UNITED STATES

AMLR ANTARCTIC MARINE LIVING RESOURCES PROGRAM

AMLR 2006/2007 FIELD SEASON REPORT

Objectives, Accomplishments and Tentative Conclusions

Edited by
Jessica D. Lipsky

November 2007

NOAA-TM-NMFS-SWFSC-409

Southwest Fisheries Science Center
Antarctic Ecosystem Research Division

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The U.S. Antarctic Marine Living Resources (AMLR) program provides information needed to formulate U.S. policy on the conservation and international management of resources living in the oceans surrounding Antarctica. The program advises the U.S. delegation to the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), part of the Antarctic treaty system. The U.S. AMLR program is managed by the Antarctic Ecosystem Research Division located at the Southwest Fisheries Science Center in La Jolla.

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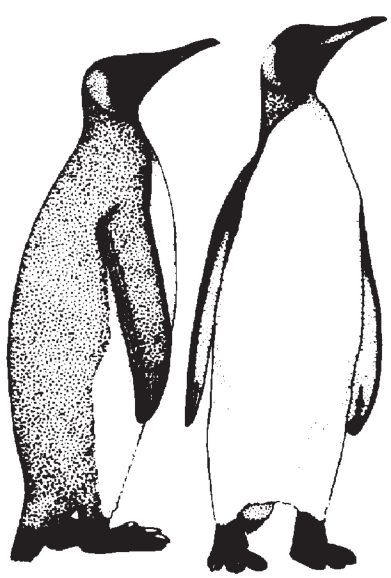

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BACKGROUND

The long-term objective of the U.S. AMLR field research program is to describe the functional relationships between Antarctic krill (*Euphausia superba*), their predators, and key environmental variables. The field program is based on two working hypotheses: (1) krill predators respond to changes in the availability of their food source; and (2) the distribution of krill is affected by both physical and biological aspects of their habitat. To refine these hypotheses a study area was designated in the vicinity of Elephant, Clarence, and King George Islands, and a field camp was established at Seal Island, a small island off the northwest coast of Elephant Island. From 1989-1996, shipboard studies were conducted in the study area to describe variations within and between seasons in the distributions of nekton, zooplankton, phytoplankton, and water zones. Complementary reproductive and foraging studies on breeding pinnipeds and seabirds were also accomplished at Seal Island.

Beginning in the 1996/97 season, the AMLR study area was expanded to include a large area around the South Shetland Islands, and a new field camp was established at Cape Shirreff, Livingston Island (Figure 1). Research at Seal Island was discontinued due to landslide hazards. Shipboard surveys of the pelagic ecosystem in the expanded study area are accomplished each season, as are land-based studies on the reproductive success and feeding ecology of pinnipeds and seabirds at Cape Shirreff.

Beginning in the 1997/98 season, bottom trawl surveys were conducted to assess benthic fish and invertebrate populations. Bottom trawl surveys were conducted in 1998, 1999, 2001, 2003 and 2006.

This is the 19th issue in the series of AMLR field season reports.

SUMMARY OF 2007 RESULTS

The Russian R/V *Yuzhmorgeologiya* was chartered to support the U.S. AMLR Program during the 2006/07 field season. Shipboard operations included: 1) a region-wide survey of krill and oceanographic conditions in the vicinity of the South Shetland Islands (Leg I) (See Figure 2 for station locations); 2) calibration of acoustic instrumentation at the beginning and end of survey operations; 3) underway seabird and marine mammal observations; 4) deployment of XBT’s and an acoustically instrumented buoy with buoy-to-shore telemetry in the vicinity of Cape Shirreff; 5) a joint Zodiac/ship inshore survey of krill and oceanographic conditions near Cape Shirreff (See Figure 3 for station locations); and 6) shore camp support. Land-based operations at Cape Shirreff included: 1) observations of chinstrap, gentoo and Adélie penguin breeding colony sizes, foraging locations and depths, diet composition, breeding chronology and success, and fledging weights; 2) instrumentation of adult penguins to determine winter-time migration routes and foraging areas; 3) observations of fur seal pup production and pup growth rates, adult female attendance behavior, diet composition, foraging locations and depths, and metabolic rates; 4) collection of female fur seal milk samples for determination of fatty acid signatures; 5) collection of fur seal teeth for age determination and other demographic studies; 6) tagging of penguin chicks and fur seal pups for demographic studies; and 7) establishment of a weather station for continuous recording of meteorological data.

An oceanic frontal zone was mapped along the north side of the South Shetland Islands, running parallel to the continental shelf break and separating Drake Passage water to the north from Bransfield Strait water to the south. During the southward transit of Leg I, a wide front was well defined between 57°55'S and 59°10'S, with sea surface temperature (SST) changing from 6.20°C to 2.80°C. On the northern transect the front had become narrower and defined between 57°55'S and 58°40'S, with a change in SST from 4.47°C to 6.15°C. During Leg I, there was a clearly defined distinction of the classical Zone I (ACC) waters at the offshore stations of the west and northwestern stations of the Elephant Island Areas, in the area of the Shackleton Fracture Zone. The most northern stations of the Elephant Island Area, east of the Fracture Zone were found to be Zone II (Transition) waters, becoming Zone III waters further east in the area. Zone IV (Bransfield Strait) waters were evident around the islands extending into the southeastern portion of the Elephant Island Area and the northern Joinville Island and South Areas. Zone V (Weddell Sea) waters was present along the southwestern part of the Joinville Island Area and in the extreme southeastern Bransfield Strait. Weather during the main survey was generally fair and sunny, with a few days being cloudy and overcast, as can be seen from results obtained from the PAR sensor, which indicate reduced levels of photosynthetic radiation. Air temperatures averaged around 1.7°C, with a minimum temperature of –0.9°C and maximum temperature of 6.5°C being recorded during the survey.

The phytoplankton data indicate that this season was close to normal based on our 17 previous years. The most unusual feature was the either very deep (>100m) or absence of the Deep Chlorophyll Maximum (DCM) in Zone IA waters. This might have been a result of the violent storm activity (water sampling was halted for ~40 hours) that directly preceded our survey of the Elephant Island Area, and is where a majority of the Zone IA stations lie in the survey area. Zone I waters are Fe-stressed, and one suspected result is that *in situ* fluorescence yield is enhanced, which will lead to over-estimated Chl-*a* concentrations. Stations with the lowest Chl-*a* concentrations at 5m depth (<0.5 mg m^{-3}) were found in the northern portions of the sampling grid (pelagic Drake Passage waters) and in the eastern and southern regions where the water is mainly of Weddell Sea origin. The highest Chl-*a* concentrations (>1.5 mg m^{-3}) were found over or close to the continental shelf regions of the South Shetland Islands and Elephant Island. Stations with intermediate concentrations of Chl-*a* (~1.0 mg m^{-3}) were generally located close to the continental shelf break east of Elephant Island and in the southwestern and central Bransfield Strait. Data show that the mean Chl-*a* concentrations in the Elephant Island (EI), West (WA), South (SA), and Joinville Island (JI) Areas at 5m during 2007 were about the same as the historical means. In the Elephant Island Area, the Upper Mixed Layer (UML) was slightly deeper than normal, thus resulting in slightly higher than normal Chl-*a* concentrations within the upper mixed layer (phytoplankton are generally mixed uniformly throughout the UML). In the Joinville Island Area, the UML was slightly shallower than normal yielding a slightly higher CHL_{UML} as compared to the historical mean.

The krill bioacoustic survey showed that the mean krill abundance was 68, 344, and 26 g/m² for the West, Elephant Island, and South Areas, respectively. Very high concentrations of krill were found off the north and east coasts of Elephant Island. There were also high concentrations just south of the Shackleton fracture zone. The West and Elephant Island Areas had the highest biomass estimates seen back to 1996.

Mean and median krill abundance values in the Elephant Island Area (January 2007) were well above average for the past 15 years, with mean concentration the third highest after 2003 and 1996 values and median concentration the highest recorded. Peak krill abundance typically results from the massive influx of juveniles through good recruitment success. The length-frequency distribution indicated substantial proportions of one- and two-year-old krill as well as older, mature individuals. Given the synchronized spawning bouts and dense larval concentrations observed last year good recruitment success was anticipated for the 2005/06 year class. Based on dense larval concentrations in February 2004/05 relatively good recruitment by that year class was also anticipated but those individuals were under-represented in the 2006 net samples. At the time it was suspected that, like 2001, the juveniles were located to the south of the area surveyed in Bransfield Strait. Using 2007 length-frequency data Volker Siegel calculated an R1 recruitment index of 0.230 for the 2005/06 year class and an R2 of 0.200 for the 2004/05 year class. Although these values appear to be modest one must keep in mind that they are based on proportions of the one- and two-year-old length classes relative to total krill abundance and larger, older krill (2003/04 and prior year classes) were also well represented in 2007. Largest krill catches were attributed to infrequent but extremely dense concentrations of juvenile and immature stages in Bransfield Strait. Given apparent interannual latitudinal shifts of all krill length/maturity stages this reinforces the importance of adequate sampling efforts in Bransfield Strait, particularly its southern portion, for establishing krill biomass and recruitment success. The association of gravid females, larval and juvenile krill with deep basins in Bransfield Strait supports the importance of these features as spawning and nursery areas (Spiridonov, 1996). Given the advancing maturity stages, mating and spawning behavior during Survey A it is likely that peak production by abundant and large (i.e., fecund) females occurred in February-March 2007, after our survey this year. Together with favorable feeding conditions associated with the January-February phytoplankton bloom, and conditions associated with predicted La Niña conditions in 2007, this would bode well for the 2006/07 year class and continued krill population growth through multiyear sequences of moderate to strong recruitment. Mean and median *S. thompsoni* abundance values in the Elephant Island Area were both below average for the past 15 years, with the median close to the all time January low in 1995. The significant association between *S. thompsoni* and ACC water conforms to results from 2001-2006 and is consistent with minimal input from east of the Weddell Sea following a climatic regime shift in the mid-1990s. The low frequency of occurrence and numbers of *I. racovitzai* indicate minimal Weddell Sea influence during the survey. These contrast markedly with the peak values associated with El Niño conditions in 1998 and 2004 (Loeb *et al*., in prep). The overall zooplankton assemblage in the Elephant Island Area during January 2007, numerically dominated by copepods (*M. gerlachei*), postlarval *T. macrura* and krill, and patchy concentrations of *S. thompsoni* conform to the quintessential "East Wind Drift" assemblage from the Discovery Expeditions. However, the mean and median numbers of copepods, postlarval *T. macrura* and krill were all above the long term average suggesting that this assemblage is quite rich compared to those sampled in the 1990s.

Initial results from the 2007 nearshore survey are somewhat difficult to interpret given the limited duration of the survey this year. However, the data collected support the hypothesis that the nearshore waters are productive environments. There were large aggregations of scatterers at the edges of the canyons often in waters between 100 and 150m in depth. From net tow data from the *Yuzhmorgeologiya*, and multiple frequency acoustic discrimination from both vessels, these scatterers are identified as krill. As was seen in the 2000, 2002, 2004, 2005, 2006 surveys, the highest concentrations of scatterers were found in the near-shore region southeast and east of Cape Shirreff. High levels of scattering were also found along the canyon walls. From the 2007 nearshore survey net tow data from R/V *Yuzhmorgeologiya*, the acoustical targets are dominated by the euphausiids *Euphausia superba*, *Thysanoessa macrura* and *Euphausia frigida*. Additional contributors to the acoustic backscatter may include: chaetognaths, salps, siphonophores, larval fish, myctophids, and amphipods. Acoustic detections of Antarctic krill swarms by the SM20 MBE demonstrate that a small boat is a viable platform for multi-beam surveys. Further work is required to integrate motion, heading and position sensors and obtain the optimal settings for simultaneous water column and seabed depth observations.

Fur seal pup production in 2006/07 season at U.S. AMLR study beaches was consistent with last season. Early season neonate mortality (4.8%) was slightly higher than the long-term average of 4.5%. We also recorded a mid-season increase in leopard seal predation over last year. The median date of pupping based on pup counts was one day earlier than last year. Over winter survival for adult females increased over last year (88.9 vs. 86.5%). The natality rate also increased (88.5 vs. 83.9%). The mean foraging trip duration (2.70 days ±0.08) did not significantly change over last year's but was the lowest on record in ten years of data collection at Cape Shirreff. Mean visit duration (1.52 days ±0.70) showed a similar trend and, as with trip duration, was reflective of favorable summer foraging conditions. Over winter juvenile survival for 2006 was better than 2005. Last year was the first year on record that we did not observe any yearlings (i.e., tagged pups from the 2004/05 cohort). Tag resights for the 2004/05 cohort this year were similarly lacking, confirming a poor rate of success for that cohort. The 1999/00 and the 2001/02 cohorts continued to dominate tag returns, as in previous years. Fur seal diet studies for the third year in a row recorded an absence of *E. carlsbergi*. Overall, summer conditions were favorable resulting in better than average performance for summer indices. Winter conditions in 2006 resulted in average performance.

Our tenth season of seabird research at Cape Shirreff allowed us to assess trends in penguin population size, as well as inter-annual variation in reproductive success, diet and foraging behavior. The gentoo breeding population has decreased marginally from the previous season and is the third lowest population size in the ten years of census data. The number of diet samples containing fish was the highest ever and comparable to the first six years of the study. Unlike 2005/06, 18% of the gentoo penguin diet samples contained juvenile krill. Fledgling success and fledgling weights were slightly below the nine year means for these parameters at our study site. The chinstrap penguin breeding population has been declining for the past seven years and is at its lowest size in the ten years of study. Chinstrap penguins ate mainly Antarctic krill, with a strong component of juvenile krill in their diet samples. Juvenile krill were also plentiful in the chinstrap penguin's diets in the 1997/98 and 2002/03 seasons. The mean foraging trip duration during chick rearing was approximately one hour longer than in 2005/06. The data collected, using the PTTs and TDRs, on foraging location and diving behavior should assist us in interpreting the foraging trip data. Fledgling success and chick fledging mass in 2006/07 were higher than both last season and the past ten year mean.

For the fourth year consecutively, seabird and marine mammal observers collected data on the spatial distribution and abundance of seabirds and marine mammals. The data collected at sea provides insight on how pelagic predators respond to changes in the distribution of Antarctic krill and the position of oceanographic features. The number and distribution of feeding aggregations observed during this field season were the highest in the last five AMLR surveys. Most feeding activity by black-browed albatrosses (*Thalassarche melanophrys*) and cape petrels (*Daption capense*) was found in the West Area, whereas feeding aggregations by southern fulmars were concentrated in the Bransfield Strait region (South Area). However, species that are usually common in the AMLR area, such as blue petrels (*Halobaena caerulea*), prions (*Pachyptila* spp.), and white-chinned petrels (*Procellaria aequinoctialis*), were comparatively rare in contrast to previous field seasons. Sightings of cetaceans yielded exceptional insight on the dissimilar distributions of humpback (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*). The sighting records show that fin whales were concentrated in the Elephant Island Area in proximity to the ACC, whereas humpbacks were concentrated closer to the South Shetland Islands and throughout the Bransfield Strait region.

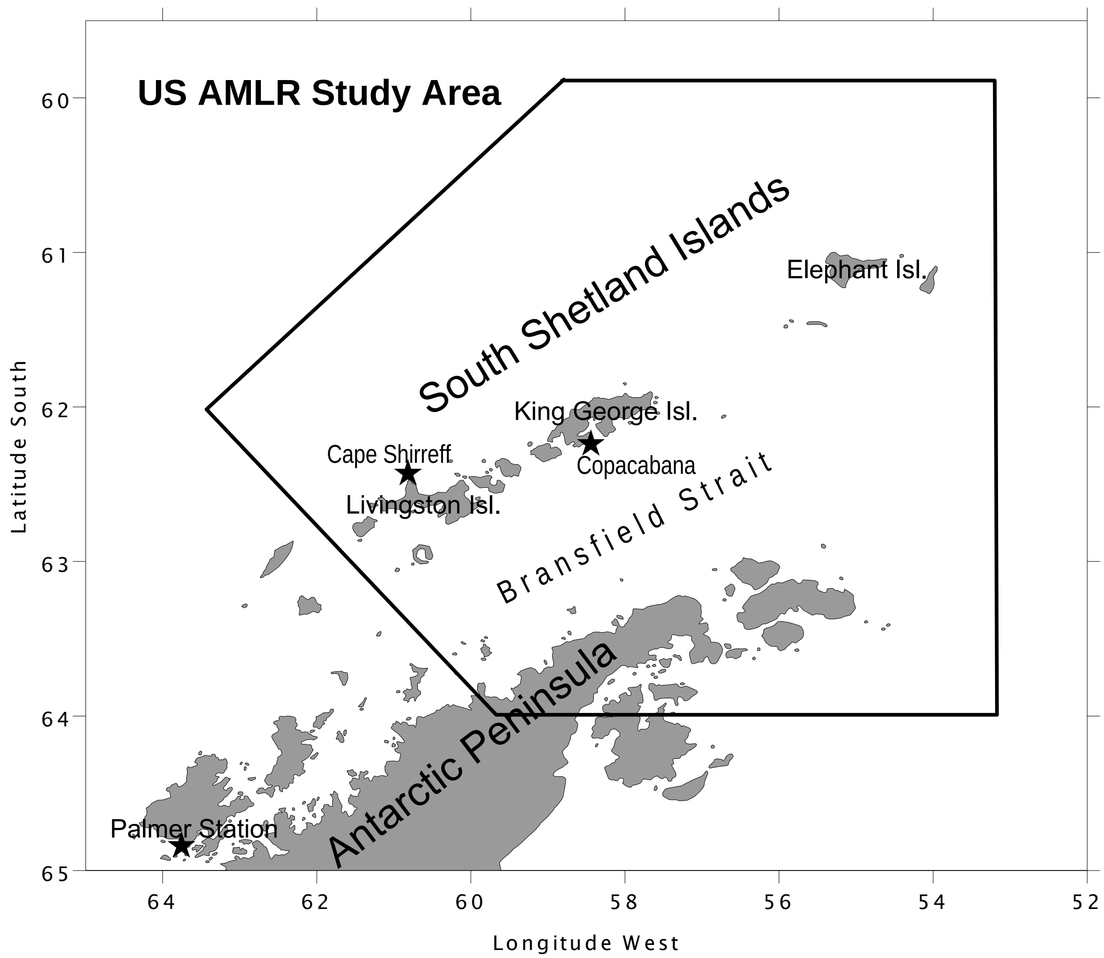

Figure 1. Locations of the U.S. AMLR field research program: AMLR study area, Cape Shirreff, Livingston Island and Copacabana, King George Island.

OBJECTIVES

Shipboard Research:

1. Conduct a survey in the AMLR study area to map meso-scale features of the dispersion of krill, water mass structure, phytoplankton biomass and productivity and zooplankton constituents using the R/V *Yuzhmorgeologiya*.
2. Estimate abundance and dispersion of krill and krill larvae in the AMLR study area.
3. Calibrate the shipboard acoustic system in Admiralty Bay, King George Island, and again at Admiralty Bay at the end of the cruise.
4. Conduct underway observations of seabirds and marine mammals during Leg I.
5. Conduct a high-resolution survey of krill in the vicinity of Cape Shirreff using specially equipped Zodiacs for the inshore areas and the *Yuzhmorgeologiya* for the offshore areas.
6. Deploy one instrumented buoy with acoustical sensors and buoy-to-shore telemetry in the vicinity of Cape Shirreff at the beginning of the cruise and to be recovered at the end of the cruise.
7. Deploy 15 drifter buoys and 53 Expendable Bathythermographs (XBT's).
8. Collect continuous measurements of the research ship's position, water depth, sea surface temperature, salinity, turbidity, fluorescence, air temperature, barometric pressure, relative humidity, and wind speed and direction.
9. Provide logistical support to two land-based field sites: Cape Shirreff (Livingston Island), and Copacabana field camp (Admiralty Bay, King George Island).

Land-based Research:

Cape Shirreff

1. Estimate chinstrap and gentoo penguin breeding population size.
2. Band 500 chinstrap and 200 gentoo penguin chicks for future demographic studies.
3. Record at sea foraging locations for chinstrap penguins during their chick-rearing period using ARGOS satellite-linked transmitters (PTTs).
4. Determine chinstrap and gentoo penguin breeding success.
5. Determine chinstrap and gentoo penguin chick weights at fledging.
6. Determine chinstrap and gentoo penguin diet composition, meal size, and krill length/frequency distributions via stomach lavage.
7. Determine chinstrap and gentoo penguin breeding chronologies.
8. Deploy time-depth recorders (TDRs) on chinstrap and gentoo penguins during chick rearing for diving studies.
9. Collect data on foraging locations (using PTTs) and foraging depths (using TDRs) of chinstrap penguins while concurrently collecting acoustically derived krill biomass and location data during the inshore survey.
10. Deploy PTTs on chinstrap penguins following adult molt to determine migration routes and winter foraging areas in the Scotia Sea region.
11. Monitor female Antarctic fur seal attendance behavior.
12. Collaborate with Chilean researchers in collecting Antarctic fur seal pup mass for 100 pups every two weeks through the season.

13. Collect 10 Antarctic fur seal scat samples every week for diet studies.
14. Collect a milk sample at each female Antarctic fur seal capture for fatty acid signature analysis and diet studies.
15. Record at-sea foraging locations for female Antarctic fur seals using Platform Terminal Transmitters (PTT).
16. Deploy time-depth recorders (TDR) on female Antarctic fur seals for diving studies.
17. Tag 500 Antarctic fur seal pups for future demographic studies.
18. Collect teeth from selected Antarctic fur seals for age determination and other demographic studies.
19. Deploy a weather station for continuous summer recording of wind speed, wind direction, ambient temperature, humidity, and barometric pressure.

DESCRIPTION OF OPERATIONS

Shipboard Research:

For the twelfth consecutive year, the cruise was conducted aboard the chartered research vessel R/V *Yuzhmorgeologiya*. "CS" stands for Cape Shirreff, and "Copa" stands for Copacabana.

Leg I:	Depart Punta Arenas and transit to CS field camp	6-8 January 2007
	Transfer personnel to CS	9 January
	Transfer personnel to Copa, calibrate in Admiralty Bay	15 January
	Conduct large area survey (Survey A)	11-25 January
	Transfer personnel to CS, deploy buoy, conduct nearshore survey	26-31 January
	Transfer personnel from CS, recover buoy	1 February
	Transit to Punta Arenas, Chile	2-4 February

Leg I

1. The R/V *Yuzhmorgeologiya* departed Punta Arenas, Chile via the eastern end of the Strait of Magellan and arrived at Cape Shirreff to deliver personnel and supplies to the field camp. The ship then transited to Admiralty Bay to deliver additional personnel and supplies to the Copacabana field camp.

2. The acoustic transducers were calibrated in Admiralty Bay, King George Island. Beam patterns for the hull-mounted 38, 70, 120 and 200kHz transducers were mapped and system gains were determined.

3. Survey components included acoustic mapping of zooplankton, direct sampling of zooplankton, Antarctic krill demography, physical oceanography and phytoplankton observations. Survey A consisting of 98 (out of 108 planned) Conductivity-Temperature-Depth (CTD) and net sampling stations, separated by acoustic transects, was conducted in the vicinity of the South Shetland Islands (Figure 2). Operations at each station included: (a) vertical profiles of temperature, salinity, oxygen, fluorescence, light transmission and collection of water samples at discreet depths; and (b) deployment of an IKMT (Isaacs-Kidd Midwater Trawl) to obtain samples of zooplankton and micronekton. Acoustic

transects were conducted between stations at 10 knots, using hull-mounted 38kHz, 70 kHz, 120kHz, and 200kHz down-looking transducers. An extensive field of icebergs was encountered in the southern and eastern portion of the survey area and precluded the conduct of survey operations in these areas.

4. Seabird and marine mammal observations were collected continuously throughout Leg I.

5. A high-resolution survey for krill and oceanographic conditions was conducted in the vicinity of Cape Shirreff (Figure 3). A specially-equipped Zodiac, R/V *Ernest*, conducted a series of acoustic transects, CTD deployments and for the nearshore areas and the *Yuzhmorgeologiya* for the offshore areas. A total of 20 stations were completed. The R/V *Roald* concurrently conducted a high resolution multibeam bathymetry survey.

6. Deployed one buoy, instrumented with acoustical sensors and buoy-to-shore telemetry in the vicinity of Cape Shirreff.

7. Deployed 15 drifter buoys and 53 XBT's for oceanographic data.

8. Optical oceanographic measurements were conducted, which also included weekly downloads of SeaWiFS satellite images of surface chlorophyll distributions and *in-situ* light spectra profiles.

9. Continuous environmental data were collected throughout Leg I, which included measurements of ship's position, sea surface temperature and salinity, fluorescence, air temperature, barometric pressure, relative humidity, wind speed, and wind direction.

Land-based Research:

1. A five-person field team (M. Goebel, G. McDonald, C. Champagne, R. Orben and S. Chisholm) arrived at Cape Shirreff, Livingston Island, on 1 November 2006 via the R/V *Lawrence M. Gould*. Equipment and provisions were also transferred from the R/V *Lawrence M. Gould* to Cape Shirreff.

2. Two additional personnel (R. Holt and R. Haner), along with supplies and equipment, arrived at Cape Shirreff via the R/V *Yuzhmorgeologiya* 9 January 2007. Additionally, two more personnel (A. Miller and R. Driscoll) arrived at Cape Shirreff via the R/V *Yuzhmorgeologiya* 1 February 2007.

3. The annual censuses of active gentoo and chinstrap penguin nests were conducted on 13 & 25 November 2006, respectively. Reproductive success was studied by following a sample of 100 chinstrap penguin pairs and 50 gentoo penguin pairs from egg laying to crèche formation.

4. Radio transmitters were attached to 18 chinstrap penguins on 29 December 2006 and remained on until their chicks fledged in mid February 2007. These instruments were

used to determine foraging trip duration during the chick-rearing phase. All data were received and stored by a remote receiver and logger set up at the bird observation blind.

5. Seventeen satellite-linked transmitters (PTTs) were deployed on adult chinstrap and gentoo penguins during the time each species was feeding chicks in mid-January. A second deployment of sixteen PTTs was made in late January; to coincide with the time when the annual AMLR 2006/07 marine survey was adjacent to Cape Shirreff during a special nearshore survey conducted by zodiacs within 10km of Cape Shirreff.

6. Diet studies of chinstrap and gentoo penguins during the chick-rearing phase were initiated on 4 January 2007 and continued through 11 February 2007. Chinstrap and gentoo adult penguins were captured upon returning from foraging trips, and their stomach contents were removed by lavaging.

7. Counts of all gentoo and chinstrap penguin chicks were conducted on 13 January and 4 February 2007; respectively. Fledging weights of 306 chinstrap penguin chicks were collected between 14-22 February. 180 gentoo penguin chicks were also weighed on 27 January 2007.

8. Five hundred chinstrap penguin chicks and 200 gentoo penguin chicks were banded for future demographic studies.

9. Reproductive studies of brown skuas and kelp gulls were conducted throughout the season at all nesting sites around the Cape.

10. Time-depth recorders (TDRs) were deployed on five chinstrap and four gentoo penguins for 7-10 days in mid-January to coincide with the marine sampling offshore at Cape Shirreff at the end of Leg I. A second deployment of the nine TDRs was made in late January in concert with the nearshore survey. The TDRs were retrieved, downloaded and await analysis.

11. Antarctic fur seal pups and female fur seals were counted at four main breeding beaches every other day from 12 November 2006 through 4 January 2007.

12. Attendance behavior of 21 lactating female Antarctic fur seals was measured using radio transmitters. Females and their pups were captured, weighed, and measured from 1-21 December 2006. An additional 16 transmitters were deployed on mothers of twins (n=3) and young females (4-5 year old first and second time breeders, n=12).

13. U.S. researchers assisted Chilean scientists in collecting data on Antarctic fur seal pup growth. Measurements of mass for a random sample of 100 pups were begun 30 days after the median date of pupping (7 December 2006) on 6 January 2007 and continued every two weeks until 21 February 2007.

14. Information on Antarctic fur seal diet was collected using scat (random collection of 10 per week) and fatty-acid signature analyses of milk collected at every capture of an adult lactating female.

15. Twenty-three Antarctic fur seals were instrumented with time-depth recorders (TDRs) for diving behavior studies.

16. Fifteen Antarctic fur seal females were instrumented with ARGOS satellite-linked transmitters (PTTs) for studies of at-sea foraging locations from 18 December 2006 to 15 February 2007.

17. Four hundred and ninety nine Antarctic fur seal pups were tagged at Cape Shirreff by U.S. and Chilean researchers for future demography studies.

18. A weather data recorders (Davis Instruments, Inc.) were set up at Cape Shirreff for wind speed, wind direction, barometric pressure, temperature, humidity, and rainfall.

19. A single post-canine tooth was extracted from ten perinatal female fur seals for aging and demographic studies. Studies of the effects of tooth extraction on attendance and foraging behavior were initiated for these perinatal seals.

20. One team member (M. Goebel) left Cape Shirreff on 8 January 2007 on the R/V *Yuzhmorgeologiya* and two team members (R. Holt and C. Champagne) left Cape Shirreff via the R/V *Yuzhmorgeologiya* on 1 February 2007.

21. The Cape Shirreff field camp was closed for the season on 28 February 2007; all U.S. personnel (G. McDonald, R. Haner, R. Orben, S. Chisholm, A. Miller and R. Driscoll), garbage, and equipment were retrieved by the R/V *LM Gould*.

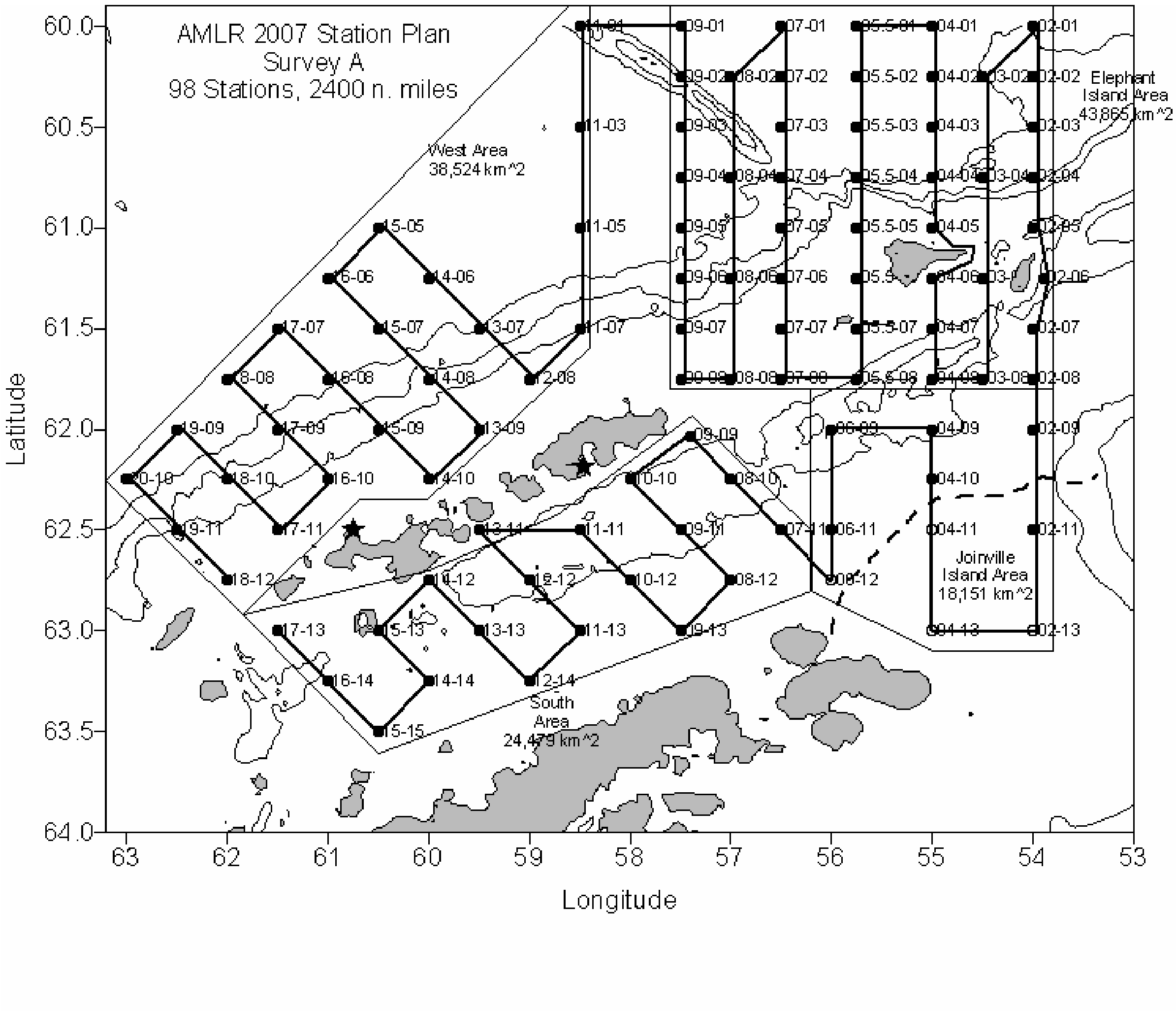

Figure 2. The planned survey design for AMLR 2006/07 (Survey A & D) in the vicinity of the South Shetland Islands; field camp locations indicated by★. The survey contains four strata outlined by thin lines: the stratum containing stations in the western portion of the survey area north of Livingston and King George Islands was designated the West Area, the stratum located south of King George Island was designated the South Area, the stratum containing stations in the northern portion of the South Shetland Islands was designated the Elephant Island Area, and the stratum south of Elephant Island was designated the Joinville Island Area. Depth contours are 500m and 2000m. Black dots indicate the location of biological/oceanographic sample stations; heavy lines indicate transects between stations; and the dashed line indicates the location of the ice edge.

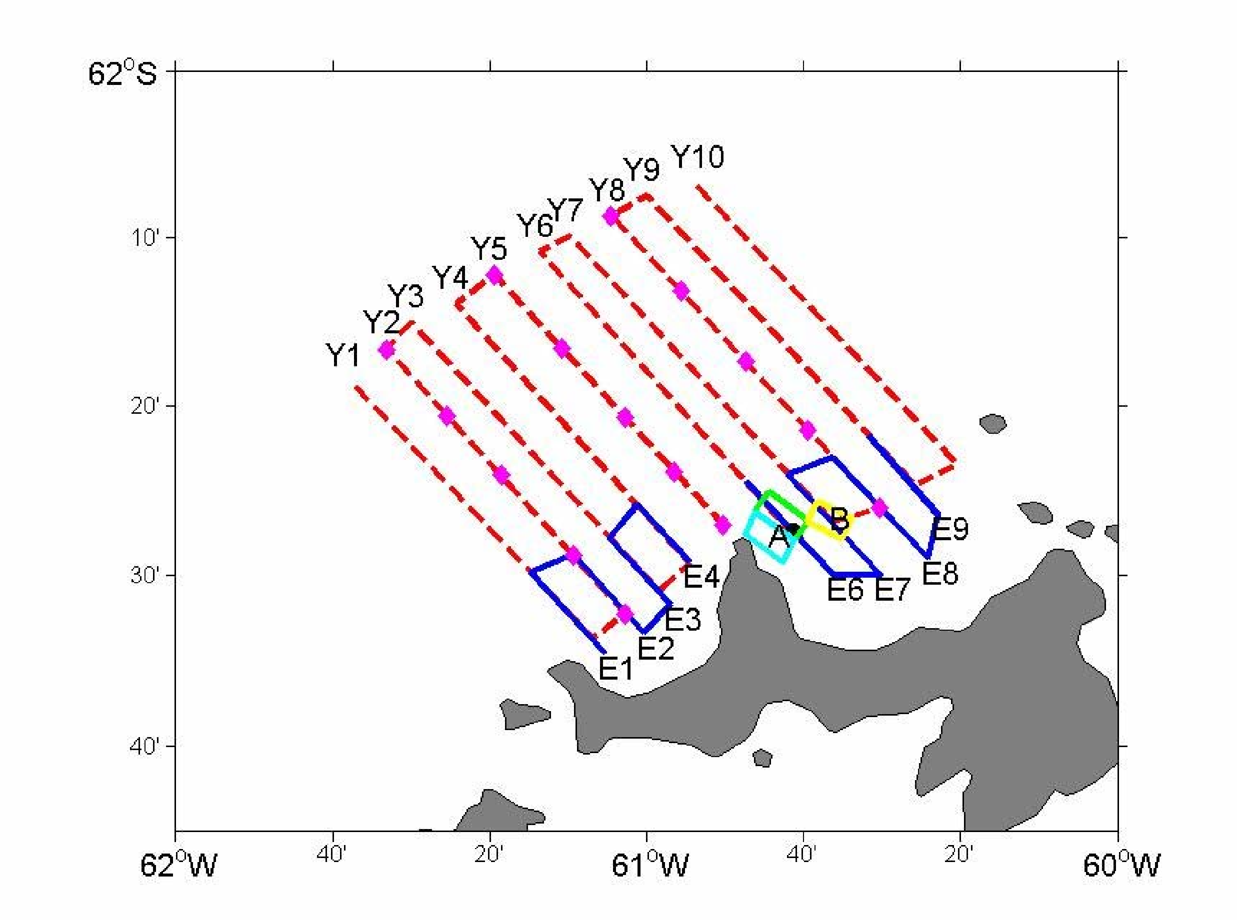

Figure 3. Cape Shirreff nearshore survey plan. Pink dots indicate positions of CTD/net stations conducted by the R/V *Yuzhmorgeologiya*. The red dotted lines indicate the track lines of the R/V *Yuzhmorgeologiya* and the blue lines indicate the track lines of the R/V *Ernest*. The rectangular boxes indicate regions where a high-resolution multibeam bathymetry survey will be conducted by the R/V *Roald*.

SCIENTIFIC PERSONNEL

Cruise Leader:
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Chief Scientist:
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Adam Jenkins, Southwest Fisheries Science Center (Leg I)
Kristen Green, Moss Landing Marine Laboratories (Leg I)
Kim Dietrich (Leg I)
Darci Lombard (Leg I)
Ryan Driscoll (Leg I)
Letise Houser (Leg I)
Kyla Zaret (Leg I)
Kelly Norton (Leg I)
Joseph Warren, Stony Brook University (Leg I)

Fur Seal Energetics Studies:
Jessica D. Lipsky, Southwest Fisheries Science Center (Leg I)

Seabird and Marine Mammal Observation Studies:
Jarrod A. Santora, College of Staten Island (Leg I)
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Nearshore Survey:

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Cape Shirreff Personnel:

Michael E. Goebel, Camp Leader, Southwest Fisheries Science Center (11/1/06 to 1/8/07)
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Birgitte I. McDonald, University of California at Santa Cruz (11/1/06 to 2/28/07)
Rachael Orben (11/1/06 to 2/28/07)
Sarah Chisholm (11/1/06 to 2/28/07)
Rennie Holt, Southwest Fisheries Science Center (1/9/07 to 2/1/07)
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Aileen Miller, Southwest Fisheries Science Center (2/1/07 to 2/28/07)
Ryan Driscoll (2/1/07 to 2/28/07)

DETAILED REPORTS

1. Physical Oceanography and Underway Environmental Observations; submitted by Derek Needham and Marcel van den Berg.

1.1 Objectives: Objectives were to; 1) collect and process physical oceanographic data in order to identify hydrographic characteristics and map oceanographic frontal zones; and 2) collect and process underway environment data in order to describe sea surface and meteorological conditions experienced during the surveys. These data may be used to describe the physical circumstances associated with various biological observations as well as provide a detailed record of the ship's movements and the environmental conditions encountered.

1.2 Accomplishments:

1.2.1 CTD/Carousel Stations: A total of 123 CTD/carousel stations were completed, 99 of these as part of Leg I. (See Figure 2 in the Introduction for station locations). Two stations (A11-05 and A11-03) were cancelled due to bad weather and five stations were cancelled due to icebergs in the eastern and southern areas of the survey grid. Three extra stations (A02-10; A05-09 and A06-10) were inserted during the survey, after the southern stations of the Joinville Island Area were abandoned due to concentrated ice. After the completion of the planned survey grid, 20 stations were completed near Cape Shirreff to accompany the data collected during the Nearshore Survey (see Nearshore Survey, Chapter 5, of this report). Three additional casts were completed during acoustic calibrations in Admiralty Bay and Maxwell Bay at the beginning and end of the survey.

Water samples were collected at eleven discrete depths on all casts and used for salinity and oxygen verification and phytoplankton analysis. These were drawn from the Niskin bottles by the Russian scientific support team. Salinity calibration samples from all stations were analyzed onboard, using a Guildline Portasal salinometer, and close agreement, between CTD measured salinity and the Portasal values was obtained, with an average error of 0.0067 %. The final CTD/Portasal correlation produced an r^2=0.9936 (n= 480) during the cruise. A first attempt was made at the comparisons of dissolved oxygen levels in the carousel water samples and the levels measured during the casts (via the O_2 sensor). The final correlation produced an r^2=0.8674 (n=176), with an average difference of 0.776.

Underway comparisons of the Seabird thermosalinograph (TSG) with CTD data were undertaken during the main survey. Salinity data compared with 7m CTD salinity data showed that the TSG salinity reading were on average 0.067 ppt (n=95) lower then the CTD, whilst the sea temperature showed the TSG to be on average 0.323°C (n=95) higher than the CTD 7m temperature data. This can be attributed to the heating effects of positioning the temperature sensor downstream of the seawater pump.

1.2.2 Underway Environmental Observations: Environmental and vessel positional data was collected for a total of 29 days via the Scientific Computer System (SCS) software package. The SCS software (SCS Version 3.3a) runs on a Windows XP based Pentium IV Dell PC with an Edgeport-8 USB serial port expander. A Coastal Environmental Company Weatherpak system and a Biospherical 4PI QSR-2100 PAR sensor were installed on the port side of the forward A-frame in front of the bridge and were used as the primary meteorological data acquisition system. The instruments measured surface environmental conditions encountered over the entire AMLR survey area for the duration of the cruise including transits to and from Punta Arenas.

1.3 Methods:

1.3.1 CTD/Carousel: Water profiles were collected with a Sea-Bird SBE-9/11+ CTD/carousel water sampler equipped with 11 Niskin sampling bottles. A Seabird SBE 43 dissolved oxygen probe, SBE pump, Chelsea Instruments Aquatracka III fluorometer; Wetlabs C-Star red transmissometer and a Wetlabs C-Star blue transmissometer were added to the CTD system. A new Biospherical QCP-2300 2pi PAR sensor was also added. The QCP200L PAR sensor, used on previous cruises, was retained on the system to obtain a cross calibration between the two. Scan rates were set at 24 scans /second during both down and up casts. Sample bottles were only triggered during the up casts. Profiles were limited to a depth of 750m or 5m above the sea bottom. A Data Sonics altimeter was used to stop the CTD descent 5 to 7m from the seabed, during the shallow casts. Standard sampling depths were 750m, 200m, 100m, 75m, 50m, 40m, 30m, 20m, 15m, 10m and 5m.

Plots of the down and up traces were generated and stored with the CTD cast log sheets, copies given to the various phytoplankton groups, together with CTD mark files (reflecting data from the cast at bottle triggering depths), and processed down traces in Ocean Data View (ODV) format. Data from casts were averaged over 1m bins and saved separately as up and down traces during post processing. The data were logged and bottles triggered using Seabird Seasave Win32 Version 5.30a and the data processed using SBE Data Processing Version 5.30a. Downcast data was re-formatted using a SAS script and then imported into ODV for further analysis.

1.3.2 Underway Data: Weather data inputs were provided by the Coastal Environmental Systems Company Weatherpak via a serial link and included relative wind speed and direction, barometric pressure, air temperature and irradiance (PAR). A Biospherical 4PI QSR-2100 PAR sensor (RS232 output version) was installed on the forward gantry, near the Weatherpak, and interfaced to the Scientific Computer System (SCS). The relative wind data were converted to true speed and true direction by the internally derived functions of the SCS logging software. Measurements of sea surface temperature and salinity were received by the SCS, in serial format, from the SeaBird SBE21 thermosalinograph (TSG) and integrated into the logged data. Ships position and heading were provided in NMEA format via a Furuno GPS Navigator and Guiys Gyro respectively. Serial data lines were interfaced to the Pentium 4 (Windows XP Professional based) logging PC via an Edgeport 8 serial RS232 to USB interface.

1.4 Results and Tentative Conclusions:

1.4.1 Oceanography: The position of the polar frontal zone, identified by pronounced sea surface temperature and salinity change, was located from the logged SCS data during the two transits from and to Punta Arenas and the South Shetland Islands survey area. This frontal zone is normally situated between 57-58°S.

During the south transit, a wide front was found between 57°55’S and 59°10’S, with sea surface temperature (SST) changing from 6.20°C to 2.80°C. On the northern transect the front had become narrower and found between 57°55’S and 58°40’S, with a change in SST from 4.47°C to 6.15°C (Figure 1.1). Two XBT (Expendable Bathy Thermograph) transects across the Drake Passage (one transect running from North to South and the other running South to North) were completed during the cruise (Figure 1.2). The 1.8°C temperature isotherm was highlighted to show the Polar fronts, which coincide with the data, obtained from the logged SCS data.

As in previous years an attempt was made to group stations with similar temperature and salinity profiles into five water zones as defined in Table 1.1. The tentative water zone classifications according to the criteria in Table 1.1 were sometimes prone to ambiguity, particularly in the coastal regions around King George & Livingston Islands and in the south and southeast of Elephant Island. Classifications of Zone IV (Bransfield Strait) and V (Weddell Sea) waters in these areas could change if other oceanographic data such as density are considered. For the purpose of this report, in which only tentative conclusions are reported, only the criteria contained in Table 1.1 were used. This was done to ensure consistency with past cruises and only serves as a “first attempt and field classification”.

During the main survey, there was a clearly defined distinction of the classical Zone I (ACC) water at the offshore stations of the West and northwestern stations of the Elephant Island Areas, in the area of the Shackleton Fracture Zone (Figure 1.3). The most northern stations of the Elephant Island Area, east of the Fracture Zone were Zone II (Transition) waters, becoming Zone III waters further east. Zone IV (Bransfield Strait) waters were evident at many of the inshore stations around the islands and this water extended into the southeastern portion of the Elephant Island Area and the northern Joinville Island and South Areas. Zone V (Weddell Sea) waters was present along the southwestern part of the Joinville Island Area and in the extreme southeastern Bransfield Strait.

Three vertical temperature transects were chosen for plotting using ODV software from the main survey – the same transects that were plotted for previous reports were chosen for comparisons (Figure 1.4). These transects are W05 in the West Area and EI03 and EI07 in the Elephant Island Area of the survey.

A “first look” field attempt was made to determine direction and intensity of water flow inferred by water density derived from the CTD data. This was done to compare zooplankton distributions (See Chapter 4 of this Report) with hydrographic patterns during the surveys. ODV was used to plot Dynamic Heights at the surface relative to 300m and 500m depths (Figure 1.5).

1.4.2 Underway Data: Environmental data were recorded for the duration of the surveys and for the transits between Punta Arenas and the survey area. Processed data were averaged and filtered over 1-minute and 5-minute intervals. (Figure 1.6 for main survey area only).

Weather during the main survey was generally fair and sunny, with a few days being cloudy and overcast, as can be seen from results obtained from the PAR sensor, which indicate reduced levels of photosynthetic radiation. Air temperatures averaged around 1.7°C, with a minimum temperature of –0.9°C and maximum temperature of 6.5°C being recorded during the survey.

Wind direction was predominately southwest to northwest with wind speeds averaging around 15-20 knots (Figure 1.7). Two storm periods of very strong easterly winds, averaging around 30 to 35 knots were experienced, associated with rough sea conditions and the cancellations of two stations in the West Area.

1.4.3 Drifter Deployments: Surface current drifters provided to US AMLR by the NOAA AOML Global Drifter program were deployed throughout the cruise (Table 1.2; Figure 1.8). Five drifters were deployed south of 58S and the South Shetland Islands during the southbound (January) and northbound (February) transits. Five additional drifters were deployed north of the South Shetland Islands (2); northwest of Elephant Island (2), and one south of Elephant Island within the Bransfield Strait. Drifter tracks for each drifter (from launch through March 15) show the eastward flow of the ACC, and several drifters show a re-circulation associated with the area east of the Shackleton Transverse Ridge. The drifter released within the Bransfield Strait did not provide any useful information.

1.5 Problems and Suggestions: In general the CTD systems performed well during the cruise, with only the usual maintenance to leaking underwater connectors being required.

The CTD, carousel, and deck unit were swapped with the spare units when erratic communications and bottle triggering problems occurred on two stations. The problem was eventually traced to an earth leakage in the ship's new coaxial sea-cable. The braid of the cable was disconnected and the outer armor was used instead, as the CTD signal and power return.

There is a problem with the ship's clean seawater supply and the TSG debubbler plumbing system that was not resolved during the cruise. The pump is too powerful and cavitates, causing excessive bubbles that the debubbler cannot clear fast enough. This causes spiking on the salinity trace. Before AMLR 2008, the debubbler needs to be changed to a gravity fed system with a flow control valve.

A field calibration was done on the Chelsea Instruments submersible fluorometer with figures provided by the phytoplankton section (Chapter 2 of this Report).

There is a discrepancy between the calibration of the four Biospherical PAR sensors on the ship (two submersible and two mast mounted). It is suggested that all four sensors be post cruise calibrated together. General technical support was given to assist in solving a number of equipment related problems.

1.6 Disposition of Data: Data are available from Christian Reiss, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA, 92037; phone/fax (858) 546-7127/ (858) 546-5608; email: Christian.Reiss@noaa.gov.

1.7 Acknowledgements: The co-operation and assistance of the Russian technical support and deck staff was once again outstanding. All requests for assistance were dealt with effectively and in a professional manner.

1.8 References: Schlitzer, R., Ocean Data View. http://www.awi.bremerhaven.de/GEO/ODV. 2001.

Table 1.1 Water Zone definitions applied for AMLR 2006/07.

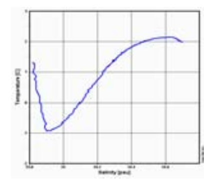
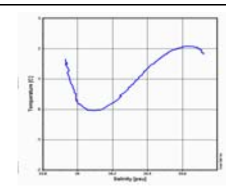
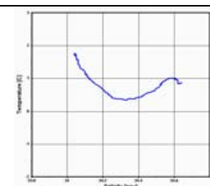
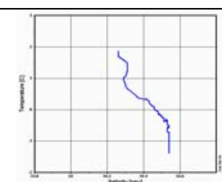
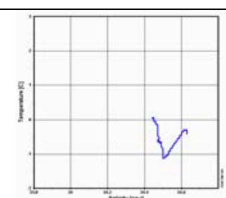
	T/S Relationship			
	Left	**Middle**	**Right**	**Typical TS Curve (from 2002)**
Water Zone I (ACW)	**Pronounced V shape with V at ≤0ºC**			
Warm, low salinity water, with a strong subsurface temperature minimum, Winter Water, approx. -1ºC, 34.0ppt salinity) and a temperature maximum at the core of the CDW near 500m.	2 to >3ºC at 33.7 to 34.1ppt	≤0ºC at 33.3 to 34.0 ppt	1 to 2ºC at 34.4 to 34.7ppt (generally >34.6ppt)	
Water Zone II (Transition)	**Broader U-shape**			
Water with a temperature minimum near 0ºC, isopycnal mixing below the temperature minimum and CDW evident at some locations.	1.5 to >2ºC at 33.7 to 34.2ppt	-0.5 to 1ºC at 34.0 to 34.5ppt (generally >0ºC)	0.8 to 2ºC at 34.6 to 34.7ppt	
Water Zone III (Transition)	**Backwards broad J-shape**			
Water with little evidence of a temperature minimum, mixing with Type 2 transition water, no CDW and temperature at depth generally >0ºC	1 to >2ºC at 33.7 to 34.0ppt	-0.5 to 0.5ºC at 34.3 to 34.4ppt (note narrow salinity range)	≤1ºC at 34.7ppt	
Water Zone IV (Bransfield Strait)	**Elongated S-shape**			
Water with deep temperature near -1ºC, salinity 34.5ppt, cooler surface temperatures.	1.5 to >2ºC at 33.7 to 34.2ppt	-0.5 to 0.5 ºC at 34.3 to 34.45ppt (T/S curve may terminate here)	<0ºC at 34.5ppt (salinity < 34.6ppt)	
Water Zone V (Weddell Sea)	**Small fish-hook shape**			
Water with little vertical structure and cold surface temperatures near or < 0ºC.	1ºC (+/- some) at 34.1 to 34.4ppt	-0.5 to 0.5ºC at 34.5ppt	<0ºC at 34.6ppt	

Table 1.2 Drifter number, deployment date, latitude and longitude for 15 drifters released during the 2007 UD AMLR field program.

DRIFTERS Released as part of US AMLR Program
January – February 2007

Drifter Number	Release Date	Latitude (S)	Longitude (W)
54395	01/08/07	-58 18.21	-63 05.76
54398	01/08/07	-58 57.16	-62 41.74
54399	01/08/07	-59 16.97	-62 30.07
54396	01/09/07	-60 00.77	-62 02.32
54397	01/09/07	-60 59.60	-61 24.8
63121	01/16/07	-61 31.13	-60 33.70
63120	01/17/07	-61 15.2	-60 02.3
63117	01/20/07	-60 44.27	-57 1.6
63118	01/20/07	-60 16.00	-57 5.27
63119	01/26/07	-62 00.7	-55 29.29
63085	02/02/07	-61 9.9	-61 18.3
63083	02/02/07	-60 30.82	-61 43.3
63084	02/02/07	-59 58.8	-62 3.8
63082	02/02/07	-59 22.66	-62 26.5
63086	02/02/07	-58 58.2	-62 41.9

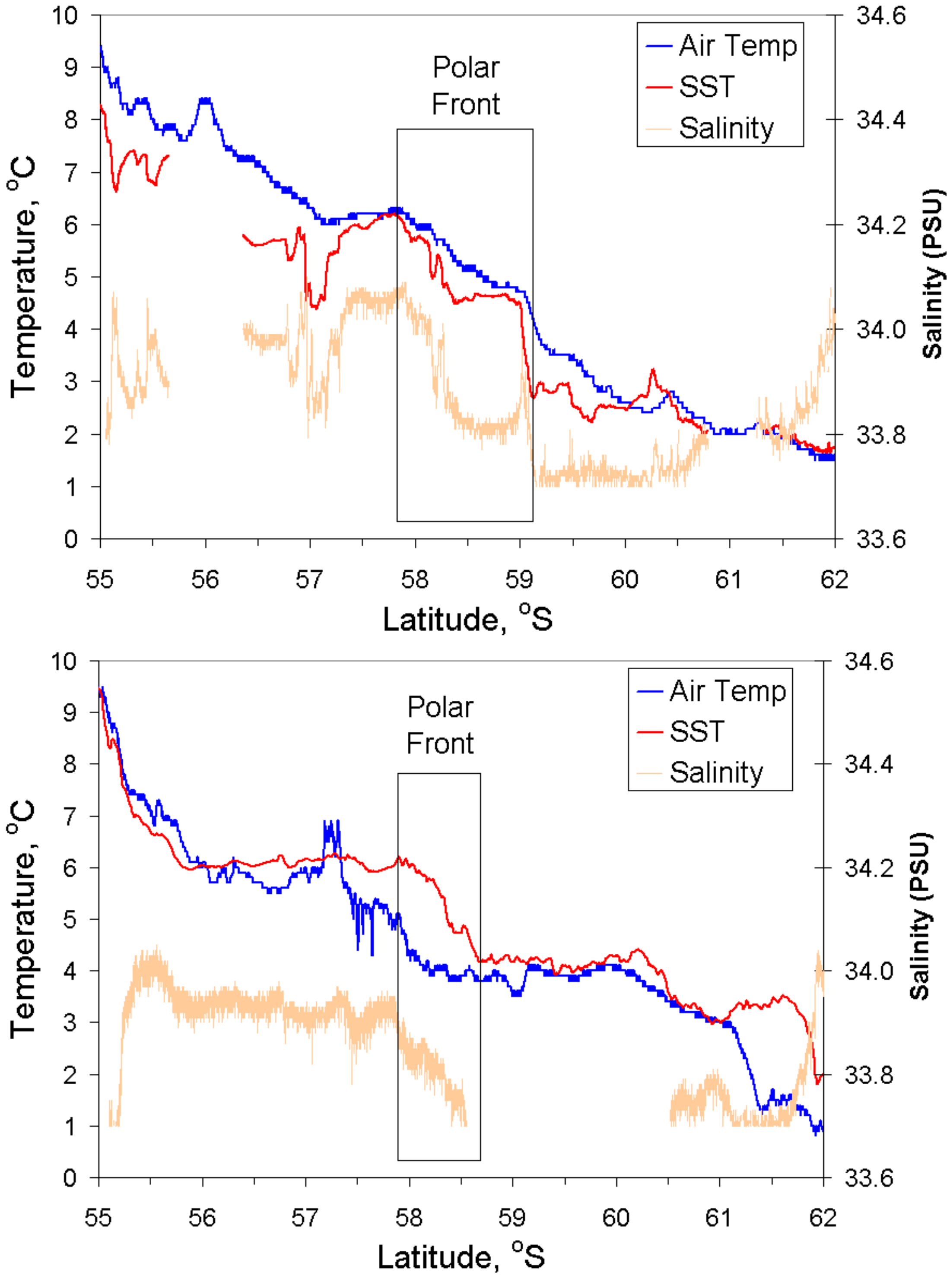


Figure 1.1 The position of the polar fronts as determined for AMLR 2006/07: North/South transect (top) and South/North transect (bottom), from measurements of air temperature, sea surface temperature and salinity for the south and north transits to and from the South Shetland Islands survey area.

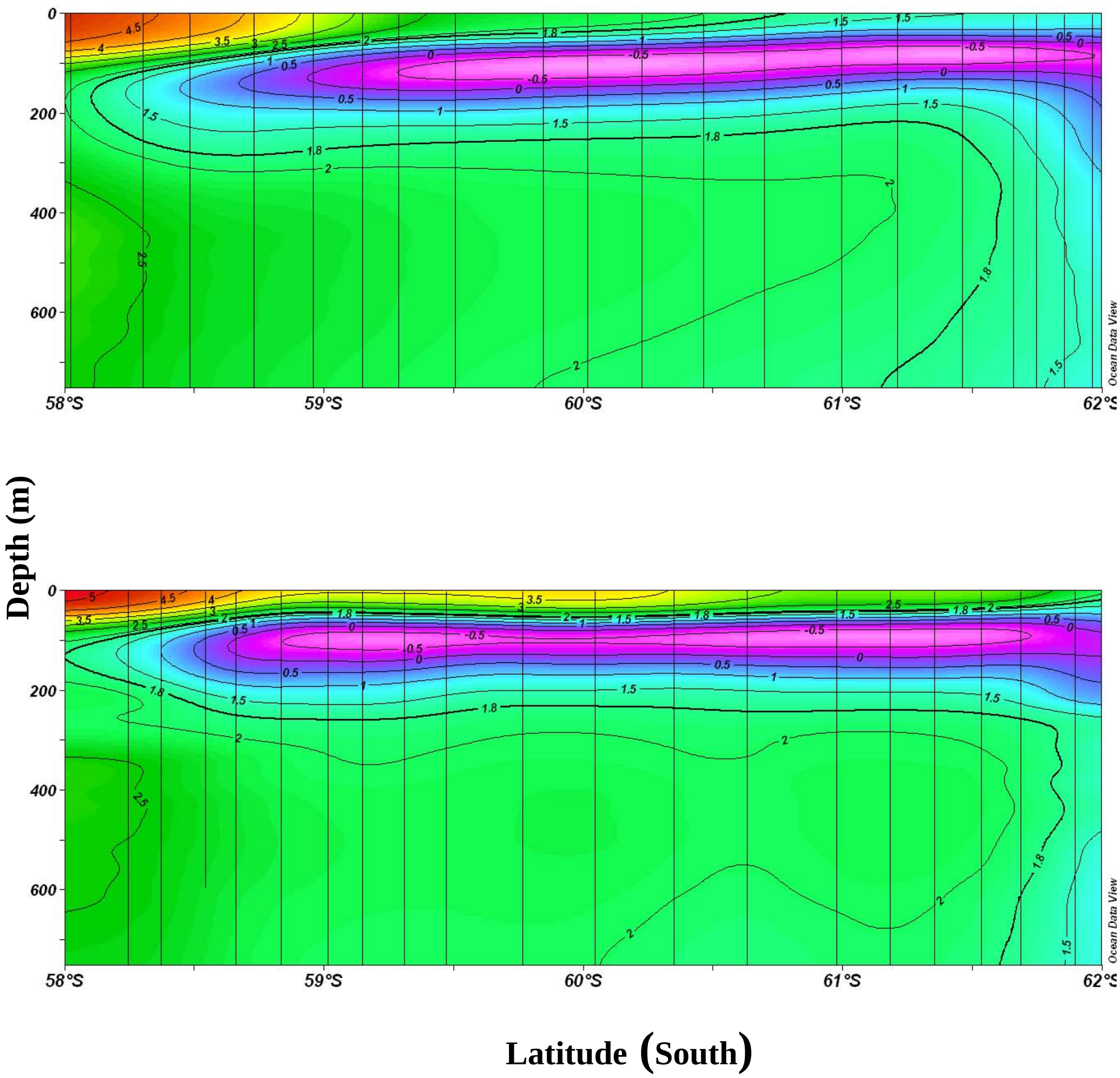


Figure 1.2 XBT (Expendable Bathythermograph) temperature data for AMLR 2006/07: North/South transect (top) and South/North transect (bottom).

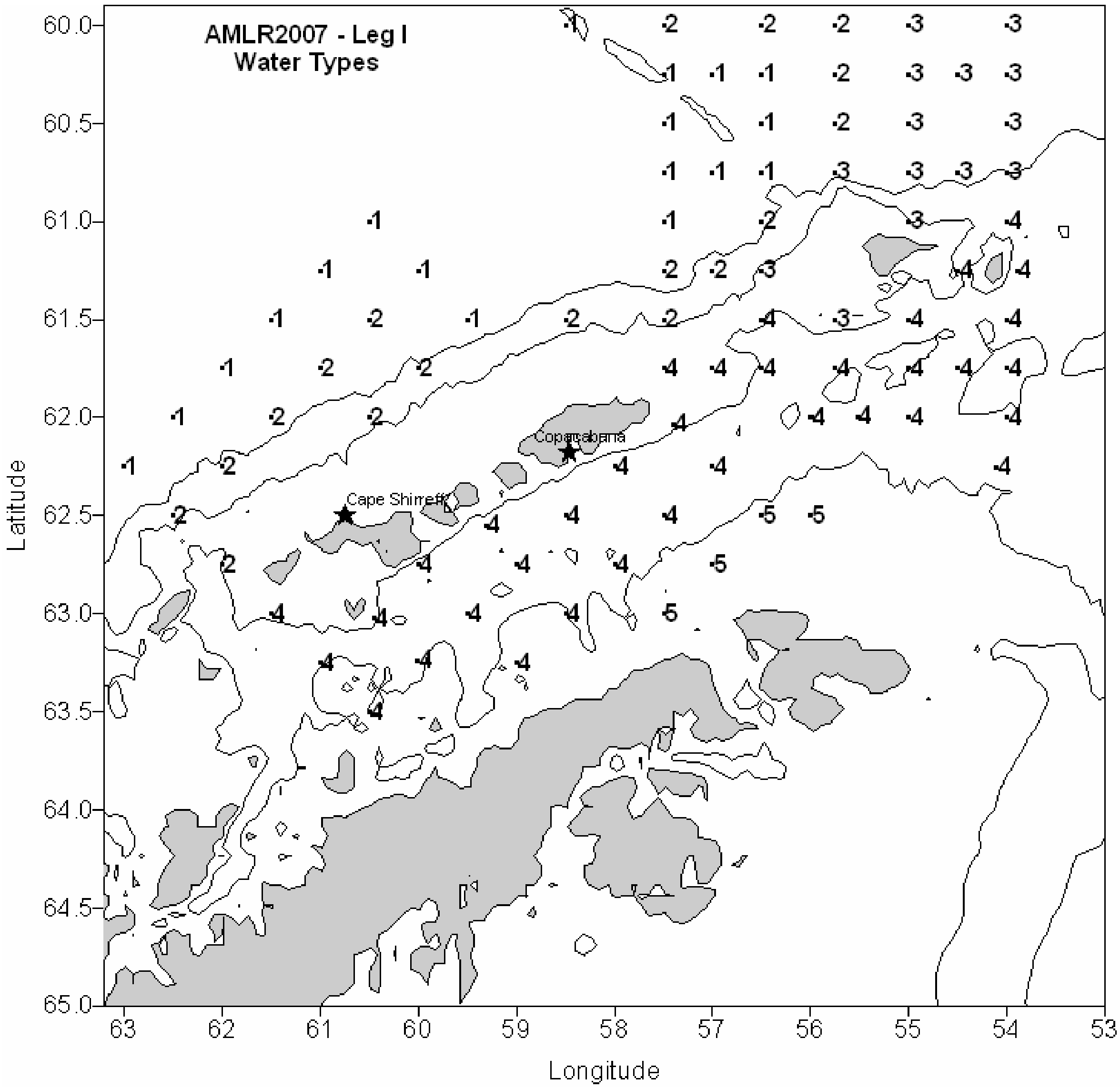


Figure 1.3 Classification of water zones for AMLR 2006/07, as defined in Table 1.1 (Water Zone definitions). Latitude is south and longitude is west.

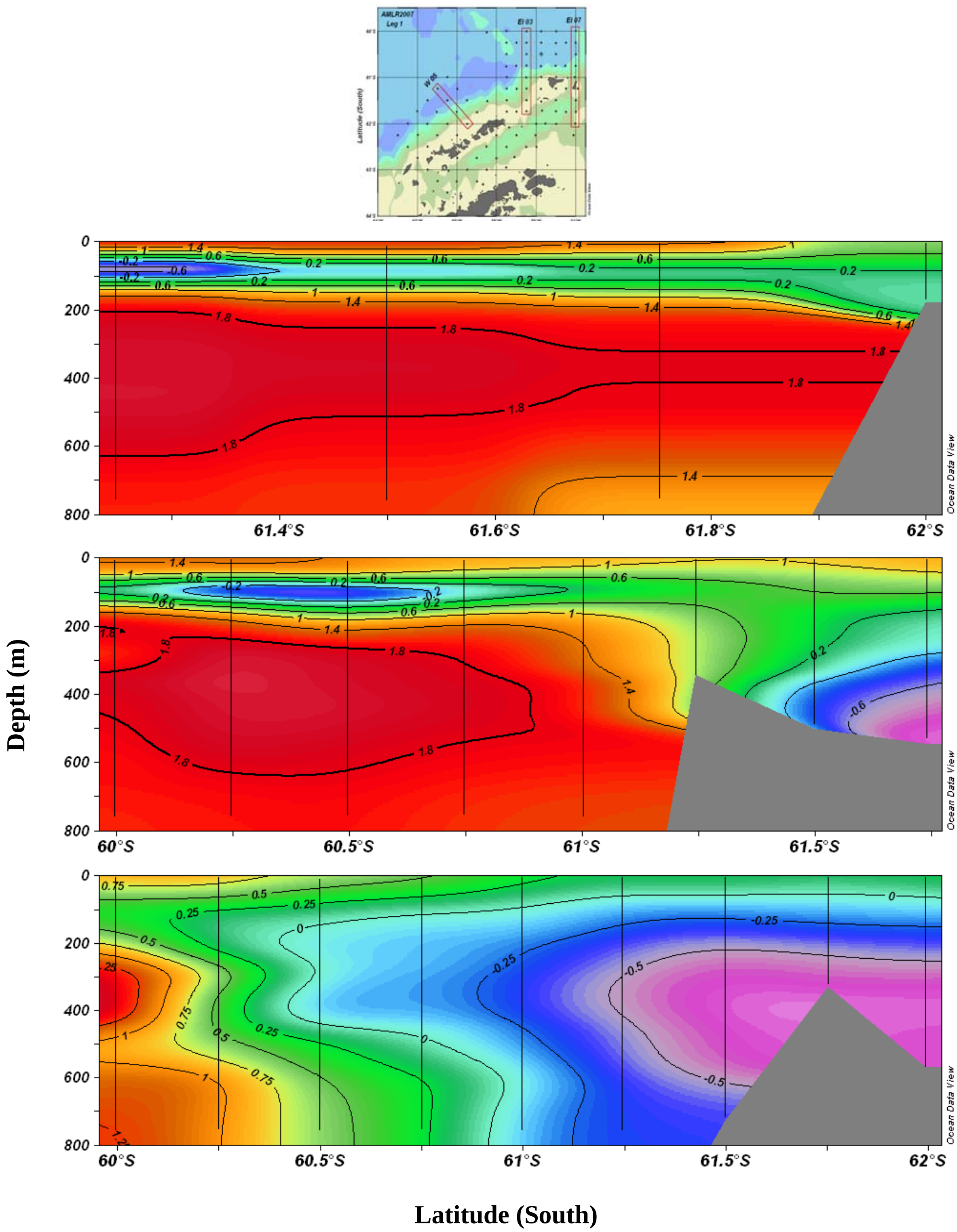
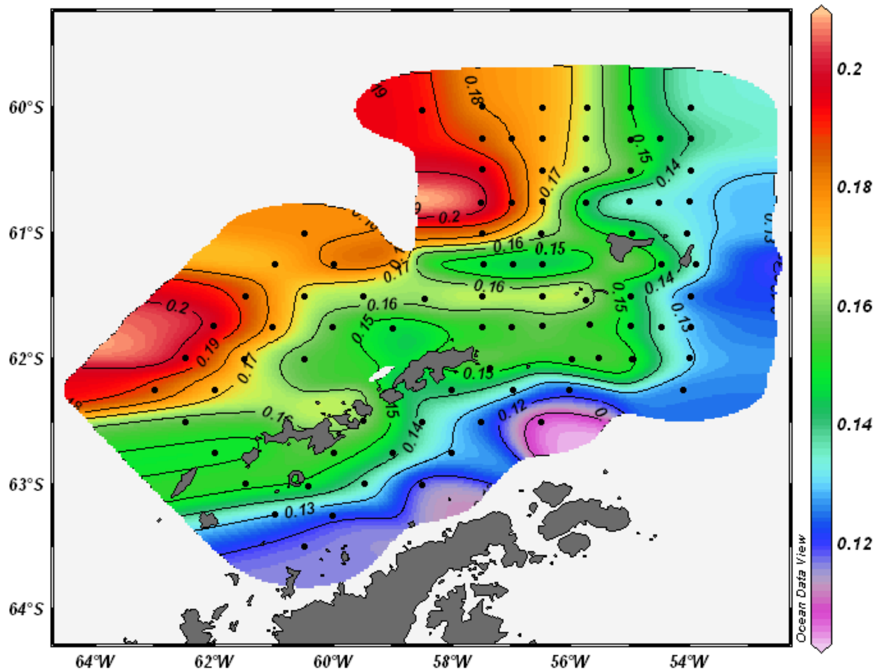
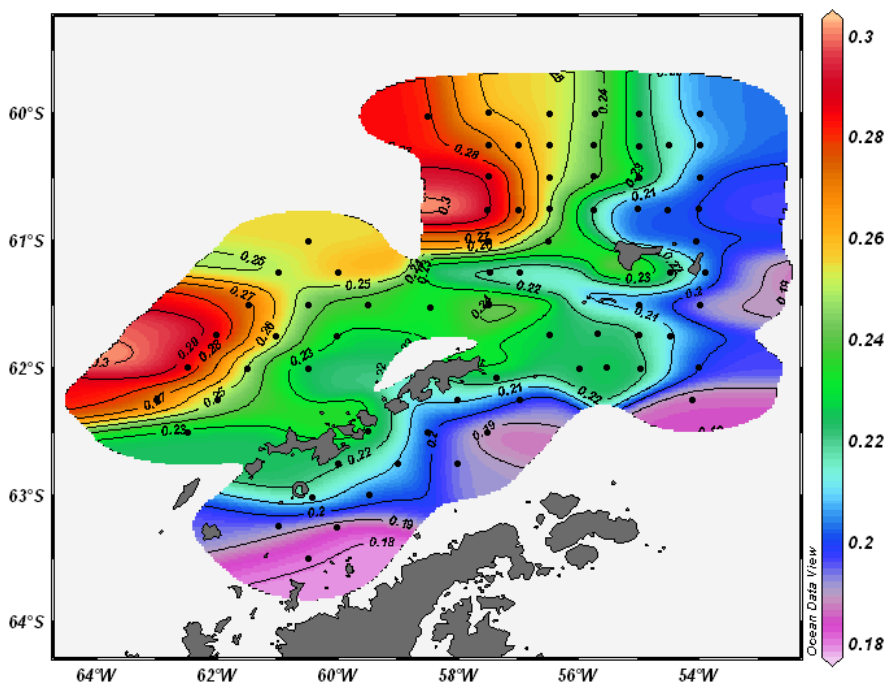


Figure 1.4 Vertical temperature profiles derived from CTD data recorded on three transects, W05 (top), EI03 (middle) and EI07 (bottom), during the AMLR 2006/07 South Shetland Island survey.



Dynamic Height – 300 (dyn m)



Dynamic Height – 500 (dyn m)

Figure 1.5 Dynamic heights for AMLR 2006/07, as determined by ODV, for the depth range between 300 and 500 meters.

AMLR 2006/07

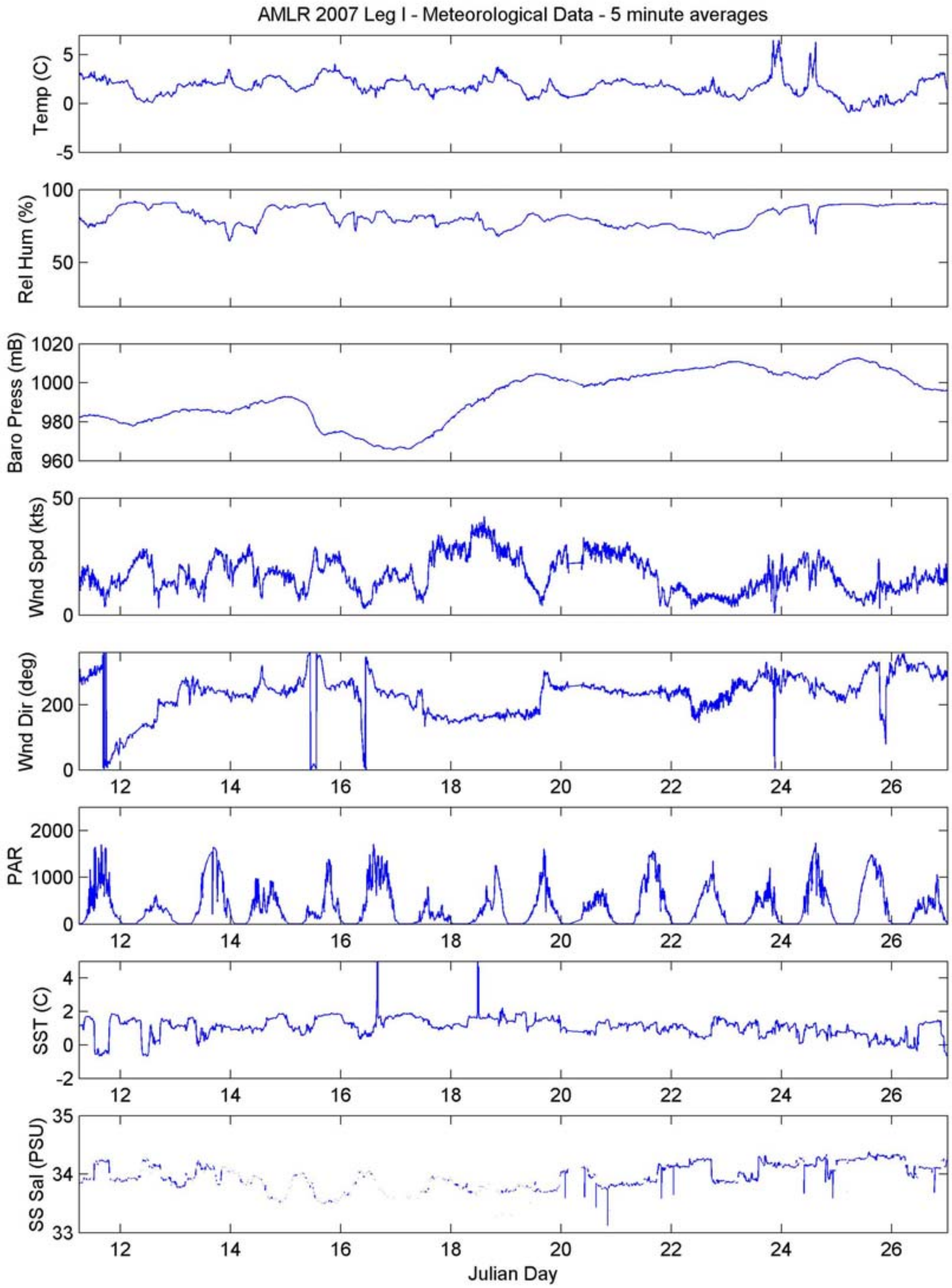


Figure 1.6 Meteorological data (5 minute averages) recorded between January 11th and January 27th during the large area survey of the AMLR 2006/07 cruise. (PAR is photo-synthetically available radiation).

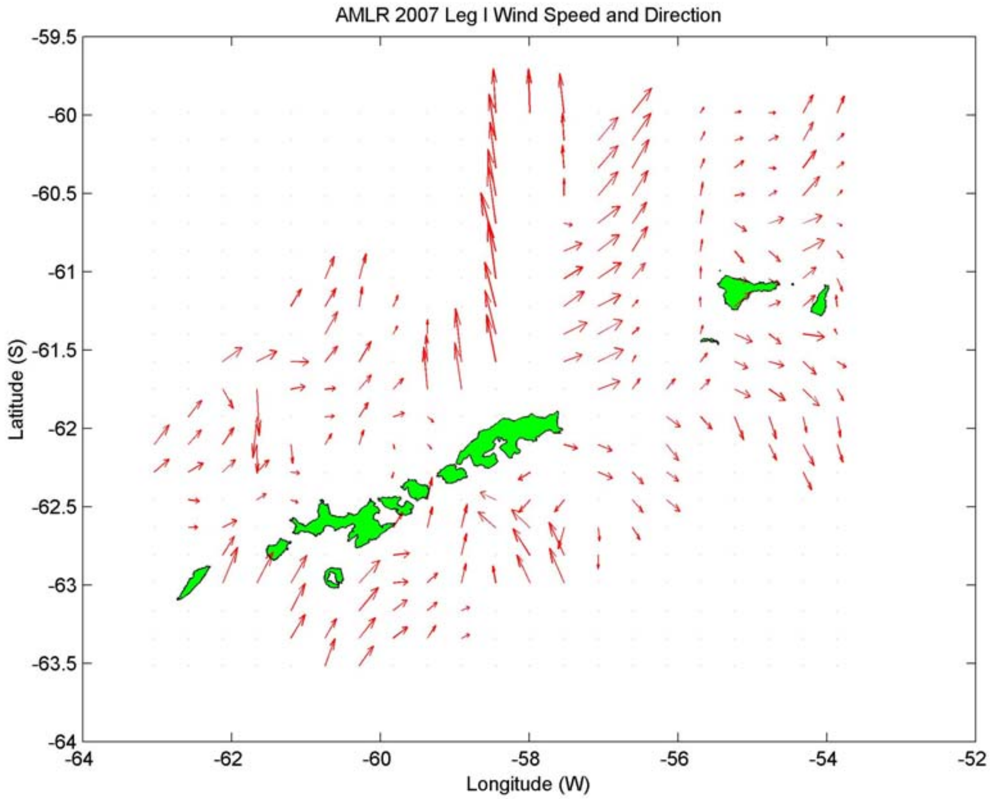


Figure 1.7 Vectors of wind speed and direction for AMLR 2006/07, derived from data recorded by the SCS logging system during the large area survey of the South Shetland Islands.

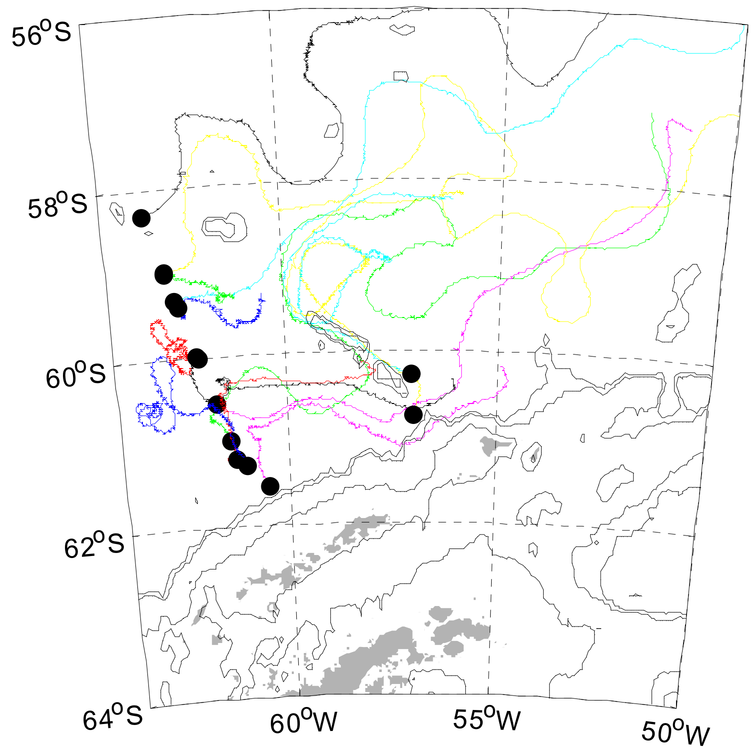


Figure 1.8 Tracks of 14 drifter buoys deployed from the R/V *Yuzhmorgeologiya*. These drifter buoys were deployed between 8 January and 2 February 2007. Black dots indicate where the drifters were released and each colored track line represents two buoys.

**2. 2. Phytoplankton Studies; submitted by Christopher D. Hewes*, Mattias Cape*, Brian Seegers*, B. Greg Mitchell, Mati Kahru, and Osmund Holm-Hansen (SIO), Murat Özturk* and Lasse Olsen* (Biological Station, Univerisity of Trondheim, Norway), Nicolas Sanchez Puerto* and José Luis Iriarte (Universidad Austral de Chile, Puerto Montt, Chile), and Nelson Silva (Escuela de Ciencias del Mar, Universidad Católica de Valparaiso, Valparaiso, Chile) ***cruise participants

2.1 Objectives: The overall objective of our research project was to assess the distribution and concentration of food reservoirs available to the herbivorous zooplankton populations throughout the AMLR study area during the austral summer. The specific objectives of our work were:

(i) To determine the taxa, distribution, biomass, and size distribution of phytoplankton in the upper water column (surface to 200m), with emphasis on the upper 100m,

(ii) To determine or estimate the rate of primary production in the water column,

(iii) To provide satellite coverage of surface chlorophyll distribution in the AMLR survey area and adjoining waters,

(iv) To explain the variability in distribution of phytoplankton in relation to dynamic physical processes, nutrient concentrations, and solar irradiance in the upper 100m of the water column.

2.2 Methods and Accomplishments: The major types of data acquired during these studies, together with an explanation of the methodology employed, are listed below.

2.2.1 Sampling Strategy: Primary water column data were obtained from a CTD carousel, which held the water sampling bottles and various profiling sensors. The carousel was lowered to 750m depth at all deep stations and within 5-7m of the bottom at the shallow stations. Profiles of the physical (salinity and temperature), optical (attenuation of solar radiation), and biological (chlorophyll-*a* fluorescence) data were recorded on the down cast. The bottles were closed on the up-cast to obtain water samples for various analyses. At the time of bottle closure, a ~1 second binned record was obtained of all data recorded by sensors on the carousel. The same sampling protocol was used during both Legs of previous AMLR surveys. Instrumentation on the CTD carousel included:

(A) Temperature, conductivity, depth, and altimeter sensors (see Physical Oceanography Chapter of this Report for details)

(B) A Chelsea profiling fluorometer for measurement of *in situ* chlorophyll-*a* (Chl-*a*) fluorescence.

(C) A Wet Labs profiling transmissometer for measurement of the attenuation of light at 660nm in the water column.

(D) Two cosine PAR (Photosynthetically Available Radiation; 400-700nm) sensors (Biospherical Instruments QCP-200L and QCP-2300) for measurement of attenuation of solar radiation in the water column.

(E) Ten 8-liter General Oceanics Niskin bottles. Water samples at every station were obtained at 5, 10, 15, 20, 30, 40, 50, 75, 100, and 200m (or 5-7m above the bottom) target depths, and used for the analyses described below in Section 2.2.2.

2.2.1.1 Trace Metal Clean Sampling Strategy: The phytoplankton component of AMLR this year included personnel from the Biological Station in Norway who were measuring trace elements (focusing on dissolved and particulate iron {Fe}). Samples were collected at 17 stations from different depths for iron and other trace metal determination of both dissolved and total acid leachable states. Seawater samples were taken with pre-cleaned GoFlo –Teflon covered samplers (5L) mounted on 4mm Ste-Line and triggered with a Teflon coated messenger at predetermined target depths. Immediately upon recovery, the GoFlo sampler was wrapped in clean plastic bags and transferred into a HEPA-filtered forced air and plastic-lined laboratory featuring an Air Clean laminar flow hood (class 100).

2.2.1.2 Incubations Under Trace Metal Clean Sampling Strategy: The roles of light and Fe on the growth rate and biomass of phytoplankton assemblages in Antarctic Winter Water remnant of Zone IA waters were examined using incubation experiments. Water was collected at Station A09-04 from 110, 115, and 120m. A deep chlorophyll maximum (DCM) was observed at 120m. Replicate water samples from each depth were combined and mixed in a 25L acid-washed polyethylene (PE) container and dispensed into 2.0L PE bags (Nalgene) for incubation on a shade-free region of the mid-ship upper deck. The 2.0L bags were additionally sealed with two more bags to further reduce possibility of contamination. Iron was added as FeSO4 solution (pH 2) to make a final concentration of 2.5nM added Fe for the experimental group. Two different natural light intensities were used in the experiment. Neutral density plastic screening was used to attenuate incident solar radiation to (1) 38-45%, and (2) 3-5% ambient PAR. Flowing seawater was used to keep the incubation temperature close to the ambient level. Chl-*a* was measured every other day with samples obtained under trace metal clean conditions.

2.2.1.3 Bio-optics Sampling Strategy: Once a day, two specialized optical profiling units were deployed at a station close to Local Apparent Noon. These two units were (1) a free-fall profiling spectral radiometer (PRR-800, Biospherical Instruments, Inc.) to determine the spectral composition of the underwater light field and (2) a profiler to record (i) chlorophyll-*a* fluorescence (Wetlabs Inc.), (ii) spectral beam transmission (Wetlabs), (iii) backscattering of light (Hydroscat, HobiLabs), and (v) variable fluorescence (Fasttracka, Chelsea Instr.). Incident spectral irradiance (Ed, PAR) was also recorded continuously with a Biospherical QSR-240 quantum irradiance meter whenever the two profiling units were being deployed.

2.2.2 Measurements and Data Acquired: The types of measurements and the data acquired during and in conjunction with the 2007 survey were:

(A) <u>Chlorophyll-*a* concentrations</u>: Chl-*a* concentrations of water samples were determined by measurement of Chl-*a* fluorescence after extraction in an organic solvent. Sample volumes of 100mL (for routine measurements) were filtered through glass fiber filters (Whatman GF/F, 25mm) at reduced pressure (maximal differential pressure of $1/3^{rd}$ atmosphere). For size-fractions of chl-*a* containing particles, water was first gravity-filtered through polycarbonate membrane filters (2, 5, 10, and 20µm) prior to being filtered for chl-*a*. The filters with the particulate material were placed in 10mL of absolute methanol in 15mL tubes and the photosynthetic pigments allowed to extract at 4 °C for at least 12 hours. The samples were then shaken, centrifuged, and the clear supernatant poured into cuvettes (13 x 100mm) for measurement of Chl-*a* fluorescence before and after the addition of two drops of 1.0 N HCl (Holm-Hansen *et al*., 1965; Holm-Hansen and Riemann, 1978). Fluorescence was measured using a Turner Designs Fluorometer (model TD-700) that had been calibrated using purified Chl-*a* concentrations (Sigma C-6144).

(B) Continuous profiles of Chl-*a* and PAR: Profiles of Chl-*a* obtained with the *in situ* fluorometer are used in two applications: (i) to analyze Chl-*a* concentrations in relation to physical, chemical, and optical conditions in the water column, and (ii) when combined with the profile of solar irradiance, one can estimate the rate of primary production in the water column.

(C) Beam attenuation: The attenuation of light as recorded by the transmissometer is the result of both scattering and absorption of light quanta. As the light in the transmissometer that was used is 660nm (within the red absorption band for Chl-*a*), the attenuation is a good indicator of both Chl-*a* concentrations and total particulate organic carbon (Villafañe *et al*., 1993). Data from the transmissometer is particularly useful in estimating Chl-*a* concentrations in the upper 10-15m of the water column when Chl-*a* fluorescence is severely inhibited by high solar irradiance (Holm-Hansen *et al*., 2000).

(D) Phytoplankton taxonomy: At 10 stations, seawater samples (100mL) were obtained from the surface and 3-4 additional depths, and then preserved with 0.5% (final dilution) buffered formalin. These samples were delivered to J.L. Iriarte (Universidad Austral de Chile, Puerto Montt, Chile) for taxonomic analysis of phytoplankton species.

(E) Incident light intensity: A Biospherical Instruments scalar PAR sensor (BSI model QSR-2100) and a LI-COR cosine PAR sensor (LI-COR model LI-190) were used to measure incident light continuously over a 24-hour period.

(F) Primary production: Space and time constraints did not permit measurement of rates of primary production as routinely done on our previous cruises (Helbling *et al*., 1995; Holm-Hansen and Hewes, 2004). However, primary production rates will be estimated by the use of algorithms (Hewes, *in prep*.) using data on Chl-*a* concentrations, solar irradiance in the water column, and photosynthesis-irradiance responses of Antarctic phytoplankton.

(G) Inorganic macronutrient concentrations: Water samples from 52 stations were taken for measurement of macronutrient concentrations at 10, 30, 50, 75, 100, and 200m target depths, with an additional 41 stations sampled at 30m. Water samples were poured into acid washed 120mL polypropylene bottles and immediately frozen. These frozen seawater samples were delivered to N. Silva (Universidad Católica de Valparaiso, Valparaiso, Chile) and analyzed by auto-analyzer for nitrate, phosphate, and silicate concentrations (Atlas, 1971).

(H) Water column trace metal concentrations (Biological Station): To obtain uncontaminated water samples for trace metal analysis, an alternate winch was used which was spooled with polyester line. Teflon-coated 10-liter General Oceanic GoFlo bottles (usually 3) were closed at desired depths of < 100m with Teflon-coated brass messengers. The GoFlo bottles were taken to a plastic covered clean lab, where seawater samples were transferred from the GoFlo bottles to acid-cleaned polyethylene bottles with a peristaltic pump in a class-100 laminar flow hood equipped with a HEPA-blower. These water samples were used for the following measurements: (i) Total and acid leachable iron (and other trace metals) will be determined by ICP-MS after pre-concentration; (ii) Total and dissolved iron will be measured on aliquots of the same samples by FIA-Chemoluminesence; (iii) Aliquots of the water samples were frozen and will be analyzed for organic ligand and labile iron by competitive ligand exchange-cathodic striping voltametry

(CLE-CSV). Details of the method used can be found in the work by Öztürk (1995) and Öztürk *et al*. (2002).

(I) Photosynthetic pigments (SIO): Water samples for pigment determination were filtered through glass fiber filters (GF/F), frozen in liquid N_2, and returned to SIO for analysis with high pressure liquid chromatography (HPLC) techniques using established methods (Wright *et al*., 1991; Goericke and Repeta, 1993; Trees *et al*., 2000).

(J) Short-term photosynthesis-irradiance (P vs. E) response (SIO): Natural populations were incubated with ^{14}C sodium bicarbonate in vials for 1-2 hours in a light gradient ranging from 0-2000 µEinst m^{-2} sec^{-1} using a photosynthetron (Lewis and Smith, 1983). Photosynthetic efficiency, functional absorption cross-section, and turnover time of photosystem-II on these samples were assessed using fast repetition rate fluorometry (Kolber and Falkowski, 1998).

(K) Particle and soluble absorption (SIO): Absorption spectra from 300 to 800nm of total particulate matter (concentrated on a Whatman GF/F filter) and dissolved substances were measured using a double beam Cary 1E spectrophotometer (Mitchell and Kiefer, 1984; Mitchell, 1990). Measurement of the filter pad after methanol extraction provided an estimate of detritus absorption (Kishino *et al*., 1985; Sosik and Mitchell, 1995).

(L) Particulate organic carbon and nitrogen (POC/PON; SIO): Water samples were filtered through pre-combusted glass fiber filters (Whatman GF/F, 25 mm), dried, and returned to SIO for analysis of POC and PON by gas chromatographic techniques.

2.3 Results and Preliminary Conclusions:

2.3.1 Phytoplankton Distribution in the AMLR Survey Area: Stations with the lowest Chl-*a* concentrations at 5m depth (<0.5 mg m^{-3}) were found in the northern portions of the sampling grid (pelagic Drake Passage waters) and in the eastern and southern regions where the water is mainly of Weddell Sea origin (Figure 2.1). The highest Chl-*a* concentrations (> 1.5 mg m^{-3}) were found over or close to the continental shelf regions of the South Shetland Islands and Elephant Island. Stations with intermediate concentrations of Chl-*a* (~1.0 mg m^{-3}) were generally located close to the continental shelf break east of Elephant Island and in the southwestern and central Bransfield Strait.

2.3.2 Mean Chlorophyll-*a* Concentrations in the Four AMLR Areas: As mentioned above (in the Description of Operations of this Report), the AMLR survey area is divided into four separate regions (Figure 2 of the Introduction Section). The mean Chl-*a* concentrations at 5m, and integrated to 100m, through depth of the euphotic zone, and through depth of the upper mixed layer in these four areas, together with the long-term mean from previous AMLR seasons (1990-2006), are summarized in Table 2.1. Data in the table show that the mean Chl-*a* concentrations in the Elephant Island (EI), West (WA), South (SA), and Joinville Island (JI) Areas at 5m during 2007 were about the same as the historical means. In the Elephant Island Area, the Upper Mixed Layer (UML) was slightly deeper than normal, thus resulting with slightly higher than normal Chl-*a* concentrations within the upper mixed layer (phytoplankton are generally mixed uniformly throughout the UML). In the Joinville Island Area, the UML was slightly shallower than normal yielding a slightly higher CHL_{UML} as compared to the historical mean.

2.3.3 Water Column Profiles in Relation to Water Zones: Previously, much of the biological variability within the AMLR survey area has been described in relation to the different water zones (WZ) which can be distinguished by physical, biological, and chemical characteristics (Holm-Hansen *et al*., 1997; Holm-Hansen and Hewes, 2004). Representative data for the different water zones are shown in the following sections.

2.3.3.1 Chl-*a* and Water Density: Figure 2.2 shows profiles of Chl-*a* concentrations and water density for the five water zones during 2007 and the mean profiles from the 17-year data record of AMLR cruises, in addition to the corresponding T/S diagrams for the two data sets. The data show (i) that Chl-*a* concentrations in 2007 were much higher for Zone III waters and lower for Zone II waters than the historical means; (ii) the most significant changes in Chl-*a* profiles for 2007 were found in Zone I waters, where the typical deep Chl-*a* maximum (DCM) layer was lower than on average.

2.3.3.2 Profiles of Chl-*a*, *in situ* Chl-*a* Fluorescence, Beam Attenuation, & Solar Irradiance: Representative data from each water zone under high (top) and low (bottom) irradiance levels are shown in Figure 2.3. The Chelsea fluorometer output has been converted to equivalent Chl-*a* concentration (Chl_{fluor}, mg m^{-3}) by exponential regression of all bottle data (fluorometer voltage has log output). The profiles of Chl-*a* fluorescence and beam attenuation tend to track each other (transmissometer voltage is high-to-low), except when high incident solar radiation causes an inhibition of Chl-*a* fluorescence. However, it is also apparent that Chl-*a* fluorescence yield was influenced by a factor in addition to that of light intensity, since variability in the profiles seems to decrease from Zone I to Zone V waters.

2.3.4 Inorganic Nutrient Concentrations: These data were received from Dr. Silva in late May 2007, and hence we have not had time to summarize the nutrient data for this Report.

2.3.5 Iron Incubation: Differences in Chl-*a* concentration between control and Fe-additions only became significant by day 7-8, with growth beginning after ~day 3 (Figure 2.4). For the high light control (no Fe added), Chl-*a* reached ~1.5 mg m-3, and for the low light, it reached 0.81 mg m^{-3} (Figure 2.4A). There was at minimum ~3- times increase in biomass in the controls (without Fe addition), which raises the question as to whether or not Fe controls biomass *in situ*. Water samples for these incubations were taken below the pycnocline and within range of the DCM which is hypothesized to be co-limited by both light and Fe (Holm-Hansen and Hewes, 2004). The results of this incubation experiment demonstrated that trace-metal clean technique is possible aboard ship, since sub-sampling to obtain Chl-*a* samples required each of the control incubation bags to be opened and sealed 6-times without contamination.

2.3.6 Photosynthesis versus Irradiance (PE): Assimilation numbers (AN) [mg C (mg Chl-*a*)$^{-1}$ hr^{-1}] showed that maximal photosynthetic rates were achieved at 100-400 µEin m^{-2} s^{-1} (Figure 2.5). This range is slightly higher than ~100 µEin m^{-2} s^{-1} obtained by on-deck incubations (Holm-Hansen and Hewes, 2004), possibly because a photosynthetron was used that permitted relatively short (~1 hr) incubations to be made. However, the AN were also about 50% lower than typically found for phytoplankton in the AMLR survey grid. No difference was found between AN for samples taken in Zone IA (filled symbols) waters and those from all other waters (open symbols) (Figure 2.5).

2.3.7 Examination of Variability for *in-situ* Fluorescence Yield: It has been previously established that in the AMLR survey area, photoinhibition of *in vivo* fluorescence occurs when ambient irradiance is >20 µEin m^{-2} s^{-1} (Holm-Hansen *et al*., 2000). In Figure 2.6A, comparison is made between extracted Chl-*a* concentration and sensor voltage for all bottle data obtained in the UML. It is evident that photoinhibition of fluorescence produces a significant decrease in fluorescence yield per unit Chl-*a* (upper regression line) compared to that from samples having <20 μEin m^{-2} s^{-1} ambient light (lower regression line). However, photoinhibition of fluorescence does not account for all of the variability observed between fluorescence and Chl-*a*. Within the AMLR survey area, Zone I waters have low Chl-*a* concentrations, probably the result of low Fe-concentrations (Holm-Hansen and Hewes, 2004; Holm-Hansen *et al*., 2005). Zone I surface waters tend to be the least saline (Figure 2.6B). Therefore, when fluorescence yield [log (CHL_{fluor})/log (Chl-*a*] is plotted against salinity (Figure 2.6C), it is shown that the fluorescence yield increases linearly with decrease in salinity and is the greatest source in the variability of fluorescence yield. This means that for Zone I waters, fluorescence yield is ~20% higher than in the other water zones, and this variability must be accounted for in equations that estimate Chl-*a* from voltage output. We speculate that the reason for the linear increase in fluorescence yield with decreasing salinity below 34 psu is a response to Fe-stress. Fe is a critical element in photosynthetic electron transfer processes (Clayton, 1971). Our Chelsea fluorometer has a Xenon flash that outputs continuous pulses of constant high intensity blue light. Fluorescence results when phytoplankton are exposed to these flashes and the photochemical apparatus dissipates some of the unused energy by emission of light quanta with longer wavelengths. With increased Fe-stress, phytoplankton might un-couple their photosynthetic pathways (to produce more fluorescence) as a result of decreased efficiency in the electron transfer processes.

2.4 General Conclusions from the AMLR 2007 Field Season: Our data indicate that this season was close to normal based on our 17 previous years. The most unusual feature was the either very deep (>100m) or absence of the DCM in Zone IA waters. This might have been a result of the violent storm activity (water sampling was halted for ~40 hours) that directly preceded our survey of the Elephant Island Area, and is where a majority of the Zone IA stations lie in the survey area. Zone I waters are Fe-stressed, and one suspected result is that *in situ* fluorescence yield is enhanced, which will lead to over-estimated Chl-*a* concentrations by the Chelsea fluorometer unless accounted for in the algorithms.

2.5 Other: Samples for phytoplankton taxonomy, dissolved and particulate trace metals, particulate carbon and nitrogen, and pigment concentrations are in the process of being analyzed at the time of this report. PE data need to be re-examined in detail to understand the reason such low ANs were obtained.

2.6 Disposition of the Data: All chlorophyll and CTD-interfaced sensor data obtained during these cruises have been archived with AERD, Southwest Fisheries Science Center. Other data from the cruise will be delivered to AERD when available.

2.7 Problems and Suggestions: Our new BSI PAR sensors do not seem to hold correct calibration factors for some unknown reason, which happens only onboard ship. Further testing against our other PAR sensors will occur during the next AMLR cruise. Additionally, a reliable software program should be developed that can process CTD bottle data. Currently, this merging of files and organization of data is a tedious method by hand. Further, a consistent convention for the naming of additional stations needs to be instigated. Lastly, galley proofs of field season reports need to be sent to the team leaders before final printings to check the quality of the figures. The 2005/2006 Field Season Report had serious reproduction errors (pictures not printed, text in figures corrupted, etc.) that need to be eliminated for the current and future issues.

2.8 Acknowledgements: We want to express our gratitude and appreciation to the entire complement of the R/V *Yuzhmorgeologiya* for their generous and valuable help during the entire cruise. They not only aided immeasurably in our ability to obtain the desired oceanographic data, but they also made the cruise most enjoyable and rewarding in many ways. We also thank all other AMLR personnel for help and support which was essential to the success of our program. This report has been funded in part to O. Holm-Hansen from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, under grant NA17RJ1231. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA, NSF or any of their sub-agencies.

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Table 2.1 Comparison of Chl-*a* concentrations for the different areas in the AMLR survey area for the 2007 field season with historical (1990-2006) data, showing depth of the upper mixed layer (UML, m), concentrations of chl-*a* at the surface (CHL_{5m}, mg m^{-3}) and integrated through 100m (CHL_{100m}, mg m^{-2}), through depth of the euphotic zone (CHL_{Zeu}), and through depth of the UML (CHL_{UML}).

Area	2007					
	No. of Stations	UML, m	CHL_{5m}, mg m^{-2}	Int CHL_{100m}, mg m^{-2}	$IntCHL_{ZEU}$, mg m^{-2}	Int CHL_{UML}, mg m^{-2}
EI	49	62 ± 32	0.9 ± 0.6	70 ± 36	37 ± 17	51 ± 35
JI	7	52 ± 18	0.9 ± 0.2	67 ± 19	36 ± 7	42 ± 12
SA	20	47 ± 44	1.1 ± 0.4	61 ± 10	39 ± 8	39 ± 19
WA	21	56 ± 18	1.0 ± 0.8	58 ± 47	34 ± 25	51 ± 43

Area	1990-2006					
	No. of Stations	UML, m	CHL_{5m}, mg m^{-2}	Int CHL_{100m}, mg m^{-2}	$IntCHL_{ZEU}$, mg m^{-2}	Int CHL_{UML}, mg m^{-2}
EI	1709	49 ± 27	0.9 ± 1.0	58 ± 51	33 ± 23	37 ± 42
JI	65	73 ± 52	0.8 ± 0.6	51 ± 27	30 ± 14	38 ± 24
SA	324	43 ± 29	1.5 ± 1.3	78 ± 73	43 ± 25	51 ± 59
WA	509	44 ± 20	0.8 ± 0.9	49 ± 38	30 ± 20	29 ± 30

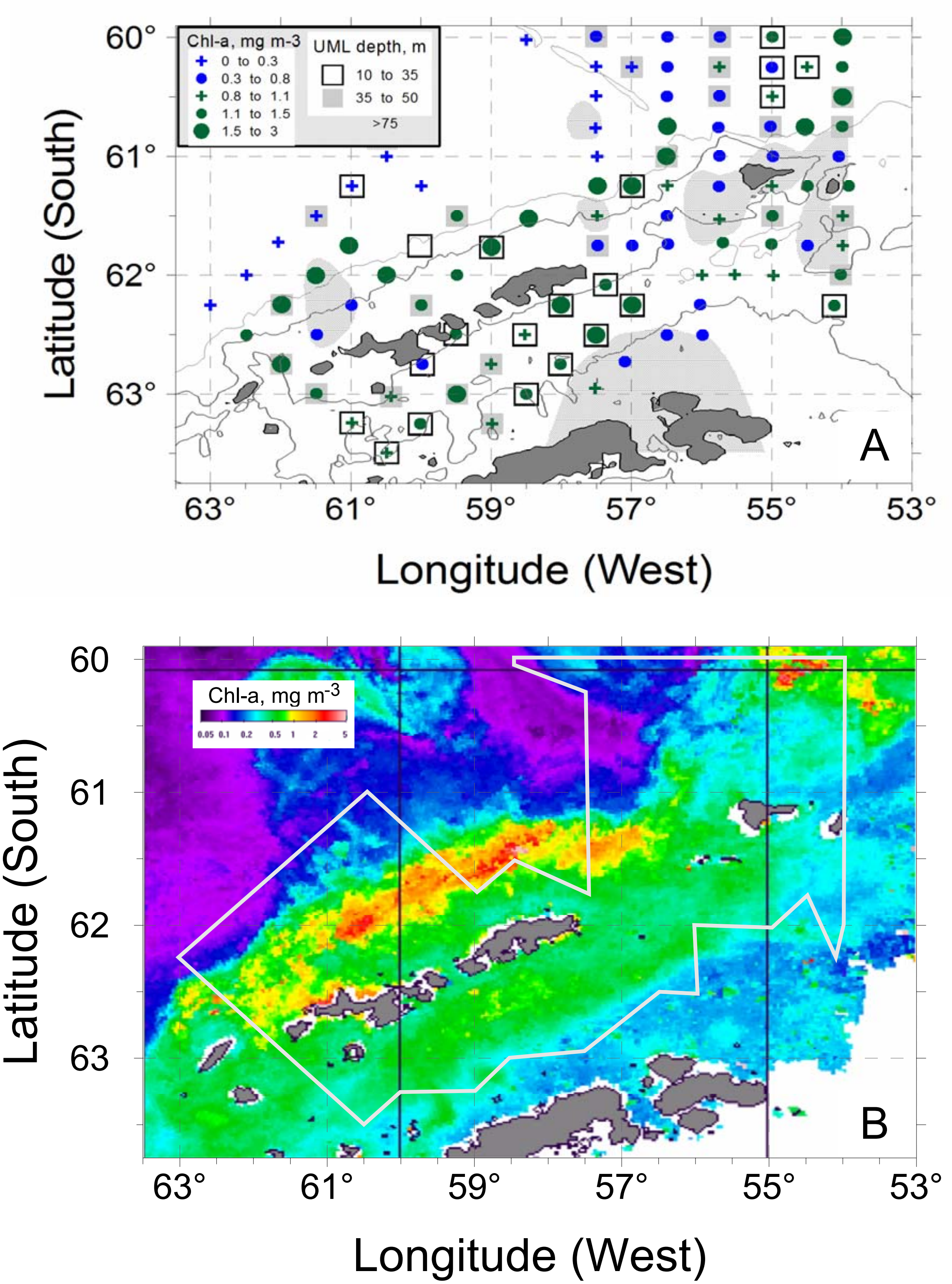


Figure 2.1 Chlorophyll-*a* concentrations in the AMLR sampling area. A) Chl-*a* concentrations at 5m depth and depth of the upper mixed layer as determined on board ship (see inset for ranges); B) mean surface chl-*a* concentration during January (2007) as estimated from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS; McClain *et al*., 1998).

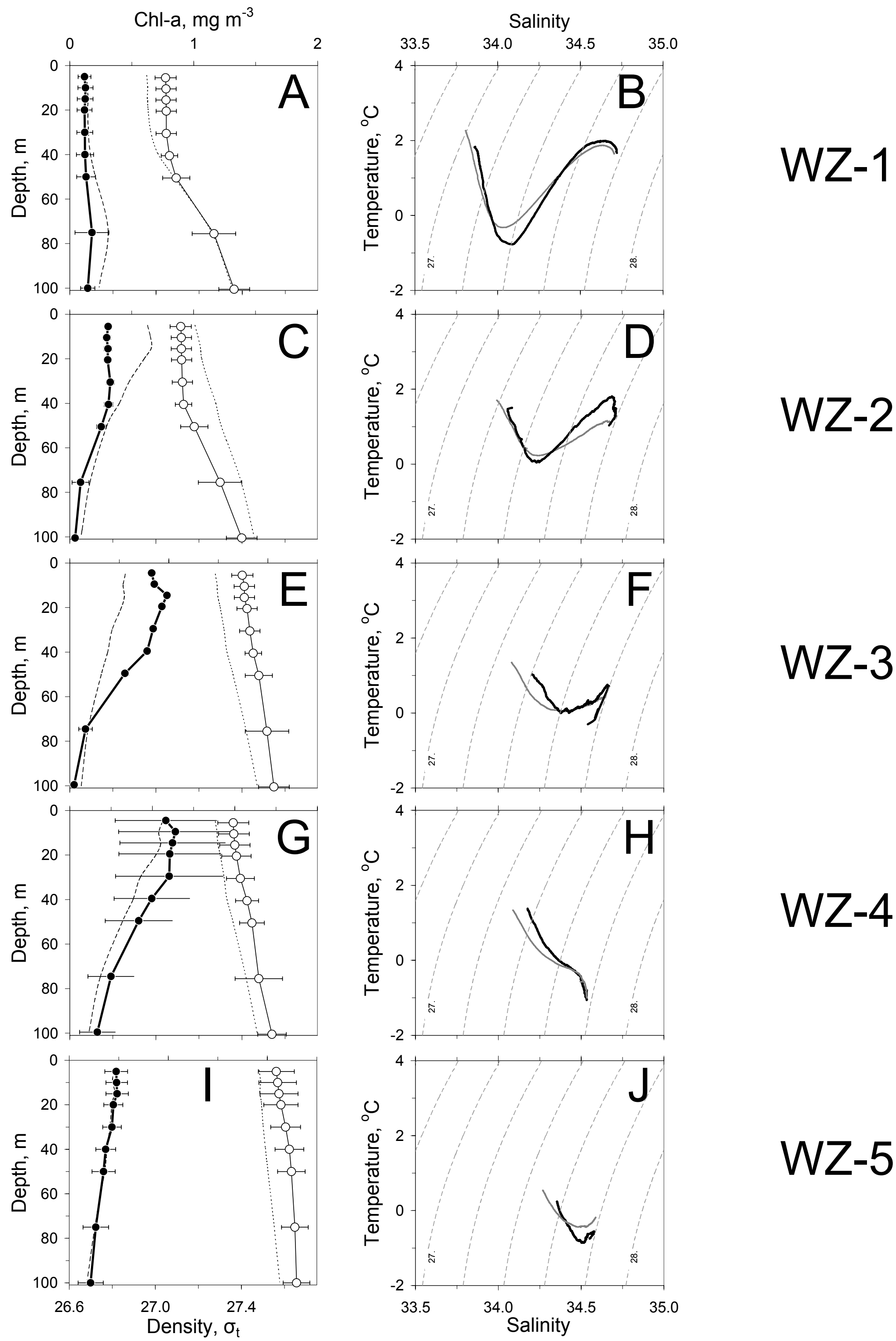


Figure 2.2 Mean profiles of mean Chl-*a* concentrations (filled circles) and density (open circles) with depth (left side) and temperature verses salinity diagrams (right side) in the five water zones during 2007. The horizontal bars show standard deviations at each sampling depth. For comparison with 2007 data, the mean Chl-*a* (dashed line) and density (stippled line) profiles, and mean T/S diagram (light line) of historical (1990-2006) AMLR data are also shown.

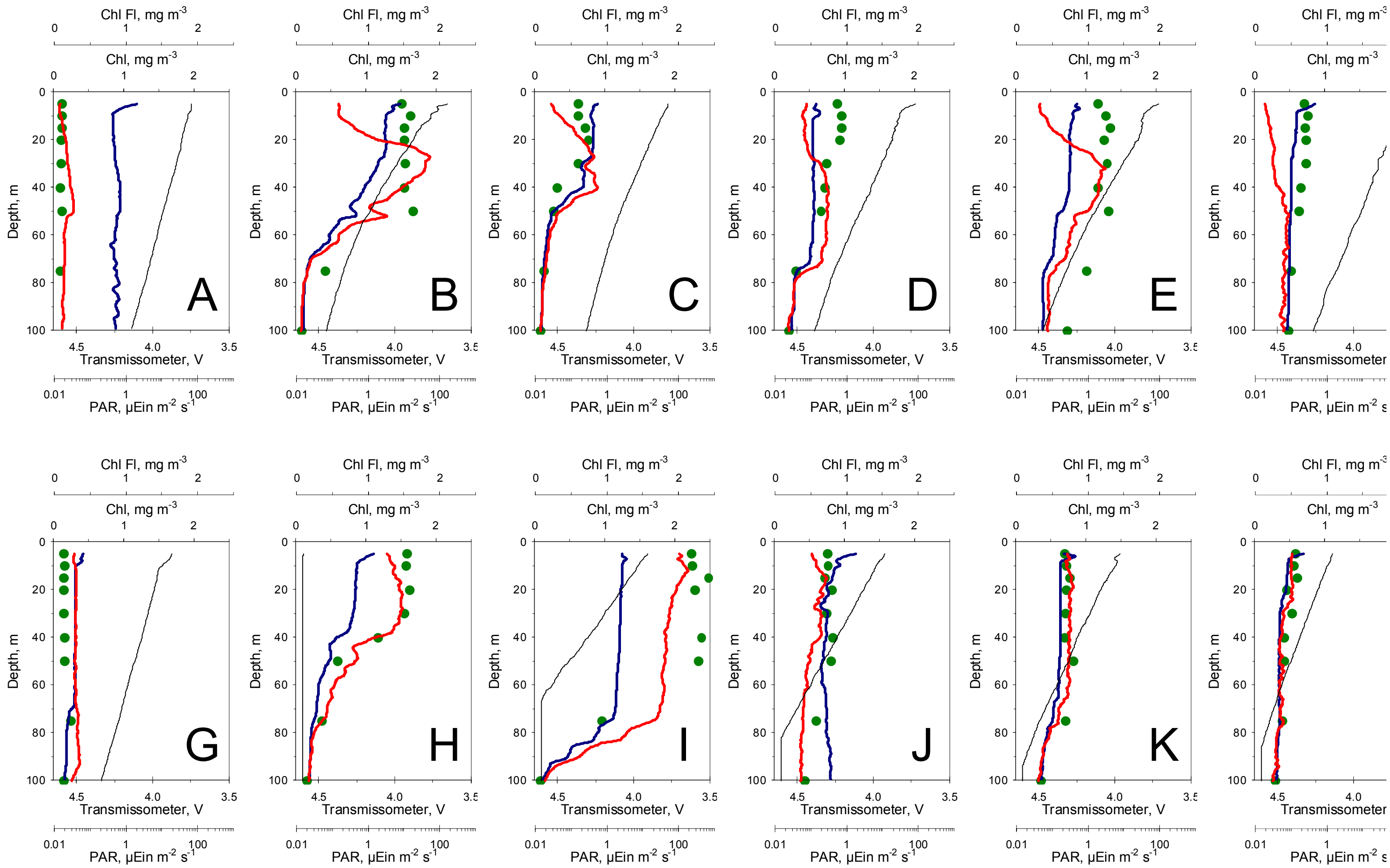
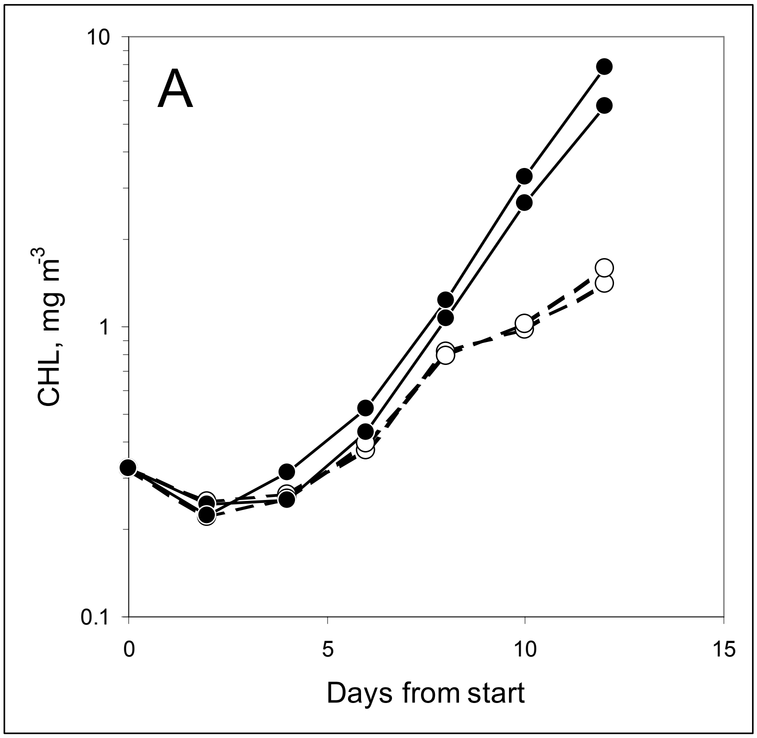


Figure 2.3 Representative profiles of Chl-*a* (green filled circles), in situ Chl-*a* fluorescence (red line), attenuation of light at 660nm as indicated by voltage recorded by the *in situ* transmissometer (blue line), and solar irradiance (PAR) in the upper water column (black line). The top row of plots (A-F) are of daytime stations with high incident light, and the bottom line of plots (G-L) are of daytime stations with low incident light. Notes: (i) The voltage from the *in situ* fluorometer has been converted to mg Chl-*a* per cubic meter using an algorithm based on extracted Chl-*a* samples; (ii) the lowest reliable value from the *in situ* light meter is ~0.15 µEin m^{-2} s^{-1}, below which the signal is shown as a vertical line.



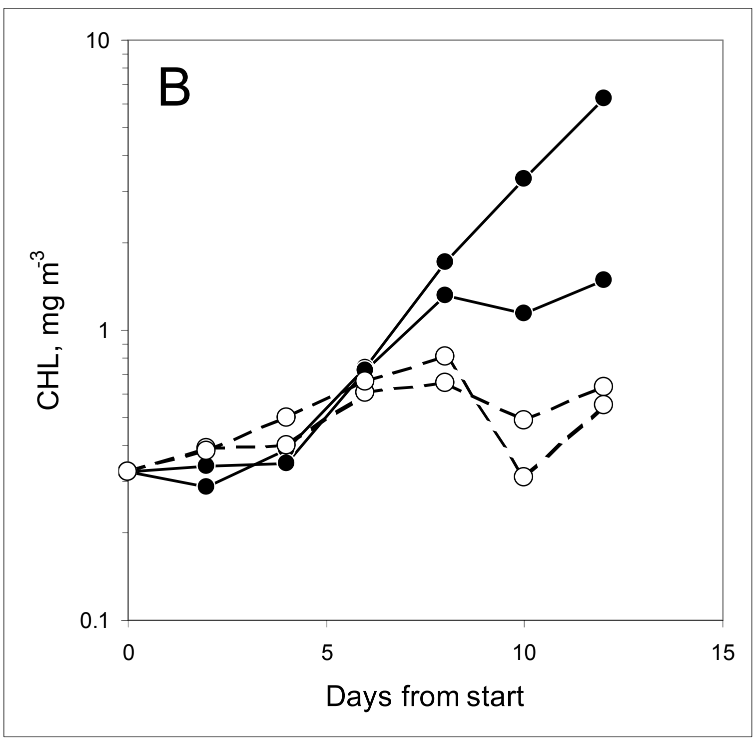


Figure 2.4 Changes in Chl-*a* concentrations over time for incubations with trace-metal clean technique, and where 2 nM Fe was added to natural water samples (solid symbols and lines) and compared with controls in which no Fe was added (open symbols, dashed lines). The cultures were incubated under 40% (A) and 4% (B) ambient incident irradiance.

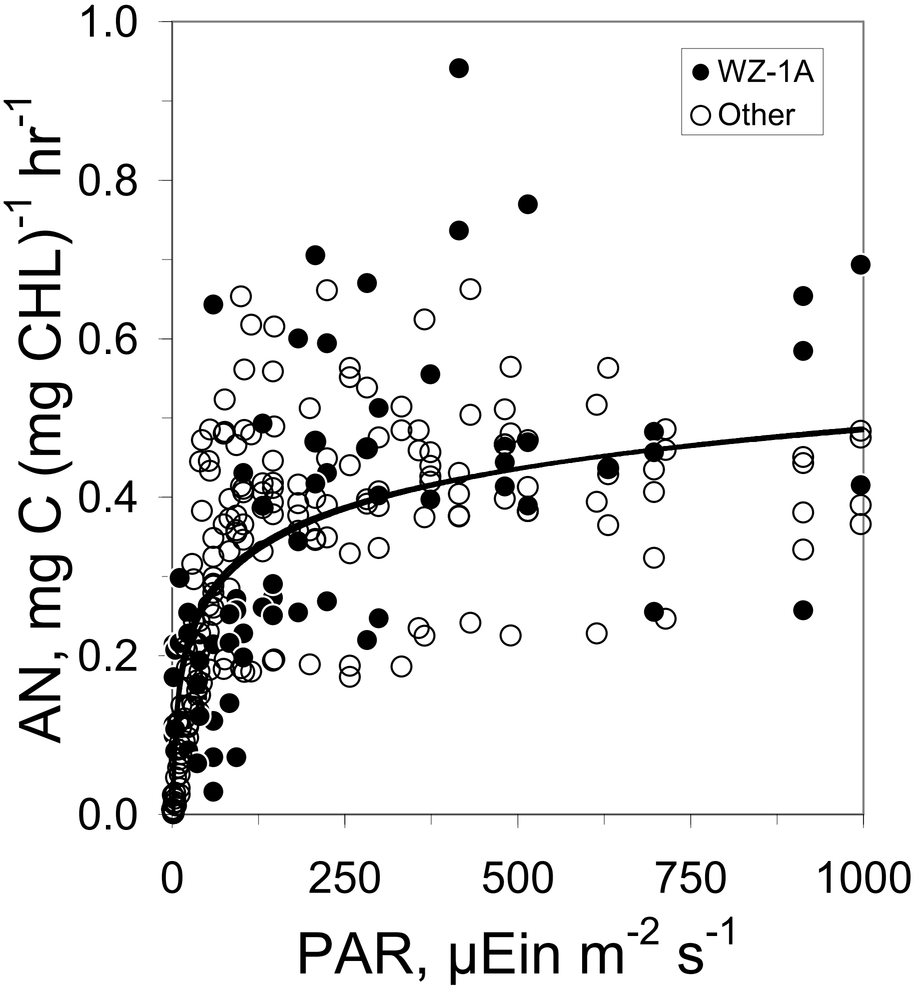


Figure 2.5 Assimilation numbers (AN) of the phytoplankton photosynthetic response to a gradient in PAR. Fe-stressed Water Zone IA populations were not found to have any different photosynthetic response than populations taken from Fe-replete waters.

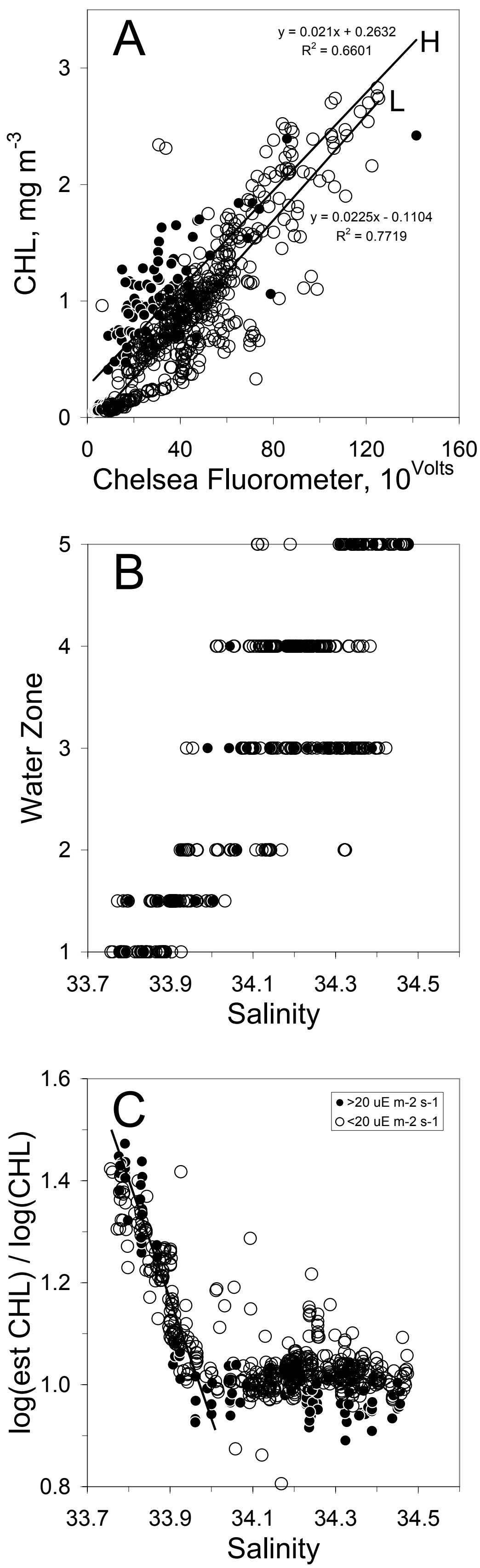


Figure 2.6 Variability in the fluorescence yield of phytoplankton in the AMLR survey area. A) Chl-*a* can be estimated linearly from the exponential of fluorometer output. Photoinhibition of fluorescence is observed in water samples from the upper water column when PAR is >20 µEin m^{-2} s^{-1} (filled symbols, line "H") as compared to low light conditions <20 µEin m^{-2} s^{-1} (open symbols, line "L"). However, this does not explain a large portion of the residual variability that is needed for a good algorithm to estimate Chl-*a* from in situ fluorescence. B) Range of salinity values for the five water zones. The lowest salinity range is found for Zone I waters, where the salinities in the UML are <34 psu. C) Variability in the fluorescence yield of chl-*a* as related to salinity of the water sample. Fluorescence yield increased dramatically at salinities <34 (in Zone I waters), and speculated to occur as a function of Fe-stress.

3. Bioacoustic survey; submitted by Anthony M. Cossio and Christian Reiss.

3.1 Objectives: The primary objectives of the bioacoustic survey were to map the meso-scale dispersion of Antarctic krill (*Euphausia superba*) in the vicinity of the South Shetland Islands and to determine their association with predator foraging patterns, water mass boundaries, spatial patterns of primary productivity, and bathymetry. In addition, efforts were made to map the distribution of myctophids and to determine their relationship with water mass boundaries and zooplankton distribution.

3.2 Methods and Accomplishments: Acoustic data were collected using a multi-frequency echo sounder (Simrad EK60) configured with down-looking 38, 70, 120, and 200 kilohertz (kHz) split-beam transducers mounted in the hull of the ship. System calibrations were conducted before and after the survey using standard sphere techniques while the ship was at anchor in Ezcurra Inlet, King George Island. During the surveys, pulses were transmitted every 2 seconds at 1 kilowatt for 1 millisecond duration at 38kHz, 70kHz, 120kHz, and 200kHz. Geographic positions were logged simultaneously every 2 seconds. Ethernet communications were maintained between the EK60 and a Windows XP workstation. The workstation was used for primary system control, data logging, and data processing with SonarData Inc.'s Echoview software.

Acoustic surveys of the water surrounding the South Shetland Islands were divided into four areas (See Figure 2 in Introduction): (1) a 43,865 km^2 area centered on Elephant Island (Elephant Island Area) was sampled with seven north-south transects; (2) a 38,524 km^2 area along the north side of the southwestern portion of the South Shetland archipelago (West Area) was sampled with six transects oriented northwest-southwest and one oriented north-south; (3) a 24,479 km^2 area in the western Bransfield Strait (South Area) was sampled with seven transects oriented northwest-southwest; (4) and an 18,151 km^2 area north of Joinville Island (Joinville Island Area). Due to extensive sea ice accumulation, no transects were completed in the Joinville Island Area during the survey.

Data collected during CTD and trawl station were discarded. Only daytime data were used in analysis due to possible bias from diurnal vertical migration (Demer and Hewitt, 1995).

All previous data from 1996 to present were re-analyzed using the simplified Stochastic Distorted-Wave Born Approximation (SDWBA) (θ= N [mean =11°, s.d. =4°]) target strength model and a dynamic ΔS_v krill delineation model (Demer and Conti, 2005; Conti and Demer, 2006; CCAMLR, 2005). Years prior to 1996 were not reanalyzed, because only 1 (1986-1991) or two (1992 to 1995) acoustic transducers were available. In previous years acoustic data were analyzed using the Greene *et al.* (1990) target strength model with a fixed ΔS_v krill delineation model. Please refer to previous field season reports for those data, as only the new technique is presented beginning with this field season report.

3.2.1 Krill Delineation: Krill are delineated from other scatters by use of a three frequency ΔS_v method (Hewitt *et al.*, 2003). The ΔS_v range is dynamic and is based on krill length ranges present in each survey area (CCAMLR, 2005). This differs from previous work when analyses were conducted using a constant range of ΔS_v ($4 \leq (S_{v,120} - S_{v,38}) \leq 16$ dB and $-4 \leq (S_{v,200} - S_{v,120})$

≤ 2 dB). Table 3.1 shows the ranges of krill lengths as well as the dynamic ΔS_v ranges used between 1996 and present.

3.2.2 Myctophid Delineation: A ΔMVBS window of -5 to 2dB was applied to a two-frequency (38kHz and 120kHz) method for the purpose of delineating myctophids. This range was chosen based on observed differences in myctophid backscattering values between 38kHz and 120kHz.

3.2.3 Abundance Estimation and Map Generation: Backscattering values were averaged over 5m by 100s bins. Time varied gain (TVG) noise was subtracted from the echogram and the ΔS_v range was applied. TVG values were based on levels required to erase the rainbow effect plus 2dB. The remaining volume backscatter classified as krill was integrated over depth (500m) and averaged over 1,852m (1 nautical mile) distance intervals.

Integrated krill nautical area scattering coefficient (NASC) (Maclennan and Fernandes, 2000) was converted to estimates of krill abundance (ρ) by dividing the sum of the weighted-mean masses per animal (*W*; g/krill) by the sum of the backscattering cross-sectional area of krill (σ) ($\sigma = 4\pi r 10^{TS/10}$ where r is the reference range of 1m; Hewitt and Demer, 1993). The length to weight relationship

(1) $$W\,(\text{g}) = 2.236 * 10^{-3} * TL^{3.314}$$

is based on net samples collected during the international krill biomass survey of the Scotia Sea conducted during January 2000 (Hewitt *et al.*, 2004). Krill abundance was estimated according to Hewitt and Demer (1993):

(2) $$\rho\,(\text{g/m}^2) = \frac{\sum_{i=1}^{n} f_i W(l_i)}{\sum_{i=1}^{n} f_i \sigma(l_i)} NASC$$

Where f_i = the relative frequency of krill of standard length l_i. Krill biomass was then estimated by multiplying ρ by the area surveyed.

For each area in the survey, mean biomass density attributed to krill and its variance were calculated by assuming that the mean abundance along a single transect was an independent estimate of the mean abundance in the area (Jolly and Hampton, 1990). We used the cluster estimator of Williamson (1982) to calculate the variance of NASC within each area and to expand the abundance estimate for the South Shetlands.

No myctophid biomass estimates were made because of the lack of target strength data and length-frequency distributions. Instead, the NASC attributed to myctophids was integrated using SonarData Echoview software and then mapped across the South Shetland Islands using SURFER (Golden Software, Inc. Golden, CO).

3.3 Tentative Conclusions:

3.3.1 Leg I: Mean krill abundance for each transect line in each area is presented in Table 3.2. Mean krill abundance was 68, 344, and 26 g/m² for the West, Elephant Island, and South Areas, respectively. Very high concentrations of krill were found off the north and east coasts of Elephant Island (Figure 3.1). There were also high concentrations just south of the Shackleton fracture zone. The West and Elephant Island Areas had the highest biomass estimates seen back to 1996 (Table 3.3).

The distribution of mean NASC of myctophids was mapped and was highest along the 2000m isobath (Figure 3.2). This is similar with previous year's patterns.

The comparison of the previous Greene TS model with the current SDWBA TS model shows different patterns. The SDWBA model shows two high peaks (1996 and 2003) with declining biomass in between (Figure 3.3).

3.4 Disposition of Data: All integrated acoustic data will be made available to other U.S. AMLR investigators in ASCII format files. The analyzed echo-integration data consume approximately 10MB. The data are available from Anthony Cossio, Southwest Science Center, 8604 La Jolla Shores Dr, La Jolla, CA 92037; phone/fax – (858) 546-5609/546-5608; e-mail: Anthony.Cossio@noaa.gov.

3.5 References:

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Williamson, N. 1982. Cluster sampling estimation of the variance of abundance estimates derived from quantitative echo sounder surveys. *Canadian Journal of Fisheries and Aquatic Science* 39:229-231.

Table 3.1 Range of total lengths (TL, minimum and maximum, mm) and acoustic ΔS_v ranges applied to assess biomass of Antarctic krill in the Elephant Island, South and West Areas of the South Shetland Islands region between 1998 and 2007, using the simplified SDWBA model (see Conti and Demer, 2005; and CCAMLR, 2005).

Cruise	Elephant Island Krill length	120-38	200-120	West Krill length	120-38	200-120	South Krill length	120-38	200-120
1996A	18-59	2.5 to 14.7	-0.5 to 2.1	x	x	x	x	x	x
1996D	20-57	2.5 to 14.7	-0.5 to 2.1	x	x	x	x	x	x
1997A	19-58	2.5 to 14.7	-0.5 to 2.1	17-58	2.5 to 17.7	-0.5 to 6.8	15-52	2.5 to 17.7	-0.5 to 6.8
1998A	17-53	2.5 to 17.7	-0.5 to 6.8	15-52	2.5 to 17.7	-0.5 to 6.8	16-44	4.6 to 17.7	-0.5 to 6.8
1998D	21-52	2.5 to 14.7	-0.5 to 2.1	19-53	2.5 to 14.7	-0.5 to 2.1	19-48	4.6 to 14.7	-0.5 to 2.1
1999A	32-54	2.5 to 11.1	-0.5 to 0.4	30-54	2.5 to 11.1	-0.5 to 0.4	26-52	2.5 to 14.7	-0.5 to 2.1
1999D	35-56	2.5 to 11.1	-0.5 to 0.4	36-51	4.6 to 11.1	-0.5 to 0.4	x	x	x
2000D	39-58	2.5 to 7.7	-0.5 to -0.3	39-59	2.5 to 7.7	-0.5 to -0.3	40-55	2.5 to 7.7	-0.5 to -0.3
2001A	18-57	2.5 to 14.7	-0.5 to 2.1	40-60	2.5 to 7.7	-0.5 to -0.3	22-55	2.5 to 14.7	-0.5 to 2.1
2001D	26-60	2.5 to 14.7	-0.5 to 2.1	26-60	2.5 to 14.7	-0.5 to 2.1	28-57	2.5 to 14.7	-0.5 to 2.1
2002A	17-59	2.5 to 17.7	-0.5 to 6.8	18-60	2.5 to 17.7	-0.5 to 6.8	20-45	4.6 to 14.7	-0.5 to 2.1
2002D	21-59	2.5 to 14.7	-0.5 to 2.1	20-56	2.5 to 14.7	-0.5 to 2.1	20-49	4.6 to 14.7	-0.5 to 2.1
2003A	13-53	2.5 to 17.7	-0.5 to 6.8	13-54	2.5 to 17.7	-0.5 to 6.8	13-45	4.6 to 17.7	-0.5 to 6.8
2003D	15-53	2.5 to 17.7	-0.5 to 6.8	19-54	2.5 to 14.7	-0.5 to 2.1	16-49	4.6 to 17.7	-0.5 to 6.8
2004A	21-55	2.5 to 14.7	-0.5 to 2.1	24-57	2.5 to 14.7	-0.5 to 2.1	20-57	2.5 to 14.7	-0.5 to 2.1
2004D	29-58	2.5 to 11.1	-0.5 to 0.4	22-55	2.5 to 14.7	-0.5 to 2.1	18-56	2.5 to 17.7	-0.5 to 6.8
2005A	20-59	2.5 to 14.7	-0.5 to 2.1	21-57	2.5 to 14.7	-0.5 to 2.1	20-57	2.5 to 14.7	-0.5 to 2.1
2005D	28-57	2.5 to 14.7	-0.5 to 2.1	39-55	2.5 to 7.7	-0.5 to -0.3	19-53	2.5 to 14.7	-0.5 to 2.1
2006A	25-61	2.5 to 14.7	-0.5 to 2.1	41-60	2.5 to 7.7	-0.5 to -0.3	26-59	2.5 to 14.7	-0.5 to 2.1
2007A	16-60	2.5 to 7.7	-0.5 to -0.3	19-58	2.5 to 14.7	-0.5 to 2.1	19-55	2.5 to 14.7	-0.5 to 2.1

Table 3.2 Daytime krill abundance estimates by area and transect for the survey. n = 1 interval = 1 nautical mile.

Area	Transect	n	Krill density (g/m²)
West Area			
	Transect 1	43	43.63
	Transect 2	16	38.52
	Transect 3	42	69.42
	Transect 4	44	156.86
	Transect 5	62	57.13
	Transect 6	59	71.82
	Transect 7	97	49.07
Elephant Island Area			
	Transect 1	76	8.97
	Transect 2	96	402.14
	Transect 3	89	103.75
	Transect 4	110	362.16
	Transect 5	105	919.74
	Transect 6	98	309.52
	Transect 7	92	148.13
South Area			
	Transect 1	42	56.97
	Transect 2	41	1.62
	Transect 3	21	16.06
	Transect 4	46	17.75
	Transect 5	23	73.04
	Transect 6	19	19.19
	Transect 7	16	12.51

Table 3.3 Mean krill biomass for surveys conducted from 1996 to 2007. Coefficients of variation (CV) are calculated by the methods described in Jolly and Hampton, 1990, and describe measurement imprecision due to the survey design. Only one survey was conducted in 1997; 1999 South Area D values are not available due to lack of data. See Figure 2 in the Introduction Section for description of each survey.

Survey	Area	Mean Density (g/m^2)	Area (km^2)	Biomass (10^3 tons)	CV %
1996 A (late January)	Elephant Island	120.97	41,673	5,834	28.5
D (early March)	Elephant Island	84.14	41,673	4,058	29.3
1997 A (late January)	Elephant Island	56.67	41,673	2,733	23.78
	West	86.59	34,149	2,957	31.3
	South	63.85	8,102	1,563	51.2
1998 A (late January)	Elephant Island	65.05	41,673	2,711	21
	West	125.56	34,149	4,288	25.9
	South	89.03	8,102	721	23
D (late February)	Elephant Island	25.29	41,673	1,054	29.4
	West	42.39	34,149	1,448	27.2
	South	54.45	8,102	441	38.5
1999 A (late January)	Elephant Island	16.95	41,673	706	47.3
	West	20.82	34,149	711	33.8
	South	52.5	8,102	425	18.3
D (late February)	Elephant Island	25.6	41,673	1,066	68.1
	West	16.09	34,149	550	41.8
2000 D (late February)	West	10.87	34,149	371	32.2
	Elephant Island	8.84	41,673	368	36.3
	South	6.02	8,102	49	0.5
2001 A (late January)	West	0.31	34,149	10	51.1
	Elephant Island	31.99	41,673	1,333	21.6
	South	21.25	8,102	172	29.9
D (late February)	West	36.28	34,149	1,239	60.5
	Elephant Island	34.17	41,673	1,424	11.4
	South	13.48	8,102	109	51.5
2002 A (late January)	West	46.93	38,524	1,808	44.6
	Elephant Island	116.88	43,865	5,127	14.9
	South	8.49	24,479	208	48.2
D (late February)	West	0.86	38,524	33	46.4
	Elephant Island	10.83	43,865	475	26.5
	South	5.95	24,479	146	79.9
2003 A (late January)	West	121.53	38,524	4,682	21.8
	Elephant Island	124.12	43,865	5,445	13.4
	South	119.53	24,479	2,926	29.9
D (late February)	West	97.41	38,524	3,753	29.5
	Elephant Island	84.08	43,865	3,688	21.2
	South	169.61	24,479	4,152	20.4
2004 A (late January)	West	80.17	38,524	3,088	8.9
	Elephant Island	49.71	43,865	2,181	17.4
	South	16.01	24,479	392	48

D (late February)	West	43.96	38,524	1,694	44
	Elephant Island	8.33	43,865	366	42.1
	South	102.92	24,479	2,519	51.4
2005 A (late January)	West	40.96	38,524	1,578	26.6
	Elephant Island	28.41	43,865	1,246	55
	South	8.71	24,479	213	55.7
D (late February)	West	0.88	38,524	339	85.2
	Elephant Island	1.78	43,865	78	37.1
	South	4.6	24,479	113	21.4
2006 (late January)	West	0.2	38,524	8	45.9
	Elephant Island	8.29	43,865	364	38.9
	South	4.64	24,479	114	49.3
2007 (late January)	West	68.45	38,524	2,637	19.72
	Elephant Island	343.71	43,865	15,077	33.75
	South	26.42	24,479	647	40.91

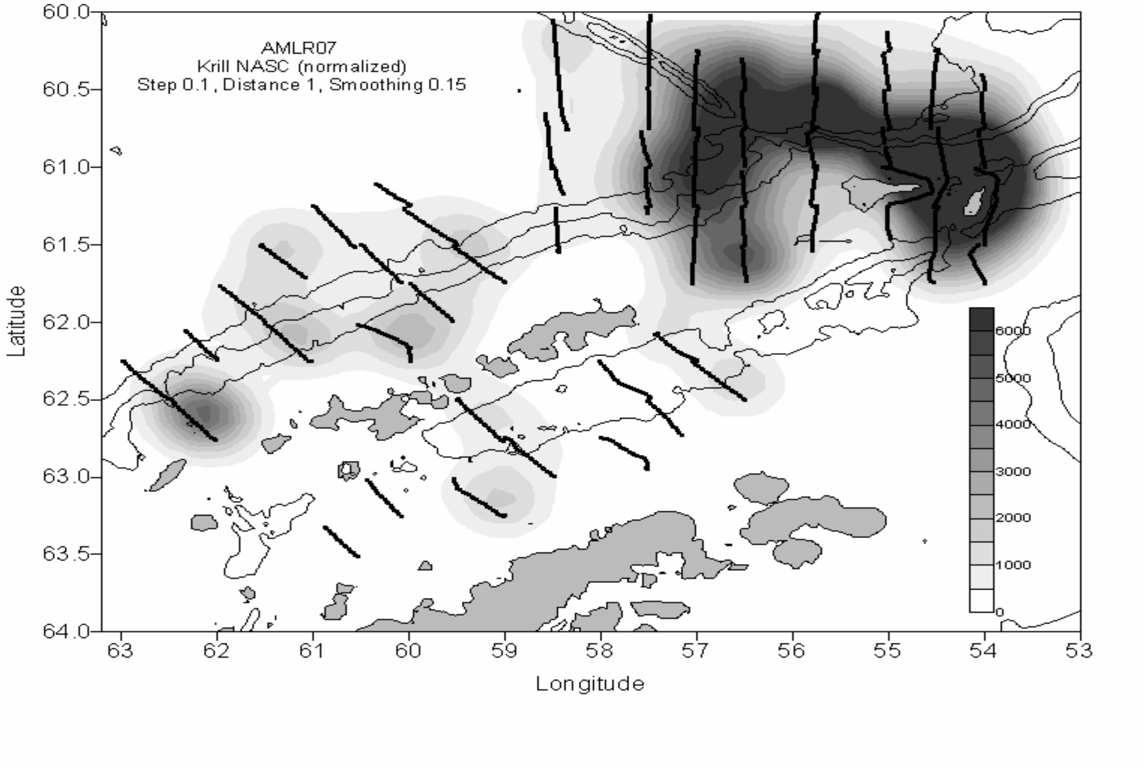

Figure 3.1 Normalized krill NASC values for Survey A at 120kHz using day data. (Latitude is south and longitude is west).

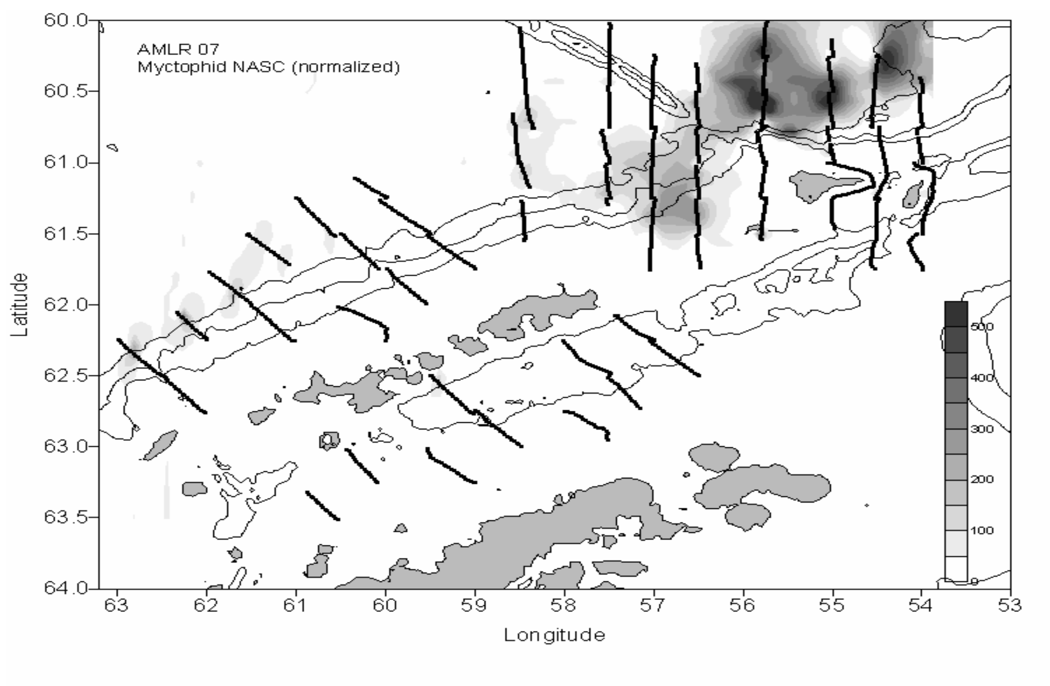

Figure 3.2 Normalized myctophid NASC values for Survey A at 120kHz using day data. (Latitude is south and longitude is west).

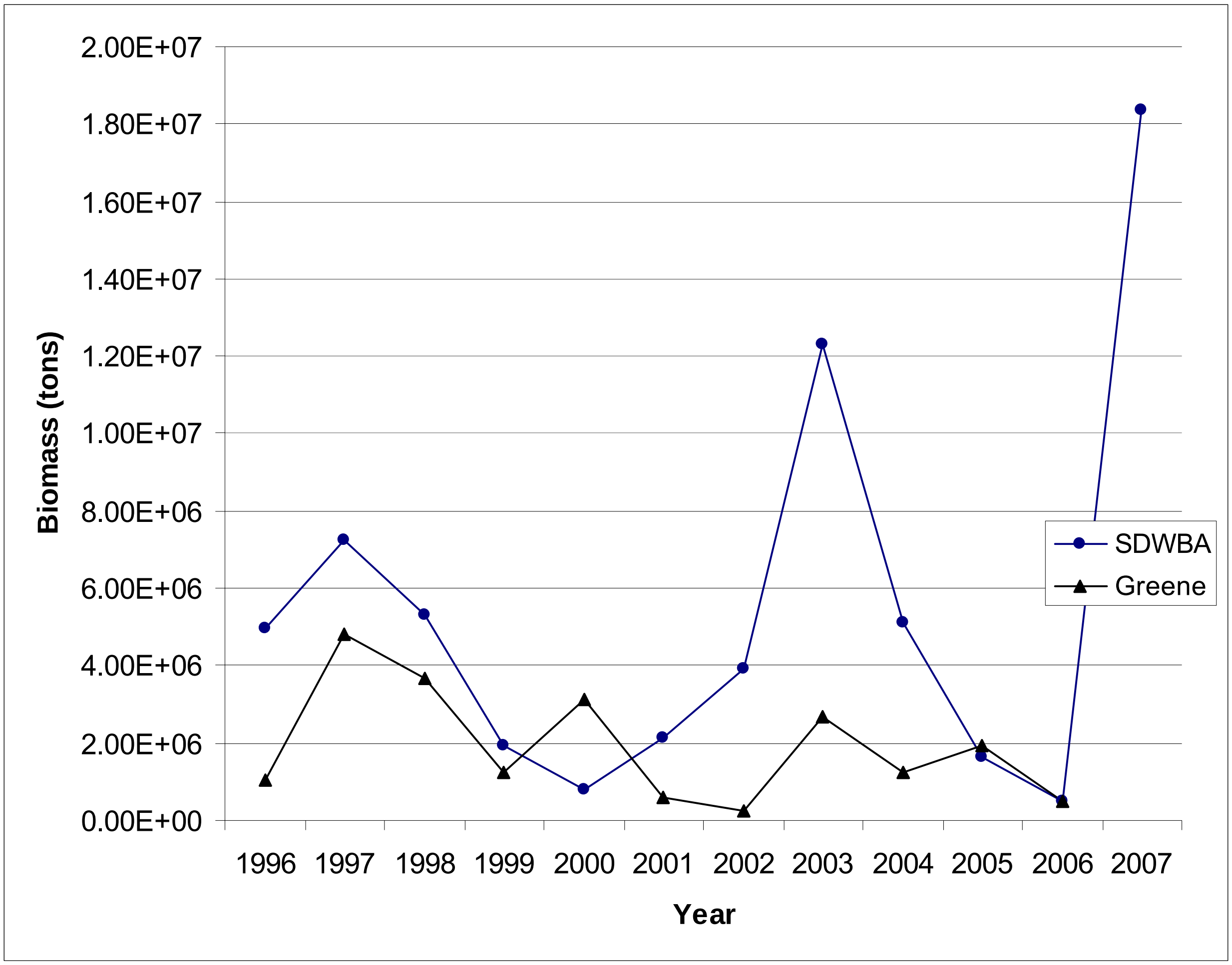

Figure 3.3 Comparison of the biomass trends from the previously used Greene *et al*. (1991), fixed ΔS_v and the currently used SDWBA TS with varying ΔS_v models. Data is the sum of the Areas and the average of the survey Legs.

4. AMLR 2007: Net sampling: Krill and zooplankton; submitted by Valerie Loeb , Kimberly Dietrich, Ryan Driscoll, Kristen Green, Letise Houser, Adam Jenkins, Darci Lombard, Aileen Miller, Kelly Norton and Kyla Zaret.

4.1 Objectives: Here we provide information on the distribution, abundance and demographic structure of Antarctic krill (*Euphausia superba*) and abundance and distribution of salps and other zooplankton in the vicinity of Elephant, King George, Livingston and Joinville Islands. Essential krill demographic information includes length, sex ratio, maturity stage composition and reproductive condition. Information useful for determining the relationships between krill and zooplankton distribution patterns and ambient environmental conditions was derived from net samples taken at established CTD/phytoplankton stations. The salps *Salpa thompsoni* and *Ihlea racovitzai* and biomass dominant copepod species receive special attention because their interannual abundance variations reveal underlying hydrographic processes influencing the Antarctic Peninsula ecosystem. Results from the single month-long cruise (Survey A) are compared to those from previous AMLR surveys to assess between-year differences in krill demography and zooplankton composition and abundance over the 1992-2007 period. Additional historical data from the Elephant Island Area are used to examine copepod species abundance and abundance relations between 1981 and present.

4.2 Accomplishments:

4.2.1 Large-Area Survey Samples: Krill and zooplankton were obtained from a 6' Isaacs-Kidd Midwater Trawl (IKMT) fitted with a 505 μm mesh plankton net. Flow volumes were measured using a calibrated General Oceanics flow meter mounted on the frame in front of the net. All tows were fished obliquely from a depth of 170m or to approximately 10m above bottom in shallower waters. Real-time tow depths were derived from a depth recorder mounted on the trawl bridle. Tow speeds were about two knots with flow volumes that averaged 2,400 m^3. Samples were collected at large area survey stations representing four areas (Figure 1 in the Introduction section of this report). Elephant Island Area stations represent the historically sampled area used for long-term analyses of the Antarctic Peninsula marine ecosystem. West Area stations, north of King George and Livingston Islands, form a data base with which to examine the abundance and length composition of krill to predator populations at Cape Shirreff and to the krill fishery that operates in this area during summer months. Additionally, the composition and abundance of zooplankton assemblages in the West and Elephant Island Areas reflect prevailing hydrographic influences, specifically the eastward flowing Antarctic Circumpolar Current and its zooplankton-rich Upper Circumpolar Deep Water environment and comparatively depauperate westward flowing coastal currents. Within Bransfield Strait the South Area stations are used to monitor krill supplies available to predator populations monitored at the Copacabana field camp, King George Island, while Joinville Island Area stations, to the east, are sampled to increase the likelihood of sampling infrequent but dense aggregations of juvenile krill that are primarily distributed within southern Bransfield Strait (Siegel *et al*., 2002).

4.2.2 Shipboard Analyses: All samples were processed on board. Krill demographic analyses were made using fresh or freshly frozen specimens. Other zooplankton analyses were made using fresh material within two hours of sample collection. Abundance estimates of krill, salps, copepods and other taxa are expressed as numbers per 1000 m^3 water filtered. For diel considerations twilight samples are defined as those collected one hour before to one hour after local sunrise and sunset. Abundance information is presented for the West, South, Elephant and Joinville Island Areas, and for the total survey area.

(A) Krill: Krill were removed and counted prior to other sample processing. All krill from samples of <100 individuals were analyzed. For larger samples, generally 100 reproductive individuals were measured, sexed, and staged. Measurements were made of total length (mm); stages were based on the classification scheme of Makarov and Denys (1981). Length-at-age estimates are based on Siegel (1987) and Siegel and Loeb (1994).

(B) Salps: All salps were removed from samples of two liters or less and enumerated. For larger catches the numbers of salps in one to two liter subsamples were used to estimate abundance. For samples with ≤100 individuals, the two life stages (aggregate/sexual and solitary/asexual) were enumerated and internal body length (Foxton, 1966) was measured to the nearest mm. Representative subsamples of ≥100 individuals were analyzed in the same manner for larger catches.

(C) Fish: All adult myctophids were removed, identified, measured to the nearest mm (Standard Length) and frozen.

(D) Zooplankton: After krill, salps, and adult fish were removed, the remaining zooplankton fraction was analyzed. All of the larger organisms (e.g., other postlarval euphausiids, amphipods, pteropods, polychaetes) were sorted, identified to species if possible, and enumerated. Following this the samples were aliquoted and smaller zooplankton (e.g., copepods, chaetognaths, euphausiid larvae) in three or four subsamples were enumerated and identified to species if possible. After analysis the zooplankton samples (without adult fish, postlarval krill, most salps) were preserved in 10% buffered formalin for long-term storage. Specimens of pteropods belonging to genera with calcareous shells, *Limacina* and *Clio*, were preserved separately in buffered 95% ethanol for use in ocean acidification studies.

The long-term AMLR zooplankton data set reflects the evolution of shipboard sample processing and identification techniques. Taxonomic diversity increases evident over the past decade result in part from the identification of smaller taxa such as copepod species and euphausiid larvae. Additionally, survey grid expansions into higher latitudes incorporate zooplankton taxa not encountered by earlier surveys. Most notable are areas influenced by Weddell Sea shelf water (eastern Elephant Island and Joinville Island Areas) and by outflow from Gerlache Strait (southwestern Bransfield Strait). Use of a more protective cod-end starting in 2002 also increased the numbers of previously unidentifiable delicate taxa such as jellies and pteropods.

4.2.3 Statistical Analyses: Data from the total survey area and four subareas are analyzed here for within-cruise and between-year comparisons. Krill, salp and zooplankton species abundances are also related to hydrography using water zones as described in the Physical Oceanography Section of this Report (Chapter 1). These water zone numbers I to V represent a variety of mixtures between Antarctic Circumpolar Current (ACC) (I), ACC-derived (II and III), Bransfield Strait (IV) and high latitude Weddell Sea shelf water (V). Analyses include a variety of parametric and nonparametric techniques including Index of Dispersion (ID), Analysis of Variance (ANOVA), Kendall's Tau (*T*) correlations, Cluster Analysis, Percent Similarity Indices (PSIs) and Kolmogorov-Smirnov cumulative percent curve comparisons (D_{max}). Cluster analyses use Euclidean distance and Ward's linkage method; clusters are distinguished by a distance of 0.30 to 0.70. Clusters based on size characteristics utilize proportional length-frequency distributions in each sample with at least 17 krill or 80 salps. Zooplankton clusters are based on log-transformed sample abundance data (N+1) for taxa present in at least 18% of samples. Statistical analyses were performed using *Statistica* (StatSoft) software.

4.2.3 Long Term Data Sets: Because of the extensive temporal coverage in various instances (e.g., zooplankton species abundance) it is no longer practical to tabulate all of the AMLR survey data collected prior to 1998. When lacking, information from 1990-1997 is available in previous AMLR Field Season Reports in print versions and on the AMLR website located at: http://swfsc.noaa.gov/textblock.aspx?Division=AERD&id=3154&ParentMenuId=42.

4.3 Results and Preliminary Conclusions:

4.3.1 Survey A:

4.3.1.1 Krill:

<u>Postlarval Frequency, Distribution and Abundance (Table 4.1; Figure 4.1)</u>: A total of 23,200 postlarval krill were collected by 98 net tows made across the large survey area. Over 6,000 of these were measured, sexed and staged to establish krill demographics. Krill were present in 91 (93%) of the samples, with greatest frequency of occurrence in the Elephant Island (96%) and Joinville Island (100%) Areas. The four largest catches, 1,082-5,000 individuals (418-2,076 per 1000 m^3), were over and adjacent to the southern rims of deep basins in Bransfield Strait (South and Joinville Island Areas). Eight relatively large samples, 528-888 individuals (213-398 per 1000 m^3), were also collected in western Bransfield Strait, over the northeast shelf of King George Island and around the Elephant Island shelf. Highest mean krill abundance was in the Joinville Island (369 per 1000 m^3) and South (150 per 1000 m^3) Areas compared to Elephant Island (66 per 1000 m^3) and West (43 per 1000 m^3) Areas. However, these two areas limited to Bransfield Strait were characterized by high catch variability (patchiness) reflected by high Index of Dispersion values (ID 1370 and 644) and low median abundance values (3.2 and 22 per 1000 m^3). Relatively low median abundance (18 per 1000 m^3) in the West Area resulted from relatively even distribution of generally small krill catches (ID=106). Comparatively large median krill abundance in the Elephant Island Area (33 per 1000 m^3) resulted from the widespread distribution of moderate catch sizes (ID=140).

<u>Length and Maturity Stage Composition (Table 4.2; Figures 4.2, 4.3)</u>: The overall krill length-frequency distribution was bimodal with a strong primary mode of 27 mm and secondary mode centered around 46-50mm. Over 69% of the krill were $\leq$35mm and another 19% were $\geq$45mm. These correspond to 1-year-old individuals (the 2005/06 year class) and krill 3-years old and older (the 2003/04 and previous year classes). Of interest are the remaining 12% of individuals

between 35 and 45mm that were underrepresented as juveniles during the 2005/06 AMLR survey but now represent the “missing” 2004/05 year class.

Juveniles comprised 62% of the total catch, mature forms 27% and immature stages 11%. As with the size composition, overwhelming dominance of juveniles reflects strong recruitment success of the 2005/06 year class. Mature krill were primarily represented by actively mating male (3b, 11%) and female (3b, 5%) stages. Decreasing proportions of more advanced female stages 3c-e (i.e., with developing ovaries, gravid and spent) suggest that sampling was done during the peak mating period. Overall, the proportion of mature females in advanced maturity stages was 48%, which suggests somewhat delayed spawning seasonality with the major reproductive effort occurring during mid- to late January and possibly into February.

As typical, krill demographics differed greatly between the areas north and south of the South Shetland Islands with juveniles and individuals <35mm clearly dominating in Bransfield Strait and larger, mature stages dominating in the West and Elephant Island Areas. Within Bransfield Strait, the length-frequency distributions were centered around 25-28mm modes, however the South Area differed by the inclusion of a substantial proportion (12%) of individuals >35mm that were rare in the Joinville Island Area. Accordingly, the maturity stage composition was more heterogeneous in the South Area where immature and mature stages contributed, respectively, 10% and 8% compared to 8% and 2% in the Joinville Island Area. The extreme patchiness characterizing these two areas was due to the localized dense concentrations of juveniles.

Length-frequency distributions in the West and Elephant Island Areas were both bimodal around large (mature adult) primary and small (juvenile) secondary modes but differed in the representation of the “missing” year class. This 36-45mm length category made up 31% of the Elephant Island krill compared to 10% in the West. Juveniles comprised approximately 28% of total krill in both areas although they were considerably less numerous than in Bransfield Strait. Due to more intermediate sized individuals there were greater proportions of immature stages in the Elephant Island vs. West Areas (15% vs. 10%). However, greater proportions of advanced female maturity stages were also in the Elephant Island Area (53% vs. 29%) suggesting an earlier initiation of the seasonal reproductive period there than in the West. Two relatively large catches of predominantly gravid females adjacent to deep basins south of Elephant and east of Clarence Islands suggested the advent of spawning activity here.

Distribution Patterns (Figures 4.4, 4.5): Cluster analysis applied to krill length-frequency distributions at 69 stations produced three groups with more or less coherent distribution patterns. Clusters 1 and 3 represent two dichotomous length-frequency distributions centered around median and modal lengths of 27mm (1-year old) and 50mm (3+ year old), respectively. Most (90%) of Cluster 1 krill were ≤38mm and juvenile (80%) and young immature (11%) stages. While Cluster 1 krill were largely distributed over the deep basins and western portion of Bransfield Strait (10 stations) two aggregations were sampled adjacent to the Shackleton Fracture Zone, one northeast of King George Island and one offshore of Smith Island. In contrast, 90% of Cluster 3 krill were >41mm and predominantly mature (92%) stages. These individuals were represented at 21 stations over outer island shelf regions and offshore Drake Passage waters. The overall male to female ratio was 2:1 with largely male-dominated aggregations offshore and mixed sex aggregations over shelf areas. About half (52%) of the mature females were in advanced reproductive stages. Cluster 2 had bimodal length-frequency distributions centered around 45-57mm and 30-32mm. This group represented a mixture of Clusters 1 and 3 plus a substantial proportion (35%) of 36-45 mm (2-year-old) individuals. Juveniles and immature stages each comprised approximately 18% and mature stages 63%. This group was represented at 34 stations located in Bransfield Strait, over northern island shelf regions and offshore waters adjacent to the Shackleton Fracture Zone. Males and females were equally represented and 54% of the mature females were in advanced stages.

Larval Krill Distribution, Abundance and Stage Composition (Tables 4.3, 4.4, 4.5; Figure 4.6): Larval krill were present in 49 (50%) of the samples and collected in all four subareas with overall mean and median abundance of 14 and 0.2 per 1000 m^3. They were least frequent (22% of samples) and abundant (2 per 1000 m^3 mean) in the West Area. Although present in 60% of the South Area samples the mean and median abundance values there were also low (3.6 and 1.8 per 1000 m^3). The three largest samples (150-400 per 1000 m^3) were collected in the Elephant Island Area. These along with three relatively large concentrations (30-88 per 1000 m^3) in the Joinville Island Area were located over and adjacent to the deep basin in Eastern Bransfield Strait. Greatest mean and median abundance were in the Joinville Island Area (32 and 14 per 1000 m^3) followed by the Elephant Island Area (22 and 2 per 1000 m^3). Virtually all of the larvae were early calyptopis stage 1 (C1) resulting from spawning about two to three weeks earlier (i.e., mid-December-early January; Spiridonov, 1995). Given the time required for developmental ascent and presence of C1 larvae in the upper water column, the one to two week time span between sampling in the South (11 January) and Elephant and Joinville Island Areas (19-26 January) may explain substantially increased larval concentrations there. These results are consistent with a somewhat delayed spawning season (Spiridonov, 1995), with initiation in mid-December and a peak possibly in late January or later. The association of gravid females and larvae (as well as juveniles resulting from last years spawn) with deep basins in Bransfield Strait supports the importance of these features for krill reproduction and retention of their young (Spiridonov, 1995).

4.3.1.2 Salps:

Salpa thompsoni Frequency, Distribution and Abundance (Tables 4.4, 4.5; Figure 4.7): *Salpa thompsoni* was present in nearly half of the samples (48%) with an overall mean abundance of 181 per 1000 m^3. It occurred in about 66% of the West and Elephant Island Area stations where its distribution and abundance were clearly associated with oceanic waters (Water Zone I) of Drake Passage. Greatest concentrations (1,481-4,800 per 1000 m^3) were at two offshore stations north of Smith Island and four stations along the Shackleton Fracture Zone. Elevated concentrations (114-999 per 1000 m^3) were adjacent to and/or downstream of these locations. Mean and median concentrations in the West Area (399 and 14 per 1000 m^3) exceeded those in the Elephant Island Area (179 and 4 per 1000 m^3). *S. thompsoni* was absent from the South and Joinville Island Areas.

Size and Maturity Stage Composition (Figure 4.8): Virtually all of the salps (99.8%) were the aggregate (chain) form released by solitaries in spring and summer. Lengths ranged from 5-55mm with a median length of 27mm. Given an estimated 0.44mm per day growth rate, these would have resulted from an onset of chain production in late September with peak production in late November-early December. Only 16% of individuals were <20mm indicating little recent production. This is consistent with the absence of any large (>50mm) mature solitary stages. Over 60% of the aggregates were reproductively mature lengths ≥25mm. The few solitaries collected were immature 4-33mm lengths, with a median length of 10mm, and resulted from recent release from the sexually mature aggregates.

Aggregate Stage Distribution Patterns (Figures 4.8, 4.9): Cluster analysis applied to aggregate length frequency distributions in 25 samples yielded three length groups with more or less spatially coherent patterns. Cluster 1 offshore of Livingston Island was limited to three stations along the periphery of an intrusion of Antarctic Circumpolar Current (ACC) core waters, indicated by the presence of 2°C water at 350m and flow suggested by the dynamic heights (See Physical Oceanography, Chapter 1, Figure 1.5). These salps had a mean abundance of 741 per 1000 m^3 and were mostly (78%) small immature aggregates <25mm in length. The majority of salps were represented in Cluster 2, present at 14 stations primarily over and east of the Shackleton Fracture Zone, with a mean abundance of 901 per 1000 m^3. These had a median length of 28mm and were predominantly mature individuals ≥25mm. Cluster 3 was present at five stations between Cluster 1 and another intrusion of ACC core water west of the Shackleton Fracture Zone and at three stations downstream of this offshore of Elephant Island. This group had a comparatively low mean abundance of 346 per 1000 m^3 and was dominated by larger aggregates with a median length of 33 mm with 80% mature individuals ≥37mm.

Ihlea racovitzai (Tables 4.4, 4.5; Figure 4.7): Relatively small numbers of this salp species were present in 17 samples. While these salps occurred in all four areas they were most frequent in the Joinville Island Area (43% of samples) and most abundant (1.3 per 1000 m^3) in the Elephant Island Area reflecting the Weddell Sea source area. Their widespread distribution within Bransfield Strait and north of the South Shetland Islands suggests a great deal of mixing between ACC-derived and coastal waters prior to the survey period.

4.3.1.3 Zooplankton and Micronekton Assemblage:

Overall Composition, Abundance and Distribution Patterns (Tables 4.4, 4.5; Figure 4.10,-4.13): A total of 97 zooplankton taxonomic categories were identified. Copepods were by far the most frequent and abundant component being present in all samples and constituting 63% of total mean zooplankton abundance. Among the copepods coastal species *Metridia gerlachei* had the greatest mean abundance, alone representing 33% of the total. *Pareuchaeta* spp., *Calanoides acutus* and "other" copepods were also frequent and relatively abundant components, contributing between 8% and 10% of the total. Postlarval stages of *Thysanoessa macrura* and chaetognaths were present in 95% of the samples. Mean, median and relative abundance values of postlarval *T. macrura* were similar to those of *Pareuchaeta* spp. and this euphausiid ranked second to pooled copepods in overall abundance. While *S. thompsoni* was only in 48% of samples (median abundance 0) its mean abundance value ranked third overall due to the large offshore concentrations. In addition to being relatively frequent (92% of samples) postlarval krill ranked fourth in mean abundance (5% of total) and third in median abundance. This taxonomic composition - dominance by *M. gerlachei*, *T. macrura* and krill with patchy concentrations of *S. thompsoni* - conforms to the quintessential coastal (East Wind Drift) assemblage described during the Discovery Expeditions (Mackintosh, 1934).

Zooplankton abundance was quite similar in the four survey areas with mean values of 1,590-2,528 per 1000 m^3 and medians 1,085-1,419 per 1000 m^3. Copepods were the dominant zooplankton component in all areas contributing between 47% (West Area) and 71% (Elephant Island Area) of total mean zooplankton abundance. Among copepod taxa, *M. gerlachei* had the largest mean concentrations, and *C. acutus* the greatest median abundance, in all but the West Area where "other" unidentified species dominated. Among the other taxa, postlarval *T. macrura* ranked second in mean and median abundance in all but the West Area where it followed larval *T. macrura* and *S. thompsoni* in mean concentrations and Joinville Island Area where it ranked third in mean abundance after krill. Widespread concentrations of krill in the Elephant Island and South Areas resulted in its ranking third in median abundance there. The shelled herbivorous pteropod *Limacina helicina* was also a relatively abundant member of the South and Joinville Island Areas where it ranked third or fourth in mean and median abundance. The separation of elevated concentrations of *L. helicina* offshore and southern Bransfield Strait is interesting and may result from transport from source areas in Drake Passage and the Palmer archipelago (Schnack-Schiel and Mujica, 1994). In terms of overall taxonomic composition, PSIs indicate greatest similarity between the South vs. Joinville (87) and Elephant (82) Island Areas and dissimilarity between West vs. South (63) and Joinville Island Areas (62). When copepod taxa are considered the similarities are reduced to 79 and 76 and dissimilarities to 44.

<u>Zooplankton Assemblages (Table 4.6; Figure 4.14):</u> Cluster analysis resulted in three groupings. The largest represented a "Coastal" assemblage (Cluster 1) distributed across 53 stations in Bransfield Strait, along the inner northern shelf of the South Shetland Islands, between King George and Elephant Islands and east of Elephant Island. The smallest was an "Oceanic" assemblage (Cluster 3) at 13 stations located well offshore of the South Shetland Island shelf and over the Shackleton Fracture Zone, areas adjacent to ACC core water. An "Intermediate" assemblage (Cluster 2) was represented at 32 stations most of which were in Drake Passage over and offshore of the South Shetland and Elephant Island outer shelves. This assemblage was also present at six stations that extended into waters adjacent to Elephant Island and over the deep basin of eastern Bransfield Strait.

The Oceanic assemblage was dominated by *S. thompsoni* and its mean abundance here was significantly greater than in the other clusters ($P<0.001$). Copepods followed salps in abundance and constituted 33% of total mean abundance with "other" copepods being the dominant taxon. Abundance of "other" copepods and *C. propinquus* here were significantly greater ($P<0.05$ and $P<0.01$, respectively) than in the other clusters. Abundance of third and fourth ranked larval *T. macrura* and *L. helicina,* as well as salp-associated amphipods *Vibilia antarctica* and *Cyllopus magellanicus*, were also significantly greater here ($P<0.01$). Although total mean and median zooplankton abundance values of the Oceanic assemblage were larger than the other two, the difference was not significant. Copepods, postlarval *T. macrura* and krill dominated both the Coastal and Intermediate assemblages. Differences in copepod composition were due to greater mean and median concentrations of *Pareuchaeta* spp. and "other" taxa and more uniform distributions of *M. gerlachei* in the Intermediate assemblage and greater mean and median concentrations of *C. acutus* in the Coastal assemblage. Among other taxa, *S. thompsoni* and *E. frigida* were relatively abundant in the Intermediate assemblage while *L. helicina* and ice krill *Euphausia crystallorophias* were relatively abundant in the Coastal assemblage. PSIs resulting from comparisons of overall taxonomic composition between the three assemblages showed greatest similarity between the Coastal and Intermediate assemblages (85) compared to the Oceanic assemblage (39-41). When copepod taxonomic composition is included the similarities are reduced to 68 and dissimilarities to 22-33.

Diel Abundance Differences: While most of the samples (63 of 98) were collected during day various zooplankton taxa demonstrated significant diel abundance differences reflecting vertical migrations into the upper water column during twilight (19 samples) and/or night (16 samples). Among these were euphausiids *E. frigida,* which was more abundant at twilight and night vs. day (ANOVA, $P<0.05$), and *E. triacantha,* which was more abundant at night vs. day ($P<0.05$). Interestingly, larval krill were also collected in significantly greater numbers during night vs. day ($P<0.05$). Among the copepods *M. gerlachei* exhibited large diel abundance differences with concentrations during twilight and night significantly greater than those during day ($P<0.01$). The extremely large standard deviations and relatively low median abundance values of *M. gerlachei* may in part be a consequence of this diel variability. Strong vertical migrations by adults of the myctophid fish species *Electrona antarctica* were also indicated by larger night vs. twilight and day catches ($P<0.01$). Ostracods were collected in greater numbers during night and twilight than day ($P<0.05$) while the shell-less pteropod *Spongiobranchaea australis* was more abundant during twilight than night ($P<0.05$).

Water Zone Affiliations: Distribution and abundance variations of various taxa characteristic of the zooplankton assemblages can be linked to water zone affiliations. The obvious relationship between *S. thompsoni* (and its amphipod associates *V. antarctica* and *C. magellanicus*) and oceanic water is substantiated by significantly greater abundance of all three species in Water Zone I vs. ACC-derived (Water Zone II and III) and Bransfield Strait (Water Zone IV) water (ANOVA, $P<0.01$). Other taxa with significant relationships with Water Zone I water are *T. macrura* larvae (vs. Water Zones II and IV, $P<0.05$), the amphipod *Themisto gaudichaudii* and polychaete worm *Tomopteris* spp. (vs. Water Zone III and IV, $P<0.05$), *Calanoides propinquus* and "other" copepod taxa (vs. Water Zone IV, $P<0.01$ and $P<0.05$, respectively), and pteropod *L. helicina* (vs. Water Zone II, $P<0.01$). Taxa with elevated concentrations in Bransfield Strait Water Zone IV vs. Water Zone I and II water include sipunculids ($P<0.01$), the siphonophore *Diphyes antarctica* and larvae of the nototheniid fish species *Leptonotothen larseni* (both $P<0.05$). Another common nototheniid larvae, *L. kempi* exhibited significantly greater concentrations in Water Zone II vs. other Water Zones ($P<0.01$). Limited to four stations in southeast Bransfield Strait, Weddell Sea shelf (Water Zone V) water was associated with juvenile silver fish, *Pleuragramma antarcticum*, and barnacle larvae ($P<0.05$).

4.3.2 Survey A, Between-Year Comparisons:

4.3.2.1 Krill:

Postlarvae (Tables 4.7, 4.8; 4.9, 4.10; Figure 4.15): Mean and median krill abundance values in the Elephant Island Area January 2007 (66 and 33 per 1000 m^3) were well above the long term averages of 50 and 10 per 1000 m^3, respectively. The median value was the highest recorded in January over the past 15 years, exceeding the previous peak value in 2003, while the mean ranked third behind those of 2003 and 1996. The overall length-frequency distribution most resembled those in 1997, 1998 and 2002 (Kolmogorov-Smirnov tests, D_{max} = 16.7-18.7). All four surveys included multiple length modes from a succession of moderate to strong year classes (e.g., 1990/91, 1994/95, 1995/96, 1999/00, 2000/01, 2001/02, 2004/05, 2005/06) separated by years with modest recruitment. The relatively large contribution of one- and two-year-old krill this year indicates good recruitment success of both the 2004/05 (R2=0.200) and 2005/06 (R1=0.230) year classes. The revised recruitment index for the 2004/05 year class based on this years' sampling supports the hypothesis that in 2006 those individuals were concentrated in coastal regions south of the area surveyed and thus underrepresented (Loeb *et al.*, 2006). This has relevance to the importance of adequately sampling this region for establishing recruitment success from the previous year (R1). PSI values indicate that the overall maturity stage composition (28% juvenile, 15% immature and 57% mature) most resembled those of 1992 (87), 1997, 1998 and 2002 (82-84).

Analysis of the data presented in Table 4.8 demonstrates significant positive correlations between recruitment success and proportion of mature females in advanced stages during the A survey (n=15, T=+0.48, P=0.01), and particularly the proportions of gravid females (3d) during January-February Survey A (T=+0.50, P<0.01) and spent females (3e) during February-March Survey D (T=+0.43, P<0.05). The moderate proportions of advanced female maturity stages (53%) and gravid females (7.5%) this year were low compared to the previous two years and most resembled proportions during 2001. However, given the strong recruitment success of the 2000/01 year class good recruitment resulting from the 2006/07 spawn is not out of the realm of possibility.

The overall distribution of krill length-maturity stages resulting from cluster analysis was typical for the area during early summer, with smaller and younger stages in coastal regions and older mature stages offshore (Siegel, 1988). However, the pattern observed this year was quite similar to that of January 2002 when the smaller primarily juvenile stages were concentrated in central Bransfield Strait and larger primarily immature stages were distributed to the south and north of these and offshore to the east of Elephant Island. In this respect, examination of krill abundance and distributional attributes in the survey area during January indicates the importance of the South and Joinville Island Areas of Bransfield Strait in supporting the juvenile and immature krill. Highest or second highest mean January abundance values were represented in the Joinville Island Area during six of the seven years it was surveyed and in the South Area during seven of thirteen years. In contrast, second highest mean values were represented in the Elephant Island Area during only two of thirteen years. The large ID values associated with these means highlight the extreme patchiness of the younger stages in Bransfield Strait. In conjunction with interannual changes in the latitudinal distribution of krill length-maturity stages these results are of direct relevance for acoustic assessment of krill biomass which depends on adequately sampling those areas supporting sporadic dense concentrations of one- and two-year-old krill which constitute an important proportion of the total biomass.

Larvae (Tables 4.3; 4.7; 4.11): Like last year virtually all of the larval krill were calyptopis stage 1 resulting from initial spawning in late December-early January. However, the mean and median concentrations overall and within the Joinville and Elephant Island Areas were one and two orders of magnitude smaller than in 2006. This, together with lower proportions of advanced female maturity stages, suggests that spawning did not begin as a massive synchronized bout as it appeared to have in 2005/06. While larval concentrations were modest compared to 2006, they were comparable to those of January 2005 which was followed by elevated concentrations the following month with good success of the 2004/05 year class. Analysis of data presented in Table 4.3 yields a significant positive correlation between recruitment success and mean larval krill concentrations across the survey area in January (n=10, T=+0.58, $P<0.05$). Given the advancing maturity stages, mating and spawning behavior observed during Survey A, it is likely that appropriately timed larval production by large fecund females would have occurred in February-March 2007. Together with favorable feeding conditions associated with the January-February phytoplankton bloom in the South Shetland Islands region (See primary productivity in the Phytoplankton Section, this volume) and optimal conditions associated with current and predicted "Niño neutral" to La Niña conditions (NOAA Climate Prediction Center assessment, April 2007) this would bode well for good 2006/07 year class success and continued krill population growth.

4.3.2.2 Salps:

Salpa thompsoni (Tables 4.7, 4.9, 4.10): Mean and median salp abundance values in the Elephant Island Area were both below average (398 and 176 per 1000 m^3) for the 1992-2007 period. The mean was elevated over that of last year and similar to values of January 1999 and 2004, however the median (3.9 per 1000 m^3) approached the all time January low recorded here in 1995 (1.9 per 1000 m^3). The overall aggregate length-frequency distribution, with the majority of individuals between 25 and 35mm most resembled those of 1994 and 2004 (D_{max} 15.8-16.7). The combination of extremely low median salp abundance and extremely high median krill abundance in the Elephant Island Area resulted in an all time low salp:krill carbon biomass ratio of 0.005 in 2007. The significant association between *S. thompsoni* and ACC water this year conforms to results from the 2001-2006 period and supports reduced input from east of the Weddell Sea following a climatic regime shift in the mid-1990s (Loeb *et al*., 2007 submitted).

Ihlea racovitzai (Tables 4.11, 4.12): The low frequency of occurrence and numbers of *I. racovitzai* in the Elephant Island and large survey areas were similar to those in 2003 and 2006 and indicate minimal input from the Weddell Sea. These contrast markedly with the peak values associated with El Niño conditions in 1998 and 2004 (Loeb *et al*., 2007 submitted).

4.3.2.3 Nekton and Micronekton (Tables 4.7, 4.11, 4.12, 4.13, 4.14): Mean and median numbers of copepods in the Elephant Island Area were above the 1992-2007 long term average (1,028 and 470 per 1000 m^3) and were the third largest values recorded over this period, following the peaks in January 2002 and 2006. Proportions of total mean zooplankton abundance represented by copepods (72%) approached that of 2002 (76%). The mean abundance of second ranked postlarval *T. macrura* was well above the long term average and followed the highs in 2002 and 2003, but its median abundance was about average and similar to that in 2004. Similarly, the mean value of *S. thompsoni* placed it third in overall abundance and like postlarval *T. macrura* it constituted ca. 8.5% of total zooplankton but its median abundance was quite low. In contrast, the median abundance of postlarval krill in the Elephant Island Area was the highest recorded but its mean value ranked fourth, representing 3% of the total zooplankton. These results indicate how interannual variations in distributional attributes can dramatically influence species relative abundance assessments. Chaetognaths and larval krill both were represented by below average values, contributed respectively 2% and 1% of the total, and ranked fifth and sixth in mean abundance. In terms of mean abundance the overall zooplankton assemblage most resembled those in January 1997 and 2002 (PSIs 83 and 84), both of which were transition periods between La Niña and El Niño events. Of note is the relative paucity of typically abundant *T. macrura* larvae in 2007. Similarly low concentrations were recorded in January 1998, 2003 and 2004 suggesting that these may be somehow related to hydrographic conditions associated with ENSO variability, possibly during the late winter (September) spawning season. Barnacle larvae have been identified during past AMLR cruises but were not tabulated under the impression that they were derived from fouling organisms on the ships hull. However, Ryan Driscoll indicated that the developmental stages obtained in this years samples could not have been derived from the ship. The significant relationship between the abundance of these larvae and Weddell Sea shelf water supports the idea of a high latitude benthic source. Larvae of an acorn barnacle *Bathylasma corolliforone* have been described from plankton samples taken in the Ross Sea. This species is also found in the Antarctic Peninsula region.

With respect to the copepod species composition, *M. gerlachei, C. acutus* and *C. propinquus* typically dominate in the Elephant Island Area in terms of mean abundance, with coastal *M. gerlachei* usually the most abundant. A notable exception was January 2002 when *C. propinquus* far outnumbered *M. gerlachei.* In January 2007 mean concentrations of *M. gerlachei* were the fourth highest reported for AMLR surveys, following those of 1989, 1990 and 2006. *Calanus propinquus* was comparatively rare with the lowest mean and median values so far recorded while a previously unidentified taxon, *Pareuchaeta* spp., followed *M. gerlachei* in mean abundance and *C. acutus* in median abundance. Whether these shifts result from a change in copepod species identifications implemented in 2007 or are indeed due to actual abundance fluctuations between a typically common species and otherwise infrequent taxon must be resolved. However, the latter possibility is perhaps not out of the realm of possibility given large interannual abundance variations exhibited by all the copepod taxa.

4.4 AMLR 2007 Cruise Summary:

1. Mean and median krill abundance values in the Elephant Island Area January 2007 were well above average for the past 15 years, with mean concentration the third highest after 2003 and 1996 values and median concentration the highest recorded. Peak krill abundance typically results from the massive influx of juveniles through good recruitment success.

2. The length-frequency distribution indicated substantial proportions of one- and two-year-old krill as well as older, mature individuals. Given the synchronized spawning bouts and dense larval concentrations observed last year good recruitment success was anticipated for the 2005/06 year class. Based on dense larval concentrations in February 2004/05 relatively good

recruitment by that year class was also anticipated but those individuals were under-represented in the 2006 net samples. At the time it was suspected that, like 2001, the juveniles were located to the south of the area surveyed in Bransfield Strait. Using 2007 length-frequency data Volker Siegel calculated an R1 recruitment index of 0.230 for the 2005/06 year class and an R2 of 0.200 for the 2004/05 year class. Although these values appear to be modest one must keep in mind that they are based on proportions of the one- and two-year-old length classes relative to total krill abundance and larger, older krill (2003/04 and prior year classes) were also well represented in 2007.

3. Largest krill catches were attributed to infrequent but extremely dense concentrations of juvenile and immature stages in Bransfield Strait. Given apparent interannual latitudinal shifts of all krill length/maturity stages this reinforces the importance of adequate sampling efforts in Bransfield Strait, particularly its southern portion, for establishing krill biomass and recruitment success.

4. The association of gravid females, larval and juvenile krill with deep basins in Bransfield Strait supports the importance of these features as spawning and nursery areas (Spiridonov, 1996).

5. Given the advancing maturity stages, mating and spawning behavior during Survey A it is likely that peak production by abundant and large (i.e., fecund) females occurred in February-March 2007 (Survey D not sampled this year). As noted in this report, krill recruitment success is significantly correlated with proportions of advanced female maturity stages and mean larval abundance during Survey A. Together with favorable feeding conditions associated with the January-February phytoplankton bloom, and conditions associated with predicted La Niña conditions in 2007, this would bode well for the 2006/07 year class and continued krill population growth through multiyear sequences of moderate to strong recruitment.

6. Mean and median *S. thompsoni* abundance values in the Elephant Island Area were both below the average of the past 15 years, with the median close to the all time January low in 1995. The significant association between *S. thompsoni* and ACC water conforms to results from 2001-2006 and is consistent with minimal input from east of the Weddell Sea following a climatic regime shift in the mid-1990s. The low frequency of occurrence and numbers of *I. racovitzai* indicate minimal Weddell Sea influence during the survey. These contrast markedly with the peak values associated with El Niño conditions in 1998 and 2004 (Loeb *et al*., 2007 submitted).

7. The overall zooplankton assemblage in the Elephant Island Area during January 2007, numerically dominated by copepods (*M. gerlachei*), postlarval *T. macrura* and krill, and patchy concentrations of *S. thompsoni* conform to the quintessential "East Wind Drift" assemblage from the Discovery Expeditions. However, the mean and median numbers of copepods, postlarval *T. macrura* and krill were all above the long term average suggesting that this assemblage is quite rich compared to those sampled in the 1990s.

4.5 Problems and Suggestions:

(1) Despite overcrowded conditions the AMLR 2007 field season was probably the most harmonious ever. Unfortunately it was far too short, and while it was sweet, it was still far too crowded. Hopefully both issues will be resolved in 2008 and subsequent years. Fortunately we are looking forward to two cruise legs during the 2008 International Polar Year and we all certainly hope that these, plus the additional third fish stock assessment cruise leg, will continue well into the future.

(2) As indicated in this report, larval krill concentrations in February-March form a valuable predictive tool for year class success. Recognizing this, it is now important to focus on seasonal changes in larval distribution patterns with respect to advective processes and ultimate local recruitment success.

(3) Year after year the Joinville Island Area and southern Bransfield Strait have been shown to be important locations of larval, juvenile and immature krill stages yet they remain under-sampled. We highly recommend increased sampling effort in the Joinville Island Area to a level similar to that represented by the South Area (i.e., 1 per 1224 km^2, or 15 stations). Also, it is imperative that at all stations in Bransfield Strait that are not sampled due to ice conditions be replaced by alternative stations nearby.

(4) One of these days it would be wonderful to replace the old worn out and rusty plankton van.

(5) Collaboration among the AMLR scientists should be encouraged and supported. The La Jolla workshop last November where the different scientific components discussed their projects was a very productive exercise that has led to greater understanding, cooperation and collaboration. We hope that these will occur on an annual basis and result in subsequent collaboration on manuscript preparation.

4.6 Acknowledgments: It was wonderful to once again enjoy the facilities and personnel of the R/V *Yuzhmorgeologiya*. Captain Sasha was superb in his command of the ship and crew and in his positive interactions with the scientific party! Thanks to all of the many scientists who, despite the difficulties of being dense packed into living conditions, worked hard together in such a harmonious and congenial manner! Again, it was quite satisfying to have the Santora-Force underway bird and mammal team keeping us informed of the exciting wildlife that surrounds us while we toil way below decks....often giving us enough time to capture some of these on film! We thank Volker Siegel for his continued efforts in generating krill recruitment indices for the long term data base.

4.7 References:

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Table 4.1. AMLR 2007 Large-area survey IKMT station information. Double lines denote subarea divisions.

SURVEY A

STATION	DATE	TIME START (LOCAL)	TIME END (LOCAL)	DIEL	TOW DEPTH (m)	FLOW VOL. (m3)	TOTAL N	KRILL ABUNDANCE N/m2	KRILL ABUNDANCE N/1000m3
SOUTH AREA:									
A09-09	11/01/07	0340	0411	D	170	2689.0	77	4.9	28.6
A08-10	11/01/07	0659	0726	D	170	2331.7	15	1.1	6.4
A07-11	11/01/07	1026	1053	D	170	2336.8	57	4.1	24.4
A08-12	11/01/07	1311	1343	D	170	2656.7	79	5.1	29.7
A09-11	11/01/07	1805	1833	D	170	2205.6	428	33.0	194.0
A10-10	11/01/07	2138	2203	T	170	2155.3	5	0.4	2.3
A11-11	12/01/07	0129	0152	N	170	1754.7	0	0.0	0.0
A10-12	12/01/07	0452	0519	T	170	2262.2	2588	194.5	1144.0
A09-13	12/01/07	0749	0813	D	170	2139.1	17	1.4	7.9
A11-13	12/01/07	1143	1210	D	169	2287.7	2290	169.2	1001.0
A12-12	12/01/07	1658	1724	D	170	2039.8	77	6.4	37.7
A13-11	12/01/07	2016	2042	D	169	2043.2	0	0.0	0.0
A14-12	13/01/07	0022	0048	N	172	2039.3	0	0.0	0.0
A13-13	13/01/07	0354	0423	T	170	2330.9	37	2.7	15.9
A12-14	13/01/07	0711	0729	D	120	1663.8	39	2.8	23.4
A14-14	13/01/07	1025	1056	D	170	2738.0	48	3.0	17.5
A15-13	13/01/07	1536	1606	D	172	2648.5	760	49.4	287.0
A15-15	13/01/07	2000	2026	D	170	2128.6	711	56.8	334.0
A16-14	13/01/07	2338	0005	N	171	2226.5	45	3.5	20.2
A17-13	14/01/07	0300	0328	N	171	2482.5	3	0.2	1.2
WEST AREA:									
A18-12	14/01/07	0738	0803	D	171	2058.0	34	2.8	16.5
A19-11	14/01/07	1104	1135	D	170	2497.1	65	4.4	26.0
A20-10	14/01/07	1349	1417	D	170	2384.9	9	0.6	3.8
A19-09	14/01/07	1915	1941	D	170	2182.5	61	4.8	27.9
A18-10	14/01/07	2243	2309	T	170	2348.7	0	0.0	0.0
A17-11	15/01/07	0151	0211	N	110	1807.8	12	0.7	6.6
A16-10	15/01/07	0504	0530	D	171	2165.0	10	0.8	4.6
A17-09	15/01/07	0829	0956	D	170	2251.9	3	0.2	1.3
A18-08	15/01/07	1111	1143	D	170	2691.8	66	4.2	24.5
A17-07	15/01/07	1953	2021	D	172	2563.8	123	8.3	48.0
A16-08	15/01/07	2303	2331	T	170	2441.0	65	4.5	26.6
A15-09	16/01/07	0338	0407	T	171	2440.6	29	2.0	11.9
A14-10	16/01/07	0707	0721	D	73	1282.6	241	13.7	187.9
A13-09	16/01/07	1018	1048	D	170	2541.2	170	11.4	66.9
A14-08	16/01/07	1307	1336	D	170	2550.5	33	2.2	12.9
A15-07	16/01/07	1842	1915	D	170	2962.4	114	6.5	38.5
A16-06	16/01/07	2213	2238	T	170	1959.1	13	1.1	6.6
A15-05	17/01/07	0155	0227	N	170	2969.0	0	0.0	0.0
A14-06	17/01/07	0626	0654	D	169	2622.4	5	0.3	1.9
A13-07	17/01/07	1004	1031	D	170	2385.9	42	3.0	17.6
A12-08	17/01/07	1255	1325	D	170	2637.7	770	49.6	291.9
A11-07	17/01/07	1924	1951	D	170	2513.5	275	18.6	109.4
A11-01	18/01/07	2341	0011	N	171	2698.4	158	10.0	58.6
ELEPHANT ISLAND AREA:									
A09-01	19/01/07	0436	0511	T	170	3167.5	6	0.3	1.9
A09-02	19/01/07	0734	0802	D	170	2446.5	189	13.1	77.3
A09-03	19/01/07	1027	1056	D	170	2176.1	86	6.7	39.5
A09-04	19/01/07	1233	1304	D	170	2781.2	24	1.5	8.6
A09-05	19/01/07	1834	1859	D	170	2053.3	56	4.6	27.3
A09-06	19/01/07	2125	2151	T	170	2102.9	72	5.8	34.2
A09-07	20/01/07	0015	0046	N	170	2519.8	184	12.4	73.0
A09-08	20/01/07	0301	0332	N	170	2656.2	727	46.5	273.7
A08-08	20/01/07	0602	0628	D	171	2224.4	20	1.5	9.0
A08-06	20/01/07	1037	1104	D	170	2368.3	160	11.5	67.6
A08-04	20/01/07	1424	1453	D	170	2508.7	29	2.0	11.6
A08-02	20/01/07	2029	2053	D	170	2122.5	40	3.2	18.8
A07-01	21/01/07	0022	0051	N	171	2530.8	208	14.1	82.2
A07-02	21/01/07	0337	0407	T	175	2638.5	55	3.6	20.8
A07-03	21/01/07	0637	0704	D	171	2316.4	295	21.8	127.4
A07-04	21/01/07	0928	0955	D	169	2556.7	190	12.6	74.3
A07-05	21/01/07	1139	1208	D	169	2449.1	28	1.9	11.4
A07-06	21/01/07	1616	1644	D	170	2054.3	113	9.4	55.0

Table 4.1 (Contd.)

SURVEY A

STATION	DATE	TIME START (LOCAL)	TIME END (LOCAL)	DIEL	TOW DEPTH (m)	FLOW VOL. (m3)	TOTAL N	KRILL ABUNDANCE N/m2	KRILL ABUNDANCE N/1000m3
A07-07	21/01/07	1853	1920	D	170	2465.1	141	9.7	57.2
A07-08	21/01/07	2132	2202	T	170	2451.7	109	7.6	44.5
A05.5-08	22/01/07	0123	0150	N	170	2164.6	0	0.0	0.0
A05.5-07	22/01/07	0357	0428	T	170	2536.7	82	5.5	32.3
A05.5-06	22/01/07	0650	0707	D	110	1458.1	528	39.8	362.1
A05.5-05	22/01/07	0922	0948	D	146	2133.2	18	1.2	8.4
A05.5-04	22/01/07	1150	1220	D	170	2459.6	888	61.4	361.0
A05.5-03	22/01/07	1620	1650	D	170	2772.3	70	4.3	25.2
A05.5-02	22/01/07	1935	2004	D	170	2467.3	41	2.8	16.6
A05.5-01	22/01/07	2233	2302	T	170	2294.3	4	0.3	1.7
A04-01	23/01/07	0307	0335	N	171	2312.8	79	5.8	34.2
A04-02	23/01/07	0603	0632	D	170	2350.8	53	3.8	22.5
A04-03	23/01/07	0851	0920	D	170	2593.0	26	1.7	10.0
A04-04	23/01/07	1101	1129	D	170	2461.4	146	10.1	59.3
A04-05	23/01/07	1539	1609	D	170	2537.8	2	0.1	0.8
A04-06	23/01/07	2015	2041	D	170	2256.9	0	0.0	0.0
A04-07	23/01/07	2253	2318	T	170	1999.7	795	67.6	397.6
A04-08	24/01/07	0143	0211	N	169	2434.1	5	0.3	2.1
A03-08	24/01/07	0525	0554	T	172	2443.2	2	0.1	0.8
A03-06	24/01/07	0947	1014	D	170	2400.1	123	8.7	51.2
A03-04	24/01/07	1344	1414	D	170	2476.1	110	7.6	44.4
A03-02	24/01/07	1931	1955	D	171	2048.2	25	2.1	12.2
A02-01	24/01/07	2138	2346	N	170	2494.7	296	20.2	118.6
A02-02	25/01/07	0309	0338	N	170	2422.7	118	8.3	48.7
A02-03	25/01/07	0607	0635	D	170	2306.3	12	0.9	5.2
A02-04	25/01/07	0855	0923	D	170	2417.5	180	12.7	74.5
A02-05	25/01/07	1112	1144	D	169	2681.5	445	28.0	166.0
A02-06	25/01/07	1649	1717	D	170	2474.2	528	36.3	213.4
A02-07	25/01/07	1931	1959	D	171	2564.3	4	0.3	1.6
A02-08	25/01/07	2220	2248	T	171	2317.8	2	0.1	0.9
JOINVILLE ISLAND AREA:									
A02-09	26/01/07	0126	0201	N	171	2530.1	8	0.5	3.2
A02-10	26/01/07	0459	0532	T	170	2701.7	7	0.4	2.6
A04-09	26/01/07	1000	1029	D	169	2408.1	4999	350.8	2075.9
A05-09	26/01/07	1206	1235	D	170	2633.9	208	13.4	79.0
A06-09	26/01/07	1603	1633	D	171	2587.4	1082	71.5	418.2
A06-10	26/01/07	1853	1919	D	169	2285.0	5	0.4	2.2
A06-11	26/01/07	2132	2156	T	170	2447.8	2	0.1	0.8

		F(N)	F(%)	TOTAL		KRILL ABUNDANCE N/m2	KRILL ABUNDANCE N/1000m3
SURVEY A TOTAL	N=98	91	92.9	23197	MEAN	17.0	102.4
					STD	44.7	265.3
					MED	4.0	23.9
SOUTH AREA:	N=20	17	85.0	7276	MEAN	26.9	158.8
					STD	54.2	319.7
					MED	3.2	21.8
WEST AREA:	N=23	21	91.3	2298	MEAN	6.5	43.0
					STD	10.4	67.7
					MED	3.0	17.6
ELEPHANT ISLAND AREA:	N=48	46	95.8	7314	MEAN	10.8	66.4
					STD	15.3	96.5
					MED	5.7	33.2
JOINVILLE ISLAND AREA:	N= 7	7	100	6311	MEAN	62.5	368.8
					STD	120.2	711.0
					MED	0.5	3.2

Table 4.2 Maturity stage composition of krill collected in the large survey area and subareas during January 2007. Advanced maturity stages are proportions of mature females that are 3c-3e (i.e., with ovarian development, gravid and spent).

	Euphausia superba				
	January 2007				
Area	Survey A	West	Elephant I.	Joinville I.	South
Stage	%	%	%	%	%
Juveniles	62.4	28.7	28.1	90.8	82.0
Immature	11.0	10.2	15.1	7.6	10.1
Mature	26.5	61.0	56.8	1.6	7.9
Females:					
F2	0.9	1.2	1.4	0.8	0.3
F3a	2.6	2.3	5.1	0.1	2.4
F3b	4.9	15.5	10.8	0.0	0.3
F3c	3.7	5.2	9.6	0.0	0.7
F3d	2.6	0.8	7.5	0.1	0.3
F3e	0.7	1.1	0.5	0.8	0.7
Advanced Stage	48.2	28.4	52.7	91.0	38.5
Males:					
M2a	5.7	7.0	5.5	5.4	5.7
M2b	2.8	1.2	4.3	1.4	3.1
M2c	1.6	0.8	3.9	0.0	1.0
M3a	1.2	0.9	2.6	0.3	0.6
M3b	10.8	35.0	20.7	0.4	3.0
Male:Female	1.4	1.7	1.1	4.3	2.9
No. measured	6081	1216	3398	387	1080

Table 4.3. Larval krill stage composition and abundance in (A) Large Survey Areas, 1996-2007, and (B) individual survey areas, 2001-2006. Only pooled calyptopis and furcilia stages provided for 1996-1999. Individual stages provided for 2000-2007 surveys. R is the proportional recruitment index for each year class. n.a. indicates that samples were not available.

(A) Large Survey Area

Stage %	A96	A97	A98	A99	A00	A01	A02	A03	A04	A05	A06	A07
Calyptopis	100	93	68	100	n.a.	100	70	100	95	99	100	100
Furcilia	---	7	32	---	n.a.	---	30	---	5	1	---	---
No. 1000 m-3												
Mean	2.7	15.4	1.0	103.1	n.a.	160.2	19.4	3.4	7.0	18.6	1005.2	14.0
STD	7.5	27.1	4.5	587.4	n.a.	710.8	48.6	12.1	14.6	66.8	3702.8	50.2
Med	0.0	0.8	0.0	2.6	n.a.	12.5	0.0	0.0	0.4	0.5	4.1	0.2

Stage %	D96	D97	D98	D99	D00	D01	D02	D03	D04	D05	D06	D07
Calyptopis	86	100	99	97	97	98	85	89	44	85	n.a.	n.a.
Furcilia	14	---	1	3	3	2	15	11	56	15	n.a.	n.a.
No. 1000 m-3												
Mean	13.9	25.0	1.6	49.8	2129.6	683.4	61.0	3.9	107.7	183.1	n.a.	n.a.
STD	40.2	81.4	14.1	119.3	7247.8	3607.1	220.4	10.5	523.1	840.6	n.a.	n.a.
Med	3.0	0.0	0.0	9.0	34.2	10.5	0.0	0.0	20.2	0.0	n.a.	n.a.

R	0.198	0.120	0.000	0.000	0.573	0.403	0.478	0.001	0.014	0.200	0.230

(B) Elephant Island, West, South and Joinville Island Areas

Survey	A01			A02				A03			
Stage %	West	Eleph	South	West	Eleph	South	Joinvl	West	Eleph	South	Joinvl
C1	17.6	68.4	95.3	50.0	40.3	13.9	5.0	77.7	89.7	100	100
C2	72.7	22.1	---	50.0	16.3	7.0	2.9	1.9	8.8	---	---
C3	9.7	9.3	---	---	20.3	---	52.5	20.4	1.5	---	---
Unid.	---	0.2	4.7	---	---	---	---	---	---	---	---
Calyptopis	100	100	100	100	76.9	20.9	60.4	100	100	100	100
F1	---	---	---	---	6.2	35	38.2	---	---	---	---
F2	---	---	---	---	17.0	44.1	1.4	---	---	---	---
F3	---	---	---	---	---	---	---	---	---	---	---
Unid.	---	---	---	---	---	---	---	---	---	---	---
Furcilia	---	---	---	---	23.1	79.1	39.6	---	---	---	---
No. 1000 m-3											
Mean	472.6	32.8	2.9	1.5	35.8	13.4	1107.0	3.6	4.7	1.0	7.1
STD	1243.8	86.2	6.9	7.6	64.6	30.3	2602.6	7.5	16.8	3.1	6.4
Med	66.5	9.0	---	---	---	---	92.9	---	---	---	5.7

Survey	A04				A05				A06				A07			
Stage %	West	Eleph	South	Joinvl	West	Eleph	South	Joinvl	West	Eleph	South	Joinvl	West	Eleph	South	Joinvl
C1	80.0	63.4	60.7	68.2	84.3	90.8	64.2	78.6	94.2	99.9	94.7	99.9	100	100	99.0	97.3
C2	8.3	22.1	7.6	24.9	---	6.6	22.2	10.3	3.4	0.1	3.9	0.1	---	---	1.0	1.6
C3	---	12.4	8.6	---	---	0.2	8.0	11.0	---	---	---	---	---	---	---	1.1
Unid.	4.3	2.0	0.0	---	3.7	1.4	4.2	---	---	---	---	---	---	---	---	---
Calyptopis	92.6	100	76.9	93.1	88.0	100	98.6	100	97.6	100	98.6	100	100	100	100	100
F1	---	---	19.3	6.9	12.0	---	1.4	---	1.8	---	1.4	---	---	---	---	---
F2	---	---	3.9	---	---	---	---	---	---	---	---	---	---	---	---	---
F3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Unid.	7.4	---	---	---	---	---	---	---	0.6	---	---	---	---	---	---	---
Furcilia	7.4	---	23.1	6.9	12.0	---	1.4	---	2.4	---	1.4	---	---	---	---	---
No. 1000 m-3																
Mean	2.2	9.8	7.0	4.6	2.8	22.0	26.4	30.9	8.2	2029.4	16.4	261.5	1.9	22.1	3.6	31.7
STD	6.5	18.5	9.4	6.3	8.3	78.3	79.6	40.6	22.1	5118.2	53.0	554.5	4.5	68.8	4.7	33.6
Med	---	0.4	2.4	2.0	---	1.1	1.2	13.8	0.0	18.9	0.0	14.2	---	2.3	1.8	13.9

Survey	D01			D02				D03			
Stage %	West	Eleph	South	West	Eleph	South	Joinvl	West	Eleph	South	Joinvl
C1	37.6	58.4	17.8	3.2	42.2	50.3	---	100	63.4	78.8	100
C2	36.1	29.4	15.2	16.7	4.1	49.7	15.6	---	22.8	21.2	---
C3	18.0	10.7	67.0	70.0	23.5	---	29.5	---	---	---	---
Unid.	0.8	---	---	9.5	---	---	---	---	---	---	---
Calyptopis	92.5	98.6	100	99.3	69.8	100	45.1	100	86.2	100	100
F1	7.4	1.4	---	0.7	22.8	---	26.8	---	1.3	---	---
F2	0.1	---	---	---	7.4	---	12.1	---	12.5	---	---
F3	---	---	---	---	---	---	16.1	---	---	---	---
Unid.	---	---	---	---	---	---	---	---	---	---	---
Furcilia	7.5	1.4	---	0.7	30.2	---	54.9	---	13.8	---	---
No. 1000 m-3											
Mean	2119.3	71.9	4.8	133.7	49.9	0.4	29.2	0.1	6.1	2.8	4.8
STD	6328.9	176.9	9.8	380.9	140.9	1.1	38.4	0.6	13.0	9.1	7.9
Med	42.5	5.1	---	---	---	---	0.0	---	---	---	0.4

Survey	D04				D05				D06 (n.a.)				D07 (n.a.)			
Stage %	West	Eleph	South	Joinvl	West	Eleph	South	Joinvl								
C1	31.6	14.2	37.5	17.8	100	22.2	2.2	0.3								
C2	27.1	10.7	29.6	41.3	---	45.0	15.6	86.0								
C3	40.2	8.0	14.9	13.5	---	18.1	21.7	8.7								
Unid.	---	---	---	---	---	4.5	---	---								
Calyptopis	98.9	32.9	82.0	72.6	100	89.9	39.5	95.0								
F1	1.1	5.8	9.0	11.4	---	9.9	46.3	3.5								
F2	---	29.3	4.7	13.4	---	---	13.9	1.1								
F3	---	31.6	4.3	2.6	---	---	---	0.4								
Unid.	---	0.4	---	---	---	0.3	0.3	---								
Furcilia	1.1	67.1	18.0	27.4	---	10.1	60.5	5.0								
No. 1000 m-3																
Mean	41.0	177.3	23.2	87.2	0.8	194.8	127.9	1014.4								
STD	79.7	741.5	31.6	86.4	3.9	969.1	511.8	1511.1								
Med	15.1	38.9	5.2	40.7	---	4.6	0.4	33.2								

Table 4.4. Composition and abundance of zooplankton assemblages sampled in the large Survey A area, January, 2007. F(%) is frequency of occurrence in samples. R is rank and % is percent of total mean abundance represented by each taxon. L and J denote larval and juvenile stages.

	AMLR 2007 SURVEY A (N=98)						
TAXON	F(%)	R	%	MEAN	STD	MEDIAN	MAX
Total Copepods	100.0	1	63.0	1325.4	2466.7	636.0	21572.8
Other copepods	100.0		8.3	174.8	278.7	106.6	1901.6
Pareuchaeta spp.	96.9		9.5	200.8	275.9	89.1	1926.0
Calanoides acutus	96.9		8.8	184.6	190.2	116.9	904.9
Rhincalanus gigas	88.8		1.7	35.3	43.8	16.1	228.4
Metridia gerlachei	80.6		33.0	695.1	2236.1	22.5	19858.8
Calanus propinquus	80.6		1.5	31.6	81.0	9.3	536.3
Pareuchaeta antarctica	19.4		0.0	0.4	1.4	0.0	7.9
Heterorhabdus sp.	17.3		0.0	0.8	2.2	0.0	12.2
Haloptilus ocellatus	10.2		0.0	0.5	2.0	0.0	13.3
Pleuromama robusta	8.2		0.1	1.5	7.1	0.0	59.3
Candacia spp.	3.1		0.0	0.0	0.2	0.0	2.0
Copepodites	1.0		0.0	0.0	0.0	0.0	0.0
Thysanoessa macrura	94.9	2	9.3	195.9	297.0	89.9	2196.9
Chaetognaths	94.9	6	2.1	43.2	76.0	12.1	511.7
Euphausia superba	91.8	4	4.8	101.3	264.2	24.5	2075.9
Primno macropa	85.7		0.5	10.8	15.2	5.6	101.3
Limacina helicina	76.5	7	1.7	36.0	91.8	9.8	780.8
Tomopteris spp.	75.5		0.2	4.9	8.3	1.6	59.6
Spongiobranchaea australis	71.4		0.1	1.1	1.3	0.7	6.9
Radiolaria	69.4		0.3	6.5	12.2	3.0	97.7
Thysanoessa macrura (L)	63.3	5	4.7	99.7	511.1	2.1	3129.7
Euphausia spp.	61.2		0.5	10.7	22.7	1.2	149.8
Hyperiella dilatata	61.2		0.1	1.2	2.0	0.4	10.5
Themisto gaudichaudii	54.1		0.3	6.4	15.5	0.4	114.9
Lepidonotothen larseni (L)	53.1		0.1	1.9	4.1	0.4	25.0
Ostracods	52.0	9	0.5	11.2	35.5	0.4	301.8
Euphausia superba (L)	50.0	8	0.7	14.3	50.2	0.2	399.3
Vibilia antarctica	49.0		0.2	3.5	9.9	0.0	74.3
Salpa thompsoni	48.0	3	8.6	181.4	597.3	0.0	4805.7
Euphausia frigida	46.9	10	0.5	11.1	33.3	0.0	229.6
Limacina spp.	44.9		0.3	5.6	12.3	0.0	88.5
Euphausia crystallorophias	39.8		0.4	9.1	25.2	0.0	172.6
Larval Fish (unid)	38.8		0.0	1.0	2.3	0.0	15.1
Diphyes antarctica	38.8		0.0	0.5	1.1	0.0	6.3
Siphonophora (unid)	36.7		0.1	2.8	8.4	0.0	75.0
Clione limacina	34.7		0.0	0.6	1.9	0.0	17.5
Sipunculids	34.7		0.0	0.4	0.7	0.0	3.4
Cyllopus magellanicus	33.7		0.1	2.8	9.3	0.0	77.3
Amphipods (unid)	24.5		0.1	2.0	11.8	0.0	115.9
Isopods (unid)	24.5		0.0	0.6	1.2	0.0	7.8
Hydromedusae (unid)	24.5		0.0	0.2	0.6	0.0	5.7
Hyperiella spp.	20.4		0.0	0.4	1.3	0.0	6.7
Lepidonotothen kempi (L)	19.4		0.0	0.6	1.9	0.0	9.8
Rhynchonereelia bongraini	19.4		0.0	0.4	1.2	0.0	6.6
Euphausia triacantha	18.4		0.1	1.2	3.9	0.0	20.9
Hyperiella macronyx	18.4		0.0	0.1	0.4	0.0	2.7
Ihlea racovitzai	17.3		0.0	0.8	3.2	0.0	19.8
Barnacle larvae	17.3		0.0	0.7	2.0	0.0	11.7
Ctenophora (unid)	17.3		0.0	0.2	0.7	0.0	4.9
Electrona spp. (L)	15.3		0.0	0.4	2.1	0.0	20.4
Pelagobia longicirrata	15.3		0.0	0.1	0.5	0.0	3.9
Larvaceans	14.3		0.0	1.0	3.5	0.0	21.3
Polychaetes (unid)	14.3		0.0	0.4	1.3	0.0	8.7

Table 4.4 (Contd.)

TAXON	F(%)	R	%	MEAN	STD	MEDIAN	MAX
Callanira antarctica	14.3		0.0	0.2	1.0	0.0	7.5
Euphausia spp. (L)	13.3		0.1	1.3	9.1	0.0	89.7
Notolepis coatsi (L)	12.2		0.0	0.2	0.6	0.0	3.4
Clio pyramidata spp?	12.2		0.0	0.1	0.7	0.0	4.9
Eggs (unid)	11.2		0.0	0.5	1.7	0.0	8.9
Spongiobranchaea sp.	11.2		0.0	0.2	0.6	0.0	4.1
Vanadis antarctica	10.2		0.0	0.1	0.7	0.0	5.6
Orchomene plebs	9.2		0.0	0.1	0.3	0.0	2.8
Dimophyes arctica	9.2		0.0	0.1	0.3	0.0	2.1
Cyllopus spp.	8.2		0.0	0.2	0.9	0.0	6.4
Orchomene spp.	8.2		0.0	0.1	0.3	0.0	1.9
Beroe cucumis	8.2		0.0	0.0	0.2	0.0	1.1
Acanthophyra pelagica	8.2		0.0	0.0	0.1	0.0	0.8
Euphausia frigida (L)	7.1		0.0	0.4	1.9	0.0	15.1
Cyllopus lucasii	7.1		0.0	0.1	0.4	0.0	2.6
Pegantha martgon	7.1		0.0	0.1	0.3	0.0	2.6
Gastropods (unid)	7.1		0.0	0.0	0.2	0.0	2.0
Clio pyramidata sulcata	6.1		0.0	0.3	1.9	0.0	14.4
Scina spp.	6.1		0.0	0.2	0.7	0.0	4.8
Orchomene rossi	6.1		0.0	0.0	0.2	0.0	1.2
Cephalopods	5.1		0.0	0.0	0.1	0.0	0.6
Hyperiids (unid)	4.1		0.0	0.1	0.5	0.0	3.0
Calycopsis borchgrevinki	3.1		0.0	0.0	0.1	0.0	0.8
Electrona antarctica	3.1		0.0	0.0	0.1	0.0	0.8
Electrona carlsbergi	3.1		0.0	0.0	0.1	0.0	0.8
Epimeriella macronyx	3.1		0.0	0.0	0.1	0.0	0.4
Notolepis spp. (L)	3.1		0.0	0.0	0.1	0.0	0.4
Mysids (unid)	2.0		0.0	0.6	5.7	0.0	56.4
Thyphloscolecidae	2.0		0.0	0.1	0.8	0.0	7.5
Thyploscolex muelleri	2.0		0.0	0.1	0.5	0.0	5.2
Eusirus antarcticus	2.0		0.0	0.0	0.2	0.0	1.5
Hyperiella antarctica	2.0		0.0	0.0	0.1	0.0	0.8
Chionodraco rastrospinosus (L)	2.0		0.0	0.0	0.1	0.0	0.5
Mertensia spp.	2.0		0.0	0.0	0.1	0.0	0.5
Schyphomedusae (unid)	2.0		0.0	0.0	0.1	0.0	0.4
Clione antarctica	2.0		0.0	0.0	0.0	0.0	0.0
Cumaceans	1.0		0.0	0.1	0.5	0.0	5.0
Lepidonotothen larseni (J)	1.0		0.0	0.0	0.3	0.0	3.0
Decapods (unid)	1.0		0.0	0.0	0.1	0.0	1.2
Gymnoscopelus braueri	1.0		0.0	0.0	0.1	0.0	0.8
Clio pyramidata antarctica?	1.0		0.0	0.0	0.1	0.0	0.7
Staurophora mertensi?	1.0		0.0	0.0	0.0	0.0	0.5
Pleuragramma antarcticum (L)	1.0		0.0	0.0	0.0	0.0	0.5
Eusirus spp.	1.0		0.0	0.0	0.0	0.0	0.4
Pleurobrachia pileus	1.0		0.0	0.0	0.0	0.0	0.4
Beroe forskalii	1.0		0.0	0.0	0.0	0.0	0.4
Electrona antarctica	1.0		0.0	0.0	0.0	0.0	0.4
Pleuragramma antarcticum	1.0		0.0	0.0	0.0	0.0	0.4
Atolla wyvillei	1.0		0.0	0.0	0.0	0.0	0.4
Beroe spp.	1.0		0.0	0.0	0.0	0.0	0.4
Mertensiidae (family)	1.0		0.0	0.0	0.0	0.0	0.4
Cryodraco antarctica (L)	1.0		0.0	0.0	0.0	0.0	0.4
Hyperoche medusarum	1.0		0.0	0.0	0.0	0.0	0.4
Krefftichthys anderssoni	1.0		0.0	0.0	0.0	0.0	0.4
Artedidraco mirus (L)	1.0		0.0	0.0	0.0	0.0	0.0
TOTAL				2104.0	2748.6	1347.7	22648.0
TAXA	97			21.3	4.8	21.5	35

Table 4.5. Composition and abundance of zooplankton assemblages sampled in four subareas during January 2007 Survey A. F(%) is frequency of occurrence in samples. R is rank and % is proportion of total mean abundance represented by each taxon. (L) and (J) denote larval and juvenile stages.

	ELEPHANT ISLAND AREA N=48							WEST AREA N=23							SOUTH AREA N=20							JOINVILLE ISLAND AREA N=7						
TAXA	F(%)	R	%	MEAN	STD	MED	MAX	F(%)	R	%	MEAN	STD	MED	MAX	F(%)	R	%	MEAN	STD	MED	MAX	F(%)	R	%	MEAN	STD	MED	MAX
Total Copepods	100.0	1	71.3	1515.6	3190.0	716.3	21572.8	100.0	1	47.2	1193.3	1078.1	726.3	3974.2	100.0	1	65.2	1036.2	1688.3	250.9	6615.5	100.0	1	62.8	1281.1	1702.3	650.7	5362.1
Other copepods	100.0		7.0	148.2	113.7	115.6	498.6	100.0		13.7	346.4	504.8	176.6	1901.6	100.0		3.8	60.3	64.8	29.4	248.0	100.0		5.9	120.6	86.6	123.3	257.7
Calanoides acutus	100.0		9.5	200.9	180.8	170.0	739.5	91.3		5.4	135.4	190.4	86.8	904.9	95.0		9.3	147.6	158.8	111.0	478.0	100.0		16.7	340.0	231.3	406.2	643.0
Pareuchaeta spp.	95.8		10.1	215.2	236.0	122.3	1056.6	100.0		12.0	302.2	412.4	125.1	1926.0	95.0		5.2	82.2	96.5	48.7	356.3	100.0		5.3	107.3	119.5	63.5	367.2
Rhincalanus gigas	89.6		2.2	45.8	50.2	34.0	228.4	87.0		0.8	21.1	20.1	11.9	66.0	90.0		1.3	21.3	33.3	9.6	144.2	85.7		2.4	49.6	53.7	33.6	154.6
Metridia gerlachei	85.4		41.7	885.3	2953.0	27.3	19858.8	78.3		11.5	291.4	437.5	54.5	1708.6	70.0		45.0	715.9	1503.7	4.2	5693.6	85.7		32.2	657.3	1525.8	9.7	4392.6
Calanus propinquus	83.3		0.8	16.0	19.0	9.2	83.6	91.3		3.7	92.8	148.7	21.1	536.3	70.0		0.5	8.1	9.9	4.2	35.3	57.1		0.3	5.2	9.2	1.3	27.3
Pareuchaeta antarctica	20.8		0.0	0.6	1.7	0.0	7.9	4.3		0.0	0.0	0.0	0.0	0.0	30.0		0.0	0.6	1.5	0.0	6.8	28.6		0.0	0.2	0.3	0.0	0.8
Heterorhabdus sp.	18.8		0.0	0.7	2.0	0.0	9.9	21.7		0.1	1.6	3.3	0.0	12.2	10.0		0.0	0.2	0.7	0.0	2.5	14.3		0.0	0.3	0.8	0.0	2.2
Haloptilus ocellatus	8.3		0.0	0.7	2.6	0.0	13.3	17.4		0.0	0.5	1.4	0.0	5.9	5.0		0.0	0.1	0.2	0.0	1.1	14.3		0.0	0.6	1.6	0.0	4.4
Pleuromama robusta	12.5		0.1	2.2	9.0	0.0	59.3	8.7		0.1	1.9	6.4	0.0	26.7	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Candacia spp.	6.3		0.0	0.1	0.3	0.0	2.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Copepodites	2.1		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Thysanoessa macrura	95.8	2	8.5	180.4	350.1	57.0	2196.9	100.0	4	8.1	205.6	247.3	133.3	973.6	85.0	2	13.9	221.1	233.6	182.1	784.8	100.0	3	9.7	197.9	183.3	146.1	530.0
Euphausia superba	95.8	4	3.1	66.4	96.5	33.2	397.6	87.0	7	1.7	42.8	67.8	17.6	291.9	85.0	3	10.0	158.8	319.7	21.8	1144.0	100.0	2	18.1	368.8	711.0	3.2	2075.9
Chaetognaths	89.6	5	2.1	44.6	88.7	7.7	511.7	100.0	6	2.6	64.6	76.6	37.2	337.8	100.0	5	1.8	28.3	37.7	12.6	130.7	100.0		0.3	5.3	4.7	1.9	12.3
Primno macropa	87.5	9	0.5	10.7	16.1	6.6	101.3	78.3	10	0.6	15.8	18.4	9.9	61.2	90.0	10	0.4	5.7	6.6	3.2	19.6	85.7		0.5	9.2	6.7	10.3	19.3
Tomopteris spp.	83.3		0.3	6.0	10.4	2.8	59.6	87.0		0.2	6.1	6.3	4.4	23.5	55.0		0.1	1.4	2.5	0.2	10.8	42.9		0.2	3.1	4.3	0.0	10.0
Radiolaria	79.2		0.3	7.1	9.1	3.9	45.4	52.2		0.2	4.9	7.5	0.4	30.2	65.0		0.1	2.3	2.8	1.3	11.5	71.4		1.0	19.6	32.6	7.1	97.7
Spongiobranchaea australis	75.0		0.1	1.3	1.4	1.0	6.9	60.9		0.0	0.8	1.2	0.4	4.6	70.0		0.1	1.0	1.1	0.7	3.8	85.7		0.0	0.6	0.4	0.4	1.2
Limacina helicina	72.9	8	0.7	15.4	23.4	5.2	95.3	60.9	5	2.8	70.8	174.3	3.0	780.8	95.0	4	2.1	33.1	36.0	18.5	130.3	100.0	4	3.5	71.5	51.0	68.7	172.0
Salpa thompsoni	66.7	3	8.4	179.4	407.2	3.9	1731.0	65.2	3	15.8	398.7	1043.1	13.9	4805.7	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Hyperiella dilatata	56.3		0.1	1.4	2.4	0.4	10.5	60.9		0.1	1.3	2.2	0.4	10.2	65.0		0.0	0.5	0.5	0.4	1.3	85.7		0.1	1.0	0.8	1.1	2.6
Euphausia superba (L)	54.2	6	1.0	22.1	68.8	2.3	399.3	21.7		0.1	1.9	4.5	0.0	16.9	60.0		0.2	3.6	4.7	1.8	13.1	85.7	5	1.6	31.7	33.6	13.9	88.1
Ostracods	54.2	10	0.5	10.6	25.1	0.8	145.5	52.2		0.2	5.5	8.7	0.8	31.1	50.0	6	1.4	22.0	66.3	0.0	301.8	42.9		0.1	2.8	3.7	0.0	9.7
Euphausia spp.	54.2		0.4	7.9	22.8	0.7	149.8	91.3	9	0.7	16.8	24.0	7.9	95.5	55.0	8	0.9	14.3	22.5	0.8	72.9	28.6		0.0	0.2	0.4	0.0	1.2
Vibilia antarctica	54.2		0.1	2.6	4.1	0.4	16.3	73.9		0.4	9.4	18.1	0.8	74.3	20.0		0.0	0.3	0.8	0.0	3.7	14.3		0.0	0.1	0.1	0.0	0.4
Thysanoessa macrura (L)	52.1		0.2	4.9	10.1	1.2	62.5	82.6	2	16.3	410.8	993.0	7.6	3129.7	70.0		0.2	2.6	3.9	0.9	16.2	57.1		0.2	4.4	6.4	2.2	19.3
Themisto gaudichaudii	50.0		0.1	1.6	2.9	0.2	10.8	95.7	8	0.9	23.6	25.0	18.0	114.9	30.0		0.0	0.3	0.5	0.0	1.9	14.3		0.0	0.1	0.2	0.0	0.4
Euphausia frigida	47.9	7	0.8	17.7	45.0	0.0	229.6	52.2		0.4	9.2	16.9	0.4	57.8	35.0		0.0	0.7	1.1	0.0	4.0	57.1		0.1	1.5	1.5	1.7	4.1
Larval Fish (unid)	47.9		0.1	1.1	1.9	0.0	6.8	47.8		0.1	1.8	3.5	0.0	15.1	15.0		0.0	0.2	0.5	0.0	1.9	14.3		0.0	0.1	0.1	0.0	0.4
Cyllopus magellanicus	45.8		0.1	2.8	6.7	0.0	38.8	47.8		0.2	5.9	15.9	0.0	77.3	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Lepidonotothen larseni (L)	45.8		0.1	1.3	2.7	0.0	15.1	26.1		0.0	1.3	4.3	0.0	21.0	90.0		0.2	3.9	6.1	1.2	25.0	85.7		0.1	1.8	1.8	0.8	5.3
Diphyes antarctica	37.5		0.0	0.4	0.8	0.0	4.5	13.0		0.0	0.0	0.1	0.0	0.4	65.0		0.1	1.2	1.4	1.1	5.7	57.1		0.1	1.4	2.1	0.7	6.3
Limacina spp.	35.4		0.2	4.4	13.5	0.0	88.5	30.4		0.1	1.3	3.0	0.0	12.9	85.0	9	0.7	11.9	13.0	6.7	57.0	42.9		0.5	9.6	13.0	0.0	36.8
Sipunculids	33.3		0.0	0.3	0.6	0.0	2.5	4.3		0.0	0.0	0.2	0.0	0.8	60.0		0.1	0.8	1.0	0.5	3.4	71.4		0.0	0.9	0.9	0.8	2.6
Rhynchonereelia bongraini	31.3		0.0	0.8	1.6	0.0	6.6	4.3		0.0	0.1	0.3	0.0	1.5	0.0		0.0	0.0	0.0	0.0	0.0	42.9		0.0	0.7	1.2	0.0	3.4
Siphonophora (unid)	27.1		0.1	2.9	10.9	0.0	75.0	17.4		0.0	1.3	4.0	0.0	17.0	80.0		0.3	4.3	5.6	1.6	18.2	42.9		0.1	2.5	3.8	0.0	9.0
Amphipods (unid)	27.1		0.0	0.9	2.0	0.0	9.4	17.4		0.2	6.0	23.6	0.0	115.9	30.0		0.0	0.4	1.2	0.0	5.3	14.3		0.0	0.2	0.4	0.0	1.2
Clione limacina	25.0		0.0	0.6	2.5	0.0	17.5	30.4		0.0	0.4	0.9	0.0	3.4	60.0		0.1	0.9	1.3	0.7	5.7	42.9		0.0	0.8	1.1	0.0	2.8
Hydromedusae (unid)	22.9		0.0	0.2	0.8	0.0	5.7	21.7		0.0	0.1	0.3	0.0	1.0	35.0		0.0	0.2	0.3	0.0	0.9	14.3		0.0	0.2	0.4	0.0	1.2
Euphausia triacantha	20.8		0.1	1.2	3.6	0.0	15.3	21.7		0.1	2.6	6.0	0.0	20.9	15.0		0.0	0.1	0.3	0.0	1.5	0.0		0.0	0.0	0.0	0.0	0.0
Electrona spp. (L)	20.8		0.0	0.7	3.0	0.0	20.4	21.7		0.0	0.1	0.3	0.0	0.8	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Euphausia crystallorophias	16.7		0.1	2.6	9.3	0.0	48.2	69.6		0.6	14.8	36.8	2.0	172.6	60.0	7	1.3	20.8	32.2	7.0	112.8	42.9		0.1	2.2	4.3	0.0	12.7
Hyperiella spp.	16.7		0.0	0.5	1.5	0.0	6.7	26.1		0.0	0.6	1.2	0.0	4.4	30.0		0.0	0.2	0.3	0.0	1.1	0.0		0.0	0.0	0.0	0.0	0.0
Lepidonotothen kempi (L)	16.7		0.0	0.3	1.2	0.0	8.4	34.8		0.1	1.9	3.1	0.0	9.8	5.0		0.0	0.0	0.1	0.0	0.4	28.6		0.0	0.1	0.2	0.0	0.4
Larvaceans	14.6		0.0	1.0	3.3	0.0	20.9	0.0		0.0	0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0	0.4	85.7		0.4	7.4	7.0	6.8	21.3
Cyllopus spp.	14.6		0.0	0.4	1.2	0.0	6.4	4.3		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Isopods (unid)	14.6		0.0	0.3	0.8	0.0	4.5	13.0		0.0	0.2	0.7	0.0	2.8	60.0		0.1	1.5	1.9	1.2	7.8	28.6		0.0	0.7	1.1	0.0	2.6
Clio pyramidata spp.	14.6		0.0	0.2	0.9	0.0	4.9	8.7		0.0	0.1	0.3	0.0	1.5	5.0		0.0	0.0	0.0	0.0	0.0	28.6		0.0	0.2	0.3	0.0	0.8
Acanthophyra pelagica	14.6		0.0	0.1	0.2	0.0	0.8	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	14.3		0.0	0.1	0.1	0.0	0.4
Ctenophora (unid)	14.6		0.0	0.1	0.2	0.0	0.8	13.0		0.0	0.3	1.0	0.0	4.9	30.0		0.0	0.3	0.6	0.0	2.0	14.3		0.0	0.4	1.0	0.0	3.0
Ihlea racovitzai	12.5		0.1	1.3	4.4	0.0	19.8	13.0		0.0	0.2	0.5	0.0	2.1	25.0		0.0	0.6	1.4	0.0	6.3	42.9		0.0	0.5	0.9	0.0	2.7
Eggs (unid)	12.5		0.0	0.4	1.3	0.0	7.8	0.0		0.0	0.0	0.0	0.0	0.0	10.0		0.0	0.2	0.8	0.0	3.4	42.9		0.2	3.5	4.1	0.0	8.9
Barnacle larvae	12.5		0.0	0.3	1.0	0.0	4.1	4.3		0.0	0.0	0.2	0.0	0.9	35.0		0.1	2.0	3.4	0.0	11.7	42.9		0.1	2.0	2.7	0.0	7.5
Polychaetes (unid)	12.5		0.0	0.2	0.6	0.0	3.5	13.0		0.0	0.3	1.1	0.0	4.5	10.0		0.0	0.5	1.9	0.0	8.7	42.9		0.1	1.6	2.5	0.0	7.5
Pegantha martgon	12.5		0.0	0.1	0.5	0.0	2.6	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	14.3		0.0	0.1	0.1	0.0	0.4
Clio pyramidata sulcata	10.4		0.0	0.7	2.7	0.0	14.4	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	14.3		0.0	0.1	0.1	0.0	0.4

Table 4.5 (Contd.)

	ELEPHANT ISLAND AREA							WEST AREA							SOUTH AREA							JOINVILLE ISLAND AREA						
TAXA	F(%)	R	%	MEAN	STD	MED	MAX	F(%)	R	%	MEAN	STD	MED	MAX	F(%)	R	%	MEAN	STD	MED	MAX	F(%)	R	%	MEAN	STD	MED	MAX
Euphausia frigida (L)	10.4		0.0	0.4	1.5	0.0	10.2	8.7		0.0	0.8	3.1	0.0	15.1	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Callanira antarctica	10.4		0.0	0.2	1.1	0.0	7.5	17.4		0.0	0.1	0.2	0.0	0.8	20.0		0.0	0.6	1.5	0.0	5.1	14.3		0.0	0.1	0.2	0.0	0.4
Vanadis antarctica	10.4		0.0	0.1	0.5	0.0	2.9	17.4		0.0	0.3	1.2	0.0	5.6	0.0		0.0	0.0	0.0	0.0	0.0	14.3		0.0	0.1	0.1	0.0	0.4
Hyperiella macronyx	10.4		0.0	0.1	0.4	0.0	2.7	8.7		0.0	0.1	0.4	0.0	2.0	50.0		0.0	0.4	0.5	0.2	1.9	14.3		0.0	0.1	0.1	0.0	0.4
Euphausia spp. (L)	8.3		0.0	0.4	1.8	0.0	11.8	8.7		0.0	0.3	1.0	0.0	4.4	30.0		0.3	4.6	19.5	0.0	89.7	14.3		0.0	0.6	1.6	0.0	4.4
Scina spp.	8.3		0.0	0.2	0.7	0.0	4.8	8.7		0.0	0.3	1.1	0.0	4.4	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Spongiobranchaea sp.	8.3		0.0	0.2	0.6	0.0	4.1	13.0		0.0	0.2	0.6	0.0	2.0	20.0		0.0	0.2	0.5	0.0	2.5	0.0		0.0	0.0	0.0	0.0	0.0
Pelagobia longicirrata	8.3		0.0	0.1	0.6	0.0	3.9	8.7		0.0	0.2	0.6	0.0	2.9	45.0		0.0	0.3	0.3	0.0	1.1	0.0		0.0	0.0	0.0	0.0	0.0
Orchomene spp.	8.3		0.0	0.1	0.3	0.0	1.9	0.0		0.0	0.0	0.0	0.0	0.0	15.0		0.0	0.1	0.4	0.0	1.3	14.3		0.0	0.1	0.1	0.0	0.4
Beroe cucumis	8.3		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0	0.4	42.9		0.0	0.3	0.4	0.0	1.1
Notolepis coatsi (L)	6.3		0.0	0.1	0.6	0.0	2.9	17.4		0.0	0.2	0.7	0.0	3.4	10.0		0.0	0.2	0.7	0.0	2.9	42.9		0.0	0.3	0.4	0.0	1.2
Electrona antarctica	6.3		0.0	0.0	0.2	0.0	0.8	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Electrona carlsbergi	6.3		0.0	0.0	0.1	0.0	0.8	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Cyllopus lucasii	6.3		0.0	0.0	0.1	0.0	0.5	8.7		0.0	0.2	0.7	0.0	2.6	10.0		0.0	0.1	0.2	0.0	0.9	0.0		0.0	0.0	0.0	0.0	0.0
Thyphloscolecidae	4.2		0.0	0.2	1.1	0.0	7.5	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Thyploscolex muelleri	4.2		0.0	0.1	0.7	0.0	5.2	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Dimophyes arctica	4.2		0.0	0.0	0.1	0.0	0.8	0.0		0.0	0.0	0.0	0.0	0.0	35.0		0.0	0.3	0.6	0.0	2.1	0.0		0.0	0.0	0.0	0.0	0.0
Clione antarctica	4.2		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Decapods (unid.)	2.1		0.0	0.0	0.2	0.0	1.2	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Gymnoscopelus braueri	2.1		0.0	0.0	0.1	0.0	0.8	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Calycopsis borchgrevinki	2.1		0.0	0.0	0.1	0.0	0.7	4.3		0.0	0.0	0.2	0.0	0.8	5.0		0.0	0.0	0.1	0.0	0.6	0.0		0.0	0.0	0.0	0.0	0.0
Staurophora mertensi?	2.1		0.0	0.0	0.1	0.0	0.5	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Mertensia spp.	2.1		0.0	0.0	0.1	0.0	0.5	0.0		0.0	0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0
Beroe forskalii	2.1		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Gastropods (unid)	2.1		0.0	0.0	0.1	0.0	0.4	4.3		0.0	0.1	0.4	0.0	2.0	20.0		0.0	0.0	0.1	0.0	0.5	14.3		0.0	0.1	0.1	0.0	0.4
Orchomene plebs	2.1		0.0	0.0	0.1	0.0	0.4	13.0		0.0	0.2	0.6	0.0	2.8	20.0		0.0	0.1	0.3	0.0	1.3	14.3		0.0	0.1	0.3	0.0	0.8
Schyphomedusae (unid)	2.1		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0
Atolla wyvillei	2.1		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Beroe spp.	2.1		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Mysids (unid)	2.1		0.0	0.0	0.1	0.0	0.4	4.3		0.1	2.5	11.5	0.0	56.4	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Mertensiidae	2.1		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Hyperiella antarctica	2.1		0.0	0.0	0.1	0.0	0.4	4.3		0.0	0.0	0.2	0.0	0.8	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Krefftichthys anderssoni	2.1		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Artedidraco mirus (L)	2.1		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Hyperiids (unid.)	0.0		0.0	0.0	0.0	0.0	0.0	17.4		0.0	0.4	0.9	0.0	3.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Cephalopods	0.0		0.0	0.0	0.0	0.0	0.0	17.4		0.0	0.1	0.2	0.0	0.5	5.0		0.0	0.0	0.1	0.0	0.6	0.0		0.0	0.0	0.0	0.0	0.0
Notolepis spp. (L)	0.0		0.0	0.0	0.0	0.0	0.0	8.7		0.0	0.0	0.1	0.0	0.4	5.0		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0
Cumaceans	0.0		0.0	0.0	0.0	0.0	0.0	4.3		0.0	0.2	1.0	0.0	5.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Orchomene rossi	0.0		0.0	0.0	0.0	0.0	0.0	4.3		0.0	0.0	0.1	0.0	0.6	20.0		0.0	0.1	0.2	0.0	0.5	14.3		0.0	0.2	0.4	0.0	1.2
Electrona antarctica	0.0		0.0	0.0	0.0	0.0	0.0	4.3		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Epimeriella macronyx	0.0		0.0	0.0	0.0	0.0	0.0	4.3		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0	28.6		0.0	0.1	0.2	0.0	0.4
Clio pyramidata antarctica?	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	14.3		0.0	0.1	0.3	0.0	0.7
Eusirus antarcticus	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	28.6		0.0	0.3	0.5	0.0	1.5
Eusirus spp.	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	14.3		0.0	0.1	0.2	0.0	0.4
Pleuragramma antarcticum (L)	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0	0.5	0.0		0.0	0.0	0.0	0.0	0.0
Lepidonotothen larseni (J)	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	5.0		0.0	0.2	0.7	0.0	3.0	0.0		0.0	0.0	0.0	0.0	0.0
Chionodraco rastrospinosus (L)	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	10.0		0.0	0.0	0.1	0.0	0.5	0.0		0.0	0.0	0.0	0.0	0.0
Pleurobrachia pileus	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0
Pleuragramma antarcticum	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	14.3		0.0	0.1	0.1	0.0	0.4
Hyperoche medusarum	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0
Cryodraco antarctica (L)	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0	0.4	0.0		0.0	0.0	0.0	0.0	0.0
TOTAL				2124.7	3285.9	1418.9	22648.0				2527.7	2361.3	1402.3	8438.2				1590.1	1724.1	1085.3	6792.5				2038.4	1887.1	1398.3	6087.8
TAXA				20.7	4.0	21.0	28.0				20.3	4.4	21.0	28.0				23.0	5.0	23.5	31.0				23.4	7.5	26.0	35.0

Table 4.6. Taxonomic composition of zooplankton clusters during January, 2007. R and % are rank and proportions of total abundance represented by each taxon. Asterisks denote significantly higher abundance in the Offshore than Intermediate and Coastal Clusters based on ANOVA: * P<0.05; ** P<0.01; *** P<0.001.

	CLUSTER1 COASTAL (N=53)					CLUSTER 2 INTERMEDIATE (N=32)					CLUSTER 3 OCEANIC (N=13)					
TAXON	R	%	AVG	STD	MED	R	%	AVG	STD	MED	R	%		AVG	STD	MED
Total Copepods	1	70.0	1350.3	3123.1	600.1	1	76.4	1481.3	1428.2	1128.1	2	32.7		1160.4	1476.1	315.7
Metridia gerlachei		46.2	890.1	2906.1	10.7		31.6	611.9	1048.3	95.5		3.0		104.6	189.0	17.8
Calanoides acutus		11.1	214.9	186.9	141.2		8.9	171.9	158.5	96.5		2.6		92.3	236.5	11.0
Pareuchaeta spp.		5.1	97.8	129.0	55.9		17.7	342.2	250.0	364.0		7.7		272.5	504.5	78.6
Other		4.8	92.2	75.2	77.9		10.2	197.9	123.6	180.8		12.8	*	454.7	646.1	110.7
Rhincalanus gigas		1.9	36.5	44.4	16.4		2.3	44.5	46.1	28.9		0.2		7.3	12.7	2.0
Calanus propinquus		0.5	10.6	14.3	6.5		1.4	26.2	28.3	14.8		3.7	**	130.6	187.0	28.3
Thysanoessa macrura	2	13.9	267.2	371.2	165.3	2	7.3	140.8	139.4	125.4	5	1.1		40.5	53.3	14.4
Euphausia superba	3	7.4	142.4	342.9	28.6	4	3.1	59.6	110.7	19.2	6	1.0		36.4	33.9	27.3
Limacina helicina	4	1.4	27.7	36.5	12.4		0.3	6.7	12.8	0.4	4	4.0	**	142.0	210.0	79.1
Chaetognaths	5	1.4	26.6	39.0	11.6	3	3.9	75.1	112.7	13.1	7	0.9		32.2	47.9	12.8
Euphausia superba (L)	6	0.9	17.4	63.0	1.8	8	0.8	15.0	32.2	4.1		0.0		0.0	0.0	0.0
Euphausia crystallorophias	7	0.7	14.3	31.7	0.0		0.2	3.1	11.8	0.0		0.1		2.7	9.2	0.0
Ostracods	8	0.6	11.7	42.9	0.0	9	0.6	12.5	27.6	3.8		0.2		5.6	9.4	0.0
Limacina spp.	9	0.5	9.3	15.6	3.4		0.1	1.3	3.0	0.0		0.0		1.2	3.5	0.0
Primno macropa	10	0.3	6.6	9.2	3.0	7	0.9	16.9	19.5	11.8		0.4		12.9	16.8	6.0
Euphausia frigida		0.3	6.1	31.4	0.0	6	1.0	20.2	38.5	0.7		0.2		8.7	19.7	0.0
Radiolaria		0.3	5.3	14.1	0.9		0.4	8.0	9.3	5.2		0.2		7.9	9.0	4.4
Lepidonotothen larseni (L)		0.2	2.9	4.9	1.1		0.0	0.9	2.8	0.0		0.0		0.0	0.0	0.0
Thysanoessa macrura (L)		0.1	2.9	4.4	0.8	10	0.6	11.8	22.9	4.4	3	20.0	***	710.5	1239.9	10.8
Tomopteris spp.		0.1	2.8	8.3	0.5		0.3	5.6	7.3	3.2		0.3		11.6	6.3	10.6
Themisto gaudichaudii		0.1	2.2	8.5	0.0		0.4	7.3	12.8	1.1	8	0.6	*	21.3	28.8	10.6
Clione limacina		0.1	1.0	2.5	0.0		0.0	0.1	0.3	0.0		0.0		0.6	1.1	0.0
Diphyes antarctica		0.0	0.9	1.4	0.4		0.0	0.2	0.5	0.0		0.0		0.0	0.0	0.0
Spongiobranchaea australis		0.0	0.9	1.2	0.5		0.1	1.2	1.3	0.7		0.0		1.5	1.3	1.4
Sipunculids		0.0	0.7	0.9	0.4		0.0	0.1	0.2	0.0		0.0		0.0	0.0	0.0
Hyperiella dilatata		0.0	0.6	1.0	0.0		0.1	1.5	2.2	0.8		0.1		2.8	3.3	1.7
Rhynchonereelia bongraini		0.0	0.6	1.5	0.0		0.0	0.3	0.7	0.0		0.0		0.1	0.5	0.0
Salpa thompsoni		0.0	0.4	1.6	0.0	5	1.9	35.9	48.0	15.7	1	36.0	***	1277.6	1138.5	998.9
Euphausia triacantha		0.0	0.4	1.7	0.0		0.2	3.1	6.1	0.0		0.0		0.0	0.0	0.0
Vibilia antarctica		0.0	0.2	0.7	0.0		0.1	1.9	2.1	1.4	9	0.6	***	21.0	19.1	14.7
Hyperiella macronyx		0.0	0.2	0.5	0.0		0.0	0.0	0.1	0.0		0.0		0.2	0.5	0.0
Lepidonotothen kempi (L)		0.0	0.1	0.3	0.0		0.1	1.6	3.0	0.0		0.0		0.1	0.3	0.0
Cyllopus magellanicus		0.0	0.0	0.2	0.0		0.1	1.1	1.6	0.4	10	0.5	***	17.9	19.4	10.8
TOTAL			1928.6	3245.5	1120.3			1938.1	1508.7	1583.5				3545.1	2805.9	2086.4
TAXA			21.6	5.4	22.0			21.5	3.6	22.0				19.5	4.2	17.0

Table 4.7. Abundance of krill and other dominant zooplankton taxa collected in the Elephant Island area during January-February and February-March surveys, 1992-2007. Zooplankton data are not available for February-March 1992, 2006 and 2007 or January 2000.

	Euphausia superba															
	January-February															
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N	63	70	63	71	72	71	61	40	n.a.	60	44	38	46	48	48	48
Mean	23.7	28.8	34.5	9.5	82.1	29.6	27.1	5.3	---	18.9	39.0	318.8	59.8	27.1	23.8	66.4
SD	78.0	64.4	94.2	20.6	245.1	80.5	42.3	8.1	---	32.7	93.3	1386.0	170.5	33.0	47.7	96.5
Med	5.7	8.2	3.1	3.6	11.4	5.6	10.2	1.7	---	6.0	7.5	30.9	3.1	15.3	11.1	33.2
Max	594.1	438.9	495.9	146.1	1500.6	483.2	175.0	35.1	---	217.7	458.6	8683.2	852.2	127.6	301.4	397.6
	February-March															
N	67	67	70	71	72	16	61	39	60	57	44	48	47	48	n.a.	n.a.
Mean	38.0	35.0	17.1	5.2	133.2	30.4	162.6	35.5	14.4	80.5	10.1	94.9	50.9	48.1	---	---
SD	77.4	89.7	63.5	12.0	867.7	56.4	768.3	155.7	35.3	374.0	25.4	240.2	91.0	179.9	---	---
Med	7.1	3.0	0.4	1.2	4.1	4.6	4.5	0.8	3.3	4.6	0.4	8.7	10.4	2.9	---	---
Max	389.9	542.0	371.1	90.0	7385.4	204.2	5667.0	978.6	253.5	2817.0	112.1	1309.1	425.2	1112.2	---	---

	Salpa thompsoni															
	January-February															
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N	63	70	63	71	72	71	61	40	n.a.	60	44	38	46	48	48	48
Mean	94.3	1213.4	931.9	20.2	25.5	223.2	939.7	197.5	---	622.8	410.0	61.9	176.6	1208.7	63.2	179.4
SD	192.3	2536.7	950.2	46.5	36.3	336.4	1556.3	191.6	---	576.4	614.6	132.7	166.7	1274.7	99.6	407.2
Med	14.0	245.8	582.3	1.6	10.5	87.1	348.9	159.1	---	449.3	85.8	8.7	134.1	670.8	9.4	3.9
Max	1231.1	16078.8	4781.7	239.9	161.6	2006.3	8030.4	873.4	---	3512.4	2816.8	709.2	754.8	5022.5	501.2	1731.0
	February-March															
N	n.a.	67	70	71	72	16	61	39	60	57	44	48	47	48	n.a.	n.a.
Mean	---	1585.9	495.1	20.6	33.2	1245.5	977.3	309.1	912.8	452.4	570.4	60.7	159.1	861.0	---	---
SD	---	2725.5	579.4	66.5	85.7	1224.6	1496.5	376	3395.1	501.2	782.3	119.7	252.2	1109.7	---	---
Med	---	605.9	242.6	0.7	5.6	521.0	553.8	160.7	262.9	312.1	250.9	7.0	45.5	493.1	---	---
Max	---	16662.5	2377.5	391.9	659.4	4348.3	10712.9	1550.2	24031.9	2416.8	2903.7	475.4	1216.3	5399.9	---	---

	Thysanoessa macrura															
	January-February															
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N	63	70	63	71	72	71	61	40	n.a.	60	44	38	46	48	48	48
Mean	48.1	48.6	74.6	104.1	103.4	101.0	135.3	46.6	---	46.2	200.9	239.0	108.2	171.4	159.4	180.4
SD	57.0	60.1	144.3	231.9	118.1	127.2	150.8	54.1	---	49.2	784.8	405.3	161.5	247.1	211.8	350.1
Med	22.5	27.5	25.4	36.1	52.3	52.8	98.0	23.2	---	32.2	33.1	103.9	55.4	109.6	79.6	57.0
Max	233.7	307.1	901.6	1859.0	500.1	616.2	992.3	215.8	---	251.7	5302.0	2134.8	971.4	1490.8	967.0	2196.9
	February-March															
N	n.a.	67	70	71	72	16	61	39	60	57	44	48	47	48	n.a.	n.a.
Mean	---	128.9	77.1	79.7	116.1	181.3	140.6	95.2	35.1	1040.9	56.4	232.6	138.9	441.1	---	---
SD	---	235.1	132.6	138.5	147.4	168.0	232.3	131.9	61.5	7262.6	132.5	271.3	205.7	511.4	---	---
Med	---	22.1	23.8	22.2	53.6	122.6	70.0	18.0	14.0	44.1	3.5	156.0	59.8	275.0	---	---
Max	---	1141.5	815.9	664.9	679.4	538.9	1638.5	589.2	291.6	55381.1	662.7	1441.5	963.6	2520.0	---	---

Table 4.7 (Contd.)

	Copepods															
	January-February															
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N	n.a.	70	63	71	72	71	61	40	n.a.	60	44	38	46	48	48	48
Mean	---	73.5	32.4	741.0	897.5	656.4	41.2	928.2	---	1003.2	5484.3	541.0	494.5	364.6	3677.8	1515.6
SD	---	302.7	92.2	1061.3	1726.4	799.1	55.1	1590.8	---	1582.4	14585.6	798.6	796.1	687.3	3563.5	3190.0
Med	---	0.0	0.0	346.0	338.2	399.7	21.5	333.0	---	252.2	2174.9	317.0	208.7	126.4	2279.8	716.3
Max	---	2312.6	465.3	7047.5	10598.0	4090.0	276.0	7524.8	---	6909.7	96514.5	4390.2	3554.4	3502.6	14003.8	498.6
	February-March															
Year	n.a.	n.a.	70	71	72	16	61	39	60	57	44	48	47	48	n.a.	n.a.
Mean	---	---	3453.3	3707.3	1483.7	1267.8	110.4	1558.4	8019.1	4501.5	17473.4	1674.3	6303.1	1022.1	---	---
SD	---	---	8190.8	5750.3	2209.2	1755.6	170.3	2337.5	11824.4	8072.4	20036.9	2593.6	17739.5	1254.5	---	---
Med	---	---	172.4	1630.9	970.2	659.8	50.9	621.6	3478.0	1518.0	7563.8	737.5	2233.5	344.3	---	---
Max	---	---	37987.2	40998.5	16621.0	7289.2	901.1	10786.6	57498.5	39800.7	90224.5	15990.9	120411.5	5508.1	---	---

	Euphausia superba Larvae															
	January-February															
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N	n.a.	n.a.	n.a.	71	72	71	61	40	n.a.	60	44	38	46	48	48	48
Mean	---	---	---	172.1	3.4	19.3	0.4	175.1	---	32.8	35.8	4.7	9.8	22.0	2029.4	22.1
SD	---	---	---	969.4	8.3	27.0	1.6	795.5	---	86.2	64.6	16.8	18.5	78.3	5118.2	68.8
Med	---	---	---	0.0	0.0	6.4	0.0	4.3	---	9.0	0.0	0.0	0.4	1.1	18.9	2.3
Max	---	---	---	8076.1	42.7	96.5	11.4	5083.2	---	654.0	356.3	95.5	95.7	521.8	20541.3	399.3
	February-March															
N	n.a.	n.a.	n.a.	71	72	16	61	39	60	57	44	48	47	48	n.a.	n.a.
Mean	---	---	---	4593.4	14.1	25.0	2.5	67.2	3423.2	71.9	49.9	6.1	177.3	194.8	---	---
SD	---	---	---	20117.0	44.0	81.4	18.3	146.0	8974.1	176.9	140.9	13.0	741.5	969.1	---	---
Med	---	---	---	268.6	3.3	0.0	0.0	12.3	248.7	5.1	0.0	0.0	38.9	4.6	---	---
Max	---	---	---	167575.6	368.5	339.0	144.1	692.5	44478.2	1197.7	728.6	56.1	5160.5	6755.5	---	---

	Euphausia frigida															
	January-February															
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N	63	70	63	71	72	71	61	40	n.a.	60	44	38	46	48	48	48
Mean	5.4	4.2	4.7	12.1	2.0	9.6	0.3	15.9	---	23.4	28.0	10.6	19.2	28.5	33.4	17.7
SD	14.9	18.4	14.9	32.1	4.5	21.4	1.4	29.1	---	55.9	56.1	27.3	44.5	73.7	59.3	45.0
Med	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	---	0.0	0.4	0.0	0.0	0.0	4.8	0.0
Max	76.7	143.0	76.7	175.6	22.5	91.4	10.0	116.0	---	315.6	256.1	135.2	223.7	385.2	328.4	229.6
	February-March															
N	n.a.	67	70	71	72	16	61	39	60	57	44	48	47	48	n.a.	n.a.
Mean	---	1.0	28.9	19.7	9.5	44.8	9.0	23.0	43.1	37.7	78.4	50.9	26.8	34.9	---	---
SD	---	4.7	62.0	36.7	12.7	54.2	26.0	38.7	73.0	82.0	192.3	92.0	45.8	50.6	---	---
Med	---	0.0	5.5	2.9	1.2	21.0	0.0	7.6	6.8	0.0	5.1	11.5	0.6	6.7	---	---
Max	---	32.6	439.7	216.1	48.8	176.2	178.4	159.1	307.2	319.2	1149.9	478.7	162.7	223.2	---	---

Table. 4.7 (Contd.)

	Thysanoessa macrura larvae															
	January-February															
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N	n.a.	n.a.	n.a.	71	72	71	61	40	n.a.	60	44	38	46	48	48	48
Mean	---	---	---	20.2	372.0	21.5	0.0	116.5	---	269.3	773.3	1.2	6.7	43.0	224.6	4.9
SD	---	---	---	75.2	858.1	38.4	0.0	348.8	---	608.8	1379.1	2.7	11.0	139.9	481.3	10.1
Med	---	---	---	0.0	32.1	1.5	0.0	2.8	---	42.7	181.7	0.0	2.1	0.5	19.6	1.2
Max	---	---	---	441.5	4961.8	159.9	0.0	1519.6	---	3621.0	8984.2	14.5	45.3	836.0	2444.9	62.5
	February-March															
N	n.a.	n.a.	70	71	72	16	61	39	60	57	44	48	47	48	n.a.	n.a.
Mean	---	---	31.7	344.3	511.5	10.8	0.5	185.9	1084.8	613.3	1444.9	1.3	386.8	1.2	---	---
SD	---	---	111.1	594.2	1432.5	24.9	2.0	535.7	4147.3	1009.5	2665.1	3.0	989.5	2.7	---	---
Med	---	---	0.0	79.9	36.1	1.0	0.0	10.0	26.8	265.3	364.0	0.0	0.0	0.0	---	---
Max	---	---	809.1	3735.5	10875.0	104.7	12.1	2990.8	31132.5	5461.9	12270.6	18.1	4637.7	12.9	---	---

	Chaetognaths															
	January-February															
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N	n.a.	70	63	71	72	71	61	40	n.a.	60	44	38	46	48	48	48
Mean	---	3.1	0.2	84.7	11.9	20.1	3.3	63.9	---	57.4	139.8	119.3	35.3	15.8	314.3	44.6
SD	---	7.9	0.5	159.5	25.1	26.1	5.2	159.1	---	110.9	221.1	33.6	78.5	37.3	409.5	88.7
Med	---	0.0	0.0	30.0	4.2	10.3	0.9	14.7	---	11.3	76.6	5.3	9.3	2.9	178.8	7.7
Max	---	41.3	2.2	781.8	184.9	120.4	24.7	960.2	---	660.7	1283.4	130.2	385.3	236.5	2264.1	511.7
	February-March															
N	n.a.	67	70	71	72	16	61	39	60	57	44	48	47	48	n.a.	n.a.
Mean	---	0.7	21.8	330.2	58.4	18.4	8.9	147.4	792.3	93.5	1073.1	103.2	446.8	47.9	---	---
SD	---	4.2	87.7	404.6	72.3	23.9	23.3	261.4	1543.7	173.4	1210.4	130.6	1114.1	66.1	---	---
Med	---	0.0	0.0	161.0	31.8	5.5	1.0	48.7	229.4	10.5	435.6	56.3	127.3	16.4	---	---
Max	---	34.9	578.9	1769.9	383.8	77.9	124.7	1146.6	8221.0	836.9	5052.6	579.9	7568.7	262.9	---	---

Table 4.8. Maturity stage composition of krill collected in the Elephant Island area during 2007 compared to 1992-2006. Advanced maturity stages are proportions of mature females that are (A) 3c-3e in January-February and (B) 3d-3e in February-March. Data are not available for January-February, 2000 or February-March 2006 and 2007. R is proportional recruitment index for the year class resulting from each seasons' spawning activity.

A. Survey A	*Euphausia superba* January-February															
Stage	1992 %	1993 %	1994 %	1995 %	1996 %	1997 %	1998 %	1999 %	2000 n.a.	2001 %	2002 %	2003 %	2004 %	2005 %	2006 %	2007 %
Juveniles	37.1	7.2	4.0	4.6	55.0	15.2	18.4	0.4	---	9.7	46.3	42.4	1.8	2.6	0.5	28.1
Immature	19.1	30.7	18.8	4.0	18.3	30.6	31.7	11.7	---	6.2	9.0	39.1	38.5	8.7	6.7	15.1
Mature	43.9	62.2	77.2	91.4	26.7	54.2	49.9	87.9	---	84.1	44.7	18.5	59.7	88.7	92.7	56.8
Females:																
F2	0.8	7.8	2.3	0.1	1.1	6.3	9.1	1.6	---	0.2	0.4	12.3	4.3	0.9	0.4	1.4
F3a	0.6	11.7	18.0	0.2	0.0	3.5	21.4	1.7	---	0.9	0.5	11.7	18.1	2.0	0.6	5.1
F3b	12.3	14.3	19.3	1.2	0.2	0.6	9.0	1.8	---	14.6	2.3	1.3	7.5	5.2	10.0	10.8
F3c	9.2	5.1	20.1	15.3	1.9	6.9	1.0	14.7	---	13.2	13.7	1.6	11.2	11.8	7.0	9.6
F3d	0.4	1.2	2.3	17.7	0.7	6.1	0.3	23.9	---	7.4	10.0	0.0	0.1	15.8	10.9	7.5
F3e	0.0	0.0	0.0	3.7	11.6	7.4	0.7	9.2	---	1.3	6.2	0.0	0.6	3.5	16.2	0.5
Advanced Stages	42.7	19.5	37.5	96.3	98.3	83.2	6.2	93.2	---	58.5	91.6	11.2	11.8	81.2	76.2	52.7
Males:																
M2a	8.7	6.8	0.3	0.9	14.6	14.6	8.5	2.2	---	2.1	3.0	13.6	7.4	2.5	2.5	5.5
M2b	7.3	11.9	9.4	1.5	2.1	8.2	8.4	3.9	---	2.1	4.0	10.2	14.7	2.4	2.6	4.3
M2c	2.3	4.2	6.8	1.5	0.5	1.5	5.7	4.1	---	1.7	1.5	3.1	12.2	2.9	1.3	3.9
M3a	2.8	3.7	4.3	4.4	1.4	1.5	3.1	1.7	---	2.1	1.7	1.1	11.5	2.1	1.9	2.6
M3b	18.7	26.2	13.2	48.9	10.9	28.1	14.4	34.9	---	44.6	10.4	2.9	10.8	18.3	46.0	20.7
Male:Female ratio	1.7	1.3	0.5	1.5	1.9	1.8	1.0	0.9	---	1.4	0.6	1.2	1.4	1.5	1.2	1.1
No. measured	2472	4283	2078	2294	4296	3209	3600	751	---	2063	1437	2466	1410	2189	1721	3398
R1	0.000	0.068	0.046	0.622	0.198	0.120	0.000	0.000	0.573	0.403	0.478	0.001	0.014	0.200	0.230	

B. Survey D	February-March															
Stage	1992 %	1993 %	1994 %	1995 %	1996 %	1997 %	1998 %	1999 %	2000 %	2001 %	2002 %	2003 %	2004 %	2005 %	2006 n.a.	2007 n.a.
Juveniles	33.6	3.5	3.7	1.1	20.8	8.0	3.6	0.0	0.1	13.4	38.9	20.6	0.1	0.8	---	---
Immature	27.1	51.4	6.2	2.5	9.9	19.7	25.4	1.3	2.3	14.7	17.3	52.4	16.3	9.7	---	---
Mature	39.2	45.1	90.1	96.4	69.3	72.3	71.0	98.7	97.5	71.9	43.8	27.0	83.6	89.5	---	---
Females:																
F2	0.8	21.8	0.7	0.3	0.6	1.1	6.9	0.0	0.2	0.7	3.3	21.4	2.9	0.8	---	---
F3a	10.3	12.4	3.5	0.0	0.0	0.1	10.9	0.4	1.0	2.4	0.9	13.4	3.7	16.2	---	---
F3b	10.2	6.2	7.8	0.0	0.0	0.0	11.8	0.0	0.7	0.2	0.2	2.5	0.3	9.3	---	---
F3c	4.3	3.7	4.3	2.0	5.0	1.8	3.0	11.1	6.5	1.5	2.2	2.3	2.2	12.1	---	---
F3d	1.2	1.1	4.6	21.8	10.9	29.1	1.3	47.3	21.9	3.8	14.7	0.3	17.0	3.6	---	---
F3e	<0.01	1.2	0.9	20.4	4.9	7.3	0.1	4.8	22.0	42.6	3.6	0.6	13.0	0.0	---	---
Advanced Stages	4.6	9.3	26.1	95.5	76.0	95.0	5.2	81.8	84.2	91.8	85.2	4.7	82.9	8.7	---	---
Males:																
M2a	4.3	6.9	0.2	0.7	6.5	8.6	1.9	0.0	0.1	4.1	8.8	12.0	2.4	1.5	---	---
M2b	19.8	19.1	1.2	0.4	1.2	8.8	6.6	0.7	0.7	2.7	3.6	14.9	7.3	0.8	---	---
M2c	2.2	3.6	4.2	1.1	1.6	1.2	10.0	0.6	1.3	7.3	1.6	4.2	3.7	6.6	---	---
M3a	2.5	2.1	24.1	4.4	5.3	3.7	17.5	2.6	7.4	2.2	0.3	2.0	4.8	13.2	---	---
M3b	10.7	18.4	44.7	47.8	43.2	30.3	26.2	32.4	38.0	19.2	22.1	5.8	42.7	35.0	---	---
Male:Female ratio	1.5	1.1	3.4	1.2	2.7	1.3	1.9	0.6	0.9	0.7	1.5	0.9	1.6	1.4	---	---
No. measured	3646	3669	1155	1271	2984	560	3153	1176	1371	1739	558	1936	2081	1018	---	---

Table 4.9. Krill abundance (No. per 1000 m3) and distributional attributes in subareas surveyed during (A) January-February and (B) February-March 1995-2007. Largest concentrations typically reflect abundant juveniles and good recruitment success from the previous year. Index of Dispersion (ID) is a measure of distribution with smaller numbers indicating evenness and larger numbers patchiness.

A. January-February Survey A

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
West Area (N)	8	8	20	28	27	n.a.	30	25	25	24	25	25	23
Mean	79.4	92.8	28.7	56.0	5.0	-----	12.8	42.0	38.2	11.3	8.4	9.9	43.0
SD	131.6	115.3	69.1	99.7	9.7	-----	18.7	141.2	85.8	21.2	13.0	12.6	67.7
Median	20.5	41.9	5.9	15.1	0.0	-----	2.3	0.8	8.0	2.1	2.3	7.9	17.6
ID	218.1	143.2	166.2	177.4	18.9	-----	27.3	475.1	192.8	39.8	20.1	16.0	106.6
Elephant Island Area (N)	71	72	71	61	40	n.a.	60	44	38	46	48	48	48
Mean	9.7	82.1	29.6	27.1	5.3	-----	18.9	39.0	318.8	59.8	27.1	23.8	66.4
SD	20.7	245.1	80.5	42.3	8.1	-----	32.7	93.3	1386.0	170.5	33.0	47.7	96.5
Median	4.1	11.4	5.6	10.2	1.7	-----	6.0	7.5	30.9	3.1	15.3	11.1	33.2
ID	44.6	731.7	218.5	66.1	12.2	-----	56.6	223.1	6025.7	485.7	40.0	95.4	140.2
Joinville Island Area (N)	n.a.	n.a.	5	n.a.	n.a.	n.a.	n.a.	9	3	5	6	6	7
Mean	-----	-----	191.8	-----	-----	-----	-----	78.3	502.1	0.3	27.7	95.0	368.8
SD	-----	-----	209.9	-----	-----	-----	-----	153.4	666.5	0.4	56.3	185.4	711
Median	-----	-----	145.5	-----	-----	-----	-----	10.3	60.0	0.0	1.8	15.9	3.2
ID	-----	-----	229.8	-----	-----	-----	-----	300.4	884.7	0.5	114.7	361.9	1370.7
South Area (N)	11	11	8	15	8	n.a.	11	17	17	16	20	20	20
Mean	0.3	325.6	66.5	40.7	13.3	-----	116.2	161.7	87.3	65.1	13.6	26.2	158.8
SD	0.4	975.3	104.3	77.6	25.6	-----	179.6	390.5	191.8	112.1	37.0	60.5	319.7
Median	0.3	12.2	4.1	3.6	3.3	-----	22.5	0.8	1.1	1.2	1.0	7.7	21.8
ID	0.5	2921.7	163.4	148.1	49.2	-----	277.7	942.7	421.3	193.0	100.6	139.5	643.6

B. February-March Survey D

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
West Area (N)	7	8	n.a.	28	25	29	29	24	25	25	25	n.a.	n.a.
Mean	15.0	4.9	-----	22.3	9.6	38.5	35.9	694.3	92.9	52.5	7.8	-----	-----
SD	13.1	4.6	-----	44.2	45.6	120.7	86.7	2317.5	172.8	237.9	15.2	-----	-----
Median	12.9	3.9	-----	2.7	0.0	3.9	5.2	0.0	21.2	0.4	1.4	-----	-----
ID	11.5	4.3	-----	87.6	216.6	378.4	209.4	7735.6	321.4	1078.0	29.6	-----	-----
Elephant Island Area (N)	71	72	n.a.	61	39	60	57	44	48	47	48	n.a.	n.a.
Mean	5.2	133.2	-----	162.6	35.5	14.4	86.5	9.7	94.9	5.6	48.1	-----	-----
SD	12.0	867.7	-----	768.3	155.7	35.3	387.4	25.4	24.2	9.7	179.9	-----	-----
Median	1.2	4.1	-----	4.5	0.8	3.3	4.9	0.4	8.7	10.5	2.9	-----	-----
ID	27.7	5652.4	-----	3630.3	682.9	86.5	1735.0	66.5	6.2	16.8	672.8	-----	-----
Joinville Island Area (N)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	9	4	8	6	n.a.	n.a.
Mean	-----	-----	-----	-----	-----	-----	-----	4.3	27.2	71.7	29.7	-----	-----
SD	-----	-----	-----	-----	-----	-----	-----	5.4	16.7	120.7	63.4	-----	-----
Median	-----	-----	-----	-----	-----	-----	-----	1.7	22.3	9.5	1.3	-----	-----
ID	-----	-----	-----	-----	-----	-----	-----	6.8	10.3	203.2	135.3	-----	-----
South Area (N)	11	11	n.a.	15	3	8	10	17	18	17	18	n.a.	n.a.
Mean	2.9	7.4	-----	222.4	4.4	6.7	3.3	548.2	411.7	28.5	97.1	-----	-----
SD	3.0	18.4	-----	479.7	4.3	11.2	8.2	1765.5	632.3	92.0	270.3	-----	-----
Median	1.9	0.5	-----	3.3	1.7	2.3	0.3	6.4	34.5	0.1	10.5	-----	-----
ID	3.2	45.8	-----	1034.7	4.2	18.7	20.4	5685.9	971.1	297.0	752.4	-----	-----

Table 4.10. Salp and krill carbon biomass (mg C per m^2) in the Elephant Island area during 1995-2007 surveys. N is number of samples. Salp:Krill ratio is based on median values.

Survey A	January-February																									
Year	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006		2007	
Biomass	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill
Mean	7.8	242.3	20.2	337.3	334.5	229.0	430.8	173.1	151.8	48.6	---	---	334.5	248.5	287.4	218.6	35.9	1426.0	120.5	472.7	707.6	295.2	23.4	301.8	107.9	481.7
SD	16.1	201.1	30.9	756.1	1115.6	522.1	565.3	290.6	166.1	66.1	---	---	272.8	425.3	418.3	552.0	69.8	6818.3	135.8	1403.2	770.3	371.9	37.8	670.1	250.4	572.7
Med.	1.3	43.5	10.0	72.2	108.9	45.1	187.0	46.7	93.2	14.5	---	---	251.7	81.0	127.0	37.6	4.5	137.7	84.9	28.2	411.7	169.9	3.6	164.0	1.4	301.7
Max	75.3	1545.2	134.2	4721.0	9434.6	3115.5	2699.0	1488.4	882.7	304.4	---	---	1395.1	2561.2	1855.4	3509.2	388.6	42745.4	628.0	7254.5	3121.1	1680.6	191.5	4492.1	1270.0	2300.1
N	57	71	72	72	71	71	61	60	40	40	---	---	60	60	44	44	38	38	46	46	48	48	48	48	48	48
Salp:Krill	0.03		0.14		2.4		4.0		6.4		n.a.		3.1		3.4		0.03		3.0		2.4		0.02		0.005	

Survey D	February-March																									
Year	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006		2007	
Biomass	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill	Salps	Krill
Mean	13.1	59.2	50.7	1702.3	1139.7	313.1	694.6	1555.8	321.9	451.0	741.2	204.4	333.9	890.3	738.4	62.3	62.0	451.9	123.7	559.1	674.3	510.3	---	---	---	---
SD	47.3	149.1	146.5	12441.6	1269.8	655.2	1121.2	8218.7	335.1	2082.6	2314.9	507.6	352.4	4116.8	2129.0	179.5	122.9	1082.7	219.1	1037.1	831.0	1957.6	---	---	---	---
Med.	0.7	13.1	4.6	40.7	504.8	50.0	379.4	31.6	193.5	6.9	239.0	42.8	216.3	45.9	327.1	2.7	6.2	27.4	42.5	82.9	466.0	24.2	---	---	---	---
Max	325.2	1107.1	954.0	106458.5	4645.4	2638.7	8543.0	62155.8	1698.1	13133.1	16400.1	3634.6	1702.8	30967.9	14362.1	1062.6	550.4	5165.6	1201.3	5221.1	5458.6	12312.4	---	---	---	---
N	71	71	72	72	16	16	61	60	39	39	60	60	57	57	44	44	48	48	47	47	48	48	---	---	---	---
Salp:Krill	0.05		0.11		10.1		12.0		28.0		5.6		4.7		121.1		0.23		0.51		19.3		n.a.		n.a.	

Table 4.11. Zooplankton and nekton taxa present in the large survey area samples during January 2007 compared to 1998-2006 surveys. There was no January 2000 survey. F is the frequency of occurrence (%) in (N) tows. Mean is number per 1000 m^3. Dashes indicate that taxa were not yet identified and/or enumerated. (L) and (J) denote larval and juvenile stages.

Survey A	January-February																	
	2007 N=98		2006 N=99		2005 N=99		2004 N=91		2003 N=83		2002 N=95		2001 N=101		1999 N=75		1998 N=105	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Copepods	100.0	1325.4	100.0	5993.5	100.0	544.9	98.9	479.9	100.0	609.2	100.0	7536.2	100.0	2247.1	100.0	711.6	94.2	56.5
Thysanoessa macrura	94.9	195.9	96.0	249.2	94.9	232.5	95.6	156.4	100.0	243.5	92.6	222.6	93.1	73.5	93.3	135.1	100.0	180.8
Salpa thompsoni	48.0	181.4	61.6	49.1	98.0	1028.4	93.4	179.1	81.9	63.0	88.4	267.7	100.0	520.7	100.0	163.3	100.0	808.2
Euphausia superba	91.8	101.3	86.9	25.1	79.8	19.7	83.5	44.7	92.8	193.0	74.7	65.5	89.1	27.7	60.0	6.1	92.3	36.8
Thysanoessa macrura (L)	63.3	99.7	74.7	646.0	51.5	43.0	57.1	13.3	21.7	1.0	90.5	1428.1	85.1	458.0	69.3	72.5	1.9	0.0
Chaetognaths	94.9	43.2	100.0	308.6	80.8	22.2	84.6	36.1	94.0	31.3	81.1	170.9	84.2	174.2	49.3	47.8	42.3	8.9
Limacina helicina	76.5	36.0	71.7	32.6	36.4	6.0	83.5	22.1	68.7	31.9	12.6	0.8	51.5	4.9	61.3	2.4	73.1	8.1
Euphausia superba (L)	50.0	14.3	58.6	1005.2	51.5	18.6	50.5	7.0	32.5	3.4	28.4	19.4	68.3	160.2	65.3	103.1	11.5	1.0
Ostracods	52.0	11.2	54.5	18.5	42.4	8.9	63.7	14.6	45.8	6.8	28.4	111.0	37.6	6.7	49.3	2.8	51.0	4.8
Euphausia frigida	46.9	11.1	70.7	25.1	45.5	19.8	36.3	16.1	39.8	10.9	42.1	20.5	45.5	28.8	32.0	9.0	5.8	0.2
Primno macropa	85.7	10.8	79.8	12.2	62.6	3.6	67.0	5.4	85.5	5.2	52.6	6.3	7.9	0.1	69.3	2.5	26.0	0.7
Euphausia crystallorophias	39.8	9.1	22.2	13.4	15.2	0.5	11.0	0.3	30.1	29.7	12.6	16.5	1.0	0.0	9.3	0.1	0.0	0.0
Radiolaria	69.4	6.5	72.7	81.3	32.3	2.1	65.9	3.6	47.0	2.2	42.1	1030.2	19.8	46.1	40.0	8.9	27.9	0.7
Themisto gaudichaudii	54.1	6.4	57.6	7.1	87.9	16.8	72.5	2.9	74.7	7.8	86.3	32.5	66.3	4.0	32.0	0.3	31.7	0.3
Limacina spp.	44.9	5.6	5.1	0.4	14.1	3.1	2.2	0.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Tomopteris spp.	75.5	4.9	73.7	5.4	43.4	1.1	53.8	1.4	74.7	3.4	46.3	3.0	45.5	1.9	56.0	2.0	31.7	1.3
Vibilia antarctica	49.0	3.5	58.6	6.2	74.7	3.6	54.9	0.7	74.7	2.3	66.3	3.9	98.0	16.3	94.7	3.8	96.2	13.2
Siphonophora	36.7	2.8	22.2	3.9	41.4	5.3	4.4	0.1	3.6	0.1	2.1	0.0	3.0	0.3	-----	-----	-----	-----
Cyllopus magellanicus	33.7	2.8	42.4	1.2	79.8	13.7	35.2	0.4	37.3	0.5	44.2	3.3	30.7	0.5	78.7	2.0	64.4	1.9
Arctapodema ampla	24.5	2.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepidonotothen larseni (L)	53.1	1.9	37.4	0.7	19.2	0.3	36.3	0.9	48.2	1.5	18.9	3.8	10.9	0.7	20.0	0.2	23.1	0.5
Euphausia spp. (L)	13.3	1.3	32.3	12.2	23.2	6.0	0.0	0.0	0.0	0.0	11.6	93.5	0.0	0.0	10.7	11.1	0.0	0.0
Euphausia triacantha	18.4	1.2	19.2	1.4	11.1	2.6	15.4	0.7	10.8	0.7	7.4	0.8	13.9	1.6	17.3	0.4	7.7	0.3
Hyperiella dilatata	61.2	1.2	49.5	0.6	36.4	0.7	47.3	0.4	65.1	0.8	53.7	1.3	24.8	0.4	52.0	0.5	39.4	0.4
Spongiobranchaea australis	71.4	1.1	79.8	2.5	51.5	1.5	79.1	2.5	57.8	1.4	69.5	1.9	68.3	2.1	69.3	1.4	45.2	0.9
Larval Fish	38.8	1.0	38.4	2.0	12.1	0.2	0.0	0.0	12.0	0.4	8.4	3.3	18.8	0.6	9.3	0.1	8.7	0.1
Larvacean	14.3	1.0	13.1	87.1	20.2	3.4	3.3	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ihlea racovitzai	17.3	0.8	11.1	0.6	22.2	2.4	42.9	37.0	13.3	0.2	12.6	1.1	12.9	1.1	25.3	3.3	5.8	41.5
Barnacle larvae	17.3	0.7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Clione limacina	34.7	0.6	54.5	0.8	47.5	1.0	33.0	0.6	54.2	2.9	40.0	2.3	26.7	0.9	17.3	0.1	38.5	0.9
Lepidonotothen kempi (L)	19.4	0.6	29.3	0.8	9.1	0.2	11.0	0.3	15.7	0.2	8.4	0.3	7.9	0.4	6.7	0.0	13.5	0.3
Mysids	2.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.1	1.0	0.0	-----	-----	-----	-----
Diphyes antarctica	38.8	0.5	30.3	0.4	19.2	0.2	23.1	0.3	33.7	0.5	15.8	0.4	23.8	0.5	34.7	0.5	37.5	1.1
Rhynchonereella bongraini	19.4	0.4	35.4	1.5	2.0	0.1	9.9	0.2	18.1	0.5	0.0	0.0	1.0	0.0	33.3	0.8	9.6	0.2
Hyperiella spp.	20.4	0.4	10.1	0.9	2.0	0.0	1.1	0.0	6.0	0.0	11.6	0.1	5.9	0.1	-----	-----	-----	-----
Sipunculids	34.7	0.4	28.3	1.1	33.3	16.2	19.8	0.3	26.5	0.2	3.2	0.0	3.0	0.0	10.7	0.0	11.5	0.1
Polychaetes	14.3	0.4	22.2	3.3	22.2	1.4	8.8	0.1	0.0	0.0	15.8	6.7	7.9	0.7	20.0	0.6	28.8	1.5
Euphausia frigida (L)	7.1	0.4	34.3	30.1	7.1	1.7	2.2	0.2	8.4	0.4	-----	-----	-----	-----	-----	-----	-----	-----
Electrona spp. (L)	15.3	0.4	57.6	2.7	5.1	0.1	16.5	0.3	44.6	1.5	3.2	0.0	10.9	0.4	24.0	0.2	10.6	0.2
Clio pyramidata sulcata	6.1	0.3	2.0	0.0	1.0	0.0	2.2	0.1	7.2	0.1	75.8	53.4	32.7	5.9	9.3	0.1	4.8	0.3
Callianira antarctica	14.3	0.2	24.2	0.5	3.0	0.1	0.0	0.0	14.5	0.1	-----	-----	-----	-----	-----	-----	-----	-----
Cyllopus spp.	8.2	0.2	6.1	0.0	18.2	0.8	0.0	0.0	10.8	0.2	3.2	0.0	2.0	0.0	28.0	0.4	1.0	0.0
Hydromedusae	24.5	0.2	17.2	0.1	14.1	0.1	6.6	0.0	0.0	0.0	15.8	0.4	14.9	0.4	37.3	0.2	0.0	0.0

Table 4.11 (Contd.)

Survey A	January-February																	
	2007		2006		2005		2004		2003		2002		2001		1999		1998	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Ctenophora	17.3	0.2	8.1	0.0	7.1	0.1	2.2	0.0	3.6	0.0	1.1	0.0	5.0	0.1	6.7	0.0	3.8	
Notolepis coatsi (L)	12.2	0.2	32.3	0.5	6.1	0.1	18.7	0.2	16.9	0.1	4.2	0.0	1.0	0.0	5.3	0.0	3.8	0.0
Spongiobranchaea sp.	11.2	0.2	2.0	0.0	10.1	0.2	2.2	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----
Scina spp.	6.1	0.2	8.1	0.9	1.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	1.0	0.1	0.0	0.0	0.0	0.0
Hyperiella macronyx	18.4	0.1	9.1	0.0	2.0	0.0	1.1	0.0	6.0	0.1	3.2	0.0	-----	-----	2.7	0.0	2.9	0.1
Pelagobia longicirrata	15.3	0.1	3.0	0.1	2.0	0.0	2.2	0.0	0.0	0.0	1.1	0.0	3.0	0.0	0.0	0.0	0.0	0.0
Vanadis antarctica	10.2	0.1	2.0	0.0	3.0	0.1	0.0	0.0	0.0	0.0	2.1	0.0	5.0	0.1	5.3	0.1	4.8	0.1
Clio pyramidata sp.?	12.2	0.1	9.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Hyperiids	4.1	0.1	9.1	0.3	11.1	0.2	1.1	0.0	6.0	0.1	4.2	0.5	12.9	0.7	-----	-----	-----	-----
Thyploscolex spp.	2.0	0.1	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Orchomene plebs	9.2	0.1	7.1	0.1	10.1	0.1	2.2	0.0	2.4	0.0	1.1	0.0	-----	-----	-----	-----	1.0	0.0
Cyllopus lucasii	7.1	0.1	7.1	0.1	27.3	0.5	78.0	3.0	31.3	0.5	34.7	1.4	87.1	22.4	6.7	0.0	20.2	0.5
Dimophyes arctica	9.2	0.1	5.1	0.0	7.1	0.2	9.9	0.2	16.9	0.1	13.7	0.6	10.9	0.2	6.7	0.1	2.9	0.1
Pegantha martagon	7.1	0.1	13.1	0.2	0.0	0.0	8.8	0.2	7.2	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Orchomene spp.	8.2	0.1	2.0	0.0	0.0	0.0	0.0	0.0	2.4	0.1	-----	-----	-----	-----	-----	-----	-----	-----
Thyphloscolex muelleri	2.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cumaceans	1.0	0.1	3.0	0.7	0.0	0.0	3.3	0.1	2.4	0.3	2.1	2.7	1.0	0.0	-----	-----	-----	-----
Beroe cucumis	8.2	0.0	7.1	0.1	3.0	0.0	5.5	0.0	8.4	0.1	2.1	0.0	20.8	0.3	4.0	0.0	3.8	0.0
Acanthophyra pelagica (L)	8.2	0.0	24.2	0.2	8.1	0.1	5.5	0.0	10.8	0.1	2.1	1.5	0.0	0.0	17.3	0.2	3.8	0.0
Gastropods	7.1	0.0	11.1	0.2	8.1	0.2	0.0	0.0	3.6	0.1	2.1	0.0	-----	-----	-----	-----	-----	-----
Orchomene rossi	6.1	0.0	3.0	0.4	2.0	0.0	1.1	0.0	6.0	0.0	0.0	0.0	1.0	0.0	4.0	0.0	0.0	0.0
Lepidonotothen larseni (J)	1.0	0.0	1.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----
Cephalopods	5.1	0.0	1.0	0.0	2.0	0.0	1.1	0.0	1.2	0.0	0.0	0.0	1.0	0.0	1.3	0.0	1.0	0.0
Calycopsis borchgrevinki	3.1	0.0	6.1	0.0	1.0	0.0	3.3	0.0	2.4	0.0	1.1	0.0	4.0	0.2	2.7	0.0	1.0	0.0
Electrona antarctica	3.1	0.0	5.1	0.0	4.0	0.0	8.8	0.1	1.2	0.0	3.2	0.0	5.9	0.0	1.3	0.0	3.8	0.1
Eusirus antarcticus	2.0	0.0	6.1	0.0	7.1	0.0	13.2	0.1	4.8	0.0	1.1	0.0	-----	-----	0.0	0.0	1.0	0.0
Electrona carlsbergi	3.1	0.0	3.0	0.0	4.0	0.0	0.0	0.0	1.2	0.0	2.1	0.0	2.0	0.0	2.7	0.0	1.0	0.0
Epimeriella macronyx	3.1	0.0	2.0	0.0	1.0	0.0	4.4	0.0	1.2	0.0	0.0	0.0	1.0	0.0	0.0	0.0	5.8	0.2
Notolepis spp. (L)	3.1	0.0	15.2	0.3	2.0	0.0	1.1	0.0	2.4	0.0	0.0	0.0	2.0	0.0	0.0	0.0	1.0	0.0
Decapods (L)	1.0	0.0	1.0	0.0	1.0	0.0	2.2	0.0	2.4	0.0	3.2	1.7	0.0	0.0	1.3	0.0	2.9	0.0
Hyperiella antarctica	2.0	0.0	1.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chionodraco rastrospinosus (L)	2.0	0.0	1.0	0.0	1.0	0.0	5.5	0.0	4.8	0.0	2.1	0.0	-----	-----	1.3	0.0	1.9	0.0
Mertensia spp.	2.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Gymnoscopelus braueri	1.0	0.0	3.0	0.0	2.0	0.0	1.1	0.0	1.2	0.0	1.1	0.0	1.0	0.0	-----	-----	-----	-----
Schyphomedusae	2.0	0.0	8.1	0.0	3.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	2.0	0.0	1.3	0.0	1.9	0.0
Clio pyramidata antarctica	1.0	0.0	0.0	0.0	24.2	1.1	11.0	0.1	15.7	1.7	2.1	0.0	-----	-----	-----	-----	-----	-----
Staurophora mertensi ?	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----
Eusirus spp.	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Pleurobrachia pileus	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Beroe forskalii	1.0	0.0	1.0	0.0	2.0	0.0	18.7	0.2	30.1	0.4	0.0	0.0	17.8	0.2	2.7	0.0	1.0	0.0
Pleuragramma antarcticum (J)	2.0	0.0	22.2	1.5	2.0	0.0	0.0	0.0	15.7	0.4	1.1	0.0	4.0	0.1	1.3	0.1	4.8	0.0
Atolla wyvillei	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mertensiidae	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Cryodraco antarctica (L)	1.0	0.0	0.0	0.0	2.0	0.0	1.1	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyperoche medusarum	1.0	0.0	3.0	0.0	2.0	0.0	2.2	0.0	6.0	0.0	1.1	0.0	5.0	0.1	5.3	0.0	1.0	0.0
Krefftichthys anderssoni	1.0	0.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4.11 (Contd.)

Survey A	January-February																	
	2007		2006		2005		2004		2003		2002		2001		1999		1998	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Clione antarctica	2.0	0.0	1.0	0.0	0.0	0.0	13.2	0.1	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----
Artededraco mirus (L)	1.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	1.2	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gammarids	0.0	0.0	2.0	0.1	0.0	0.0	7.7	0.1	3.6	0.4	1.1	0.0	0.0	0.0	2.7	0.0	1.0	0.0
Pasiaphaea sp. (L)	0.0	0.0	3.0	0.1	10.1	0.3	1.1	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----
Harpagifer antarcticus (L)	0.0	0.0	2.0	0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notolepis annulata (L)	0.0	0.0	6.1	0.0	0.0	0.0	1.1	0.0	2.4	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0
Bathylagus sp. (L)	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	3.2	0.3	0.0	0.0	0.0	0.0	1.0	0.0
Oediceroides calmani	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leusia sp.	0.0	0.0	2.0	0.0	1.0	0.0	0.0	0.0	1.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----
Periphylla periphylla	0.0	0.0	3.0	0.0	0.0	0.0	1.1	0.0	1.2	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0
Eusirus perdentatus	0.0	0.0	1.0	0.0	1.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.3	0.0	0.0	0.0
Heterophoxus videns	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Desmonema gaudichaudi	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Solomdella spp.	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Nansithae spp.	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Gonatus antarcticus	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Trematomus scotti (L)	0.0	0.0	1.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----
Botrynema brucei	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.1	0.0	0.0	0.0	0.0
Euphausia crystallorophias (L)	0.0	0.0	0.0	0.0	1.0	0.5	3.3	0.0	4.8	0.2	-----	-----	-----	-----	-----	-----	-----	-----
Lepidonotothen nudifrons (L)	0.0	0.0	0.0	0.0	13.1	0.2	4.4	0.1	0.0	0.0	5.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Chorismus antarcticus (L)	0.0	0.0	0.0	0.0	5.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notothenia spp. (L)	0.0	0.0	0.0	0.0	4.0	0.1	0.0	0.0	0.0	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----
Bargmannia elongata	0.0	0.0	0.0	0.0	4.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Euphausia triacantha (L)	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	4.8	2.8	-----	-----	-----	-----	-----	-----	-----	-----
Halitholus spp.	0.0	0.0	0.0	0.0	2.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bolinopsis sp.	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Modeeria rotunda	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	1.2	0.0	2.1	0.2	-----	-----	-----	-----	-----	-----
Eusirus properdentatus	0.0	0.0	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Electrona subaspera	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.0	0.0	-----	-----	-----	-----
Laodicea undulata	0.0	0.0	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mitrocomella brownei	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----
Gymnoscopelus nicholsi	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chromatonema rubra	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	2.1	0.1	-----	-----	-----	-----	-----	-----
Cyphocaris richardi	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bolinopsis infundibulus	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	4.8	0.0	1.1	0.0	-----	-----	5.3	0.0	1.9	0.0
Travisiopsis coniceps	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trematomus lepidorhinus (L)	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.1	0.1	-----	-----	-----	-----	-----	-----
Travisiopsis levinseni	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clio pyramidata martensi?	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----
Notocrangon antarcticus(?)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.1	-----	-----	-----	-----	-----	-----	-----	-----
Fish Eggs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.1	0.0	0.0	0.0	0.0	1.3	0.0	1.0	0.0
Krefftichthys anderssoni (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyperia antarctica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.1	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Maupasia coeca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	1.0	0.0	1.3	0.0	0.0	0.0
Atolla sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----
Vogtia serrata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0

Table 4.11 (Contd.)

Survey A	January-February																	
	2007		2006		2005		2004		2003		2002		2001		1999		1998	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Russelia mirabilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----
Phalacrophorus pictus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Prionodraco evansii (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	-----	-----	-----	-----	-----	-----
Notothenia coriiceps (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0
Parachaenechthys charcoti (L)	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----
Gosea brachyura	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyperia macrocephala	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1
Gymnodraco acuticeps (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Patagonitothen b. guntheri (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	-----	-----
Gymnoscopelus opisthopteris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaenodraco wilsoni (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----	-----	-----	-----	-----	-----
Eusirus microps	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphysora gigantea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Schizobrachium polycotylum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----
Crustacean larvae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.8	-----	-----	-----	-----	-----	-----
Trematomus newnesi (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.1	-----	-----	-----	-----	-----	-----
Bylgides pelagica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0
Zanclonia weldoni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----
Gobionotothen gibberifrons (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.3	0.0	1.0	0.0
Artededraco sp. B (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artededraco skottsbergi (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Chaenocephalus aceratus (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0
TOTAL		2104.0		8648.3		2037.0		1033.1		1264.9		11143.1		3812.2		1294.2		1172.7
TAXA	91		98		95		89		88		89		63		65		63	

Table 4.12. Percent contribution and abundance rank (R) of numerically dominant zooplankton and nekton taxa in the Elephant Island area during January-February 1996-2007. Only the 10 ten most abundant taxa are included for each year. Radiolaria excluded as a taxonomic category. No samples were collected January-February 2000. Dashes indicate that the taxon was not enumerated during that survey.

	January-February																					
	2007		2006		2005		2004		2003		2002		2001		1999		1998		1997		1996	
TAXON	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R
Copepods	71.59	1	53.61	1	18.54	2	50.37	1	42.52	1	75.69	1	46.76	1	58.05	1	4.80	3	57.16	1	56.18	1
Thysanoessa macrura	8.52	2	2.32	6	8.71	3	11.02	3	18.79	3	2.77	4	2.15	5	2.92	6	15.38	2	10.24	3	7.56	4
Salpa thompsoni	8.47	3	0.92	7	61.45	1	17.94	2	4.87	4	5.66	3	29.03	2	12.35	2	68.76	1	17.79	2	1.45	6
Euphausia superba	3.14	4	0.35		1.38	6	6.10	4	25.06	2	0.54	6	0.88	10	0.33	8	3.13	5	3.96	4	7.95	3
Chaetognaths	2.11	5	4.58	3	0.80	9	3.60	5	1.51	6	1.93	5	2.68	4	4.00	5	0.92	7	2.28	5	0.90	7
Euphausia superba (L)	1.04	6	29.58	2	1.12	7	0.99	10	0.37	10	0.49	7	1.53	6	10.95	3	0.09		1.49	7	0.19	10
Euphausia frigida	0.83	7	0.49	9	1.45	5	1.96	6	0.84	7	0.39	9	1.09	7	1.00	7	0.02		1.45	8	0.14	
Limacina helicina	0.73	8	0.37	10	0.05		1.30	9	2.55	5	0.03		0.14		0.07		0.69	8	0.28		2.38	5
Primno macropa	0.50	9	0.12		0.17		0.40		0.44	9	0.12		0.10		0.13		0.06		0.42	10	0.01	
Ostracods	0.50	10	0.19		0.08		1.74	7	0.53	8	0.09		0.25		0.13		0.41	9	0.54	9	0.35	8
Tomopteris spp.	0.28		0.09		0.05		0.11		0.20		0.03		0.11		0.15	10	0.11		0.19		0.06	
Thysanoessa macrura (L)	0.23		3.27	4	2.19	4	0.69		0.09		10.67	2	12.55	3	7.29	4	0.00		1.67	6	21.82	2
Cyllopus magellanicus	0.13		0.02		0.88	8	0.07		0.04		0.09		0.01		0.15		0.21		0.45		0.13	
Vibilia antarctica	0.12		0.11		0.18		0.07		0.19		0.06		0.98	8	0.32	9	1.12	6	0.24		0.04	
Themisto gaudichaudii	0.07		0.02		0.64	10	0.24		0.35		0.32	10	0.17		0.02		0.03		0.35		0.34	9
Ihlea racovitzai	0.06		0.00		0.16		1.63	8	0.03		0.02		0.02		0.15		3.53	4	---		---	
Spongiobranchaea australis	0.06		0.04		0.05		0.29		0.15		0.02		0.09		0.09		0.07		0.22		0.13	
Euphausia triacantha	0.06		0.04		0.15		0.10		0.05		0.02		0.10		0.03		0.02		0.14		0.04	
Larvaceans	0.05		2.60	5	---		---		---		---		---		---		---		---		---	
Clio pyramidata spp.	0.01		0.00		0.05		0.01		0.01		0.46	8	0.08		0.01		0.02		0.00		0.01	
Euphausia frigida (L)	0.02		0.78	8	---		---		---		---		---		---		---		---		---	
Cyllopus lucasii	0.00		0.00		0.03		0.38		0.06		0.02		0.98	9	0.15		0.16	10	0.37		0.11	
TOTAL	98.53		99.51		98.13		98.94		98.65		99.43		99.68		98.15		99.32		98.79		99.64	

Table 4.13. Percent Similarity Index (PSI) values from comparisons of overall zooplankton composition in the Elephant Island Area during Survey A,1994-2007

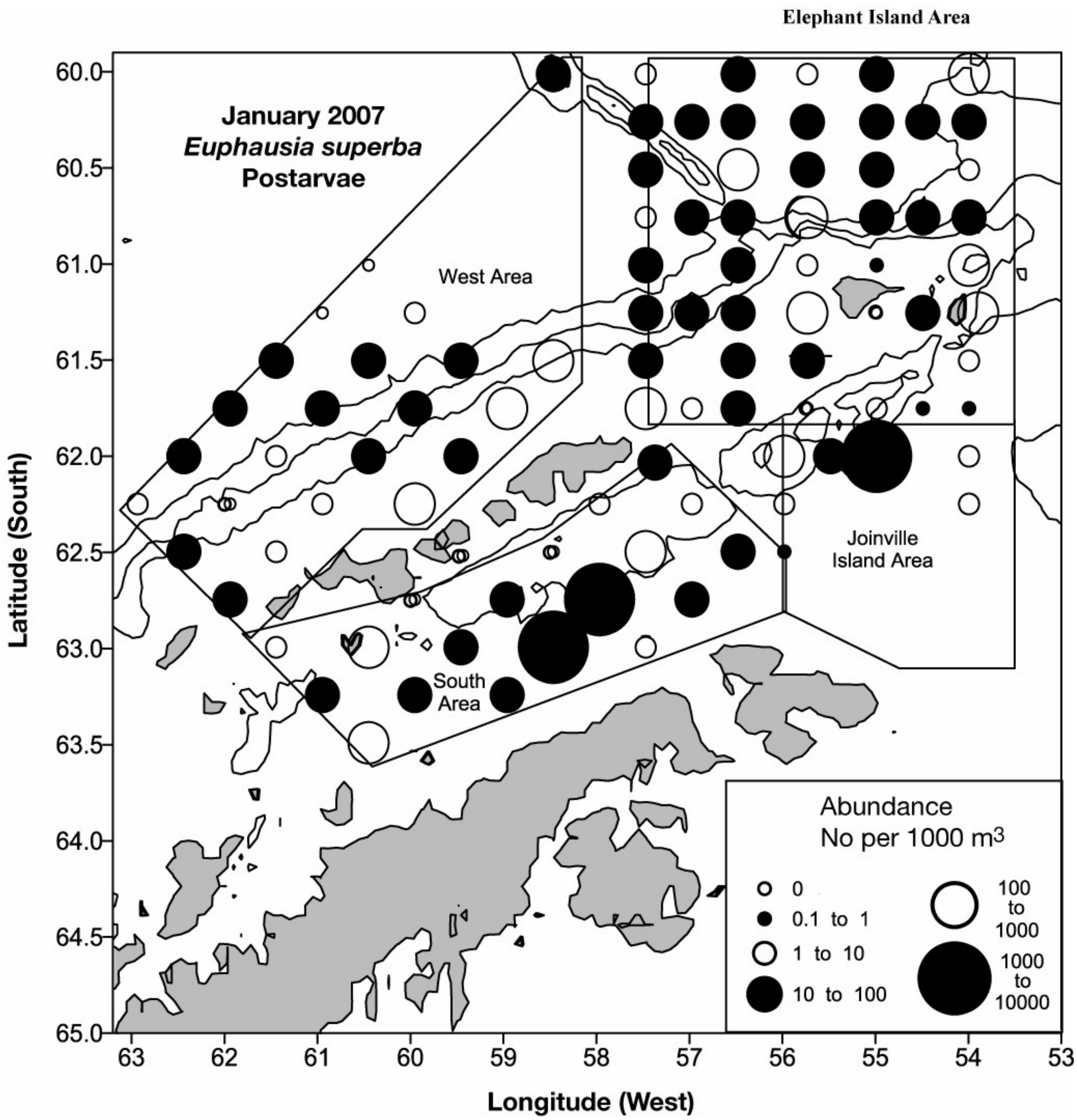
	January-February PSI Values												
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1994	16.7	16.6	34.2	85.0	20.9	n.a	38.7	14.5	20.9	34.0	76.4	8.5	24.2
1995	xxxxx	70.3	76.8	18.7	80.7	n.a.	58.9	71.7	58.7	70.2	35.4	77.2	78.4
1996		xxxxx	73.4	19.3	70.0	n.a.	65.9	73.4	64.2	69.7	32.9	62.5	71.3
1997			xxxxx	38.4	80.2	n.a.	75.7	71.3	66.6	90.1	52.6	64.0	83.3
1998				xxxxx	22.6	n.a.	39.8	15.2	30.9	41.2	78.0	10.3	27.7
1999					xxxxx	n.a.	75.1	77.4	54.4	73.2	40.0	76.5	74.9
2000						xxxxx	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
2001							xxxxx	69.2	54.4	74.6	56.7	58.9	63.4
2002								xxxxx	53.8	63.5	32.2	63.7	84.2
2003									xxxxx	70.3	36.7	49.6	64.1
2004										xxxxx	51.5	60.7	76.8
2005											xxxxx	27.3	40.7
2006												xxxxx	62.1

Table 4.14. Abundance of biomass dominant copepod species in the Elephant Island area during various cruises 1981-2007. 1981-1990 data provided by John Wormuth. Dashes indicate that data are not available.

Survey Period	No. per 1000 m3	*Calanoides acutus*	*Calanus propinquus*	*Metridia gerlachei*	*Rhincalanus gigas*	*Pleuromamma robusta*	*Paraeuchaeta antarctica*	*Paraeuchaeta* spp.	*Haloptilus ocellatus*	*Heterorhabdus austrinus*	Copepodites	Other Copepods	Total Copepods
Jan-Feb	Mean	429.7	93.6	1639.0	---	---	---	---	---	---	---	---	---
1989	STD	676.8	104.3	3488.0	---	---	---	---	---	---	---	---	---
N=48	Med	80.5	45.5	57.0	---	---	---	---	---	---	---	---	---
Jan	Mean	302.5	354.4	981.3	---	---	---	---	---	---	---	---	1700.2
1990	STD	405.8	365.8	1620.7	---	---	---	---	---	---	---	---	2003.7
N=23	Med	170.1	243.6	192.3	---	---	---	---	---	---	---	---	656.7
Jan	Mean	335.4	109.1	340.5	---	---	---	---	---	---	---	---	927.0
1999	STD	1009.5	161.9	512.7	---	---	---	---	---	---	---	---	1590.8
N=40	Med	28.9	52.0	66.0	---	---	---	---	---	---	---	---	332.9
Jan	Mean	241.0	50.4	488.4	20.2	5.5	0.2	---	0.0	---	---	197.5	1003.2
2001	STD	392.0	85.9	1103.3	74.8	21.0	0.6	---	0.0	---	---	527.3	1582.4
N=60	Med	117.7	12.5	45.5	0.0	0.0	0.0	---	0.0	---	---	41.8	252.2
Jan	Mean	2931.3	1862.2	350.8	141.6	1.4	122.7	---	0.0	---	30.2	44.2	5484.3
2002	STD	8293.0	5659.2	467.6	381.0	6.3	185.6	---	0.0	---	154.1	89.0	14585.6
N=44	Med	876.4	502.7	130.3	16.4	0.0	57.7	---	0.0	---	0.0	11.0	2174.9
Jan	Mean	75.6	80.1	241.2	11.1	1.8	0.0	---	0.2	---	0.1	41.0	541.0
2003	STD	67.9	65.0	639.3	23.4	10.9	0.0	---	1.0	---	0.9	34.9	798.6
N=38	Med	52.0	55.1	6.7	1.9	0.0	0.0	---	0.0	---	0.0	27.8	317.0
Jan	Mean	77.4	73.2	293.6	9.7	24.1	16.4	---	0.0	---	0.1	0.0	494.5
2004	STD	97.2	63.8	706.6	19.0	41.0	25.0	---	0.0	---	0.9	0.0	796.1
N=46	Med	42.7	57.1	25.4	0.2	7.8	7.6	---	0.0	---	0.0	0.0	208.7
Jan	Mean	39.0	26.4	220.0	12.6	1.4	0.6	---	0.0	0.0	0.0	49.1	364.6
2005	STD	62.7	41.8	614.4	21.0	7.0	2.6	---	0.0	0.0	0.0	57.9	687.3
N=48	Med	16.1	9.5	3.9	4.7	0.0	0.0	---	0.0	0.0	0.0	35.2	126.4
Jan	Mean	948.0	284.2	1157.1	292.7	1.6	0.5	---	15.3	0.0	0.0	644.1	3677.8
2006	STD	1526.1	358.1	2000.0	414.4	5.8	1.5	---	30.9	0.0	0.0	722.8	3563.5
N=48	Med	260.3	141.1	254.3	165.9	0.0	0.0	---	0.0	0.0	0.0	390.1	2279.8
Jan	Mean	200.9	16.0	885.3	45.8	2.2	0.6	215.2	0.7	0.7	0.0	148.2	1515.6
2007	STD	180.8	19.0	2953.0	50.2	9.0	1.7	236.0	2.6	2.0	0.0	113.7	3190.0
N=48	Med	170.0	9.2	27.3	34.0	0.0	0.0	122.3	0.0	0.0	0.0	115.6	716.3

4.14 cont.

Survey Period	No. per 1000 m3	*Calanoides acutus*	*Calanus propinquus*	*Metridia gerlachei*	*Rhincalanus gigas*	*Pleuromama robusta*	*Pareuchaeta antarctica*	*Paraeuchaeta* spp.	*Haloptilus ocellatus*	*Heterorhabdus austrinus*	Copepodites	Other Copepods	Total Copepods
Mar	Mean	4786.9	5925.8	2402.5	---	---	---	---	---	---	---	---	---
1981	STD	5482.2	6451.6	3321.4	---	---	---	---	---	---	---	---	---
N=10	Med	2197.7	2048.7	609.5	---	---	---	---	---	---	---	---	---
Feb-Mar	Mean	25.5	121.7	1154.4	---	---	---	---	---	---	---	---	---
1984	STD	29.6	134.4	2999.9	---	---	---	---	---	---	---	---	---
N=13	Med	16.2	51.4	23.1	---	---	---	---	---	---	---	---	---
Feb	Mean	161.4	194.9	3189.3	---	---	---	---	---	---	---	---	---
1989	STD	240.9	151.5	4017.2	---	---	---	---	---	---	---	---	---
N=25	Med	88.0	162.0	1051.0	---	---	---	---	---	---	---	---	---
Feb	Mean	511.8	300.9	521.1	---	---	---	---	---	---	---	---	1557.9
1999	STD	1395.6	630.6	699.0	---	---	---	---	---	---	---	---	2337.8
N=39	Med	70.7	70.8	216.9	---	---	---	---	---	---	---	---	621.6
Feb	Mean	1846.3	741.8	3051.7	1089.0	100.0	107.3	---	1.5	---	---	1171.4	8019.1
2000	STD	3177.2	1546.5	4783.5	2456.5	34.7	249.1	---	7.8	---	---	28232.0	11824.4
N=60	Med	225.2	193.3	1249.7	79.9	0.0	11.0	---	0.0	---	---	297.6	3478.0
Feb-Mar	Mean	2540.2	247.1	1450.0	32.4	3.7	74.7	---	0.4	---	116.1	37.0	4501.5
2001	STD	6921.6	402.9	2966.0	129.1	13.6	137.9	---	2.7	---	343.8	188.4	8072.4
N=57	Med	111.5	122.2	140.1	0.0	0.0	20.8	---	0.0	---	23.2	0.0	1518.0
Feb-Mar	Mean	9569.2	3827.4	2515.1	1226.4	30.0	169.3	---	14.8	---	5.2	116.0	17473.4
2002	STD	12553.1	4288.9	3124.5	1952.7	97.2	269.2	---	66.0	---	22.5	337.2	20036.9
N=44	Med	4855.6	2037.2	1183.6	346.2	0.0	52.5	---	0.0	---	0.0	0.0	7563.8
Feb	Mean	138.1	68.2	1092.8	39.0	5.9	3.8	---	0.5	---	0.0	205.0	1674.3
2003	STD	114.2	70.2	2239.6	45.9	17.5	10.0	---	1.7	---	0.0	235.4	2593.6
N=48	Med	119.3	47.9	197.3	17.9	0.0	0.0	---	0.0	---	0.0	130.2	737.5
Feb-Mar	Mean	1821.7	1113.3	1791.8	1209.3	7.7	168.9	---	15.1	88.2	0.3	89.7	6303.1
2004	STD	7439.2	3524.0	3902.9	5315.2	25.3	195.3	---	53.6	552.6	2.2	195.0	17739.5
N=47	Med	277.0	324.3	368.9	117.3	0.0	68.4	---	0.0	0.0	0.0	5.9	2233.5
Feb-Mar	Mean	144.2	22.6	708.9	54.0	2.2	1.1	---	0.2	0.9	0.0	54.2	1022.1
2005	STD	385.5	45.1	1075.7	54.2	9.7	3.0	---	1.1	5.2	0.0	64.7	1254.5
N=48	Med	47.8	9.9	76.7	31.6	0.0	0.0	---	0.0	0.0	0.0	32.3	344.3



4.1 Postlarval krill abundance in IKMT tows collected during Survey A, January 2007. The outlined stations included in the Elephant Island Area are used for between-year comparisons. West, South and Joinville Island Areas and stations are also indicated.

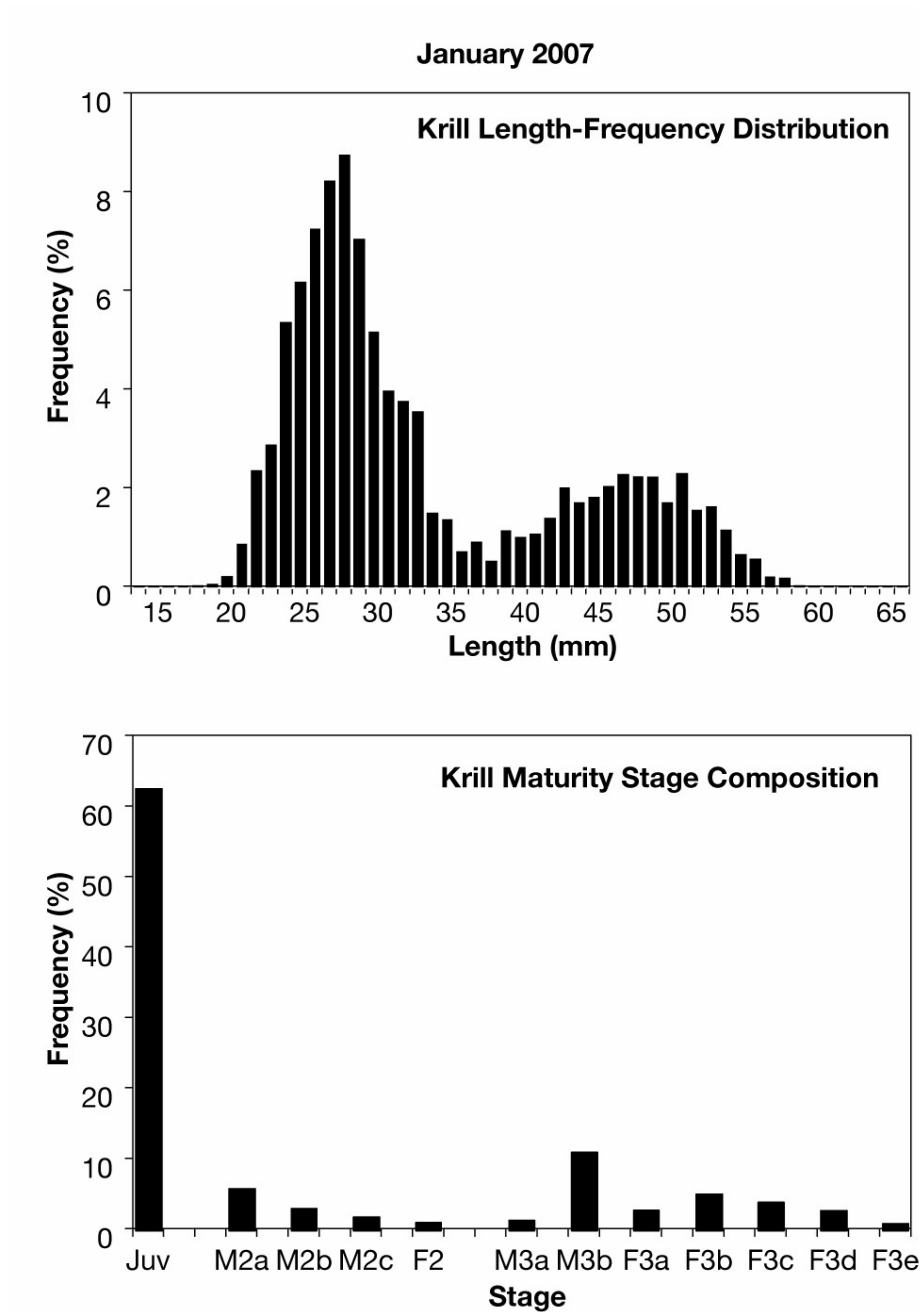


Figure 4.2 Overall krill length-frequency distribution and maturity stage composition during January 2007.

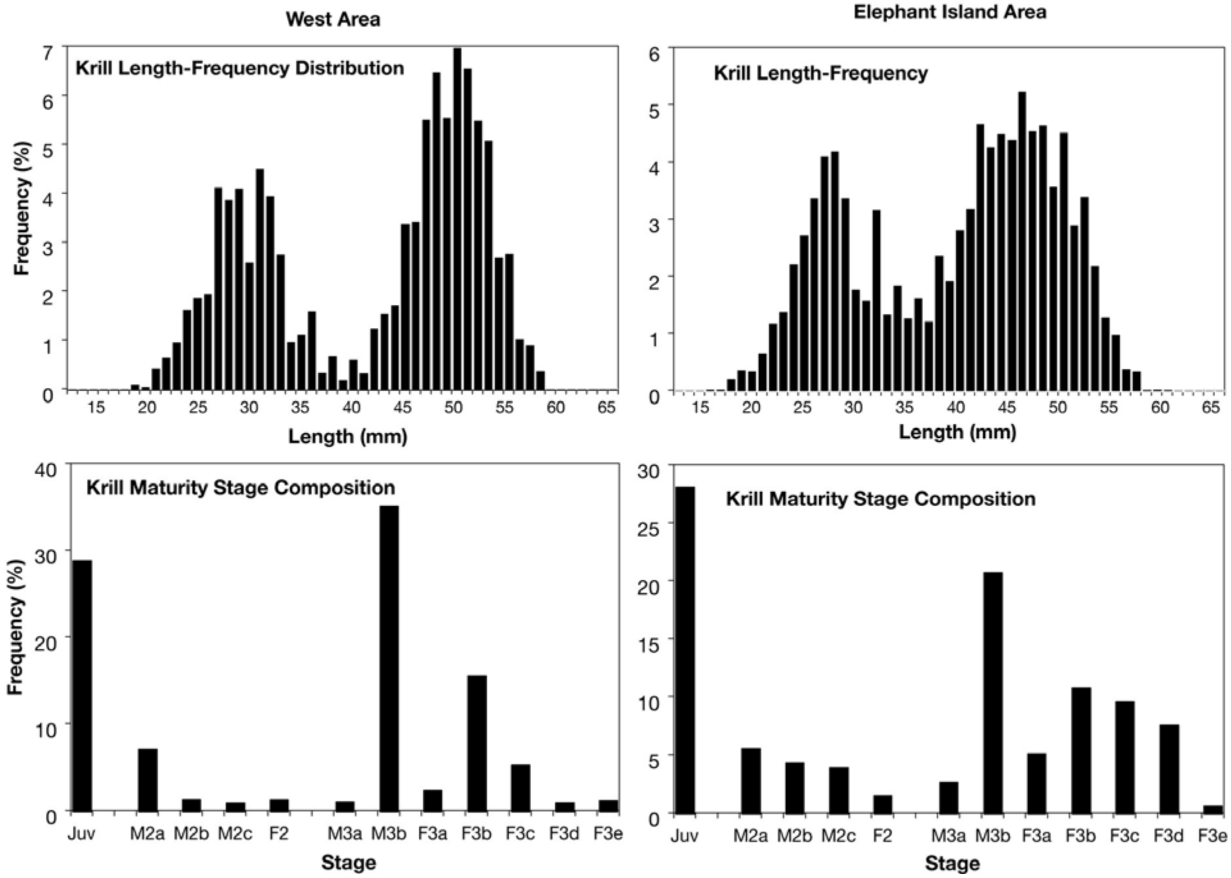


Figure 4.3a Krill length-frequency distribution and maturity stage composition in the West, Elephant Island, South and Joinville Island Areas during January 2007.

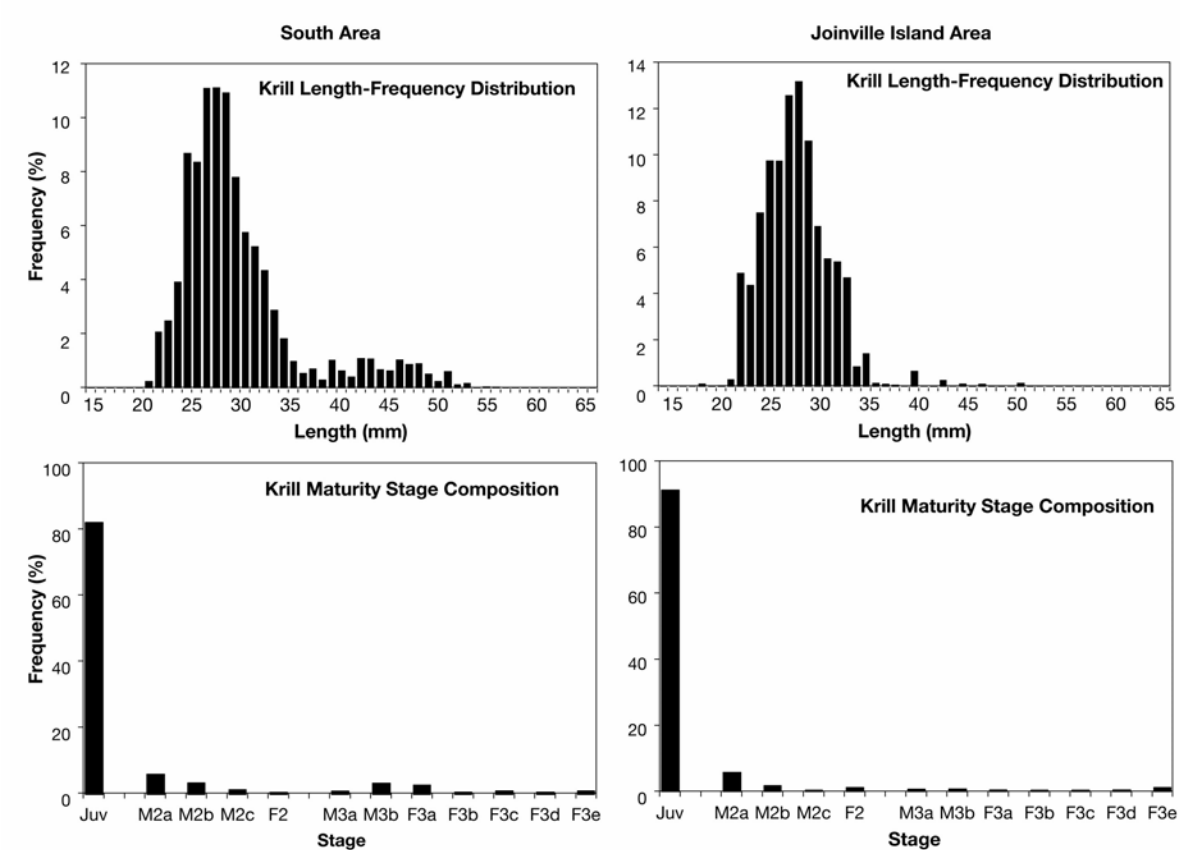


Figure 4.3b Krill length-frequency distribution and maturity stage composition in the West, Elephant Island, South and Joinville Island Areas during January 2007.

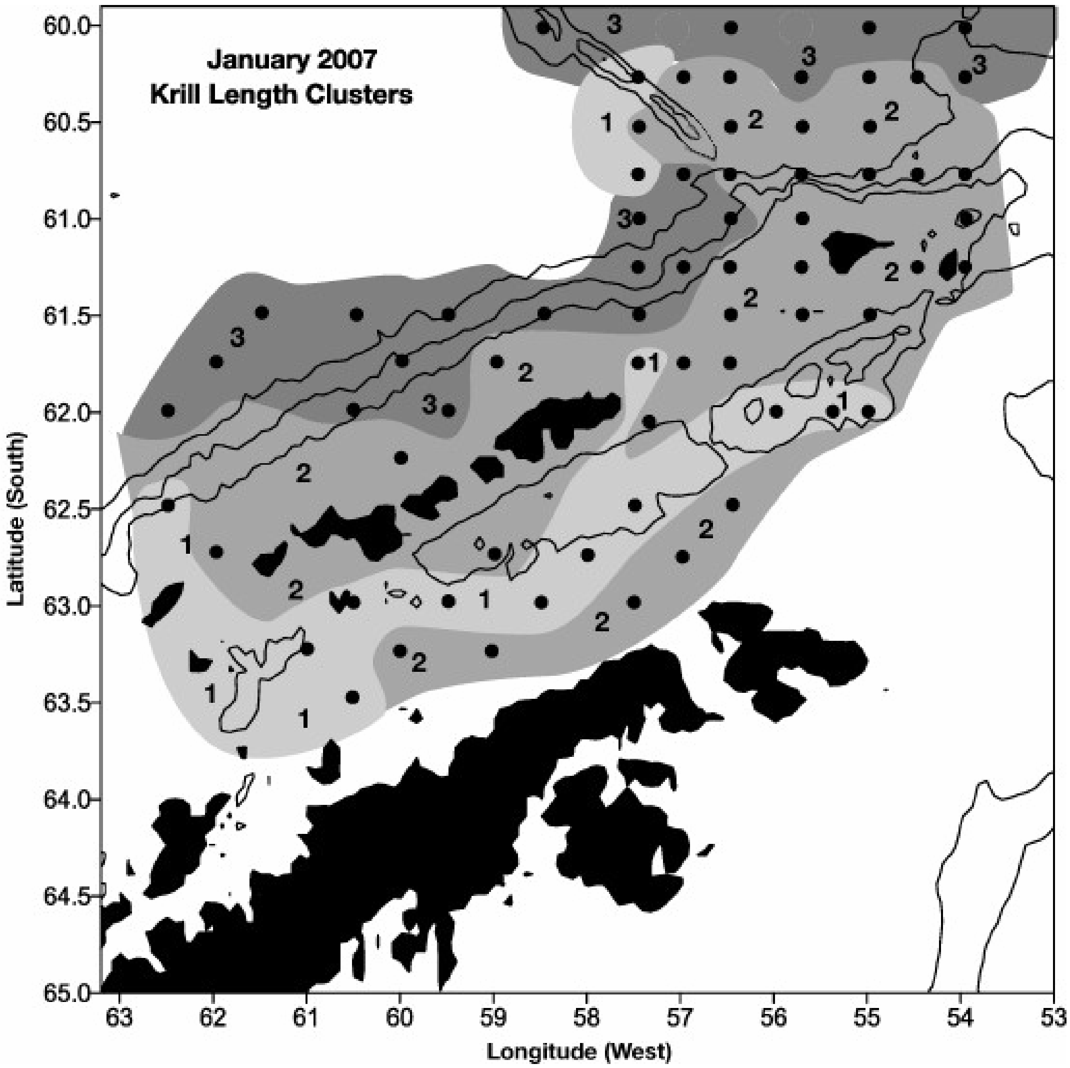


Figure 4.4 Distribution patterns of krill belonging to three length categories (Clusters) during January 2007.

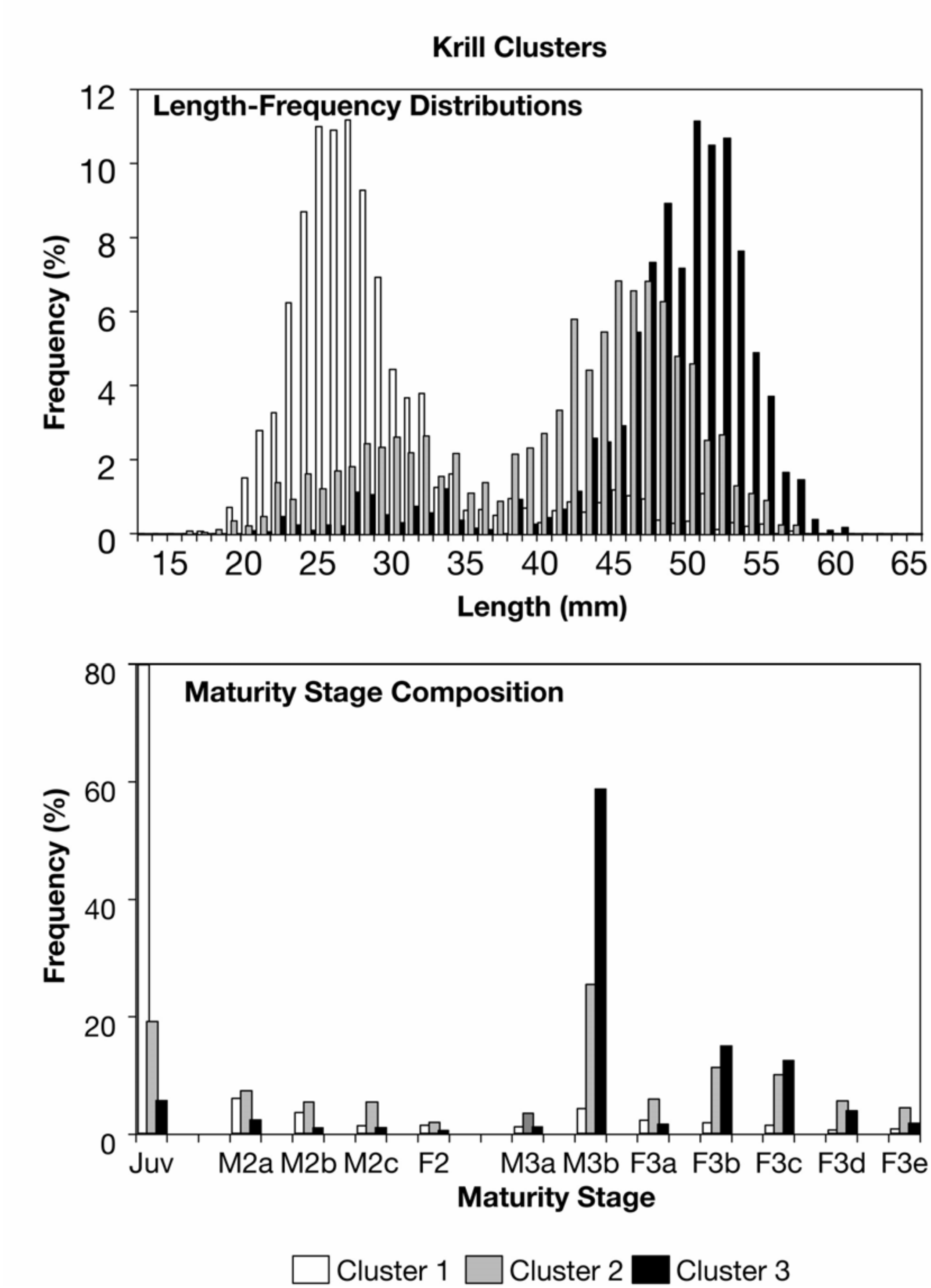


Figure 4.5 Length-frequency distribution and maturity stage composition of krill belonging to three Clusters during January 2007.

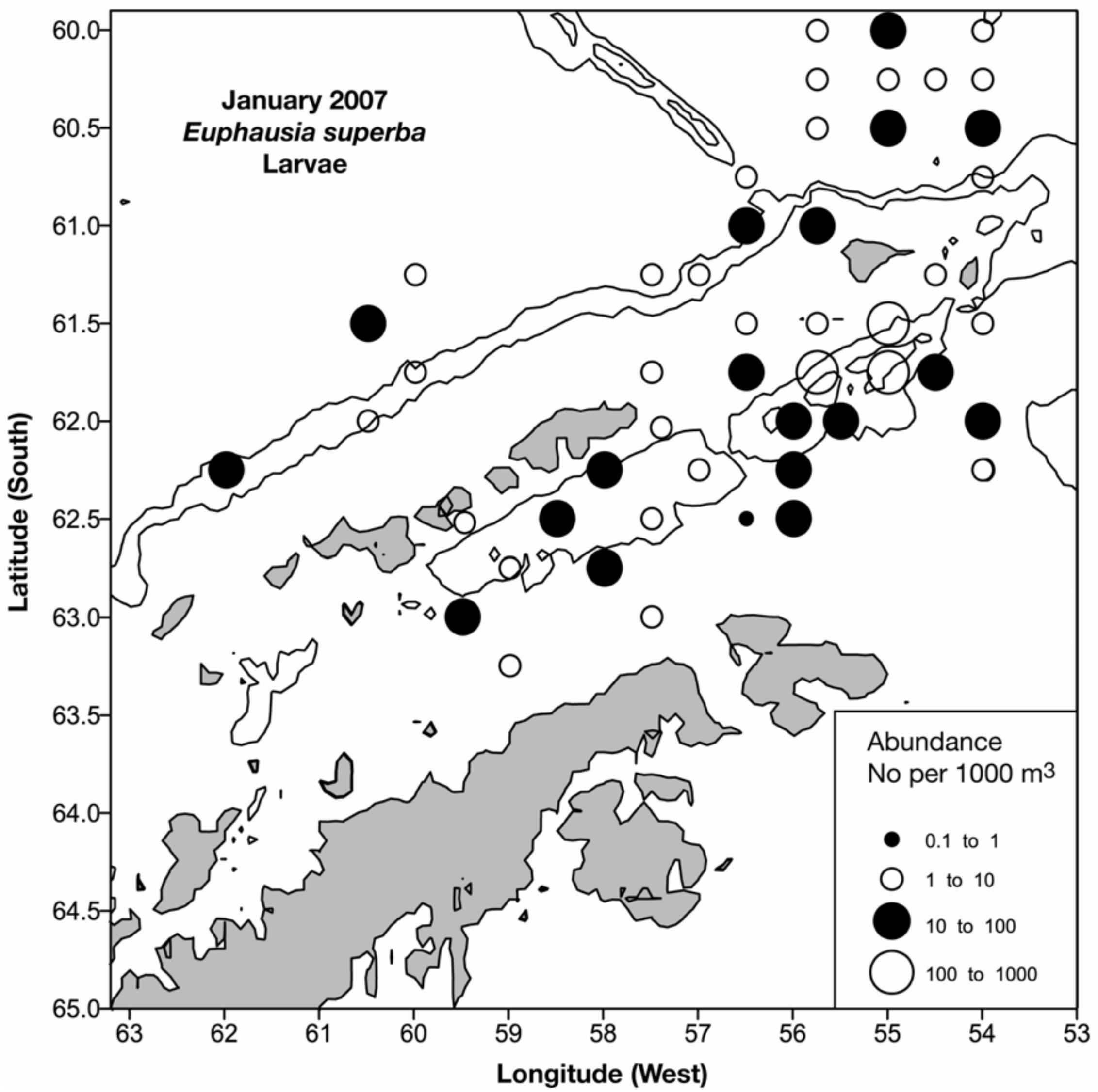


Figure 4.6 Distribution and abundance of krill larvae during January 2007.

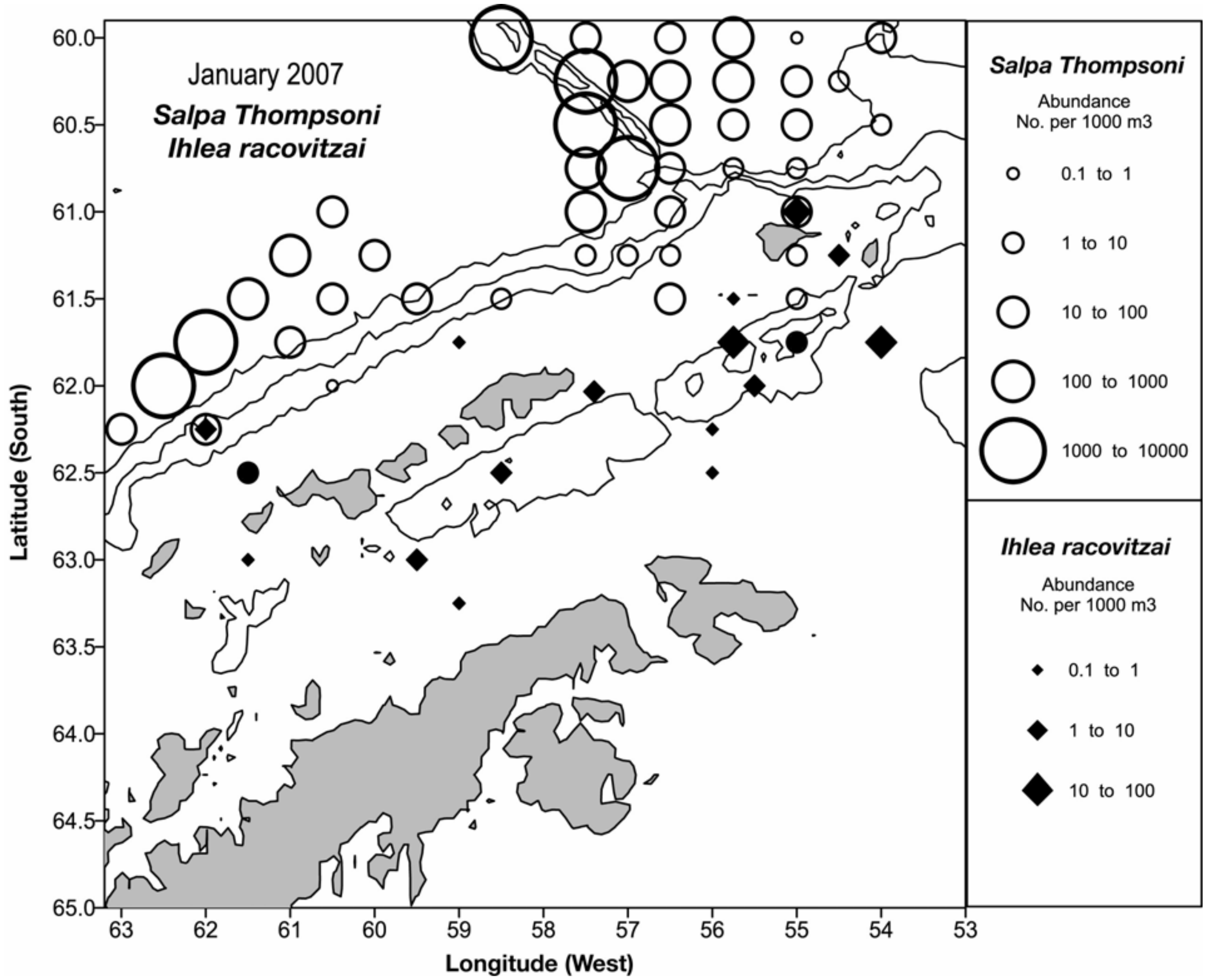


Figure 4.7 Distribution and abundance of *Salpa thompsoni* and *Ihlea racovitzai* during January 2007.

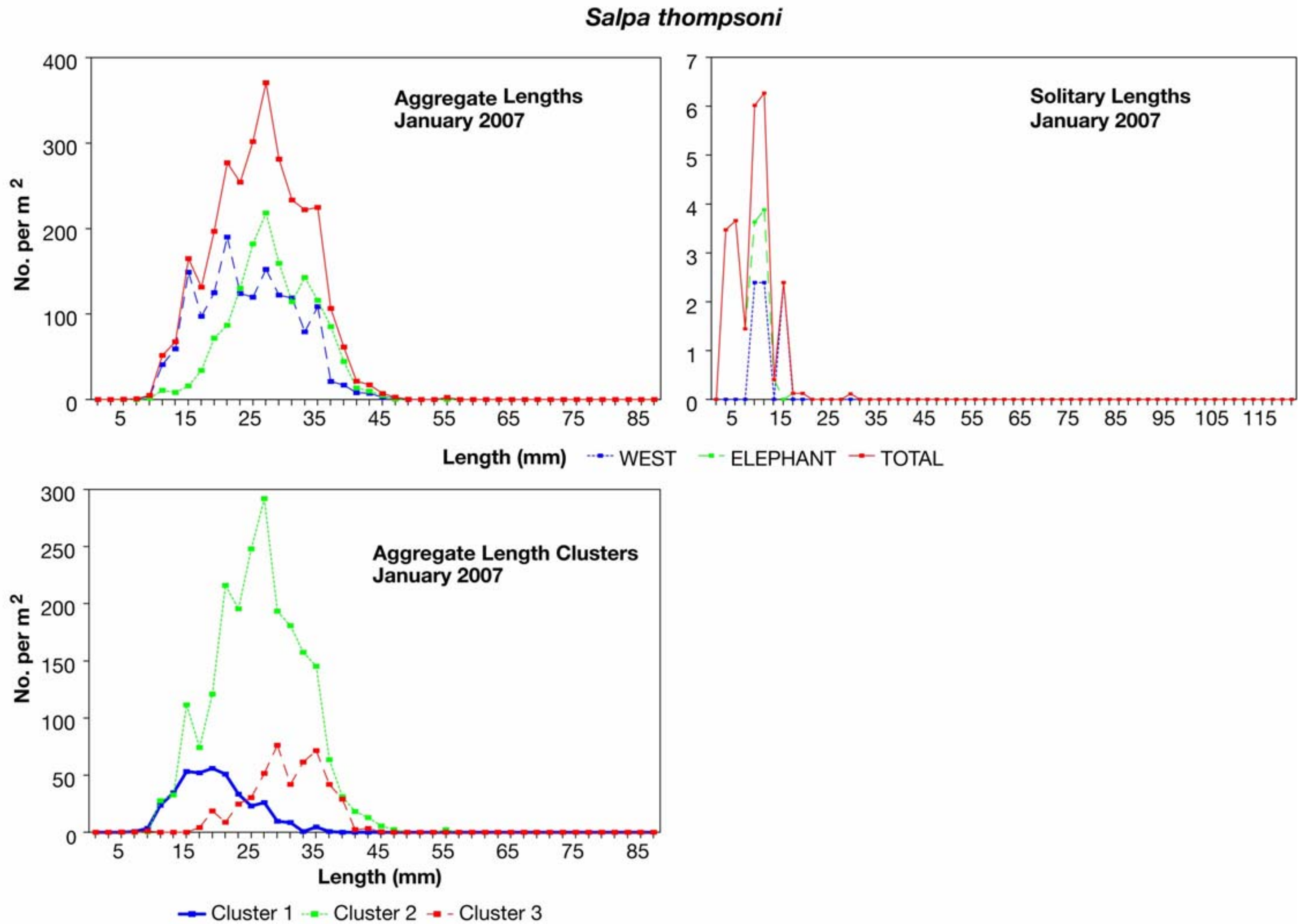


Figure 4.8 Length-frequency distributions of aggregate and solitary stage *Salpa thompsoni* overall and in the West and Elephant Island Areas during January 2007. No individuals were collected in the South or Joinville Island Areas.

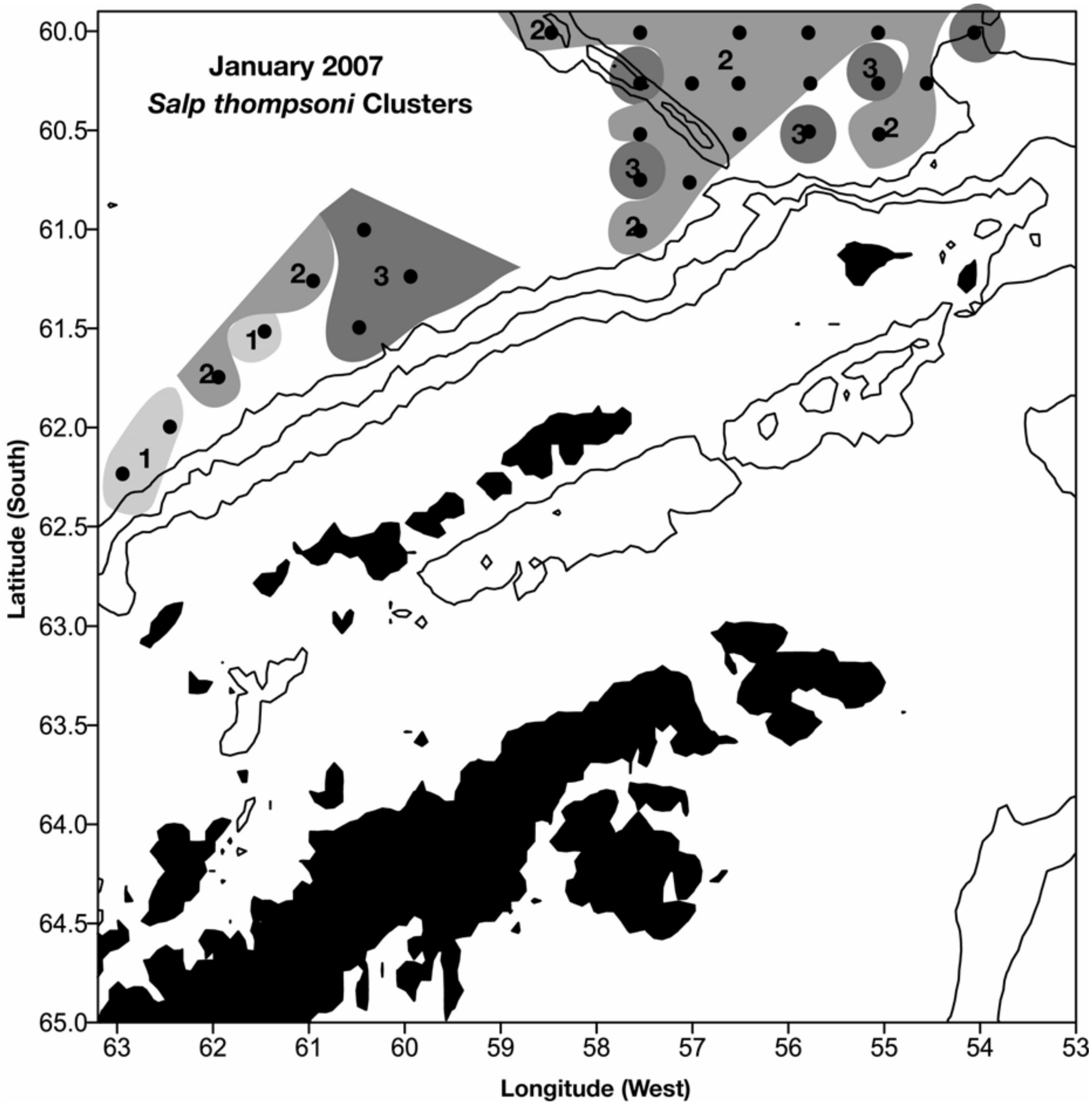


Figure 4.9 Distribution of aggregate salps belonging to three length categories (Clusters) during January 2007.

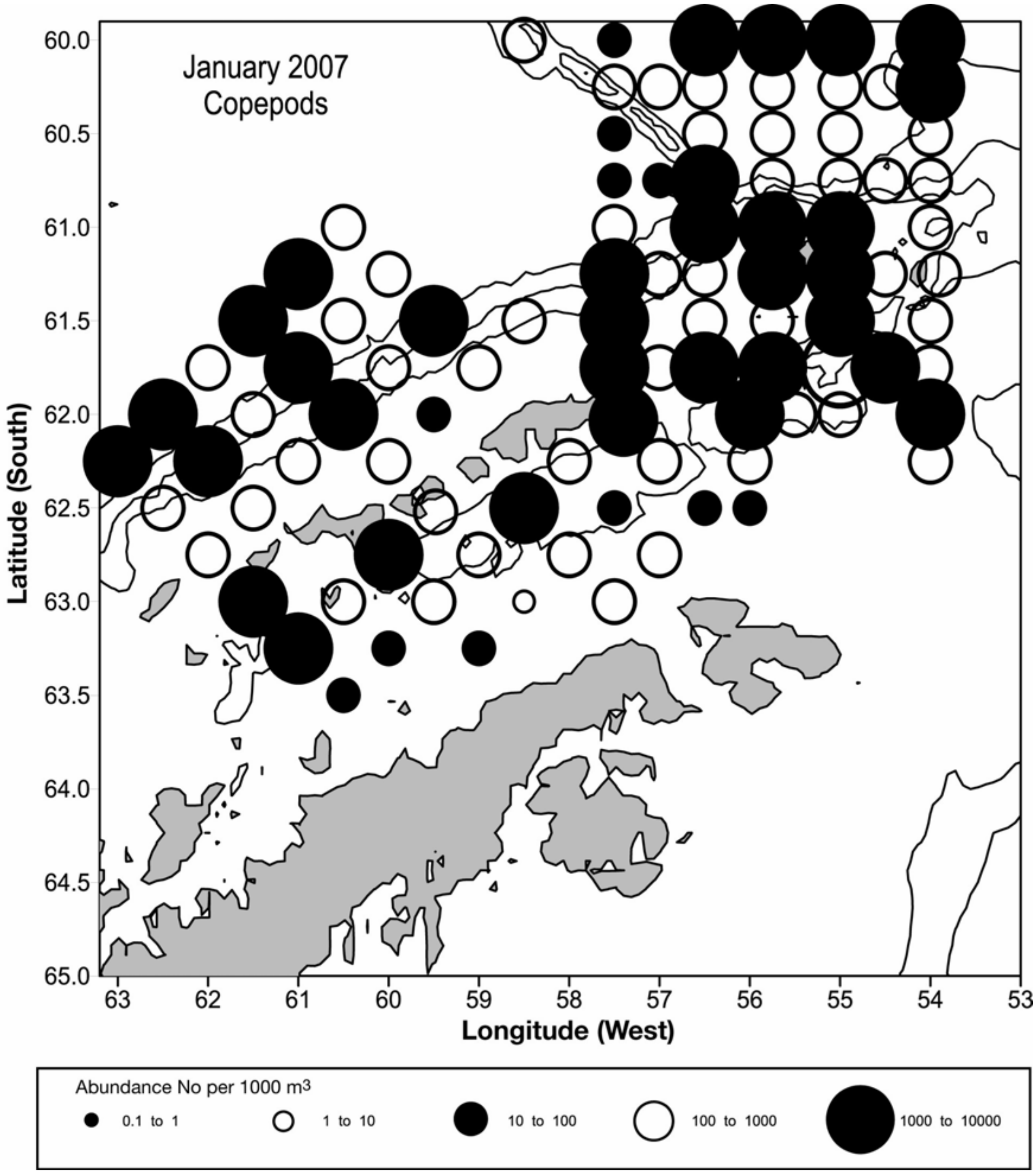


Figure 4.10 Distribution and abundance of total copepods, January 2007.

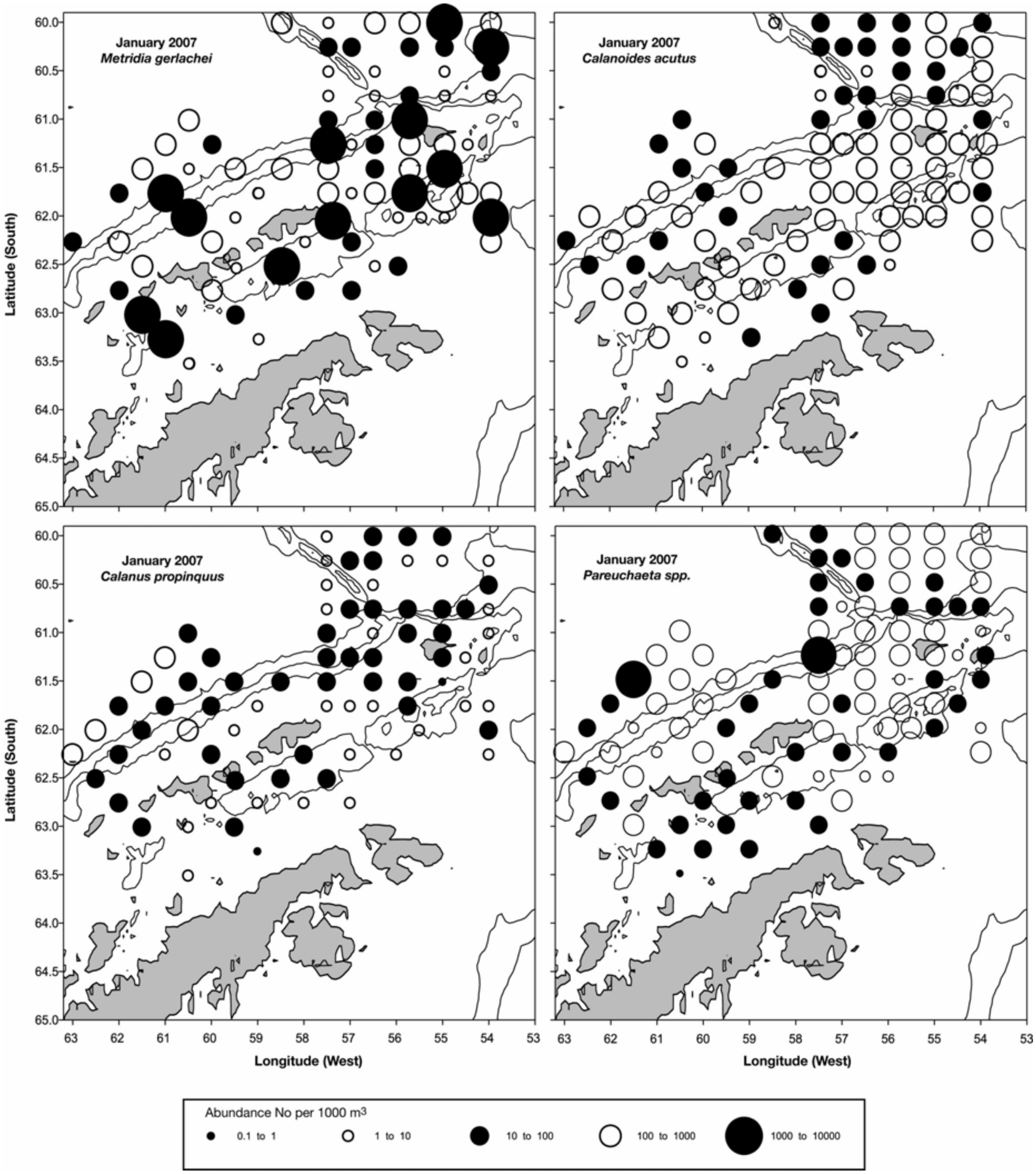


Figure 4.11 Distribution and abundance of four copepod taxa, *Metridia gerlachei*, *Calanoides acutus*, *Calanus propinquus* and *Pareuchaeta* spp., during January 2007.

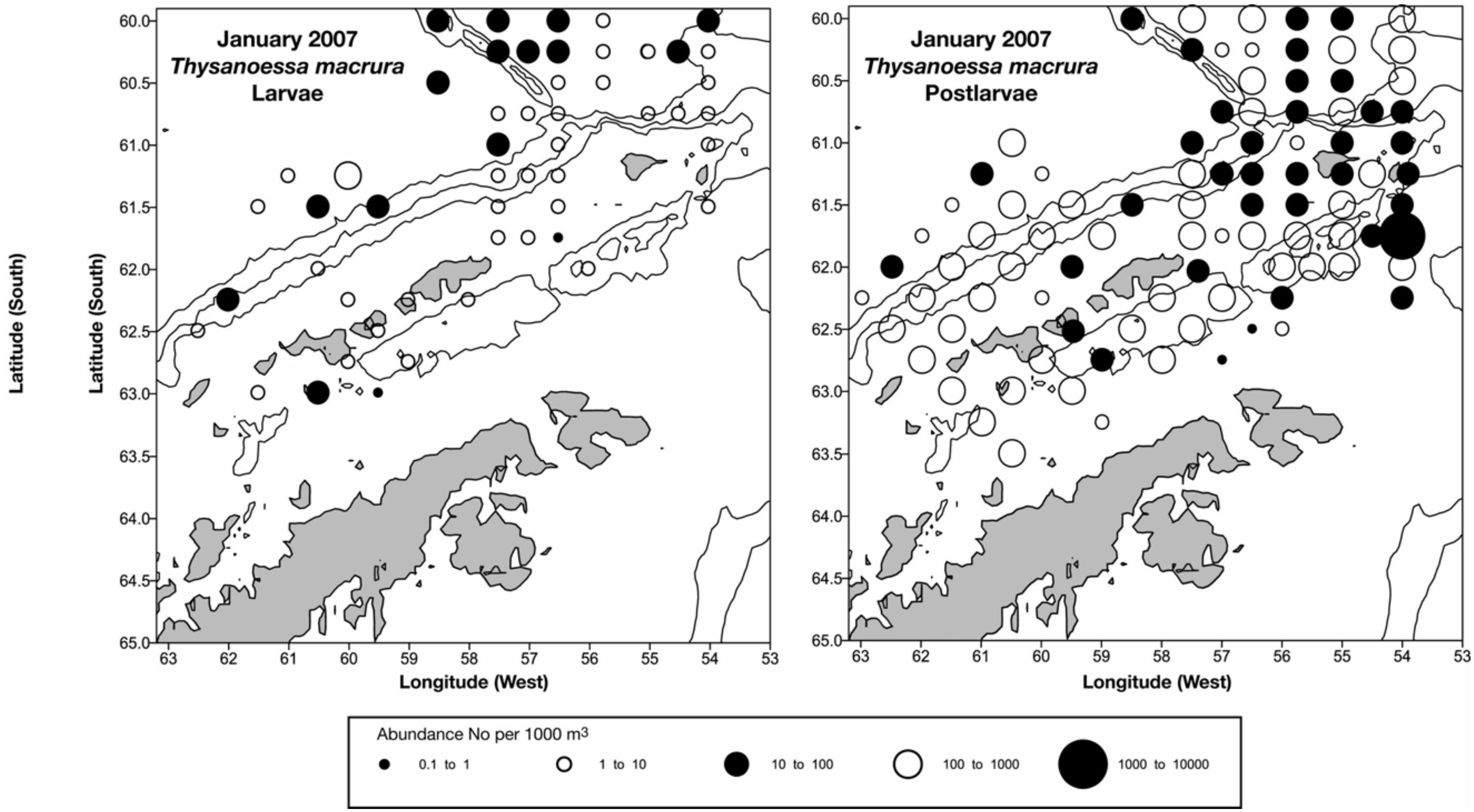


Figure 4.12 Distribution and abundance of postlarval and larval *Thysanoessa macrura* during January 2007.

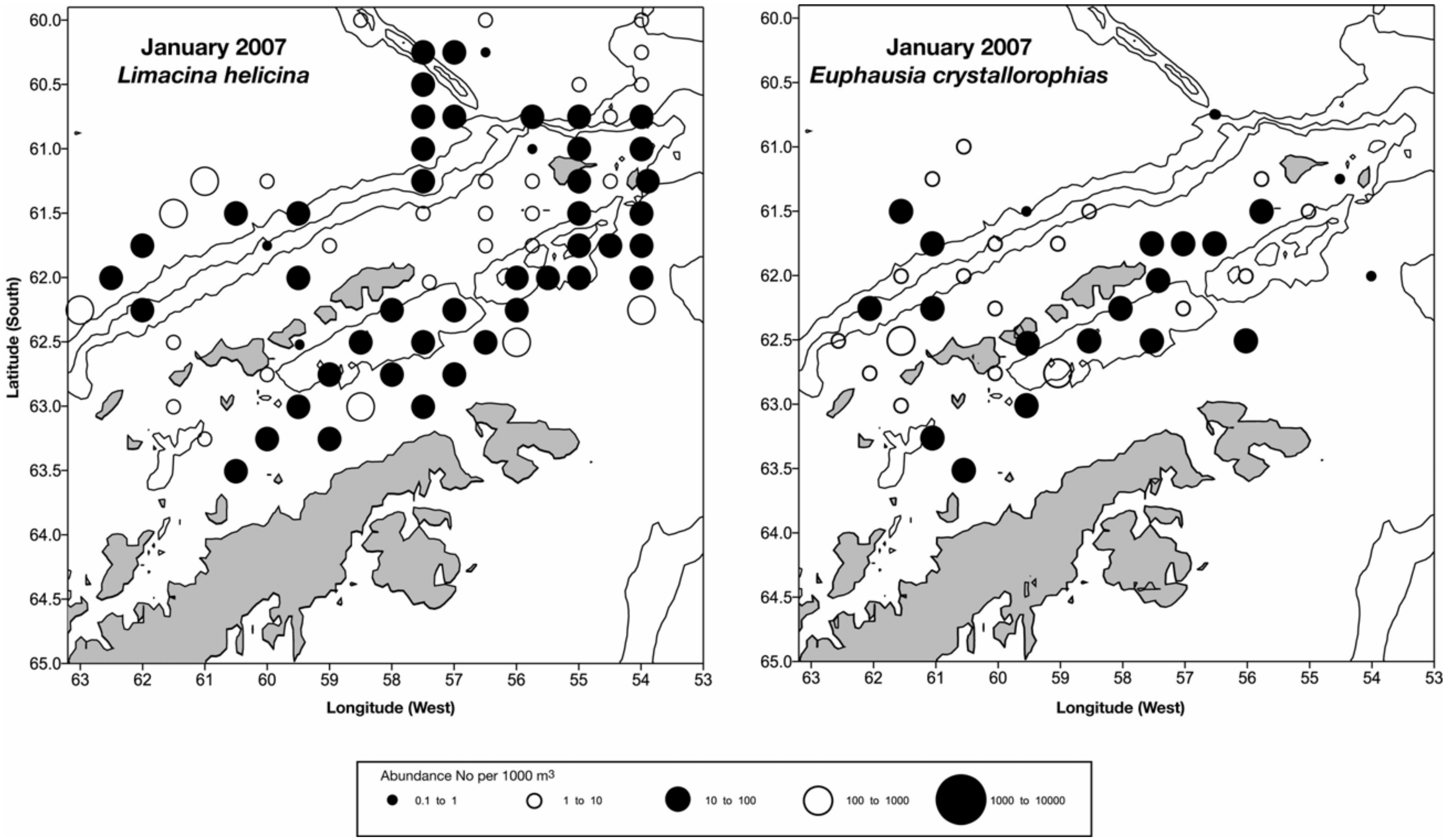


Figure 4.13 Distribution and abundance of *Euphausia crystallorophias* and *Limacina helicina* during January 2007.

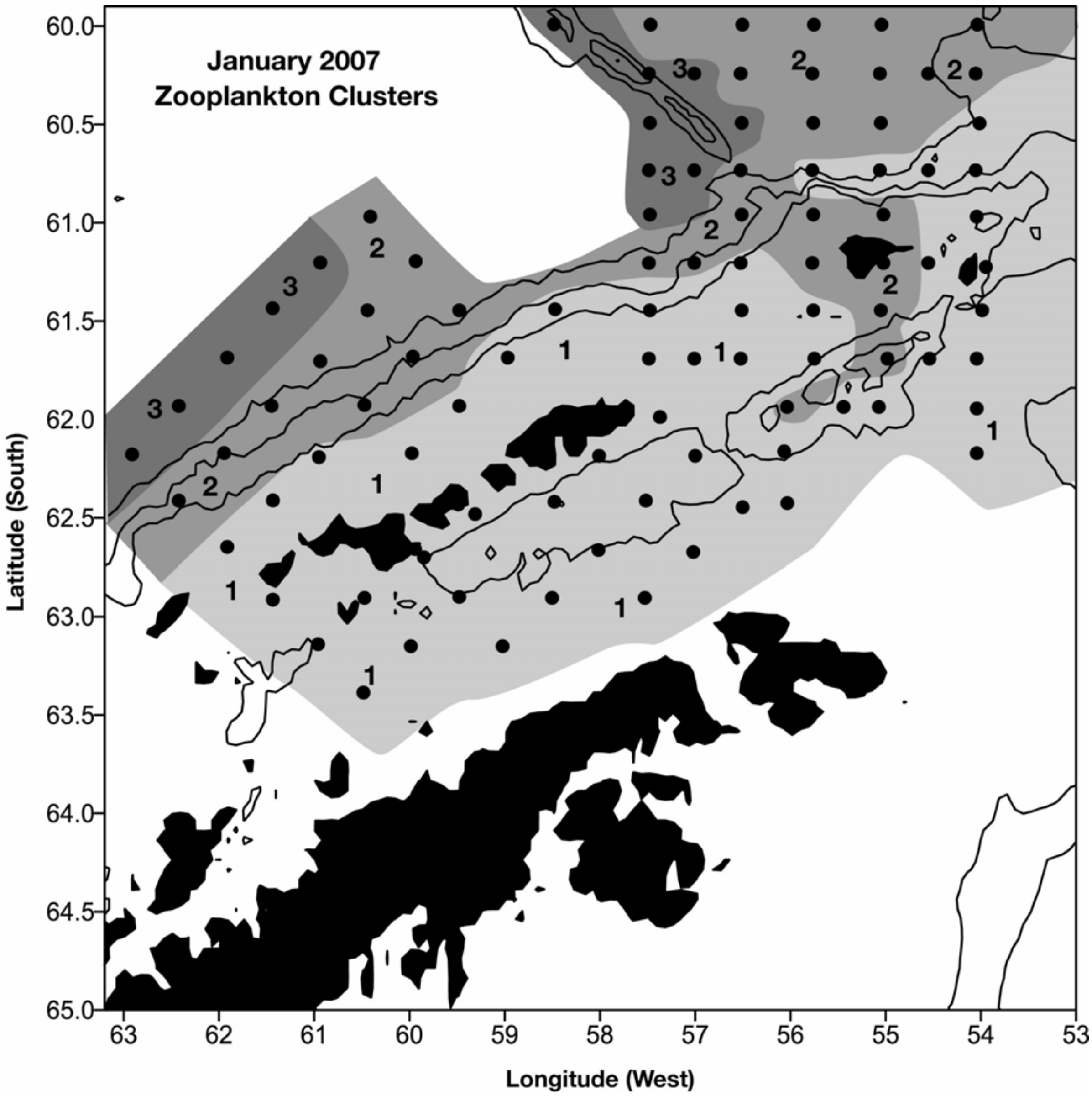


Figure 4.14 Distribution patterns of zooplankton taxa belonging to different station groupings corresponding to Coastal, Intermediate and Offshore Clusters 1, 2 and 3.

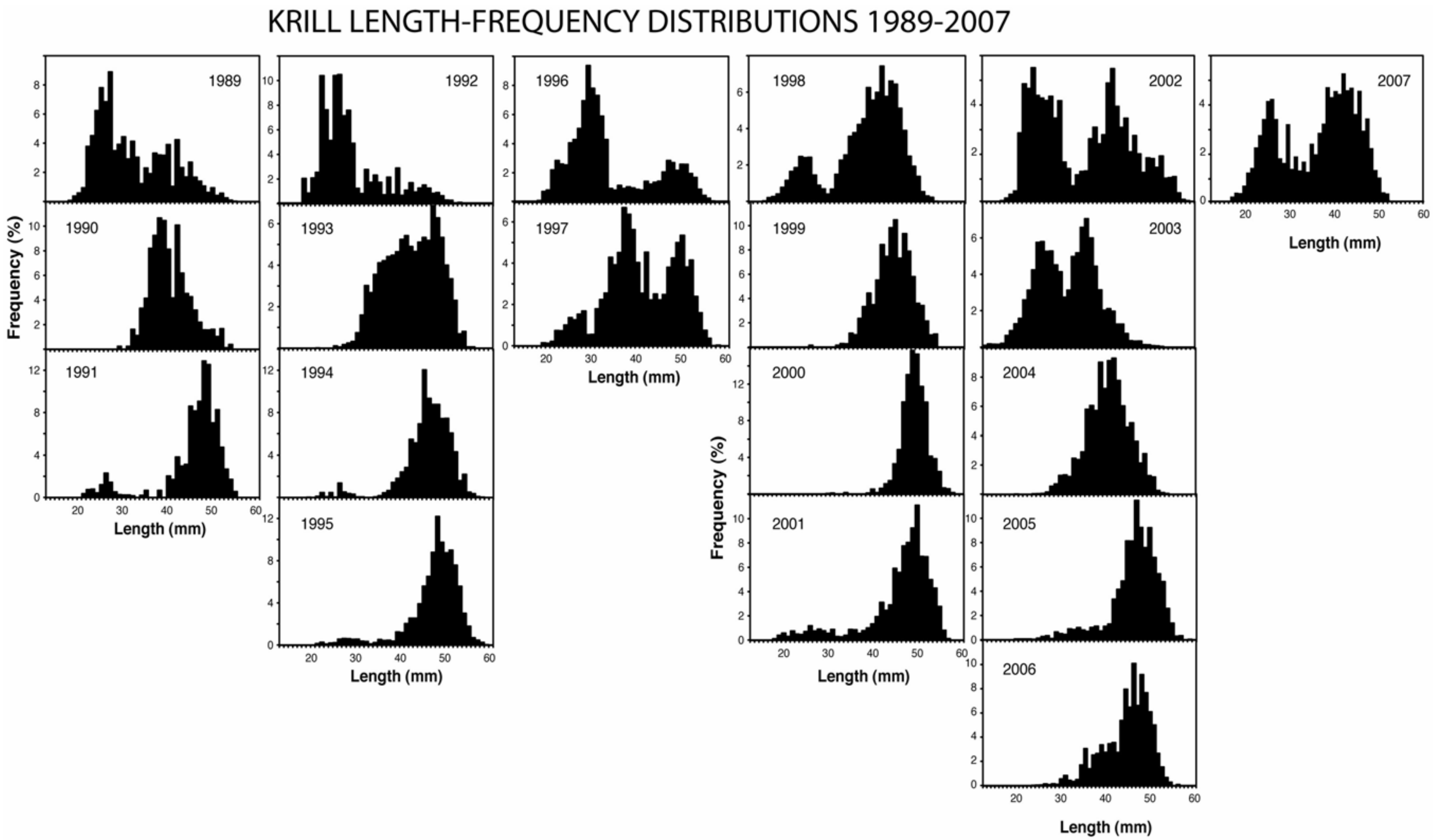


Figure 4.15 Krill length-frequency distributions represented in the Elephant Island Area during 1989-2007 showing temporal sequences of good and poor recruitment success. January-February surveys are used for all years except 2000.

5. Nearshore Acoustical Survey Near Cape Shirreff, Livingston Island; submitted by Joseph D. Warren, Martin Cox, Steve Sessions, Marcel Van den Berg, Derek Needham, and David A. Demer.

5.1 Objectives: The nearshore area around Cape Shirreff serves as the main feeding ground for the seasonally resident fur seal and penguin populations at Cape Shirreff. These animals feed primarily on Antarctic krill, which aggregates in large swarms and layers in the waters just offshore of the island. Shallow and highly variable bathymetry makes this area unsuitable for study from large ships. In order to study the krill abundance in this region, multiple research platforms were used in this year's nearshore survey. The R/V *Ernest II*, a modified 6m Zodiac, conducted an acoustic backscatter survey of the eastern canyon in shallow waters (Figure 5.1). The *Ernest* collected surface temperature and salinity measurements, meteorological data, and predator observations. During the survey, the R/V *Yuzhmorgeologiya* conducted a complementary survey of the shelfbreak and western and eastern canyon areas (Figure 5.2). An additional modified zodiac (R/V *Roald*) conducted a bathymetric and water column survey using a multibeam acoustic system (Figure 5.1). This survey focused on the western edge of the eastern canyon, that is, the waters immediately east of Cape Shirreff. The multibeam system project this year is a joint effort between: Stony Brook University; Simrad, USA; the U.S. AMLR Program; and SWFSC's Advanced Survey Technologies Program. One instrumented buoy was deployed along the 90m isobath on the western edge of the eastern canyon during the nearshore survey to obtain longer time records of acoustic backscatter in the water column and current velocity information. All of these data sets were analyzed to study the relationships between the oceanography and biology of the area. It is believed that the two submarine canyons flanking Cape Shirreff serve as a source of deep, nutrient-rich water which increases the productivity of this nearshore area. This work is partially supported by the National Science Foundation.

5.2 Methods and Accomplishments:

5.2.1 R/V *Ernest*: Over 55km were surveyed using *Ernest* from 29-30 January 2007 (Figure 5.2). *Ernest* is a Mark V 19-ft Zodiac powered by a 55-hp Johnson (Figure 5.1). The Zodiac is equipped with multiple GPS, VHF radio, a WeatherPak 2000 meteorological station (measuring temperature, humidity, barometric pressure, bearing and apparent and true wind speed and direction), and a 38 and 200kHz Simrad ES60 echosounder. GPS and meteorological data were recorded on a laptop computer on board the Zodiac. A surface temperature and conductivity sensor (SeaBird MicroCAT) was mounted to the transducer arm and collected measurements for part of the survey period at a depth of roughly 1.5m while *Ernest* was underway. The *Ernest* is also capable of deploying small nets or a video camera system for ground-truthing the acoustic data. Two modified waterproof cases were used to protect and house data acquisition and processing systems. One case contained a battery bank supplying all power for the boat (two 12V marine batteries), the ES60 echosounder processing unit, a DC/AC power inverter, and an 802.11g wireless network access point. The other case contained a 15" LCD screen, laptop computer with wireless card, GPS receiver, and a power inverter. Power was supplied from the battery case to the other case with weatherproof connectors, while all acoustic data was transferred to the laptop via the wireless network. As was done in the previous year, personnel onboard the vessel made predator observations when weather and conditions permitted.

A stainless steel insert with a canvas and vinyl cover is mounted to the Zodiac floorboards to protect the equipment and personnel from the elements. The boat is also equipped with survival and tool kits, manual and automatic bilge pumps, three survival suits, fuel tanks, binoculars, and anchorage equipment. The acoustic transducer is on a transom mount which was extended in length this year that locates the transducer approximately 1.75m below the water line. The lower depth of the transducer was done to reduce engine noise on the 38kHz echogram such that survey speeds could be increased. The transducer can also be raised out of the water for quicker transit or rough sea state.

5.2.2 R/V *Roald*: R/V *Roald*, tasked with multi-beam operations, was equipped with a Simrad SM20 multi-beam echosounder (MBE) (Figure 5.1). The MBE head, an external profiling transducer and a Honeywell compass and motion unit were housed in a hydrodynamic blister fairing attached to a transom mounted frame. Seabed depth profile and along track water column resolution were improved through the use of the external profiling transducer. The frame was designed to allow deployment and recovery of the fairing as required and given the design of the frame and blister survey speeds of 7 knots were achieved.

All, power, control and data storage for the MBE and associated sensors were housed in a single waterproof pelican case. Power was provided by two 12V marine gel batteries and a DC/AC inverter. The system was configured to allow simultaneous observation and logging of water column and depth data. The MBE was controlled, water column target, and position data from the Garmin GPS unit were logged using Simrad SM20 software. Seabed depth swath profiles were calculated and logged using Triton ISIS software, again running on the same PC. Pitch, roll and heading data, used to correct for boat motion during post processing, were recorded using ASCII logging software. Data transfer was via a standard network connection. Finally, R/V *Roald* was equipped with a similar cover protective working cover and identical safety equipment as R/V *Ernest*.

5.2.3 Instrumented Buoy: The buoy (Figure 5.1) contained a 900MHz spread-spectrum radio modem, GPS, radar reflector, strobe light, batteries, wind generator and power control circuitry. It also contained a 38 and 200kHz echosounder. The buoys were set to activate themselves for three minutes and switch themselves off for seventeen minutes. A shore radio, antenna and logging PC were setup at the base on Cape Shirreff where the buoy data was recorded.

5.2.4 Operations: The nearshore survey was scheduled to begin on 26 January 2007, however due to delays in weather and calibration of the *Yuzhmorgeologiya* during the broad area survey, the nearshore operations did not begin until 28 January. Nearshore survey operations commenced at 0600 (local time) with the deployment of the instrumented echosounder buoy. The ground tackle (including a SeaBird temperature pressure sensor on the anchor) was deployed from the small boat in 90 m of water at the same location where a buoy was deployed during the previous season (62 25.296 S, 60 40.524 W). The anchor was set by the small boat during deployment. The buoy floated normally in the water and the zodiac arrived at Cape Shirreff at ~0730 where the shore station was installed and started up. Communications with the buoy were established and data was being collected by ~ 0845. Several zodiac runs brought the equipment (2.5 fish boxes plus fuel) and scientists to the island. Two tents were set up on the deck of the Cape Shirreff field camp for nearshore personnel to sleep. All non-nearshore personnel returned to the *Yuzhmorgeologiya* at approximately 1230 where the two zodiacs were deflated, the wooden frames inserted, pontoons re-inflated and acoustic equipment installed. The boats were lowered over the side at approximately 1430 where they were taken to shore. Mooring lines were installed and equipment was moved into the boats. The *Ernest* equipment was all tested and checked (GPS acquisition failed on initial power up, but a system reboot fixed that problem) and at approximately 1600 the R/V *Ernest* (M. van den Berg and J. Warren) departed the anchorage to calibrate the echosounder. Currents were strong enough to cause difficulty with obtaining a high-quality echo return despite numerous attempts with different target sphere depths, position of target sphere relative to boat (starboard/port/aft/forward). Although echoes were achieved on both transducers, target strengths were relatively weak. The *Ernest* returned to shore at ~ 1700. During this time period, S. Sessions and M. Cox were troubleshooting the R/V *Roald* acoustic system. At approximately 1700, they departed from the shore to test equipment. They returned at ~ 1900 where operations ceased for the day.

Operations began at approximately 0930 (local time) on 29 January 2007. The buoy was still operational that morning, although battery voltage was approximately 10.2V. As S. Sessions and M. Cox were working on the multibeam transducer bracket armature, M. van den Berg took over as Captain of the *Ernest*. The *Ernest* left anchorage and surveyed the OSCR line (L0001). High densities of krill were found in the water column at the end of the line. We steamed past the buoy where the wind generator was not spinning but otherwise the buoy appeared fine. The new, longer transducer arm worked well, noise was reduced so that it wasn't apparent on the 200 or 38kHz until ~ 150 to 200m depths. Survey speeds were approximately eight knots. After running OSCR line, we surveyed north to ERN8N (L002) (about a six nautical mile run), this was across the canyon, with little scattering on echogram and relatively few predator sightings. Upon reaching ERN8N, we surveyed south towards ERN8S (L003). We concluded this line and began steaming towards ERN7S. Visibility was generally poor due to fog, and seas were ~ 3m but spaced pretty far apart. When running towards ERN7S (L004), we were going into the waves. Not very far into the steam (at 1257 local time), the transducer arm broke apart at the pivot and locking pin point. The longer extended arm resulted in more force on these points. In addition we had the CTD sensor on the arm which added weight. These factors combined with the higher survey speeds probably added to the stress on the metal. We brought the arm back on board, suspended survey operations and proceeded to return to the anchorage. Along the way, we met up with the R/V *Roald* and swapped Captains M. van den Berg and S. Sessions. The R/V *Roald* had begun operations by transiting the OSCR line and then proceeded to fill in gaps in the survey done the previous year.

The R/V *Ernest* returned to shore around 1400. S. Sessions and R. Haner (from the Cape Shirreff field camp) then sawed off the end of the transducer arm and fabricated slices of aluminum plate to fill in the inside of the rectangular tube section. Upon completion of fabrication, the transducer arm was refitted on the R/V *Ernest*. It appears to be a tighter fit as some labor was involved in getting the arm down and locked in place. At approximately 1900, we mounted the new transducer arm. We steamed out of the anchorage and deployed the transducer and collected a small amount of data (L005). We motored at approximately five knots to see how the arm moved/performed and all appeared to be normal. At 2000, the R/V *Ernest* returned to the camp for dinner, then post-dinner went back to the beach to charge batteries and re-do the mooring tackle. Returned to camp around 2130 and checked data. J. Warren forgot to start the microcat temperature and salinity sensor so no data were collected from that instrument. Because of the added mass of the T/S sensor on the transducer arm, it was decided not to remount the T/S sensor. Echoview data were checked. Data quality was good and files loaded into Echoview without problems. Data from the instrumented buoy was still being transmitted (along with location information), although there were occasional drop-outs.

Operations began at ~ 1000 local time on 30 Jan 2007. Both vessels ran the OSCR line at which point the R/V *Ernest* began to survey the ERN7 line, met up with R/V *Roald* at the end of this line and continued to survey running towards ERN6S while the R/V *Roald* continued to survey the area southeast of last year's multibeam survey grid (Figure 7.2). At approximately 1430 local time, the weather and sea conditions worsened and both boats decided to meet at the eastern end of the OSCR line, and follow that back to the anchorage location. Wind was blowing strong from the east resulting in a following sea that made transit challenging. Both vessels arrived at the anchorage at approximately 1515 by which time the seas had grown such that breaking waves were ridden into the anchorage location. Boats were secured on the beach at which point data were offloaded. It was decided to leave the boats high on the beach at that time and check on them throughout the rest of the evening. After dinner that night, S. Sessions checked on the boats and reported that there was water in the R/V *Ernest* due to waves breaking over the bow. All four nearshore personnel returned to the beach and attempted to move the R/V *Ernest* which was too heavy with water to move and could not be bailed faster than it was filling due to waves. The R/V *Roald* was able to be moved out to the anchorage location because of the exceptional efforts of S. Sessions and M. van den Berg. Data from the buoy became very intermittent during this day with several missed data transmissions. Occasional transmissions were received indicating that the buoy had sufficient power and had not moved geographically. One possible explanation for the lack of data transmission was if the buoy was tilted over at an extreme angle by the wind and waves, its transmission beam pattern would be altered such that the shore station would not receive the signal.

The next morning (31 Jan 2007), the winds continued to blow strong from the east resulting in high seas which precluded field operations. The dodger and all other *Ernest* equipment were dissembled in order to expedite departure the following day. Lines securing the R/V *Roald* were double-checked and the empty R/V *Ernest* was tied to the R/V *Roald* off the beach to avoid further damage to the boat. Throughout the day and night personnel monitored the condition of the boats at the anchorage. During the day, the shore station was shut down to expedite the departure from the camp the following morning.

On 1 February 2007, the R/V *Roald* headed back to the *Yuzhmorgeologiya* to be taken aboard and have the acoustic equipment and dodger frame offloaded while the R/V *Ernest* did multiple shuttle runs of equipment and personnel to and from the R/V *Yuzhmorgeologiya*. Operations were done in the early afternoon at which point the R/V *Yuzhmorgeologiya* moved to the buoy location to recover the buoy. The buoy was located despite numerous efforts including setting up the shore station receiver on the bridge of the ship and searching for data transmissions. After several hours of searching for the buoy, the search effort was called off and the nearshore survey ended.

Because of the poor weather experienced during the broad-scale AMLR survey period and during the nearshore survey period, both the R/V *Ernest* and *Roald* had very limited time (roughly two days) in the field collecting data. Despite these limitations, the R/V *Yuzhmorgeologiya* was able to complete all of its survey operations during the nearshore survey period and the *Ernest* and *Roald* were able to collect useful data.

5.3 Results and Tentative Conclusions: Initial results from the 2007 nearshore survey are somewhat difficult to interpret given the limited duration of the survey this year. However, the data collected support the hypothesis that the nearshore waters are productive environments. There were large aggregations of scatterers at the edges of the canyons often in waters between 100 and 150m in depth. From net tow data from the *Yuzhmorgeologiya*, and multiple frequency acoustic discrimination from both vessels, these scatterers are identified as krill.

Integrated acoustic backscatter from the 200kHz echosounder from the R/V *Ernest* shows similar spatial patterns as the results from the 120kHz backscatter surveys during 2000 and 2002, and 200kHz survey in 2005 and 2006 (Figure 5.3). Volume backscattering coefficients at 200kHz were integrated over the upper water column from 5m below the surface to the shallower of 3m above the bottom or 500m. Furthermore, the 200kHz data was only integrated in areas where the relationship between backscatter at 38 and 200kHz was indicative of krill. Backscattering was averaged over 0.1-n.mi. of survey distance to produce NASC (Nautical Area Scattering Coefficient) values which are proportional to the density of krill. As was seen in the 2000, 2002, 2004, 2005, 2006 surveys, the highest concentrations of scatterers were found in the near-shore region southeast and east of Cape Shirreff. High levels of scattering were also found along the canyon walls.

From the 2007 nearshore survey net tow data from R/V *Yuzhmorgeologiya*, the acoustical targets are dominated by the euphausiids *Euphausia superba*, *Thysanoessa macrura* and *Euphausia frigida*. Additional contributors to the acoustic backscatter may include: chaetognaths, salps, siphonophores, larval fish, myctophids, and amphipods.

CTD casts taken by the R/V *Yuzhmorgeologiya* covered the entire survey area with multiple casts at many locations over the course of the survey (Figure 5.2). The stations in the eastern (Y8 survey line) canyon were each surveyed twice during the survey, while only one sample was collected along the mid-canyon (Y5 survey line) and western canyon (Y2 survey line) transect. Potential temperature (Θ) and salinity are plotted for all stations to determine if Circumpolar Deep Water was present. Previous cruises have shown evidence of deep water intrusions moving up the canyons towards the nearshore waters and surface upwelling of Upper Circumpolar Deep Water has been linked to increased productivity by other studies. The CTD data had hydrographic characteristics of Circumpolar Deep Water as defined by Klinck *et al*. (2004) (Figure 5.4). However it should be noted that all the hydrographic profiles that showed evidence of CDW were from the furthest off-shore stations of each transect (near the 500m isobath). Therefore if the CDW water is migrating up the canyons to the nearshore area, it is most likely mixing as it moves and in the process loses the Θ−S characteristics. Hydrographic transects along the western canyon (Y8-A survey line) show a strongly varying hydrography in this area which may be related or caused by the presence of the submarine canyon (Figure 5.5).

IKMT net tow data were collected at almost all stations along the western, middle, and eastern canyon transects (Figure 5.1). As expected, euphausiids, copepods, larval fish, chaetognaths, and salps were the most common animals found (Figures 5.7 and 5.8) and occurred in numerical densities up to several animals per cubic meter (copepods and krill). The most common species for various zooplankton types were: krill (*E. superba, T. macrura, and E. frigida)*, copepods (*M. gerlachei, C. acutus, C. propinquus*, *R. gigas* and *Pareucheata* spp.), salps (*S. thompsoni*), amphipods (*C. lucasii, P. macropa, and T. gaudichaudii*), chaetognaths, siphonophores, larval fish (*L. larseni, N. coatsi,* and *T. scotti*), and gastropods (*S. australis*, and *C. limacina*). Adult krill (*E. superba*) were typically 5cm in length.

Both for *E. superba* and *T. macrura*, the distribution of larval animals was different than the distribution of the adults (Figure 5.7). Salps were only found in a few offshore locations, with reduced numerical densities compared to previous years. Chaetognaths were more abundant than other non-copepod, non-euphausiid species. The distribution of the different copepod species showed differences in their distribution as well (Figure 5.8). *M. gerlachei* was the most abundant species and had a fairly uniform distribution among all three transects. *C. acutus* and *R. gigas* were the next most abundant animals (although one station had a large catch of *C. propinquus*) and showed a fairly uniform geographical distribution. This year a large number of copepods were unidentified and showed a variable distribution across the survey area.

Weather conditions were poor during the 28 January – 01 February 2007 survey period (Figures 5.8 & 5.9). The gale that arrived on 30 January 2007 greatly reduced the small vessel portion of the nearshore survey, although large vessel operations were not significantly affected by the storm. The meteorological data collected by the WeatherPak 2000 system aboard the *Ernest* shows that wind speeds were generally in excess of 4 m/s. Wind direction was variably but most often from the northwest and southwest. True wind speed and direction were calculated from the apparent wind speed and direction and the speed and course of the R/V *Ernest*. Temperature was generally between 2^{o} C and 5^{o} C. The sea state was typically 1-3m and occasionally up to 4m. Typical survey speeds were five knots and an average of 4-7 hours per day were spent on the water.

Acoustic detections of Antarctic krill swarms by the SM20 MBE demonstrate that a small boat is a viable platform for multi-beam surveys. Further work is required to integrate motion, heading and position sensors and obtain the optimal settings for simultaneous water column and seabed depth observations.

5.4 Disposition of Data: Data are available from Joseph D. Warren, Marine Sciences Research Center, Stony Brook University, 239 Montauk Hwy, Southampton, NY 11968, phone (631) 632-5045; email: joe.warren@stonybrook.edu.

5.5 Acknowledgments: We are indebted to the scientists and crew aboard R/V *Yuzhmorgeologiya* for keeping a watchful eye over R/Vs *Ernest* and *Roald* and crew, and for collecting CTD, acoustical, and net tow data during the survey. We would also like to thank the personnel of the Cape Shirreff field camp for their hospitality during our stay at their home. Additional thanks go to the members of the Chilean camp at Cape Shirreff who offered members of the nearshore party housing in their camp during the nearshore survey. Derek

Needham and David Demer designed and Sea Technology Services built the instrumented buoys and the transom mount for the scientific echosounder. The multibeam survey was supported by: Stony Brook University; Simrad, USA; the U.S. AMLR Program; and SWFSC's Advanced Survey Technologies Program. Additional support for this project was provided by NSF Office of Polar Programs Grant #0388196 and 0633939.

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Figure 5.1 The R/Vs *Ernest* (left, background) and *Roald* (left, foreground) at anchor by Cape Shirreff. The instrumented buoy (right) after being deployed off Livingston Island. Photos by Steve Sessions (left) and Marcel van den Berg (right).

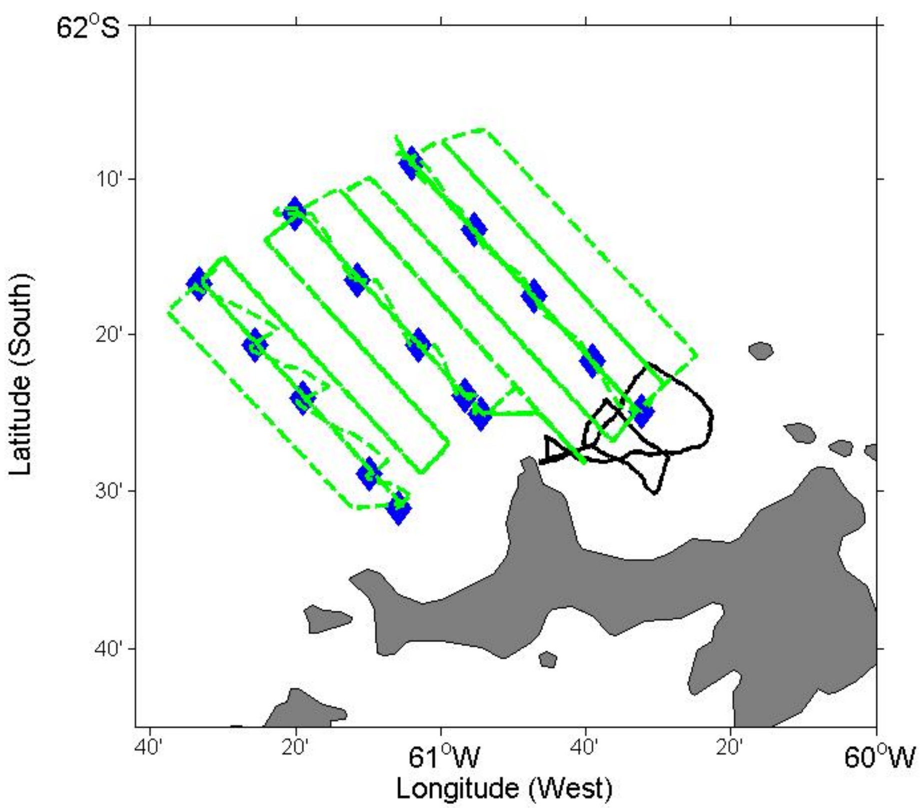

Figure 5.2 Cruise-tracks of the R/V *Yuzhmorgeologiya* (dashed offshore lines) and R/V *Ernest* (solid inshore lines) during the nearshore survey (28 January – 1 February 2007). Diamonds represent locations of CTD casts and IKMT net tows. The R/V *Roald* cruise-track is not shown but took place between Cape Shirreff and the western-most survey line of the R/V *Ernest*.

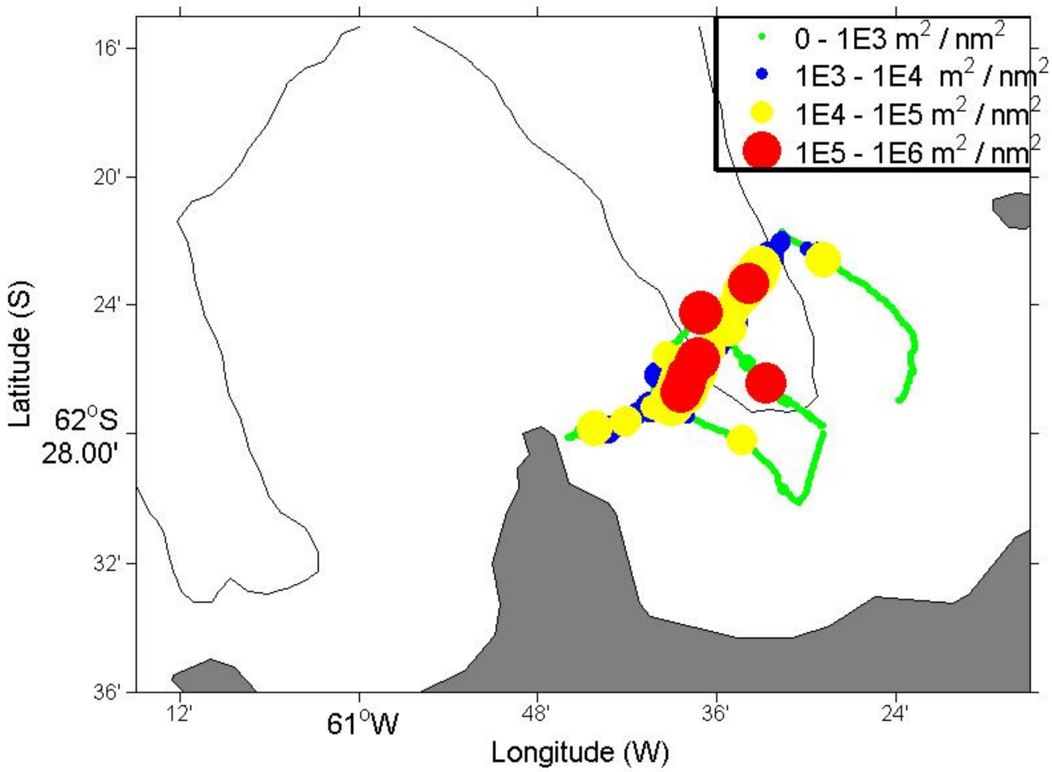

Figure 5.3 Volume backscattering coefficients at 200 kHz integrated from 5m depth to either 3m above the bottom or 500m if no bottom present and averaged over 0.1 n.mi. bins (Sa). Elevated backscatter (indicative of the presence of krill) occurred in the areas immediately east and southeast of Cape Shirreff and throughout the canyon region particularly along the canyon boundaries. The 200m isobath is a thin black line.

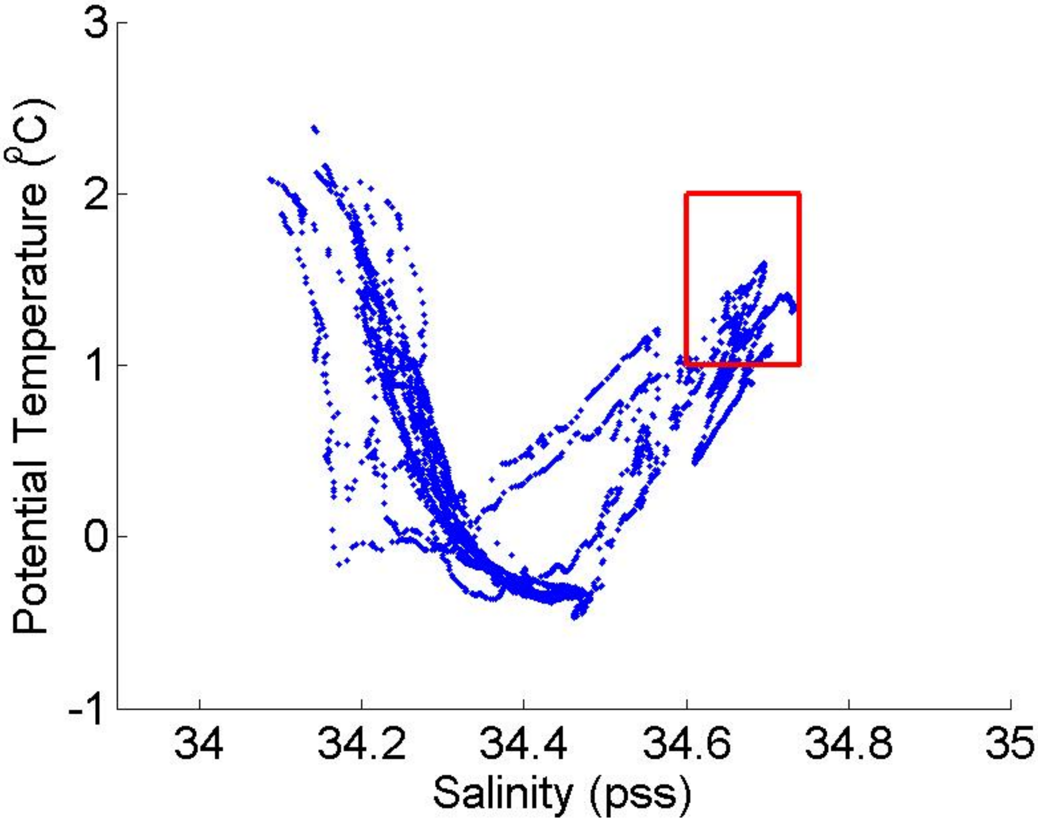

Figure 5.4 Theta-S plot for the CTD casts from the R/V *Yuzhmorgeologiya* during the nearshore survey. The box indicates water that meets the criteria of Circumpolar Deep Water (CDW) as specified by Klinck *et al*., 2004. CDW was mostly found at the CTD stations furthest from the island, along the 500m isobath.

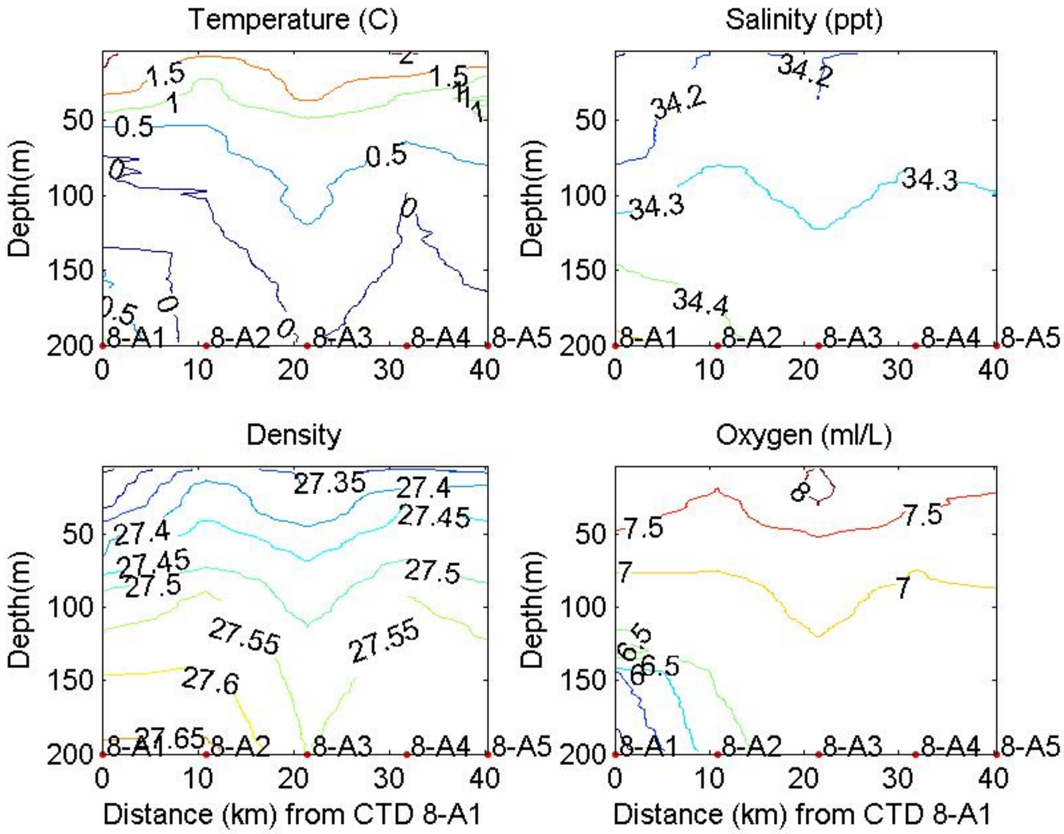

Figure 5.5 Hydrographic profiles along transect Y8-A (the western canyon). Distance is measured from the furthest offshore station.

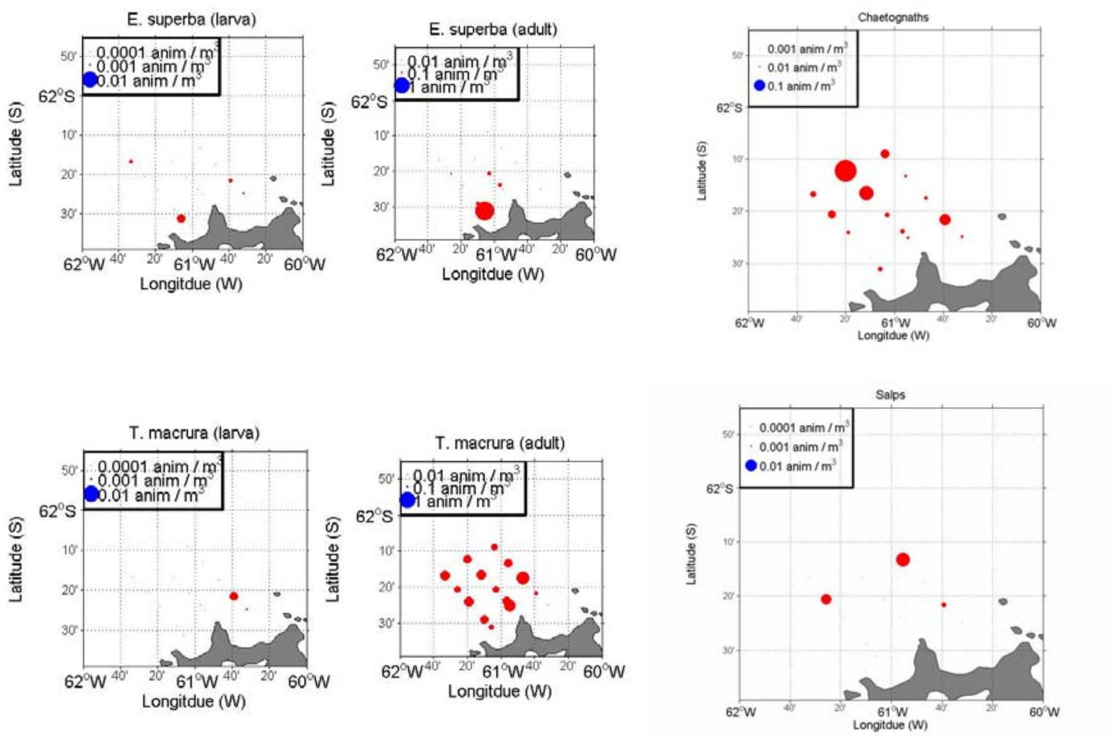

Figure 5.6 Distribution of *E. superba* larvae (top left), *E. superba* adult (top middle), chaetognaths (top right), *T. macrura* larvae (bottom left), *T. macrura* adult (bottom middle), and salps (bottom right) from IKMT new samples collected by the R/V *Yuzhmorgeologiya* during the 2007 nearshore survey. The diameter of the circles correspond to numerical densities of animals per m^3, but are different for each image. Most net surveys were conducted between 2400 and 0900 hours (at night) to avoid biases associated with diel migration of the zooplankton.

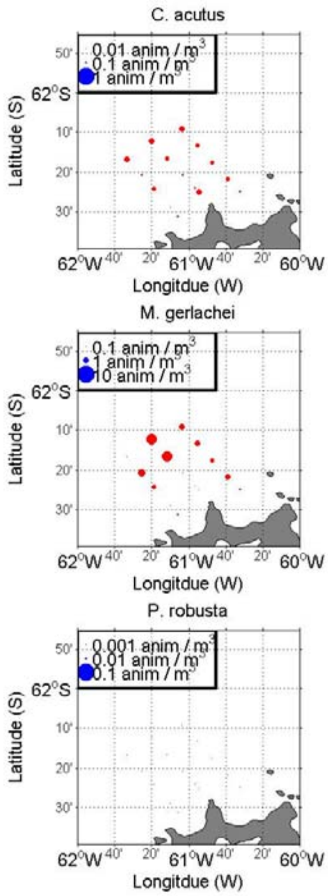

Figure 5.7 Distribution of copepod species collected during the 2007 nearshore survey. *M. gerlachei* were the most abundant copepods followed by *C. acutus*, *R. gigas*, and *C. propinquus*. It appears that copepod distribution is not uniform and differs for the different species. Note that the scale for each sub-figure is different.

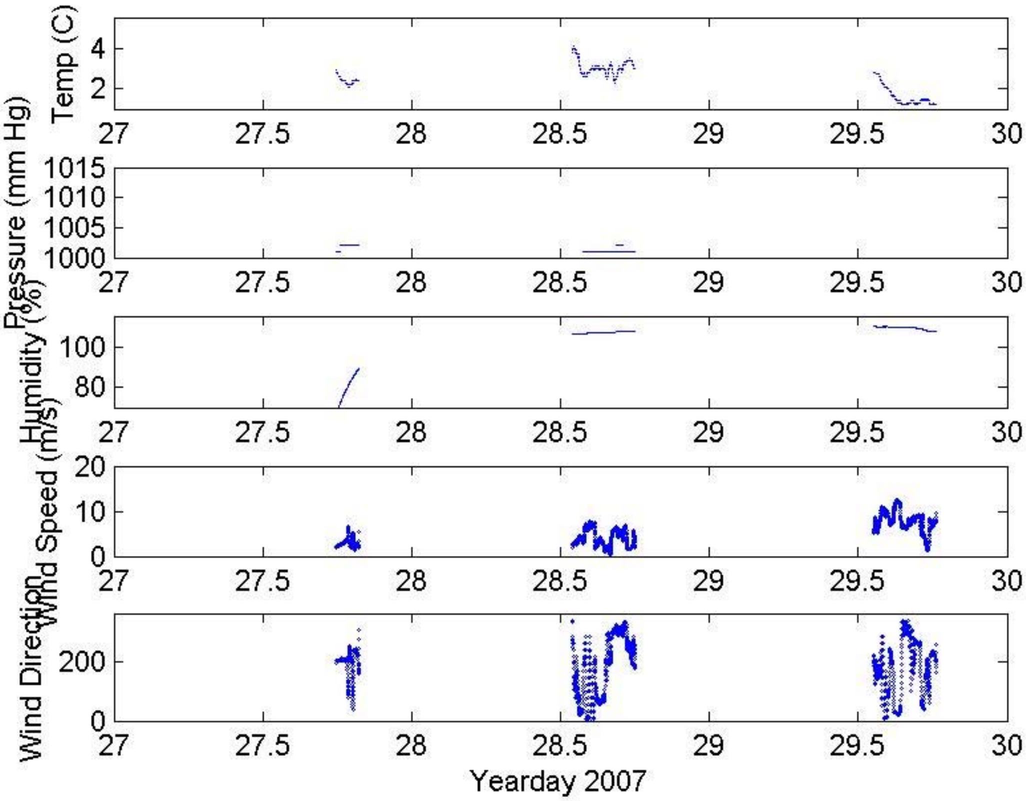

Figure 5.8 Meteorological data from R/V *Ernest* during the 2007 nearshore survey. Mean wind speed was 5 m/s with a peak gust recorded of 13 m/s. Most frequent wind direction was from the SW and NW. Compared to previous surveys, these weather conditions were very poor, particularly in the later half of the survey. The year-day for the *Ernest* data is one less than the year-day for the *Yuzhmorgeologiya* meteorological data (Figure 5.9).

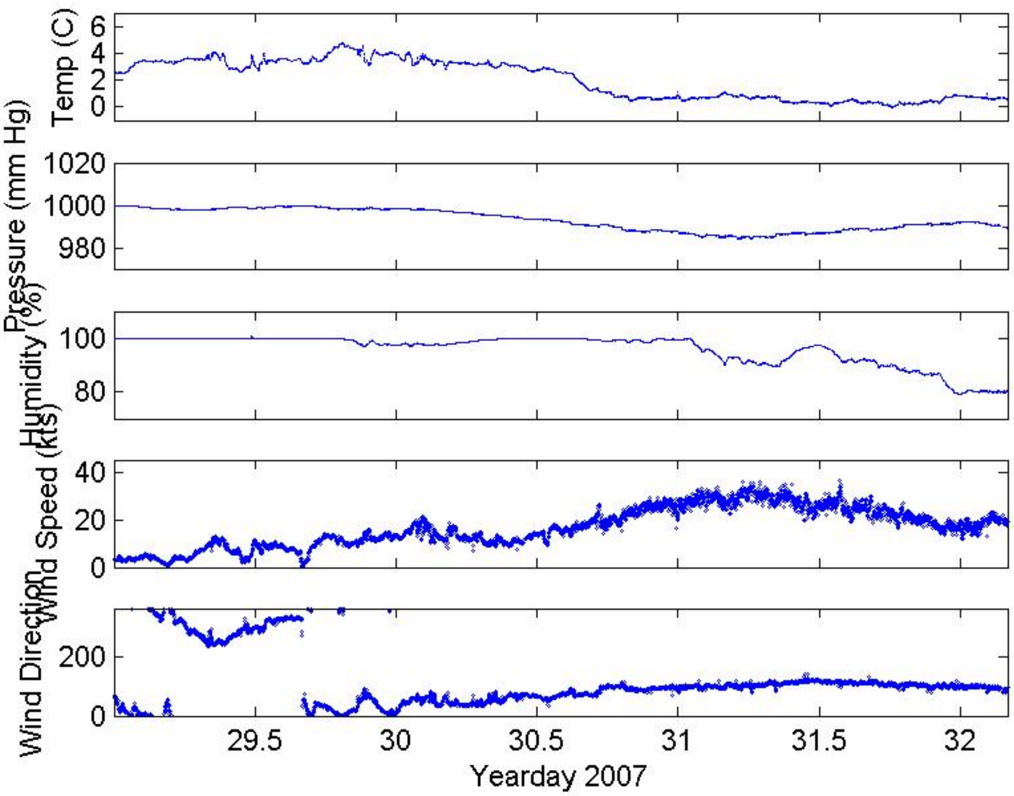

Figure 5.9 Meteorological data from R/V *Yuzhmorgeologiya* during the 2007 nearshore survey. Mean wind speed was 15 kts with a peak gust recorded of 38 kts. The wind direction was originally from the SW and then shifted to be from the E (as velocity increased as well). Although these conditions halted the small boat operations, the *Yuzhmorgeologiya*-based aspects of the nearshore survey continued.

6. Pinniped Research at Cape Shirreff, Livingston Island, Antarctica, 2006/07; **submitted by Michael E. Goebel, Birgitte I. McDonald, Russell G. Haner, Cory D. Champagne, Jessica D. Lipsky, Ryan Driscoll, Stephanie N. Sexton and Rennie S. Holt.**

6.1 Objectives: The Antarctic fur seal is the most abundant pinniped at Cape Shirreff and our studies are focused to a large degree on the foraging ecology, diving, foraging range, energetics, diet, and reproductive success of this species. As upper trophic level predators, pinnipeds are a conspicuous component of the marine ecosystem around the South Shetland Islands. They respond to spatio-temporal changes in physical and biological oceanography and are directly dependent upon availability of krill (*Euphausia superba*) for maintenance, growth, and reproduction during the austral summer. Because of their current numbers and their pre-exploitation biomass in the Antarctic Peninsula region and the Scotia Sea, Antarctic fur seals (*Arctocephalus gazella*) are recognized to be an important "krill-dependent" upper trophic level predator. The general objectives for U.S. AMLR pinniped research at Cape Shirreff (62°28'S, 60°46'W) are to monitor population demography and trends, reproductive success, and status of pinnipeds throughout the summer months.

The 2006/07 field season began with the arrival at Cape Shirreff of a five person field team via the R/V *Laurence M. Gould* on 31 October 2006. Research activities were initiated soon after and continued until closure of the camp on 24 February 2007. Our specific research objectives for the 2006/07 field season were to:

A. monitor Antarctic fur seal female attendance behavior (time at sea foraging and time ashore attending a pup);

B. monitor pup growth in cooperation with Chilean researchers by collecting mass measurements;

C. document fur seal pup production at designated rookeries on Cape Shirreff and assist Chilean colleagues in censuses of fur seal pups for the entire Cape and the nearby San Telmo Islands;

D. collect and analyze fur seal scat contents on a weekly basis for diet studies;

E. collect a milk sample at each adult female fur seal capture for fatty acid signature analysis for diet studies;

F. deploy time-depth recorders (TDRs) on adult female fur seals for diving studies;

G. record at-sea foraging locations for adult female fur seals using ARGOS satellite-linked transmitters (with most deployments coinciding with the U.S.-AMLR oceanographic survey cruises);

H. tag 500 fur seal pups for future demographic studies;

I. re-sight animals tagged as pups in previous years for population demography studies;

J. monitor survival and natality of the tagged adult female population of fur seals;

K. extract a lower post-canine tooth from tagged adult female fur seals for aging studies;

L. deploy a weather station for continuous recording of wind speed, wind direction, ambient temperature, humidity and barometric pressure during the study period;

M. document any pinnipeds carrying marine debris (i.e., entanglement); and

N. document any other tagged pinnipeds observed on the Cape.

6.2 Methods, Accomplishments, and Results (by objective):

A. Female Fur Seal Attendance Behavior: Pup rearing (and lactation) in otariid females is characterized by a cyclical series of trips to sea and visits to shore to suckle their offspring. The sequential sea/shore cycles are commonly referred to as attendance behavior. Changes in attendance behavior (especially the duration of trips to sea) are a standard indicator of a change in the availability of prey resources in the foraging environment. Generally, the shorter the duration of trips to sea, the more resources a female can deliver to her pup during the period from birth to weaning.

We instrumented 22 lactating females from 3-21 December 2006. The study was conducted according to CCAMLR protocol (CCAMLR Ecosystem Monitoring Program Standard Method C1.2 Procedure A) using VHF radio transmitters (Advanced Telemetry Systems, Inc., Model 7PN with a pulse rate of 40ppm). Standard Method C1.2 calls for monitoring of trip durations for the first six trips to sea. All females were instrumented 0-1 day post-partum (determined by the presence of a newborn with an umbilicus) and were left undisturbed for at least their first six trips to sea. Pups were captured at the same time as their mothers, and were weighed, measured, and marked with an identifying bleach mark. The general health and condition of the pups was monitored throughout the study by making daily visual observations. Presence or absence on shore was monitored for each female by scanning for 30 seconds every 30 minutes using a remote VHF receiving station with an automated data collection and storage device. Data were downloaded weekly. Daily visual observations of instrumented females were conducted to validate automated data collection and to confirm proper functioning of the remote system.

The first female in our study to begin her foraging cycles did so on 8 December. All females had completed six trips to sea by 25 January. Two females lost their pups before the completion of six trips to sea.

The mean trip duration for the combined first six trips to sea was 2.72 days (±0.09, $N_{Females}$=22, N_{Trips}=127, range: 0.30-6.29; Table 6.1, Figure 6.1). The mean duration for the first six, non-perinatal visits was 1.51 days (±0.06, $N_{Females}$=22, N_{Visits}=126, range: 0.51-4.48) (Table 6.1, Figure 6.1). The two females that lost their pups had their subsequent visits excluded from calculations of mean visit duration.

We use female post-partum mass as an index of condition at the start of the breeding season. The mean post-partum mass this year was 49.1kg (±0.81, N=23; Figure 6.2a). The mass-to-length ratio (arc-sin transformed) was 381.6g/cm (±5.57, N=23; Figure 6.2b).

An additional 12 females, 4-5 years of age were instrumented 0-1d postpartum for a study of age-related maternal investment and reproductive success. Seven of the 12 were instrumented with TDRs as well as a VHF transmitter.

B. Fur Seal Pup Growth: Measures of fur seal pup growth were a collaborative effort between the U.S. research team and Chilean researchers. Data on pup weights and measures were collected every two weeks beginning 30 days after the median date of pupping (7 December 2006) and ending 21 February (four bi-weekly samples: 6 January, 21 January, 5 February, and 21 February). Data were collected as directed in CCAMLR Standard Method C2.2 Procedure B. The results are submitted to CCAMLR by Chilean researchers.

C. Fur Seal Pup Production: Fur seal pups (live and dead) and females were counted by U.S. researchers at the four main breeding beaches on the east side of the Cape that comprise the U.S.-AMLR study site. Censuses were conducted every other day from 12 November 2006 through 4 January 2007. The maximum number of pups counted (live plus cumulative dead) for the combined four beaches during that time was 2,144 on 27 December 2006 (Figure 6.3). The median date of parturition was 7 December; since 1997/98, the median date of parturition has varied by four days (7-10 December).

Neonate mortality was higher than last year (4.8 % vs. 3.2%). Neonate mortality is defined as pup mortality occurring from the start of the breeding season (circa 15 November) through one month after the median date of pupping (6 January). It occurs before the start of leopard seal predation (roughly mid-January). It is measured by recording the number of new pup carcasses on our census beaches at each count and calculating a cumulative mortality every other day (i.e. at each census) from the start of births (17 November) until the last day of pupping (~10 January). The long-term average (based on nine years of data, 1998-2006), is 4.5% (±0.67).

Our measures of neonate mortality extend only to the end of the pupping (~10 January). In most years, neonate mortality experiences a peak during the perinatal period or soon after females begin their trips to sea. Another peak in pup mortality occurs later when young, inexperienced pups enter the water for the first time around one month of age and become vulnerable to leopard seal predation; these data are not included in our estimates of neonate mortality. Since remains are rare, evidence of this type of mortality is difficult to quantify. Nonetheless, leopard seal predation is significant and may be a factor controlling recovery of South Shetland populations of fur seals (Boveng *et al*., 1998). To estimate the extent of leopard seal predation on neonates, we calculated the loss of pups from our tagged population of females. We assumed that once pups survived to one month of age that their disappearance was due to leopard seal predation. We included only females whose pup status could be confirmed, excluding female/pup pairs whose status was uncertain. Our estimate of pup mortality due to leopard seal predation was calculated 13 February, 67 days after the median date of pupping, and was based on daily tag resights of adult females. By that date 40.8% of pups were lost to leopard seals.

D. Diet Studies: Information on fur seal diet was collected using two different sampling methods: collection of scats and fatty acid signature analysis of milk. Ten scats were collected opportunistically from female suckling sites every week beginning 20 December. The weekly scat samples are collected by systematically walking transects of female suckling areas and collecting any fresh scats within a short range of the observer. This method prevents any bias associated with the difference in visibility between krill laden scats, which are bright pink, and fish laden scats, which are gray to brown, and blend in with the substrate more easily. Scats are also opportunistically collected from captured animals that defecate while captive. In addition to scats, an occasional regurgitation is found in female suckling areas. Regurgitations often provide whole prey that is only minimally digested.

In total, we collected and processed 99 scats from 20 December 2006 through 22 February 2007. Diet samples that could not be processed within 24 hours of collection were frozen. All samples were processed by 26 February. Up to 25 krill carapaces were measured from each sample that contained krill. Otoliths were sorted, dried, and identified to species. Squid beaks were counted and preserved in 70% alcohol for later identification. A total of 2,175 krill carapaces were measured. Most scats (98.0%) contained krill. In addition, 991 otoliths were collected from 23.2% of the scats. Most (90.3%, 895 otoliths) were from two species of myctophid fish (*Electrona antarctica*, n=166 and *Gymnoscopelus nicholsi*, n=729); an additional 9.6% (n=95) were eroded and unidentifiable. A single *Electrona carlsbergi* otolith was found. A total of 44 squid beaks (*Brachioteuthis picta*; 11 dorsal, 33 ventral) were collected from 12.1% of the scats.

The proportions of krill, fish and squid were different from last year (X^2=6.78, d.f.=2, P<0.034). Results for 2006/07 showed similar trends to past years in regards to an increasing proportion of fish and squid from December through February (Figure 6.4). In 2002/03 and 2003/04 the percent occurrence of fish was greater than krill in February. This year showed results similar to those of last year and prior to 2002/03 with a greater proportion of krill in the diet regardless of month. The weekly occurrence of five primary prey species in fur seal diet varies inter-annually and intra-seasonally (Figure 6.5).

The length and width of krill carapaces found in fur seal scats were measured in order to determine the length distribution of krill consumed. Up to twenty-five carapaces from each scat were randomly selected and measured according to Hill (1990). The following linear discriminant function (Goebel *et al*. 2007) was applied to the carapace length (CL) and width (CW) to determine the sex of individual krill:

$$D = -10.68 + 0.433(CL) + 0.287(CW)$$

Positive discriminant function values were identified as female and negative values male. Once the sex for each krill was determined the following regression equations from Goebel *et al*. (2007) were applied to calculate total length (TL) from the carapace length:

Females: $TL = 11.6 + 2.13(CL)$

Males: $TL = 0.62 + 3.13(CL)$

A total of 2,175 carapaces were measured from 97 scats in 2006/07. Summary statistics are presented in Table 6.2. Data from 2002/03 through 2005/06 are also presented for comparison. Krill consumed by fur seals in 2006/07 was on average smaller than last year (Table 6.2; ANOVA, $F_{1,212} = 49.26$, $P<0.0001$). The length distribution (in 2mm increments) for this year is presented in Figure 6.6. Unlike previous years, the overall mean length of krill did not increase (Figure 6.7).

E. Fatty Acid Signature Analysis of Milk: We collected 100 milk samples from 48 female fur seals. Each time a female was captured (either to instrument or to remove instruments), ≤30mL of milk was collected by manual expression. Prior to collection of the milk sample, an intra-muscular injection of oxytocin (0.25mL, 10 UI/mL) was administered. Milk was returned (within several hours) to the lab where two 0.25mL aliquots were collected and each stored in a solvent-rinsed glass tube with 2mL of chloroform with 0.01% butylated hydroxytoluene (BHT, an antioxidant). Samples were flushed with nitrogen, sealed, and stored frozen until later extraction of lipid and transesterification of fatty acids. Of the 100 samples, 39 were collected from perinatal females and 29 were collected from females that had dive data for the foraging trip prior to milk collection.

F. Diving Studies: Twenty of the 37 females transmittered for attendance studies (n=22, CCAMLR attendance; n=12, 4-5 year-old attendance experimental group; n=3, attendance females with twins) also received a time-depth recorder (Wildlife Computers Inc., Mark 9s, 66 x 18 x 18mm, 31g) on their first visit to shore. All but two females carried their TDRs for at least their first six trips to sea; the two females who lost their pups before completion of six trips had their TDRs and transmitters removed early. All females captured for at-sea foraging studies also received a TDR. A total of 32 dive records were collected from 27 females in 2006/07. All TDRs were recovered this season.

G. Adult Female Foraging Locations: We instrumented 15 females with satellite-linked transmitters (ARGOS-linked Platform Terminal Transmitters or PTTs) from 18 December – 15 February. Five of the 15 were deployed to coincide with the U.S.-AMLR large- and small-scale oceanographic surveys in January. All females carried a PTT for at least three trips to sea; two carried a PTT for four trips, one for five trips, and one for seven trips. At-sea locations varied by time of the season (Figure 6.8). The trip mean maximum distance traveled was 88.2 km (±7.46, N=15). All PTTs deployed were recovered this season.

H-J. Demography and Tagging: Chilean and U.S. researchers tagged 500 fur seal pups (238 females, 261 males, 1 unrecorded) from 2 January – 19 February 2007. All tags placed at Cape Shirreff in 2006/07 were either Dalton Jumbo Roto or Dalton Jumbo Superflexi tags. All tags had white tops and orange bottoms. Tags were placed to assess differential tag loss with the objective to eventually determine which tag is the best tag for use on fur seals. Each pup was tagged on both fore-flippers with identical numbers. Series numbers for 2006/07 were 5000-5500 (tag 5047 was not deployed). All pups were tagged on study beaches on the east side of the Cape from Playa Marko to Ballena Norte. Pups at Loberia beach on the northwest side of the Cape were not tagged this season.

In addition to the 500 pups, we retagged twelve adult lactating females (397, 402-403, 405-408, 410-411, 413-416). We also added twelve new tags to the adult female population (391-396, 399-401, 404, 409, and 412).

Last year we did not add any adult females to our tagged population. The total number of adult tagged females expected to return from 2005/06, including new recruits (primaparous females) was 225 (Table 6.3). Of these, 200 (88.9%) returned in 2006/07 to Cape Shirreff and 177 (88.5%) returned pregnant (Figure 6.9).

Last year we reported that for the first year since our monitoring program began in 1997/98, we did not observe any yearlings tagged as pups. This year we observed that some yearlings did return but no tagged two-year-olds, suggesting that the 2004/05 cohort did, in fact, have very low survival. This year we observed eight tagged yearlings return. Table 6.4 presents observed tag returns for nine cohorts in their first year. Tag deployment, the total number placed and re-sighting effort for all nine cohorts were similar and the variance is likely due to differences in the post-weaning physical and/or biological environment. The differences in return rates are not necessarily due to survival alone but may be due to other factors (e.g., physical oceanography of the region, over-winter prey availability) that influence whether animals return to natal rookeries in their first year.

We calculated the minimum percent survival for year one based upon tag re-sights for the first two years following tagging (Table 6.5). The survival values are adjusted based upon the probability that an individual would lose both tags. Tag loss (right or left) was assumed to be independent. The results presented are for the minimum percent survival because animals return for the first time to natal rookeries at different ages and the probability of returning at age 1, age 2, *et cetera* may vary for different cohorts. Given similar re-sighting effort the eight cohorts presented have return rates in the first two years that are very different (Figure 6.10). Most notable is that the 1999/00 cohort appears exceptional in its rate of return in both its first year and its second. The minimum survival to age-1 for the 1999/00 cohort was 25.0%. The observed cohort differences are important whether due to survival or differences in dispersal that result in a different rate of return. This year's tag returns were again dominated by the 1999/00 cohort and to a lesser degree by the 2001/02 cohort, which had 16.1% minimum survival in its first year.

K. Age Determination Studies: We began an effort of tooth extraction from adult female fur seals for age determination in 1999/00. Tooth extractions are made using gas anesthesia (isoflurane, 2.5-5.0%), oxygen (4-10 liters/min), and midazolam hydrochloride (1cc). A detailed description of the procedure is described in the AMLR1999/00 Field Season Report.

This year we collected a single post-canine tooth from eight newly tagged females and one previously tagged female. The mean age of the sample was 12.5 years (± 1.31, N=8).

L. Weather at Cape Shirreff: A weather data recorder (Davis Weather Monitor II) was set up at the U.S.-AMLR field camp at Cape Shirreff from 3 November 2006 to 22 February 2007. The recorder archived wind speed and direction, barometric pressure, temperature, humidity, and rainfall at 15-minute intervals. The sampling rate for wind speed, temperature, and humidity was every eight seconds; the averaged value for each 15-minute interval was stored in memory. Barometric pressure was measured at 15-minute intervals and stored in memory. When wind speed was greater than 0, the wind direction for each 8-second interval was stored in one of 16 bins corresponding to the 16 compass points. At the end of the 15-minute archive interval, the most frequent wind direction was stored in memory. Solar radiation was recorded at 15-min intervals.

M. Entangled pinnipeds: Seven fur seals (five males and two females) were observed this season with entanglements around their neck. Four of the seals had packing bands around their necks. Two others had packing twine (small gauge plastic rope). The entanglement on the remaining seal was not identifiable. Three of the seals (one juvenile male, one adult male, and one adult female) had their entanglements removed. All were removed without capture or restraint.

N. Other pinnipeds: Southern elephant seals - Four tagged elephant seals returning from last year or from other islands were observed this year. Three of these returned to Cape Shirreff with CTD instruments deployed the previous season. They were captured and their instruments removed. In addition to those captures, US-AMLR, in collaboration with University of California researchers, tagged 11 elephant seal pups (6 males, 4 females, and one of unknown sex) and 12 adult females. The adult females were captured late in their molt and were also instrumented with satellite-linked CTD (conductivity temperature depth) transmitters for post-molt dispersal at sea.

6.3 Preliminary Conclusions: Fur seal pup production in 2006/07 season at U.S. AMLR study beaches was consistent with last season. Early season neonate mortality (4.8%) was slightly higher than the long-term average of 4.5%. We also recorded a mid-season increase in leopard seal predation over last year. The median date of pupping based on pup counts was one day earlier than last year. Over winter survival for adult females increased over last year (88.9 vs. 86.5%). The natality rate also increased (88.5 vs. 83.9%). The mean foraging trip duration (2.70 days ±0.08) did not significantly change over last year's but was the lowest on record in ten years of data collection at Cape Shirreff. Mean visit duration (1.52 days ±0.70) showed a similar trend and, as with trip duration, was indicative of favorable summer foraging conditions. Over winter juvenile survival for 2006 was better than 2005. Last year was the first year on record that we did not observe any yearlings (i.e., tagged pups from the 2004/05 cohort). The lack of tag resights from the 2004/05 cohort this year confirmed a poor rate of success for that cohort. The 1999/00 and the 2001/02 cohorts continued to dominate tag returns, as in previous years. Fur seal diet studies for the third year in a row recorded an absence of *E. carlsbergi*. Overall, summer conditions were favorable resulting in better than average performance for summer indices. Winter conditions in 2006 resulted in average performance.

6.4 Disposition of Data: All raw and summarized data are archived by the Antarctic Ecosystem Research Division of the National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, CA 92037.

6.5 Problems and Suggestions: The monitoring program at Cape Shirreff is confined to measuring parameters during the first three months of fur seal pup rearing. Only a few of the summer-measured parameters (e.g. adult female over-winter survival, pregnancy rates, and cohort survival) reflect ecological processes over broader temporal and spatial scales. Yet these data suggest that post-weaning environments are equally important for survival, recruitment, and sustainability of the Cape Shirreff fur seal population. The dominance of the 1999/00 cohort in tag return data and differential cohort strength (Table 6.5, Figure 6.10) offer one of the best examples of this. Recent technology in the miniaturization and programmability of satellite-linked transmitters provide the means by which to develop an understanding of post-weaning environments, dispersal of females and pups post-weaning. These instruments not only provide information on dispersal, but can measure the physical environment encountered by individuals.

Future studies should use this technology to measure dispersal, survival and various parameters of the physical environment in order to identify factors leading to increased survival and recruitment of juvenile pinnipeds and seabirds.

6.6 Acknowledgements: The National Science Foundation provided support and transportation to and from Cape Shirreff field site for the station crew. We thank the captain, crew and staff of R/V *Laurence M. Gould* for their assistance and expertise. We are grateful to our Chilean colleagues: Romeo Vargas, Daniel Torres Jr., Gisele Hernandez and Cesar Cifuentes, for their assistance in the field and for sharing their considerable knowledge and experience of Cape Shirreff. Some of the tag re-sight data used in this report were provided by our Chilean colleagues. We thank Wayne Trivelpiece, Sarah Chisholm, and Rachael Orben for their help with pinniped studies. We are, likewise, grateful to Adam Jenkins, Christian Reiss, other AMLR personnel, and the captain and crew of the R/V *Yuzhmorgeologiya* for their invaluable support and assistance to the Cape Shirreff based research effort. All pinniped research conducted at Cape Shirreff this season was authorized under Marine Mammal Protection Act Permits No. 774-1847 and 87-1851 granted by the Office of Protected Resources, National Marine Fisheries Service.

6.7 References:

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Table 6.1 Summary statistics for the first six trips and visits (non-perinatal) for female Antarctic fur seals rearing pups at Cape Shirreff, Livingston Island, 1997/98 – 2006/07.

Year	Female N	Trip/Visit N	Min.	Max.	Median	Mean	St.Dev.	Skewness (SE)
Trip Durations								
1997/98	30	180	0.50	9.08	4.07	4.19	1.352	0.083 (0.181)
1998/99	31	186	0.48	11.59	4.23	4.65	1.823	0.850 (0.178)
1999/00	23	138	0.60	8.25	3.25	3.47	0.997	1.245 (0.206)
2000/01	28	168	0.75	5.66	2.69	2.71	0.828	0.874 (0.187)
2001/02	28	166	0.50	7.85	2.87	3.18	1.207	0.740 (0.188)
2002/03	15	90	2.83	10.78	6.89	6.83	0.731	-0.072 (0.254)
2003/04	28	166	0.58	6.97	3.60	3.61	1.241	0.365 (0.188)
2004/05	29	174	0.40	9.50	3.90	3.91	1.565	0.764 (0.184)
2005/06	28	168	0.35	5.88	2.79	2.79	0.863	0.359 (0.187)
2006/07	22	127	0.30	6.29	2.67	2.70	0.822	0.502 (0.491)
Visit Durations								
1997/98	30	179	0.46	2.68	1.25	1.35	0.462	0.609 (0.182)
1998/99	31	186	0.21	3.49	1.27	1.33	0.535	0.947 (0.178)
1999/00	23	138	0.10	4.25	1.51	1.72	0.635	1.088 (0.206)
2000/01	28	168	0.44	3.15	1.52	1.68	0.525	0.485 (0.187)
2001/02	28	166	0.19	4.84	1.43	1.55	0.621	1.328 (0.188)
2002/03	15	82	0.23	2.18	0.98	0.98	0.051	0.447 (0.266)
2003/04	28	163	0.23	3.99	1.43	1.55	0.579	0.870 (0.190)
2004/05	29	174	0.15	3.86	1.28	1.45	0.614	1.439 (0.184)
2005/06	28	168	0.46	4.73	1.63	1.69	0.658	1.247 (0.188)
2006/07	22	126	0.51	4.48	1.49	1.52	0.328	0.293 (0.491)

Table 6.2 Krill length (mm) in fur seal diet from 2002/03 - 2006/07. Data are derived from measuring length and width of krill carapaces found in fur seal scats. A discriminant function is applied to first determine sex before applying sex-specific regression equations to calculate krill total length.

Krill Length (mm)	**2002/03**	**2003/04**	**2004/05**	**2005/06**	**2006/07**
N_{krill}:	2091	2337	2675	2741	2175
N_{scats}:	77	98	107	109	97
Median:	41.3	45.5	46.3	47.6	47.6
Mean:	41.2	44.8	45.9	47.6	47.0
St. Dev.:	3.11	3.66	1.96	1.52	3.81
Minimum:	34.5	35.3	38.2	43.7	33.0
Maximum:	48.4	49.8	48.6	51.4	58.5
Kurtosis:	-0.56	-0.05	2.35	-0.41	0.21
Skewness:	0.14	-0.98	-1.32	-0.22	-0.55
Sex Ratio (M:F):	0.10	0.60	0.25	1.00	1.45
% Juveniles:	37.2%	18.5%	5.4%	1.3%	4.0%

Table 6.3 Tag returns and natality rates for adult female fur seals at Cape Shirreff, Livingston Island, 1998/99 – 2006/07.

Year	Known tagged population[1]	Returned	Pregnant	% Return	% Natality	Tags placed	Primaparous females tagged as pups
1997/98						37[2]	0
1998/99	37	31	28	83.8	90.3	52	0
1999/00	83	78	72	94.0	92.3	100	0
2000/01	173	156	136	90.4	87.2	35	0
2001/02	195[3]	191	174	97.9	91.1	42	2
2002/03	226	194	168	85.8	86.6	28	6
2003/04	227	209	186	92.1	89.0	26	14
2004/05	235	211	179	89.8	84.8	30	11
2005/06	251	217	182	86.5	83.9	0	10
2006/07	225	200	177	88.9	88.5	12	9

[1]Females tagged and present on Cape Shirreff beaches the previous year.

[2]Includes one female present prior to the initiation of current tag studies.

[3]Includes one female tagged as an adult with a pup in 1998/99, which was present in 1999/00 but was never observed in 2000/01.

Table 6.4 A comparison of first year tag returns for nine cohorts: 1997/98 – 2005/06. Values in parentheses are percent total tagged.

Cohort	Total Tags Placed	Tag Returns in Year 1 (%) Total	Males	Females
1997/98	500	22 (4.4)	10 (2.0)	12 (2.4)
1998/99	500	6 (1.2)	5 (2.0)	1 (0.4)
1999/00	500	26 (5.2)	15 (3.0)	11 (2.2)
2000/01	499	9 (1.8)	6 (2.6)	3 (1.1)
2001/02	499	23 (4.6)	12 (4.8)	11 (4.0)
2002/03	498	12 (2.4)	4 (1.7)	8 (3.0)
2003/04	499	9 (1.8)	4 (1.6)	5 (2.4)
2004/05	496	0 (0.0)	0 (0.0)	0 (0.0)
2005/06	495	8 (1.6)	3 (1.2)	5 (2.0)

Table 6.5 Tag returns and minimum percent survival for eight cohorts (1997/98 – 2004/05) using only the first two years of re-sight data for each cohort. Assuming cohort return rates correlate with survival and are similar for each cohort, our data show survival to age-1 varies considerably.

		Tags re-sighted:			Tag loss:					Survival estimates:	
Year		Sighted in Year 1:	Additional Tags Sighted in Year 2:	Minimum survival in year 1:	Unknown tag status:	Both tags present:	Missing 1 tag:	Probability of missing one tag:	Probability of missing both tags[1]:	Minimum % Survival 1st year:	Adj. Min. % Survival for year 1[2]:
1997/98	♀	12	20	32	2	14	16	0.53	0.28	12.8	16.4
	♂	10	10	20	1	13	6	0.32	0.1	8.0	8.8
	Total	**22**	**32**	**54**[3]	**3**	**29**	**22**	**0.43**	**0.19**	**10.8**	**12.8**
1998/99	♀	1	6	7	0	6	3	0.33	0.11	2.8	3.1
	♂	5	7	12	2	6	2	0.25	0.06	4.8	5.1
	Total	**6**	**13**	**19**	**2**	**12**	**5**	**0.29**	**0.09**	**3.8**	**4.1**
1999/00	♀	11	53	64	1	48	15	0.24	0.06	27.6	29.2
	♂	15	40	55	3	42	10	0.19	0.04	20.6	21.4
	Total	**26**	**93**	**119**	**4**	**90**	**25**	**0.22**	**0.05**	**23.8**	**25.0**
2000/01	♀	3	13	16	0	11	5	0.29	0.08	6.0	6.6
	♂	6	2	8	1	5	2	0.29	0.08	3.4	3.8
	Total	**9**	**15**	**24**	**1**	**16**	**7**	**0.30**	**0.09**	**4.8**	**5.3**
2001/02	♀	12	28	40	4	29	7	0.19	0.04	15.3	15.9
	♂	11	26	37	2	27	8	0.23	0.05	15.5	16.4
	Total	**23**	**54**	**77**	**6**	**56**	**15**	**0.21**	**0.04**	**15.4**	**16.1**
2002/03	♀	9	13	22	1	9	4	0.31	0.09	8.4	9.2
	♂	4	9	13	0	4	4	0.5	0.25	5.5	6.8
	Total	**13**	**22**	**35**	**1**	**13**	**8**	**0.38**	**0.15**	**7.0**	**8.0**
2003/04	♀	5	3	8	0	6	1	0.14	0.02	3.1	3.1
	♂	4	0	4	0	4	0	0.00	0.00	1.7	1.7
	Total	**9**	**3**	**12**	**0**	**10**	**2**	**0.17**	**0.03**	**2.4**	**2.5**
2004/05	♀	0	0	0	0	0	0	0.00	0.00	0.0	0.0
	♂	0	0	0	0	0	0	0.00	0.00	0.0	0.0
	Total	**0**	**0**	**0**	**0**	**0**	**0**	**0.00**	**0.00**	**0.0**	**0.0**

[1]Assumes tag loss is independent for right and left tags.

[2]Minimum percent survival adjusted for double tag loss.

[3]Includes two sightings of seals that were of unknown sex.

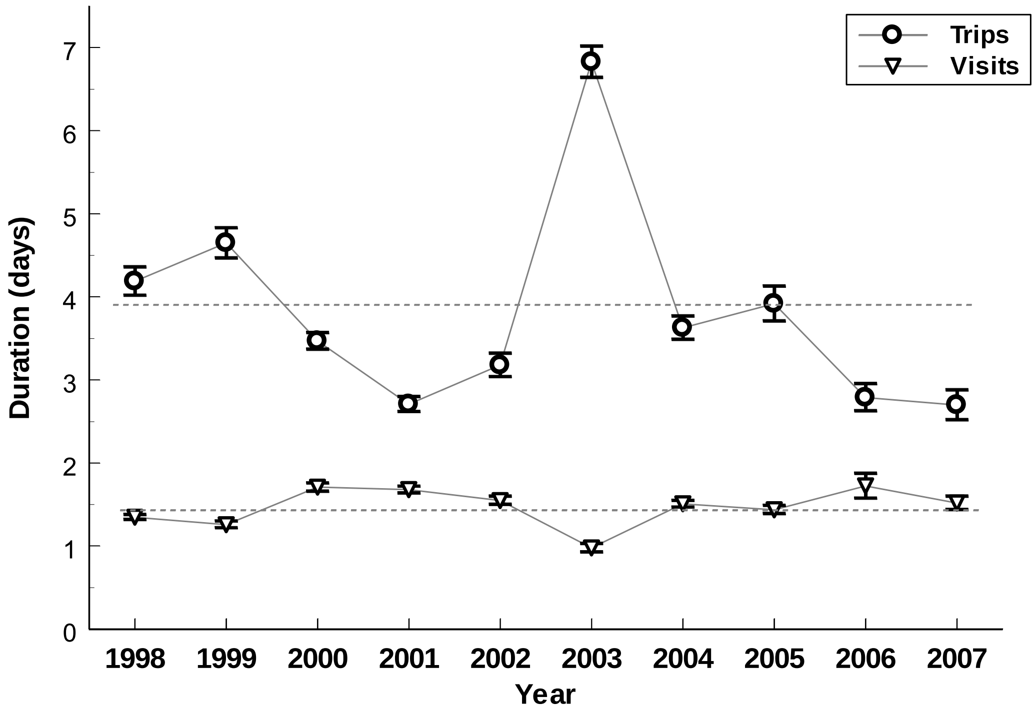

Figure 6.1 Antarctic fur seal mean trip and visit durations (with standard error) for females rearing pups at Cape Shirreff, Livingston Island. Data plotted are for the first six trips to sea and the first six non-perinatal visits following parturition for eight years (see Table 6.1 for annual sample size). Long-term means are plotted as dashed gray lines.

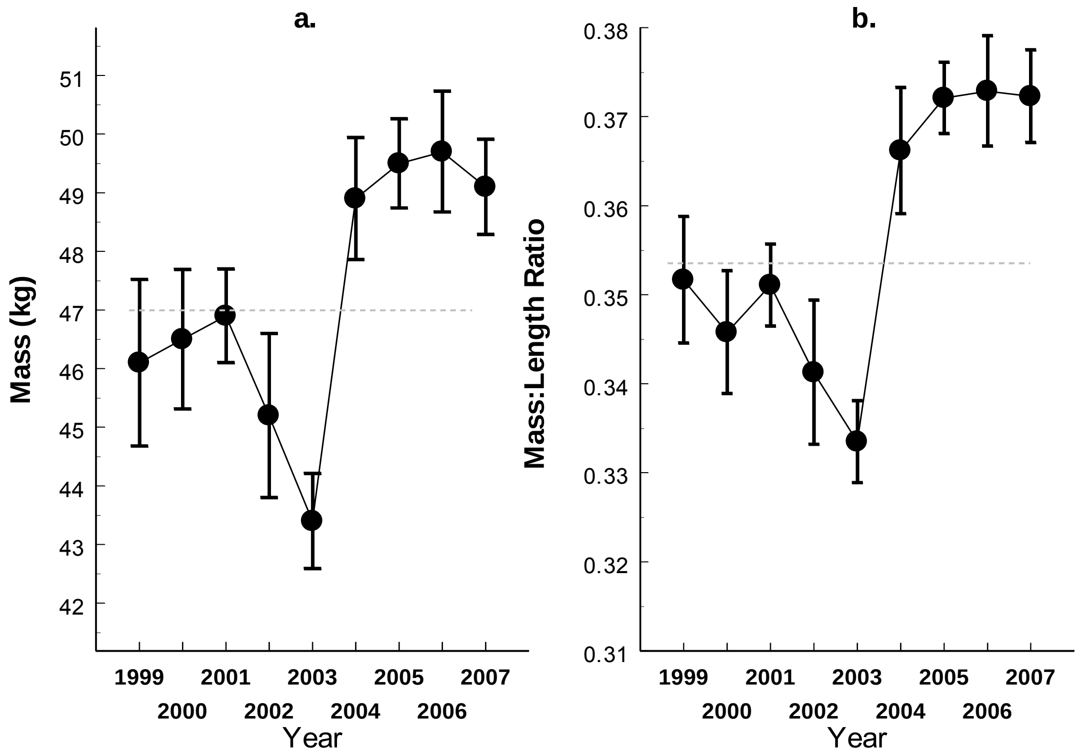

Figure 6.2 The mean mass (a.) and mass:length ratio (b.) for females at parturition 1998/99 – 2006/07 **(98/99**: N=32, **99/00**: N=23, **00/01, 04/05**: N=29, **01/02-03/04, 05/06**: N=28, **06/07**: N=23). Long-term average is plotted as a gray dashed line (mass: 47.3 ±1.03; mass:length ratio: 0.356 ±0.005).

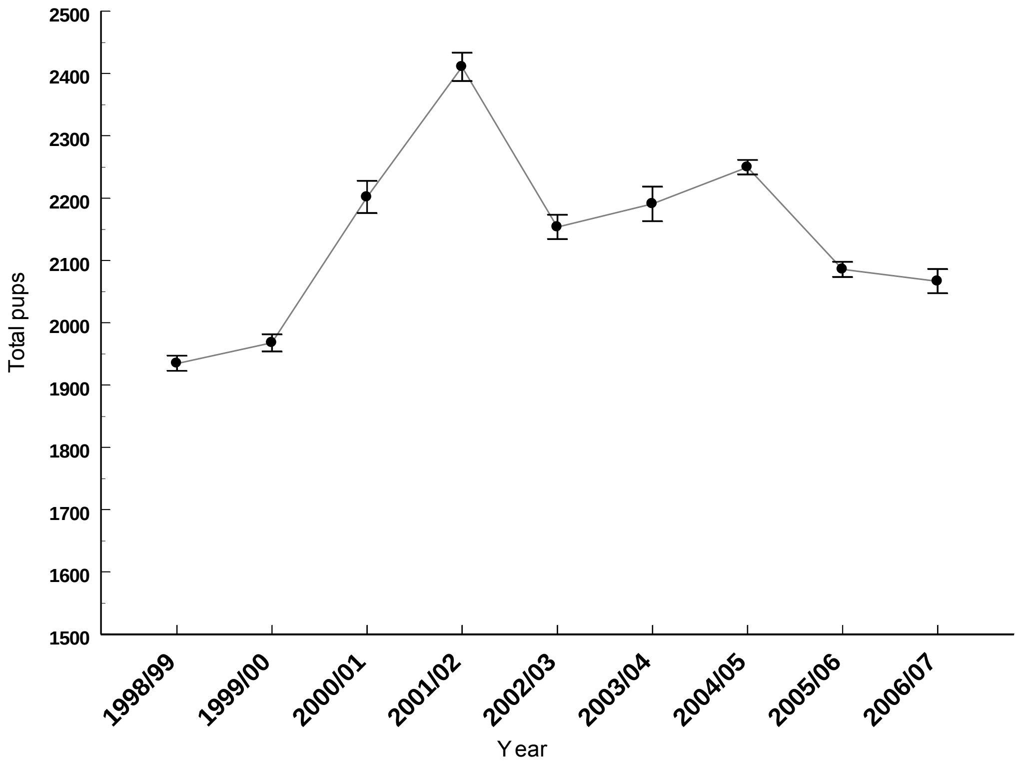

Figure 6.3 Antarctic fur seal pup production at U.S. AMLR study beaches, Cape Shirreff, Livingston Island, 1998/99-2006/07.

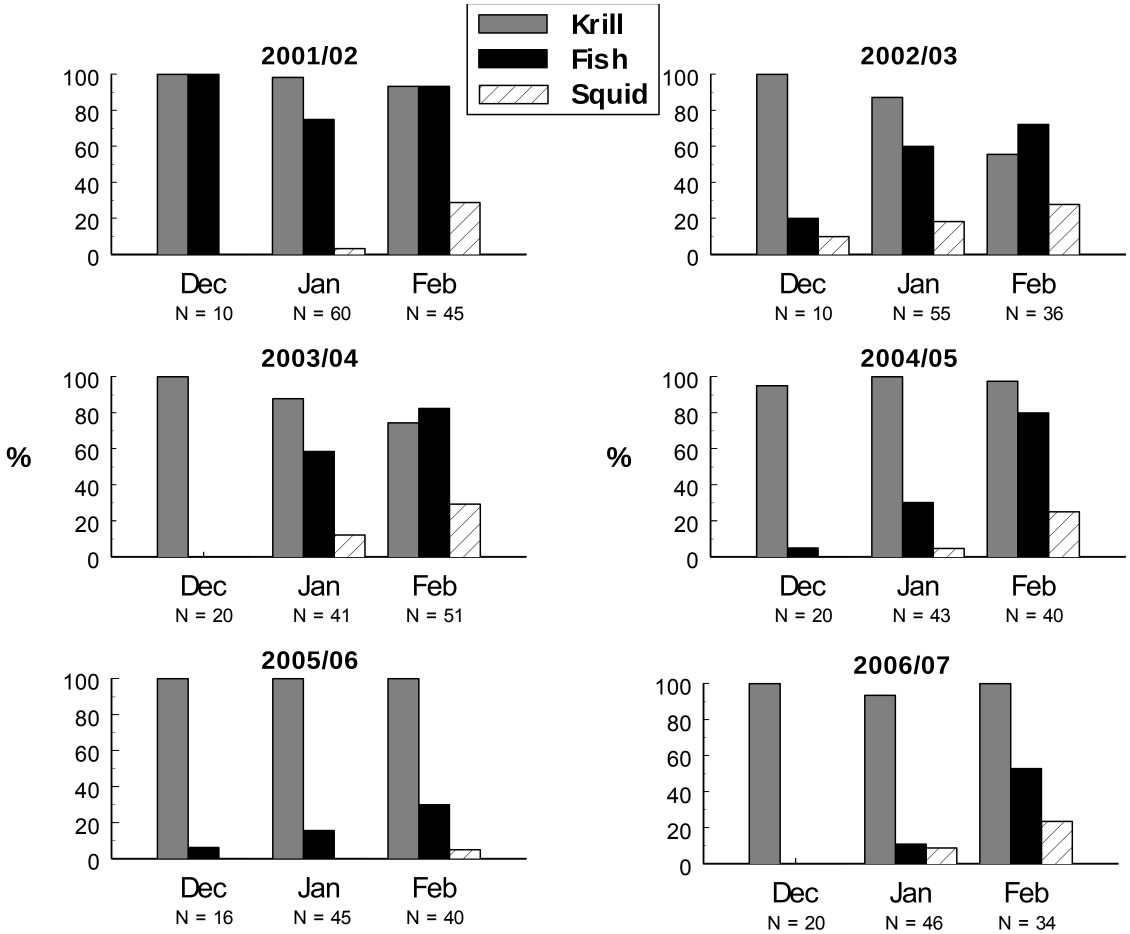

Figure 6.4 The percent occurrence of primary prey types (krill, fish, and squid) from December through February for Antarctic fur seal scats collected from female suckling areas and enemas from females carrying time-depth recorders. All samples were collected from study beaches at Cape Shirreff, Livingston Island from 2001/02 through 2006/07.

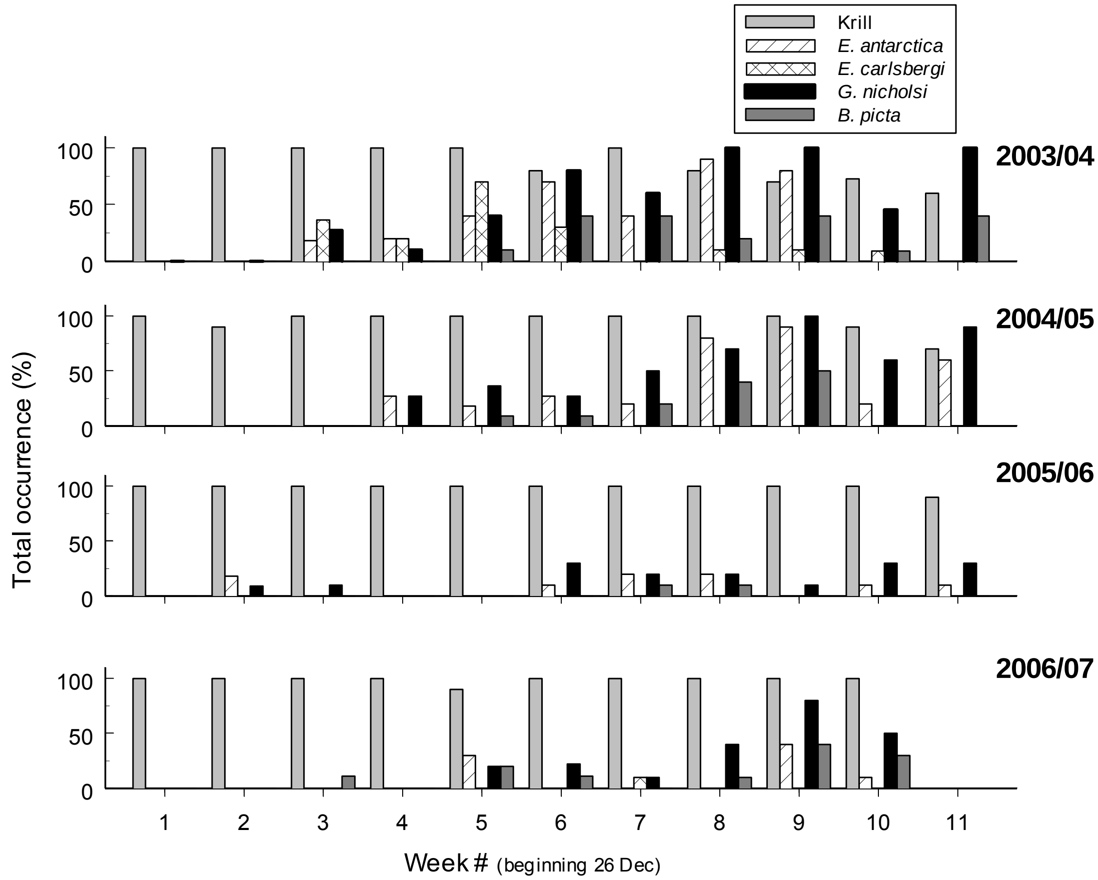

Figure 6.5 The weekly percent occurrence of five primary prey species found in fur seal diets at Cape Shirreff, Livingston Island from 2003/04-2006/07. The five species are krill (*Euphausia superba*), *Electrona antarctica*, *E. carlsbergi*, *Gymnoscopelus nicholsi*, and *Brachioteuthis picta*. The first three non-krill species are myctophid fish (lantern fish) and the fourth species is a cephalopod (squid).

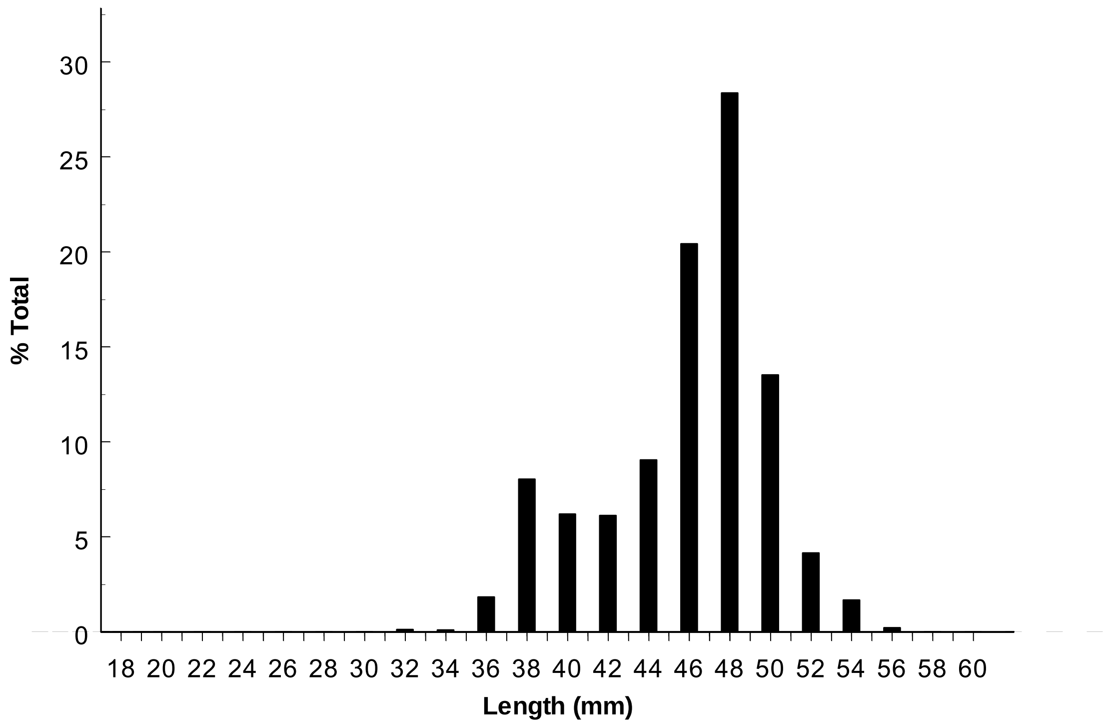

Figure 6.6 The size distribution of krill (n=2175) in Antarctic fur seal diet at Cape Shirreff, Livingston Island (2006/07). Krill length is derived from measuring length and width of carapaces found in fur seal scats. A discriminant function to determine sex is applied before calculating length from sex-specific regression equations.

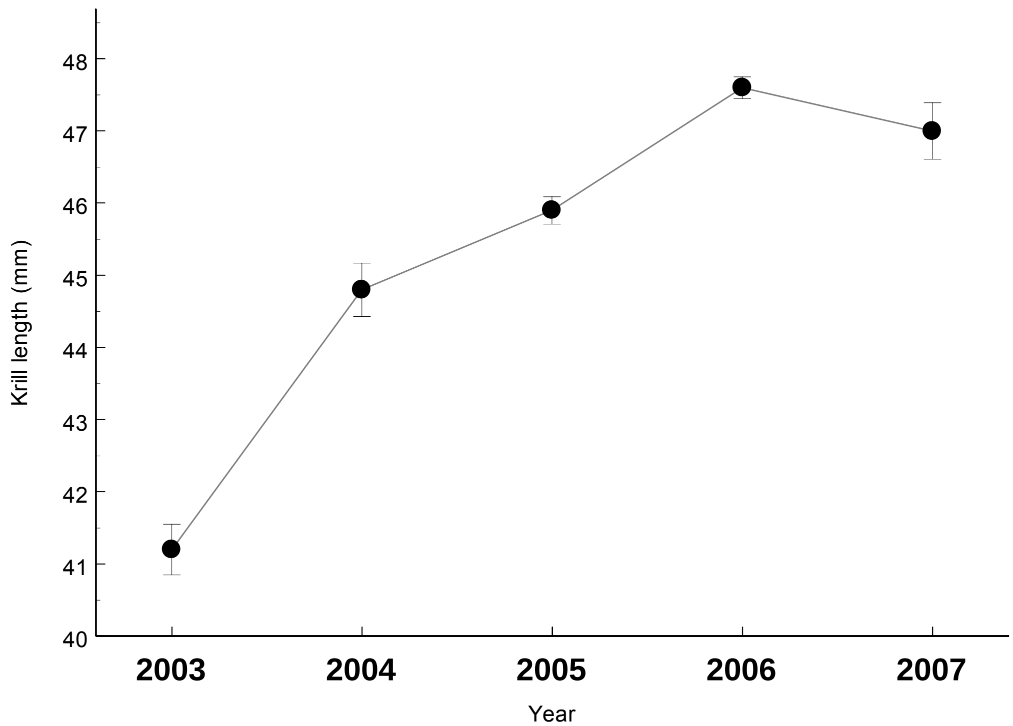

Figure 6.7 The mean length of krill (*Euphausia superba*) in Antarctic fur seal diet at Cape Shirreff, Livingston Island from 2002/03 through 2006/07 (see Table 6.2 for annual sample size). Krill length is derived from carapace length and width using a discriminant function to determine sex before applying sex-specific regression equations. Twenty-five carapaces are measured from each scat collected.

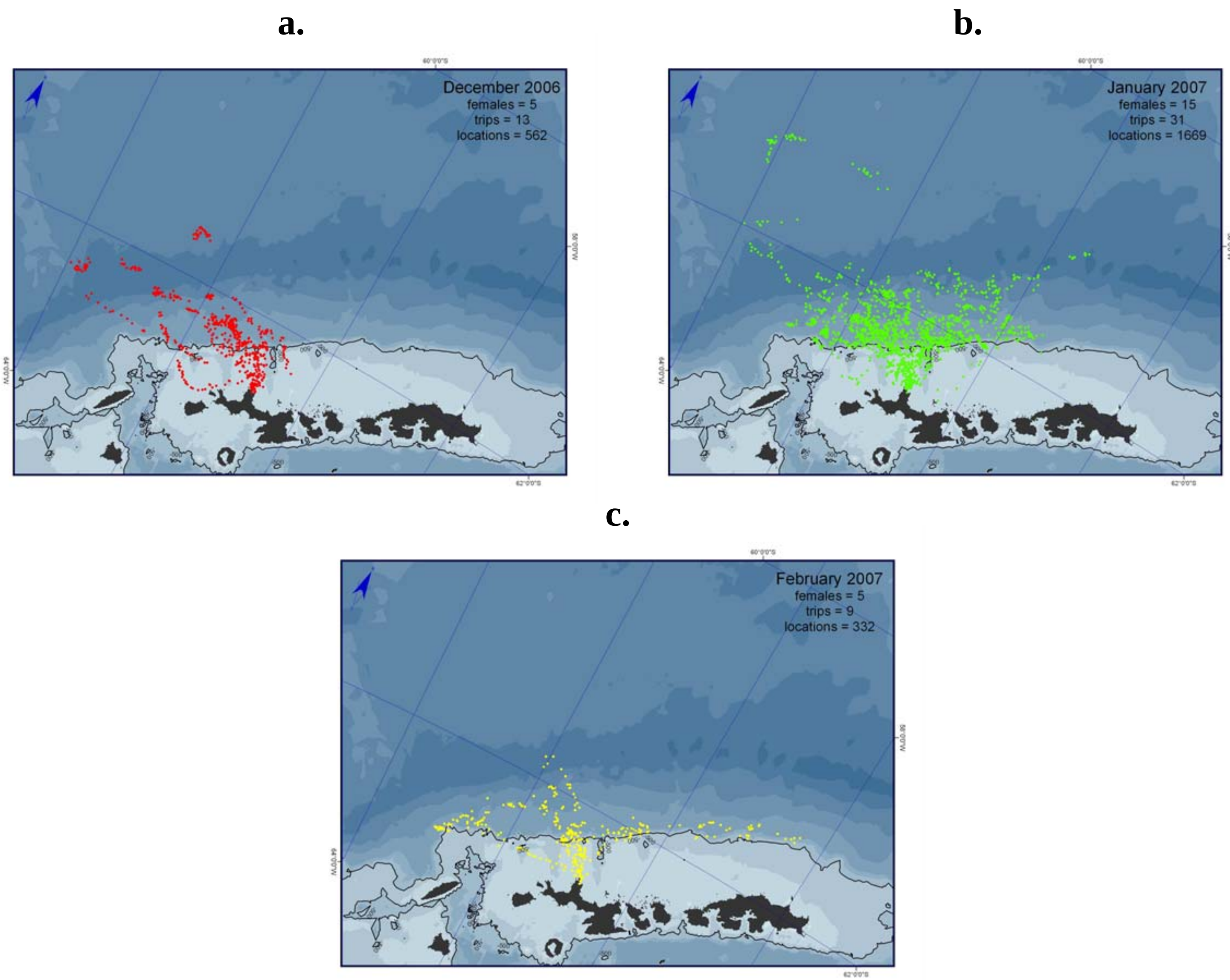

Figure 6.8 At-sea locations of lactating Antarctic fur seals foraging from Cape Shirreff, Livingston Island, South Shetland Islands in December 2006 (a, red), January 2007 (b, green), and February 2007 (c, yellow). The 500m bathymetry contour (—) is demarcated to show the location of the continental shelf edge.

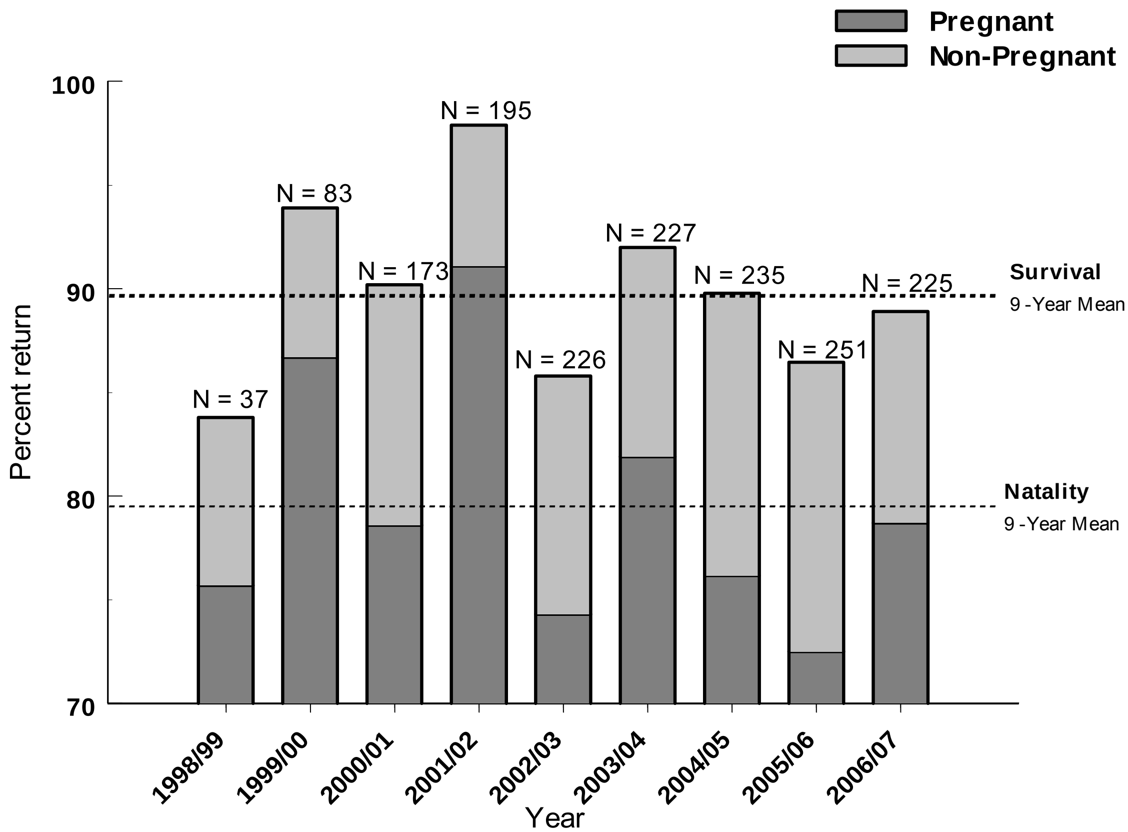

Figure 6.9 Adult female Antarctic fur seal tag returns for nine years (1998/99-2006/07) of study at Cape Shirreff, Livingston Island.

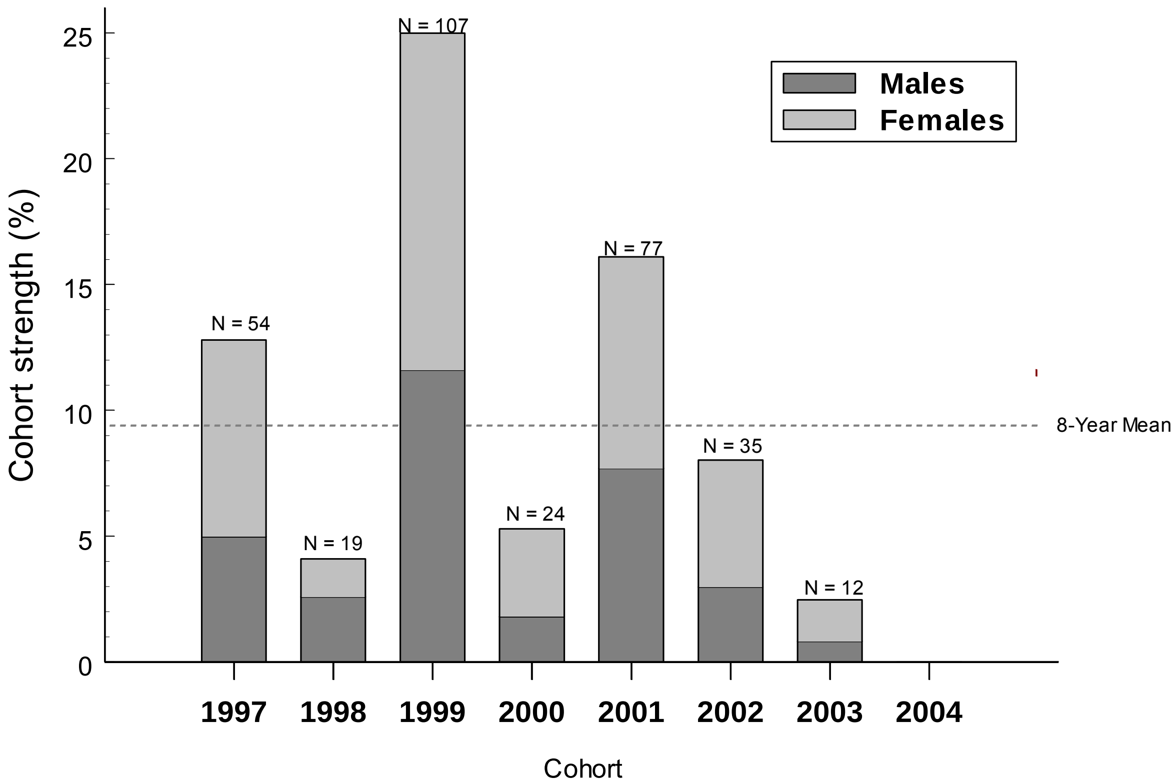

Figure 6.10 Minimum survival to age-1 based on tag returns for the first two years for eight cohorts (97/98-04/05) of fur seals tagged as pups at Cape Shirreff, Livingston Island. Not all pups that survive their first year return as yearlings or two year olds, thus our estimates represent a minimum survival. There were no differences in tag re-sight effort among years. Tags from the 2004/05 cohort have not been observed.

7. Seabird research at Cape Shirreff, Livingston Island, Antarctica, 2006/07; submitted by Rachael A. Orben, Sarah E. Chisholm, Aileen K. Miller and Wayne Z. Trivelpiece.

7.1 Objectives: The U.S. Antarctic Marine Living Resources (AMLR) program conducted its tenth field season of land-based seabird research at the Cape Shirreff field camp on Livingston Island, Antarctica (62º 28'S, 60º 46'W), during the austral summer of 2006/07. Cape Shirreff is a Site of Special Scientific Interest (SSSI) and long-term monitoring of predator populations are conducted in support of US participation in the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR).

The 2006/07 field season began via the National Science Foundation vessel R/V *Laurence M. Gould*. We arrived at Cape Shirreff on November 1, 2006 and conducted research until we closed camp on February 24, 2007. The AMLR chartered vessel R/V *Yuzhmorgeologiya* provided logistical support during the month of January and the R/V *Laurence M. Gould* provided transit back to Punta Arenas, Chile, at the end of the field season. The objectives of the seabird research for the 2006/07 season were to collect the following long-term monitoring data:

1. To estimate chinstrap (*Pygoscelis antarctica)* and gentoo penguin (*P. papua)* breeding population size (Standard Method A3);
2. To band 500 chinstrap and 200 gentoo penguin chicks for demography studies (Std. Method A4);
3. To determine chinstrap penguin foraging trip durations during the chick rearing stage of the reproductive cycle (Std. Method A5);
4. To determine chinstrap and gentoo penguin breeding success (Std. Methods 6a,b&c);
5. To determine chinstrap and gentoo penguin chick weights at fledging (Std. Method 7c);
6. To determine chinstrap and gentoo penguin diet composition, meal size, and krill length/frequency distributions (Std. Methods 8a,b&c); and
7. To determine chinstrap and gentoo penguin breeding chronologies (Std. Method 9).

7.2 Results:

7.2.1 Breeding Biology Studies: The penguin rookery at Cape Shirreff consisted of 22 sub-colonies of gentoo and chinstrap penguins during the 2006-07 breeding season. We conducted nest censuses for gentoos on November 13, 2006 and for chinstraps on November 25, 2006, approximately 1 week after mean clutch initiation for each species, respectively. Mean clutch initiation for both species was the earliest in the nine years of our study. A total of 781 gentoo penguin nests were counted; this count is slightly lower than the 2005/06 season count of 807 nests and is 7% lower than the pervious nine year mean of 838 nests (Figure 7.1). There were 4,544 chinstrap penguin nests, representing a 6% decrease from the previous year and the eighth continuous year of decline (Figure 7.2).

Chick censuses were conducted for gentoo penguins on January 13, 2007 and for chinstrap penguins on February 4, 2007, about a week after mean crèche. We counted 956 gentoo penguin chicks; this is a 17% decrease from 2005/06, but only 4% below the mean of the prior ten years (Figure 7.1). The chinstrap penguin count was 5,299 chicks; similar to last season's count, but it is 26% below the prior ten year average (Figure 7.2).

Based on census data, overall gentoo penguin fledging success was 1.22 chicks/nest. This is only slightly lower than the past nine year mean. Overall, chinstrap penguins fledged 1.17 chicks/nest. This is a 9% increase from the 2005/06 season and is 7% above the previous nine year mean. Individually, the fledging success of the fifteen sub-colonies of chinstrap penguins varied from a low of 0.69 chicks/nest in one of the smaller sub-colonies to 1.51 chicks/nest in one of the larger sub-colonies. Reproductive success was also measured by following a sample of 49 pairs of breeding gentoo penguins and 87 pairs of breeding chinstrap penguins from clutch initiation through to crèche formation (Std. Methods 6b). Because chick mortality is typically low following crèche, these numbers are also an estimate of fledging success. Based on data from our reproductive study, gentoo penguins fledged 1.37 chicks/nest and chinstrap penguins fledged 1.24 chicks/nest. Known-aged penguins who initiated clutches were also followed to crèche. Sixteen gentoo penguins, with one member of the pair of known-age, initiated clutches and fledged 1.31 chicks/nest. Thirty known-age chinstrap penguins initiated clutches and fledged 0.87 chicks/nest.

We banded a sample of 200 gentoo and 500 chinstrap penguin chicks for future demographic studies. The banded chicks that survive and return to the colony as adults will be observed for age-specific survival and reproductive success. This year the cohort from 2005/06 composed 50% of the 48 known-aged gentoo penguins that were seen throughout the season. This was the largest influx into the population since the cohort from 2001/02. In addition, 26% of the 129 known-aged chinstrap penguins seen were also from the 2005/06 cohort. This was the largest return of one-year old birds since the 2000/01 cohort.

We collected fledging weights from gentoo and chinstrap penguin chicks as a measure of chick condition. Gentoo penguin chicks are still provisioned by their parents after they begin making trips to sea, so it is not possible to obtain definitive fledging weights by catching and weighing chicks prior to departure. Alternatively, we weighed a sample of gentoo penguin chicks 85 days after their mean clutch initiation date; which is approximately the age when other *Pygoscelis* chicks fledge. We weighed 180 gentoo penguin chicks weighed on January 27, 2007 had an average mass of 4,126g (n = 180; S.D. = 588), which represents a 9% decrease from 2005/06, but is only slightly below the nine year mean weight for this species. Chinstrap penguin chicks were caught on the beaches just before fledging, during the period February 14-22, 2007. Chinstrap penguin fledglings, had an average mass of 3,174g (n = 307; S.D. = 302). This is slightly higher than both last season and the past ten year mean.

7.2.2 Foraging Ecology Studies: Diet samples were collected from 20 gentoo and 40 chinstrap penguins via the wet-offloading technique between January 4 and February 11, 2007. The majority of the sampling coincided with the AMLR oceanographic survey. We followed adults returning from foraging trips back to their nests to verify that they were breeders and captured them before they fed their chicks. Antarctic krill (*Euphausia superba*) were present in all samples and comprised the majority of the diet samples by mass. The next largest component consisted of fish. The number of other marine invertebrates found was negligible.

In the 2006/07 season, all of the gentoo penguin diet samples contained evidence of fish. This is the first year of our study in which all 20 gentoo penguin diet samples contained evidence of fish and it represents a significant increase from the 2005/06 season in which fish were present in only 25% of the samples. Evidence of fish was found in 25% of the chinstrap penguin diet samples; this percentage is similar to 2005/06 and comparable to the previous nine year mean of 29%. Fish represented 13% of the gentoo penguin diet by mass, but only 1% of the chinstrap penguin samples.

A sub-sample of 50 individual Antarctic krill from each diet sample were measured and sexed to determine length and sex frequency distributions of the krill selected by the foraging penguins. Both the chinstrap and gentoo penguin diet samples included a significant amount of juvenile krill (< 35mm in length) that were not present in 2005/06 samples. Overall the diets of both species were composed of 23% juveniles and 63% females with 71% of the krill from 41 to 55mm in length (Figures 7.3 & 7.4).

The average chick meal mass for chinstrap penguins was 635g (S.D. = 212); this is 5% higher than the previous nine year mean of 607g (S.D. = 54). The ratio of fresh to digested portions in the chinstrap penguin's diet samples was comparable to the previous nine seasons. We only collected the fresh portion of diet samples from gentoo penguins, so chick meal mass was not be evaluated.

To measure foraging trip durations during the chick rearing phase we deployed eighteen radio transmitters on adult chinstrap penguins brooding two chicks. We began logging their colony attendance on December 28, 2006 and continued until February 15, 2007, just prior to fledging. Nests were followed daily until crèche and only one chick was lost during this time period. The mean trip duration was 10.95 hours (n = 702; S.D. = 4.58). This is longer than the average trip duration from last season of 9.7 hours. Fifty-nine percent of all foraging trips were between eight and fourteen hours.

We instrumented penguins with satellite transmitters (PTTs), to provide geographic data on foraging trips, for two deployments of approximately seven days each in mid-January and the end of January. The first deployment on chinstrap penguins was during the brood stage and the second was after the chicks had crèched; while both deployments on gentoo penguins were during the crèche phase. The timing of the first deployment coincided with the AMLR oceanographic survey (Leg I) and the second deployment coincided with the AMLR nearshore hydroacoustic survey. We instrumented ten chinstrap and seven gentoo penguins during the first deployment and we deployed nine and seven PTTs on chinstrap and gentoo penguins, respectively, in the final deployment.

Time-depth recorders (TDRs), instruments that collect data on diving behavior, were deployed at the same time as the PTTs on five additional chinstrap and four gentoo penguins during for survey period. Dive data and the PTT data are awaiting analysis.

7.2.3 Other Seabirds: We monitored the breeding success of all reproductive skuas at Cape Shirreff, as well as two pairs of skuas at Punta Oeste, a small promontory 1-2 km to the west. There were 27 skua pairs holding territories, all of which were brown skuas (*Catharacta lonnbergi*) with the exception of one pair that are likely hybrid, brown-South Polar skuas (*C. maccormicki*). Clutches were initiated by 25 pairs and overall fledging success was 0.44 fledglings/pair. The poor reproductive success was largely due to losses following a wind storm which occurred on December 17th, just prior to hatching. Six skua pairs lost their entire clutch and one pair lost an egg during the storm. Two of the pairs did relay, only one produced a fledgling. In addition, only one of the 25 skua pairs that bred in 2006/07 fledged two chicks. We have banded skua chick fledglings for ten years at our site and currently, 19% of the territory holders are of known-age and were born at Cape Shirreff.

We followed the reproductive performance of kelp gulls (*Larus dominicanus*) nesting on Cape Shirreff throughout the season. The first full clutch was observed on November 10, 2006. Fifty-six nests were initiated on the cape and a small group of empty nest bowls was observed at Punta Oeste in early December. Overall fledging success the kelp gulls at Cape Shirreff was 1.02 fledglings/pair.

7.3 Conclusions: Our tenth season of seabird research at Cape Shirreff allowed us to assess trends in penguin population size, as well as inter-annual variation in reproductive success, diet and foraging behavior.

The gentoo breeding population has decreased marginally from the previous season and is the third lowest population size in the ten years of census data. The number of diet samples containing fish was the highest ever and comparable to the first six years of the study. Unlike 2005/06, 18% of the gentoo penguin diet samples contained juvenile krill. Fledgling success and fledgling weights were slightly below the nine year means for these parameters at our study site.

The chinstrap penguin breeding population has been declining for the past seven years and is at its lowest size in the ten years of study. Chinstrap penguins ate mainly Antarctic krill, with a strong component of juvenile krill in their diet samples. Juvenile krill were also plentiful in the chinstrap penguin's diets in the 1997/98 and 2002/03 seasons. The mean foraging trip duration during chick rearing was approximately one hour longer than in 2005/06. The data collected, using the PTTs and TDRs, on foraging location and diving behavior should assist us in interpreting the foraging trip data. Fledgling success and chick fledging mass in 2006/07 were higher than both last season and the past ten year mean.

7.4 Acknowledgements: We would like to sincerely thank Mike Goebel, Gitte McDonald, Cory Champagne, Russell Haner, Ryan Driscoll and Rennie Holt for their invaluable assistance in the field and companionship. We would also like to thank the Chilean research team at Cape Shirreff for their assistance in the field, as well as their personal camaraderie. We are grateful to the crew of the NSF research vessel *Laurence M. Gould* for our smooth transit to Cape Shirreff, for their help with camp opening, camp closing, and for providing transit back to Punta Arenas, Chile. We also thank the crew of the AMLR chartered research vessel *Yuzhmorgeologiya* for their efforts in resupplying our camp mid-season.

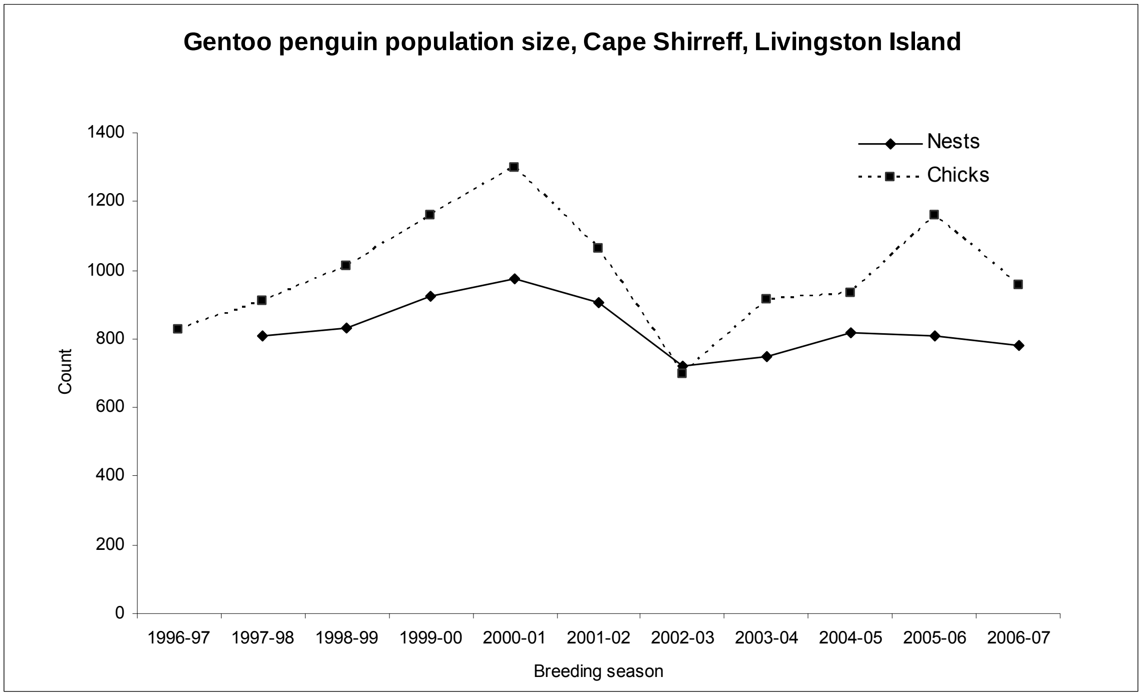

Figure 7.1 Gentoo penguin population size at Cape Shirreff, Livingston Island, Antarctica, 1996/97 to 2006/07.

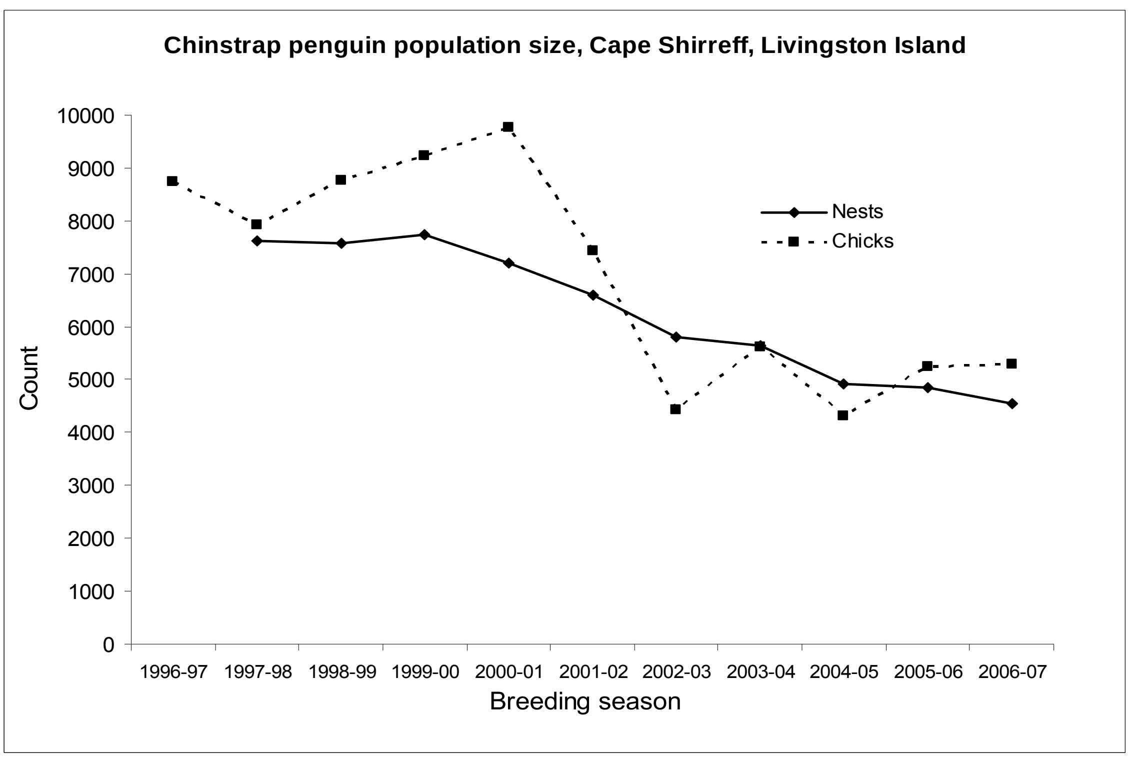

Figure 7.2 Chinstrap penguin population size at Cape Shirreff, Livingston Island, Antarctica, 1996/97 to 2006/07.

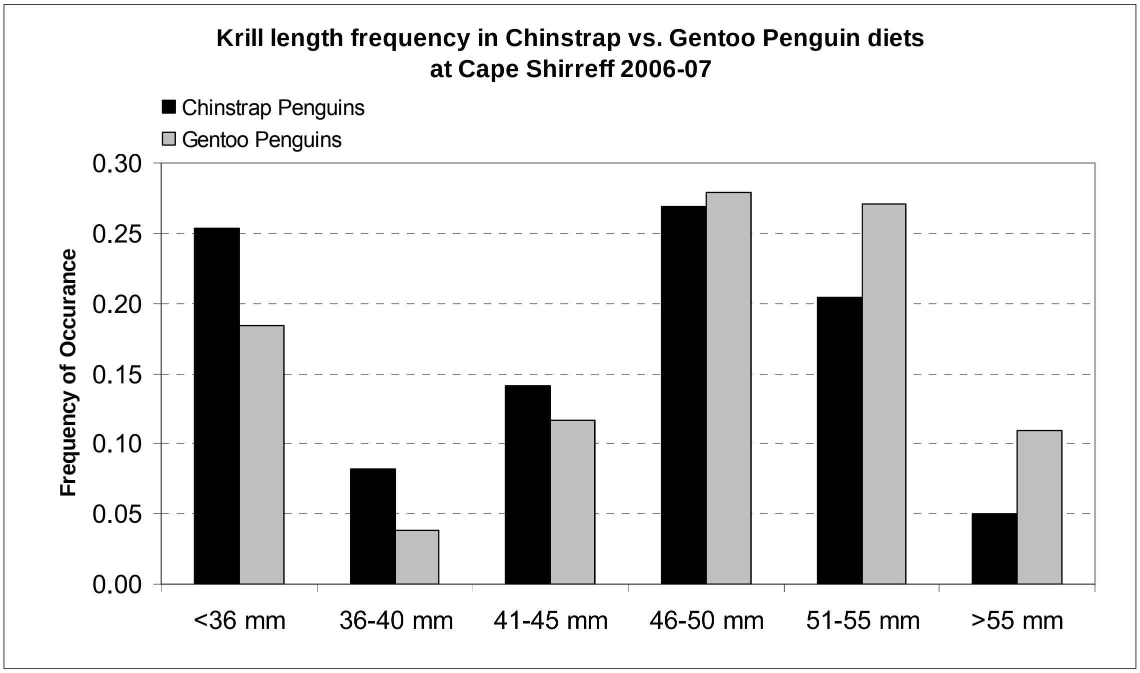

Figure 7.3 Krill length frequency distribution in gentoo and chinstrap penguin diet samples at Cape Shirreff, Livingston Island, Antarctica, 2006/07.

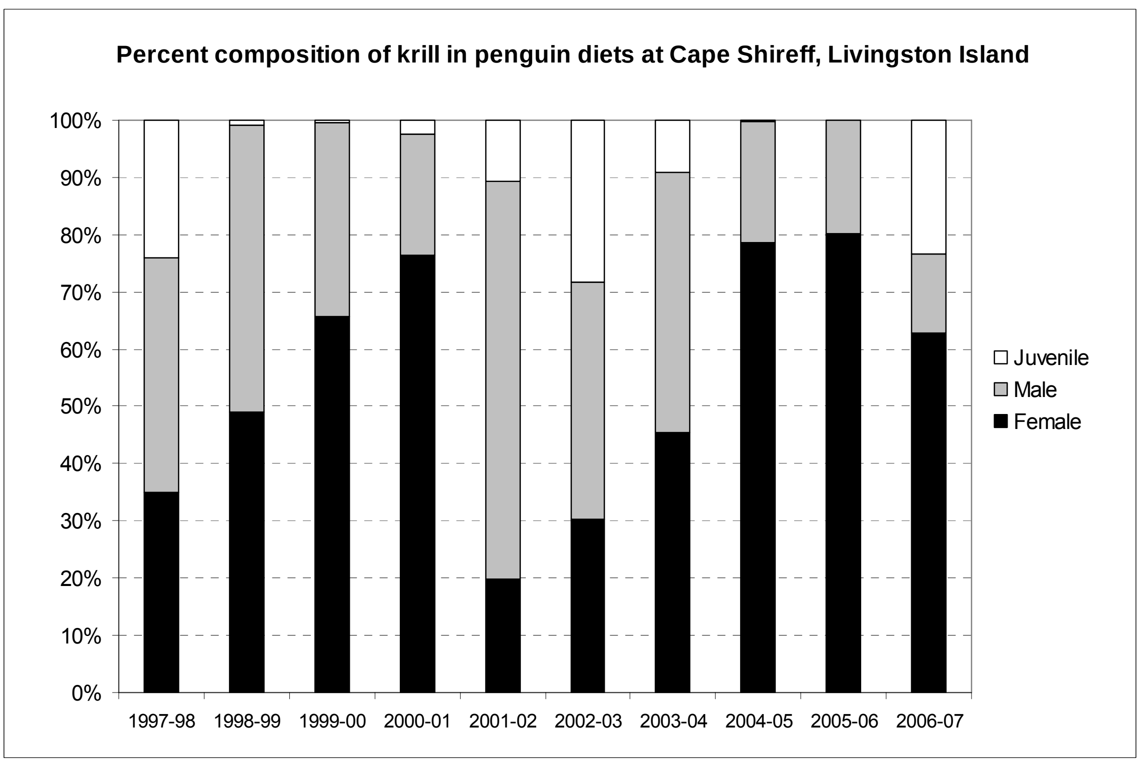

Figure 7.4 Percent composition of Antarctic krill (*Euphausia superba*) in gentoo and chinstrap penguin diet samples at Cape Shirreff, Livingston Island, Antarctica, 1997/98 to 2006/07.

8. Distribution, Abundance, and Behavior of Seabirds and Mammals at Sea, During the 2006/07 AMLR Survey; submitted by Jarrod A. Santora, Michael P. Force, Anthony Cossio, Derek Needham, Christian Reiss, Timothy P. White

8.1 Objectives: This investigation focuses on the at sea abundance and behavior of seabirds and marine mammals in response to oceanography and prey aggregations. The primary objectives were to map the behavior and abundance of seabirds and mammals at sea and use the resulting data set to investigate:

A) Impact of krill abundance and patchiness on seabirds and mammals.
B) Response of foraging predators to krill swarms of different size.
C) Community structure and habitat selection by predator groups.
D) Annual and seasonal change in the spatial distribution of foraging seabirds at sea.

8.2 Methods - Seabird and Mammal Observations: Data on predator abundance and behavior were collected using binoculars while underway between stations during daylight hours. Surveys followed strip transect methods (Tasker *et al*., 1984) and counts were made within an arc of 300m directly ahead and to one side of the ship. In this report, transects are referred to as the duration of travel time and space coverage while the vessel was underway between stations. Each record was immediately assigned a time and a position directly fed by the ships navigational computer. The computer clock was synchronized with the ships data acquisition computer and the hydro-acoustic system used to collect krill biomass estimates. Individual birds, or flocks of birds, were assigned a behavioral code. The behaviors were: flying, sitting on water, milling (circling), feeding, porpoising (penguins, seals, and dolphins), and ship-following. Ship-followers were entered when encountered and were ignored thereafter. Predators which were flying or porpoising were assigned a direction. Data recorded for mammals included traveling direction, distance from ship and behavior. All sightings were downloaded each day, error checked and stored in a database.

8.3 Accomplishments: In total, 83 transects were collected representing approximately 3,066km (1,655.5 n.mi.) of survey effort. In total, 22 seabird species and 9 species of marine mammals were recorded. The density of each species is presented in Table 8.1. Densities are calculated by the dividing the total abundance, by the total kilometers surveyed in each stratum.

The distribution of "Total Seabird Abundance" and "Feeding Seabird Abundance" (#/10 n.mi.) recorded during AMLR 2006/07 is presented in Figures 8.2 and 8.3 respectively. The distribution of humpback whales (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*) sightings is presented in Figure 8.3.

8.4 Results and Tentative Conclusions:

8.4.1 Elephant Island Area: Thirty-six transects were collected totaling approximately 1,170.3km (632 n.mi.) of survey effort. Seabird community composition was not concordant with previous AMLR surveys. The community consisted primarily of cape petrels (*Daption capense*), chinstrap penguins, (*Pygoscelis antarctica*), southern fulmars (*Fulmarus glacialoides*), southern giant petrels (*Macronectes giganteus*), black-bellied storm petrels (*Fregetta tropica*), black-browed albatrosses (*Thalassarche melanophrys*), gentoo penguins (*Pygoscelis papua*), and Wilson's storm petrels (*Oceanites oceanicus*). Surprisingly, abundance of white-chinned petrels (*Procellaria aequinoctialis*), blue petrels (*Halobaena caerulea*) and prion species (*Pachyptila spp.*) were especially low, and soft-plumaged petrels (*Pterodroma mollis*) were entirely absent from the Elephant Island Area (Table 8.1). In contrast to the West Area, the distribution and abundance of feeding aggregations was comparatively lower (Figure 8.2). Feeding activity, which was predominantly by cape petrels, occurred primarily in the western region of the Elephant Island Area, and in offshore waters closest to the ACC front (Antarctic Circumpolar Current).

Fin whales were the most common cetaceans in the Elephant Island Area (Figure 8.3). We collected 95 sightings of fin whales. Group size was typically two to three whales, but a few sightings of six were observed. We collected 35 of humpback whale sightings (Figure 8.3). As in previous AMLR surveys, humpback whales were more common in proximity to Elephant Island, but were more abundant in southern portion of the strata. Southern bottlenose whales (*Hyperoodon planifrons*) were observed along the shelf break and on one occasion we observed a group of seven whales. The most exciting cetacean observation was of two unidentified *Mesoplodon* beaked whales.

8.4.2 Joinville Island Area: Too few observations were collected in the Joinville Island Area.

8.4.3 South Area: Sixteen transects were collected totaling approximately 756.3km (408.4 n.mi.) of survey effort. Seabird community composition was concordant with previous AMLR surveys in the Bransfield Strait region. The community consisted primarily of southern fulmars, cape petrels, chinstrap penguins, Wilson's storm petrel, gentoo penguins, black-browed albatrosses, black-bellied storm petrels and south polar skuas (*Catharacta maccormicki*).

Southern fulmars were the most abundance avian predator (Table 8.1). On transit to station 14.14 (see Introduction Section for station locations) there were continuous sightings of numerous feeding aggregations of southern fulmars numbering in the thousands (Figures 8.1 & 8.2). Birds were observed sitting in large rafts averaging in size of approximately 500 birds. In addition, cape petrels were also observed in feeding aggregations within the waters of the southern Bransfield Strait.

Humpback whales were the most common cetaceans in the South Area (Figure 8.3). We collected 95 sightings of humpback whales. Group size was typically two to three whales, but on a few occasions we observed groups that were five and six in size. These numbers of humpbacks are the largest estimated since AMLR 2003 (2002/03 season). In addition, seven minke whales and one crabeater seal were observed.

8.4.4 West Area: Twenty-four transects were collected totaling approximately 1,010.6km (545.7 n.mi.) of survey effort. Seabird community composition was concordant with previous AMLR surveys. The community consisted primarily of cape petrels, black-browed albatrosses, blue petrels, chinstrap penguins, black-bellied storm petrels, Antarctic prions, gray-headed albatrosses, and southern giant petrels.

Cape petrels were the most conspicuous avian predator and were observed feeding throughout the West Area. The numbers of cape petrels observed in West Area are the highest recorded within the past five AMLR surveys. However, the majority of cape petrels were observed on two transits in a few dense aggregations (Figures 8.1 & 8.2). On transit to stations 12.08 and 11.07, there were numerous feeding frenzies, which coincided with large densities of krill collected during net sampling. At these locations, krill were actively mating and spawning (Pers. Comm. V. Loeb). To determine what feeding petrels were probably consuming, a Manta-neuston net was towed along side the vessel to sample surface plankton. Krill, pteropods, amphipods and copepods were present in net samples.

Humpback whales were the most common cetaceans in the West Area (Figure 8.3). We collected 38 sightings of humpback whales. Group size was typically two to three whales. In addition, minke whales, fin whales and southern bottlenose whales were observed.

8.5 Disposition of Data: After all data have been thoroughly proofed, a copy will be retained and available from Jarrod Santora, College of Staten Island, Biology Department, 2800 Victory Boulevard, Staten Island, NY, 10314; phone: (718) 982-3862; email: jasantora@gmail.com

8.6 Acknowledgements: Everyone involved in the 2006/07 AMLR field season. Much appreciation to the captain and crew of the R/V *Yuzhmorgeologiya* for maintaining the excellent viewing platform on the flying bridge.

8.7 Reference:

Tasker, M.L., Jones, P.H., Dixon, T., and Blake, B.F. 1984. Counting seabirds at sea from ships: A review of methods employed and a suggestion for a standardized approach. *Auk* 101: 567-577.

Table 8.1 Seabird and Mammal densities recorded for Leg I AMLR 2006/07. Densities are presented as #/km surveyed per strata.

Common Name	Latin Name	Elephant	Joinville	South	West
Gentoo Penguin	*Pygoscelis papua*	0.0829	0	0	0.1158
Chinstrap Penguin	*Pygoscelis antarctica*	1.9363	0.9317	0.513	0.1722
Macaroni Penguin	*Eudyptes chrysolophus*	0.0222	0	0	0
Wandering Albatross	*Diomedea exulans*	0.0043	0	0	0.003
Royal Albatross	*Diomedea epomorpha*	0	0	0	0.001
Black-browed Albatross	*Thalassarche melanophrys*	0.0863	0	0.0595	0.4008
Grey-headed Albatross	*Thalassarche chrysostoma*	0.0043	0	0	0.0445
Light-mantled Sooty Albatross	*Phoebetria palpebrata*	0.0051	0	0.0013	0.0208
Southern Giant Petrel	*Macronectes giganteus*	0.1239	0.0233	0.0357	0.0871
Northern Giant Petrel	*Macronectes halli*	0.0034	0	0	0
Southern Fulmar	*Fulmarus glacialoides*	0.7451	0.8929	7.1268	0.0376
Antarctic Petrel	*Thalassoica antarctica*	0	0	0	0.001
Cape Petrel	*Daption capense*	1.6355	0.0078	2.0865	3.1417
White-chinned Petrel	*Procellaria aequinoctialis*	0.0111	0.0155	0.0053	0.0188
Antarctic Prion	*Pachyptila desolata*	0.0188	0	0	0.1366
Blue Petrel	*Halobaena caerulea*	0	0	0	0.189
Wilson's Storm Petrel	*Oceanites oceanicus*	0.082	0.0388	0.2393	0.0851
Black-bellied Storm Petrel	*Fregetta tropica*	0.1119	0.1398	0.0502	0.1563
Brown Skua	*Catharacta antarctica*	0.0009	0	0	0.004
South Polar Skua	*Catharacta maccormicki*	0.0051	0	0.0476	0.0049
Kelp Gull	*Larus dominicanus*	0	0	0.0026	0.001
Antarctic Tern	*Sterna vittata*	0.0137	0.0155	0.0291	0.0228
Antarctic fur seal	*Arctocephalus gazella*	0.0197	0	0.0066	0.0148
Elephant Seal	*Mirounga leonina*	0.0009	0	0	0
Weddell Seal	*Leptonychotes weddellii*	0.0017	0	0	0
Crabeater Seal	*Lobodon carcinophagus*	0	0	0.0013	0
Humpback whale	*Megaptera novaeangliae*	0.0273	0.2096	0.1071	0.0346
Fin Whale	*Balaenoptera physalus*	0.0812	0.0311	0	0
Minke Whale	*Balaenoptera bonaerensis*	0.0009	0	0.0106	0.001
Un-identified Whale	*Balaenoptera species*	0.0077	0	0	0.004
Southern Bottlenose Whale	*Hyperoodon planifrons*	0.0128	0	0	0.0049
Mesoplodon sp.	*Mesoplodon sp.*	0.0017	0	0	0

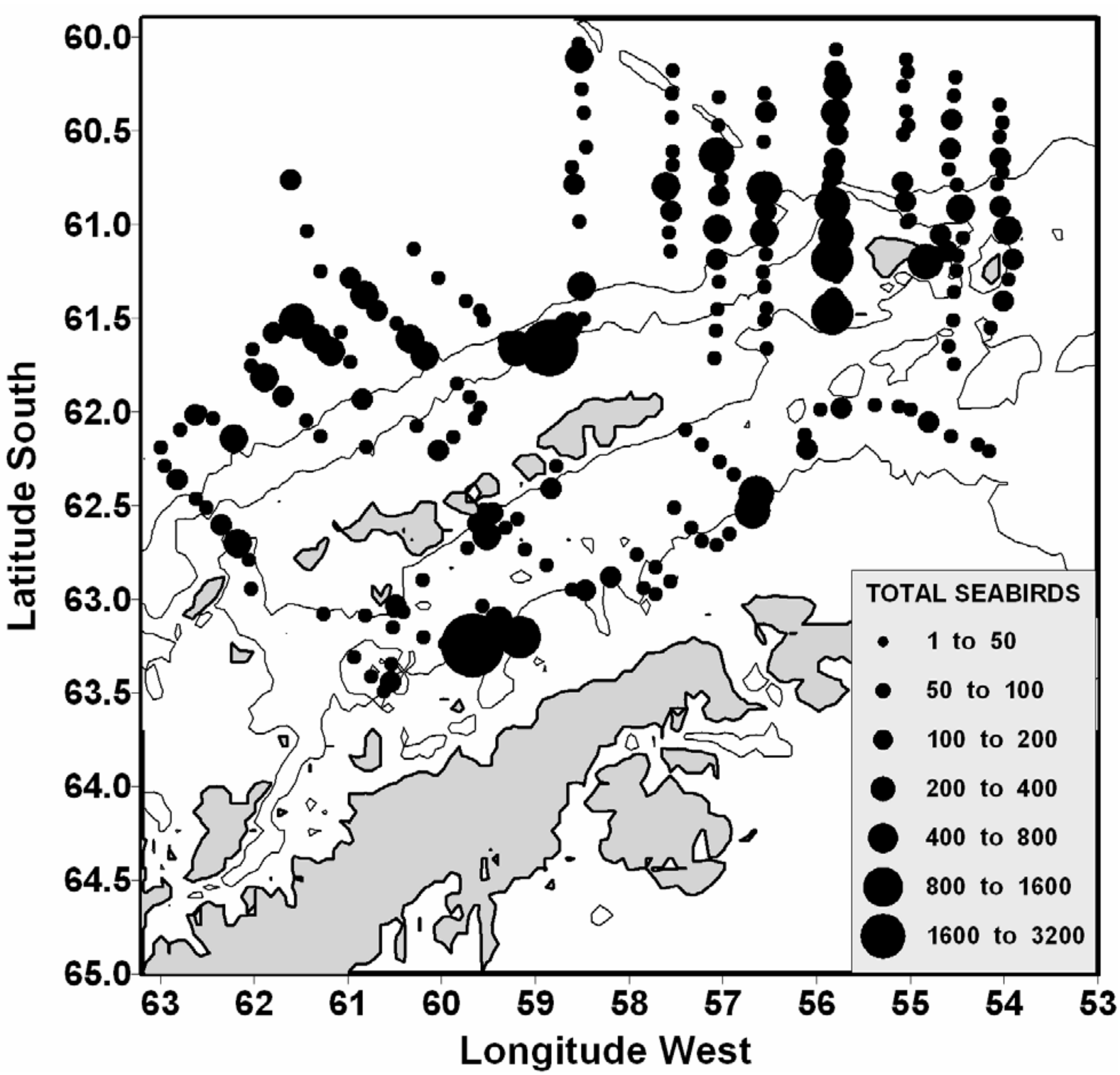

Figure 8.1 Distribution of total seabird abundance (#/10 n.mi.)

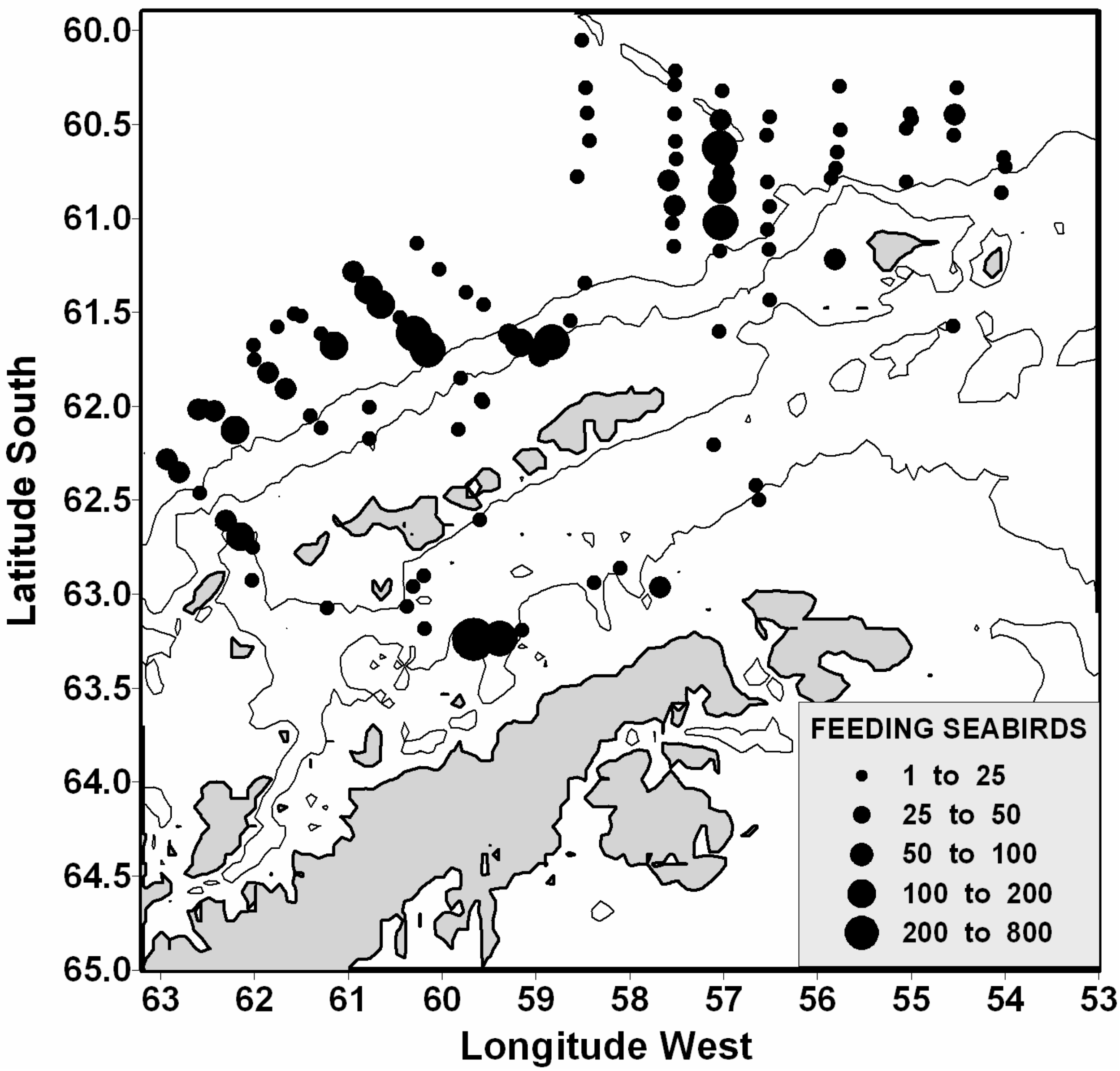

Figure 8.2 Distribution of feeding seabird abundance (#/10 n.mi.); primarily cape petrels.

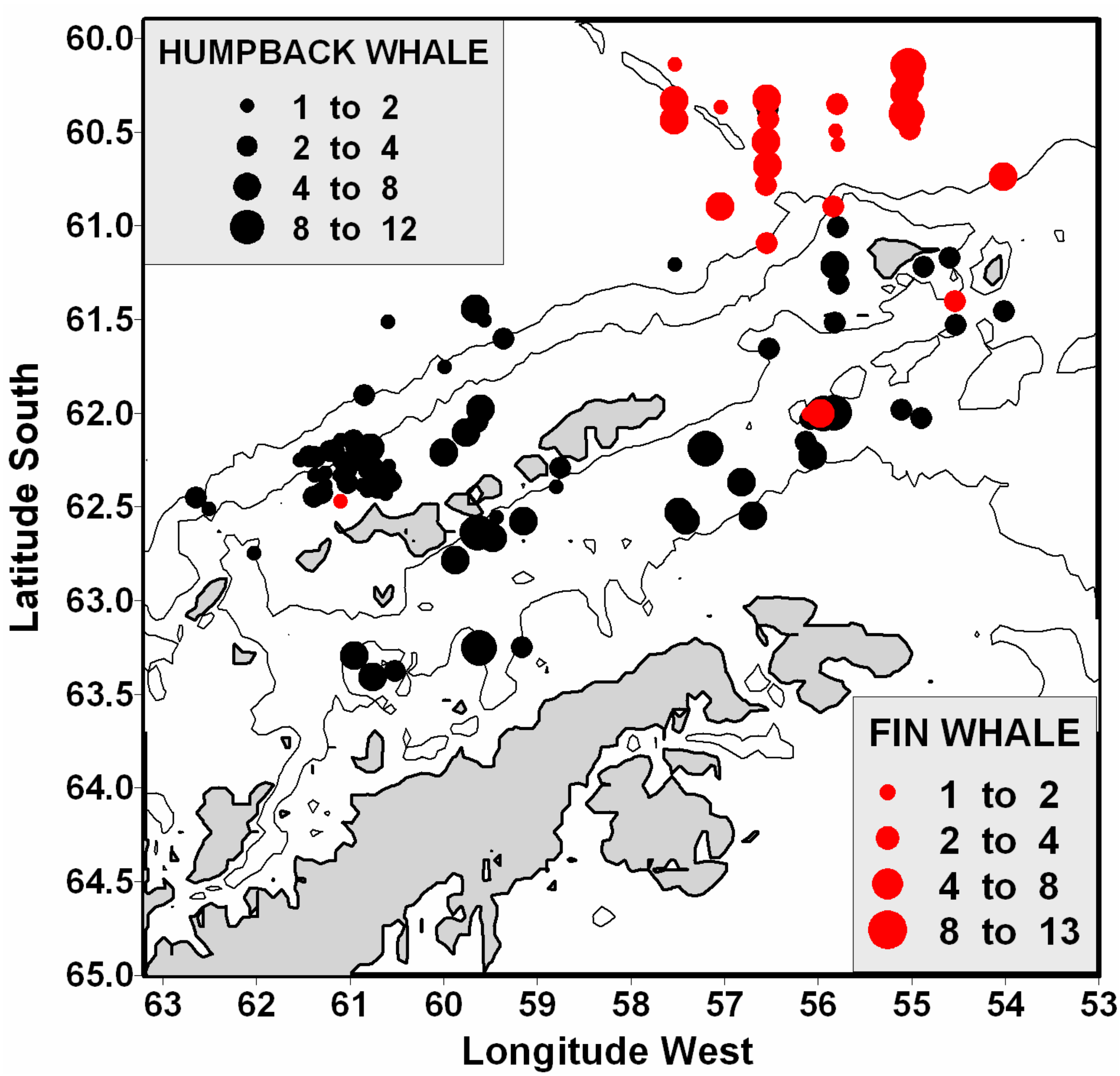

Figure 8.3 Distribution of humpback and fin whale sightings grouped into one-hour bins.

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