced cetacean researchers conducting line transect sighting surveys throughout daylight hours in acceptable weather conditions. Data are recorded on a laptop based tracking program (Wincruz), and photographic and video records are also obtained for species identification, group size, verification, feeding (and other behavior), ice habitat use and individual identification (taken from D. Thiele).

During this cruise, observations were made from the bridge level by a single observer (Ari Friedlaender). When conditions permitted, the observer was outside along the bridge wings, otherwise, observations were made from inside. Effort was focused 45E to port and starboard of the bow ahead of the vessel, while also scanning to cover the full 180E ahead of the vessel. In sea ice, the method was adjusted to include searching in behind the vessel track as well, in order that cetaceans and seals hidden by ice would be detected more readily. The observer used a combination of naked-eye and binocular (7x50 Fujinon) searching. Effort would commence when the following conditions allowed: appropriate daylight, winds less than 20 kts or Beaufort Sea State less than or equal to 5, visibility greater than 1 mile (measured in the distance a minke whale blow could be seen with the naked eye as judged by the observer) and the ship actually steaming.

Sightings were recorded on a laptop-based Wincruz Antarctic program which also logged GPS position, course, ship speed, and a suit of other environmental and sighting conditions automatically. Visual observations were made during daylight hours whenever the ship was in transit. When possible, photographic and/or video documentation was made of each sighting for later use in individual identification, species confirmation, and habitat description.

A second component to the marine mammal work is biopsy sampling from small boats. On the occasion that weather conditions, daylight, timing, and whales were present, biopsy sampling was attempted from Zodiacs. Samples were obtained with a Barnett Wildcat Crossbow equipped with custom made floating bolts, and screw-on hollow point biopsy plugs. The bolts are designed to penetrate the skin and blubber (depending on the size of the plug; either 1 inch or 0.5 inches) to the end of the plug, where the float begins, and bounce out of the whale, securing a sample with three small barbs inside the plug. Skin samples are preserved in dimethyl sulfoxide solution and will be send to the National Marine Fisheries Service, Southwest Fisheries Science Center for genetic analysis. Blubber samples will be frozen for later use in contaminant, pesticide, heavy metal, etc. analysis.

Sightings Results

Generally, sighting conditions were very good during the cruise. Fine visibility and sighting conditions prevailed throughout much of the work at or between inshore stations. The only bout of poor weather came during work at the offshore station. This said, 73 hours were spent on full survey effort during this cruise.

In Antarctic waters (south of 60ES), 93 sightings of 248 cetaceans were made. These included 15 sightings of 34 minke whales, 5 sightings of 44 orcas, 71 sightings of 168 humpback whales, and two sightings of two unidentified large cetaceans (Figures 23 and 24**).** With respect to humpback whales, the sightings were generally clustered in open water or near ice edges where large aggregations of krill were observed on the ACDP (Figure 25) (see M. Zhou et al. report). These areas were around Alexander Island, the western edge of the trough bisecting Marguerite Bay (Figure 26), Johnston Passage southwest of Adelaide Island, and the French Passage/Argentine Islands (see Zhou et al. for details on krill distribution in these areas), and to a lesser extent the Bransfield Strait and Neumayer Channel between Port Lockroy and Anvers Island.

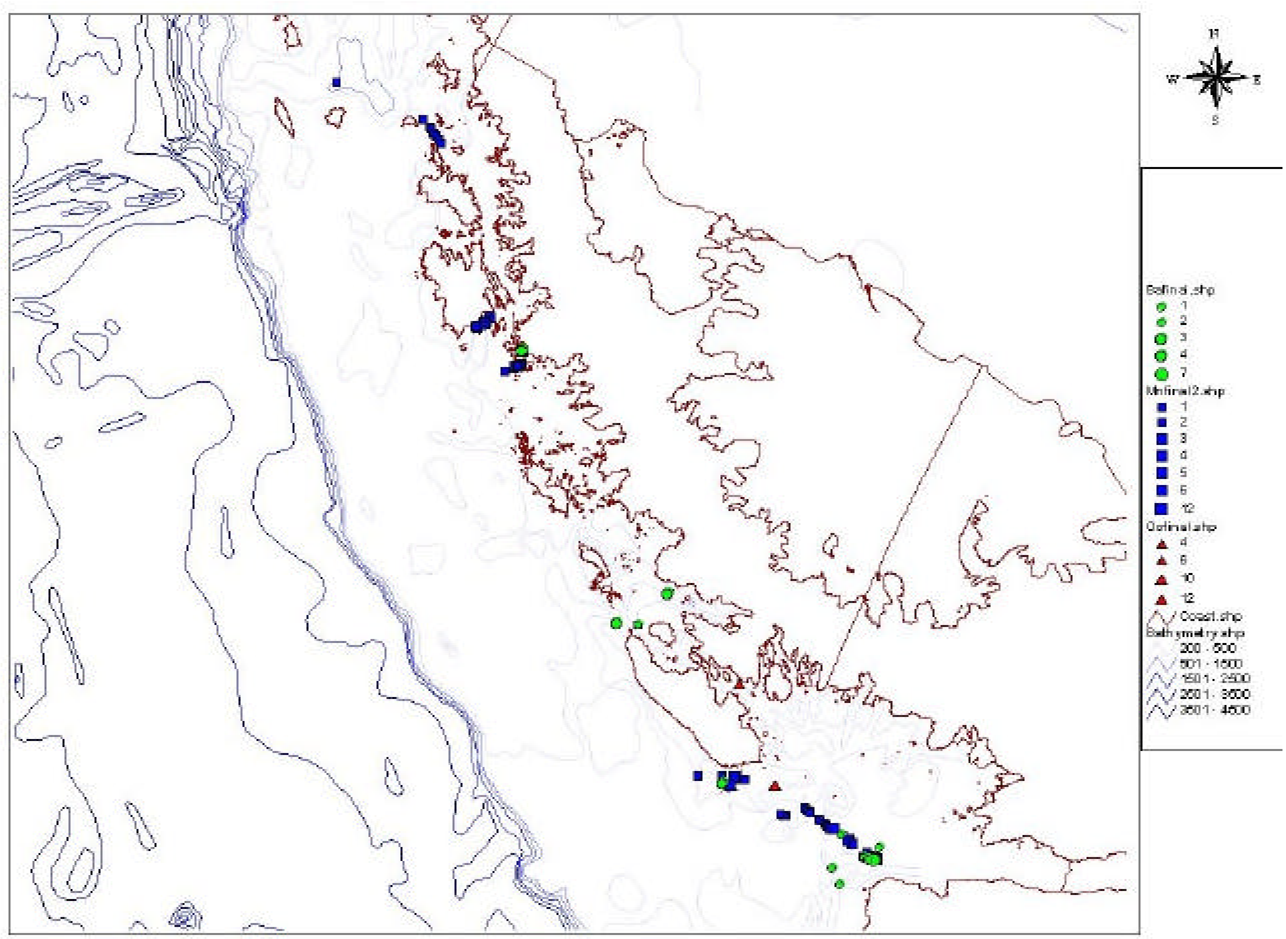


Figure 23. Geographic Information System (GIS) map of all cetacean sightings from LMG02-03.

<u>Biopsy</u>

A total of 20 biopsy samples were collected during this cruise. All of the samples came from humpback whales. All 20 samples collected contained skin, while 19 also contained blubber samples. Biopsy samples were collected on three separate days during the cruise. The first four samples were collected on 11 April 2002 in Bransfield Strait in open water (63º 57'S, 61° 41'W). The next eight samples were collected on 1 May 2002 north and east of Alexander Island near an ice edge (68º 44'S, 69º 52'W). The last eight samples were collected near the French Passage in the Argentine Islands in open water on 13 May 2002 (65º 10'S, 64º 08'W). Dorsal fin photographs were taken for all but the final four whales that were biopsied. Blowing snow and difficult working conditions precluded using photograph or video cameras during this final trip. Digital video was taken of all biopsy samples taken on 11 April and 1 May, and for the first four animals sampled on 13 May. For details and behavioral observations, see Appendix 3.

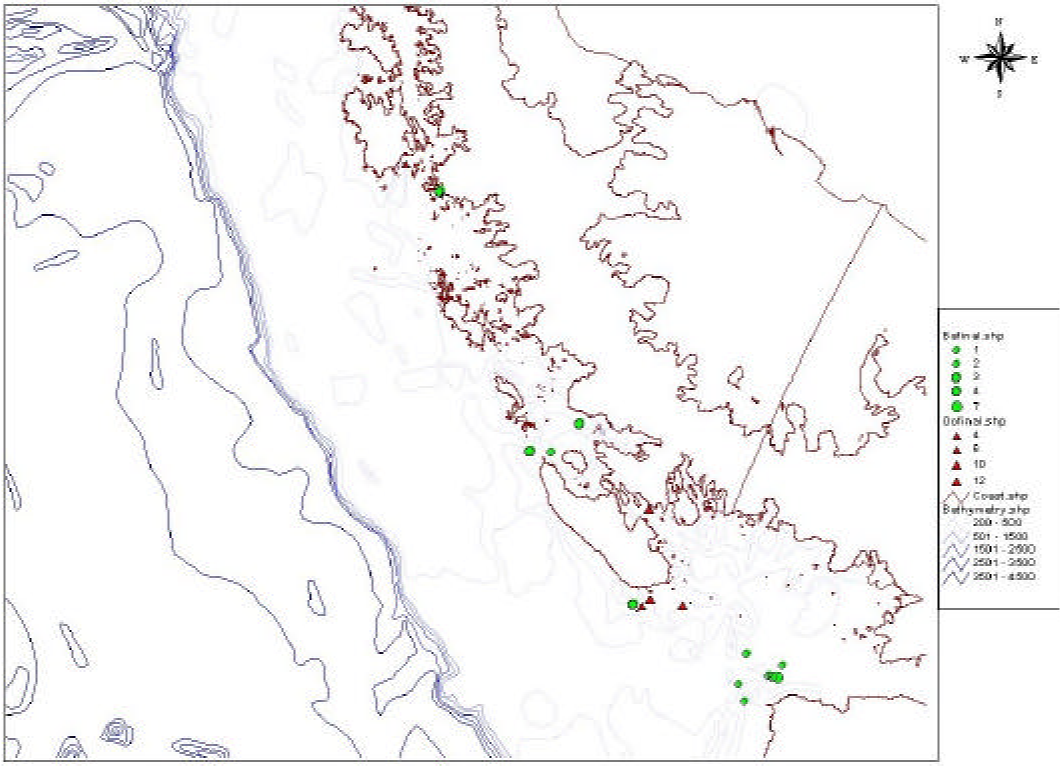


Figure 24. Geographic Information System (GIS) map of all minke whale and Orca sightings from LMG02-03.

Table 1. Biopsy samples collected during LMG02-03

Date	**Sample #**	**WOS#**	**Species**	**Skin**	**Blubber**
11 April	1	6	M.n.*	Y	Y
11 April	2	7	M.n.	Y	Y
11 April	3	9A	M.n.	Y	Y
11 April	4	9B	M.n.	Y	Y
1 May	5	53A	M.n.	Y	Y
1 May	6	53B	M.n.	Y	Y
1 May	7	53C	M.n.	Y	Y
1 May	8	54A	M.n.	Y	Y
1 May	9	54B	M.n.	Y	Y
1 May	10	56A	M.n.	Y	N
1 May	11	56B	M.n.	Y	Y
1 May	12	56C	M.n.	Y	Y
13 May	13	76A	M.n.	Y	Y
13 May	14	76B	M.n.	Y	Y
13 May	15	77A	M.n.	Y	Y
13 May	16	77B	M.n.	Y	Y
13 May	17	78A	M.n.	Y	Y
13 May	18	78B	M.n.	Y	Y
13 May	19	78C	M.n.	Y	Y
13 May	20	79A	M.n.	Y	Y
TOTAL				20	19

* *Megaptera novaeangliae* (humpback whale)

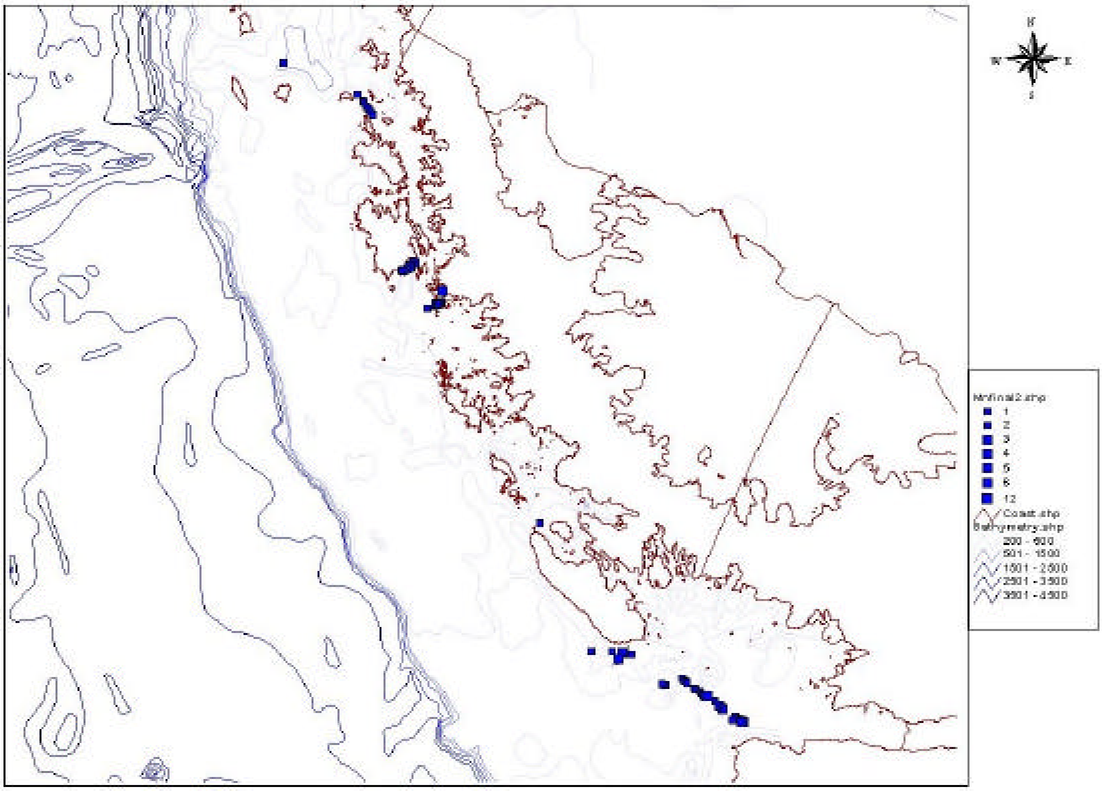


Figure 25. Geographic Information System (GIS) map of all humpback whale sightings from LMG02-03.

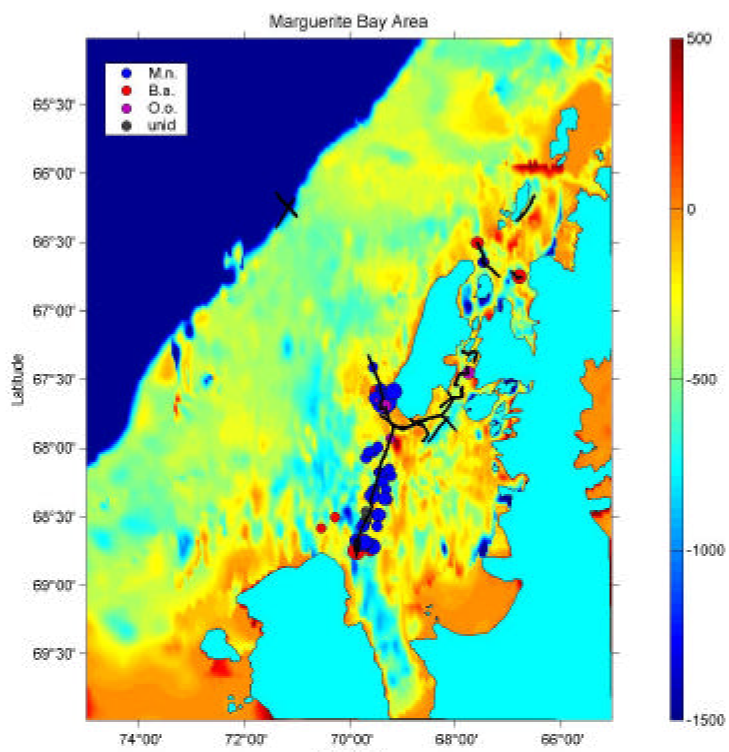


Figure 26. Map of sighting transect lines and whale sightings in and around Marguerite Bay.

Discussion/Preliminary Findings

A primary research objective of the cetacean studies being conducted as part of the SO GLOBEC program is to determine the fall/winter distribution and ecology of baleen whales in relation to characteristics of their environment (physical, chemical, hydrographic, and biological) and the distribution of their prey (krill). Thus, at the planning meeting for the second year of SO GLOBEC, it was decided that cetacean observation effort could better serve the primary research objectives by using both survey platforms (*N.B. Palmer* and *L.M. Gould*). Thanks to the generosity of K. Daly, a berth was made available for a cetacean biologist on the *L.M. Gould* for the April-May 2002 cruise.

Environmental conditions in and around Marguerite Bay were somewhat different than those encountered last year. Sea ice had already begun to form in the south and in the southern portion of the Bay, and by the end of the trip nearly all of Marguerite Bay had begun to freeze over with new sea ice. It is difficult to judge the true distribution within the study area from the data obtained from this cruise. These data were collected on the *N.B. Palmer* by D. Glasgow and will be used in further spatial analysis. The data from this cruise, however, are a good indication of the relative distribution of baleen whales in nearshore waters and around 'hot spots' of prey distribution (krill) during the austral fall and early winter.

Humpback whales were sighted with relative frequency from the Bransfield Strait at the northern reaches of the Antarctic Peninsula to Alexander Island. High densities of humpback whales were seen in several areas where increased acoustic backscatter, associated with krill swarms, was observed. This indicates that many humpback whales are still foraging around the Antarctic Peninsula and seem to be driven north only by the advance of new sea ice. When the LMG was in transit south from Avian Island towards Alexander Island, over 50 humpback whales were seen in open water, clustered along the western edge of the deep trough bisecting Marguerite Bay. Similarly, at the ice edge off Alexander Island over two dozen humpback whales were sighted. As the sea ice advanced in the following week, and the ship moved north, another aggregation of at least 25 humpback whales was seen at the southern portion of the Johnston Passage on the southwest coast of Adelaide Island. This area, along with the Alexander Island site, showed high densities of krill (Zhou et al. cruise report). It is very possible that the same whales that were feeding near Alexander Island had moved north and were foraging in the Johnston Passage area. Presumably, these whales could simply follow the advance of the sea ice throughout the winter. Many sightings made on this and previous trips were of pairs of humpback whales, one of which was often times substantially larger than the other. These may be mothers with dependent calves that are not reproducing in the coming year and thus have no pressing cause to migrate to higher latitudes, especially if there are abundant food supplies throughout the Antarctic Peninsula.

Several research questions remain a high priority to better understand the ecology of top predators (especially humpback whales) around the Antarctic Peninsula ecosystem. These questions have been generated and refocused through the success and insights from SO GLOBEC. From the fine to the broad spatial/temporal scale, some ideas for future research include: attaching short-term, high resolution dive profile tags to whales to understand the foraging behavior and interactions between individual whales and a krill swarm (using side-scan sonar systems to monitor movements of krill); attachment of long-term, implantable satellite positioning tags (similar to those described by Burns et al. cruise report) to understand the daily, weekly, and seasonal movement patterns of individual whales of different age/size classes. These projects would allow a far greater understanding of dynamics of the Antarctic ecosystem. As well, they would allow and understanding of the linkages between physical and biological processes on top level predators and how they would be affected by climate change.

BG 245 - Krill and fish ecology, krill physiology - Torres

Process sites 4A and 4B. Site 4A included George VI Sound and the area immediately to the north of it, located to the east of Alexander Island. Site 4B was the area immediately to the north of Alexander Island. Site 4A is located directly over the axis of the Marguerite Trough, whereas 4B is in a shoal area that is peppered with small deep canyons. Site 4B had been reported as a hot spot for seals and whales, so it was assumed that a large krill presence would also be found. We completed five MOC-10 tows, 15 Tucker trawls, two dives, and 150 individual determinations of metabolism and excretion at site 4A. We found that the oceanic fauna was well represented at site 4A. No trawls were attempted at site 4B. Vertical distribution was as follows, with species listed in order of abundance. Species list is incomplete.

Night

0-50 m:	*Euphausia superba, Themisto gaudichaudii, Callianira sp. Electrona antartica, Gymnoscopelus braueri*
50-100 m:	*Euphausia superba, Salpa thompsoni, thimble jellies*
100-200 m:	*Euphausia superba, Salpa thompsoni, Callianira sp., Gymnoscopelus braueri, Gymnoscopelus nicholsi, Eusirus sp.*
200-500 m:	*Antarctomysis sp, E. superba, Electrona antarctica, Atolla sp.,Gymnoscopelus braueri, Melanostigma gelatinosum*
500-800 m:	*Eusirus sp., thimble jellies, Pasiphaea scotiae, Gigantocypris mulleri, Thysanoessa macrura, Electrona antarctica, Pleuragramma antarcticum, Antarctomysis sp., Bathylagus antarcticus*

Day

0-50 m:	*Themisto gaudichaudii*
50-100 m:	*Euphausia superba (juveniles), Themisto gaudichaudii*
100-200 m:	*Euphausia superba, Eusirus sp.*
200-500 m:	*Eusirus sp., Salpa thompsoni, Pleuragramma, Electrona*,
500-800 m:	Thimble jellies, *Atolla sp., Eusirus sp., Euphausia superba, Pleuragramma, Electrona*

Our dives revealed no krill in association with the bottom of the sea ice at site 4, despite the presence of brown ice on the undersurface of the floes.

Process site 2. Site 2 was located at the mouth of Marguerite Bay and situated directly over the Marguerite Trough. Three MOC-10 tows and 9 Tucker trawls were completed in addition to 90 individual determinations of metabolism and excretion. Vertical distributions and species compositions were virtually identical to those found at site 4. Fish biomass was about twice that at site 4 though, and we captured one individual of *Paradiplospinus gracilis*, a gempylid fish, in the upper 50 m of the water column.

Process site 6. Site 6 was located within Marguerite Bay in the vicinity of Neny Fjord, a small embayment located roughly in the center of the land margin that forms Marguerite Bay. It is mainly a shoal area with bottom depths of about 500 m. We completed 2 MOC-10 tows, both at night, and found that species composition differed from that at sites 2 and 4, mainly in the presence of *Euphausia crystallorophias*. In addition, we completed 2 dives and 6 Tucker trawls. During our dives we looked under several floes well invested with brown ice on the bottom, but found no euphausiid larvae.

Night

0-50 m:	*Euphausia crystallorophias, Themisto gaudichaudii*
50 - 100 m:	*Euphausia crystallorophias, Euphausia superba*
100-200 m:	*Euphausia crystallorophias, Pleuragramma antarcticum*
200-300 m:	*Antarctomysis spp., Electrona antarctica, Pleuragramma antarcticum*
300-400 m:	*Antarctomysis spp., Electrona antarctica, Pleuragramma antarcticum, Eusirus sp.*

Overall, we concluded that the fauna in the Marguerite Bay area is a blend of Antarctic coastal species and oceanic species that are normally absent from shelf waters. *Electrona antarctica* is ubiquitous throughout Marguerite Bay and off the shelf, as well. *Pleuragramma antarcticum* is found exclusively on the shelf. *Gymnoscopelus* is found in the deeper areas that were sampled within the Bay and adjoining fjords, including sitens 1, 2, 4, 5, and 7. The oceanic crustacean fauna was limited to sites 2 and 4.

BG 248 - Krill ecology, behavior, and modeling – Zhou (Ryan D. Dorland, Joe P. Smith, Yiwu Zhu, M. Zhou**,** University of Massachusetts Boston)

Avian Island and Johnston Passage (27-28 April 2002)

An acoustic survey using both ADCP and HTI in the areas of Avian Island and Johnston Passage was called for mainly due to the dozens of whales observed during the transit from the shelf break station to Laubeuf Fjord. A krill swarm was found in the deep canyon very close to Avian Island. This krill swarm was not sampled due to both time limitation and unknown bottom topography. We revisited this deep canyon later for the penguin operations. Then the net tow was done.

The circulation over the deep canyon near Avian Island varies temporally. In general, it is protected by the shallows on both sides. Thus, the lack of strong currents provides a retention mechanism for the krill population. Other nearby canyons are exposed to coastal currents, and less krill were found in those areas.

Johnston Passage is very different from the canyons in Crystal Sound and Laubeuf Fjord, as well as the deep canyon nearby Avian Island. The deep canyon at Johnston Passage is on the shelf and stays in the middle of the coastal current. Our plan was to map the circulation and krill distribution at night and to survey whales, seals and penguins during the day.

The coastal current flowed southward along the eastern flank of the deep basin (Figure 27). As it reached the southern end of the deep basin, the current was forced to turn to the west, or to flow over the shallow. It seems that the current transports and concentrates krill swarms into this corner (Figure 28). Even though the survey was conducted mostly at night, most of krill swarms stayed near bottom. Is this phenomenon caused by the presence of predators or did they stay deep to avoid being advected to the shallow waters? Are these really krill swarms? It requires us to conduct net tows and day-night observations to answer these questions.

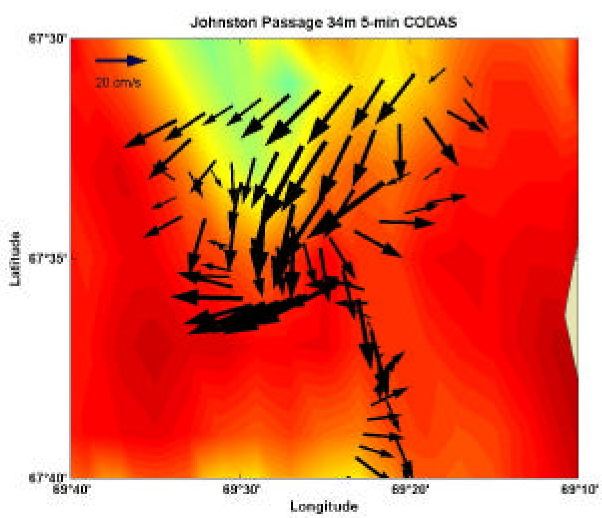


Figure 27. The currents at Johnston Passage. The color indicates depth. See Figure 5 for the color scale.

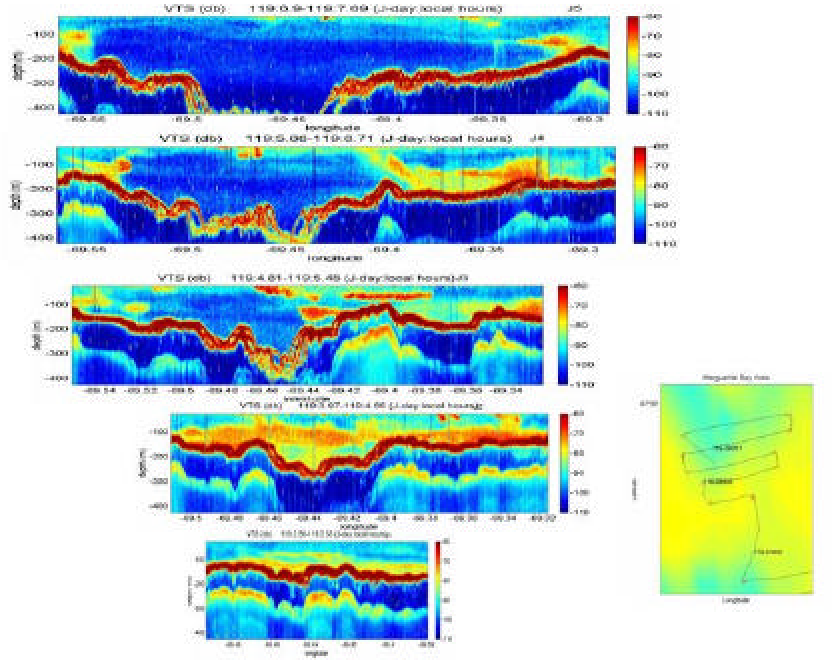


Figure 28. Transects of ADCP backscattering in Johnston Passage.

At the end of our survey in the morning, the wind reached 35 kts with a 3-5 m sea. Whale, seal and penguin operations had to be cancelled. This station was cancelled because of the unworkable conditions for other groups. The decision was made to move to George VI Sound.

<u>George VI, Station 4 (28 April-5 May 2002)</u>

The transit from Johnston Passage to George VI Sound provided a good opportunity to observe whales and krill swarms during the day on the open shelf crossing the entrance of Marguerite Bay. The distribution of whales sighted matched the gradient of the krill swarm distribution (See Ari Friedlaender's report for details).

Investigation of the gradient of krill distribution, aggregation behavior, and the effects of the circulation were among our objectives for the George VI Sound site. Our study started with a small-scale survey of circulation and krill distribution over the deep canyon where we observed the coastal current jet and a mesoscale eddy during the cruise last fall.

Our measurements show a southward current along the eastern flank of the deep canyon. It turned around to the west and then north at the end of our survey line. The coastal jet remained on the western flank of the canyon.

The krill distribution within the pack ice and outside of it showed significant differences. In general, there are fewer krill away from the ice edge, more aggregations around the ice edge, and more krill in the ice but distributed more diffusely (Figure 29). The gradient of biota from the sea ice-covered area to open area is clearly shown. However we still cannot determine if such a concentration is caused by the circulation patterns or by the behavior of zooplankton. Food resources do not explain the observed krill distribution because there was no significant difference in chlorophyll in waters inside and outside the sea ice, nor any significant productivity in the sea ice and water column (See Kendra Daly's report for details).

Krill formed highly concentrated swarms near the ice edge and were more evenly distributed in the sea ice (Figures 30 and 31). It is unknown if the difference in aggregation behavior was caused by the presence of predators at the ice edge and the absence of predators in ice. However, we do know that there were hundreds of seals and tens of whales near the ice edge feeding on krill during our survey period, but none in the deep ice.

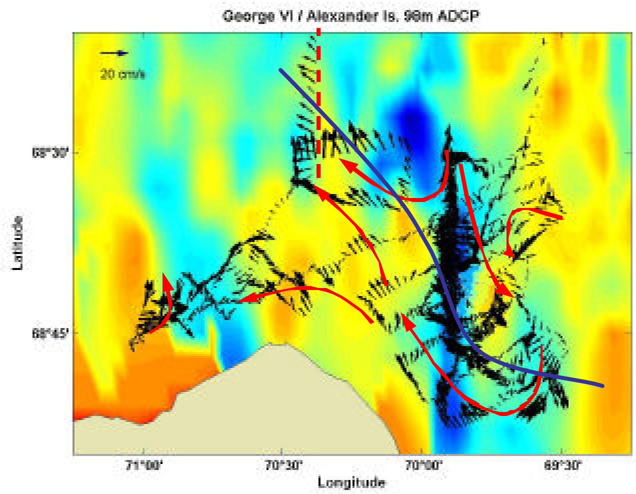


Figure 29. The current field within George VI Sound station. The blue line indicates the ice edge at the beginning of the survey. The red dashed line indicates the transect of backscattering shown in Figure 14.

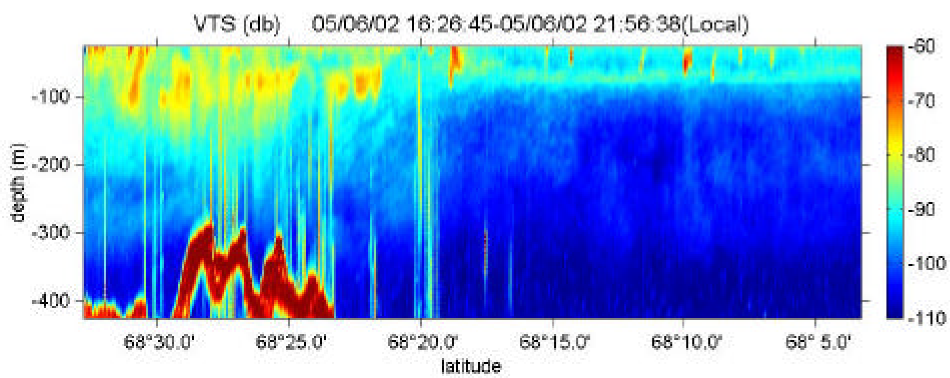


Figure 30. The ADCP backscattering observed along the transect indicated in Figure 13 (red dashed line).

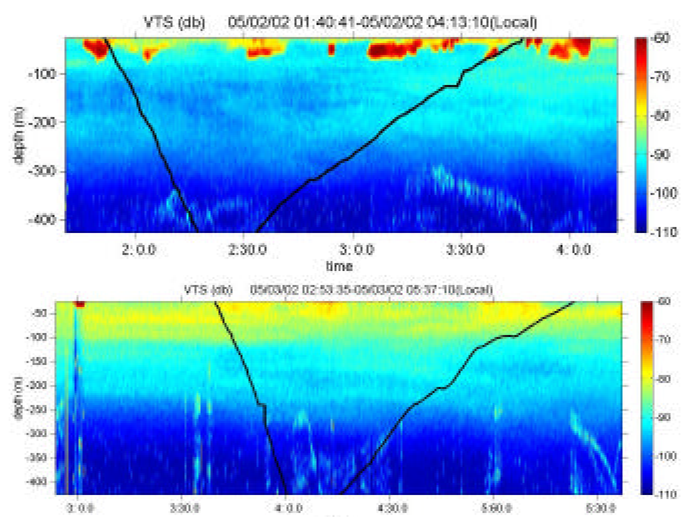


Figure 31. Two transects of ADCP backscattering and MOCNESS tow tracks (black solid lines) at the ice edge (upper panel) and in the sea ice (lower panel).

Figure 31 shows a typical example of a net tow using fixed (standard) depth strata. Considering the patchiness of krill distribution, such a net tow could easily miss krill swarms, which actually happened often during the last two fall cruises. Later on, we adopted a combined format of both standard strata and targeted tows.

The biovolume spectra in this area were more like ones found in Laubeuf Fjord showing a mature community, that is a community of mixed larvae and adult krill, and other zooplankton.

A PI meeting was held on 5 May 2002 to decide our plan for next two weeks. The first decision was made to respond to the report from *N.B. Palmer* that a large number of seals and whales were spotted in the Iceberg Graveyard, near survey station 60. Our new process site was named as 4B. A high resolution survey of ADCP currents and backscattering was made during the night. Our group spent the whole morning processing all current and backscattering data so that it could be used for making future plans for this study site. After lunch time, we realized that the ship had been moved back to site 4. Though there were many seals and penguins at site 4B, they were not accessible because of the sea ice conditions. Site 4B was then abandoned. The new decision was to finish our process site at the middle of Marguerite Bay entrance.

Deep trough, Marguerite Bay entrance, Station 2 (6-7 May 2002)

Current measurements showed our site was in the southward coastal current and in an intrusion current into Marguerite Bay (Figure 9). The ADCP backscattering measurements showed little krill throughout most of this area, which was also demonstrated by the net tow samples. A night-long ADCP survey revealed several small krill patches in the deep canyons (Figure 32). Two tows were conducted targeting the krill swarms. Because of the vast opening area without any shelter for retention, we suspect any adult krill swarms found in this area were in transit. Some krill larvae were found in the surface nets, which may be simply dispersed by horizontal diffusion and small-scale circulation.

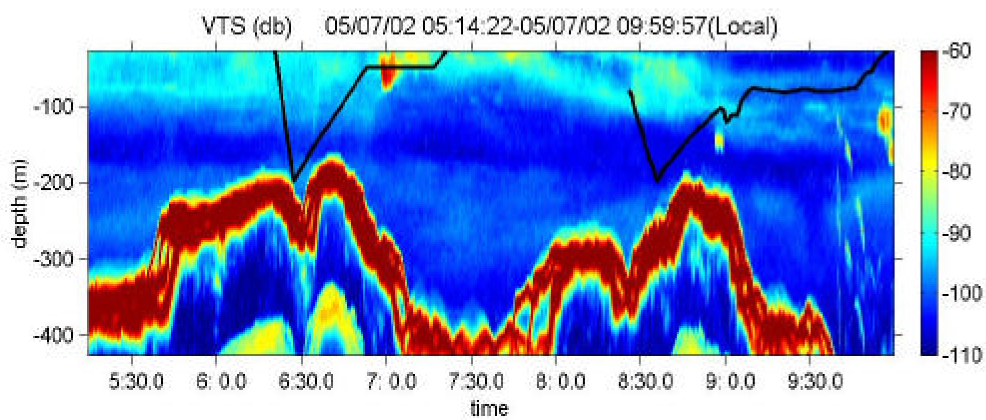


Figure 32. Two MOCNESS tows at Station 2.

Avian Island (8 May 2002)

The purpose of the revisit to Avian Island was to put out three more penguin satellite transmitters which were originally planned to be placed on penguins near George VI Sound. Because the penguin operation had to be done during the day, our group and Dr. Kendra Daly's group decided to utilize the spare nighttime to repeat the acoustic survey in the canyons near Avian Island.

The measurements indicate that there was one large aggregation near Avian Island. This aggregation stayed at the surface at night and migrated down to the deep water, near 200 m, during the day (Figure 33). One MOC-1 tow was conducted, which confirmed this to be an aggregation of krill.

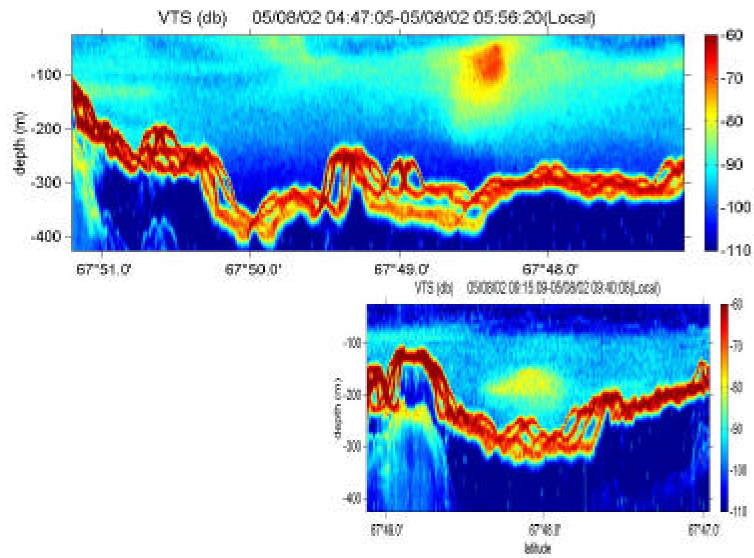


Figure 33. Transects of ADCP backscattering along the deep canyon at Avian Island at night (upper panel) and during the day (lower panel).

Middle of Marguerite Bay, process site 6 (9-11 May 2002)

Site 6 is located over a deep basin which connects to the south end of the deep Laubeuf canyon. The current in the Laubeuf canyon intrudes through a deep channel into the deep basin forming a clockwise circulation (Figure 9). Both acoustic surveys and MOC-1 tows show the similarity in backscattering layers and species composition to those in Laubeuf Fjord (Figure 34). A quick inspection of samples obtained during the day showed that few krill larvae and copepods were found within 0-50 m; more than 20 fish larvae were caught between 50-75 m; abundant krill larvae and juveniles were found between 75 and 150 m; and some krill adults and amphipods were responsible for the backscattering between 150 and 250 m.

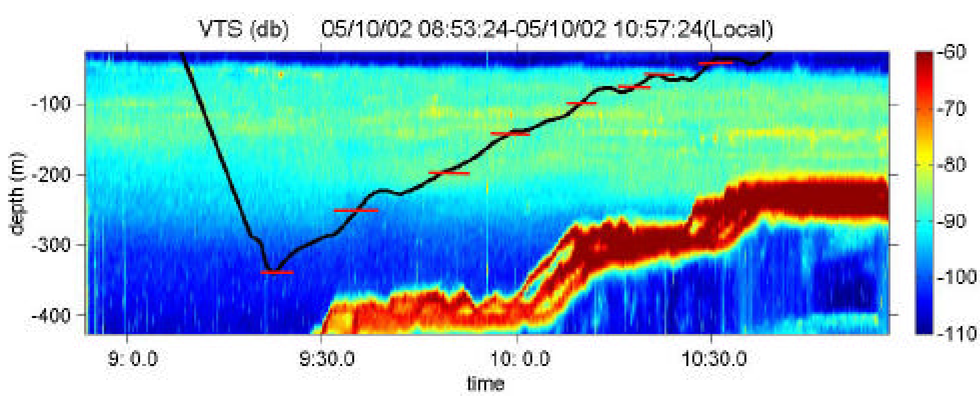


Figure 34. A transect of ADCP backscattering and the MOCNESS tow track (black solid line). The red lines indicate where the nets were opened and closed.

Crystal Sound (12-13 May 2002)

The daytime transit through the Johnston Passage provided whale counts. Many whales and seals were sighted at the same time krill aggregations were being measured by ADCP backscattering. Significant aggregations of krill were found until we reached the northern part of Adelaide Island (Figure

35). During the transit we measured the biggest swarm thus far encountered: approximately 30 nm long with 10 to 100s m^{-3} adult krill estimated from the volume echo intensity. Because we passed through this area at night, no mammal observations could be made.

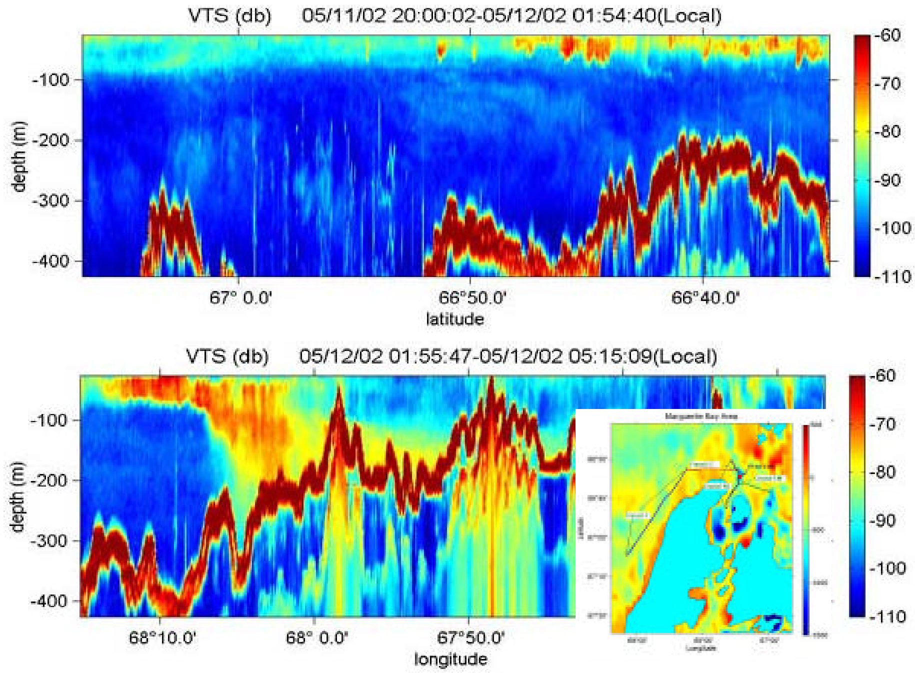


Figure 35. The two transects of ADCP backscattering from the transit to Crystal Sound.

A survey over the deep canyon was conducted to see whether the krill aggregation measured a few weeks ago was still in the same place (See Report 1 for details). The overnight survey showed no significant krill aggregation in the canyon. However, two strong acoustic layers appeared when the *Gould* stopped for the seal operation during the day, which suggests horizontal movement of swarms of krill and other organisms.

A further investigation of these two layers was conducted by looking at their swimming patterns from the ADCP Doppler spectra. It appears that organisms in the upper layer moved passively in the center, and more aggressively at the edge, which is more-like swarming behavior. Those in the lower layer moved less randomly, which is more-like schooling behavior. The request of net tows was declined, and that marked the end of our official activity on this cruise.

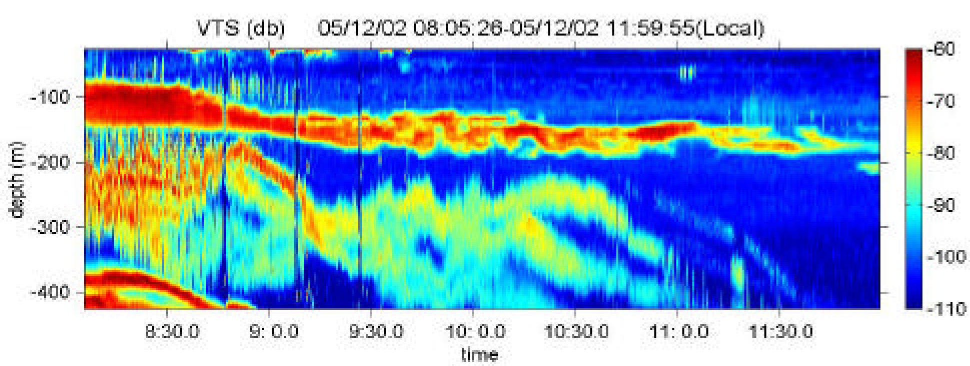


Figure 36. A time series in the deep canyon near Matha Strait, Crystal Sound.

Appendix 1. Event Log for LMG02-03

event #	Instr	Cast #	Consec. Station #	Stand. Station #	Mth	Local Time Day	hhmm	Event s/e	Univ. Coor. Time (UCT) Mth	Day	hhmm	Latitude (°S) Deg. Min.	Longitude (°W) Deg. Min.	Water Depth (m)	Cast Depth (m)	Science Invest.	Comments
1	HTI	1	Dock		4	5	1630		4	5		53 08.56	70 47.94	8		Daly	Test/PA
2	HTI	2	Dock		4	6	1315		4	6		53 08.56	70 47.94			Daly	Test/PA
3	HTI	3	St Magellan		4	7	1548		4	7		53 08.56	70 47.94	157		Daly	Test/St Magellan
4	CDOM	1			4	9	845		4	9		56 28.93	64 30.72	2600		Zhou	
5	Chl+CDOM/DOC		Drake		4	9	2216		4	10	216	58 15.16	62 20.86	3859	6	Daly	
6	Chl+CDOM/DOC		Drake		4	10	858		4	10	1258	59 41.60	60 50.10				
7	Chl+CDOM/DOC		Drake		4	10	1259		4	10	1649	60 16.52	60 51.40				
8	Chl+CDOM/DOC		Drake		4	10	1857		4	10	2257	61 01.78	61 06.56				
9	Chl+CDOM/DOC		Drake		4	11	856		4	11	1256	63 15.10	61 31.50				
10	Whale Ops				4	11			4	11		63 57	61 41			Friedlaender	
11	Chl+CDOM/DOC		Drake		4	11	1339		4	10	1739	63 57.59	61 41.44				
12	Chl+CDOM/DOC		Drake		4	11	1856		4	11	2256	64 19.56	61 57.02				
13	Chl		Palmer Station		4	11			4	11		64 48.73	64 03.69				
14	Whale Ops				4	13			4	13							
15	HTI	4	Test		4	13	1839		4		2239	65 11.43	64 15.17	293		Daly	Calibration
16	CTD	1	Test		4	13			4			65 11.21	64 15.54	293			
17	Sonobuoy	1			4	13	1935		4	13	2335	65 11.21	64 15.54			Friedlaender	
18	Chl				4	13	2235		4	14	235	65 06.48	65 07.91			Daly	Flow thru Flourometer
19	Seal Ops				4	14	950		4	14	1100	66 21.48	66 48.78	495.1		Burns	seal sighting
20	CTD	2			4	14	1215		4	14	1615	66 21.48	66 48.78	495.1			
21	Seal Ops				4	14	1325	S	4	14	1725	66 21.36	66 48.49			Burns	seal G017
					4	14	1615	E	4	14	2015	66 21.36	66 48.49				
22	Tucker Trawl	1	7	7	4	14	1707	S	4	14	2107	66 19.96	66 47.09			Torres	
					4	14	1815	E	4	14	2215	66 22.35	66 47.87				
23	CTD	3			4	14	2122	S	4	14	122	66 31.70	67 17.18	796		Daly/Zhou	
					4	14	2143	E	4	14	143	66 31.70	67 17.18				
24	ADCP				4	14	2210	S	4	14	210	66 31.75	67 17.18				
25	CTD				4	14	2312	S	4	14	320	66 35.66	67 22.76	450		Zhou	
					4	15	100	E	4	15	337	66 35.66	67 22.76				
26	CTD				4	15	52	S	4	15	500	66 39.56	67 26.95	551		Zhou	
					4	15	137	E	4	15	537	66 39.56	67 26.95				
27	CTD	6			4	15	255	S	4	15	655	66 40.48	67 14.11	302		Zhou	
		6			4	15	320	E	4	15	720	66 40.47	67 14.05	302		Zhou	
28	CTD	7			4	15	524	S	4	15	924	66 42.22	66 57.00	1200	1000	Zhou	
		7			4	15	614	E	4	15	1014	66 42.28	66 57.18	1200	1000	Zhou	

29	CTD	8			4	15	736	S	4	15	1136	66 45.17	66 44.21	237	223	Zhou	
		8			4	15	752	E	4	15	1152	66 42.13	66 44.22	237	223	Zhou	
30	ADCP				4	15	800	E	4	15	1200	66 44.99	66 45.29			Zhou	
31	Seal Ops				4	15	900	S	4	15	1300	66 45.22	66 46.55			Burns	Seal G018
					4	15	1450	E	4	15	1850	66 46.44	66 46.98			Burns	Seal G019
32	CTD	9			4	15	1200		4	15	1600	66 45.60	66 45.26	251.2			
33	Adélie Diets	1			4	15	1600		4	15	2000	66 42.93	66 57.61	1226		Fraser	
34	Tucker Trawl	2	7	7	4	15	1910	S	4	15	2310	66 39.51	67 26.54			Torres	
		2	7	7	4	15	2020	E	4	16	20	66 37.86	67 25.31			Torres	
35	Tucker Trawl	3	7	7	4	15	2026	S	4	16	26	66 39.36	67 27.32			Torres	
		3	7	7	4	15	2154	E	4	16	154	66 38.16	67 25.29			Torres	
36	CTD	10	7	7	4	15	2239	S	4	16	239	66 38.28	67 24.16	320		Daly/Zhou	
		10	7	7	4	15	2315	E	4	16	315	66 38.34	67 24.11				
37	ADCP				4	15	2320	S	4	16	320	66 38.34	67 24.11			Zhou	
38	CTD	11			4	16	215	S	4	16	615	66 47.13	67 37.82	386		Zhou	
		11			4	16	230	E	4	16	630	66 47.19	67 37.92	363		Zhou	
39	Seal Ops				4	16	1006	S	4	16	1406	66 37.53	67 29.21			Burns	
					4	16	1256	E	4	16	1656	66 37.53	67 29.21			Burns	
40	CTD	12			4	16	1240	S	4	16	1640	66 36.52	67 29.01	850		Zhou	
41	Adélie Diets				4	16	1630		4	16	2030	66 44.63	67 09.07	203		Fraser	
42	Tucker Trawl	4	7	7	4	16	1815	S	4	16	2215	66 38.45	67 25.84	391		Torres	
		4	7	7	4	16	1915	E	4	16	2315	66 36.56	67 24.36			Torres	
43	HTI	5			4	16	2013	S	4	17	13	66 38.09	67 26.41	400		Daly	
44	HTI	6			4	16	2149	S	4	17	149	66 38.23	67 25.13	410		Daly	
		6			4	16	2228	E	4	17	228	66 37.93	67 25.91	360		Daly	
45	MOC-10	1			4	16	2310	S	4	17	310	66 38.58	67 26.11			Torres	Aborted
		1			4	17	15	E	4	17	415					Torres	
46	MOC-10	2			4	17	101	S	4	17	501	66 38.58	67 26.11			Torres	
47	MOC-1	1			4	17	255	S	4	17	655	66 36.12	67 25.98			Zhou	
		1			4	17	442	E	4	17	842	66 39.51	67 26.04			Zhou	
48	MOC-10	3			4	17	520	S	4	17	920	66 38.62	67 26.09	421		Torres	
49	MOC-1	2	7	7	4	17	724	S	4	17	1124	66 36.20	67 26.53	605		Zhou	
		2	7	7	4	17	928	E	4	17	1328	66 39.80	67 23.22			Zhou	
50	CTD	13	7	7	4	17	1010	S	4	17	1410	66 38.61	67 26.64	498	478	Ju	
51	Seal Ops		7	7	4	17	1120	S	4	17	1520	66 37.18	67 28.99			Burns	
			7	7	4	17	1220	E	4	17	1620	66 37.18	67 28.99			Burns	
52	CTD	14	7	7	4	17	1245		4	17	1645	66 38.09	67 29.53	821			
53	Seal Ops		7	7	4	17	1415	S	4	17	1815	66 36.86	67 30.54	571		Burns	G021
			7	7	4	17	1654	E	4	17	2054	66 37.24	67 31.39			Burns	
54	HTI	7			4	18	1541	S	4	18	1941	67 54.17	68 31.19	56		Daly	
55	ADCP				4	18	1542	S	4	18	1942	67 54.23	68 31.32	56		Zhou	
56	XCTD	1			4	18	1740	S/E	4	18	2140	67 58.20	68 29.20	708		Zhou	
57	Tucker Trawl	5	5	5	4	18	1845	S	4	18	2245	67 58.14	68 18.96	656		Torres	
		5	5	5	4	18	1935	E	4	18	2335	67 58.40	68 14.10	212		Torres	
58	XCTD	2			4	18	1957	S/E	4	19	57	67 58.36	68 00.79	249		Zhou	
59	XCTD	3			4	18	2240	S/E	4	19	240	67 52.23	68 06.14	280		Zhou	

60	XCTD	4			4	18	2356	S/E	4	19	356	67 52.19	68 15.06	870		Zhou	
61	XCTD	5			4	19	42	S/E	4	19	442	67 51.99	68 22.59	800		Zhou	
62	XCTD	6			4	19	142	S/E	4	19	542	67 47.75	68 16.17	260		Zhou	
63	XCTD	7			4	19	245	S/E	4	19	645	67 47.76	68 05.48	926	850	Zhou	
64	XCTD	8			4	19	410	S/E	4	19	810	67 47.60	67 52.29	480		Zhou	
65	XCTD	9			4	19	550	S/E	4	19	950	67 42.58	67 51.81	571		Zhou	
66	XCTD	10			4	19	630	S/E	4	19	1030	67 42.50	68 00.87	754		Zhou	
67	XCTD	11			4	19	744	S/E	4	19	1144	67 42.43	68 14.45	527		Zhou	
68	XCTD	12			4	19	955	S/E	4	19	1355	67 38.03	68 03.70	431		Zhou	
69	XCTD	13			4	19	1030	S/E	4	19	1430	67 37.91	67 57.43	545		Zhou	
70	XCTD	14			4	19	1120	S/E	4	19	1520	67 36.29	67 51.79	375		Zhou	
71	CTD	15			4	19	1223	S	4	19	1623	67 33.23	67 51.78	360			
72	XCTD	15			4	19	1340	S/E	4	19	1740	67 32.40	67 56.85	542		Zhou	
73	XCTD	16			4	19	1520	S/E	4	19	1920	67 27.31	67 54.01	115		Zhou	
74	XCTD	17			4	19	1547	S/E	4	19	1947	67 27.21	67 48.74	562	238	Zhou	
75	XCTD	18			4	19	1601	S/E	4	19	2001	67 27.21	67 44.68	333	240	Zhou	
76	Sonobuoy				4	19	1645	S/E	4	19	2045	67 23.53	67 46.86			Friedlaender	
77	XCTD	19			4	19	1650	S/E	4	19	2050	67 23.40	67 49.26	540/333	100/153	Zhou	Bad case of XCTDs
78	Sonobuoy				4	19	1651	S/E	4	19	2051	67 23.20	67 47.90	459			
79	XCTD	20			4	19	1715	S/E	4	19	2115	67 23.29	67 53.98	367	181	Zhou	
80	XCTD	21			4	19	1745	S/E	4	19	2145	67 20.90	67 50.87	350	85/55	Zhou	
81	ADCP				4	19	1752		4	19	2152	67 28.70	67 50.22			Zhou	
82	Tucker Trawl	6	5	5	4	19	1848	S	4	19	2248	67 15.76	67 51.94	317		Torres	
			5	5	4	19	2000	E	4	20	0	67 18.06	67 50.25	400		Torres	
83	Moc10	4	5	5	4	19	2005	S	4	20	5	67 18.06	67 50.25	608		Torres	
			5	5	4	19	2131	E	4	20	105	67 20.85	67 48.82			Torres	
84	Moc10	5	5	5	4	19	2142	S	4	20	205	67 18.16	67 50.18			Torres	
85	Moc1	3	5	5	4	20	128	S	4	20	528	67 18.06	67 50.16	620		Zhou	
			5	5	4	20	306	E	4	20	706	67 21.01	67 48.82	380		Zhou	
86	ADCP		5	5	4	20	430	S	4	20	830	67 19.00	67 45.00			Zhou	
87	CTD	16	5	5	4	20	500	S	4	20	900	67 25.03	67 52.20			Zhou	
			5	5	4	20	524	E	4	20	924	67 25.03	67 52.20			Zhou	
88	Seal Ops.		5	5	4	20	1008	S	4	20	1408	67 22.45	67 38.45			Burns	
89	CTD	17	5	5	4	20	1235	S	4	20	1635	67 22.34	67 39.35	190	167		
90	Dive	1	5	5	4	20	1530	S	4	20	1930	67 25.35	67 49.10			Torres	
			5	5	4	20	1650	E	4	20	2050	67 25.35	67 49.10			Torres	
91	Tucker Trawl	7	5	5	4	20	1947	S	4	20	2350	67 37.90	68 00.30			Torres	
			5	5	4	20	2047	E	4	21	47	67 37.88	67 56.0			Torres	
92	ADCP		5	5	4	20	2048	S	4	21	48	67 37.70	67 55.70	301		Zhou	
93	CTD	18	5	5	4	21	1222		4	22	1622	67 34.57	67 36.26	250			
94	Dive	2	5	5	4	21	1445		4	21	1845	67 33.25	67 21.50			Torres	
95	Tucker Trawl	8	5	5	4	21	1728	S	4	21	2128	67 39.59	67 06.93			Torres	
			5	5	4	21	2030	E	4	21	30					Torres	
96	Tucker Trawl	9	5	5	4	21	2100	S	4	21	100	67 42.80	67 11.80	461		Torres	
			5	5	4	21	2150	E	4	21	150	67 44.30	67 14.10	587		Torres	
97	Moc10	6	5	5	4	21	2237	S	4	22	237	67 45.80	68 06.80			Torres	

98	Moc1	4	5	5	4	22	200	S	4	22	600	67 46.29	68 07.73			Zhou	
			5	5	4	22	435	E	4	22	835	67 41.99	68 00.80			Zhou	
99	ADCP		5	5	4	22	435	S	4	22	835	67 41.99	68 00.80			Zhou	
100	Moc1	5	5	5	4	22	951	S	4	22	1351	67 46.50	68 08.20			Zhou	
			5	5	4	22	1221	E	4	22	1621	67 41.81	68 00.81			Zhou	
101	CTD	19	5	5	4	22	1255	S/E	4	22	1655	67 41.92	68 00.89			Hodges	
102	Moc10	7	5	5	4	22	1510	S	4	22	1910	67 46.20	68 07.20			Torres	
103	HTI		5	5	4	22	1520	S	4	22	1920	67 45.90	68 06.90			Daly	
104	Tucker Trawl	10	5	5	4	22	1806	S	4	22	2206	67 40.90	68 01.20	617		Torres	Failed:Codend broke
105	Tucker Trawl	11	5	5	4	22	2045	S	4	23	45	67 46.06	68 07.40			Torres	
106	Tucker Trawl	12	5	5	4	22	2159	S	4	23	159	67 43.70	68 07.70			Torres	
107	Moc10	8	5	5	4	22	2250	S	4	23	250	67 42.50	68 04.80	606	500	Torres	
108	HTI		5	5	4	22	2316	S	4	23	316	67 41.40	68 03.70	653		Daly	
109	Tucker Trawl	13	5	5	4	23	136	S	4	23	536	67 42.20	68 04.20			Torres	
110	ADCP		5	5	4	23	300	S	4	23	700	67 42.50	68 04.80			Zhou	
111	Moc1	6	1	1	4	24	304	S	4	24	704	66 01.73	71 32.46	3224		Zhou	
			1	1	4	24	528	E	4	24	928	65 59.251	71 22.791	3213		Zhou	
112	ADCP		1	1	4	24	725	S	4	24	1125	66 02.50	71 35.60	3222		Zhou	
113	CTD	20	1	1	4	24	1200	S	4	24	1600	66 10.44	71 20.63	3014		Stuart	
			1	1	4	24		E	4	24		66 10.47	71 19.85	3014		Stuart	
114	Tucker Trawl	14	1	1	4	24	1445	S	4	24	1845	66 09.91	71 18.97			Torres	
			1	1	4	24	1501	E	4	24	1901					Torres	
115	Tucker Trawl	15	1	1	4	24	1510	S	4	24	1910	66 09.54	71 18.41			Torres	
116	Tucker Trawl	16	1	1	4	24	1550	S	4	24	1950	66 07.70	71 16.40			Torres	
			1	1	4	24	1725	E	4	24	2125	66 05.52	71 14.16			Torres	
117	Moc10	9	1	1	4	24	1745	S	4	24	2145	66 05.14	71 13.77			Torres	
			1	1	4	24	2049	E	4	25	49	65 59.55				Torres	
118	HTI	7	1	1	4	24	1837	S	4	24	2237	66 03.71	71 11.89	3045	6	Daly	
			1	1	4	24		E	4			65 59.80	71 08.24			Daly	
119	Moc10	10	1	1	4	24	2300	S	4	25	300	66 07.40	71 16.28			Torres	
120	HTI	8	1	1	4	24	2307	S	4	25	307	66 07.14	71 15.87	2904	6	Daly	
			1	1	4	25	31	E	4	25	431	66 04.85	71 12.56			Daly	
121	ADCP		1	1	4	25	420	S	4	25	820	66 13.70	71 10.40	2472		Zhou	
122	Moc1	7	1	1	4	25	647	S	4	25	1047	66 14.25	71 13.69	2700		Zhou	
			1	1	4	25	1130	E	4	25	1530	66 06.66	71 35.08	3100		Zhou	
123	CTD	21	1	1	4	25	1240	S	4	25	1640	66 05.35	71 35.03	3201	3160		
			1	1	4	25	1530	E	4	25	1930						
124	Tucker Trawl	17	1	1	4	25	1650	S	4	25	2050	66 15.20	71 15.00	2838		Torres	
			1	1	4	25	1700	E	4	25	2100	66 14.40	71 16.00	2838		Torres	
125	Tucker Trawl	18	1	1	4	25	1705	S	4	25	2105	66 14.10	71 16.20	2838		Torres	
126	Moc10	11	1	1	4	25	1833	S	4	25	2233	66 12.76	71 21.28			Torres	
127	ADCP		1	1	4	25	2250	S	4	26	250	66 05.70	71 07.20			Zhou	
128	Moc1	8	1b	1b	4	27	315	S	4	27	715	66 24.96	71 04.78	547		Zhou	
			1b	1b	4	27	526	E	4	27	926	66 20.91	70 57.59			Zhou	
129	Moc10	12	1	1	4	27	1045	S	4	27	1445	66 03.18	71 27.84			Torres	
130	Tucker Trawl	19	1	1	4	27	1550	S	4	27	1950	65 57.40	71 04.10	3078		Torres	

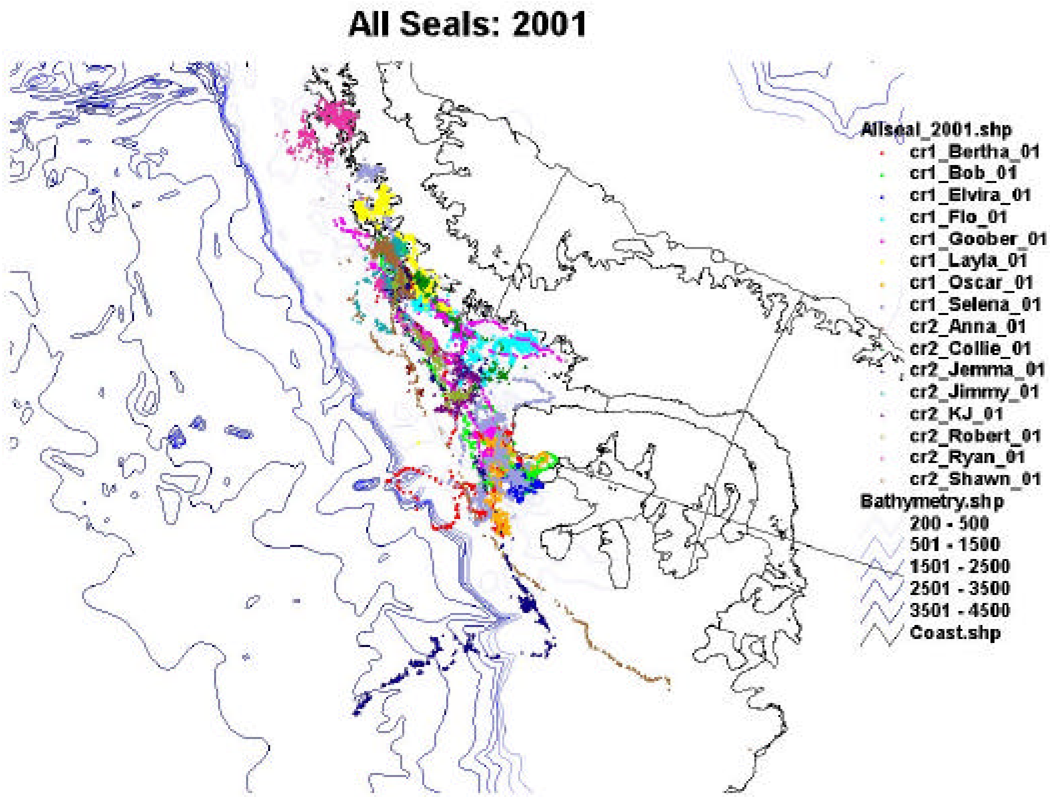
			1	1	4	27	1655	E	4	27	2055					Torres	
131	Tucker Trawl	20	1	1	4	27	1700	S	4	27	2100	65 56.42	70 58.73			Torres	
			1	1	4	27	1710	E	4	27	2110					Torres	
132	Tucker Trawl	21	1	1	4	27	1715	S	4	27	2115	65 56.26	70 57.40			Torres	
			1	1	4	27	1800	E	4	27	2200					Torres	
133	CTD	22	1	1	4	27	2031	S	4	28	30	66 20.55	71 05.06	523.4		Stuart	
			1	1	4	27	2130	E	4	28	131					Stuart	
134	Moc10	13	1	1	4	27	2228	S	4	28	228	66 25.38	71 06.06			Torres	
135	HTI		5	5	4	29	1415	S	4	29	1815	67 48.90	68 45.40		265	Daly	
136	ADCP		5	5	4	29	1415	S	4	29	1815	67 48.90	68 45.90		265	Zhou	
			5	5	4	30	800	E	4	30	1200	67 33.72	69 28.60			Zhou	
137	HTI		5	5	4	30	16	S	4	30	416	67 41.90	69 18.20	307		Daly	
			5	5		30	400	E	4	30	800					Daly	
138	ADCP		5	5	4	30	16	S	4	30	416	67 41.90	69 18.20	307			
			5	5	4	30	744	S	4	30	1144	67 32.10	69 33.40	204			
139	Tucker Trawl	22			4	30	1704	S	4	30	2104	67 48.50	69 53.60	1122	300	Torres	
					4	30	1842	E	4	30	2242	67 49.80	69 54.70	1100	300	Torres	
140	Tucker Trawl	23			4	30	1921	S	4	30	2321	68 50.00	69 54.90	1068	300	Torres	
					4	30	2100	E	4	30	100					Torres	
141	ADCP		4	4	4	30	2337	S	5	1	337	68 52.20	69 54.6	1292		Zhou	
			4	4	5	1	940	E	5	1	1340	68 44.97	69 52.12	980		Zhou	
142	CTD	23	4	4	5	1	331	S	5	1	731	68 44.84	69 35.97	656		Zhou	
			4	4	5	1	359	E	5	1	759	68 44.84	69 35.97	656		Zhou	
143	CTD	24	4	4	5	1	522	S	5	1	922	68 47.15	69 45.75	650		Zhou	
			4	4	5	1	537	E	5	1	937	68 47.15	69 45.75	650		Zhou	
144	Whale Ops		4	4	5	1	1015	S	5	1	1415	68 44.90	69 51.80			Friedlaender	
145	CTD	25	4	4	5	1	1428	S	5	1	1828	68 46.35	69 48.83	7300		Stuart	
			4	4	5	1	1530	E	5	1	1930					Stuart	
146	Dive	3	4	4	5	1	1445	S	5	1	1845	68 46.26	69 49.40			Torres	
			4	4	5	1	1630	E	5	1	2030	68 46.26	69 49.40			Torres	
147	Tucker Trawl	24	4	4	5	1	1718	S	5	1	2118	68 45.30	69 52.70	1037	500	Torres	
			4	4	5	1	1845	E	5	1	2245					Torres	
148	Sonobouy		4	4	5	1	1827	S/E	5	1	2227	68 42.6	69 53.2	960		Friedlaender	
149	Tucker Trawl	25	4	4	5	1	1900	S	5	1	2300	68 43.0	69 53.4		tow yo	Torres	
150	Tucker Trawl	26	4	4	5	1	2011	S	5	1	11	68 44.6	69 53.2	1037	tow yo	Torres	
151	Moc10	14	4	4	5	1	2120	S	5	1	120	68 45.20	69 52.72	1055		Torres	
152	Moc1	9	4	4	5	2	150	S	5	5	550	68 36.7	69 53.85	811	500	Zhou	
			4	4	5	2	400	E	5	2	800	68 40.77	69 53.02	980		Zhou	
153	Moc1	10	4	4	5	2	445	S	5	2	845	68 40.45	69 53.41	785		Zhou	
			4	4	5	2	653	E	5	2	1053	68 36.23	69 53.87	850		Zhou	
154	Seal Ops		4	4	5	2	1201	S	5	2	1601	68 45.28	69 52.51			Burns	
			4	4	5	2	1750	E	5	2	2150	68 43.41	69 59.58			Burns	
155	CTD	26	4	4	5	2	1220	S	5	2	1620	68 44.70	69 53.49	1061			
156	Tucker Trawl	27	4	4	5	2	1810	S	5	2	2210	68 43.2	70 00.2	1374		Torres	
			4	4	5	2	1849	E	5	2	2249	68 41.8	69 58.2	1358		Torres	
157	Tucker Trawl	28	4	4	5	2	1900	S	5	2	2300	68 40.9	69 55.8	1320		Torres	

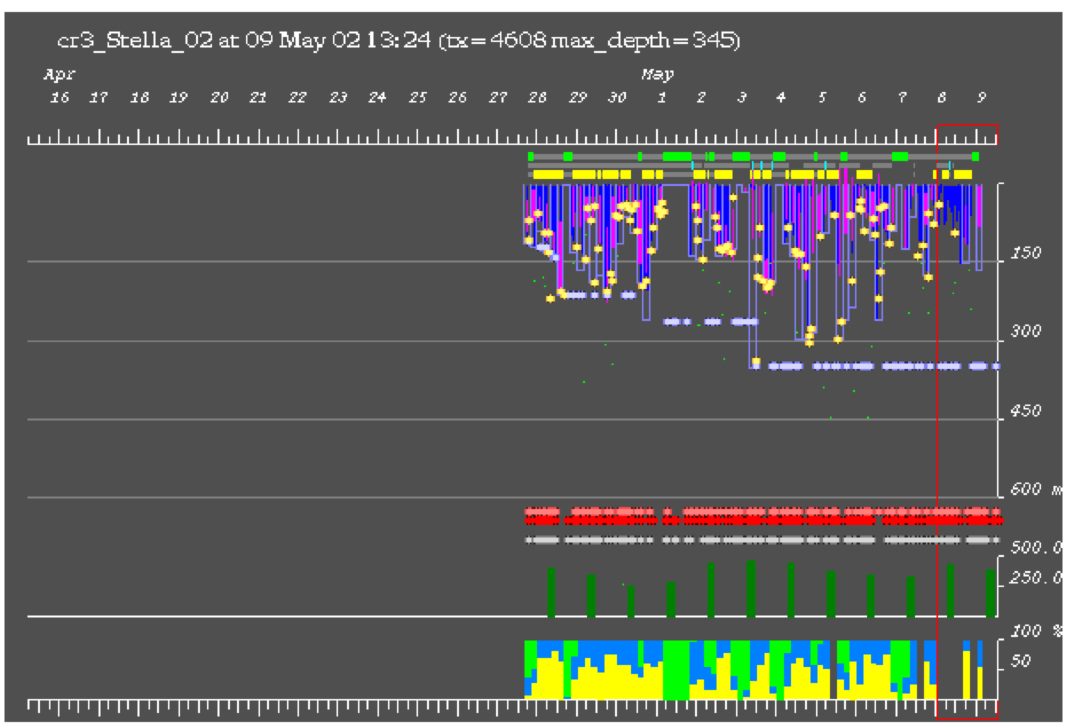
			4	4	5	2	1933	E	5	2	2333	68 40.6	69 55.2	1053		Torres	
158	Moc10	15	4	4	5	2	2036	S	5	3	36	68 45.13	69 53.09	1022		Torres	
159	Moc1	11	4	4	5	3	340	S	5	3	740	68 46.73	69 51.73	627	500	Zhou	
			4	4	5	3	533	E	5	3	933	68 48.79	69 42.63	786		Zhou	
160	Moc1	12	4	4	5	3	824	S	5	3	1224	68 46.52	69 50.95	650	500	Zhou	
			4	4	5	3	1025	E	5	3	1425	68 48.75	69 41.21	695		Zhou	
161	Tucker Trawl	29	4	4	5	3	1720	S	5	3	2120	68 41.36	69 44.26	554		Torres	
			4	4	5	3	1828	E	5	3	2228	68 43.4	69 45.6	493		Torres	
162	Tucker Trawl	30	4	4	5	3	1835	S	5	3	2135	68 43.5	69 46.3	539		Torres	
			4	4	5	3	1914	E	5	3	2314	68 44.5	69 48.3	564		Torres	
163	Tucker Trawl	31	4	4	5	3	1920	S	5	3	2320	68 44.5	69 48.7	629		Torres	
			4	4	5	3	1939	E	5	3	2339	68 44.7	69 50.4	1042		Torres	
164	Moc10	16	4	4	5	3	2028	S	5	4	38	68 46.50	69 49.37	700		Torres	
165	ADCP		4	4	5	4	56	S	5	4	456	68 44.45	69 50.9	1098		Zhou	
166	Seal Ops.		4	4	5	4	1000	S	5	4	1400	68 38.3	69 46.6			Burns	
			4	4	5	4	1120	E	5	4	1520					Burns	
167	CTD	27	4	4	5	4	1145	S	5	4	1545	68 38.81	69 48.20	788	790		
			4	4	5	4	1240	E	5	4	1640	68 38.81	69 48.20	788	790		
168	Moc10	17	4	4	5	4	1300	S	5	4	1700	68 38.6	69 52.6	865		Torres	
			4	4	5	4	1626	E	5	4	2026	68 30.9	69 53.6	738		Torres	
169	Tucker Trawl	32	4	4	5	4	1701	S	5	4	2101	68 29.9	69 53.4	610		Torres	
			4	4	5	4	1741	E	5	4	2143	68 28.6	69 53.9	560		Torres	
170	Tucker Trawl	33	4	4	5	4	1743	S	5	4	2143	68 28.5	69 53.9	534		Torres	
			4	4	5	4	1807	E	5	4	2207	68 27.6	69 54.4	434		Torres	
171	Moc10	18	4	4	5	4	1933	S	5	4	2333	68 32.58	69 54.32	820		Torres	
172	ADCP		4	4	5	4	2342	S	5	4	342	68 41.6	69 52.57	780		Zhou	
173	Seal Ops		4	4	5	5	922	S	5	5	1322	68 30.9	69 48.6	520		Burns	
174	Dive	4	4	4	5	5	1416	S	5	5	1816	68 30.25	69 51.90	628		Torres	
			4	4	5	5	1545	E	5	5	1945	68 30.25	69 51.90			Torres	
175	CTD	28	4	4	5	5	1358	S	5	5	1758	68 30.27	69 52.04	620			
176	Tucker Trawl	34	4	4	5	5	1555	S	5	5	1955	68 32.34	69 52.5			Torres	
			4	4	5	5	1605	E	5	5	2005	68 34.34	69 52.7	730		Torres	
177	Tucker Trawl	35	4	4	5	5	1606	S	5	5	2006	68 34.34	69 52.7	730		Torres	
			4	4	5	5	1620	S	5	5	2020	68 34.60	69 52.7	814		Torres	
178	ADCP		4b	4b	5	5	2230	S	5	6	230	68 44.98	70 59.58	317		Zhou	
			4b	4b	5	6	900	E	5	6	1300	68 45.1	71 01.4			Zhou	
179	CTD	29	4b	4b	5	6	1650	S	5	6	2050	68 32.67	70 24.19	427			
180	Moc10	19	2	2	5	6	2008	S	5	6	8	68 05.13	70 21.84	926		Torres	
181	ADCP		2	2	5	7	100	S	5	7	500	67 58.0	70 15.5	840		Zhou	
182	Moc1	13	2	2	5	7	620	S	5	7	1020	68 08.53	69 38.20	211	200	Zhou	
			2	2	5	7	731	E	5	7	1131	68 06.45	69 39.34	421		Zhou	
183	Moc1	14	2	2	5	7	821	S	5	7	1221	68 05.64	69 39.98	300	200	Zhou	
			2	2	5	7	1010	E	5	7	1410	68 01.51	69 41.29	860		Zhou	
184	Moc10	20	2	2	5	7	1344	S	5	7	1744	68 00.18	70 02.93	832		Torres	
			2	2	5	7	1806	E	5	7	2206	67 53.9	70 20.5	960		Torres	
185	Moc10	21	2	2	5	7	1933	S	5	7	2333	67 25.35	70 08.90	682		Torres	

186	ADCP		5	5	5	8	306	S	5	8	706	67 48.9	68 45.30	247		Zhou	
187	Survey				5	8	1343	S	5	8	1743	67 47.55	68 49.60	276			
188	Penguin boys				5	8	1100	S	5	8	1500					Frasier	Avian Island
					5	8	1230	E	5	8	1630					Frasier	Avian Island
189	Plummet	1			5	8	1427	S	5	8	1827	67 48.0	68 49.3	299		Daly	
					5	8	1439	E	5	8	1839	67 48.0	68 49.3	299		Daly	
190	Plummet	2			5	8	1512	S	5	8	1912	67 48.0	68 49.3	299		Daly	
					5	8	1524	E	5	8	1924	67 48.0	68 49.3	299		Daly	
191	CTD	30			5	8	1552	S	5	8	1952	68 48.04	69 49.32	299		Elvis	
192	Moc1	15			5	8	1815	S	5	8	2215	67 43.30	68 49.63	318		Zhou	
					5	8	1937	E	5	8	2337	67 50.21	68 48.16	330		Zhou	
193	ADCP		6	6	5	8	2332	S	5	9	332	67 59.5	68 29.2	540		Zhou	
			6	6	5	9	845	E	5	9	1245					Zhou	
194	CTD	31	6	6	5	9	1300	S	5	9	1745	68 09.28	67 47.79	495		Smith	
			6	6	5	9	1350	E	5	9	1750					Smith	
195	Dive	5	6	6	5	9	1412		5	9	1812	68 09.25	67 45.7	495		Torres	
196	Tucker Trawl	36	6	6	5	9	1824	S	5	9	2245	68 05.38	68 17.03	246		Torres	
			6	6	5	9	1910	E	5	9	2310	68 06.1	68 13.6	456		Torres	
197	Tucker Trawl	37	6	6	5	9	1915	S	5	9	2315	68 06.3	68 11.6	544		Torres	
			6	6	5	9	1947	E	5	9	2347	68 06.7	68 08.3	543		Torres	
198	Tucker trawl	38	6	6	5	9	1951	S	5	9	2351	68 06.7	68 08.3	543		Torres	
199	Moc10	22	6	6	5	9	2127	S	5	10	127	68 05.75	68 14.86	290		Torres	
200	ADCP		6	6	5	9	2338	S	5	10	358	68 07.1	68 05.4	586		Zhou	
			6	6	5	10	900	E	5	10	1300					Zhou	
201	Moc1	16	6	6	5	10	908	S	5	10	1308	68 07.12	67 50.44	513		Zhou	
			6	6	5	10	1054	E	5	10	1454	68 03.21	67 49.36	217	224	Zhou	
202	CTD	32	6	6	5	10	1130	S	5	10	1530	68 03.21	67 49.36	217	224	Zhou	
			6	6	5	10	1230	E	5	10	1630	68 03.21	67 49.36	217	224	Zhou	
203	Dive	6	6	6	5	10	1339	S	5	10	1739	68 03.25	67 49.1	212		Torres	
			6	6	5	10	1500	E	5	10	1900	68 03.25	67 49.1	212		Torres	
204	Tucker Trawl	38	6	6	5	10	1757	S	5	10	2157	68 15.12	67 05.7	399	100	Torres	
			6	6	5	10	1835	E	5	10	2235	68 14.8	67 09.2	383	100	Torres	
205	Tucker Trawl	39	6	6	5	10	1842	S	5	10	2242	68 14.8	67 09.2	383	100	Torres	
			6	6	5	10	1903	E	5	10	2303	68 14.17	67 11.5	286	100	Torres	
206	Moc10	23	6	6	5	10	2213	S	5	11	213	68 07.92	68 01.21	457		Torres	
207	ADCP		6	6	5	11	50	S	5	11	450	68 12.0	67 50.0	218		Zhou	
			6	6	5	11	348	E	5	11	748	68 12.8	68 31.9			Zhou	
208	Sonobuoy				5	11	755	S/E	5	11	1155	68 13.4	69 28.3	434		Friedlaender	
209	Sonobuoy				5	11	1600	S/E	5	11	2000	67 34.3	69 30.1	229		Friedlaender	
210	ADCP				5	12	532	S	5	12	932	66 34.2	67 26.4	344		Zhou	
211	Seal Ops				5	12	945	S	5	12	1345					Burns	
					5	12	1530	E	5	12	1930					Burns	
212	Whale Ops				5	13			5	13		65 10	64 08			Friedlaender	
Seal Ops at Rothera																	
1	Seal Ops				4	23	930	S	4	23	1330	67 35.00	68 10.00			Burns	

	Seal Ops				4	23	1140	E	4	23	1540					Burns	
2	Seal Ops				4	23	1400	S	4	23	1800	67 35.00	68 10.00			Burns	
	Seal Ops				4	23	1615	E	4	23	2015					Burns	
3	Seal Ops				4	24	1400	S	4	24	1800	67 37.00	68 15.00			Burns	
	Seal Ops				4	24	1515	E	4	24	1915					Burns	
4	Seal Ops				4	25	1100	S	4	25	1500	67 34.00	68 06.00			Burns	
	Seal Ops				4	25	1200	E	4	25	1600					Burns	
5	Seal Ops				4	25	1400	S	4	25	1800	67 34.00	68 06.00			Burns	
	Seal Ops				4	25	1445	E	4	25	1845					Burns	
6	Seal Ops				4	26	1100	S	4	26	1500	67 34.00	68 06.00			Burns	
	Seal Ops				4	26	1200	E	4	26	1600					Burns	
7	Seal Ops				4	27	1000	S	4	27	1400	67 35.30	68 60.40			Burns	
	Seal Ops				4	27	1600	E	4	27	2000					Burns	
Penguin Ops at Avian Island																	
1	Penguin Ops				4	19	1500	S	4	19	1900					Fraser	
					4	19	1700	E	4	19	2100					Fraser	
2	Penguin Ops				4	20	1400	S	4	20	1800					Fraser	
					4	20	1530	E	4	20	1930					Fraser	
3	Penguin Ops				4	22	1500	S	4	22	1900					Fraser	
					4	22	1700	E	4	22	2100					Fraser	
4	Penguin Ops				4	23	1600	S	4	23	2000					Fraser	
					4	23	1730	E	4	23	2130					Fraser	
5	Penguin Ops				4	24	1530	S	4	24	1930					Fraser	
					4	24	1730	E	4	24	2130					Fraser	
6	Penguin Ops				4	25	1600	S	4	25	2000					Fraser	
					4	25	1730	E	4	25	2130					Fraser	
7	Penguin Ops				4	27	1600	S	4	27	2000					Fraser	
					4	27	1730	E	4	27	2130					Fraser	

Appendix 2. Seal tagging data: Upper panel shows locations of seals tagged in 2001. Lower panel shows dive-depth data obtained from one seal tagged in May 2002.





Appendix 3. Whale biopsy and behaviorial data summary.

11 April 2002, Bransfield Strait, 63º 57'S, 61º 41'W. c. 11 April 2002, Bransfield Strait, 63º 57'S, 61º 41'W.

WOS6: humpback whale. Biopsy 1. 63° 57'S, 61º 41'W. Potential mom and calf pair. The whales were approachable to 50 m then altered course away from the Zodiac. We followed at a distance until the surfaced again, then sped up to get up close to animals. Took sample from the larger animal. Bolt hit the animal on the left lateral side posterior to the dorsal fin. The animal did not show significant behavioral change from the impact. Video 1, photos 2-26 on P33-02.

WOS7: humpback whale. Biopsy 2. 63º 57'S, 61º 41'W. Pair of larger animals traveling slowly at the surface. Animals swam away from the Zodiac as we approached. We sped up to catch them at their next surfacing before they dove. Biopsy bolt hit on the left lateral, posterior to the dorsal fin. No behavioral response to the impact. Video 2, photos 2-26 on P33-02.

WOS9A: humpback whale. Biopsy 3. 64º 00'S, 61º 45'W. Two larger whales swimming together diving for 2-3 minutes at a time. Animals avoided the Zodiac's approach at first. Then when they surfaced near us, we sped to reach them. Biopsy bolt hit left lateral posterior to the dorsal fin as the animal was diving. Animal raised and slapped its flukes in reaction to the dart. Video 1, photos 4-8 on P28-02.

WOS9B: humpback whale. Biopsy 4. 64° 00'S, 61º 45'W. Following the pair of animals and watching them just under the surface until they surfaced near the Zodiac. Biopsy bolt hit mid lateral on the right side. There was no apparent reaction to the impact of the dart. Video 1, photos 9-11 on P28-02.

1 May 2002, north end of Alexander Island, at sea ice edge, 68º 44'S, 69º 52'W.

WOS53A: humpback whale. Biopsy 5. From a group of three animals that were lazy and logging at the surface. Upon approaches they simply dove shallow, returning to the same general area. WOS53A&C were larger animals, while WOS53B was somewhat smaller. Sample taken from WOS53A was right side lateral below the dorsal fin. Skin and blubber collected. Photos and video of all animals in the group. Minimal reaction to the biopsy dart.

WOS53B: humpback whale. Biopsy 6. The smaller of the three whales in this group. Sample of blubber and skin collected from left lateral side of the animal. Animal quickly dove after being struck.

WOS53C: humpback whale. Biopsy 7. Final animal from the group. Sample of blubber and skin taken from right lateral side. Lead animal began to dive, followed by this animal which was struck and showed no sudden movement or change in diving rate/behavior.

WOS54A: humpback whale. Biopsy 8. A group of two animals that were swimming rather slowly and deliberately. Both animals in the group were sampled. Blubber and skin taken from right lateral side. Animal swiped its tail as it was diving when it got struck. Both animals were relatively large.

WOS54B: humpback whale. Biopsy 9. Second in the group of two animals. Were chased for 4 minutes after first encountered. Left lateral blubber and skin sample taken as the animal was surfacing.

WOS56A: humpback whale. Biopsy 10. From a group of animals that initially appeared to be two animals, but turned into four that were socializing and diving and rolling a bit among each other. First

dart hit posterior left lateral side and bounced off without any sample. The dart may have hit near a transverse process. The next dart hit higher up, just below the dorsal fin and collected only a skin sample.
WOS56B: humpback whale. Biopsy 11. Second of the animals in this group sampled. This animal surfaced at angles with its tail bent to one side typically. Blubber and skin sample collected as the animals were surfacing together from the left lateral side. Animal splashed with its fluke as the dart hit and it was diving.

WOS56C: humpback whale. Biopsy 12. Final animal sampled in this group that appeared, at this point, to be avoiding the Zodiac. Blubber and skin sample collected from left lateral side of fast approach of the whales as they were swimming away.

13 May 2002 Argentine Islands, French Passage, 65º 10'S, 64º 08'W.

WOS76A Biopsy 13. First of two humpback whales from the pair. Biopsied from 10 meters away, left lateral blubber and skin sample. No adverse reaction to the dart.

WOS76B Biopsy 14. Second humpback whale of the group. Both large animals logging at the surface. Blubber and skin sample from 12 meters away on left lateral side. No adverse reaction to the dart.

WOS77A Biopsy 15. First of a group of two large humpback whales diving and feeding in the area. Blubber and skin sample taken from 10 meters, left lateral side. The animal waved its fluke as it dove and was struck by the dart.

WOS77B Biopsy 16. The second humpback from the group. Blubber and skin sample taken from 15 meters at the right lateral flank. The animal showed no visible reaction to the dart as it dove.

WOS78A Biopsy 17. Three samples taken from a group of 3 that joined with two other whales during work. All animals seemed large and were diving and feeding, as well as socializing at the surface. They became more aware of our presence eventually and we left them after they showed signs of annoyance with us. Blubber and skin sample collected from 15 m on left lateral flank. Animal waved its flukes as it dove and was struck by the dart.

WOS78B Biopsy 18. Second animal from this group. Blubber and skin sample collected from 15 m from the right lateral flank. No reaction to the dart.

WOS78C Biopsy 19. Third animal from this group. Blubber and skin samples collected from left lateral side, shot from 15 m. No apparent reaction to the dart.

WOS79A Biopsy 20. Single animal sampled from a group of two humpback whales that swam away from us after one sample was collected. Blubber and skin were collected from the left lateral flank on a shot from 10 m. No apparent reaction to the dart.