UNITED STATES
AMLR ANTARCTIC MARINE LIVING RESOURCES PROGRAM

AMLR 2005/2006 FIELD SEASON REPORT

Objectives, Accomplishments and Tentative Conclusions

Edited by
Jessica D. Lipsky

December 2006

NOAA-TM-NMFS-SWFSC-397

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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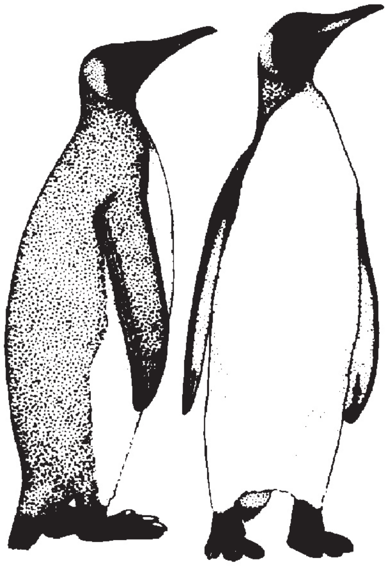

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BACKGROUND

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 18th issue in the series of AMLR field season reports.

SUMMARY OF 2006 RESULTS

The Russian R/V *Yuzhmorgeologiya* was chartered to support the U.S. AMLR Program during the 2005/06 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 acoustically instrumented buoys 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; 6) a finfish bottom trawl survey (Leg II) (See Figure 4 for station locations); and 7) 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 south transit of Leg I, a wide front was defined between 57° 58' S and 59° 00'S. On the northward transect the front had become more clearly defined between 57° 50' S and 58° 00' S. On the south bound transit of Leg II the front had moved further south when compared to the north bound transect of Leg I, and was less clearly defined, laying between 58° 10' S and 59° 00' S. On the return transit, at the end of Leg II, the zone had once again become more clearly defined and was located between 57° 30' S and 58° 10' S. During Leg I, 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. The northeastern sector of the Elephant Island Area displayed mainly Zone II and III (Transition) waters, with two stations (A02-02 and A02-03) showing clear characteristics of Zone I (ACC) waters. Outer shelf stations in this area displayed a mixing of Zone II and III (Transition) waters. Zone IV (Bransfield Strait) waters were evident at many of the inshore stations 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) water was present along the Joinville Island Area and in the extreme southeastern Bransfield Strait. During Leg II, the bottom trawl survey, the stations were mainly around the southern Bransfield Straits (South Area) and northern Joinville Island Areas. The stations occupied in the southwestern Bransfield Straits showed classical Zone IV (Bransfield Straits) waters, whereas the waters around the eastern Bransfield Straits and the northern Joinville Island areas showed characteristics of Zone V (Weddell Sea) waters. Although no distinct Zone V water was observed, all stations occupied in the area showed lower surface temperatures (< 0°C) and higher salinity values.

Both the cruise data and satellite imagery of the AMLR survey area covering the 2005/2006 field season indicate that this was an unusual year with regard to phytoplankton biomass as well as physical oceanographic conditions. The uniqueness of this year is recognized when placed in context with a matrix of our historical data collected during AMLR cruises since 1990. The major changes documented in 2006 included (i) phytoplankton biomass in 2006 was higher than the historical mean by a factor of 2-3; (ii) surface water temperatures in the northern regions of the AMLR sampling grid were warmer than in past years by ~ 1.0 °C; (iii) There was only one station with a deep chl-*a* maximum (DCM), in contrast to the usual 10-20 stations with a DCM in past years (Holm-Hansen and Hewes, 2004). It is likely that these results are due to intrusion of Fe and Si rich shelf waters into the northern regions of the AMLR sampling grid.

Mean and median krill abundance in the Elephant Island Area were similar to the modest values observed during January 1993, 1998 and 2005 and, along with the length-frequency distribution, reflect relatively poor recruitment success from the previous three years (i.e., since the 2001/02 year class). Despite their modest concentrations rich krill supplies were apparently available to land-based predators suggesting that the krill distributional attributes, particularly over the inner island shelf areas, provided good forage. Elevated concentrations of 1- and 2-year old krill in the Joinville Island Area suggest that, like 2001, the young stages were concentrated as dense patches within this sparsely sampled area resulting in underestimated proportional recruitment values. Mean and median concentrations and carbon biomass levels represented by *Salpa* *thompsoni* rivaled lows observed during 1995, 1996 and 2003. The association of this salp with the ACC since 2001 conforms to its historical distribution pattern in the Antarctic Peninsula region and to its reported distribution elsewhere in the Southern Ocean. Presumably overwintering conditions were not favorable for their population growth poleward of the SACCF (Southern Antarctic Circumpolar Current Front). Extremely low concentrations of *Ihlea racovitzai* this season reflected minimal input from the Weddell gyre. Total mean zooplankton abundance was exceeded only by that observed during January 2002 and similarly resulted from dense offshore concentrations of copepods, particularly *Calanoides acutus, Calanus propinquus* and *Rhincalanus gigas,* along with elevated numbers of larval *Thysanoessa macrura, Euphausia frigida*, chaetognaths, radiolaria, ostracods, *Limacina helicina*, *Primno macropa* and *Tomopteris* spp. This abundant, species-rich zooplankton assemblage characterizes the SACCF and its presence was associated by the poleward location of this front well into the survey area. Elevated zooplankton abundance within Bransfield Strait was due primarily to large concentrations of the coastal copepod *Metridia gerlachei* and postlarval *Thysanoessa macrura.* Relatively large numbers of ice krill, *Euphausia crystallorophias*, and juvenile Antarctic silverfish, *Pleuragramma antarcticum*, indicate enhanced faunal input from Gerlache Strait. Zooplankton abundance, taxonomic composition and abundance relationships during 2006 reflected strong oceanic influences by the Southern boundary of the Antarctic Circumpolar Front (SACCF) and coastal influences through enhanced flow from Gerlache Strait into Bransfield Strait. These conditions, like the 1995-1996 and 1999-2003 periods, coincided with cool La Nina events in the tropical Pacific and are consistent with coupled atmospheric-oceanic processes resulting from the Antarctic dipole that result in increased eastward transport by the ACC and reduced intensity of the Weddell Sea gyre.

Initial results from the 2006 nearshore survey support the hypothesis that the nearshore waters are productive environments. There were many large aggregations of scatterers at the edges of the canyons often in waters between 100 and 150m in depth. From video observations from the *Ernest*, net tow data from the *Yuzhmorgeologiya*, and multiple frequency acoustic discrimination from both vessels, these scatterers were identified as krill. As with R/V *Ernest* predator observations, seabirds were the most frequently encountered predator group, making up 75% of sightings. Three humpback whale and one minke whale groups were seen feeding close to the surface. Antarctic fur seals made up the other sightings. Acoustic detections of Antarctic krill swarms by the SM20 MBE demonstrate that a small boat is a viable platform for multibeam surveys.

During Leg II in mid-February through mid-March, a finfish survey was conducted. A total of 1,918kg (7,990 individuals) of 52 finfish species were processed from all hauls. The dominant element of the Antarctic fish fauna both in terms of biomass and numbers was within the suborder Notothenioidei (Perciformes). The highest standardized densities of combined finfish occurred at stations along a relatively narrow band north of Joinville Island. The highest mean densities for finfish species combined were within the 100-200m depth strata, these were not significantly different than those in the 200-300m depth strata. The species with the greatest nominal catch in numbers was *Gobionotothen gibberifrons*, followed by *Trematomus newnesi*, and *Pleuragramma antarcticum*. The greatest yield in kilograms was *G. gibberifrons* followed by *Chionodraco rastrospinosus* and *Trematomus eulepidotus*. The 38 species of notothenioid demersal fish encountered during the course of the AMLR 2006 survey was by far the largest number for any AMLR bottom trawl survey. More than 300 tissue biopsies and preserved carcasses were collected for genetic studies.

The benthic invertebrate assemblages encountered along the majority of the northern Antarctic Peninsula's shelf are indicative of a stable environment that has largely escaped disturbance frequently experienced by much of Antarctica's shelf communities. Evidence for this is seen in terms of high biomass and high diversity, as well as in long- and well-established communities of slow growing sessile filter feeders such as hexactinellid sponges. Typically, as a result of disturbance, Antarctic benthic invertebrate assemblages exhibit a patchiness whereby one particular species dominates a localized area as seen in similar studies (Kim *et al*., 2003; Jones *et al*., 2004). The more exposed regions sampled during the present survey show evidence of such recent disturbance in the form of low biomass, low diversity, and a dominance of highly mobile invertebrates with their greater ability to colonize newly disturbed habitats. In contrast, fish population density appears to be lower in the more stable environments and highest in the more exposed regions. A more detailed analysis is required before this relationship can be confirmed or explained. A comparison of individual fish species population densities with different components of the invertebrate communities is currently underway.

For the third year consecutively, independent seabird and marine mammal observers joined the survey to collect 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. Seabird community composition was similar to the 2003-2005 AMLR field seasons (Santora and Mitra, 2003; Santora, 2004; Santora *et al*., 2005), and primarily comprised the following species: chinstrap penguin (*Pygoscelis antarctica*), black-browed albatross (*Thalassarche melanophrys*), southern giant petrel (*Macronected giganteus*), cape petrel (*Daption capense*), southern fulmar (*Fulmarus glacialoides*), white-chinned petrel (*Procellaria aequinoctialis*), black-bellied storm petrel (*Fregetta tropica*), Wilson's storm petrel (*Oceanites oceanicus*), and prions (*Pachyptila spp.)*. We have found that there are distinct differences in the abundance of local and non-locally breeding species in the survey area, which may be linked to availability of krill around Elephant Island.

Our ninth complete consecutive 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 penguin breeding population declined marginally from the previous season and is the third lowest population size in the 10 years of census data. The chinstrap penguin breeding population has been declining for the past seven years and is at its lowest size in the 10 years of study. Gentoo penguin fledging success was the highest recorded in all the years of study. The fledging success for chinstrap penguins was noticeably higher during the 2005/06 season than in the previous season and was slightly higher than the previous eight year mean. The gentoo penguin fledge weights for this season were the highest recorded in all the years of study. Chinstrap penguin fledge weights increased slightly from the 2004/05 season and were close to the previous eight year mean. Both gentoo and chinstrap penguin diets were comprised mainly of adult female Antarctic krill, the majority of which were 51-55mm in length. This is a continuation of a four year trend with increasing proportions of female krill and increasingly larger krill. Chinstrap penguin total chick meal mass was lower than almost all of the previous eight years of diet sampling; however, foraging trip durations were shorter than during the 2004/05 season. This may indicate that the provisioning rate of chicks by adults may have been higher, which would account for this difference. This interpretation may be aided by analysis of foraging location and diving behavior data to be done at a later date.

Fur seal pup production in 2005/06 at U.S. AMLR study beaches declined over last year. Early season neonate mortality (3.1%) was below the long-term average of 4.4%. We also recorded a mid-season decrease in leopard seal predation over last year. The median date of pupping, based on pup counts, was one day earlier than last year and our tag returns of adult females confirm a 2- day change in the parturition date. Over winter survival for adult females, however, declined for the second consecutive year (86.5 vs. 89.8%). The natality rate also declined (83.9 vs. 84.8%). However, mean foraging trip duration (2.79 days ±0.08) decreased over last year and was the second lowest recorded in nine years of data collection at Cape Shirreff. Visit duration (1.69 days ±0.05) showed a similar trend and like trip durations were reflective of favorable summer foraging conditions. We recorded poor over winter juvenile survival for 2005 similar to the trend in adult female survival. This was the first year on record that we did not observe any yearlings (i.e. tagged pups from the 2004/05 cohort. The 1999/00 and the 2001/02 cohorts even with decreased survival for 2005 continued to dominate tag returns as in previous years. Fur seal diet studies for second year in a row recorded a total absence of *Electrona carlsbergi*. In general, summer conditions were favorable resulting in better than average performance for summer indices; however, winter conditions in 2005 resulted in below average performance.

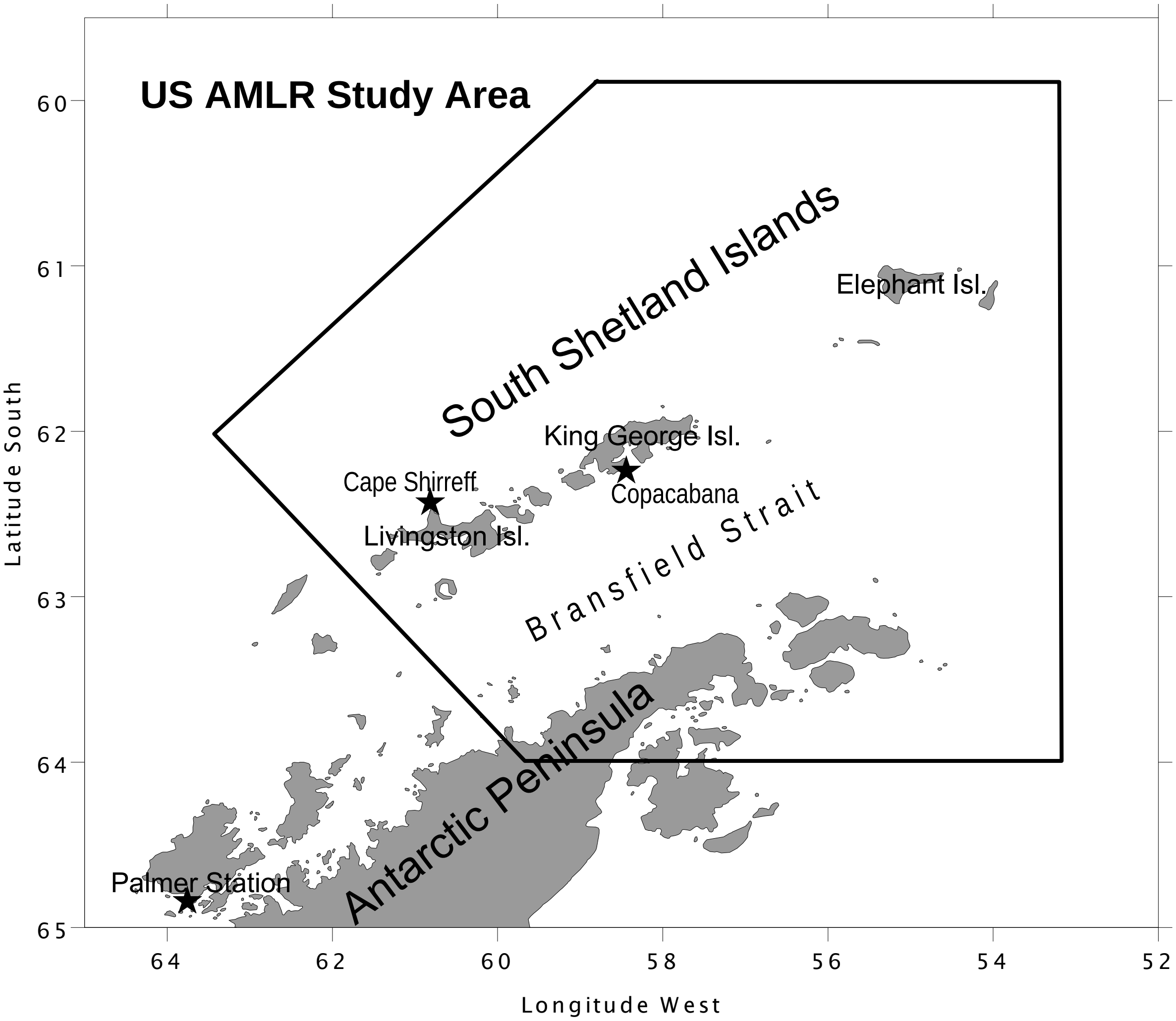


Figure 1. Locations of the U.S. AMLR field research program: AMLR study area, Cape Shirreff, Livingston Island and Copacabana, King George Island.

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 a specially equipped Zodiac for the inshore areas and the *Yuzhmorgeologiya* for the offshore areas.
6. Deploy five instrumented buoys 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 XBT buoys.
8. Conduct bottom trawls at selected sites in the area around the South Shetland Islands to provide baseline estimates of abundance, species size and composition and demographic structure of finfish species.
9. 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.
10. 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 (PTT's).
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 (TDR's) on chinstrap and gentoo penguins during chick rearing for diving studies.
9. Collect data on foraging locations (using PTT's) and foraging depths (using TDR's) of chinstrap penguins while concurrently collecting acoustically derived krill biomass and location data during the inshore survey.
10. Deploy PTT's 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 eleventh 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 Copa field camp	11-13 January 2006
	Calibrate in Admiralty Bay and transfer personnel	14 January
	Resupply & transfer personnel to CS, deploy buoys	15 January
	Large-area survey (Survey A)	16 January - 01 February
	Transfer personnel to CS, conduct nearshore survey	02-08 February
	Transfer personnel from Cape Shirreff	09 February
	Transfer personnel from Copa	10 February
	Transit to Punta Arenas	11-13 February
Leg II:	Depart Punta Arenas	16-18 February
	Transfer supplies and personnel to Cape Shirreff	19 February
	Bottom trawl survey, bottom typing and CTDs	22 February - 14 March
	Close Cape Shirreff	15 March
	Close Copacabana and calibrate in Admiralty Bay	16 March
	Transit to Punta Arenas	17-19 March

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 99 (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 40 stations were completed.

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

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

8. 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.

Leg II

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 supplies to the field camp.

2. A total of 65 hauls were conducted within the 500m isobath of the South Shetland Islands (See Figure 4). The trawl gear consisted of a two-warp/four panel bottom trawl and a third-wire linked net sonde.

3. Other scientific operations included continuous acoustic data collection, bottom type habitat characterization using underwater video and camera mounted grab sampler, 32

days of continuous underway measurements of meteorological and sea surface conditions, and CTD casts.

4. As on Leg I, continuous environmental data were collected throughout Leg II.

5. At the end of Leg II, the ship then transited to Cape Shirreff to embark personnel and close the field camp.

6. Following the completion of the close of Cape Shirreff, the acoustic transducers were calibrated in Ezcurra Inlet, Admiralty Bay, and King George Island. The Copacabana field camp was closed and field personnel were retrieved.

Land-based Research:

1. A five-person field team (M. Goebel, G. McDonald, S. Seganti, E. Leung and R. Orben) arrived at Cape Shirreff, Livingston Island, on 11 November 2005 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 (W. Trivelpiece and R. Haner), along with supplies and equipment, arrived at Cape Shirreff via the R/V *Yuzhmorgeologiya* 15 January 2006.

3. The annual censuses of active gentoo and chinstrap penguin nests were conducted on 17 & 25 November 2005, 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 in the first week of January 2006 and remained on until their chicks fledged in late February 2006. 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. Nine satellite-linked transmitters (PTTs) were deployed on adult chinstrap penguins and seven on adult gentoo penguins during the time each species was feeding chicks in mid-January. The PTT deployment coincided with the time when the annual AMLR 2005/06 marine survey was adjacent to Cape Shirreff during Leg I. A second deployment of seventeen PTTs was made in early February during a special nearshore survey conducted by zodiacs within 10km of Cape Shirreff. Finally we epoxied 7 PTTs to post-molt chinstrap penguins in early March to study their movements during the winter migration.

6. Diet studies of chinstrap and gentoo penguins during the chick-rearing phase were initiated on 5 January 2006 and continued through 11 February 2006. 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 26 January and 10 February 2006; respectively. Fledging weights of 178 chinstrap penguin chicks were collected between 17-21 February. Two hundred gentoo penguin chicks were also weighed on 03 February 2006.

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. The TDRs were retrieved, downloaded and await analysis.

11. Temperature tags were epoxied to the backs of 40 gentoo penguins following their molt. These tags will record data on the amount of time gentoo penguins spend in the water or ashore during the 2006 winter.

12. Antarctic fur seal pups and female fur seals were counted at four main breeding beaches every other day from 17 November 2005 through 10 January 2006.

13. Attendance behavior of 28 lactating female Antarctic fur seals was measured using radio transmitters. Females and their pups were captured, weighed, and measured from 2-21 December 2005.

14. 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 on 8 December 2005 and continued every two weeks until 21 February 2006.

15. Information on Antarctic fur seal diet was collected using three different methods: scat collection, enemas of captured animals, and fatty-acid signature analyses of milk.

16. Twenty-six Antarctic fur seals were instrumented with time-depth recorders (TDR’s) for diving behavior studies.

17. Fifteen Antarctic fur seal females were instrumented with ARGOS satellite-linked transmitters for studies of at-sea foraging locations from 21 December 2005 to 28 February 2006.

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

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

20. A single post-canine tooth was extracted from twelve 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.

21. One team member (S. Seganti) left Cape Shirreff on 23 December 2005 on the R/V *LM Gould* and one team member (M. Goebel) left Cape Shirreff via the R/V *Yuzhmorgeologiya* on 8 February 2006.

22. The Cape Shirreff field camp was closed for the season on 9 March 2006; all U.S. personnel (R. Holt, D. Krause, G. McDonald, R. Haner, E. Leung and R. Orben), garbage, and equipment were retrieved by the R/V *Yuzhmorgeologiya*.

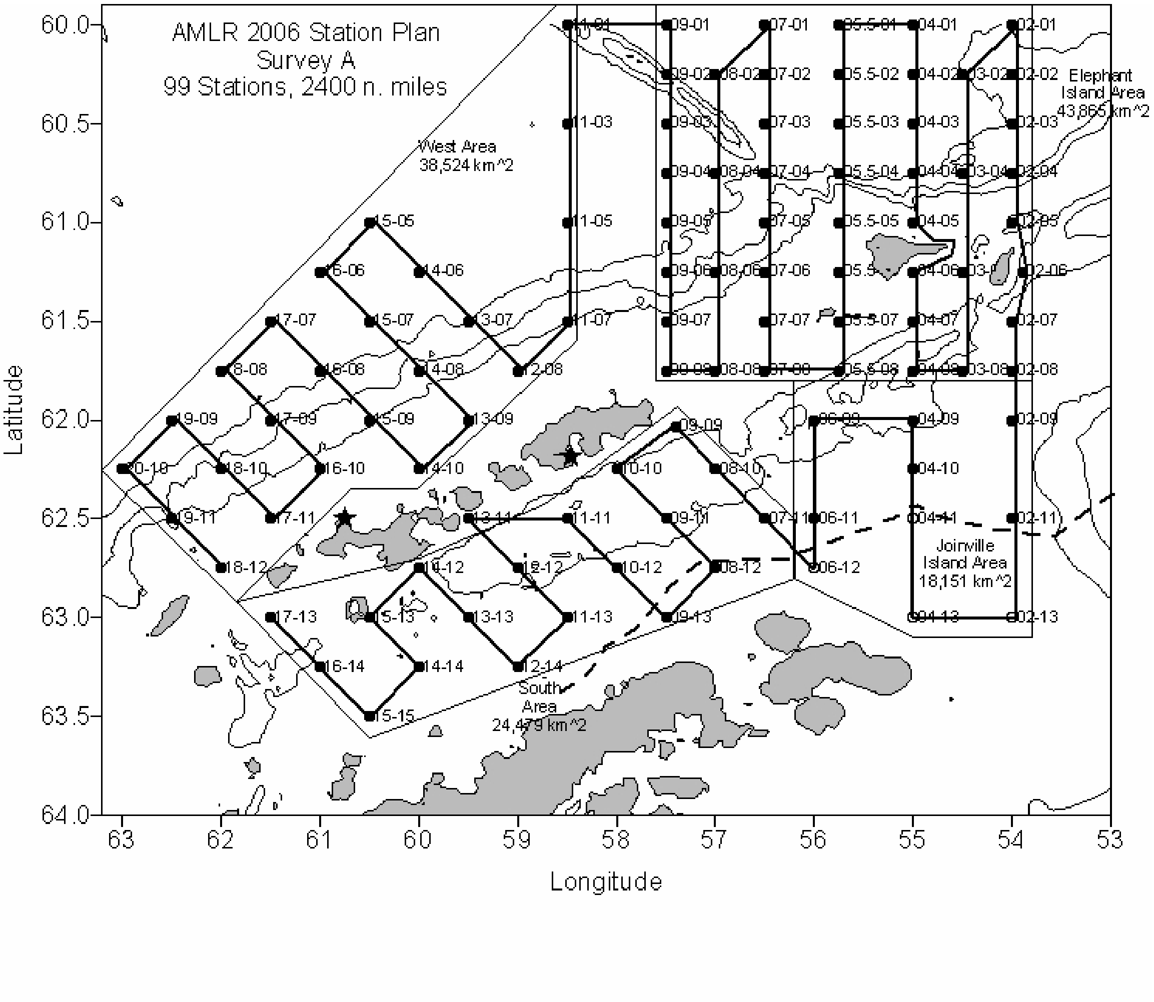


Figure 2. The planned survey for AMLR 2005/06 (Survey A & D) in the vicinity of the South Shetland Islands; field camp locations indicated by ★. The survey contained four strata: the stratum containing stations in the western portion of the survey area north of Livingston and King George Islands was 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 station locations performed; clear dots indicate stations planned but not performed; heavy lines indicate transects between stations; the dashed like indicates the ice edge and thin lines outline the stratum.

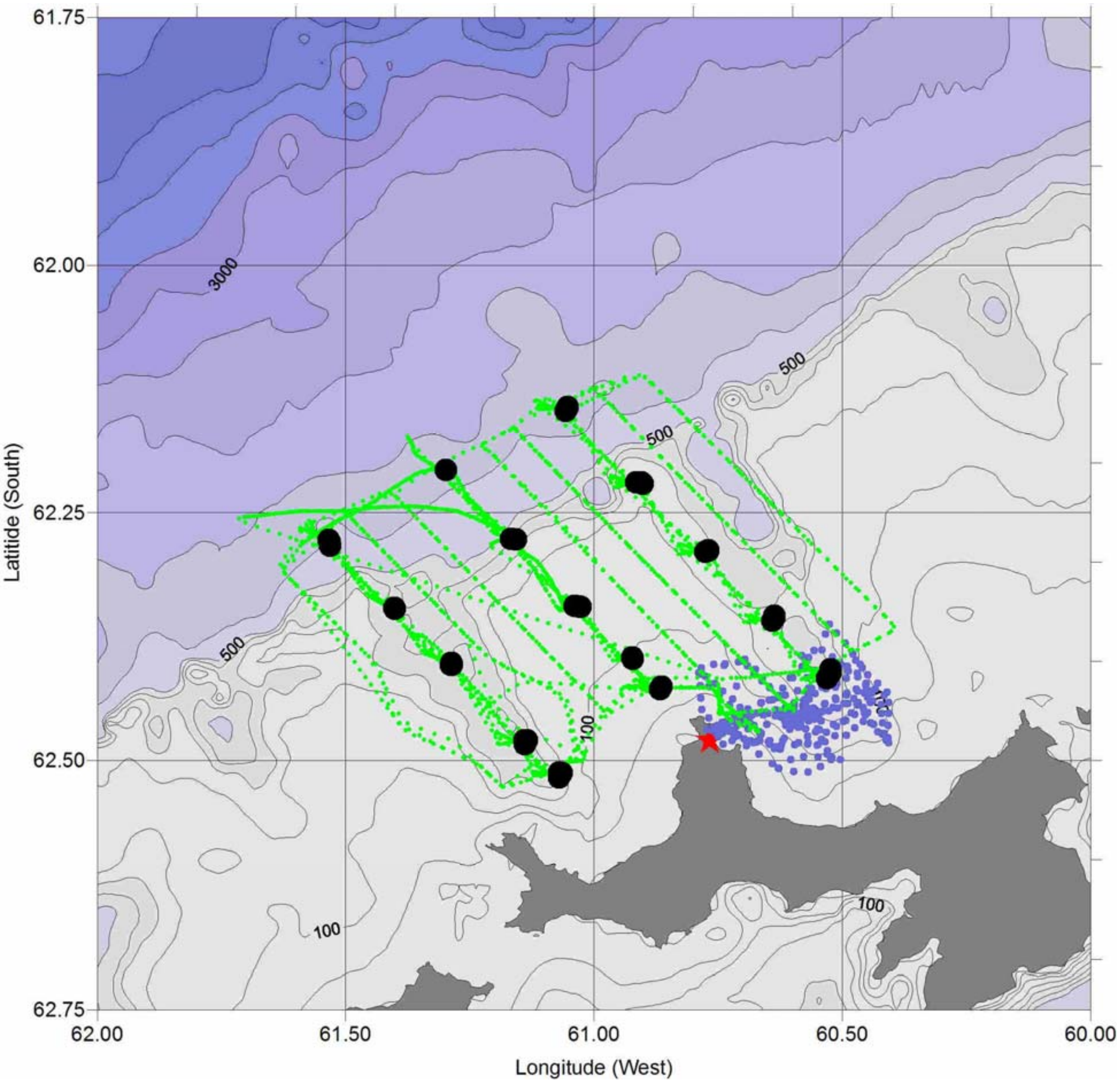


Figure 3. Cape Shirreff nearshore survey plan. Black dots indicate positions of CTD/net stations conduct by the R/V *Yuzhmorgeologiya*. The green dotted lines indicate the track lines of the R/V *Yuzhmorgeologiya* and the blue dotted lines indicate the track lines of the R/V *Ernest*.

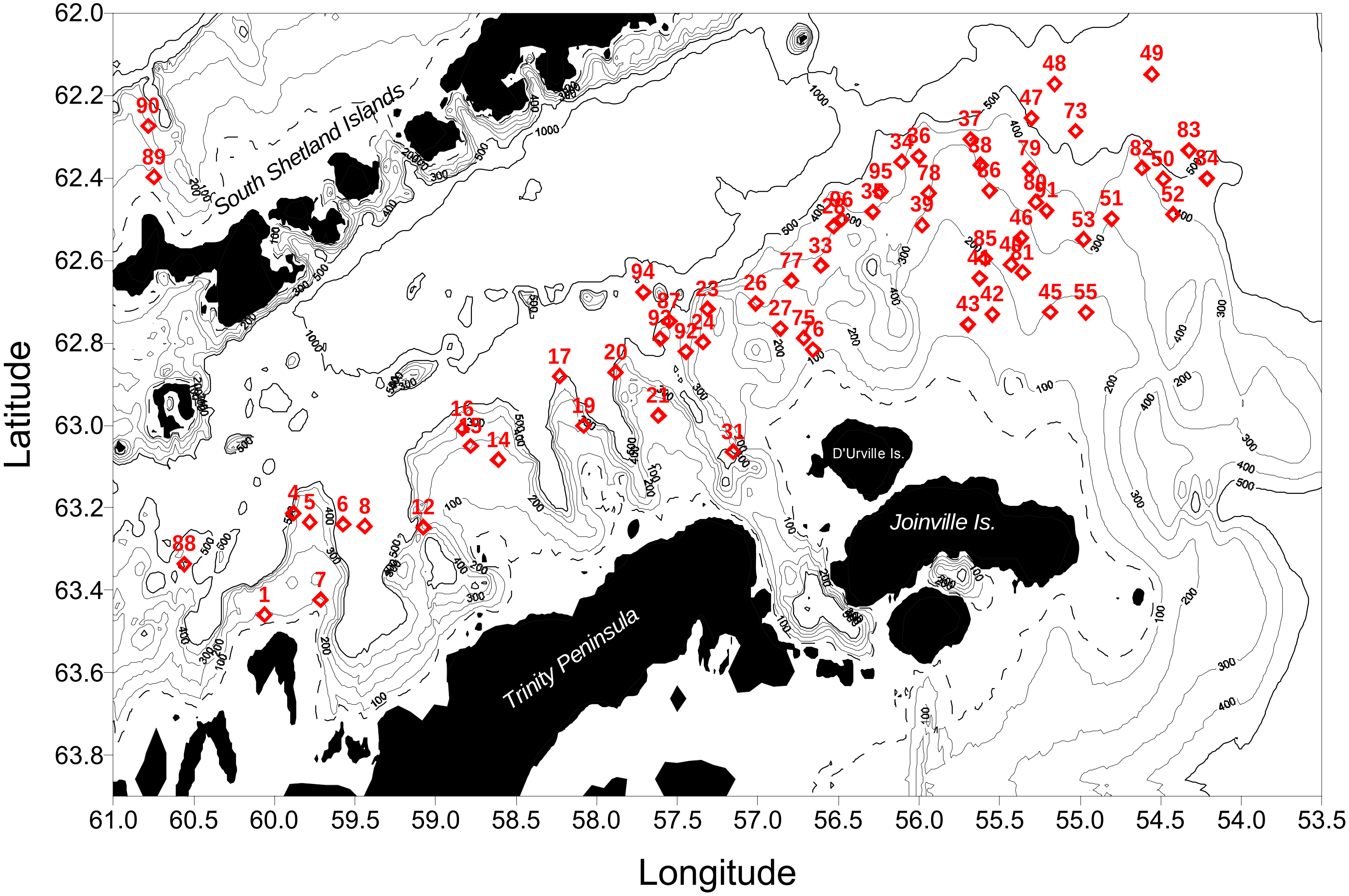


Figure 4. Station locations for the 2005/06 AMLR finfish bottom trawl survey.

SCIENTIFIC PERSONNEL

Cruise Leader:
- Adam Jenkins, Southwest Fisheries Science Center (Leg I)
- Christopher Jones, Southwest Fisheries Science Center (Leg II)

Physical Oceanography:
- Derek Needham, Sea Technology Services (Leg I)
- Marcel van den Berg, Sea Technology Services (Legs I & II)

Phytoplankton:
- Christopher D. Hewes, Scripps Institution of Oceanography (Leg I)
- Brian Seegers, Scripps Institution of Oceanography (Leg I)
- Nigel Delaney, Scripps Institution of Oceanography (Leg I)
- Paul Henderson, Woods Hole Oceanographic Institution (Leg I)
- Henrieta Dulaiova, Woods Hole Oceanographic Institution (Leg I)
- Murat Ozturk, University of Trondheim (Leg I)

Bioacoustic Survey:
- Anthony Cossio, Southwest Fisheries Science Center (Legs I & II)
- Christian Reiss, Southwest Fisheries Science Center (Leg I)

Krill and Zooplankton Sampling:
- Valerie Loeb, Moss Landing Marine Laboratories (Leg I)
- Cassandra Brooks, Moss Landing Marine Laboratories (Leg I)
- Olga Gorobets, Southwest Fisheries Science Center (Leg I)
- Lara Asato, Southwest Fisheries Science Center (Leg I)
- Adam Jenkins, Southwest Fisheries Science Center (Leg I)
- Kim Dietrich (Leg I)
- Darci Lombard (Leg I)
- Mitch Meredith (Leg I)
- Ryan Driscoll (Leg I)
- Joe Warren, Stony Brook University (Leg I)

Fur Seal Energetics Studies:
- Jessica D. Lipsky, Southwest Fisheries Science Center (Leg I)
- Jennifer Van Dommelen, Dalhousie University (Leg II)

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

Nearshore Survey:
- Joe Warren, Stony Brook University (Leg I)
- Steve Sessions, Southwest Fisheries Science Center (Leg I)

Multibeam Survey:

Adam Jenkins, Southwest Fisheries Science Center (Leg I)
Martin Cox, University of St. Andrews (Leg I)

Cape Shirreff Personnel:

Michael E. Goebel, Camp Leader, Southwest Fisheries Science Center (11/11/05 to 2/8/06)
Scott Seganti, University of California at Santa Cruz (11/11/05 to 12/23/05)
Gitte McDonald, University of California at Santa Cruz (11/11/05 to 3/9/06)
Elaine Leung (11/11/05 to 3/9/06)
Rachael Orben (11/11/05 to 3/9/06)
Rennit Holt, Southwest Fisheries Science Center (2/19/06 to 3/9/06)
Russell Haner, Southwest Fisheries Science Center (2/19/06 to 3/9/06)
Douglas Krause, Southwest Fisheries Science Center (2/19/06 to 3/9/06)

DETAILED REPORTS

1. Physical Oceanography and Underway Environmental Observations; submitted by Derek Needham (Leg I), Marcel van den Berg (Legs I & II).

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 187 CTD/carousel stations were completed, 99 of these as part of Leg I (Survey A). (See Figure 2 in the Introduction for station locations). No casts were cancelled due to bad weather, but 8 stations were cancelled due to icebergs in the eastern and southern areas of the survey grid. An extra station (A04-10) was inserted during the survey, after the southern stations of the Joinville Island Area were abandoned due to concentrated ice. An additional 16 CTD casts to 300m (one deep cast to 2500m) were done in support of the plankton "Super Stations". Another three extra surface casts were completed to collect seawater for Scripps Institution of Oceanography. After the completion of the planned Leg I survey grid, 25 stations were completed near Cape Shirreff to accompany the data collected during the Nearshore Acoustic Survey (see Nearshore Survey, Chapter 7, of this report). Three additional casts were completed during acoustic calibrations in Admiralty Bay and Zodiac inter-calibrations at Cape Shirreff, at the beginning and end of the survey. During Leg II (Bottom Trawl Survey), 41 stations were completed to obtain daily water column profiles at selected trawling stations (see Fish Trawl Chapter 5 of this report for CTD station locations).

During Leg I only, water samples were collected at 11 discrete depths on all casts and used for salinity 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 -0.0054 %. The final CTD/Portasal correlation produced an r^2=0.9982 (n= 481) during Leg I of the survey.

Underway comparison of the Seabird thermosalinograph (TSG) with CTD data were undertaken during Leg I of the survey. Salinity data compared with 7m CTD salinity data showed that the TSG salinity reading were on average 0.014 ppt (n=114) lower then the CTD, whilst the sea temperature showed the TSG to be on average 0.591°C (n=102) 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. Comparisons of dissolved oxygen levels in the carousel water samples and the levels measured during the casts (via the O_2 sensor) were not attempted during the survey.

1.2.2 Underway Environmental Observations: Environmental and vessel positional data was collected for a total of 67 days (35 days and 32 days during Legs I and II respectively) via the Scientific Computer System (SCS) software package. The SCS software (SCS Version 3.3a) was running 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 new 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 data provided covered surface environmental conditions encountered over the entire AMLR survey area for the duration of the cruise including transits to and from Punta Arenas. An additional Biospherical 4pi PAR sensor, installed mid-ships on the port side of the vessel, was integrated into the SCS system via a Fluke Hydra Data Bucket for the duration of the surveys.

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. All bottles were fitted with new Teflon coated springs. A new Seabird SBE 43 dissolved oxygen probe, SBE pump, Chelsea Instruments Aquatracka III fluorometer and a Wetlabs C-Star blue transmissometer were added to the CTD system. The old Wetlabs fluorometer and red transmissometer, used on previous cruises, were also fitted, cabled and interfaced to the CTD system, to cross-calibrate them with the new sensors. The Biospherical 2pi PAR sensor, used on previous cruises, was retained on the system to provided additional water column data. Scan rates were set at 24 scans/second during both down and up casts. Sample bottles were only triggered during up casts. Profiles were limited to a depth of 750m or 5m above the sea bottom when shallower than 750m. A Data Sonics altimeter was used to stop the CTD decent 5 to 7m from the seabed, on the shallow casts. Standard sampling depths were 750m, 200m, 100m, 75m, 50m, 40m, 30m, 20m, 15m, 10m and 5m. One 2500m cast was undertaken to collect water samples for the Radium work onboard.

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 reformatted 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 new Biospherical 4PI QSR-2100 PAR sensor with a RS232 output was installed on the forward gantry, near the Weatherpak, cabled to the Computer Room and interfaced to the Scientific Computer System (SCS) logging computer. 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. An additional Biospherical 4pi PAR sensor, installed mid-ships on the port side of the vessel, was integrated into the SCS system via a Fluke Hydra Data Bucket for the duration of Leg I.

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 all four 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 of Leg I, a wide front was defined between 57° 58’ S and 59° 00’S. On the northward transect the front had become more clearly defined between 57° 50’ S and 58° 00’ S. On the south-bound transit of Leg II the front had moved further south when compared to the north bound transect of Leg I, and was less clearly defined, laying between 58° 10’ S and 59° 00’ S. On the return transit, at the end of Leg II, the zone had once again become more clearly defined and was located between 57° 30’ S and 58° 10’ S (Figure 1.1).

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 field classification”.

During Leg I, 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 (See Figure 1.2). The northeastern sector of the Elephant Island Area displayed mainly Zone II and III (Transition) waters, with two stations (A02-02 and A02-03) showing clear characteristics of Zone I (ACC) waters. Outer shelf stations in this area displayed a mixing of Zone II and III (Transition) waters. Zone IV (Bransfield Strait) waters were evident at many of the inshore stations 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) water was present along the Joinville Island Area and in the extreme southeastern Bransfield Strait.

During Leg II, the bottom trawl survey, the stations were mainly around the southern Bransfield Straits (South Area) and northern Joinville Island Areas. The stations occupied in the southwestern Bransfield Straits showed classical Zone IV (Bransfield Straits) waters, whereas the waters around the eastern Bransfield Straits and the northern Joinville Island areas showed characteristics of Zone V (Weddell Sea) waters (See Figure 1.2). Although no distinct Zone V water was observed, all stations occupied in the area showed lower surface temperatures (< 0°C) and higher salinity values.

Three vertical temperature transects were chosen for plotting using ODV software from Leg I – the same transects that were plotted for the 2001/02, 2002/03, 2003/04 and 2004/05 reports were chosen for comparisons (Figure 1.3). 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 the Dynamic Heights at the surface relative to 300m and 500m depths (Figure 1.4).

1.4.2 Underway Data: Environmental data were recorded for the duration of both Legs I and II and for the transits between Punta Arenas and the survey area. Processed data were averaged and filtered over 1-minute and 5-minute intervals. (Figures 1.5 and 1.6 for Legs I and II respectively).

Comparisons between the weather conditions experienced during Legs I & II show significant differences, primarily between wind speed and direction (Figure 1.7). During Leg I, wind direction was predominately west to northwest, with wind speeds averaging around 20 knots. This wind regime shifted from westerly to predominantly easterly winds towards the latter part of Leg II, with wind speeds averaging around 30 knots.

Weather during Leg II, compared with Leg I, was more often partly cloudy or overcast. A number of days of poor visibility and fog were experienced and snowfalls were recorded during Leg II, as can be seen when comparing the results from the PAR sensor, which indicate reduced levels of photosynthetic radiation, between Leg I and Leg II.

1.5 Problems and Suggestions The CTD system performed well on all 187 casts, with virtually no time being lost due to malfunctions. The usual attention to the underwater connectors had to be given. Two stations had to be restarted when the Seasave software froze on the downcasts and the CTD/SCS PC had to be rebooted on occasions when it became slow and unresponsive.

The CTD system, with its auxiliary sensor configuration for 2007 should be planned well in advance, so that the correct cables, blanking plugs, jointing kits and spares can be procured to make the 2007 port setup efficient.

A comparison of the dissolved oxygen levels in the carousel water samples and the levels measured during the casts (via the O_2 sensor) was not attempted, but there have been requests to start doing oxygen titrations on AMLR 2007, especially with the sensors being upgraded to Seabird SBE43 types.

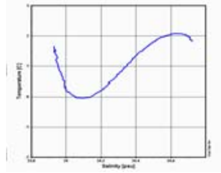
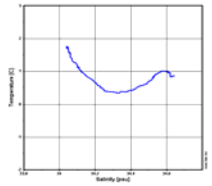
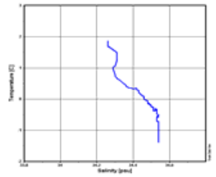
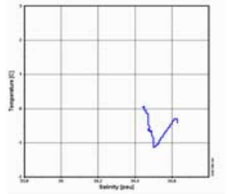
The TSG pump and debubbler system had to be periodically stopped and cleaned due to clogging by krill, seaweed and other biologicals.

1.6 Disposition of Data: Data are available from the Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA, 92037; phone/fax: +1 (858) 546-5604/(858) 546-5608; email: Stephanie.Sexton@noaa.gov.

1.7 Acknowledgements: The co-operation and assistance of the Russian technical support staff was once again outstanding. All requests for assistance were dealt with efficiently and in a thoroughly 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 Legs I and II, AMLR 2005/06.

	T/S Relationship			
	Left	**Middle**	**Right**	**Typical TS Curve (from 2002)**
Water Zone I (ACW)	**Pronounced V shape with V at ≤0°C**			
Warm, low salinity water, with a strong subsurface temperature minimum, Winter Water, approx. -1°C, 34.0ppt salinity) and a temperature maximum at the core of the CDW near 500m.	2 to >3°C at 33.7 to 34.1ppt	≤0°C at 33.3 to 34.0 ppt	1 to 2°C at 34.4 to 34.7ppt (generally >34.6ppt)	
Water Zone II (Transition)	Broader U-shape			
Water with a temperature minimum near 0°C, isopycnal mixing below the temperature minimum and CDW evident at some locations.	1.5 to >2°C at 33.7 to 34.2ppt	-0.5 to 1°C at 34.0 to 34.5ppt (generally >0°C)	0.8 to 2°C 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 >0°C	1 to >2°C at 33.7 to 34.0ppt	-0.5 to 0.5°C at 34.3 to 34.4ppt (note narrow salinity range)	≤ 1°C at 34.7ppt	
Water Zone IV (Bransfield Strait)	Elongated S-shape			
Water with deep temperature near -1°C, salinity 34.5ppt, cooler surface temperatures.	1.5 to >2°C at 33.7 to 34.2ppt	-0.5 to 0.5 °C at 34.3 to 34.45ppt (T/S curve may terminate here)	<0°C 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 < 0°C.	1°C (+/- some) at 34.1 to 34.4ppt	-0.5 to 0.5°C at 34.5ppt	<0°C at 34.6ppt	

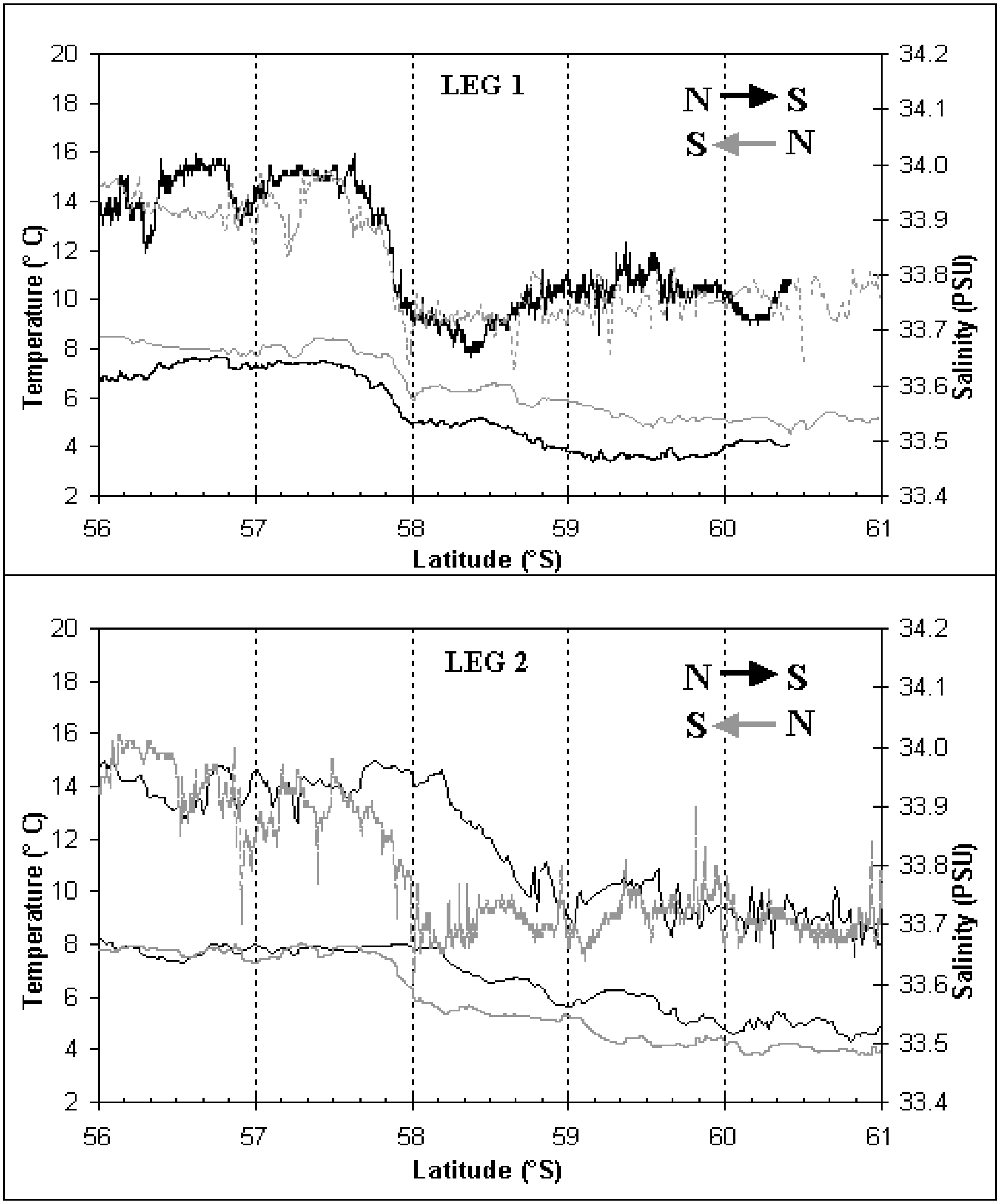


Figure 1.1 The position of the polar fronts as determined for AMLR 2005/06 Legs I (top) & II (bottom), from measurements of sea surface temperature (solid line) and salinity (broken line) for the south and north transits to and from the South Shetland Islands survey area.

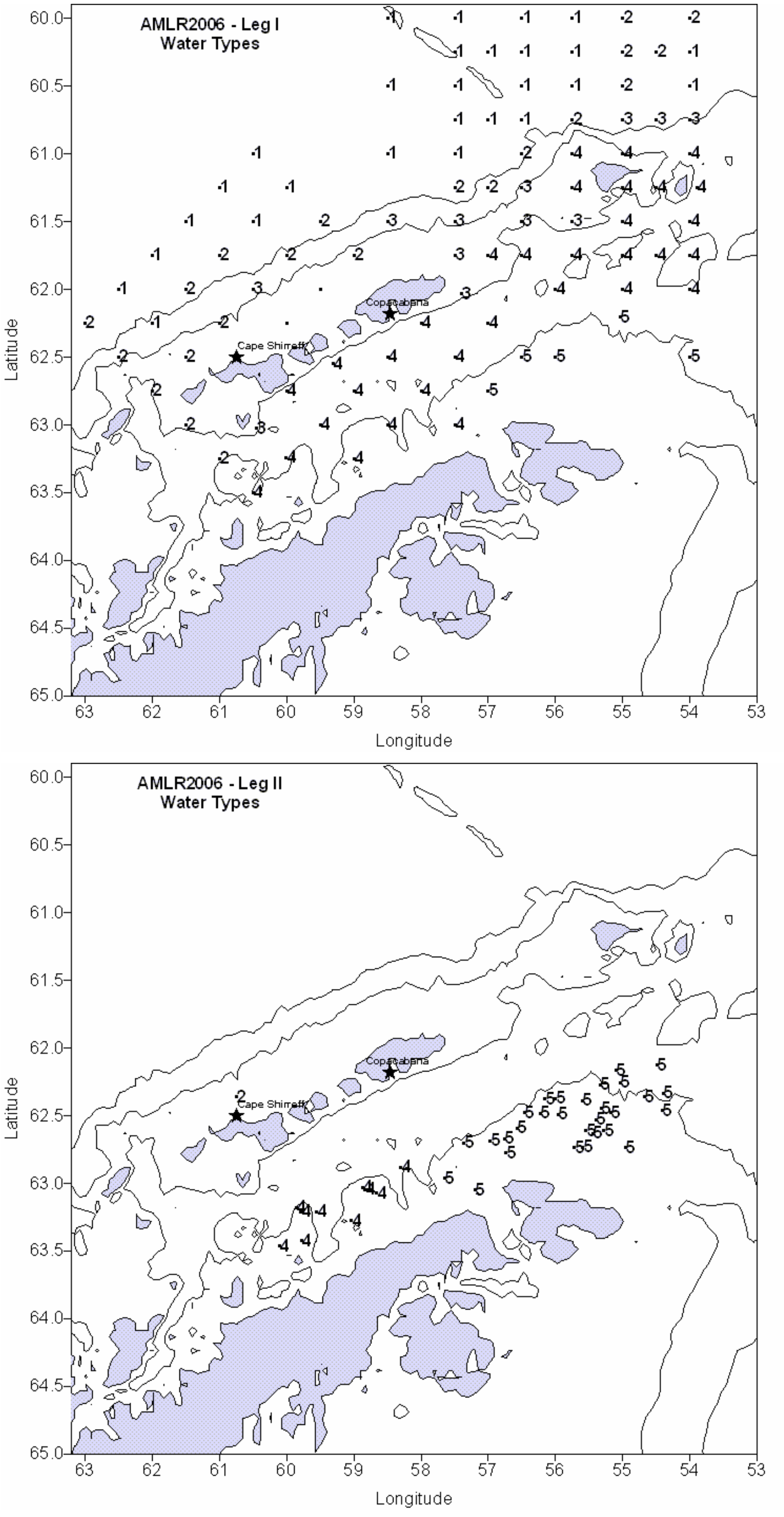


Figure 1.2 Classification of water zones for Leg I & II (top and bottom panels respectively) for AMLR 2005/06, as defined in Table 1.1 (Water Zone definitions).

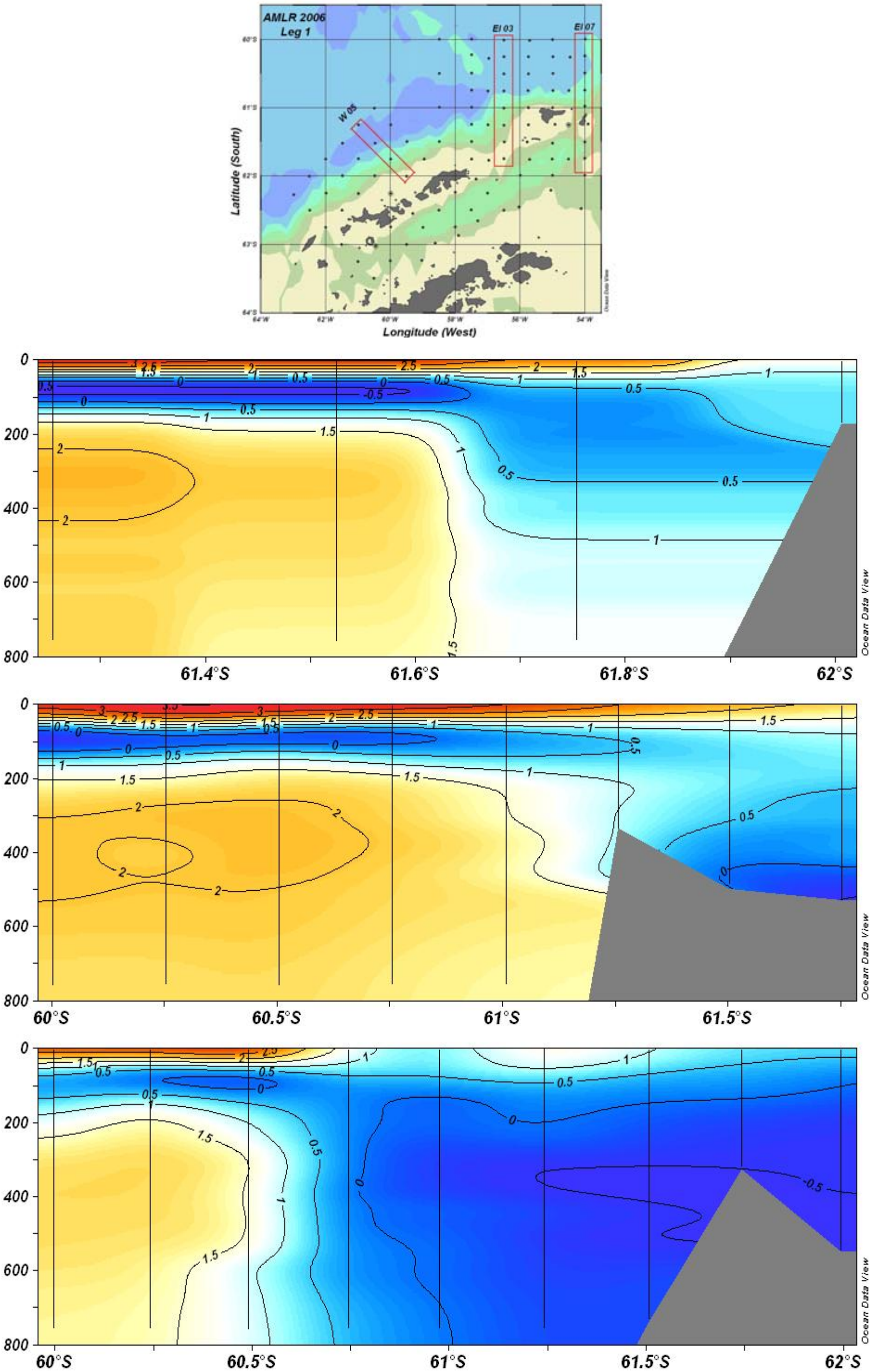


Figure 1.3 Vertical temperature profiles derived from CTD data recorded on three transects, W05 (top), EI03 (middle) & EI07 (bottom), during Leg I of the AMLR 2005/06 S. Shetland Island survey.

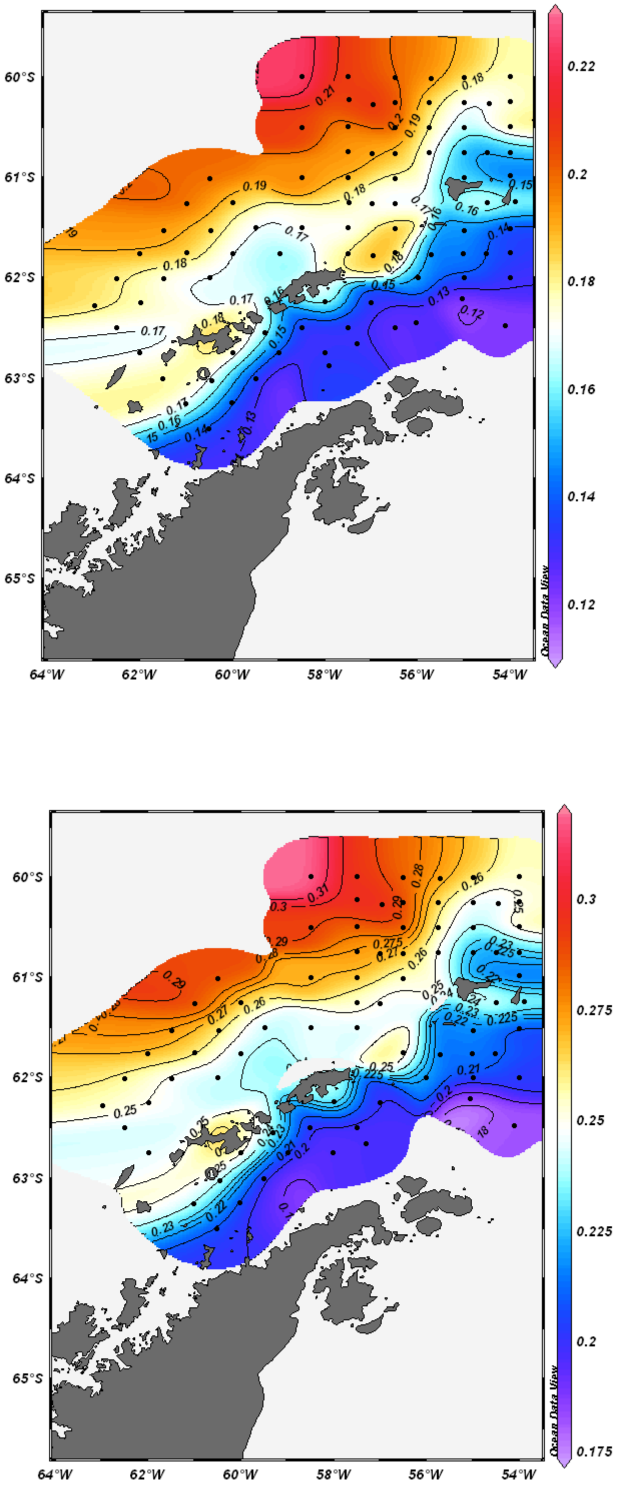


Figure 1.4 Dynamic heights for Leg I for AMLR 2005/06 ranging between 300 and 500m, as determined by ODV.

AMLR 2005/06 – Leg I

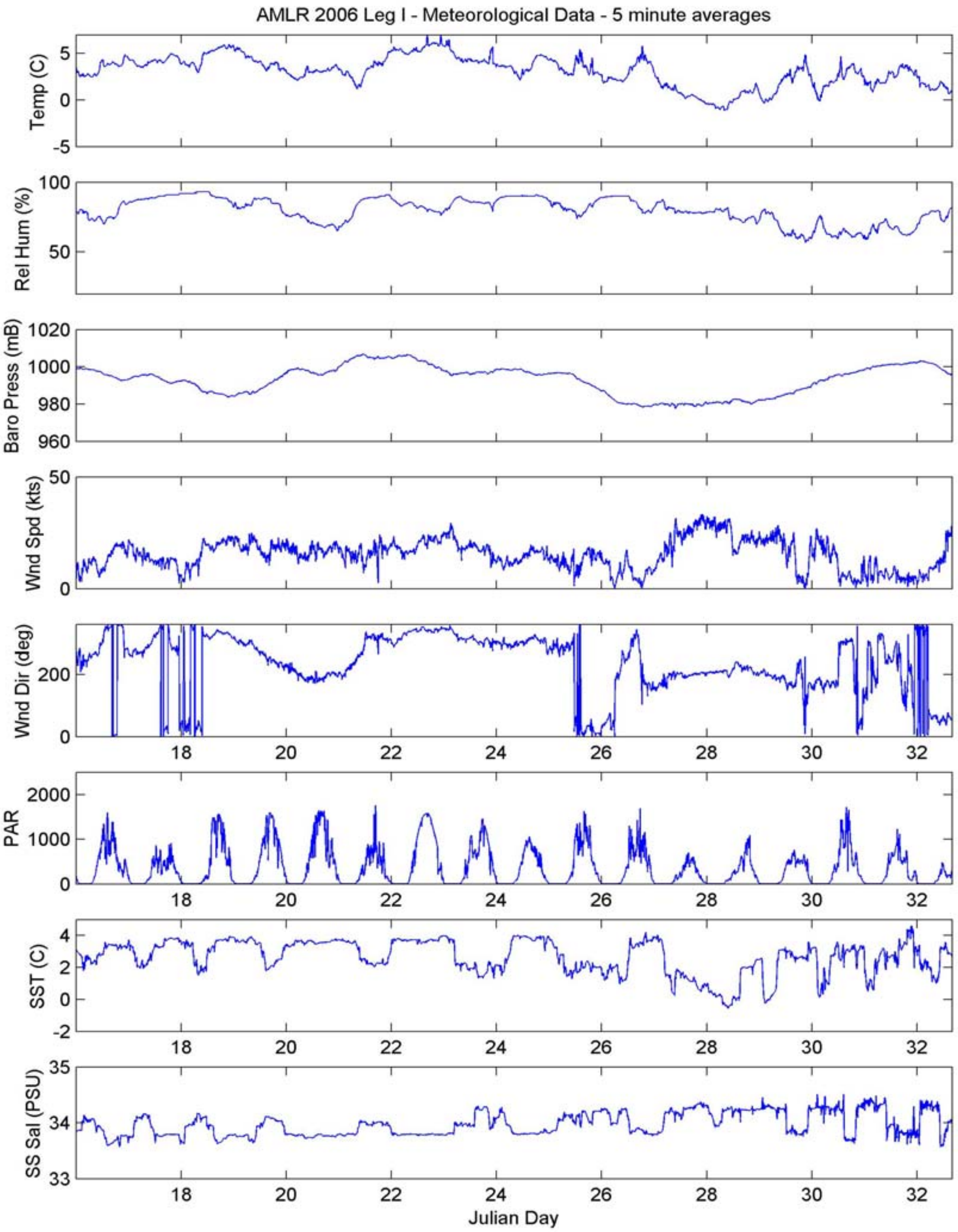


Figure 1.5 Meteorological and oceanographic data (5 minute averages) recorded between January 16th and January 31st during Leg I (survey only) of the AMLR 2005/06 cruise. (PAR is photo-synthetically available radiation).

AMLR 2005/06 – Leg II

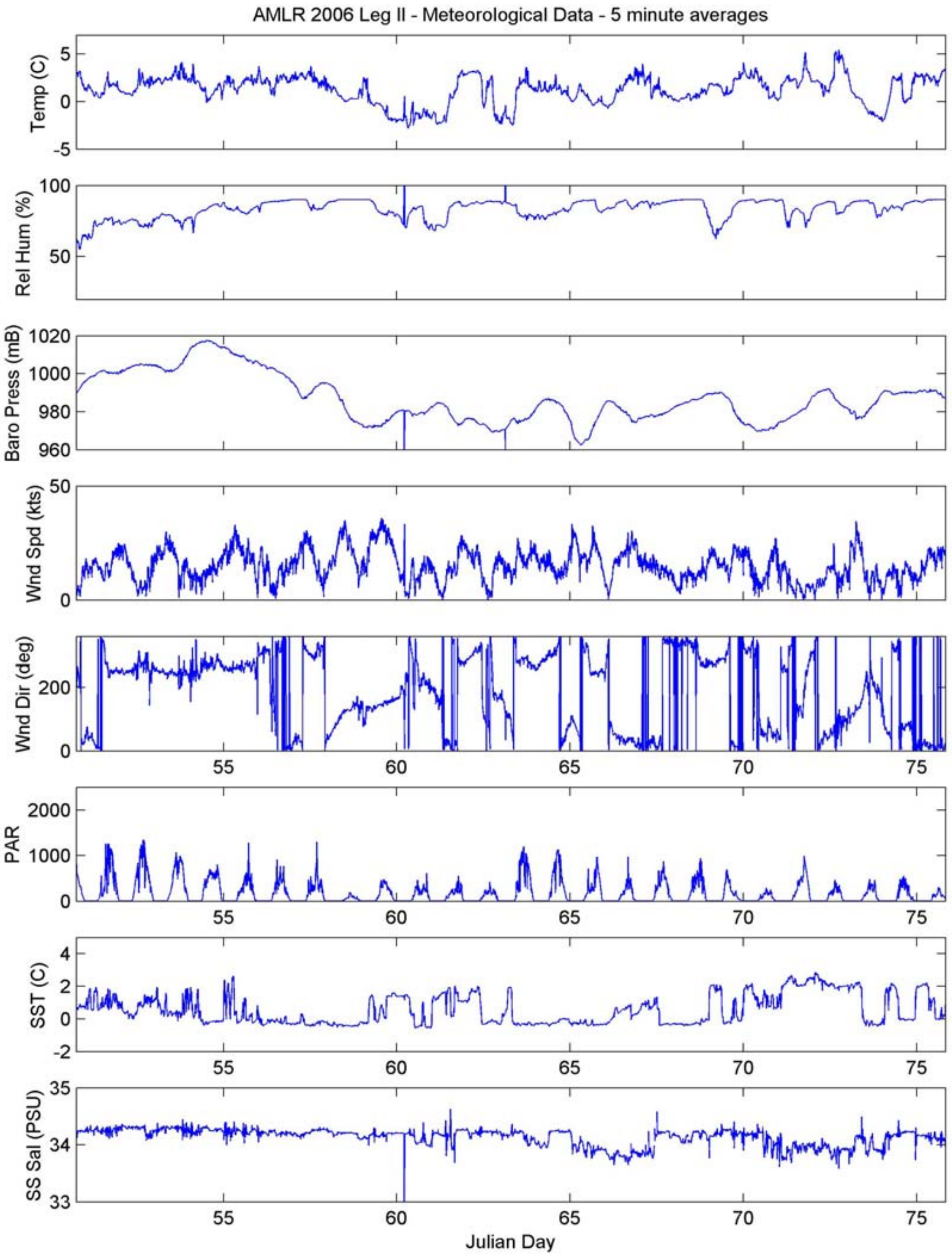


Figure 1.6. Meteorological and oceanographic data (5 minute averages) recorded between February 19th and March 16th during Leg II (survey only) of the AMLR 2005/06 cruise. (PAR is photo-synthetically available radiation).

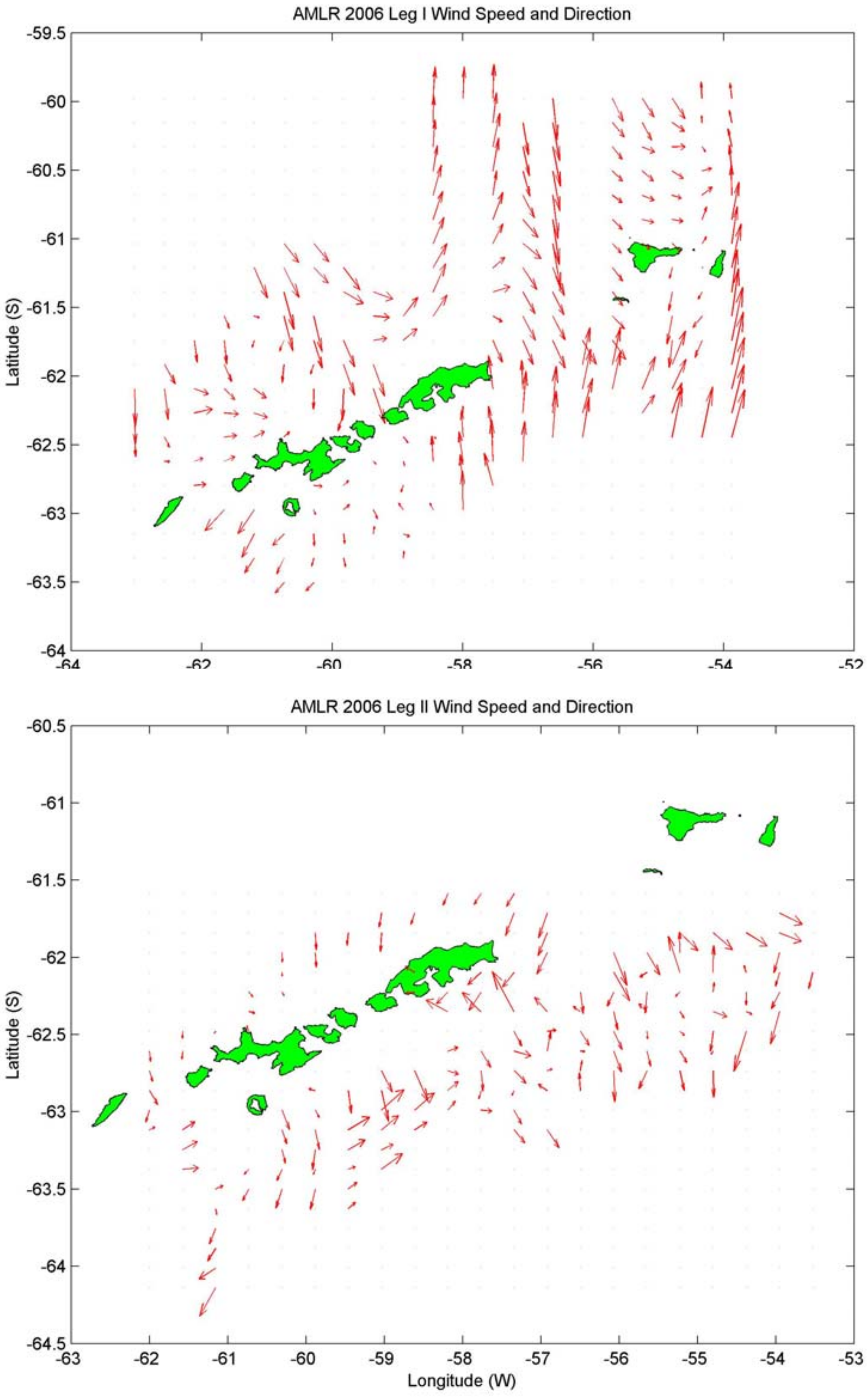


Figure 1.7 Vectors representing wind speed and direction for Legs I (top) & II (bottom) derived from data recorded by the SCS logging system during AMLR 2005/06 survey of the South Shetland Islands.

2. Phytoplankton Studies; submitted by Christopher D. Hewes (Leg I), Nigel Delany (Leg I) Brian Seegers (Leg I), B. Greg Mitchell, Mati Kahru, and Osmund Holm-Hansen (SIO), Murat Özturk (Leg I) (Biological Station, Univerisity of Trondheim, Norway), Henrieta Dulaiova (Leg I), Paul Henderson (Leg I), Matt Charette (WHOI), José Luis Iriarte (Universidad Austral de Chile, Puerto Montt, Chile), and Nelson Silva (Escuela de Ciencias del Mar, Universidad Católica de Valparaiso, Valparaiso, Chile).

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 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 better our understanding of the reasons for the variability in distribution of phytoplankton in relation to dynamic physical processes, nutrient concentrations, and solar irradiance in the upper 100 m 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 10m of the bottom at the shallow stations. The bottles were closed on the up-cast to obtain water samples for various analyses. At the time of bottle closure, about a one 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 (entire survey) and a Sea Tek profiling fluorometer (first half of survey) 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) A cosine PAR (Photosynthetic Available Radiation; 400-700nm) sensor (Biospherical Instruments QCP-200L) 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 10m above the bottom) target depths, and used for the analyses described below.

The phytoplankton component of AMLR this year included personnel from three additional groups (from SIO, WHOI, and the Biological Station in Norway) who were invited to participate in the cruise as they have special analytical expertise which is useful for understanding the production and fate of organic carbon within the AMLR sampling grid. Sampling for these additional studies was conducted at a "super station", once per day at selected locations within the survey area. These studies involved a more detailed analysis of chemical, biological, and optical characteristics of the water column and particulate material and are detailed in Section 2.2.2.1.

2.2.2 Measurements and Data Acquired: The types of measurements and the data acquired during and in conjunction with the 2006 survey were:

(A) Chlorophyll-*a* concentrations: Chl-*a* concentrations in 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 1/3rd atmosphere). 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 #700) that had been calibrated using purified chl-*a* concentrations (Sigma C-6144). Stability of the fluorometer was verified daily by use of a fluorescence standard (Turner Designs #7000-994).

(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 (Villafane *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 26 stations, seawater samples (100 mL) were obtained from the surface and 3-4 additional depths and preserved with 0.5% 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) was used to measure incident light continuously over a 24-hour period. This new sensor replaced our old BSI sensor which had been used for >10 years.

(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).

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 (Helbling *et al*., 1995; data from the Mitchell group as mentioned in section 2.2.2.1).

(G) Inorganic macronutrient concentrations: Twenty six stations were chosen for macronutrient sampling at 10, 30, 50, 75m, and, when possible, 100, and 200m target depths. Water samples were pored into acid washed 4 oz. polypropylene bottles and immediately frozen. These frozen seawater samples were delivered to and analyzed by auto-analyzer for nitrate, phosphate, and silicate concentrations (Atlas, 1971) by N. Silva (Universidad Católica de Valparaiso Valparaiso, Chile).

(H) Satellite tracked drifters: Eighteen langrangian drifter buoys were released during the last week of January (Table 2.1) to examine surface currents at various locations within the AMLR survey area. Based on results from releases during previous years, three general areas of interest were examined,: (a) seven drifters were released close to Elephant Island along the northeast and southeast coasts, (b) four drifters were released in the Bransfield Strait south and west of Elephant Island, and (c) seven drifters were released to the southeast of King George Island. The locations of these buoys, drogue depth of approximately 15m, were transmitted daily via orbiting polar satellites.

2.2.2.1 Super Station Sampling: Once per day, a “super station” was conducted which included the following specialized sampling methods and measurements, which were in addition to those analyses mentioned in section 2.2.2.

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 Go-Flo bottles (usually 3) were closed at desired depths of < 100m with Teflon-coated brass messengers. The GO-FLO bottles were taken to a plastic covered clean lab, where seawater samples were transferred from the GO-FLO 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).

^{34}Th disequilibria (WHOI): Samples for water column total ^{234}Th (particulate + dissolved) were collected and analyzed according to procedures modified from Buesseler *et al.* (2001). *In situ* pumps were used to collect particulate ^{234}Th in five size-classes (0.7-µm, 5-µm, 20-µm, 53-µm, and 210-µm) in the mixed layer and at 100m.

Radium isotopes (WHOI): Water samples for radium isotopes were collected from the ship’s seawater intake system, filtered, and pumped directly into polyethylene barrels. This water was then filtered through MnO$_2$-impregnated fibers for extraction of radium isotopes. ^{223}Ra and ^{224}Ra activities, which were quantified using a portable delayed coincidence counter (Moore and Arnold, 1996) using the techniques described in Charette *et al.* (2001).

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).

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}. 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).

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).

Particulate Organic Carbon and Nitrogen (POC/PON; SIO): Water samples were filtered through pre-combusted glass fiber filters (Whatman GF/F, 25mm), 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 (<1.0 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 (see Figure 2.1). The highest chl-*a* concentrations (> 3.0 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 to 3.0 mg m^{-3}) were generally located close to the continental shelf break.

2.3.2 Mean Chlorophyll-*a* Concentrations in the Four AMLR Areas: As mentioned in the "Description of Operations", the AMLR survey area is divided into four separate regions. The mean chl-*a* concentrations (at 5.0m depth and when integrated to 100m) in these four areas, together with the long-term mean from previous AMLR seasons (15 years), are summarized in Table 2.2. 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 2006 were greater than the comparable historical means by factors of 2.9, 3.5, 2.2, and 1.7, respectively. The integrated values of chl-*a* for these three areas were also greater by 1.5 times.

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 (WZs) 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 2006 and the mean profiles from the 15-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 2006 were much higher than the historical means, except for WZ-V. (ii) The most significant changes in chl-*a* profiles in 2006 were found in WZ-I waters (Water Zone), where chl-*a* concentrations were high in the upper water column and did not show the typical deep chl-*a* maximum (DCM) layer. (iii) Surface water temperatures in 2006 were considerably warmer than the historical means except for WZ-V, where the water column was colder than usual. (iv) Water densities in the upper water column in WZs I, II, and III in 2006 were lower than the historical means, whereas in WZ-IV water density was higher than usual. (v) The remnant of winter water mixing (defined by the low salinity-temperature minimum) in WZ-I was colder and with lower salinity than found on average.

2.3.3.2 Profiles of chl-*a*, *in situ* chl-*a* fluorescence, beam attenuation, and solar irradiance: Representative data from four stations are shown in Figure 2.3 and illustrate the following observations. (i) The profiles of chl-*a* fluorescence and beam attenuation tend to be mirror images, except when high incident solar radiation causes an inhibition of chl-*a* fluorescence (compare Figures A and B). (ii) The profile of solar irradiance reflects the profile of chl-*a* concentrations, as seen by the change of slope in Figure 2.3C. (iii) The profile of chl-*a* with depth at stations in Water Zone 1A show the presence of a DCM, in contrast to the profile at stations in Water Zone 1B, which have higher concentrations of chl-*a* in the upper water column but no DCM (compare Figures C and A). (iv) The profiles for chl-*a* fluorescence and beam attenuation tend to be fairly smooth at most stations, but when the phytoplankton are large or aggregated in chains or clumps, the profiles for chl-*a* fluorescence and beam attenuation tend to be very jagged (see Figure 2.3D). Floristic analysis of the phytoplankton assemblage at station #1707 showed that chain-forming large pinnate diatoms accounted for most of the biomass. At a nearby station (#2010) where the fluorometer trace was smooth, there were relatively few diatoms and the phytoplankton consisted mainly of small unicells (< 10.0 um in diameter).

2.3.3.3 Inorganic nutrient concentrations: The range in concentrations of nitrate, phosphate, and silicic acid at 5m depth at the 26 sampled stations was 14 to 30 uM, 1.1 to 2.1 uM, and 31 to 74 uM, respectively. As these minimal concentrations of N, P, and Si greatly exceed the concentrations at which these nutrients start to limit phytoplankton growth rates, phytoplankton biomass in the AMLR study are should not be limited by any macro-nutrient deficiency. Station #1707 had the lowest nitrate and phosphate concentrations of all the 26 sampled stations as well as very low Si concentrations (41 uM in the UML). Although phytoplankton biomass is not limited by low concentrations of N, P, or Si in the AMLR sampling grid, concentrations of these nutrients are useful as indicators of degree of mixing of different water masses. This is illustrated by the profiles of Si concentrations in the different water zones (Figure 2.4).

2.3.4 Langrangean Drifter Buoys: The seven drifters were released close to Elephant Island along the northeast and southeast coasts (Figure 2.5A) showed a general east-northeast current flow, with some counter-clockwise flow directly around Elephant Island. Of the four drifters released in Bransfield Strait south and west of Elephant Island (Figure 2.5B), one was lost, two drifted between Elephant and Clarence Islands (with one circling Elephant Island), and the fourth circled within small eddies within Bransfield Strait. Of the seven drifters released south of the southeastern shores of King George Island (Figure 2.5C), one was lost, four drifted in the counter current flow (to the southwest) along the northern shelf of the South Shetland Islands, and two drifted to the northeast within Bransfield Strait.

2.3.5 Natural Isotopes:

2.3.5.1. Radium: The large-scale input of shelf-derived radium isotopes and their short half-lives can be used to estimate the rate of dispersion based on their decay as they are mixed away from the source. Recent use of naturally occurring radium isotopes ^{224}Ra ($t_{½}$ = 3.66 days) and ^{223}Ra ($t_{½}$ = 11.4 days) can be used to examine the short-term mixing processes on time-scales of days to weeks (Moore and Arnold, 1996; Moore, 2000). The continual sediment source of particle-bound thorium isotopes in sediments and their conservative behavior in marine waters make these radium isotopes useful for tracing shelf water mixing rates, and thus are ideally suited for evaluating sources and mixing rate of shelf-derived iron in Southern Ocean waters. A full suite of radium isotopes in surface waters surrounding the South Shetland Islands were measured during AMLR 2006. ^{224}Ra ($t_{½}$ =3.66 days) was highly correlated with density, which supports the idea that the radium source in this region is entirely shelf derived. Off-shelf streamers of high ^{224}Ra to the north and northwest of Elephant Island were found and indicate that (presumably) high dissolved Fe shelf water had been rapidly transported (100km in ~4 days).

2.3.5.2 ^{234}Thorium: ^{234}Th ($t_{½}$ = 24.1 days) is often used to study rates of particle flux on time scales ranging from days to weeks (Bhat *et al*., 1969; Coale and Bruland, 1985) because of its affinity for particle surfaces,. Recent studies have linked the disequilibria between ^{234}Th and its parent radionucleotide ^{238}U ($t_{½}$ = 4.5 x 109 years) to the export flux of particulate organic carbon (e.g. Buesseler *et al*., 1992, 1995; Cochran *et al*., 1995; Bacon *et al*., 1996; Charette and Moran, 1999). Since POC export via sinking particles is the primary mechanism for carbon sequestration in the Southern Ocean, a better understanding of controls of this process are essential for improving export flux models such as by the parameterization of Laws (2004). During AMLR 2006, ^{234}Th-derived POC export was ~10-times higher at stations with high chl-*a* concentrations to the east of the Shackleton Fracture Zone as compared to waters with low chl-*a* concentrations waters to the west of the Shackleton Fracture Zone (Figure 2.6). These data indicated that a relatively significant POC re-mineralization occurred below the mixed layer for bloom stations that lead to a 3-4 fold decrease in POC export between 50 and 100 m (Figure 2.7B). In contrast, low chl-*a* containing ACC waters indicated export carbon followed the biomass profile (Figure 2.7A).

2.4 General Conclusions from the AMLR 2006 Field Season: Both the cruise data and satellite imagery of the AMLR survey area covering the 2005/2006 field season indicate that this was an unusual year with regard to phytoplankton biomass as well as physical oceanographic conditions. The uniqueness of this year is recognized when placed in context with a matrix of our historical data collected during AMLR cruises since 1990. The major changes documented in 2006 included (i) phytoplankton biomass in 2006 was higher than the historical mean by a factor of 2-3; (ii) surface water temperatures in the northern regions of the AMLR sampling grid were warmer than in past years by ~ 1.0 °C; (iii) There was only one station with a deep chl-*a* maximum (DCM), in contrast to the usual 10-20 stations with a DCM in past years (Holm-Hansen and Hewes, 2004). It is likely that these results are due to intrusion of Fe and Si rich shelf waters into the northern regions of the AMLR sampling grid.

2.5 Other: Samples for phytoplankton taxonomy, dissolved and particulate trace metals, bio-optics, and natural isotopes are in the process of being analyzed at the time of this report.

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: Due to Homeland Security policies, our frozen trace metal samples were opened and our N_2 frozen samples brought to room temperature by United States Customs officials for inspection. As a consequence, all HPLC samples were lost, and we are awaiting results from our trace metal analyses to determine the degree of contamination that occurred.

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. Research carried out during the "super stations" was partially funded through National Science Foundation, Office of Polar Programs, with grants ANT-0444134 (Mitchell, SIO) and ANT-0443869 (Charette,WHOI).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. Sequence of deployment, drifter number, date, time, and position of Lagrangian surface drifter buoy releases made during the AMLR 2006 field season. Refer to Figure 2.5 for the traces of drifters tracked through March 7, 2006, and covering the duration of our oceanographic survey.

Seq. No	Drifter #	Date	Time (GMT)	Latitude	Longitude
1	59856	1/23/06	19:44	-61.74	-55.78
2	59873	1/23/06	19:50	-61.74	-55.78
3	59869	1/25/06	19:27	-61.47	-54.99
4	59883	1/25/06	20:23	-61.62	-55.00
5	59872	1/25/06	23:02	-61.73	-54.98
6	59875	1/26/06	06:35	-61.22	-54.48
7	59870	1/26/06	07:59	-61.01	-54.39
8	59880	1/26/06	11:01	-61.74	-54.55
9	59847	1/27/06	03:42	-60.52	-54.00
10	59888	1/27/06	04:51	-60.71	-53.99
11	59916	1/27/06	09:08	-61.00	-54.00
12	59913	1/27/06	12:06	-61.26	-53.91
13	59878	1/29/06	11:00	-62.28	-57.03
14	59894	1/29/06	11:38	-62.19	-57.15
15	59889	1/29/06	12:12	-62.11	-57.25
16	59890	1/29/06	14:44	-62.05	-57.38
17	59891	1/29/06	15:28	-62.12	-57.57
18	59849	1/29/06	16:16	-62.19	-57.80

Table 2.2. Mean chlorophyll-*a* values (at 5m depth and when integrated to 100m depth) for all stations within each of the four areas of the AMLR survey grid during the 2006 AMLR cruise in comparison with the mean historical values for that area. N is the number of stations within each of the four sampling areas for which data were available. The N values in the parentheses are the number of stations used for calculating the integrated chl-*a* values.

Area	2006			1990 - 2004		
	N	5 m, mg Chl-a m^{-3}	Integrated, mg Chl-a m^{-2}	N	5 m, mg Chl-a m^{-3}	Integrated, mg Chl-a m^{-2}
WA	25	2.20 ± 1.81	85 ± 60	429 (389)	0.63 ± 0.99	46 ± 33
EI	48	2.32 ± 1.90	101 ± 72	1541 (1471)	0.90 ± 0.97	57 ± 50
JI	6	1.20 ± 0.71	78 ± 26	47 (46)	0.70 ± 0.43	48 ± 26
SA	19	2.88 ± 1.69	123 ± 60	267 (258)	1.39 ± 1.33	76 ± 76

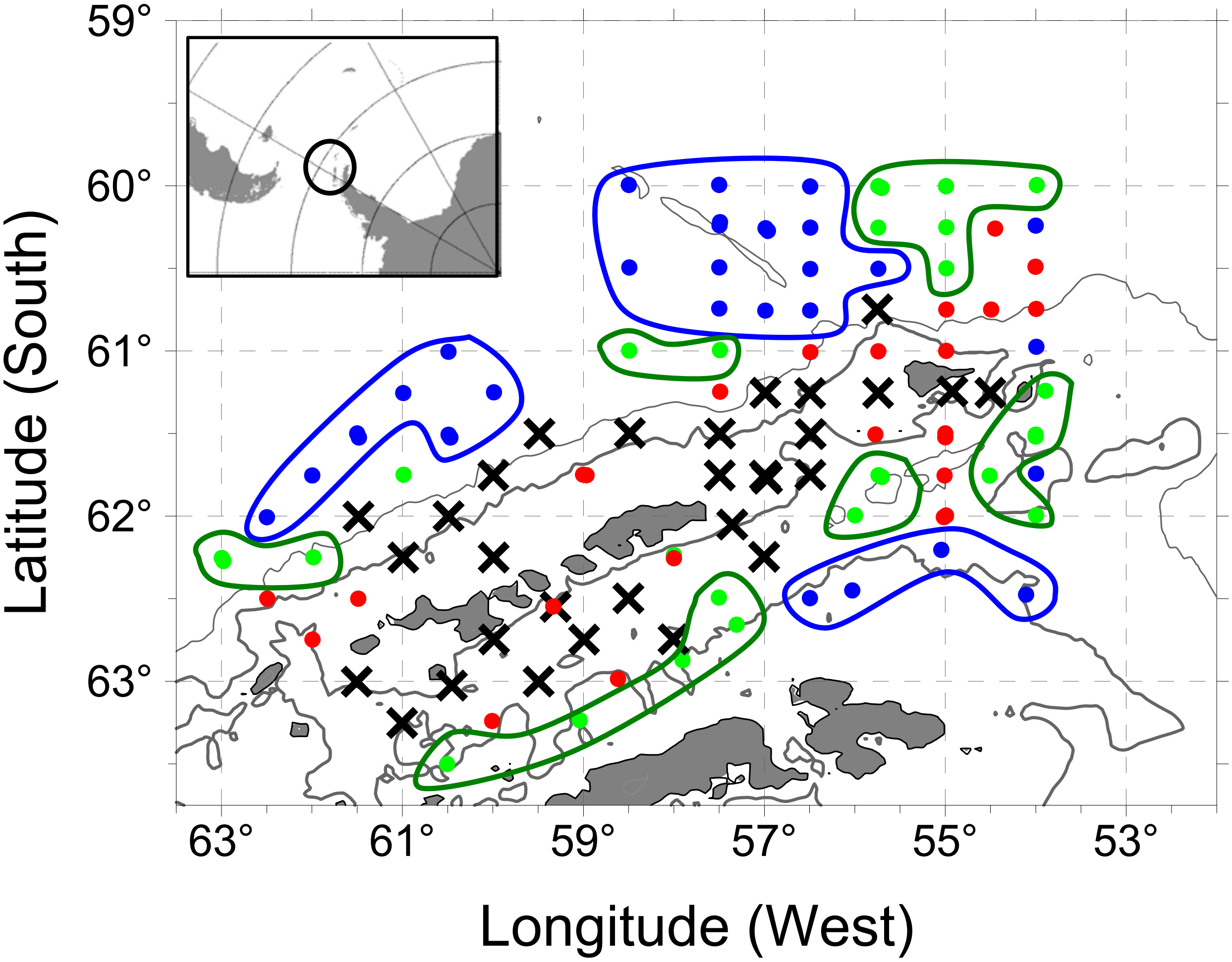

Figure 2.1. Chlorophyll-*a* concentrations at 5m depth in the AMLR sampling area. The four concentration ranges (mg chl-*a* m^{-3}) are < 1.0 (blue symbols), 1.0 to 2.0 (green symbols), 2.0 to 3.0 (red symbols) and > 3.0 (black crosses).

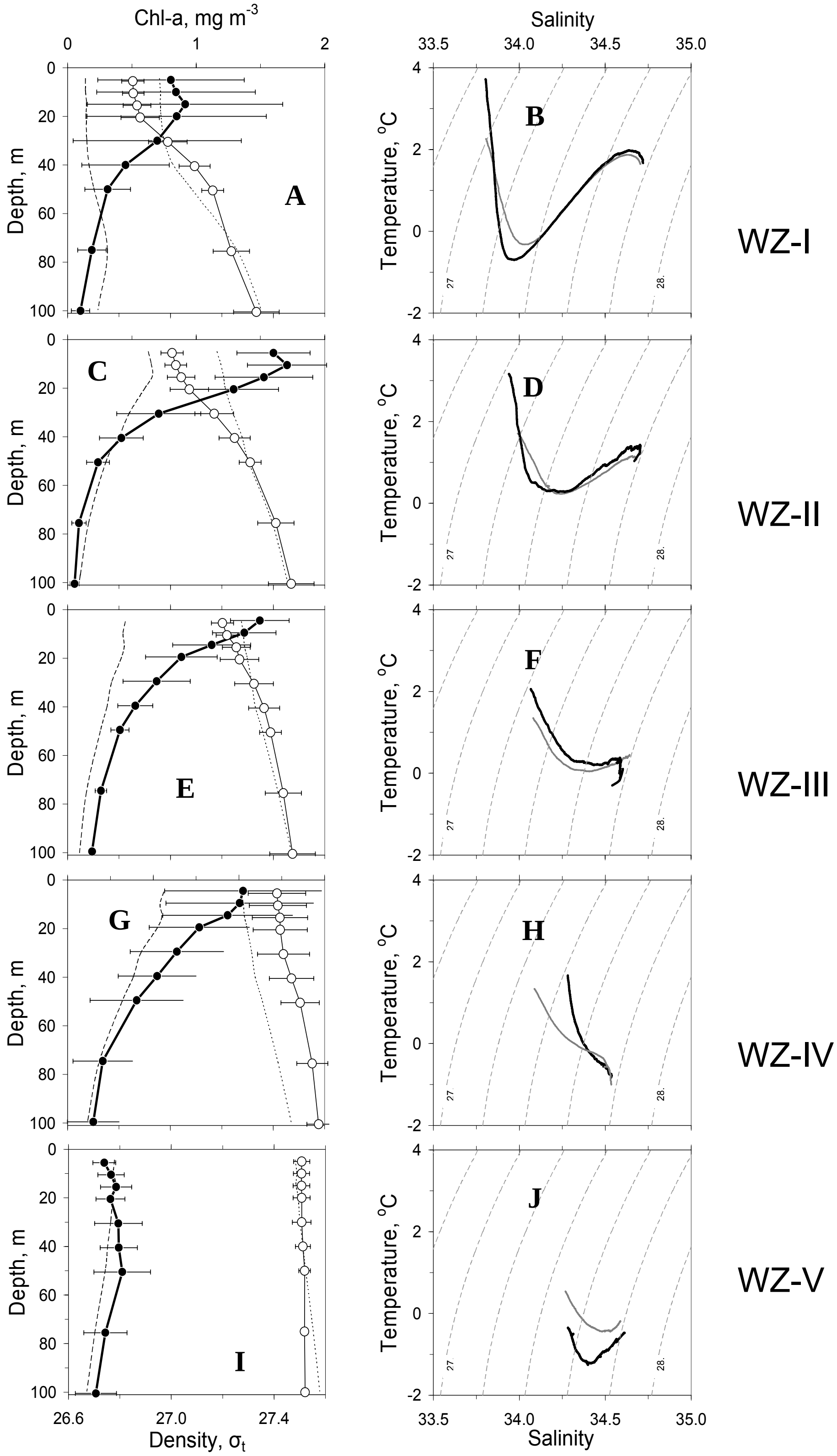

Figure 2.2. Mean profiles of mean chl-*a* concentrations (filled circles) and density (open circles) with depth (left side) and temperature verses salinity diagrams (right side) in the five water zones during 2006. The horizontal bars show standard deviations at each sampling depth. For comparison with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

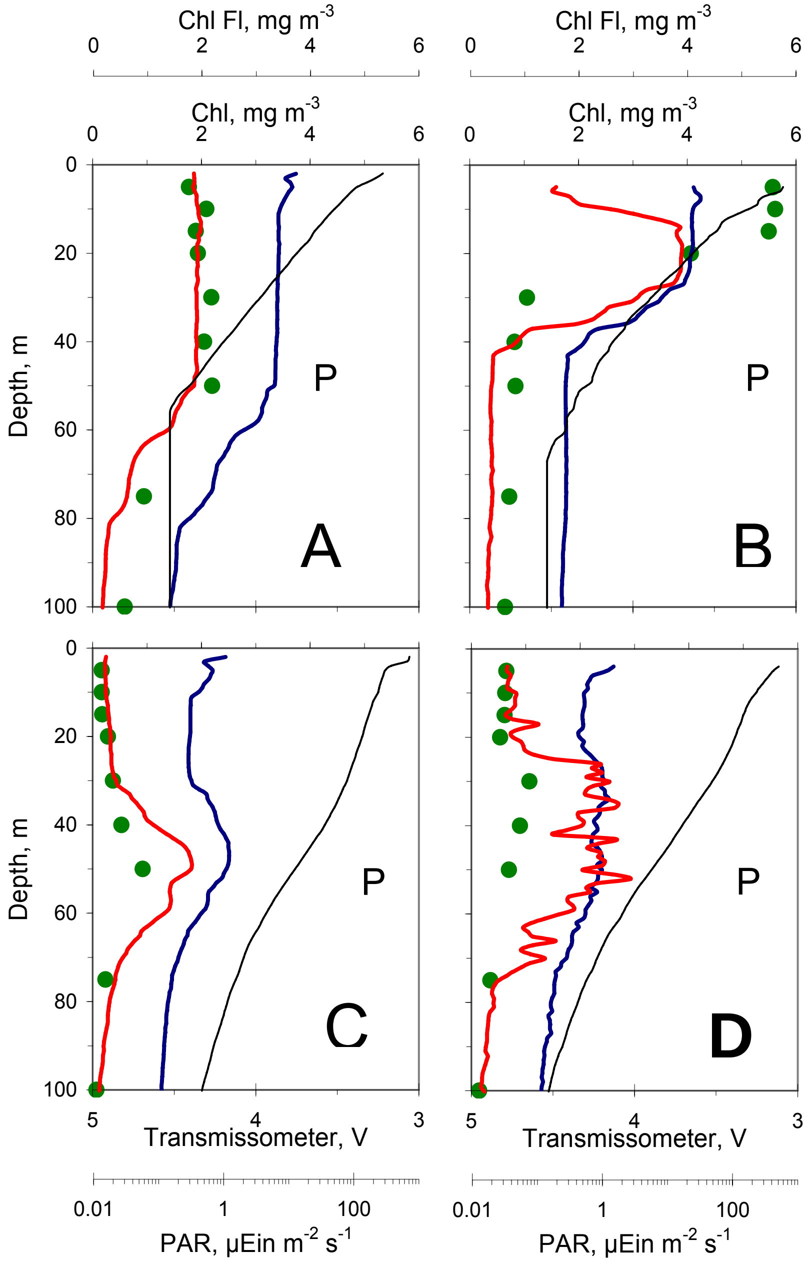

Figure 2.3. Representative profiles of chl-*a* (green symbols), *in situ* chl-*a* fluorescence (Chl Fl; red line), attenuation of light at 660nm as indicated by voltage recorded by the in situ transmissometer (blue line), and solar irradiance (PAR) in the upper water column (black line and labeled P). A, Station 0206, showing no photoinhibition of chl-*a* fluorescence at moderate incident solar irradiance; B, Station 0708, showing marked photoinhibition of chl-*a* fluorescence at high incident solar irradiance; C, Station 1909, a station with low chl-*a* concentrations in the upper mixed layer and a deep chlorophyll-*a* maximum; D, Station 1707, showing the jagged nature of the profiles for chl-*a* fluorescence and beam attenuation when the phytoplankton assemblage is dominated by larger particles such as chain forming diatoms. 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 micro-Einsteins per square meter per second, below which the signal is shown as a vertical line.

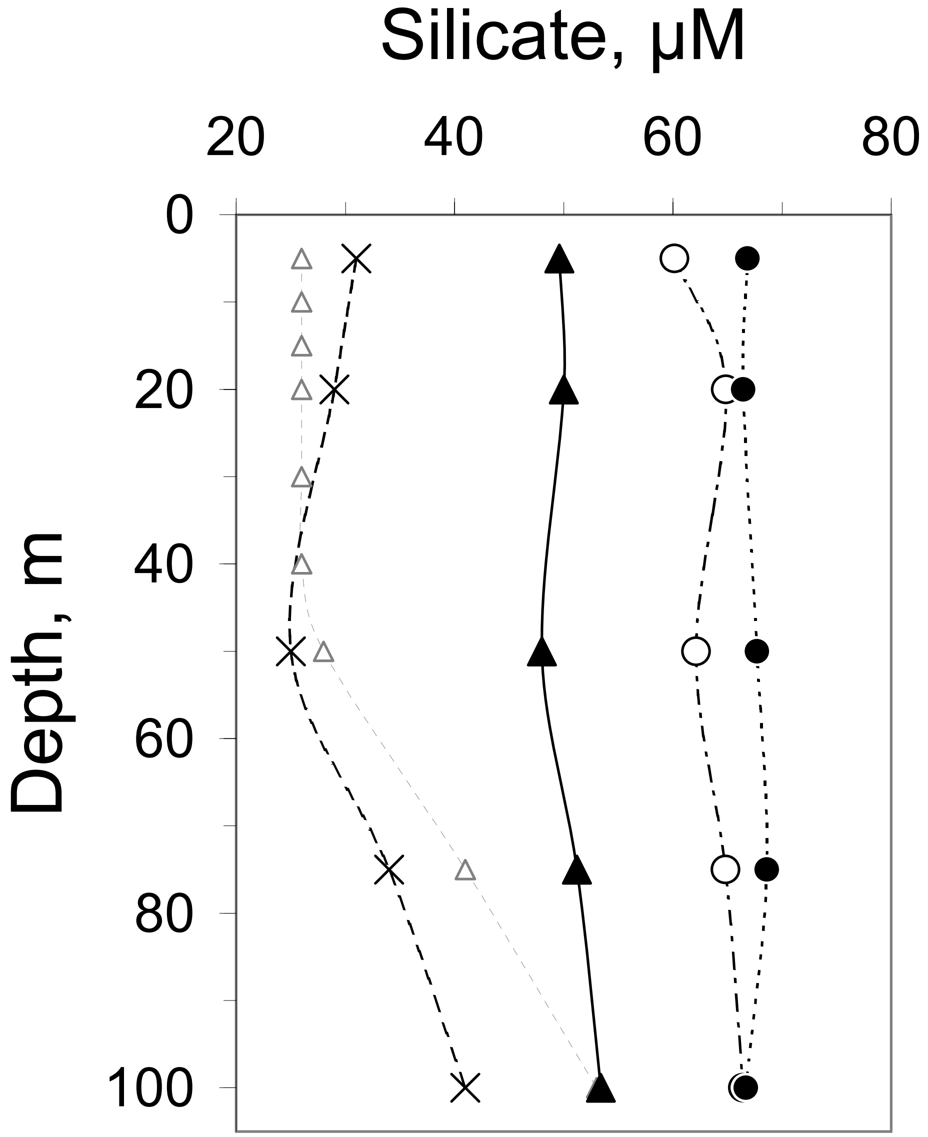

Figure 2.4. Profiles of Si concentrations in different water masses found in the AMLR sampling area. Mean Si concentrations in Water Zone 1A waters from previous AMLR studies (Silva *et al.*, 1995), open triangles; Station 0902 in water zone 1A, “X”; mean of five stations in Water Zone 1B, filled triangles; mean of two stations in Water Zones 2 and 3, open circle; mean of 18 stations in Water Zones 4 and 5, solid circles.

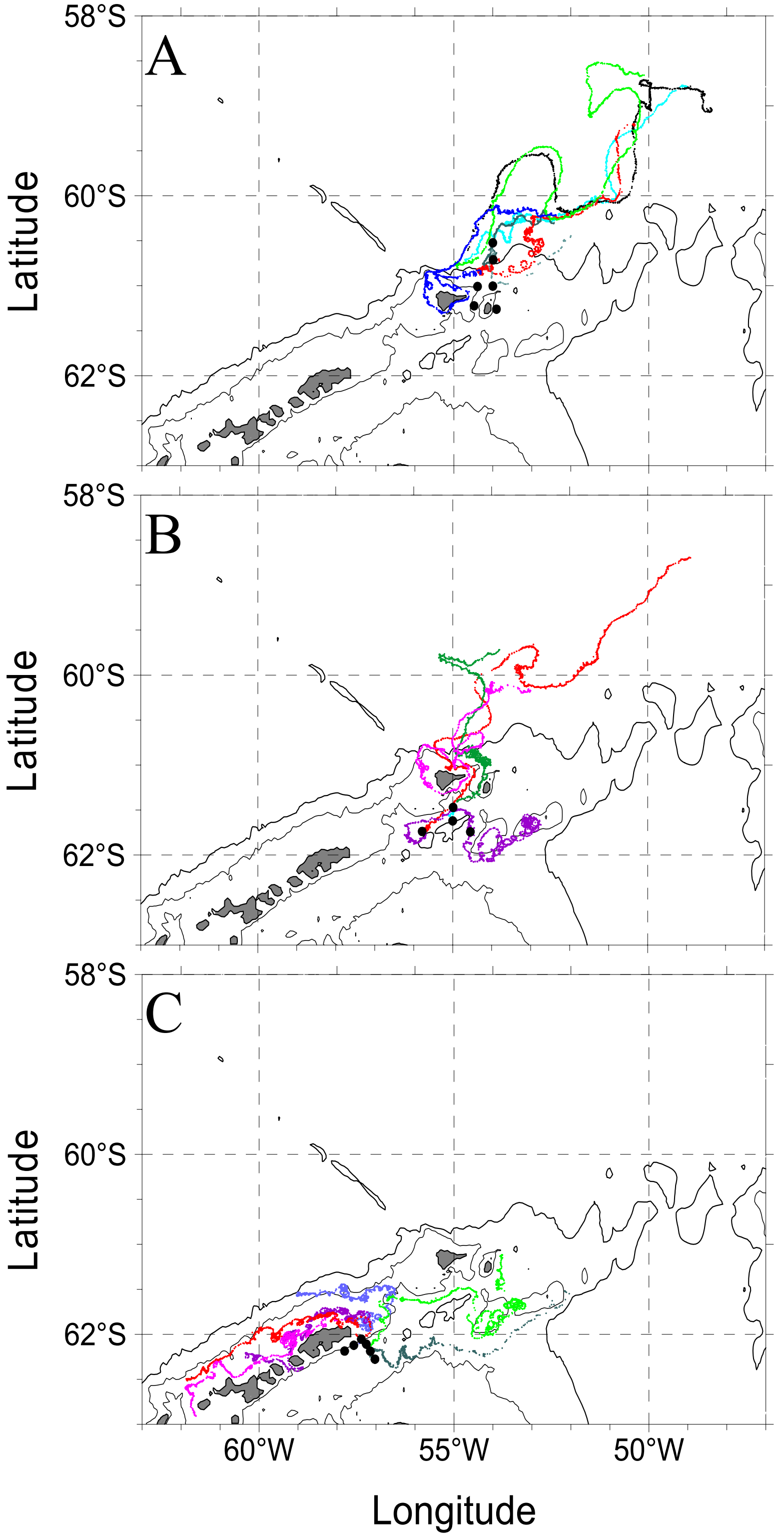

Figure 2.5. Tracks of the Lagrangian surface drifter buoys deployed during our AMLR 2006 survey. Dark circles indicate location of deployment. (A) Seven buoys released around Elephant Island (two were released at the same location). (B) Four buoys in Bransfield Strait south of Elephant Island. (C) Seven buoys released in Bransfield Strait southeast of King George Island. Colors are used to differentiate the individual tracks of the buoys. (Latitude is South and Longitude is West).

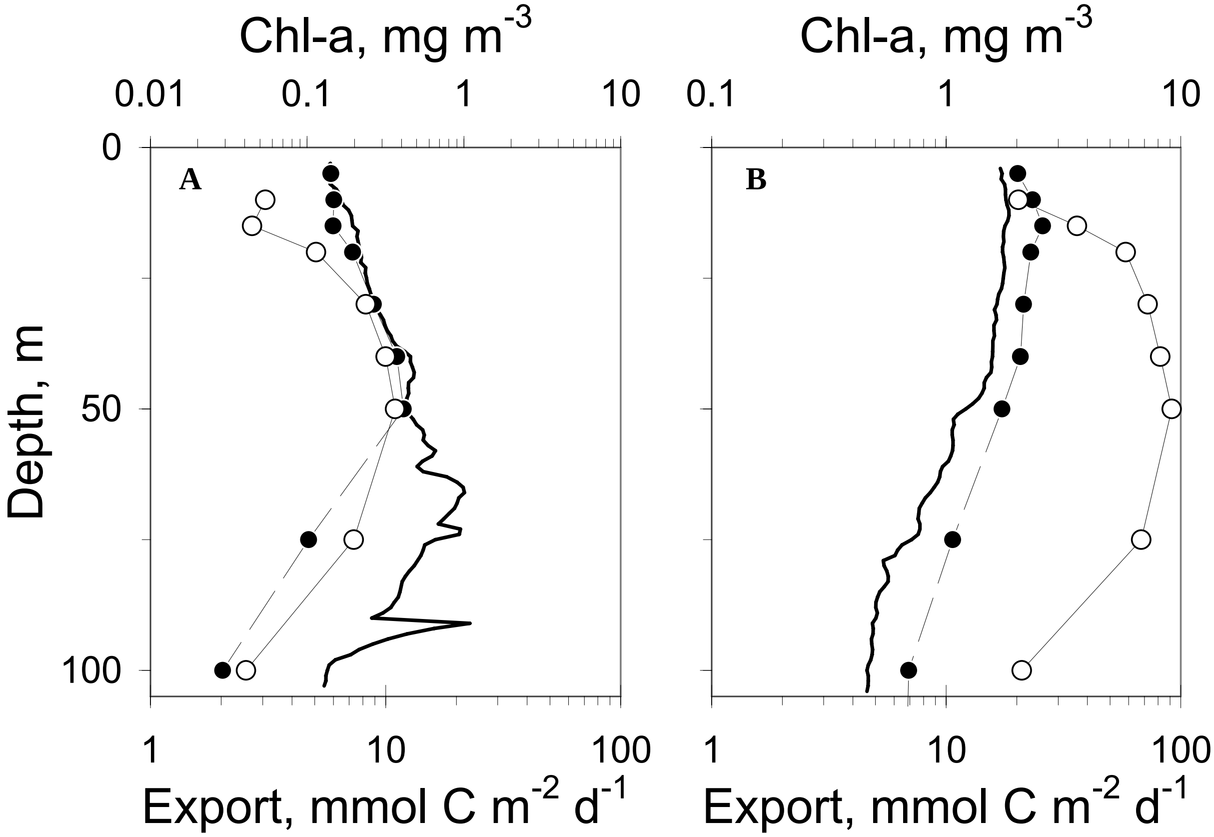

Figure 2.6. Export carbon rates as based on 234^{Th} (open circles) in relation to MeOH-extracted chl-*a* (filled circles) and estimated chl-*a* with the Chelsea fluorometer (dark line). A, data from Station A18-08, a low biomass station west of the Shackleton Fracture Zone. B. data from Station A05.5-05, a phytoplankton bloom station east of the Shackleton Fracture Zone. 234^{Th} and MeOH-extracted chl-*a* concentrations measured from bottle samples during the upcast, and Chelsea estimated chl-*a* measured during the downcast of the profiling carousel.

3. Bioacoustic survey; submitted by Anthony M. Cossio (Legs I & II) and Christian Reiss (Leg I).

3.1 Objectives: The primary objectives of the bioacoustic survey during Leg I were to map the meso-scale dispersion of Antarctic krill (*Euphausia superba*) in the vicinity of the South Shetland Islands; 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. The focus during Leg II was to estimate krill abundance at each bottom trawl location as well as to map and bottom type the various benthic habitats surrounding the Antarctic Peninsula.

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 38 kHz, 70 kHz, 120 kHz, and 200 kHz. Geographic positions were logged every 2 seconds. Ethernet communications were maintained between the EK60 and one Windows XP workstation. The workstation was used for primary system control, data logging, and data processing with SonarData Echoview software. Bottom typing was processed with Quester Tangent Corporation (QTC) Impact software.

Acoustic surveys of the water surrounding the South Shetland Islands were conducted on Leg I. These surveys 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 seven 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, only three transects were completed in the Joinville Island Area during Leg I (Survey A).

During Leg II, acoustics were taken for krill when the net was in the water till the net left the bottom. Bottom typing data was continuously recorded.

3.2.1 Krill Delineation: Krill abundance was estimated using a three-frequency delineation method (Hewitt *et al.*, 2003) as opposed to the two-frequency method used in past research (Madureira *et al.*, 1993). A ΔMVBS window of 4 to 16 was selected between 120 kHz and 38 kHz with the second window of -4 to 2 defined between 120 kHz and 200 kHz. The window ranges for krill were selected based on models of krill backscattering strength at each frequency.

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

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 ΔMVBS window 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. These data were processed using SonarData Echoview software.

Integrated krill nautical area scattering coefficient (NASC) (MacLennan and Fernandes, 2000) was converted to estimates of krill biomass density (ρ) by applying a factor equal to the quotient of the weight of an individual krill and its backscattering cross-sectional area, both expressed as a function of body length and summed over the sampled length frequency distribution for each survey (Hewitt and Demer, 1993):

$$\rho = 0.249 \sum_{i=1}^{n} f_i (l_i)^{-0.16} NASC \quad (\mathrm{g/m^2})$$

Where

$$\mathrm{NASC} = 4\pi r_0^2 (1852)^2 \int_{15}^{500} S_v \qquad (\mathrm{m^2/n.mi.^2})$$

And f_i = the relative frequency of krill of standard length l_i. Where the reference range for backscattering strength equals 1 m (r_0= 1 m).

For each area in each survey, mean biomass abundance 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 each leg to the South Shetlands.

No myctophid biomass estimates were made because of the lack of target strength data and length frequency distributions. The NASC attributed to myctophids was integrated using SonarData Echoview software and then used to map their distribution.

Acoustic volume backscattering strength sample data were collected for seabed classification purposes. This data was analyzed using QTC Impact software. A series of algorithms were applied to the data in order to generate values that are descriptive of each echo. A Principal Components Analysis (PCA) reduced this data further into three primary dimensions. Next, a series of cluster analyses were performed in order to establish a statistical classification scheme descriptive of the seabed found around the South Shetland Islands.

3.3 Tentative Conclusions:

3.3.1 Leg I (Survey A): Krill abundances are (Figure 3.1). Acoustic estimates of krill abundance were 2.68, 6.18, 4.32, and 3.56 g/m² for the West, Elephant Island, South and Joinville Island Areas, respectively (Table 3.1). Krill were predominately found off the east coast of Elephant Island. Abundance estimates by transect are listed in Table 3.2. These are lower than the previous years. Larger *E. superba* (>55mm) were seen in net tows that might have not been picked up by the 120-38 kHz windows established.

The distribution of mean NASC of myctophids was mapped and found to be highest along the 2000m isobath (Figure 3.2). High NASC values could possibly be krill since the ΔMVBS windows are similar to where large krill would be classified. This is being looked into.

3.3.2 Leg II: Krill abundance ranged from 0.1 to 338.5 g/m^2 over 64 trawl stations. Average length of transects were 4 nmi. Higher abundances were seen at shallower depths and near canyon mouths (Figure 3.3). Bottom characteristics are still being analyzed.

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 10 MB. 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. *Can. J. Fish. Aquat. Sci*. 39:229-231.

Table 3.1. Mean krill biomass for surveys conducted from 1992 to 2006. Coefficients of variation (CV) are calculated by the methods described in Jolly and Hampton, 1990, and describe measurement imprecision due to the survey design. 1993 estimates are omitted due to system calibration uncertainties; only one survey was conducted in 1997; 1999 South Area D values are not available due to lack of data. Data values from 1992-1995 are based on the two-frequency method. Data values from 1996 on are based on the three-frequency krill delineation method (4-16dB difference between 120 and 38 kHz and –4-2dB difference between 200 and 120 kHz). Numbers in parenthesis are previous estimates. 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 %
1992 A (late January)	Elephant Island	38.03	36,271	194	20.1
D (early March)	Elephant Island	7.91	36,271	287	14.3
1994 A (late January)	Elephant Island	3.07	41,673	128	34.7
D (early March)	Elephant Island	2.14	41,673	13	33.7
1995 A (late January	Elephant Island	7.47	41,673	311	23.5
D (early March)	Elephant Island	13.22	41,673	551	28.8
1996 A (late January)	Elephant Island	26.85	41,673	1,119	29
D (early March)	Elephant Island	17	41,673	708	36
1997 A (late January)	Elephant Island	50.04	41,673	2,085	21.4
1998 A (late January)	Elephant Island	48.53 (60.22)	41,673	2022 (2509)	14.4 (19.4)
	West	56.68 (75.39)	34,149	1935 (2575)	19.2 (30.5)
	South	37.42 (29.35)	8,102	303 (238)	17.2 (27.1)
D (late February)	Elephant Island	25.41 (20.84)	41,673	1059 (868)	15.5 (16.3)
	West	52.65 (75.03)	34,149	1832 (2563)	23.6 (28.7)
	South	42.98 (37.87)	8,102	348 (307)	12.6 (12.4)
1999 A (late January)	Elephant Island	14.16 (14.84)	41,673	590 (619)	40.6 (38.1)
	West	16.59 (16.92)	34,149	567 (578)	31.2 (31.6)
	South	15.66 (15.52)	8,102	127 (126)	13.5 (14.8)
D (late February)	Elephant Island	16.14 (13.37)	41,673	684 (557)	37.6 (39.8)
	West	16.33 (16.18)	34,149	558 (552)	33.4 (35.7)
2000 D (late February)	West	36.67 (32.51)	34,149	1252 (1110)	33.2 (37.4)
	Elephant Island	38.76 (34.57)	41,673	1615 (1441)	25.6 (28.6)
	South	32.33 (19.83)	8,102	262 (161)	32.1 (4)
2001 A (late January)	West	5.44 (4.7)	34,149	186 (161)	20.0 (16.4)
	Elephant Island	5.54 (6.65)	41,673	231 (277)	20.6 (19.1)
	South	28.06 (6.5)	8,102	227 (53)	60.2 (20.9)
D (late February)	West	8.51 (7.83)	34,149	291 (268)	38.9 (42.8)
	Elephant Island	7.01 (5.99)	41,673	292 (250)	10.8 (10.4)
	South	2.17 (2.77)	8,102	18 (22)	52.7 (40.1)
2002 A (late January)	West	0.91 (2.29)	38,524	35 (88)	30.1 (117.6)
	Elephant Island	4.17 (3.34)	43,865	183 (147)	42.0 (78.7)
	South	2.26 (2.11)	24,479	55 (351)	44.9 (53.3)
D (late February)	West	1.42 (1.69)	38,524	55 (65)	54.2 (19.3)
	Elephant Island	3.22 (1.17)	43,865	141 (51)	21.7 (23.5)
	South	1.42 (1.05)	24,479	34 (26)	40.7 (32.9)
2003 A (late January)	West	30.57 (28.42)	38,524	1178 (1095)	16.5 (15.1)
	Elephant Island	26.61 (25.06)	43,865	1167 (1099)	8.4 (16.2)
	South	14.66 (11.5)	24,479	359 (281)	23.9 (35.4)
D (late February)	West	39.31 (35.86)	38,524	1514 (1381)	21.2 (20.2)

	Elephant Island	1859 (17.05)	43,865	816 (748)	20.2 (18.4)
	South	19.1 (17.18)	24,479	468 (421)	25.1 (15.4)
2004 A (late January)	West	18.53 (36.39)	38,524	714 (1402)	9.3 (14.8)
	Elephant Island	12.33 (40.06)	43,865	541 (1757)	17.2 (15.5)
	South	9.58 (40.65)	24,479	234 (995)	26.2 (11.1)
D (late February)	West	10.85 (12.19)	38,524	418 (470)	43.3 (37.3)
	Elephant Island	11.98 (41.75)	43,865	523 (1832)	23.8 (15.9)
	South	4.62 (30.77)	24,479	113 (753)	88.8 (40.8)
2005 A (late January)	West	25.59 (23.5)	38,524	986 (905)	18.5 (18.8)
	Elephant Island	43.12 (37.48)	43,865	1891 (1644)	17.8 (17.7)
	South	16.5 (16.55)	24,479	404 (405)	14.1 (11.7)
D (Late Februray)	West	9.98 (13.16)	38,524	384 (507)	62.8 (51.6)
	Elephant Island	1.87 (6.57)	43,865	82 (288)	21.0 (15.5)
	South	4.56 (3.67)	24,479	112 (90)	39.0 (26.9)
2006 A (Late January)	West	2.68	38,524	103	22.2
	Elephant Island	6.18	43,865	271	39.1
	South	4.32	24,479	106	17.7

Table 3.2. Daytime krill density estimates by area and transect for Survey A.
n = 1 interval = 1 nautical mile.

West Area		
		Survey A
	n	krill (g/m^2)
Transect 1	39	1.38
Transect 2	24	2.18
Transect 3	40	2.79
Transect 4	31	3.94
Transect 5	60	4.82
Transect 6	52	2.27
Transect 7	61	1.25
Elephant Island Area		
		Survey A
	n	krill (g/m^2)
Transect 1	65	1.68
Transect 2	45	1.52
Transect 3	90	3.43
Transect 4	70	3.99
Transect 5	109	3.00
Transect 6	53	22.9
Transect 7	68	11.5
Joinville Island Area		
		Survey A
	n	krill (g/m^2)
Transect 1	16	1.86
Transect 2	16	5.25
Transect 3	0	0
South Area		
		Survey A
	n	krill (g/m^2)
Transect 1	38	7.40
Transect 2	20	1.63
Transect 3	35	4.57
Transect 4	35	4.05
Transect 5	21	4.20
Transect 6	3	0.09
Transect 7	43	3.23

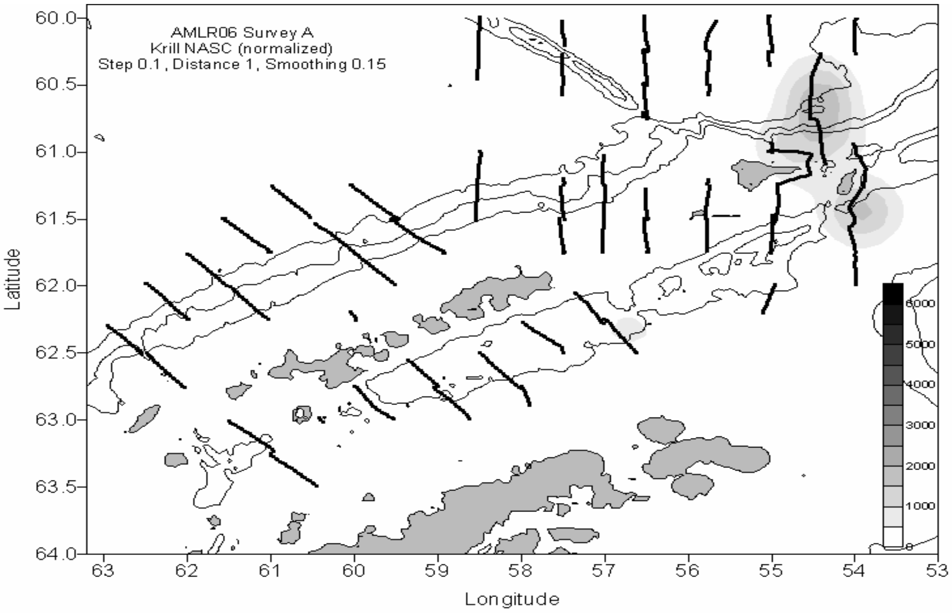

Figure 3.1. Normalized krill NASC values for Survey A at 120kHz using day data. (Latitude is South and longitude is West).

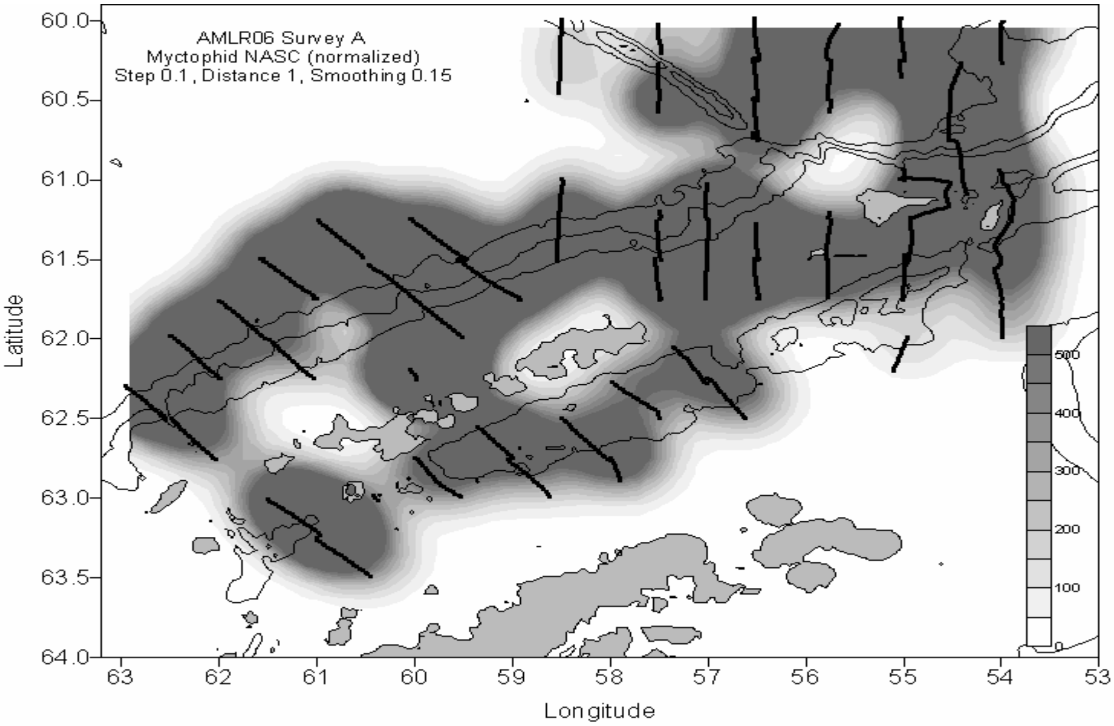

Figure 3.2. Normalized myctophid NASC values for Survey A at 120kHz using day data. (Latitude is South and longitude is West).

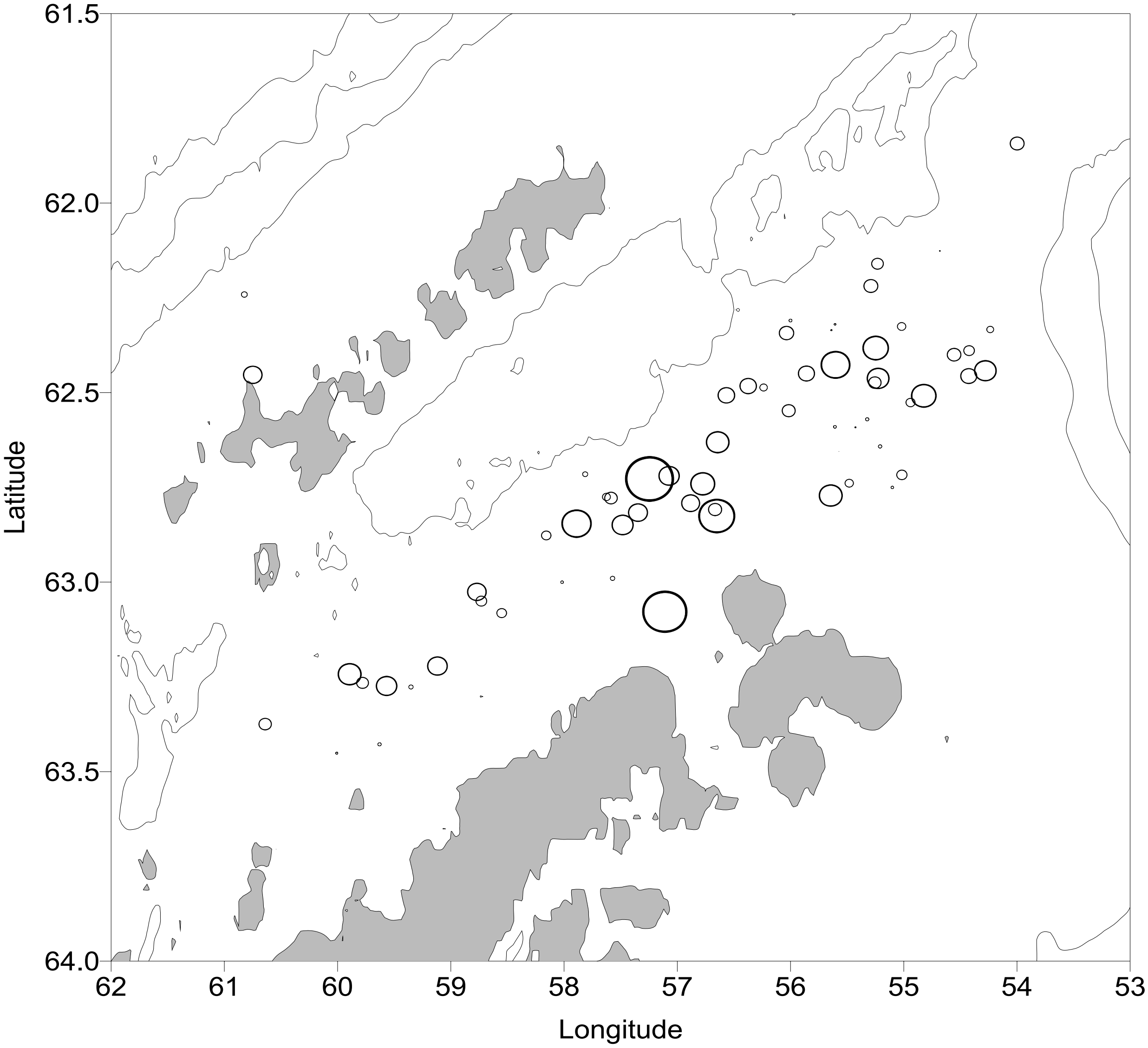

Figure 3.3. *E. superba* abundances (g/m^2) for Leg II trawl stations. See Figure 5.1 for haul numbers. (Latitude is South and longitude is West).

4. AMLR 2006: Net sampling: Krill and zooplankton; submitted by Valerie Loeb, Laralyn Asato, Cassandra Brooks, Kimberly Dietrich , Ryan Driscoll, Adam Jenkins, Darci Lombard and Mitchell Meredith.

4.1 Objectives: Here we provide information on the demographic structure of Antarctic krill (*Euphausia superba*) and abundance and distribution of salps and other zooplankton taxa 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 augmented by larval abundance and developmental stage composition. 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 1992-2006 period. Results from February-March sampling efforts in previous years (Survey D) are included to maintain temporal coherency of the long term data set. 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 1.8 m^2 Isaac-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 170 m or approximately 10 m 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 and volumes averaged 2300 m^3. Samples were collected at large area survey stations representing four regionally distinct areas (See Figure 1 - Introduction Section; this chapter - Figure 4.1). "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 stocks available to predator populations at Cape Shirreff and to the krill fishery that operates in this area during summer months. Additionally, the taxonomic composition and abundance of zooplankton assemblages in the West and Elephant Island Areas reflect prevailing hydrographic influences that directly affect krill food supplies, spawning seasonality, reproductive effort and recruitment success (Loeb *et al.*, ms). These are the eastward flowing Antarctic Circumpolar Current (ACC) 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 in Admiralty Bay, King George Island, while "Joinville Island Area" stations, to the east, are sampled to determine whether significant aggregations of juvenile krill occur there and, if so, whether these are associated with a Weddell Sea influence.

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, and other taxa are expressed as numbers per 1000 m^3 water filtered. Twilight samples were collected between one hour before and one hour after local sunrise and sunset. Information is presented for the Elephant Island, West, South and Joinville Island Areas and for the total survey area.

(A) Postlarval Krill: Krill were removed and counted prior to other sample processing. All krill from samples containing <100 individuals were analyzed. For larger samples, generally 100 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 using dissecting microscopes. Larval krill were enumerated according to developmental stage. After analysis the zooplankton were preserved in 10% buffered formalin for long-term storage.

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 inclusion of smaller taxa (e.g., 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 and by outflow from Gerlache Strait. Use of a more protective cod-end starting in 2002 also increases the numbers of previously unidentifiable delicate taxa such as jellies and pteropods.

4.2.3 Statistical Analyses: Data from the total large survey area and included subareas are analyzed here for between-year comparisons. Because distinct water zones were represented across the survey area this year (See Physical Oceanography Report, this Volume) krill and zooplankton species abundances are also related to Water Zone numbers I to V which represent mixtures between Antarctic Circumpolar Current (ACC) water (1), Bransfield Strait (4) and

Weddell Sea water (V). Analyses include a variety of parametric and nonparametric techniques. Among these are 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* software (StatSoft).

4.3 Results and Preliminary Conclusions:

4.3.1 Survey A

4.3.1.1 Krill:

Postlarval Distribution and Abundance (Table 4.1; Figure 4.1)
Postlarval krill were broadly distributed in generally low concentrations across the survey area but present in 86 of the total 99 (87%) samples. These were generally rare or absent in offshore waters adjacent to the Shackleton Fracture Zone resulting in lower frequency of occurrence in the West and Elephant Island Areas (81-84%) compared to the South (100%). Krill were present in five of six Joinville Island samples (83%). Greatest concentrations (130-510 per 1000 m^3) were associated with frontal features over the outer shelf region northeast of Elephant Island and off Joinville Island in southeastern Bransfield Strait. Highest mean and median abundance values (95 and 16 per 1000 m^3) were represented in the Joinville Island Area followed by the South (26 and 8 per 1000 m^3), Elephant Island (24 and 11 per 1000 m^3) and West Areas (10 and 8 per 1000 m^3).

Length and Maturity Stage Composition (Table 4.2; Figures 4.2, 4.3)
Krill length ranged from 23-61mm and demonstrated 32mm, 38mm, 42mm and 50-52mm modes with a median length of 48mm. These roughly correspond to four age categories (Siegel, 1987): <35mm, 1-year old (2%); 35-40mm, 2-year old (9%); 41-49mm, 3 year old (37%); $\geq$50mm, 4+ years (52%). Therefore, the bulk of the population sampled is represented by the highly successful 1999/00, 2000/01 and 2001/02 year classes now four to six years of age and nearing the end of their life expectancy.

Overall, juveniles comprised about 6%, immature stages 13% of individuals and 81% were mature forms most of which were reproductively active. Males slightly outnumbered females (1.3:1 ratio) with spermatophore-producing stage 3b males contributing 39% of the total. The majority of mature females (85%) was in advanced stages (3c-e), with gravid (3d) and spent (3e) individuals constituting, respectively, 18% and 9% of all krill sampled, including most of the small 36-40mm 2-year old females.

The four areas demonstrated differences in krill length and maturity composition that are typical for January surveys. Predominantly large animals in the West Area had 52mm median and modal lengths; 99.6% of these were mature. Here males outnumbered females by nearly three fold with stage 3b males comprising 73% of the total. Most of the females were in advanced stages (96%) with gravid and spent forms representing, respectively, 18% and 5% of the catch. Large krill also dominated in the Elephant Island Area and exhibited 49mm median and 50mm primary modal lengths. Only 3% were ≤35mm reflecting low representation of the 2004/05 year class while 9% were 36-40mm centered around a 38mm (2-year old) length mode. Males and females were similarly represented and predominantly mature. Stage 3b males constituted 46% of the total while a mixture of female stages comprised 47%: 10% recently mated (3b); 7% with developing ovaries (3c); 11% gravid (3d) and 16% spent (3e). These results suggest active mating and spawning within the Elephant Island Area. Krill collected in the Joinville Island Area samples demonstrated a much more heterogeneous, polymodal length-frequency distribution that included substantial proportions of 23-34mm (30%) and 35-40mm (15%) individuals representing the 2004/05 and 2003/04 year classes. Accordingly, the median length here was 42mm and 19% of individuals were juveniles, 29% immature and 52% mature stages. The majority of mature females (59%) were gravid. The overall length-frequency distribution in the South resembled that in the Elephant Island Area (48mm and 50mm median and modal lengths) but with greater proportions of <35mm 1-year old krill (13%). Here juveniles made up 5%, immature forms 15% and mature individuals 80% of the total catch. As in the other areas greatest proportions of females were gravid and males were stage 3b; together these comprised 66% of total South Area krill.

Distribution Patterns (Figures 4.4, 4.5)

Cluster analysis applied to krill length-frequency distributions in 57 samples produced three spatially coherent groups representing different age categories. The largest of these, Cluster 1, occurred at 33 stations generally over the northern island shelf areas and in the complex frontal zone region east of the Shackleton Fracture Zone (See Physical Oceanography Report, this Volume). Presence of this group at three stations in northwest Bransfield Strait was associated with Zone 2 water and suggests poleward advection into the area from Drake Passage. The size and maturity characteristics of Cluster 1 krill are similar to those described above for the West Area: 84% ≥50mm with 52mm median and modal lengths (e.g., 4 years and older); males outnumbering females by 1.5:1 with 3b stage males representing 60% of the total catch; 92% of mature females in advanced stages with gravid (3d) and spent (3e) individuals comprising, respectively, 23% and 9% of the total catch. Cluster 3 krill were represented at 17 stations located in southeast Bransfield Strait and between King George and Elephant Islands, regions influenced by fronts between, and mixtures of, Bransfield Strait (Zone 4), Weddell Sea (Zone 5) and intermediate water (Zones 2-3). These represent a mixture of primarily younger (e.g., 1- to 3-year old) krill with 12% of individuals <35mm, 16% between 35-40mm and 48% between 41-49mm. These included 4% juvenile, 18% immature and 78% mature stages. Among the latter, 3d males represented 30%, and gravid and spent females 22% and 10%, of the total. Cluster 2 occurred at seven stations in central Bransfield Strait. The majority of these krill (75%) were mature individuals 41-50mm (e.g., mostly 3-year olds) with equal representation of males and females. Relatively large proportions of stage 3c and 3d females (9% and 37%) and few spent individuals (1%) suggest that this cluster lagged somewhat behind the others in seasonal reproductive activity.

Larval Krill Distribution, Abundance and Stage Composition (Tables 4.3; 4.4, 4.5; Figure 4.6)

Larval krill were present in 58 of the 99 samples. They were least frequent and abundant in the West Area where they were present in seven samples (28%) with a mean abundance of 8 per 1000 m^3. Greatest concentrations here (36-89 per 1000 m^3) were offshore of Livingston Island. Larvae were slightly more frequent (45% of samples) and abundant (16 per 1000 m^3 mean) in the South Area. Greatest concentrations here (245 per 1000 m^3) occurred in the eastern portion characterized by frontal zones between Weddell and Bransfield Strait water. Extremely large concentrations (10140-20540 per 1000 m^3) were collected by five tows in the hydrographically complex area northeast of Elephant Island. Overall, 75% of the Elephant Island Area samples contained larvae and their mean and median abundance values here (2029 and 19 per 1000 m^3) were the highest of the four areas. Larvae were present in all six Joinville Island Area samples with mean and median values (262 and 14 per 10003) second to those in the Elephant Island Area.

Most krill larvae (99%) were the early calyptopis (C1) stage resulting from spawning about 3-4 weeks earlier (i.e., late December-early January; Spiridonov, 1995). Small numbers of older calyptopis (C2) and furcilia (F1) stage larvae in the West Area suggest an earlier initiation of seasonal spawning activity. However, the overwhelming predominance of C1 larvae suggests that the major spawning effort did not begin until late December.

<u>Overall Condition of Postlarval Krill and Spawning Seasonality</u>
Across the entire survey area postlarval krill were noted to be taking full advantage of the elevated primary production (See Phytoplankton Report) as indicated by the prevalent green color of the hepatopancreas and thick presumably lipid exudates released on their preservation. Favorable feeding conditions could explain the apparent temporal coherence of reproductive activity across most of the survey area (Spiridonov, 1995). Given overwhelming dominance of C1 larvae, the first major synchronous spawning effort began in late December-early January (e.g., about 25 days before the median survey date of 23 January). This is not particularly early and suggests the relative importance of hydrographically induced phytoplankton bloom conditions during late spring and summer vs. rapid and early spring sea ice retreat (Spiridonov, 1995) underlying production of the 2005/06 year class. The prevalence of gravid females across the survey area suggests a second major spawning effort would occur during early February (i.e., one month after the first bout).

4.3.1.2 Salps:

<u>*Salpa thompsoni* Distribution and Abundance (Tables 4.4, 4.5; Figure 4.7)</u>
Salpa thompsoni was present in 61 of the samples (62%) most of which were offshore of the South Shetland and Elephant Islands. With overall mean and median abundance values of 49 and 1 per 1000 m^3 it was not among the dominant zooplankton taxa encountered. Greatest concentrations (100-515 per 1000 m^3) were in Drake Passage north of the SACCF and adjacent to the Shackleton Fracture Zone where they most likely were concentrated by fronts and gyres. Accordingly, this salp was most frequent in the West Area where it was present in 92% of samples with 72 and 7 per 1000 m^3 mean and median abundance values. They were present in 73% of Elephant Island Area samples with abundance values comparable to those in the West Area (63 and 9 per 1000 m^3). In contrast *S. thompsoni* was not collected in the Joinville Island Area and was present in small

numbers at four South Area stations (20%) with an average concentration of 0.9 per 1000 m^3.

Salpa thompsoni Size and Maturity Stage Composition (Figures 4.8a,b)

Almost all salps were the aggregate (chain) form. The overwintering asexual solitary form made up only 0.5% of individuals in the West Area and 1.4% in the Elephant Island Area. Aggregate lengths ranged from 4-55mm with similar median lengths (19mm and 21mm) in the two areas. Given an estimated growth rate of 0.44mm per day this would indicate an initiation of chain production in early October with peak production in mid-December. Pulses of chain production in both areas are indicated by polymodal length-frequency distributions with peaks at 8mm, 16mm and 28mm in the West Area and at 10mm, 18mm, 25mm and 30mm in the Elephant Island Area. The 2mm difference between three of these modes can be explained by growth over the time between each was sampled (i.e., 4.5 days between the median survey dates). This approximates the 0.44mm per day growth rate previously derived from between-survey differences in length-frequency distributions. Solitary lengths ranged from 4-100mm with peaks at 4-20mm resulting from early summer production by mature aggregates and >45mm peaks resulting from the migration of mature individuals into the upper water column where they release the aggregate chains. Interestingly, 2mm differences between modal lengths of small solitaries in the two areas suggest a summer growth rate similar to that of the aggregates.

Salpa thompsoni Aggregate Stage Distribution Patterns (Figures 4.8c,d, 4.9)

Cluster analysis applied to aggregate length-frequency distributions in 28 samples resulted in three groups of stations whose distributions largely conform to flow characteristics depicted by the surface Chl-*a* maps (See Phytoplankton Report). Cluster 1 occurred at 11 stations generally offshore of the South Shetland Islands and within the Shackleton Fracture Zone gyre. This region had relatively large salp concentrations with respective mean and median values of 242 and 254 per 1000 m^3. Cluster 3, restricted to one station near the Shackleton Fracture Zone gyre boundary, had the densest salp concentrations (515 per 1000 m^3). Cluster 2, represented at 16 stations, was associated with flow of the SACCF along the outer island shelf region and predominantly in the lee of the Shackleton Fracture Zone. Here mean and median abundance values were comparatively low (92 and 80 per 1000 m^3).

Cluster 1 length-frequency distributions were centered on primary and secondary modes of 22mm and 31mm and reflect the typical seasonal production cycle with peak chain release during late spring and early summer (i.e., November-December). In contrast, 66% of the abundant Cluster 3 salps were $\leq$18mm and resulted from chain release within the past month (e.g., since mid-December). The 10mm primary length mode of Cluster 3 and Cluster 2 aggregates reflected chain release within the past two weeks while the secondary 25mm mode of Cluster 2 was from release ca. six weeks earlier (i.e., early December). Assuming that Cluster 1 salps are more characteristic of mainstream ACC populations, the seasonally lagged chain production of Clusters 2 and 3 conforms to that reported for higher latitude populations (Casereto and Nemoto, 1986).

Ihlea racovitzai Distribution and Abundance (Tables 4.4, 4.5; Figure 4.7)

Small numbers of this high latitude salp species were collected at 9 stations, seven of which were in Bransfield Strait and two between King George and Clarence Islands. Largest sample sizes contained 18-73 individuals (8-33 per 1000 m^3). These were from southeast Bransfield Strait off Joinville Island and reflect limited Weddell Sea (Zone 5 water) influence. Overall mean abundance of *I. racovitzai* was quite low (0.6 per 1000 m^3).

4.3.1.3 Zooplankton and Micronekton Assemblage:

Overall Composition, Abundance and Distribution Patterns (Tables 4.4, 4.5; Figures 4.10. 4.11)
Copepods were present in all samples, numerically dominated the zooplankton assemblage and, with a mean of 5994 per 100 m^3, comprised 69% of total mean zooplankton abundance. By far the most abundant species was *Calanoides acutus* which was present in all samples and alone made up 39% of mean zooplankton abundance. *Metridia gerlachei* and small unidentified "other" copepod species were also relatively abundant and respectively contributed 12% and 8% of the total. Mean concentrations of larval krill and larval *Thysanoessa macrura* abundance (1005 and 710 per 000 m^3) were similar to those of *M. gerlachei* and "other" copepods and respectively ranked second and third to total copepods. Because of their more limited distributions (59% and 75% of samples) the respective median values of krill and *T. macrura* larvae were relatively low (4 and 13 per 100 m^3) and ranked 8 and 4 overall. Chaetognaths were represented in all samples and followed total copepods in median abundance (146 vs. 1531 per 1000 m^3) but their mean concentrations (309 per 1000 m^3) ranked behind those of larval krill and *T. macrura.* Postlarval *T. macrura* were in 96% of samples and ranked 5 and 3 in mean and median abundance (249 and 95 per 1000 m^3). Due to their broad and relatively even distribution the median concentration of postlarval krill (9 per 1000 m^3) ranked 5. Other frequent and/or relatively abundant taxa included radiolaria, the pteropods *Limacina helicina* and *Spongiobranchaea australis*, euphausiid *Euphausia frigida*, amphipod *Primno macropa* and larvaceans. Mean abundance of *S. thompsoni* followed those of larvaceans and radiolaria and ranked 8 overall.

Copepods dominated the zooplankton taxa in each area, but were particularly abundant in the West and Elephant Island Areas leading to maximum mean and median copepod and total zooplankton values there. Dense concentrations of oceanic *C. acutus, Rhincalanus gigas, Calanus propinquus* and "other" copepod species were primarily located offshore of the South Shetland Islands and around the Shackleton Fracture Zone. Elevated concentrations of more coastal *M. gerlachei* occurred in Bransfield Strait, the Shackleton Fracture Zone and Elephant Island shelf region resulting in greatest abundance values in the Elephant Island and South Areas; it was the most abundant copepod species in the South Area.

While copepods numerically dominated the zooplankton in each area they contributed substantially greater proportions to total mean zooplankton abundance in the West (82%) and South (69%) vs. Elephant and Joinville Island Areas (53-55%). Greatest concentrations of larval *T. macrura* and chaetognaths were located offshore of the South Shetland Islands and their mean and median abundance values in the West Area ranked second and third to those of copepods. Together copepods (mostly *C. acutus*), *T. macrura* larvae and chaetognaths constituted 97% of total mean zooplankton abundance here. Due to extremely large concentrations of krill larvae in the eastern portion of the survey area and of chaetognaths over the Shackleton Fracture Zone these taxa ranked second and third in the Elephant Island Area. Larval and postlarval *T. macrura* were also relatively abundant here. Mean larval krill abundance ranked second to copepods in the Joinville Island area while postlarval *T. macrura*, which had mean and median abundance values similar to those in the Elephant Island Area, ranked third. As noted above, greatest concentrations of postlarval krill were in the Joinville Island Area where it ranked fourth in total mean zooplankton abundance. The South Area yielded greatest concentrations of postlarval *T. macrura* where these together with copepods constituted >88% of total zooplankton abundance. Chaetognaths and "ice krill" *Euphausia crystallorophias* were also relatively abundant in the South. Percent Similarity Index (PSI) comparisons of individual taxon proportions within each area, including copepod species, indicate greatest similarity between the Elephant and Joinville Island Areas (70) and greatest dissimilarity between the West vs. Joinville Island (27) and South (22) Areas.

Water Zone Affiliations

The distribution and abundance of various zooplankton taxa were associated with specific water zones. Most of these were characterized by significantly greater concentrations in Zone 1 (ACC) water than in Zones 2-4. These include larval *E. frigida* ($P<0.001$), *C. propinquus* ($P<0.001$), "other" copepods ($P<0.01$), chaetognaths ($P<0.05$), *S. australis* ($P<0.01$) and *L. helicina* ($P<0.001$), polychaete worm *Tomopteris* spp. ($P<0.01$), *S. thompsoni* and associated amphipods *Vibilia antarctica* and *Cyllopus magellanicus* (all $P<0.001$). Significantly greater abundance in Zone I vs. Zones II and IV was demonstrated by the copepods *C. acutus* and *R. gigas,* larval *T. macrura*, *P. macropa* and radiolaria (all $P<0.05$). Although Zone 5 (Weddell Sea) water was present at only two stations the concentrations of the pteropod *Clione limacina* and sipunculids were significantly greater here than in the other zones ($P<0.001$). Although greatest concentrations of *Ihlea racovitzai* were associated with Weddell Sea water their overall abundance was not sufficient to establish significant differences. Postlarval *T. macrura* , *E. crystallorophias* and larvaceans were more abundant in Bransfield Strait Zone IV than in Zones I and II ($P<0.05$).

Zooplankton Assemblages (Table 4.6; Figure 4.12)

Cluster analysis applied to the abundance of dominant taxa produced four groups that reflected water zone associations and hydrographic processes as described in the Physical Oceanography and Primary Productivity Reports of this Volume. Three groups conform to "Oceanic", "Intermediate" and "Coastal" clusters commonly observed in the AMLR survey area. Oceanic Cluster 1 was present at 24 stations offshore of the South Shetland Islands and within the Shackleton Fracture Zone gyre and was clearly associated with northeastward flowing Zone I (ACC) water. Coastal Cluster 3, present at 42 stations, was largely associated with Zone IV (Bransfield Strait) water and distributed across much of the area south of the South Shetland and Elephant Islands. Intermediate Cluster 2 occurred at 20 stations characterized by chlorophyll-rich mixed Zone II and Zone III water extending across the northern island shelf region to Elephant Island. The remaining "Northeast Fronts" Cluster 4 was restricted to 13 stations in the hydrographically complex region northeast and east of Elephant Island characterized by eddies and frontal zones between Bransfield Strait (Zone IV), ACC (Zone I) and mixed shelf (Zones II and III) water. Anomalies in distribution patterns such as the equatorward displacement of Coastal Cluster 3 across the northwest island shelf region and between King George and Livingston Islands and poleward displacement of Intermediate Cluster 2 into Bransfield Strait west of Livingston Island appear related to the complex inter-island flow dynamics depicted by dynamic heights, isothermal temperature plots and surface Chl-*a* maps.

Mean and median abundance of Oceanic Cluster 1 was an order of magnitude and significantly greater than in the Intermediate and Coastal clusters (ANOVA, P<0.01). This elevated abundance plus dominance by *C. acutus*, *R. gigas*, *C. propinquus*, larval *T. macrura*, chaetognaths, radiolaria, *S. thompsoni* and *L. helicina* correspond to zooplankton assemblages of the SACCF (Mackintosh, 1934). The comparatively depauperate fauna of the Antarctic Coastal Current ("East Wind Drift") is dominated by *M. gerlachei* and postlarval *T. macrura;* these two taxa comprised 56% of Cluster 3 mean abundance. Larval krill, postlarval krill and *E. crystallorophias* were also relatively abundant components of this group (6% mean abundance). Composition of Intermediate Cluster 2 is a mixture of SACCF and Coastal assemblages as indicated by high PSI values between this vs. Clusters 1 and 3 (both 83) compared to Cluster 1 vs. Cluster 3 (71). This is consistent with its association with mixed Zone II and III water. Cluster 4 differed greatly from the others as indicated by low PSIs (36-40). Mean and median zooplankton abundance values were similar to that of Cluster 1 but strong dominance by larval krill and *M. gerlachei* (79% total mean abundance) were unique and probably result from the juxtaposition of ACC, shelf and Bransfield Strait waters and concentration by a complex array of fronts and eddies. Larval krill concentrations in this frontal region were significantly greater than elsewhere (P<0.0001) and raise questions about their advective transport away from vs. retention and recruitment within the Antarctic Peninsula region.

Diel Abundance Differences

Although most samples were collected during daylight (70) there were sufficient numbers of night (15) and twilight (14) samples to determine significant catch differences resulting from vertical migration and/or net avoidance by various taxa. Among the euphausiids postlarval *T. macrura* and *E. frigida* had significantly greater night vs. day abundance (P<0.01) while nighttime concentrations of postlarval krill and *E. triacantha* were greater than those during day (P<0.01) and twilight (P<0.05 and P<0.01). *Euphausia crystallorophias* differed from these by having significantly greater twilight vs. day concentrations (P<0.05). Nighttime concentrations of *M. gerlachei* and *C. magellanicus* were greater than those during day and twilight (P<0.05). Lower day vs. night concentrations of juvenile silverfish *Pleuragramma antarcticum* (P<0.05) are probably due to net avoidance while those of *I. racovitzai* (P<0.01) most likely reflect vertical migration.

4.3.2 Survey A, Between-Year Comparisons:

4.3.2.1 Krill:

Postlarvae (Table 4.7, 4.8, 4.9, 4.10, Figure 4.13)

Mean and median krill abundance values in the Elephant Island Area (24 and 11 per 1000 m^3) were similar to the modest values observed during January 1993, 1998 and 2005 and suggest relatively poor recruitment success from the previous three years (i.e., since the 2001/02 year class). This is supported by similarly modest values in the South Area (26 and 8 per 1000 m^3). However, elevated concentrations and proportions of one- and two-year old krill in the Joinville Island area support the observation that during some years, such as 2001, young stages are concentrated here more than usual leading to low proportional recruitment values if not adequately sampled (Siegel *et al*., 2002). During January-February 2001 this poleward "displacement" was associated with widespread krill distributions (e.g., high frequency of occurrence in samples) and offshore concentrations dominated by 49-58mm adults with primarily gravid and spent females (Siegel *et al*., 2002), conditions also characterizing the AMLR 2006 survey. The estimated mean krill density in 2001 was largely due to two extremely large catches of juveniles in southeast Bransfield Strait. AMLR survey efforts during January 2001 yielded two relatively large juvenile catches near one of these stations located within the South Area, however no samples were collected to the east of these where the other large catch reported by Siegel *et al*. (2002) was located. If juveniles were similarly displaced and concentrated within dense patches in 2006, limited sampling of the Joinville Island Area, particularly the south and east sections, could have been inadequate to encounter them. Of note is the fact that greatest mean January krill concentrations were located in the Joinville Island Area during four of six years that it has been sampled supporting the idea that this is an important nursery area during early summer that has been chronically under sampled. However, the importance of this area for assessing krill recruitment success appears to be temporally limited due to ontogenetic seasonal migrations to higher latitudes as indicated by the February-March survey results.

Despite the marked decrease in acoustically detected krill biomass reported for the Elephant Island area during Survey A compared to last year (See Acoustics Section of this Report) the mean and median carbon biomass values based on net samples were strikingly similar for the two years. Both of the means (295-302 mg C per m^2) and medians (152-164 mg C per m^2) were slightly below the 11 year average (363 and 248 mg C per m^2). It is a puzzle why these net derived mean values correspond to the acoustically based value from 2005 (364 mg C per m^2) but not 2006 (See Acoustic Section 3 of this Report).

The overall krill length-frequency distribution in the Elephant Island area was most like those in 1995, 2000, 2001 (D_{max}=12-14) and 2005 (D_{max}=19) reflecting the prevalence of animals recruited four or five years earlier (i.e., the 1990/91, 1994/95 and 2000/01 year classes; Siegel *et al*., 2002) and paucity of juveniles. The maturity stage composition here was most like that in January-February 1995, 1999 and 2001 (PSI=73-79) when the collections were dominated by spermatophore bearing males and females in advanced maturity stages indicating a seasonally favorable spawning period.

Larvae (Tables 4.3; 4.7; 4.11)

Overall mean larval krill concentrations during Survey A (1005 per 1000 m^3) were the largest yet recorded for a January survey and ranked third after high values of the 1995 and 2000 February/March D Surveys (3690 and 2130 per 1000 m^3). Likewise, the mean value for the Elephant Island Area (2029 per 100 m^3) surpassed those from all previous January surveys and was twice the high observed in the Joinville Island Area during 2002. Among January surveys the overall 2006 median value (4 per 1000 m^3) was second to that of 2001 (12 per 1000 m^3) while that for the Elephant Island Area (19 per 1000 m^3) ranked third after the Joinville Island Area in 2002 and West Area in 2001 (93 and 66 per 1000 m^3). Krill recruitment success is associated with early spawning and abundant larvae as evidenced by the strong 1994/95, 1999/00, 2000/01 and 2001/02 year classes. Along with moderately high Joinville Island Area values (262 and 14 per 1000 m^3 mean and median) these larval krill concentrations should result in good recruitment success of the 2005/06 year class. However, both 2004 and 2005 spawning efforts apparently resulted in poor year class success despite the inclusion of more advanced larval stages during January and of moderately high concentrations during February of those years. This could be explained by larval transport out of the area with little local recruitment or, as discussed above, poleward displacement of the juveniles into unsampled coastal regions. In either case the location and movement of the SACCF are probably involved (Loeb *et al*., ms).

The larval stage composition during January 2006 was unusual in that the vast majority of individuals were C1 resulting from an apparent mass synchronized spawn in late December-early January. While the female maturity stage composition indicated some spawning activity, mostly within the Elephant Island Area, the prevalence of gravid females in the three other areas, as well as in the Nearshore Survey Area sampled in early February, three weeks after the start of Survey A, suggested a ca. month long period between two major synchronized spawning bouts. Intense synchronized spawning periods while unusual here have been noted in the past (e.g., 1980) and were attributed to the timing and speed of spring sea ice retreat and intensity of subsequent phytoplankton blooms (Spiridonov, 1995). Such appears to be the case during 2005/06, particularly if primary production associated with sea ice retreat was augmented by hydrographic conditions associated with the poleward location of the SACCF.

4.3.2.2 Salps:

Salpa thompsoni (Tables 4.7, 4.10, 4.11)

Mean and median concentrations of, and carbon biomass levels represented by, *S. thompsoni* in the Elephant Island Area (63 and 9 per 1000 m^3) were one to two orders of magnitude lower than during 2005 and quite similar to the low values in January 2003. These sparse salp concentrations rival lows observed during 1995 and 1996. All four years are distinguished by having $\leq$0.1 salp:krill median carbon biomass ratios. Of note is the fact that during 2004, 2005 and 2006 mean salp abundance values decreased sequentially from Zone I>II>III>IV>V water, supporting the idea that there was a major change in the source area and transport of this species after 2000 (Loeb and Hofmann, in press). Significantly larger salp concentrations occurred in Weddell Sea vs. ACC water (i.e., Zone V vs. I) in the pooled 1995-2000 data sets (ANOVA, $P<0.01$) while significantly greater concentrations were in ACC vs. water Zones II ($P<0.05$), III ($P<0.001$), 4 ($P<0.00001$) and 5 ($P<0.001$) in the pooled 2001-2006 data sets. This change is attributed to weakened transport of the Weddell gyre after the Pacific Ocean regime shift in 1998. Theoretically, during the "warm" 1977-1998 regime, cyclonic circulation of the Weddell gyre was strong enough to advect salp populations and favorable water column conditions from the east into the Antarctic Peninsula region. The current affiliation of *S. thompsoni* with the ACC conforms to its historical distribution pattern in the Antarctic Peninsula region (Mackintosh, 1934) and to its reported distribution elsewhere in the Southern Ocean (Atkinson *et al*., 2004).

Ihlea racovitzai (Tables 4.7, 4.11, 4.12)

Low concentrations of *I. racovitzai* during 2006 were similar to values observed during the 2000-2003 surveys and, like *S. thompsoni*, reflected reduced Weddell Sea influence during those periods. The association between this species and Weddell Sea water is indicated by significantly greater concentrations in Zone V water vs. Zones IV ($P<0.05$), III ($P<0.05$), II ($P<0.001$) and I ($P<0001$) across the 1998-2006 data sets.

4.3.2.3 Nekton and Micronekton (Tables 4.7, 4.11, 4.12, 4.13, 4.14): Total mean zooplankton abundance during January 2006 (8648 per 1000 m^3) was exceeded only by that observed during January 2002 (11,143 per 1000 m^3). Both of these were due to exceedingly large numbers of copepods that rivaled or surpassed seasonally elevated concentrations typically observed during February-March surveys. Numerical dominance by copepods and krill larvae observed in 2006 also occurred during January 1995 and probably 2000, based on their large concentrations during Survey D that year (7,139 and 2,130 per 1000 m^3, respectively). Other taxa represented by abundance maxima during this large area survey include chaetognaths, postlarval *T. macrura,* larvaceans, amphipods *Primno macropa* and *Scina* spp., polychaetes *Tomopteris* spp. and *Rhynchonereella bograni,* larval/juvenile stages of the fish *Electrona* spp., *Pleuragramma antarcticum*, *Lepidonotothen kempi* and *Notolepis coatsi* while the second highest mean concentrations were represented by larval *T. macrura*, radiolaria, *Limacina helicina*, *Euphausia frigida*, ostracods, and sipunculids.

Within the Elephant Island Area mean and median copepod concentrations also rivaled the highs of January 2002. As typical for January surveys, *M. gerlachei* was the most abundant copepod species here. However, mean and median concentrations of this coastal species were at least two times greater than those observed since 1999. Similarly, abundances of oceanic *R. gigas* and "other" copepods were the highest over this time period with means >two times and medians >9 times previous values, while the values for *C. acutus* and *C. propinquus* were second only to those of January 2002. Copepod species abundance relationships here were most like those observed in January 2001 (PSI=80). Among other zooplankton taxa, concentrations of larval krill, chaetognaths and *Euphausia frigida* in 2006 were far greater than previously observed here during January.

Together copepods and larval krill contributed 83% of total mean zooplankton abundance in the Elephant Island Area, exceeding their proportions during the 1995 (74%) and 1999 (69%) surveys. Contributions of third and fourth ranked chaetognaths and larval *T. macrura* were similar to those of 1999. In contrast, the relative contributions by *S. thompsoni* (<1%) and *I. racovitzai* (<0.01%) were the lowest observed in the long term data base. Accordingly, greatest PSI values (77) resulted from comparisons with 1995 and 1999 while lowest values (8 to 27) resulted from comparisons with 1994, 1998 and 2005 surveys when *S. thompsoni* dominated and alone constituted 61-81% of total mean zooplankton abundance.

Source Water Indicator Species

Zooplankton abundance, taxonomic composition and abundance relationships during 2006 reflect strong oceanic influences by the SACCF and coastal influences through enhanced flow from Gerlache Strait into Bransfield Strait as indicated by the satellite-derived sea surface Chl-*a* maps (See Oceanography and Phytoplankton Sections of this Volume). Late 2005-early 2006, like the 1995-1996 and 1999-2003 periods, was characterized by cool La Niña conditions in the equatorial Pacific. Such periods are marked by increased eastward transport by the ACC and reduced intensity of the Weddell Sea gyre (Loeb *et al*., ms). These contrast markedly from 1993-1994, 1997-1998 and 2003-2004 periods dominated by warm El Niño events and marked by sluggish flow of the ACC and an intensified Weddell gyre. The strong difference between these "West Wind Drift" and "East Wind Drift" periods allow us to identify "indicator species" for different source areas that supply zooplankton to the survey area and thus are responsible for interannual variations in zooplankton composition and abundance.

Weddell Sea: *Ihlea racovitzai.* The recurring distribution pattern of *I. racovitzai* during AMLR surveys and its reported distribution primarily east of the Antarctic Peninsula (Foxton, 1971) strongly suggest its affiliation with Weddell Sea water. This is supported by significantly greater concentrations within Zone 5 vs. other waters during the 1998-2006 surveys (ANOVA $P<0.05$). Large numbers of this salp were first noted in the Antarctic Peninsula region during February-March 1986; it was also reported to be abundant in the South Shetland Island Area during December 1993-January 1994 (Nishikawa *et al*., 1995) and most frequent and abundant during the 1998 and 2004 AMLR surveys. Each of these periods was characterized by negative Southern Oscillation Index (SOI) values associated with El Niños or transitions between La Niña and El Niño events and presumably reflect enhanced westward transport by Weddell Sea water at the time.

Gerlache Strait: *Euphausia crystallorophias* and *Pleuragramma antarcticum* (Figure 4.14). Ice krill and juvenile silver fish were infrequently collected until AMLR expanded survey efforts into western Bransfield Strait in 2002. Their distribution patterns reflect a source in southwest Bransfield Strait, as reported by Brinton and Townsend (1991) and Loeb (1991), with subsequent transport northeastward through Bransfield Strait and along the Antarctic Peninsula in accordance with surface currents described by Zhou *et al*. (2002). Both species had greatest mean abundance during 2002, 2003 and 2006 surveys and their mean survey abundances between 1993 and 2006 are positively correlated (n=25, Kendall's $T = +0.35$, $P<0.05$). While both *E. crystallorophias* and *P. antarcticum* also occur in the eastern Weddell Sea AMLR survey results indicate that Gerlache Strait is their primary source area. This is supported by significant negative correlations between mean survey abundance of *I. racovitzai* and *E. crystallorophias* (n=16, T=-0.38, $P<0.05$) and *P. antarcticum* (n=16, T=-0.50, $P<0.01$) between 1998 and 2006. Additionally, significant correlations between the abundance of postlarval *T. macrura* vs. *E. crystallorophias* (n=25, T=+0.31, $P<0.05$) and vs. *P. antarcticum* (n=25, T=+0.48, $P<0.001$) suggest that elevated concentrations of this euphausiid species across the survey area may also result from increased transport from Gerlache Strait. These results are consistent with ENSO and Antarctic dipole forcing of ACC (eastward flow) vs. Weddell Gyre (westward flow).

Antarctic Circumpolar Current: The zooplankton rich "West Wind Drift" assemblage. As noted above and in Table 4.6, the SACCF is characterized by dense zooplankton assemblages numerically dominated by the copepods *C. acutus*, *R. gigas* and *C. propinquus* and also containing elevated concentrations of larval *T. macrura*, chaetognaths, radiolaria, *L. helicina*, *S. australis* and *Tomopteris* spp. These taxa prevailed during the 1995-1996, 1999-2003 "copepod years" as well as 2006 and represented poleward displacement of the SACCF into the survey area during these cool La Niña or "Niño-neutral" periods.

4.4 AMLR 2006 Cruise Summary:

1. Mean and median krill abundance in the Elephant Island Area were similar to the modest values observed during January 1993, 1998 and 2005 and, along with the length-frequency

distribution, reflect relatively poor recruitment success from the previous three years (i.e., since the 2001/02 year class).

2. Despite their modest concentrations rich krill supplies were apparently available to land-based predators suggesting that the krill distributional attributes, particularly over the inner island shelf areas, provided good forage.

3. Elevated concentrations of 1- and 2-year old krill in the Joinville Island Area suggest that, like 2001, the young stages were concentrated as dense patches within this sparsely sampled area resulting in underestimated proportional recruitment values.

4. Across the entire survey area postlarval krill were obviously benefiting from favorable feeding conditions afforded by the prevailing phytoplankton bloom. Given overwhelming dominance of C1 larvae, the first major synchronous spawning effort began in late December-early January and prevalence of gravid females suggests that a second major spawning effort would occur during early February.

5. Overall mean larval krill concentrations in 2006 were the largest yet recorded for a January survey while the median value was second to that of 2001. Given these elevated concentrations, plus an anticipated second massive spawning bout in February, the 2005/06 year class may be among the most successful ever monitored. However, this will depend on favorable transport and overwintering conditions.

6. Mean and median concentrations and carbon biomass levels represented by *Salpa thompsoni* rivaled lows observed during 1995, 1996 and 2003. The association of this salp with the ACC since 2001 conforms to its historical distribution pattern in the Antarctic Peninsula region and to its reported distribution elsewhere in the Southern Ocean. Presumably overwintering conditions were not favorable for their population growth poleward of the SACCF. Extremely low concentrations of *Ihlea racovitzai* this season reflected minimal input from the Weddell gyre.

7. Total mean zooplankton abundance was exceeded only by that observed during January 2002 and similarly resulted from dense offshore concentrations of copepods, particularly *Calanoides acutus, Calanus propinquus* and *Rhincalanus gigas,* along with elevated numbers of larval *Thysanoessa macrura, Euphausia frigida*, chaetognaths, radiolaria, ostracods, *Limacina helicina*, *Primno macropa and Tomopteris* spp. This abundant, species-rich zooplankton assemblage characterizes the SACCF and its presence was associated by the poleward location of this front well into the survey area.

8. Elevated zooplankton abundance within Bransfield Strait was due primarily to large concentrations of the coastal copepod *Metridia gerlachei* and postlarval *Thysanoessa macrura.* Relatively large numbers of ice krill, *Euphausia crystallorophias*, and juvenile Antarctic silverfish, *Pleuragramma antarcticum,* indicate enhanced faunal input from Gerlache Strait.

9. Zooplankton abundance, taxonomic composition and abundance relationships during 2006 reflected strong oceanic influences by the SACCF and coastal influences through enhanced flow from Gerlache Strait into Bransfield Strait. These conditions, like the 1995-1996 and 1999-2003

periods, coincided with cool La Nina events in the tropical Pacific and are consistent with coupled atmospheric-oceanic processes resulting from the Antarctic dipole that result in increased eastward transport by the ACC and reduced intensity of the Weddell Sea gyre (Loeb *et al*. ms).

4.5 Disposition of Data and Samples: All of the krill, salp and other zooplankton data have been digitized and are available upon request from Valerie Loeb. These data have been submitted to (Southwest Fisheries Science Center). Postlarval krill length frequency data have been provided to Volker Siegel (Sea Fisheries Institute, Hamburg) for computation of krill proportional recruitment indices. Frozen krill and myctophids were provided to Mike Goebel (Southwest Fisheries Science Center) for chemical analyses. Preserved krill samples were saved for chemical analyses by Julian Ashford (Old Dominion University). Entire samples or representative subsamples from each station were preserved and shipped back to La Jolla, CA, for long term storage.

4.5 Problems and Suggestions:

(1) Given the extraordinarily high primary and secondary productivity observed during January, and an anticipated second synchronized massive krill spawning bout in February, the lack of the second krill stock assessment survey this year was a major scientific loss. We will never know the levels of larval production, but they most likely were record breaking. Nor will be able to assess the importance of seasonal changes in larval distribution patterns and ultimate local recruitment success. Hopefully we will be able to resume two month-long krill surveys in the future, and if so, at least be able to consistently monitor the Elephant Island Area across the summer season.

(2) The Joinville Island Area has shown year after year to be an important location for juvenile and immature krill, yet is highly under sampled. We highly recommend increased sampling effort there to a level similar to that represented by the South Area Elephant Island grid (i.e., 1 per 1224 km^2, or.15 stations). Also, it is imperative that sampling be done as close as possible to specified station locations (and as close to the ice as possible) here and elsewhere in the survey area.

(3) Collaboration. Collaboration among the AMLR scientists should be encouraged and supported. In the distant past the program held work sessions in order to coordinate and encourage collaborative efforts but those failed dismally, probably due to combination of personalities and the program's newness. Now with a wealth of data and insight resulting from 16 years of experience it is time to focus on data synthesis and production of publishable interdisciplinary manuscripts.

4.6 Acknowledgments: It was wonderful to once again enjoy the facilities of the R/V *Yuzhmorgeologiya*, her Captain, crew and scientists. The food gets better and better each year! It was also 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 away below decks....often giving us enough time to capture some of these on film!

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Table 4.1. AMLR 2006 Large Area Survey IKMT station information. Double lines denote subarea divisions.

SURVEY A

STATION	DATE	TIME		DIEL	TOW	FLOW		KRILL	
		START	END		DEPTH	VOL.		ABUNDANCE	
		(LOCAL)			(m)	(m3)	TOTAL (N)	No./m^2	No./1000m^3
WEST AREA:									
A18-12	16/01/06	0525	0552	D	150	2397.2	21	1.3	8.8
A19-11	16/01/06	0855	0918	D	170	1757.6	19	1.8	10.8
A20-10	16/01/06	1115	1139	D	170	2344.0	47	3.4	20.1
A19-09	16/01/06	1839	1906	D	168	2421.7	6	0.4	2.5
A18-10	16/01/06	2211	2240	D	165	2404.7	5	0.3	2.1
A17-11	17/01/06	0127	0150	T	108	2166.1	89	4.4	41.1
A16-10	17/01/06	0434	0504	D	170	2473.7	132	9.1	53.4
A17-09	17/01/06	0749	0816	D	168	2343.8	19	1.4	8.1
A18-08	17/01/06	1120	1147	D	170	2280.8	16	1.2	7.0
A17-07	17/01/06	1404	1435	D	170	2316.1	27	2.0	11.7
A16-08	17/01/06	2145	2211	D	171	2014.7	16	1.4	7.9
A15-09	18/01/06	0124	0155	N	170	2475.9	26	1.8	10.5
A14-10	18/01/06	0452	0505	T	69	1081.0	13	0.8	12.0
A13-09	18/01/06	0739	0806	D	170	2371.8	47	3.4	19.8
A14-08	18/01/06	1100	1128	D	170	2354.2	22	1.6	9.3
A15-07	18/01/06	1333	1405	D	171	2657.6	4	0.3	1.5
A16-06	18/01/06	2042	2108	D	171	2192.8	0	0.0	0.0
A15-05	19/01/06	0006	0034	N	170	2225.1	2	0.2	0.9
A14-06	19/01/06	0434	0514	D	171	2317.1	0	0.0	0.0
A13-07	19/01/06	0823	0851	D	171	2293.0	8	0.6	3.5
A12-08	19/01/06	1140	1208	D	171	2249.0	5	0.4	2.2
A11-07	19/01/06	1819	1848	D	169	2400.9	34	2.4	14.2
A11-05	19/01/06	2245	2313	T	170	2387.6	0	0.0	0.0
A11-03	20/01/06	0314	0342	T	170	2384.8	0	0.0	0.0
A11-01	20/01/06	0736	0810	D	170	2630.1	0	0.0	0.0
ELEPHANT ISLAND AREA:									
A09-01	20/01/06	1221	1253	D	171	2589.9	12	0.8	4.6
A09-02	20/01/06	1415	1444	D	170	2342.2	0	0.0	0.0
A09-03	20/01/06	2058	2124	D	170	2106.4	0	0.0	0.0
A09-04	20/01/06	2342	0008	N	170	1868.3	0	0.0	0.0
A09-05	21/01/06	0225	0255	N	170	2301.8	0	0.0	0.0
A09-06	21/01/06	0515	0546	T	170	2394.6	18	1.3	7.5
A09-07	21/01/06	0758	0825	D	168	2300.8	27	2.0	11.7
A09-08	21/01/06	1042	1100	D	170	2206.8	83	6.4	37.6
A08-08	21/01/06	1309	1342	D	170	2533.2	104	7.0	41.1
A08-06	21/01/06	2014	2042	D	169	2211.8	47	3.6	21.3
A08-04	22/01/06	0029	0058	N	171	2236.7	0	0.0	0.0
A08-02	22/01/06	0404	0432	D	170	2084.8	0	0.0	0.0
A07-01	22/01/06	1123	1159	D	170	2254.9	23	1.7	10.2
A07-02	22/01/06	1426	1456	D	170	2644.4	2	0.1	0.8
A07-03	22/01/06	1728	1800	D	170	2618.9	8	0.5	3.1
A07-04	22/01/06	2112	2137	D	170	1963.8	0	0.0	0.0
A07-05	23/01/06	0026	0058	N	170	2519.6	37	2.5	14.7
A07-06	23/01/06	0329	0355	T	172	2129.9	32	2.6	15.0
A07-07	23/01/06	0627	0659	D	170	2500.3	68	4.6	27.2
A07-08	23/01/06	0938	1006	D	171	2316.5	33	2.4	14.2
A05.5-08	23/01/06	1257	1330	D	170	2744.1	10	0.6	3.6
A05.5-07	23/01/06	1842	1900	D	109	1386.9	6	0.5	4.3
A05.5-06	23/01/06	2115	2132	D	109	1424.8	12	0.9	8.4
A05.5-05	23/01/06	2346	0011	N	155	2012.3	9	0.7	4.5
A05.5-04	24/01/06	0247	0315	N	169	2352.4	96	6.9	40.8
A05.5-03	24/01/06	0540	0613	D	171	2406.7	3	0.2	1.2
A05.5-02	24/01/06	0841	0912	D	169	2344.0	32	2.3	13.7
A05.5-01	24/01/06	1048	1117	D	170	2511.3	43	2.9	17.1
A04-01	24/01/06	1748	1821	D	169	2700.3	19	1.2	7.0
A04-02	24/01/06	2047	2114	D	170	2161.8	14	1.1	6.5
A04-03	24/01/06	2343	0011	N	170	2454.8	48	3.3	19.6
A04-04	25/01/06	0243	0303	N	170	2142.5	27	2.1	12.6
A04-05	25/01/06	0527	0556	D	170	2169.1	51	4.0	23.5
A04-06	25/01/06	1005	1017	D	77	1099.7	0	0.0	0.0
A04-07	25/01/06	1241	1313	D	171	2781.7	90	5.5	32.4
A04-08	25/01/06	1858	1928	D	170	2583.8	70	4.6	27.1
A03-08	25/01/06	2211	2240	T	169	2396.8	0	0.0	0.0
A03-06	26/01/06	0256	0324	T	170	2274.0	122	9.1	53.6

Table 4.1 (Contd.)
SURVEY A

STATION	DATE	TIME		DIEL	TOW	FLOW		KRILL	
		START	END		DEPTH	VOL.		ABUNDANCE	
		(LOCAL)			(m)	(m3)	TOTAL (N)	No./m^2	No./1000m^3
A03-04	26/01/06	0720	0751	D	171	2440.4	132	9.2	54.1
A03-02	26/01/06	1102	1131	D	170	2517.7	28	1.9	11.1
A02-01	26/01/06	1835	1905	D	170	2164.2	24	1.9	11.1
A02-02	26/01/06	2120	2147	T	169	2115.0	21	1.7	9.9
A02-03	27/01/06	0005	0035	N	170	2545.2	767	51.2	301.4
A02-04	27/01/06	0249	0316	N	167	2179.8	236	18.1	108.3
A02-05	27/01/06	0531	0601	D	170	2298.6	297	22.0	129.2
A02-06	27/01/06	0831	0859	D	170	2294.0	4	0.3	1.7
A02-07	27/01/06	1055	1122	D	169	2137.6	42	3.3	19.6
A02-08	27/01/06	1639	1710	D	170	2619.1	34	2.2	13.0
JOINVILLE ISLAND AREA:									
A02-09	27/01/06	2020	2046	D	170	2041.3	59	4.9	28.9
A02-11	28/01/06	0530	0600	D	170	2617.1	1	0.1	0.4
A04-10	28/01/06	1014	1043	D	168	2419.1	0	0.0	0.0
A04-09	28/01/06	1304	1337	D	170	2431.8	28	2.0	11.5
A06-09	28/01/06	2011	2036	D	170	2023.6	41	3.4	20.3
A06-11	29/01/06	0017	0047	N	171	2196.2	1118	87.0	509.1
SOUTH AREA:									
A07-11	29/01/06	0344	0413	T	170	2157.8	26	2.0	12.0
A08-10	29/01/06	0722	0751	D	170	2450.2	7	0.5	2.9
A09-09	29/01/06	1009	1036	D	169	2290.0	17	1.3	7.4
A10-10	29/01/06	1402	1430	D	171	2185.0	3	0.2	1.4
A09-11	29/01/06	2139	2206	T	171	2179.6	32	2.5	14.7
A08-12	30/01/06	0015	0044	N	171	2199.6	617	48.0	280.5
A09-13	30/01/06	0352	0425	T	170	2504.1	24	1.6	9.6
A10-12	30/01/06	0624	0653	D	170	2359.6	19	1.4	8.1
A11-11	30/01/06	0959	1025	D	169	2033.2	7	0.6	3.4
A13-11	30/01/06	1300	1330	D	171	2341.3	5	0.4	2.1
A12-12	30/01/06	1848	1918	D	170	2415.6	42	3.0	17.4
A11-13	30/01/06	2142	2208	T	169	2025.0	1	0.1	0.5
A12-14	31/01/06	0021	0050	N	170	2091.3	99	8.0	47.3
A13-13	31/01/06	0518	0547	T	170	2271.2	11	0.8	4.8
A14-12	31/01/06	0824	0851	D	170	2208.5	11	0.8	5.0
A15-13	31/01/06	2038	2106	D	170	2080.4	24	2.0	11.5
A14-14	01/02/06	0004	0033	N	170	2161.8	15	1.2	6.9
A15-15	01/02/06	0450	0520	D	170	2028.2	14	1.2	6.9
A16-14	01/02/06	0831	0859	D	169	2246.9	31	2.3	13.8
A17-13	01/02/06	1142	1209	D	169	2330.9	159	11.5	68.2

			TOTAL (N)	No./m^2	No./1000m^3
SURVEY A TOTAL:	N=99		5700		
		MEAN		4.2	25.1
		STD		11.2	65.7
		MEDIAN		1.4	9.3
WEST AREA:	N=25		558		
		MEAN		1.5	9.9
		STD		1.9	12.6
		MEDIAN		1.2	7.9
ELEPHANT ISLAND AREA:	N=48		2731		
		MEAN		4.0	23.8
		STD		8.1	47.7
		MEDIAN		1.9	11.1
JOINVILLE ISLAND AREA:	N= 6		1247		
		MEAN		16.2	95.0
		STD		31.7	185.4
		MEDIAN		2.7	15.9
SOUTH AREA:	N=20		1164		
		MEAN		4.5	26.2
		STD		10.3	60.5
		MEDIAN		1.3	7.7

Table 4.2 Maturity stage composition of krill collected in the Large Survey Area and subareas during January 2006. Advanced maturity stages are proportions of mature females that are 3c-3e in January.

	Euphausia superba January 2006				
Area	Survey A	West	Elephant I.	Joinville I.	South
Stage	%	%	%	%	%
Juveniles	5.7	0.0	0.5	18.7	5.2
Immature	13.2	0.4	6.7	29.3	14.9
Mature	81.1	99.6	92.7	51.9	79.9
Females:					
F2	1.8	0.0	0.4	6.0	0.9
F3a	1.0	0.2	0.6	2.6	0.3
F3b	4.9	0.8	10.0	0.6	0.4
F3c	6.8	2.8	7.0	8.2	6.7
F3d	18.1	18.1	10.9	18.9	32.6
F3e	8.6	4.6	16.2	2.1	1.0
Advanced Stages	85.1	96.2	76.2	93.2	98.3
Males:					
M2a	5.8	0.2	2.5	14.7	5.4
M2b	3.2	0.0	2.6	5.1	3.9
M2c	2.4	0.2	1.3	3.6	4.7
M3a	3.0	0.0	1.9	3.5	6.1
M3b	38.7	73.1	46.0	16.0	32.9
Male:Female	1.3	2.8	1.2	1.1	1.3
No. measured	3149	527	1721	234	667

Table 4.3. Larval krill stage composition and abundance in (A) Large Survey Areas, 1996-2006, and (B) total Large Survey Area and subareas, 2000-2006. Only pooled calyptopis and furcilia stages provided for 1996-1999. Individual stages provided for 2000-2006 surveys.

(A) Large Survey Area

Stage %	A96	A97	A98	A99	A00	A01	A02	A03	A04	A05	A06
Calyptopis Total	100	93	68	100	n.a.	100	70	100	95	99	100
Furcilia Total	---	7	32	---	n.a.	---	30	---	5	1	---
No. per 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
STD	7.5	27.1	4.5	587.4	n.a.	710.8	48.6	12.1	14.6	66.8	3702.8
Med	0.0	0.8	0.0	2.6	n.a.	12.5	0.0	0.0	0.4	0.5	4.1

Stage %	D96	D97	D98	D99	D00	D01	D02	D03	D04	D05	D06
Calyptopis Total	86	100	99	97	97	98	85	89	44	85	n.a.
Furcilia Total	14	---	1	3	3	2	15	11	56	15	n.a.
No. per 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.
STD	40.2	81.4	14.1	119.3	7247.8	3607.1	220.4	10.5	523.1	840.6	n.a.
Median	3.0	0.0	0.0	9.0	34.2	10.5	0.0	0.0	20.2	0.0	n.a.

(B) Total Large Survey Area, Elephant Island, West, South and Joinville Island Areas

Survey	A00	A01				A02				
Stage %		Total	West	Eleph	South	Total	West	Eleph	South	Joinvl
C1		24.0	17.6	68.4	95.3	37.3	50.0	40.3	13.9	5.0
C2		66.3	72.7	22.1	---	15.8	50.0	16.3	7.0	2.9
C3		9.7	9.7	9.3	---	17.4	---	20.3	---	52.5
Unid.		---	---	0.2	4.7	---	---	---	---	---
Calyptopis Total		100	100	100	100	70.5	100	76.9	20.9	60.4
F1		---	---	---	---	9.6	---	6.2	35	38.2
F2		---	---	---	---	19.9	---	17.0	44.1	1.4
F3		---	---	---	---	---	---	---	---	---
Unid.		---	---	---	---	---	---	---	---	---
Furcilia Total		---	---	---	---	29.5	---	23.1	79.1	39.6
No. per 1000 m^3										
Mean		160.2	472.6	32.8	2.9	19.4	1.5	35.8	13.4	1107.0
STD		710.8	1243.8	86.2	6.9	48.6	7.6	64.6	30.3	2602.6
Median		12.5	66.5	9.0	---	---	---	---	---	92.9

Survey	A03					A04				
Stage %	Total	West	Eleph	South	Joinvl	Total	West	Eleph	South	Joinvl
C1	87.5	77.7	89.7	100	100	64.5	80.0	63.4	60.7	68.2
C2	9.6	1.9	8.8	---	---	18.5	8.3	22.1	7.6	24.9
C3	3.6	20.4	1.5	---	---	10.3	---	12.4	8.6	---
Unid.	---	---	---	---	---	1.8	4.3	2.0	0.0	---
Calyptopis Total	100	100	100	100	100	95.1	92.6	100	76.9	93.1
F1	---	---	---	---	---	3.7	---	---	19.3	6.9
F2	---	---	---	---	---	0.7	---	---	3.9	---
F3	---	---	---	---	---	---	---	---	---	---
Unid.	---	---	---	---	---	0.6	7.4	---	---	---
Furcilia Total	---	---	---	---	---	4.9	7.4	---	23.1	6.9
No. per 1000 m^3										
Mean	3.4	3.6	4.7	1.0	7.1	7.0	2.2	9.8	7.0	4.6
STD	12.1	7.5	16.8	3.1	6.4	14.6	6.5	18.5	9.4	6.3
Median	---	---	---	---	5.7	0.4	---	0.4	2.4	2.0

Survey	A05					A06				
Stage %	Total	West	Eleph	South	Joinvl	Total	West	Eleph	South	Joinvl
C1	81.7	84.3	90.8	64.2	78.6	99.3	94.2	99.9	94.7	99.9
C2	11.2	---	6.6	22.2	10.3	0.6	3.4	0.1	3.9	0.1
C3	3.5	---	0.2	8.0	11.0	0.1	---	---	---	---
Unid.	2.0	3.7	1.4	4.2	---	---	---	---	---	---
Calyptopis Total	98.9	88.0	100	98.6	100	100	97.6	100	98.6	100
F1	1.0	12.0	---	1.4	---	---	1.8	---	1.4	---
F2	---	---	---	---	---	---	---	---	---	---
F3	---	---	---	---	---	---	---	---	---	---
Unid.	0.1	---	---	---	---	---	0.6	---	---	---
Furcilia Total	1.1	12.0	---	1.4	---	---	2.4	---	1.4	---
No. per 1000 m^3										
Mean	18.6	2.8	22.0	26.4	30.9	1005.2	8.2	2029.4	16.4	261.5
STD	66.8	8.3	78.3	79.6	40.6	3702.8	22.1	5118.2	53.0	554.5
Median	0.5	---	1.1	1.2	13.8	4.1	0.0	18.9	0.0	14.2

Survey	D00				D01				D02				
Stage %	Total	West	Eleph	South	Total	West	Eleph	South	Total	West	Eleph	South	Joinvl
C1	46.3	48.8	46.3	32.6	57.1	37.6	58.4	17.8	18.5	3.2	42.2	50.3	---
C2	40.5	29.3	40.5	55.2	29.8	36.1	29.4	15.2	12.1	16.7	4.1	49.7	15.6
C3	9.9	21.1	9.8	12.2	11.2	18.0	10.7	67.0	49.5	70.0	23.5	---	29.5
Unid.	0.6	---	0.6	---	---	0.8	---	---	5.3	9.5	---	---	---
Calyptopis Total	96.9	99.2	96.9	100	98.2	92.5	98.6	100	85.5	99.3	69.8	100	45.1
F1	1.4	0.8	1.4	---	1.8	7.4	1.4	---	10.4	0.7	22.8	---	26.8
F2	1.2	---	1.2	---	---	0.1	---	---	3.4	---	7.4	---	12.1
F3	0.1	---	0.1	---	---	---	---	---	0.7	---	---	---	16.1
Unid.	---	---	---	---	---	---	---	---	---	---	---	---	---
Furcilia Total	2.7	0.8	2.7	---	1.8	7.5	1.4	---	14.5	0.7	30.2	---	54.9
No. per 1000 m^3													
Mean	2129.6	37.8	3423.2	11.1	683.4	2119.3	71.9	4.8	61.0	133.7	49.9	0.4	29.2
STD	7247.8	75.2	8974.1	11.2	3607.1	6328.9	176.9	9.8	220.4	380.9	140.9	1.1	38.4
Median	34.2	9.5	248.7	9.6	10.5	42.5	5.1	---	---	---	---	---	0.0

Survey	D03					D04				
Stage %	Total	West	Eleph	South	Joinvl	Total	West	Eleph	South	Joinvl
C1	67.7	100	63.4	78.8	100	17.0	31.6	14.2	37.5	17.8
C2	21.2	---	22.8	21.2	---	15.1	27.1	10.7	29.6	41.3
C3	---	---	---	---	---	11.8	40.2	8.0	14.9	13.5
Unid.	---	---	---	---	---	---	---	---	---	---
Calyptopis Total	88.9	100	86.2	100	100	43.9	98.9	32.9	82.0	72.6
F1	1.1	---	1.3	---	---	5.8	1.1	5.8	9.0	11.4
F2	10.0	---	12.5	---	---	24.5	---	29.3	4.7	13.4
F3	---	---	---	---	---	25.6	---	31.6	4.3	2.6
Unid.	---	---	---	---	---	0.3	---	0.4	---	---
Furcilia Total	11.1	---	13.8	---	---	56.1	1.1	67.1	18.0	27.4
No. per 1000 m^3										
Mean	3.9	0.1	6.1	2.8	4.8	107.7	41.0	177.3	23.2	87.2
STD	10.5	0.6	13.0	9.1	7.9	523.1	79.7	741.5	31.6	86.4
Median	---	---	---	---	0.4	20.2	15.1	38.9	5.2	40.7

Survey	D05					D06
Stage %	Total	West	Eleph	South	Joinvl	
C1	12.2	100	22.2	2.2	0.3	
C2	55.2	---	45.0	15.6	86.0	
C3	15.3	---	18.1	21.7	8.7	
Unid.	2.4	---	4.5	---	---	
Calyptopis Total	85.1	100	89.9	39.5	95.0	
F1	12.4	---	9.9	46.3	3.5	
F2	2.2	---	---	13.9	1.1	
F3	0.1	---	---	---	0.4	
Unid.	0.2	---	0.3	0.3	---	
Furcilia Total	14.9	---	10.1	60.5	5.0	
No. per 1000 m^3						
Mean	183.1	0.8	194.8	127.9	1014.4	
STD	840.6	3.9	969.1	511.8	1511.1	
Median	---	---	4.6	0.4	33.2	

Table 4.4. Composition and abundance of zooplankton assemblages sampled in the large Survey A area, January, 2006. F(%) is frequency of occurrence in samples. R is rank and % is percent of total mean abundance (No. per 1000 m^3) represented by each taxon.
L & J denote larval and juvenile stages.

MLR 2006 SURVEY A (N=99)

TAXON	F(%)	R	%	MEAN	STD	MEDIAN	MAX
Total Copepods	100.0	1	69.3	5993.5	19929.5	1531.2	186740.2
Calanoides acutus	100.0		39.0	3376.1	17335.0	212.4	162989.5
Other copepods	99.0		8.2	710.5	1360.0	240.7	9714.6
Calanus propinquus	98.0		2.4	210.2	313.0	88.0	1590.4
Rhincalanus gigas	92.9		4.3	373.9	1128.0	119.6	9718.5
Pareuchaeta spp.	90.9		2.7	232.3	291.2	121.1	1382.5
Metridia gerlachei	85.9		11.7	1016.0	2332.4	130.7	17343.9
Haloptilus ocellatus	31.3		0.1	8.3	23.0	0.0	155.1
Pareuchaeta antarctica	28.3		0.0	2.6	14.3	0.0	108.8
Copepod nauplii	6.1		0.7	60.4	458.1	0.0	4317.6
Pleuromama robusta	6.1		0.0	1.3	6.6	0.0	53.0
Candacia spp.	4.0		0.0	1.4	12.8	0.0	127.6
Heterorhabdus sp.	2.0		0.0	0.2	1.6	0.0	13.9
Eucalanus sp.	2.0		0.0	0.1	1.1	0.0	11.2
Oithona spp.	2.0		0.0	0.1	0.6	0.0	5.6
Copepodites	1.0		0.0	0.0	0.0	0.0	0.0
Chaetognaths	100.0	4	3.6	308.6	571.5	146.0	4323.2
Thysanoessa macrura	96.0	5	2.9	249.2	451.3	94.6	3732.5
Euphausia superba	86.9	11	0.3	25.1	65.7	9.3	509.1
Primno macropa	79.8	15	0.1	12.2	37.1	3.8	346.0
Spongiobranchaea australis	79.8		0.0	2.5	2.9	1.5	13.3
Thysanoessa macrura (L)	74.7	3	7.5	646.0	2899.5	12.6	25905.6
Tomopteris spp.	73.7		0.1	5.4	11.7	1.5	87.4
Radiolaria	72.7	7	0.9	81.3	462.0	1.5	4066.7
Limacina helicina	71.7	9	0.4	32.6	62.4	8.3	307.8
Euphausia frigida	70.7	12	0.3	25.1	49.7	4.2	328.4
Salpa thompsoni	61.6	8	0.6	49.1	99.7	1.3	514.9
Euphausia superba (L)	58.6	2	11.6	1005.2	3702.8	4.1	20541.3
Vibilia antarctica	58.6		0.1	6.2	10.6	0.5	66.5
Themisto gaudichaudii	57.6		0.1	7.1	17.3	0.9	96.8
Electrona spp. (L)	57.6		0.0	2.7	5.6	0.4	36.3
Ostracods	54.5	13	0.2	18.5	45.9	1.5	315.2
Clione limacina	54.5		0.0	0.8	1.7	0.4	13.2
Hyperiella dilatata	49.5		0.0	0.6	1.1	0.0	6.8
Cyllopus magellanicus	42.4		0.0	1.2	2.4	0.0	13.9
Larval Fish (unid)	38.4		0.0	2.0	5.3	0.0	26.0
Lepidonotothen larseni (L)	37.4		0.0	0.7	1.5	0.0	6.5
Rhynchonereelia bongraini	35.4		0.0	1.5	4.5	0.0	40.1
Euphausia frigida (L)	34.3	10	0.3	30.1	84.2	0.0	597.7
Euphausia spp. (L)	32.3		0.1	12.2	56.7	0.0	518.6
Notolepis coatsi (L)	32.3		0.0	0.5	1.3	0.0	7.9
Diphyes antarctica	30.3		0.0	0.4	0.8	0.0	4.5
Lepidonotothen kempi (L)	29.3		0.0	0.8	2.0	0.0	12.4
Sipunculids	28.3		0.0	1.1	4.1	0.0	31.8
Callanira antarctica	24.2		0.0	0.5	3.1	0.0	30.9
Acanthophyra pelagica	24.2		0.0	0.2	0.4	0.0	2.9
Euphausia crystallorophias	22.2	14	0.2	13.4	69.0	0.0	617.8
Siphonophora (unid)	22.2		0.0	3.9	16.8	0.0	157.7
Polychaetes (unid)	22.2		0.0	3.3	15.9	0.0	128.1
Pleuragramma antarcticum (L	22.2		0.0	1.5	11.7	0.0	117.3
Euphausia triacantha	19.2		0.0	1.4	5.1	0.0	31.7
Hydromedusae (unid)	17.2		0.0	0.1	0.2	0.0	0.8
Notolepis spp. (L)	15.2		0.0	0.3	1.6	0.0	14.3
Larvaceans	13.1	6	1.0	87.1	853.8	0.0	8538.9
Amphipods (unid)	13.1		0.0	0.5	1.9	0.0	11.2
Pegantha martgon	13.1		0.0	0.2	0.7	0.0	4.9
Ihlea racovitzai	11.1		0.0	0.6	3.5	0.0	33.2
Isopods (unid)	11.1		0.0	0.3	1.3	0.0	8.8
Gastropods (unid)	11.1		0.0	0.2	0.9	0.0	7.7
Euphausia spp.	10.1		0.1	7.8	75.5	0.0	755.2
Hyperiella spp.	10.1		0.0	0.9	8.6	0.0	86.3

Table 4.4 (Contd.)

TAXON	F(%)	R	%	MEAN	STD	MEDIAN	MAX
Hyperiids (unid)	9.1		0.0	0.3	1.9	0.0	18.0
Clio pyramidata spp?	9.1		0.0	0.0	0.2	0.0	1.0
Hyperiella macronyx	9.1		0.0	0.0	0.1	0.0	0.9
Scina spp.	8.1		0.0	0.9	4.4	0.0	34.1
Ctenophora (unid)	8.1		0.0	0.0	0.2	0.0	1.8
Schyphomedusae (unid)	8.1		0.0	0.0	0.2	0.0	1.0
Orchomene plebs	7.1		0.0	0.1	0.5	0.0	3.7
Cyllopus lucasii	7.1		0.0	0.1	0.3	0.0	2.5
Beroe cucumis	7.1		0.0	0.1	0.3	0.0	2.3
Cyllopus spp.	6.1		0.0	0.0	0.2	0.0	1.3
Notolepis annulata (L)	6.1		0.0	0.0	0.2	0.0	0.9
Calycopsis borchgrevinki	6.1		0.0	0.0	0.1	0.0	0.5
Eusirus antarcticus	6.1		0.0	0.0	0.1	0.0	0.5
Limacina spp.	5.1		0.0	0.4	2.2	0.0	16.3
Electrona antarctica	5.1		0.0	0.0	0.2	0.0	1.4
Dimophyes arctica	5.1		0.0	0.0	0.2	0.0	1.4
Bathylagus sp. (L)	4.0		0.0	0.0	0.2	0.0	1.7
Tunicata (unid)	4.0		0.0	0.0	0.1	0.0	0.8
Cumaceans	3.0		0.0	0.7	6.3	0.0	62.6
Orchomene rossi	3.0		0.0	0.4	3.8	0.0	38.3
Pelagobia longicirrata	3.0		0.0	0.1	0.4	0.0	3.6
Pasiaphaea spp. (L)	3.0		0.0	0.1	0.5	0.0	4.5
Pleurobrachia pileus	3.0		0.0	0.0	0.3	0.0	2.3
Gymnoscopelus braueri	3.0		0.0	0.0	0.2	0.0	1.2
Hyperoche medusarum	3.0		0.0	0.0	0.1	0.0	0.9
Electrona carlsbergi	3.0		0.0	0.0	0.1	0.0	0.9
Periphylla periphylla	3.0		0.0	0.0	0.1	0.0	0.4
Gammarids (unid)	2.0		0.0	0.1	0.8	0.0	7.8
Harpagifer antarcticus (L)	2.0		0.0	0.1	0.4	0.0	3.6
Spongiobranchaea sp.	2.0		0.0	0.0	0.3	0.0	3.4
Oediceroides calmani (?)	2.0		0.0	0.0	0.3	0.0	2.5
Epimeriella macronyx	2.0		0.0	0.0	0.2	0.0	2.3
Lensia spp.	2.0		0.0	0.0	0.2	0.0	2.0
Orchomene spp.	2.0		0.0	0.0	0.1	0.0	1.4
Clio pyramidata sulcata?	2.0		0.0	0.0	0.1	0.0	0.9
Vanadis antarctica	2.0		0.0	0.0	0.1	0.0	0.5
Beroe forskalii	1.0		0.0	0.0	0.1	0.0	1.2
Eusirus perdentatus	1.0		0.0	0.0	0.1	0.0	1.0
Hyperia medusarum	1.0		0.0	0.0	0.1	0.0	0.9
Semaeostomea (unid)	1.0		0.0	0.0	0.1	0.0	0.9
Thyploscolex spp.	1.0		0.0	0.0	0.1	0.0	0.8
Hyperiella antarctica	1.0		0.0	0.0	0.1	0.0	0.8
Heterophoxus videns	1.0		0.0	0.0	0.0	0.0	0.5
Atolla wyvillei	1.0		0.0	0.0	0.0	0.0	0.5
Hydro/Scyphomedusae (unid)	1.0		0.0	0.0	0.0	0.0	0.5
Desmonema gaudichaudi	1.0		0.0	0.0	0.0	0.0	0.5
Cephalopods	1.0		0.0	0.0	0.0	0.0	0.5
Chionodraco rastrospinosus (I	1.0		0.0	0.0	0.0	0.0	0.5
Solomdella spp.	1.0		0.0	0.0	0.0	0.0	0.4
Decapod Larvae	1.0		0.0	0.0	0.0	0.0	0.4
Clione antarctica	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
Nansithae spp.	1.0		0.0	0.0	0.0	0.0	0.4
Gonatus antarcticus	1.0		0.0	0.0	0.0	0.0	0.4
Trematomus scotti (L)	1.0		0.0	0.0	0.0	0.0	0.4
Botrynema brucei	1.0		0.0	0.0	0.0	0.0	0.4
Euphausia triacantha (L)	1.0		0.0	0.0	0.0	0.0	0.0
Lepidonotothen larseni (J)	1.0		0.0	0.0	0.0	0.0	0.0
Parachaenichthys charcoti (L)	1.0		0.0	0.0	0.0	0.0	0.0
TOTAL				8648.3	23638.9	2403.9	
TAXA	119			21.7	4.4	22	33

Table 4.5. Composition and abundance of zooplankton assemblages sampled in four subareas during January 2006 Survey A. F(%) is frequency of occurrence in samples. R is rank and % is proportion of total mean abundance (No. per 1000 m^3) represented by each taxon. (L) and (J) denote larval and juvenile stages.

AMLR 2006 SURVEY A	WEST AREA						ELEPHANT ISLAND AREA						JOINVILLE ISLAND AREA						SOUTH AREA					
	(N=25)						(N=48)						(N= 6)						(N=20)					
TAXON	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Total Copepods	100.0	1	82.0	14599.7	37868.8	1409.3	100.0	1	52.8	3677.8	3563.5	2279.8	100.0	1	55.3	783.4	775.5	361.4	100.0	1	69.1	2356.4	4002.3	765.9
Calanoides acutus	100.0		64.1	11412.7	33146.0	269.6	100.0		13.6	948.0	1526.1	260.3	100.0		7.1	101.1	42.3	91.2	100.0		4.1	140.3	89.0	99.4
Other copepods	100.0		7.9	1403.0	2347.9	207.4	97.9		9.2	644.1	722.8	390.1	100.0		9.2	130.6	95.0	91.7	100.0		5.2	178.3	115.4	132.4
Rhincalanus gigas	96.0		4.6	820.2	2090.5	120.6	97.9		4.2	292.7	414.4	165.9	100.0		2.8	39.3	50.8	14.2	75.0		3.3	111.3	235.7	14.3
Metridia gerlachei	72.0		2.0	364.8	858.3	30.9	93.8		16.6	1157.1	2000.0	254.3	83.3		27.0	382.7	730.9	73.5	85.0		49.3	1681.5	3886.7	166.7
Calanus propinquus	96.0		1.3	226.1	320.0	74.8	97.9		4.1	284.2	358.1	141.1	100.0		5.1	72.3	61.5	53.7	100.0		1.6	54.1	66.5	20.1
Pareuchaeta spp.	88.0		1.0	186.2	323.2	45.2	87.5		4.3	297.4	306.6	192.1	100.0		4.0	57.3	56.8	44.1	100.0		5.5	186.2	196.0	117.5
Copepod nauplii	12.0		1.0	174.2	845.8	0.0	6.3		0.5	33.8	225.5	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Pareuchaeta antarctica	40.0		0.0	8.9	27.4	0.0	25.0		0.0	0.5	1.5	0.0	33.3		0.0	0.2	0.2	0.0	20.0		0.0	0.4	1.1	0.0
Pleuromama robusta	4.0		0.0	2.1	10.4	0.0	10.4		0.0	1.6	5.8	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Haloptilus ocellatus	24.0		0.0	1.5	3.4	0.0	43.8		0.2	15.3	30.9	0.0	0.0		0.0	0.0	0.0	0.0	20.0		0.1	2.7	9.2	0.0
Heterorhabdus sp.	0.0		0.0	0.0	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	1.1	3.5	0.0
Candacia spp.	0.0		0.0	0.0	0.0	0.0	6.3		0.0	2.7	18.2	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.4	1.6	0.0
Eucalanus sp.	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.2	1.6	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.1	0.4	0.0
Oithona spp.	0.0		0.0	0.0	0.0	0.0	0.00		0.0	0.1	0.8	0.0	16.7		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Thysanoessa macrura (L)	76.0	2	11.9	2115.0	5470.7	104.7	77.1	4	3.2	224.6	481.3	19.6	100.0		1.7	23.5	23.6	11.2	60.0		0.2	8.0	13.2	3.4
Chaetognaths	100.0	3	2.7	485.2	933.6	179.7	100.0	3	4.5	314.3	409.5	178.8	100.0		1.4	20.2	22.6	6.6	100.0	3	4.7	160.7	197.6	76.3
Thysanoessa macrura	100.0	4	0.7	126.3	189.3	48.9	91.7	6	2.3	159.4	211.8	79.6	100.0	3	7.6	107.6	54.3	93.8	100.0	2	19.4	660.9	800.6	396.1
Radiolaria	72.0	5	0.6	105.1	423.7	0.9	72.9	7	1.5	106.9	585.5	1.8	83.3		0.3	3.7	3.9	1.4	70.0	10	0.4	13.2	28.4	1.2
Salpa thompsoni	92.0	6	0.4	72.4	130.1	6.8	70.8	8	0.9	63.2	99.6	9.4	0.0		0.0	0.0	0.0	0.0	20.0		0.0	0.9	2.3	0.0
Limacina helicina	64.0	7	0.3	59.0	92.9	2.1	72.9		0.4	25.6	52.8	7.8	100.0	5	2.6	36.9	21.4	37.7	70.0	9	0.4	15.3	19.4	9.8
Euphausia spp. (L)	52.0	8	0.2	38.3	107.4	2.1	27.1		0.1	4.8	12.1	0.0	33.3		0.1	1.6	2.5	0.0	20.0		0.0	0.6	1.4	0.0
Euphausia spp.	4.0	9	0.2	30.2	148.0	0.0	0.0		0.0	0.0	0.0	0.0	50.0		0.0	0.5	0.6	0.2	30.0		0.0	0.6	1.2	0.0
Primno macropa	84.0	10	0.2	28.7	69.0	6.5	83.3		0.1	8.5	12.1	4.7	66.7		0.4	5.2	6.3	3.1	70.0		0.1	2.4	4.0	0.7
Ostracods	52.0		0.1	25.3	52.6	1.7	52.1		0.2	12.7	23.7	0.4	66.7		2.1	30.0	51.7	1.5	60.0	7	0.6	20.3	68.0	2.2
Themisto gaudichaudii	100.0		0.1	17.2	25.1	7.3	45.8		0.0	1.7	4.6	0.0	0.0		0.0	0.0	0.0	0.0	50.0		0.3	9.8	20.4	0.7
Euphausia frigida	64.0		0.1	16.9	21.9	4.1	70.8	10	0.5	33.4	59.3	4.8	66.7		0.1	2.0	2.1	1.2	80.0	6	0.6	22.1	52.6	6.1
Euphausia frigida (L)	28.0		0.1	15.9	52.7	0.0	54.2	9	0.8	53.8	109.6	1.9	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.1	0.4	0.0
Vibilia antarctica	76.0		0.1	10.2	13.9	3.7	66.7		0.1	7.3	10.1	2.2	16.7		0.1	1.1	2.5	0.0	30.0		0.0	0.2	0.4	0.0
Euphausia superba	84.0		0.1	9.9	12.6	7.9	81.3		0.3	23.8	47.7	11.1	83.3	4	6.7	95.0	185.4	15.9	100.0	5	0.8	26.2	60.5	7.7
Tomopteris spp.	96.0		0.0	8.7	17.0	4.5	79.2		0.1	6.0	10.8	2.0	50.0		0.1	0.9	1.4	0.2	40.0		0.0	1.1	2.2	0.0
Euphausia superba (L)	28.0		0.0	8.2	22.1	0.0	75.0	2	29.1	2029.4	5118.2	18.9	100.0	2	18.5	261.5	554.5	14.2	45.0	8	0.5	16.4	53.0	0.0
Polychaetes (unid)	28.0		0.0	4.7	17.7	0.0	20.8		0.1	4.1	18.8	0.0	50.0		0.0	0.6	0.8	0.2	10.0		0.0	0.3	1.0	0.0
Hyperiella spp.	12.0		0.0	3.5	16.9	0.0	14.6		0.0	0.1	0.2	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Electrona spp. (L)	60.0		0.0	3.0	5.5	0.4	70.8		0.1	3.7	6.8	0.8	0.0		0.0	0.0	0.0	0.0	40.0		0.0	0.5	0.8	0.0
Larval Fish (unid)	44.0		0.0	2.9	6.0	0.0	43.8		0.0	2.4	6.1	0.0	16.7		0.0	0.3	0.6	0.0	25.0		0.0	0.4	1.1	0.0
Spongiobranchaea australis	92.0		0.0	2.2	1.9	1.9	85.4		0.0	3.0	3.0	2.3	33.3		0.1	0.8	1.6	0.0	65.0		0.1	2.1	3.5	0.4
Siphonophora (unid)	16.0		0.0	1.6	4.9	0.0	12.5		0.0	1.8	5.5	0.0	66.7		0.5	6.9	9.6	1.4	40.0		0.3	11.2	34.4	0.0
Cyllopus magellanicus	52.0		0.0	1.5	2.2	0.4	52.1		0.0	1.6	2.9	0.4	33.3		0.0	0.3	0.5	0.0	10.0		0.0	0.1	0.2	0.0
Lepidonotothen kempi (L)	32.0		0.0	1.2	2.9	0.0	22.9		0.0	0.3	0.8	0.0	50.0		0.0	0.2	0.2	0.2	35.0		0.0	1.5	2.4	0.0
Hyperiella dilatata	48.0		0.0	0.8	1.1	0.0	41.7		0.0	0.3	0.4	0.0	66.7		0.2	2.2	2.4	1.4	65.0		0.0	0.8	1.1	0.5
Hyperiids (unid.)	12.0		0.0	0.8	3.5	0.0	6.3		0.0	0.1	0.6	0.0	0.0		0.0	0.0	0.0	0.0	15.0		0.0	0.1	0.4	0.0
Amphipods (unid)	16.0		0.0	0.7	2.0	0.0	10.4		0.0	0.5	2.2	0.0	33.3		0.0	0.6	0.9	0.0	10.0		0.0	0.2	0.8	0.0
Euphausia triacantha	16.0		0.0	0.6	1.9	0.0	25.0		0.0	2.5	7.0	0.0	0.0		0.0	0.0	0.0	0.0	15.0		0.0	0.1	0.2	0.0
Lepidonotothen larseni (L)	24.0		0.0	0.6	1.4	0.0	31.3		0.0	0.8	1.6	0.0	50.0		0.0	0.6	1.0	0.2	65.0		0.0	0.9	1.3	0.5
Clione limacina	48.0		0.0	0.5	0.8	0.0	50.0		0.0	0.7	1.9	0.2	83.3		0.2	2.7	2.8	1.9	65.0		0.0	0.8	0.9	0.5
Diphyes antarctica	24.0		0.0	0.3	0.6	0.0	22.9		0.0	0.2	0.5	0.0	50.0		0.1	0.8	0.9	0.4	50.0		0.0	0.7	1.1	0.2
Notolepis coatsi (L)	32.0		0.0	0.3	0.5	0.0	39.6		0.0	0.9	1.7	0.0	0.0		0.0	0.0	0.0	0.0	25.0		0.0	0.2	0.5	0.0
Acanthophyra pelagica	20.0		0.0	0.2	0.4	0.0	20.8		0.0	0.1	0.3	0.0	16.7		0.0	0.5	1.1	0.0	40.0		0.0	0.2	0.4	0.0
Pleuragramma antarcticum (J)	8.0		0.0	0.2	0.6	0.0	14.6		0.0	2.5	16.7	0.0	50.0		0.1	1.2	1.5	0.2	50.0		0.0	0.9	1.3	0.2
Pleurobrachia pileus	12.0		0.0	0.1	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
Sipunculids	4.0		0.0	0.1	0.7	0.0	20.8		0.0	0.3	0.6	0.0	66.7		0.3	4.9	8.9	0.9	65.0		0.1	3.1	7.0	0.4
Pelagobia longicirrata	4.0		0.0	0.1	0.7	0.0	2.1		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.2	0.0
Callanira antarctica	8.0		0.0	0.1	0.5	0.0	27.1		0.0	0.8	4.4	0.0	66.7		0.0	0.6	0.6	0.5	25.0		0.0	0.3	0.7	0.0
Spongiobranchaea sp.	4.0		0.0	0.1	0.7	0.0	2.1		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
Isopods (unid)	4.0		0.0	0.1	0.6	0.0	12.5		0.0	0.4	1.6	0.0	16.7		0.0	0.4	0.9	0.0	15.0		0.0	0.3	0.9	0.0
Pegantha martgon	8.0		0.0	0.1	0.4	0.0	20.8		0.0	0.3	1.0	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0
Beroe cucumis	8.0		0.0	0.1	0.5	0.0	4.2		0.0	0.0	0.1	0.0	16.7		0.0	0.1	0.2	0.0	10.0		0.0	0.0	0.1	0.0
Limacina spp.	4.0		0.0	0.1	0.5	0.0	0.0		0.0	0.0	0.0	0.0	16.7		0.0	0.1	0.2	0.0	15.0		0.0	1.6	4.6	0.0
Gastropods (unid)	4.0		0.0	0.1	0.4	0.0	4.2		0.0	0.0	0.1	0.0	66.7		0.1	1.8	2.8	0.4	20.0		0.0	0.2	0.5	0.0
Clio pyramidata spp?	16.0		0.0	0.1	0.2	0.0	2.1		0.0	0.0	0.1	0.0	50.0		0.0	0.3	0.4	0.2	5.0		0.0	0.0	0.1	0.0
Orchomene plebs	8.0		0.0	0.1	0.2	0.0	2.1		0.0	0.0	0.1	0.0	16.7		0.0	0.4	0.8	0.0	15.0		0.0	0.3	0.9	0.0
Notolepis spp. (L)	8.0		0.0	0.1	0.2	0.0	22.9		0.0	0.6	2.3	0.0	16.7		0.0	0.2	0.5	0.0	5.0		0.0	0.0	0.2	0.0
Hydromedusae (unid)	12.0		0.0	0.1	0.1	0.0	20.8		0.0	0.1	0.2	0.0	16.7		0.0	0.1	0.2	0.0	15.0		0.0	0.1	0.2	0.0

Table 4.5 (Contd.)

TAXON	WEST AREA						ELEPHANT ISLAND AREA						JOINVILLE ISLAND AREA						SOUTH AREA					
	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Schyphomedusae (unid)	12.0		0.0	0.0	0.2	0.0	4.2		0.0	0.0	0.2	0.0	16.7		0.0	0.1	0.2	0.0	10.0		0.0	0.0	0.1	0.0
Gymnoscopelus braueri	4.0		0.0	0.0	0.2	0.0	4.2		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
Bathylagus sp. (L)	8.0		0.0	0.0	0.1	0.0	4.2		0.0	0.1	0.3	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)	8.0		0.0	0.0	0.1	0.0	6.3		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.2	0.0
Electrona antarctica	4.0		0.0	0.0	0.2	0.0	6.3		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.2	0.0
Tunicata (unid)	4.0		0.0	0.0	0.1	0.0	6.3		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
Electrona carlsbergi	4.0		0.0	0.0	0.1	0.0	4.2		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
Cumaceans	4.0		0.0	0.0	0.1	0.0	4.2		0.0	1.3	8.9	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Cephalopods	4.0		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	0.0	0.0	0.0
Hyperiella macronyx	4.0		0.0	0.0	0.1	0.0	10.4		0.0	0.0	0.1	0.0	16.7		0.0	0.1	0.2	0.0	10.0		0.0	0.1	0.2	0.0
Cyllopus spp.	4.0		0.0	0.0	0.1	0.0	8.3		0.0	0.1	0.2	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.2	0.0
Calycopsis borchgrevinki	4.0		0.0	0.0	0.1	0.0	6.3		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	10.0		0.0	0.0	0.1	0.0
Clione antarctica	4.0		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	0.0	0.0	0.0
Krefftichthys anderssoni	4.0		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	0.0	0.0	0.0
Nansithae spp.	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	0.0	0.0	0.0
Ctenophora (unid)	4.0		0.0	0.0	0.1	0.0	8.3		0.0	0.0	0.2	0.0	33.3		0.0	0.3	0.7	0.0	5.0		0.0	0.0	0.1	0.0
Orchomene spp.	4.0		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	5.0		0.0	0.1	0.3	0.0
Vanadis antarctica	4.0		0.0	0.0	0.1	0.0	2.1		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
Larvaceans	0.0		0.0	0.0	0.0	0.0	12.5	5	2.6	178.6	1219.5	0.0	33.3		0.3	3.6	5.6	0.0	25.0		0.0	1.5	3.1	0.0
Rhynchonereelia bongraini	0.0		0.0	0.0	0.0	0.0	41.7		0.0	2.5	6.2	0.0	83.3		0.1	1.3	1.2	1.0	50.0		0.0	1.4	2.0	0.2
Scina spp.	0.0		0.0	0.0	0.0	0.0	14.6		0.0	1.8	6.2	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.1	0.4	0.0
Orchomene rossi	0.0		0.0	0.0	0.0	0.0	4.2		0.0	0.8	5.5	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.1	0.3	0.0
Gammarids (unid)	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.2	1.1	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0
Ihlea racovitzai	4.0		0.0	0.0	0.0	0.0	4.2		0.0	0.1	0.6	0.0	33.3		0.2	2.8	3.9	0.0	30.0		0.1	1.9	7.2	0.0
Cyllopus lucasii	0.0		0.0	0.0	0.0	0.0	6.3		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0	20.0		0.0	0.2	0.4	0.0
Dimophyes arctica	0.0		0.0	0.0	0.0	0.0	8.3		0.0	0.1	0.3	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0
Oediceroides calmani (?)	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0
Hyperoche medusarum	0.0		0.0	0.0	0.0	0.0	6.3		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
Periphylla periphylla	0.0		0.0	0.0	0.0	0.0	6.3		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
Beroe forskalii	0.0		0.0	0.0	0.0	0.0	2.1		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
Euphausia crystallorophias	0.0		0.0	0.0	0.0	0.0	4.2		0.0	0.0	0.1	0.0	83.3		0.6	8.5	11.8	3.6	75.0	4	1.9	63.7	142.5	5.5
Eusirus perdentatus	0.0		0.0	0.0	0.0	0.0	2.1		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
Semaeostomea (unid)	0.0		0.0	0.0	0.0	0.0	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
Eusirus antarcticus	0.0		0.0	0.0	0.0	0.0	4.2		0.0	0.0	0.1	0.0	50.0		0.0	0.2	0.2	0.2	5.0		0.0	0.0	0.1	0.0
Hyperiella antarctica	0.0		0.0	0.0	0.0	0.0	2.1		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
Clio pyramidata sulcata?	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.2	0.0
Heterophoxus videns	0.0		0.0	0.0	0.0	0.0	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
Solomdella spp.	0.0		0.0	0.0	0.0	0.0	2.1		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
Decapod Larvae	0.0		0.0	0.0	0.0	0.0	2.1		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
Epimeriella macronyx	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	5.0		0.0	0.1	0.5	0.0
Gonatus antarcticus	0.0		0.0	0.0	0.0	0.0	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
Trematomus scotti (L)	0.0		0.0	0.0	0.0	0.0	2.1		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
Botrynema brucei	0.0		0.0	0.0	0.0	0.0	2.1		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
Pasiaphaea spp. (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	33.3		0.0	0.1	0.2	0.0	5.0		0.0	0.2	1.0	0.0
Harpagifer antarcticus (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	10.0		0.0	0.2	0.8	0.0
Lensia 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	10.0		0.0	0.1	0.4	0.0
Hyperia 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	0.0	0.0	0.0	5.0		0.0	0.0	0.2	0.0
Thyploscolex 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	5.0		0.0	0.0	0.2	0.0
Atolla wyvillei	0.0		0.0	0.0	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
Hydro/Scyphomedusae (unid)	0.0		0.0	0.0	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
Desmonema gaudichaudi	0.0		0.0	0.0	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
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	0.0	0.0	0.0	5.0		0.0	0.0	0.1	0.0
Parachaenichthys charcoti (L)	0.0		0.0	0.0	0.0	0.0	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
Euphausia triacantha (L)	0.0		0.0	0.0	0.0	0.0	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
TOTAL				17799.5	44389.8	2403.9				6967.6	7194.1	4974.9				1416.8	1221.7	594.7				3412.4	4874.5	1994.5
TAXA				20.5	3.5	20.0				21.7	4.4	22.0				24.5	2.2	24.5				22.3	5.4	23.5

Table 4.6. Taxonomic composition of zooplankton clusters during January, 2006. R and % are rank and proportions of total abundance (No. per 1000 m^3) represented by each taxon. Asterisks denote significantly greater abundance within one cluster vs. all others based on ANOVA (**P<0.01, *P<0.05).

	CLUSTER1 (OCEANIC) (N=24)					CLUSTER 2 (INTERMEDIATE) (N=20)					CLUSTER 3 (COASTAL) (N=42)					CLUSTER 4 (NORTHEAST FRONTS) (N=13)					
TAXON	R	%	MEAN	STD	MEDIAN	R	%	MEAN	STD	MEDIAN	R	%	MEAN	STD	MEDIAN	R	%	AVG	MEAN	STD	MEDIAN
Copepods	1	79.6	18305.0 *	37583.3	7869.9	1	75.2	2447.3	2343.5	1092.4	1	65.2	1308.8	2790.3	578.0	2	32.3	3855.4		2959.6	2916.6
Calanoides acutus		57.2	13144.3 *	33362.0	2854.8		14.2	462.4	776.2	227.2		6.9	138.7	129.1	99.4		2.4	284.5		164.0	260.1
Other copepods		8.7	1989.1 **	2244.8	1547.2		10.2	332.8	290.5	205.1		7.8	155.8	111.2	120.4		6.1	723.4		616.8	517.8
Rhincalanus gigas		5.0	1154.4 **	2088.1	413.1		5.6	181.3	101.4	196.7		4.7	94.8	190.1	26.9		1.1	130.9		126.9	86.9
Metridia gerlachei		3.5	799.3	823.1	372.7		36.4	1182.5	1903.2	60.9		36.7	735.9	2720.5	50.0		17.3	2065.0		3034.9	895.5
Calanus propinquus		2.2	497.1 *	438.8	268.3		2.8	92.5	103.4	56.9		3.5	69.8	65.0	50.7		2.6	315.2		335.2	219.0
Pareuchaeta spp.		1.9	433.4	391.2	344.3		5.7	185.4	219.0	92.8		5.6	112.7	165.2	42.1		2.7	320.0		263.1	221.2
Haloptilus ocellatus		0.1	23.6	40.0	10.8		0.1	2.9	9.2	0.0		0.0	0.5	1.5	0.0		0.1	13.8		15.3	11.9
Pareuchaeta antarctica		0.0	5.1	21.7	0.0		0.2	5.5	20.2	0.0		0.0	0.4	1.1	0.0		0.0	0.5		1.4	0.0
Thysanoessa macrura (L)	2	11.1	2557.0 **	5460.1	608.9	4	2.3	76.0	216.4	10.7	10	0.4	8.8	14.6	4.3	5	0.4	53.7		71.9	18.1
Chaetognaths	3	3.4	792.8 **	978.1	520.0	3	7.2	235.4	155.6	218.8	3	4.1	82.1	118.8	41.3	3	2.2	258.9		171.5	231.7
Radiolaria	4	1.4	316.3 *	898.2	10.6		0.2	7.0	16.0	1.2		0.3	5.3	17.9	0.8		0.1	7.1		14.5	1.4
Salpa thompsoni	5	0.7	169.4 **	138.8	150.7	7	0.6	19.1	30.0	5.0		0.0	0.4	1.1	0.0	9	0.3	30.2		51.2	1.7
Limacina helicina	6	0.4	101.2 **	94.8	72.9		0.2	5.0	11.7	0.5	8	0.8	16.5	18.7	10.6		0.0	0.6		1.4	0.0
Euphausia frigida (L)	7	0.4	97.3 *	143.7	30.0		0.1	3.8	11.6	0.0		0.0	0.4	1.3	0.0	8	0.4	42.3		56.7	8.6
Euphausia spp. (L)	8	0.2	42.9	108.8	0.0		0.2	6.2	14.0	0.0		0.1	1.1	2.4	0.0		0.0	0.7		2.3	0.0
Ostracods	9	0.1	34.4	57.3	6.1	8	0.5	15.9	16.7	9.4	9	0.7	13.9	52.1	0.0	10	0.1	7.7		9.3	0.4
Primno macropa	10	0.1	33.0 *	70.4	5.8		0.2	6.3	9.8	1.8		0.2	4.6	4.6	3.8		0.1	7.4		6.9	5.6
Thysanoessa macrura		0.1	24.6	32.5	9.1	2	9.2	298.7	282.2	209.3	2	19.5	391.2	616.7	198.6	4	1.1	128.8		145.3	81.5
Euphausia superba (L)		0.1	22.3	40.2	0.2		0.2	8.1	16.7	0.0	4	2.9	57.2	232.4	3.8	1	62.1	7416.5	**	7544.2	3689.0
Vibilia antarctica		0.1	16.6 **	14.3	13.3		0.2	5.3	8.3	1.1		0.0	0.9	2.8	0.0		0.0	5.9		7.5	0.9
Tomopteris spp.		0.1	14.8 **	19.7	6.5		0.1	3.0	6.2	0.9		0.1	1.3	2.2	0.2		0.0	4.8		5.4	3.2
Euphausia frigida		0.1	14.3	26.4	0.9	5	1.2	38.5	38.8	25.2	7	0.9	18.0	61.0	1.7	6	0.4	46.9		45.6	34.6
Themisto gaudichaudii		0.0	6.4	11.6	2.0	9	0.4	14.4	19.6	6.9		0.3	6.2	20.1	0.0		0.0	0.3		0.6	0.0
Electrona spp. (L)		0.0	5.6	9.2	1.9		0.1	2.3	3.5	0.5		0.0	0.9	2.2	0.0		0.0	3.6		5.0	2.2
Spongiobranchaea australis		0.0	4.6	2.8	3.9		0.1	2.0	2.2	1.4		0.1	1.2	2.3	0.4		0.0	3.5		3.0	2.2
Cyllopus magellanicus		0.0	3.7 **	3.5	3.3		0.0	0.6	1.7	0.0		0.0	0.2	0.4	0.0		0.0	0.7		1.1	0.4
Euphausia triacantha		0.0	3.5	9.2	0.0		0.0	1.5	2.9	0.0		0.0	0.0	0.2	0.0		0.0	1.7		3.8	0.0
Euphausia superba		0.0	2.7	4.1	0.6	6	0.6	19.6	17.5	14.0	5	1.7	34.5	87.1	10.2	7	0.4	44.7		79.0	12.6
Callanira antarctica		0.0	1.5	6.1	0.0		0.0	0.0	0.1	0.0		0.0	0.3	0.6	0.0		0.0	0.2		0.4	0.0
Hyperiella dilatata		0.0	0.9	0.9	0.5		0.0	0.2	0.4	0.0		0.0	0.8	1.4	0.0		0.0	0.3		0.3	0.4
Rhynchonereelia bongraini		0.0	0.9	2.8	0.0		0.0	1.1	2.2	0.0		0.1	1.6	2.2	0.4		0.0	3.2		10.7	0.0
Clione limacina		0.0	0.8	0.9	0.4		0.0	0.5	0.7	0.0		0.0	0.9	1.5	0.5		0.0	1.1		3.5	0.0
Lepidonotothen kempi (L)		0.0	0.2	0.8	0.0		0.0	1.5	2.4	0.2		0.0	0.9	2.2	0.0		0.0	0.3		0.8	0.0
Diphyes antarctica		0.0	0.1	0.3	0.0		0.0	0.4	0.7	0.0		0.0	0.5	0.9	0.0		0.0	0.2		0.6	0.0
Lepidonotothen larseni (L)		0.0	0.0	0.1	0.0		0.0	1.1	1.8	0.0		0.1	1.1	1.7	0.4		0.0	0.3		0.6	0.0
Notolepis coatsi (L)		0.0	0.0	0.1	0.0		0.0	0.9	1.0	0.7		0.0	0.2	0.4	0.0		0.0	2.1	**	2.6	0.8
Pleuragramma antarcticum (J)		0.0	0.0	0.0	0.0		0.2	6.1	25.5	0.0		0.0	0.6	1.2	0.0		0.0	0.0		0.1	0.0
Euphausia crystallorophias		0.0	0.0	0.0	0.0		0.0	0.3	0.9	0.0	6	1.6	31.4	103.2	0.0		0.0	0.0		0.0	0.0
Acanthophyra pelagica		0.0	0.0	0.0	0.0		0.0	0.2	0.4	0.0		0.0	0.3	0.6	0.0		0.0	0.0		0.1	0.0
Sipunculids		0.0	0.0	0.0	0.0		0.0	0.2	0.8	0.0		0.1	2.4	6.1	0.4		0.0	0.2		0.4	0.0
TOTAL			22984.0	43975.9	10414.4			3252.4	2493.0	1963.2			2006.3	3471.4	1192.0			11942.5		7690.3	9149.7
TAXA			22.4	3.3	23			23.2	4.5	24			20.6	4.9	21		0.2	21.5		3.2	22

Table 4.7. Abundance of krill and other dominant zooplankton taxa collected in the Elephant Island area during January-February and February-March surveys, 1992-2006. Abundance is No. per 1000 m3. Zooplankton data are not available for February-March 1992 and 2006 or January 2000.

	Euphausia superba														
	January-February														
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
N	63	70	63	71	72	71	61	40	n.a.	60	44	38	46	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
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
Median	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
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
	February-March														
N	67	67	70	71	72	16	61	39	60	57	44	48	47	48	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	---
Median	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
N	63	70	63	71	72	71	61	40	n.a.	60	44	38	46	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
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
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
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
	February-March														
N	n.a.	67	70	71	72	16	61	39	60	57	44	48	47	48	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
N	63	70	63	71	72	71	61	40	n.a.	60	44	38	46	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
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
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
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
	February-March														
N	n.a.	67	70	71	72	16	61	39	60	57	44	48	47	48	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
N	n.a.	70	63	71	72	71	61	40	n.a.	60	44	38	46	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
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
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
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
	February-March														
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	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
N	n.a.	n.a.	n.a.	71	72	71	61	40	n.a.	60	44	38	46	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
SD	---	---	---	969.4	8.3	27.0	1.6	795.5	---	86.2	64.6	16.8	18.5	78.3	5118.2
Med	---	---	---	0.0	0.0	6.4	0.0	4.3	---	9.0	0.0	0.0	0.4	1.1	18.9
Max	---	---	---	8076.1	42.7	96.5	11.4	5083.2	---	654.0	356.3	95.5	95.7	521.8	20541.3
	February-March														
N	n.a.	n.a.	n.a.	71	72	16	61	39	60	57	44	48	47	48	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
N	63	70	63	71	72	71	61	40	n.a.	60	44	38	46	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
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
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
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
	February-March														
N	n.a.	67	70	71	72	16	61	39	60	57	44	48	47	48	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
N	n.a.	n.a.	n.a.	71	72	71	61	40	n.a.	60	44	38	46	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
SD	---	---	---	75.2	858.1	38.4	0.0	348.8	---	608.8	1379.1	2.7	11.0	139.9	481.3
Med	---	---	---	0.0	32.1	1.5	0.0	2.8	---	42.7	181.7	0.0	2.1	0.5	19.6
Max	---	---	---	441.5	4961.8	159.9	0.0	1519.6	---	3621.0	8984.2	14.5	45.3	836.0	2444.9
	February-March														
N	n.a.	n.a.	70	71	72	16	61	39	60	57	44	48	47	48	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
N	n.a.	70	63	71	72	71	61	40	n.a.	60	44	38	46	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
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
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
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
	February-March														
N	n.a.	67	70	71	72	16	61	39	60	57	44	48	47	48	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	---

	Ihlea racovitzai														
	January-February														
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
N	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	61	40	n.a.	60	44	38	46	48	48
Mean	---	---	---	---	---	---	70.7	2.4	---	0.4	1.5	0.4	16.0	3.2	0.1
SD	---	---	---	---	---	---	424.0	5.2	---	1.6	5.5	1.3	35.1	8.3	0.6
Med	---	---	---	---	---	---	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0
Max	---	---	---	---	---	---	3286.5	16.9	---	11.1	28.8	7.6	157.8	42.4	4.0
	February-March														
N	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	61	39	60	57	44	48	47	48	n.a.
Mean	---	---	---	---	---	---	42.2	8.5	0.6	0.0	0.3	0.2	32.3	2.0	---
SD	---	---	---	---	---	---	96.7	23.5	1.9	0.0	2.1	0.9	60.4	8.4	---
Med	---	---	---	---	---	---	7.7	0.0	0.0	0.0	0.0	0.0	1.7	0.0	---
Max	---	---	---	---	---	---	635.9	115.4	10.5	0.0	14.1	6.0	258.7	57.9	---

Table 4.8. Maturity stage composition of krill collected in the Elephant Island Area during 2006 compared to 1992-2005. Advanced maturity stages are proportions of mature females thatare (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.

A. SURVEY A	*Euphausia superba* JANUARY-FEBRUARY														
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Stage	%	%	%	%	%	%	%	%	n.a.	%	%	%	%	%	%
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
No. measured	2472	4283	2078	2294	4296	3209	3600	751	---	2063	1437	2466	1410	2189	1721

B. SURVEY D	FEBRUARY-MARCH														
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Stage	%	%	%	%	%	%	%	%	%	%	%	%	%	%	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 m^3) in subareas surveyed during (A) January-February and (B) February-March 1994-2006. Largest concentrations reflect abundant juveniles and good recruitment success from the previous year.

A. January-February Survey A

Year	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994
West Area (N)	25	25	24	25	25	30		27	28	20	8	8	8
Mean	9.9	8.4	11.3	38.2	42.0	12.8		5.0	56.0	28.7	92.8	79.4	2.2
SD	12.6	13.0	21.2	85.8	141.2	18.7		9.7	99.7	69.1	115.3	131.6	2.5
Median	7.9	2.3	2.1	8.0	0.8	2.3		0.0	15.1	5.9	41.9	20.5	0.8
Elephant Island Area (N)	48	48	46	38	44	60		40	61	71	72	71	63
Mean	23.8	27.1	59.8	318.8	39.0	18.9		5.3	27.1	29.6	82.1	9.7	34.5
SD	47.7	33.0	170.5	1386.0	93.3	32.7		8.1	42.3	80.5	245.1	20.7	94.2
Median	11.1	15.3	3.1	30.9	7.5	6.0		1.7	10.2	5.6	11.4	4.1	3.1
Joinville Island Area (N)	6	6	5	3	9					5			
Mean	95.0	27.7	0.3	502.1	78.3					191.8			
SD	185.4	56.3	0.4	666.5	153.4					209.9			
Median	15.9	1.8	0.0	60.0	10.3					145.5			
South Area (N)	20	20	16	17	17	11		8	15	8	11	11	10
Mean	26.2	13.6	65.1	87.3	161.7	116.2		13.3	40.7	66.5	325.6	0.3	0.4
SD	60.5	37.0	112.1	191.8	390.5	179.6		25.6	77.6	104.3	975.3	0.4	0.5
Median	7.7	1.0	1.2	1.1	0.8	22.5		3.3	3.6	4.1	12.2	0.3	0.1

B. February-March Survey D

Year	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994
West Area (N)		25	25	25	24	29	29	25	28		8	7	8
Mean		7.8	52.5	92.9	694.3	35.9	38.5	9.6	22.3		4.9	15.0	51.5
SD		15.2	237.9	172.8	2317.5	86.7	120.7	45.6	44.2		4.6	13.1	130.9
Median		1.4	0.4	21.2	0.0	5.2	3.9	0.0	2.7		3.9	12.9	0.5
Elephant Island Area (N)		48	47	48	44	57	60	39	61	16	72	71	70
Mean		48.1	5.6	94.9	9.7	86.5	14.4	35.5	162.6	30.4	133.2	5.2	17.1
SD		179.9	9.7	24.2	25.4	387.4	35.3	155.7	768.3	56.4	867.7	12.0	63.5
Median		2.9	10.5	8.7	0.4	4.9	3.3	0.8	4.5	4.6	4.1	1.2	0.4
Joinville Island Area (N)		6	8	4	9								
Mean		29.7	71.7	27.2	4.3								
SD		63.4	120.7	16.7	5.4								
Median		1.3	9.5	22.3	1.7								
South Area (N)		18	17	18	17	10	8	3	15		11	11	11
Mean		97.1	28.5	411.7	548.2	3.3	6.7	4.4	222.4		7.4	2.9	2.4
SD		270.3	92.0	632.3	1765.5	8.2	11.2	4.3	479.7		18.4	3.0	3.1
Median		10.5	0.1	34.5	6.4	0.3	2.3	1.7	3.3		0.5	1.9	1.1

Table 4.10. Salp and krill carbon biomass (mg C per m^2) in the Elephant Island Area during 1995-2006 surveys. N is number of samples. Salp:Krill ratio is based on median values.

Survey	January-February																							
	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
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
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
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
Median	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
Maximum	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
N	57	71	72	72	71	71	61	60	40	40	---	---	60	60	44	44	38	38	46	46	48	48	48	48
Salp:Krill Ratio	0.03		0.1		2.4		4.0		6.4		n.a.		3.1		3.4		0.03		3.0		2.4		0.02	

	February-March																							
	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
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
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	---	---
Median	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	---	---
Maximum	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 Ratio	0.1		0.1		10.1		12.0		28.0		5.6		4.7		121.1		0.2		0.5		19.3		n.a.	

Table 4.11. Zooplankton and nekton taxa present in the Large Survey Area samples during January 2006 compared to 1995-2005 January-February surveys. F is the frequency of occurrence (%) in (N) tows. Mean abundance is No. per 1000 m3. Dashes indicate that taxa were not yet identified and/or enumerated. (L) and (J) denote larval and juvenile stages.

SURVEY A	JANUARY-FEBRUARY																							
	2006		2005		2004		2003		2002		2001		2000		1999		1998		1997		1996		1995	
	N=99		N=99		N=91		N=83		N=95		N=101		n.a.		N=75		N=105		N=105		N=91		N=90	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean			F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Copepods	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	100.0	582.6	100.0	794.4	98.9	652.7
Euphausia superba (L)	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	55.2	15.2	22.0	2.7	22.2	135.8
Thysanoessa macrura (L)	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	44.8	17.0	90.1	308.5	36.7	15.9
Chaetognaths	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	74.3	22.9	68.1	12.5	98.9	79.7
Thysanoessa macrura	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	97.1	104.4	98.9	106.9	91.1	96.4
Larvacean	13.1	87.1	20.2	3.4	3.3	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radiolaria	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	41.0	1.8	12.1	0.1	-----	-----
Salpa thompsoni	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	97.1	181.4	64.8	20.4	66.7	16.0
Limacina helicina	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	47.6	2.9	74.7	33.7	43.3	1.9
Euphausia frigida (L)	34.3	30.1	7.1	1.7	2.2	0.2	8.4	0.4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Euphausia superba	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	93.3	40.4	96.7	112.5	87.8	14.5
Euphausia frigida	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	41.9	14.8	30.8	1.9	50.0	9.8
Ostracods	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	41.0	5.5	53.8	4.9	56.7	9.7
Euphausia crystallorophias	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	0.0	0.0	0.0	0.0	4.4	0.0
Primno macropa	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	63.8	4.3	20.9	0.1	20.0	0.1
Euphausia spp. (L)	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	0.0	0.0	1.1	0.0	-----	-----
Themisto gaudichaudii	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	92.4	3.6	92.3	4.9	76.7	4.9
Vibilia antarctica	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	70.5	2.5	48.4	0.5	22.2	0.2
Tomopteris spp.	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	54.3	1.9	60.4	0.9	84.4	4.2
Siphonophora	22.2	3.9	41.4	5.3	4.4	0.1	3.6	0.1	2.1	0.0	3.0	0.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Polychaetes	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	1.0	0.0	1.1	0.0	-----	-----
Electrona spp. (L)	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	37.1	1.4	27.5	0.7	61.1	2.5
Spongiobranchaea australis	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	67.6	2.2	47.3	1.8	64.4	0.5
Larval Fish	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	0.0	0.0	1.1	0.0	0.0	0.0
Rhynchonereella bongraini	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	4.8	0.1	2.2	0.0	3.3	0.1
Pleuragramma antarcticum (J)	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	2.9	0.0	1.1	0.0	2.2	0.0
Euphausia triacantha	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	18.1	1.4	15.4	0.5	33.3	1.5
Cyllopus magellanicus	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	76.2	3.8	41.8	1.6	24.4	0.2
Sipunculids	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	10.5	0.1	7.7	0.0	24.4	0.1
Hyperiella spp.	10.1	0.9	2.0	0.0	1.1	0.0	6.0	0.0	11.6	0.1	5.9	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Scina spp.	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	4.8	0.1	-----	-----	-----	-----
Clione limacina	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	21.9	0.3	56.0	2.1	41.1	0.5
Lepidonotothen kempi (L)	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	32.4	0.6	30.8	0.3	20.0	0.1
Lepidonotothen larseni (L)	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	27.6	1.8	22.0	0.2	40.0	1.1
Cumaceans	3.0	0.7	0.0	0.0	3.3	0.1	2.4	0.3	2.1	2.7	1.0	0.0	-----	-----	-----	-----	-----	-----	3.8	0.4	1.1	0.0	-----	-----
Hyperiella dilatata	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	56.2	2.2	41.8	0.6	54.4	0.3
Ihlea racovitzai	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	n.a	n.a	n.a	n.a	n.a	n.a
Callianira antarctica	24.2	0.5	3.0	0.1	0.0	0.0	14.5	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Notolepis coatsi (L)	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	6.7	0.0	8.8	0.0	27.8	0.1
Orchomene rossi	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	8.6	0.0	0.0	0.0	5.6	0.0
Diphyes antarctica	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	9.5	0.2	17.6	0.1	58.9	1.0
Limacina spp.	5.1	0.4	14.1	3.1	2.2	0.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Table 4.11 (Contd.)

SURVEY A	2006		2005		2004		2003		2002		2001		2000		1999		1998		1997		1996		1995	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)		Mean		F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Notolepis spp. (L)	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	-----	-----	-----	-----	-----	-----
Hyperiids	9.1	0.3	11.1	0.2	1.1	0.0	6.0	0.1	4.2	0.5	12.9	0.7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pegantha martagon	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	0.0	0.0	0.0	0.0	1.1	0.0
Acanthophyra pelagica (L)	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	9.5	0.1	0.0	0.0	22.2	0.1
Gastropods	11.1	0.2	8.1	0.2	0.0	0.0	3.6	0.1	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Orchomene plebs	7.1	0.1	10.1	0.1	2.2	0.0	2.4	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	1.0	0.0	2.9	0.0	1.1	0.0	4.4	0.0
Gammarids	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	0.0	0.0	1.1	0.0	-----	-----
Hydromedusae	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	20.0	0.1	4.4	0.0	6.7	0.1
Cyllopus lucasii	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	49.5	0.4	11.0	0.1	22.2	0.5
Pelagobia longicirrata	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	1.0	0.0	1.1	0.0	-----	-----
Pasiaphaea sp. (L)	3.0	0.1	10.1	0.3	1.1	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Beroe cucumis	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	15.2	0.1	7.7	0.0	12.2	0.0
Harpagifer antarcticus (L)	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	0.0	0.0	1.1	0.0	-----	-----
Cyllopus spp.	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	1.0	0.0	-----	-----	-----	-----
Clio pyramidata sp.?	9.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ctenophora	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	0.1	16.2	0.1	-----	-----	6.7	0.0
Hyperiella macronyx	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	8.6	0.1	5.5	0.0	23.3	0.1
Schyphomedusae	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	1.0	0.0	13.2	0.1	-----	-----
Electrona antarctica	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	9.5	0.0	13.2	0.0	13.3	0.1
Spongiobranchaea sp.	2.0	0.0	10.1	0.2	2.2	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pleurobrachia pileus	3.0	0.0	1.0	0.0	1.1	0.0	2.4	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Notolepis annulata (L)	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	1.0	0.0	0.0	0.0	13.3	0.0
Dimophyes arctica	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	19.0	0.3	15.4	0.1	25.6	0.8
Bathylagus sp. (L)	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	1.0	0.0	2.2	0.0	8.9	0.0
Oediceroides calmani	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	1.0	0.0	-----	-----	-----	-----
Epimeriella macronyx	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	1.9	1.4	1.1	0.0	8.9	0.0
Calycopsis borchgrevinki	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	2.9	0.0	2.2	0.0	1.1	0.0
Eusirus antarcticus	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	0.0	0.0	1.1	0.0	0.0	0.0
Gymnoscopelus braueri	3.0	0.0	2.0	0.0	1.1	0.0	1.2	0.0	1.1	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Leusia sp.	2.0	0.0	1.0	0.0	0.0	0.0	1.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Hyperoche medusarum	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	1.0	0.0	3.3	0.0	18.9	0.0
Orchomene spp.	2.0	0.0	0.0	0.0	0.0	0.0	2.4	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Electrona carlsbergi	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	10.5	0.1	-----	-----	-----	-----
Clio pyramidata sulcata	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	2.9	0.0	6.6	0.1	72.2	5.3
Periphylla periphylla	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	0.0	0.0	1.1	0.0	1.1	0.0
Beroe forskalii	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	0.0	0.0	1.1	0.0	-----	-----
Eusirus perdentatus	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	0.0	0.0	1.1	0.0	22.2	0.1
Vanadis antarctica	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	1.0	0.0	4.4	0.0	15.6	0.1
Thyploscolex spp.	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Hyperiella antarctica	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	0.0	0.0	2.2	0.0	2.2	0.0
Heterophoxus videns	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Atolla wyvillei	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	2.9	0.0	1.1	0.0	7.8	0.0
Desmonema gaudichaudi	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Cephalopods	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	0.0	0.0	0.0	0.0	2.2	0.0
Chionodraco rastrospinosus (L	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	1.0	0.0	-----	-----	-----	-----

Table 4.11 (Contd.)

SURVEY A	2006		2005		2004		2003		2002		2001		2000		1999		1998		1997		1996		1995	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean			F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Solomdella spp.	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Decapods (L)	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	0.0	0.0	2.2	0.2	-----	-----
Clione antarctica	1.0	0.0	0.0	0.0	13.2	0.1	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Krefftichthys anderssoni	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	1.0	0.0	0.0	0.0	-----	-----
Nansithae spp.	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Gonatus antarcticus	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Trematomus scotti (L)	1.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Botrynema brucei	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	0.0	0.0	0.0	0.0	1.1	0.0
Parachaenechthys charcoti (L)	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Lepidonotothen larseni (J)	1.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Euphausia triacantha (L)	1.0	0.0	1.0	0.0	0.0	0.0	4.8	2.8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Travisiopsis coniceps	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	1.0	0.0	-----	-----	-----	-----
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	-----	-----	1.3	0.0	0.0	0.0	2.9	0.1	0.0	0.0	5.6	0.0
Artededraco mirus (L)	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	0.0	0.0	0.0	0.0	1.1	0.0
Bargmannia elongata	0.0	0.0	4.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Trematomus newnesi (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Zanclonia weldoni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Trematomus lepidorhinus (L)	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.1	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
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	1.1	0.0	-----	-----
Travisiopsis levinseni	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	0.0	0.0	0.0	0.0	1.1	0.0
Schizobrachium polycotylum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Arctapodema ampla	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	0.0	0.0	1.1	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	1.0	0.0	-----	-----	-----	-----
Atolla sp.	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	1.2	0.0	0.0	0.0	0.0	0.0	-----	-----	1.3	0.0	0.0	0.0	3.8	0.1	-----	-----	-----	-----
Thyphloscolex muelleri	0.0	0.0	0.0	0.0	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	4.4	0.0	-----	-----
Staurophora mertensi ?	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Prionodraco evansii (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	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	1.0	0.0	1.0	0.0	-----	-----	-----	-----
Russelia mirabilis	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bolinopsis infundibulus	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	-----	-----	-----	-----	-----	-----
Bolinopsis sp.	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	-----	-----	-----	-----	-----	-----
Gymnoscopelus nicholsi	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	1.9	0.0	1.1	0.0	1.1	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	3.8	0.0	2.2	0.0	7.8	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	0.0	0.0	3.3	0.0
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	0.0	0.0	1.1	0.0
Halitholus spp.	0.0	0.0	2.0	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	1.0	0.1	1.0	0.0	0.0	0.0	3.3	0.0
Cryodraco antarctica (L)	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	0.0	0.0	1.1	0.0	-----	-----
Cyphocaris richardi	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	1.9	0.0	0.0	0.0	4.4	0.0
Hyperia antarctica	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	1.9	0.0	-----	-----	-----	-----
Electrona subaspera	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.0	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	0.0	0.0	2.2	0.0
Euphausia crystallorophias (L	0.0	0.0	1.0	0.5	3.3	0.0	4.8	0.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
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	0.0	0.0	4.4	0.0

SURVEY A	2006		2005		2004		2003		2002		2001		2000		1999		1998		1997		1996		1995	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean			F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Fish Eggs	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	2.9	0.1	1.1	0.0	4.4	0.0
Gobionotothen gibberifrons (L	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	0.0	0.0	0.0	0.0	1.1	0.0
Eusirus properdentatus	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Eusirus spp.	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	-----	-----	-----	-----	-----	-----
Chromatonema rubra	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	2.1	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Chorismus antarcticus (L)	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	0.0	0.0	1.1	0.0	-----	-----
Mysids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.1	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Notocrangon antarcticus(?)	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
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	-----	-----	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	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	3.8	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	-----	-----	1.3	0.0	-----	-----	-----	-----	-----	-----	-----	-----
Notothenia spp. (L)	0.0	0.0	4.0	0.1	0.0	0.0	0.0	0.0	2.1	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	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Crustacean larvae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Clio pyramidata martensi?	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Krefftichthys anderssoni (L)	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	1.9	0.0	-----	-----	-----	-----
Laodicea undulata	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Lepidonotothen nudifrons (L)	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	0.0	0.0	2.2	0.0	8.9	0.1
Mitrocomella brownei	0.0	0.0	1.0	0.0	0.0	0.0	1.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Modeeria rotunda	0.0	0.0	2.0	0.0	0.0	0.0	1.2	0.0	2.1	0.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Clio pyramidata antarctica	0.0	0.0	24.2	1.1	11.0	0.1	15.7	1.7	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Maupasia coeca	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	1.9	0.0	1.1	0.0	-----	-----
TOTAL		8648.3		2037.0		1033.1		1264.9		11143.1		3812.2		---		1294.2		1172.7		1015.2		1408.9		1052.2
TAXA	98		95		89		88		89		63		---		65		63		70		66		68	

Table 4.12. Percent contribution and abundance rank (R) of numerically dominant zooplankton and nekton taxa in the Elephant Island Area during (A) January-February and (B) February-March surveys, 1994-2006. Includes the 10 most abundant taxa each year. Radiolaria excluded as a taxonomic category. No samples were collected January-February 2000 or February-March 2006. Dashes indicate that the taxon was not enumerated during that survey.

A.	JANUARY-FEBRUARY																									
	2006		2005		2004		2003		2002		2001		2000		1999		1998		1997		1996		1995		1994	
TAXON	%	R	%	R	%	R	%	R	%	R	%	R	n.a.		%	R	%	R	%	R	%	R	%	R	%	R
Copepods	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	61.54	1	4.08	3
Euphausia superba (L)	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	12.80	2	---	
Chaetognaths	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	7.84	4	0.04	
Thysanoessa macrura (L)	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	1.50	6	---	
Larvaceans	2.60	5																								
Thysanoessa macrura	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	9.09	3	7.87	2
Salpa thompsoni	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	1.51	5	80.83	1
Euphausia frigida (L)	0.78	8																								
Euphausia frigida	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		0.92	8	0.38	9
Limacina helicina	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	0.18		0.03	
Euphausia superba	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	1.37	7	2.68	4
Ostracods	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	0.91	9	---	
Primno macropa	0.12		0.17		0.40		0.44	9	0.12		0.10		---	---	0.13		0.06		0.42	10	0.01		0.01		0.05	
Vibilia antarctica	0.11		0.18		0.07		0.19		0.06		0.98	8	---	---	0.32	9	1.12	6	0.24		0.04		0.02		1.17	5
Tomopteris spp.	0.09		0.05		0.11		0.20		0.03		0.11		---	---	0.15	10	0.11		0.19		0.06		0.40		0.25	10
Spongiobranchaea australis	0.04		0.05		0.29		0.15		0.02		0.09		---	---	0.09		0.07		0.22		0.13		0.05		0.01	
Euphausia triacantha	0.04		0.15		0.10		0.05		0.02		0.10		---	---	0.03		0.02		0.14		0.04		0.14		0.12	
Themisto gaudichaudii	0.02		0.64	10	0.24		0.35		0.32	10	0.17		---	---	0.02		0.03		0.35		0.34	9	0.46		1.05	6
Cyllopus magellanicus	0.02		0.88	8	0.07		0.04		0.09		0.01		---	---	0.15		0.21		0.45		0.13		0.02		0.63	
Ihlea racovitzai	0.00		0.16		1.63	8	0.03		0.02		0.02		---	---	0.15		3.53	4	---		---		---		---	
Clio pyramidata	0.00		0.05		0.01		0.01		0.46	8	0.08		---	---	0.01		0.02		0.00		0.01		0.50	10	0.53	8
Cyllopus lucasii	0.00		0.03		0.38		0.06		0.02		0.98	9	---	---	0.15		0.16	10	0.37		0.11		0.02		0.62	7
TOTAL	99.51		98.13		98.94		98.65		99.43		99.68		---		98.15		99.32		98.79		99.64		99.26		99.69	

B.	FEBRUARY-MARCH																									
	2006		2005		2004		2003		2002		2001		2000		1999		1998		1997		1996		1995		1994	
TAXON	n.a.		%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R
Copepods	---	---	37.34	1	80.19	1	73.70	1	83.13	1	64.68	1	54.20	1	62.77	1	7.38	4	44.46	1	62.07	1	40.49	2	82.15	1
Salpa thompsoni	---	---	31.46	2	2.02	5	2.67	5	2.71	4	6.50	4	6.17	4	12.46	2	65.31	1	43.62	2	1.39	6	0.22	7	11.78	2
Thysanoessa macrura	---	---	16.12	3	1.77	6	10.24	2	0.27	7	14.96	2	0.24	8	3.84	5	9.40	3	6.36	3	4.86	4	0.87	5	1.83	3
Euphausia superba (L)	---	---	7.12	4	2.26	4	0.27	8	0.20	8	1.03	7	23.14	2	2.71	6	0.16		0.88	6	0.59	7	50.16	1	---	
Euphausia superba	---	---	1.76	5	0.65	7	4.18	4	0.05		1.15	6	0.10		1.43	7	10.87	2	1.07	5	5.57	3	0.06	10	0.41	7
Chaetognaths	---	---	1.75	6	5.68	2	4.54	3	5.11	3	1.34	5	5.35	5	5.94	4	0.60	8	0.65	7	2.43	5	3.61	4	0.47	6
Euphausia frigida	---	---	1.27	7	0.34		2.24	6	0.37	6	0.54	8	0.29	7	1.00	8	0.60	7	1.57	4	0.40	8	0.21	8	0.69	5
Themisto gaudichaudii	---	---	0.65	8	0.03		0.20	10	0.12		0.07		0.02		0.01		0.01		0.10		0.09		0.01		0.27	8
Cyllopus magellanicus	---	---	0.65	9	0.01		0.09		0.02		0.02		0.07		0.17		0.55	9	0.12		0.10		0.01		0.12	
Vibilia antarctica	---	---	0.18	10	0.01		0.07		0.16	10	0.21	10	0.18	10	0.15		0.71	6	0.28	9	0.05		0.00		0.16	9
Ostracods	---	---	0.15		0.43	9	0.24	9	0.06		0.03		0.20	9	0.65	9	0.35	10	0.17	10	0.38	9	0.43	6	---	
Ihlea racovitzai	---	---	0.07		0.41	10	0.01		0.00		0.00		0.00		0.34	10	2.77	5	---		---		---		---	
Thysanoessa macrura (L)	---	---	0.05		4.92	3	0.06		6.87	2	8.81	3	7.33	3	7.49	3	0.03		0.38	8	21.40	2	3.76	3	---	
Cyllopus lucasii	---	---	0.04		0.06		0.01		0.01		0.43	9	0.00		0.01		0.14		0.08		0.01		0.01		0.14	10
Primno macropa	---	---	0.04		0.13		0.35	7	0.21	9	0.03		0.02		0.08		0.11		0.02		0.15	10	0.00		0.00	
Euphausia spp. (L)	---	---	0.04		---	---	0.01		0.00		0.01		0.04		0.10		0.00		0.00		0.00		0.00		---	
Euphausia triacantha	---	---	0.04		0.03		0.09		0.01		0.02		0.01		0.06		0.04		0.03		0.03		0.02		0.03	
Limacina helicina	---	---	0.02		0.63	8	0.06		0.00		0.00		2.21	6	0.00		0.03		0.00		0.01		0.00		0.00	
Euphausia frigida (L)	---	---	0.02		0.12		0.07		0.40	5	---		---		---		---		---		---		---		---	
Electrona spp. (L)	---	---	0.00		0.01		0.18		0.02		0.02		0.03		0.01		0.01		0.01		0.04		0.07	9	0.75	4
TOTAL	---		98.77		99.69		99.11		99.70		99.84		99.58		99.20		99.04		99.78		99.52		99.87		98.04	

Table 4.13. Percent Similarity Index (PSI) values from comparisons of overall zooplankton composition in the Elephant Island area during Surveys (A) A and (B) D, 1994-2006.

A.	JANUARY-FEBRUARY PSI VALUES											
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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
1995	xxxxx	70.3	76.8	18.7	80.7	n.a.	58.9	71.7	58.7	70.2	35.4	77.2
1996		xxxxx	73.4	19.3	70.0	n.a.	65.9	73.4	64.2	69.7	32.9	62.5
1997			xxxxx	38.4	80.2	n.a.	75.7	71.3	66.6	90.1	52.6	64.0
1998				xxxxx	22.6	n.a.	39.8	15.2	30.9	41.2	78.0	10.3
1999					xxxxx	n.a.	75.1	77.4	54.4	73.2	40.0	76.5
2000						xxxxx	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
2001							xxxxx	69.2	54.4	74.6	56.7	58.9
2002								xxxxx	53.8	63.5	32.2	63.7
2003									xxxxx	70.3	36.7	49.6
2004										xxxxx	51.5	60.7
2005											xxxxx	27.3

B.	FEBRUARY-MARCH PSI VALUES											
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1994	42.4	66.9	60.1	22.9	78.4	61.8	74.9	86.4	80.4	85.4	53.1	n.a.
1995	xxxxx	49.1	44.0	10.0	52.4	72.0	48.1	48.9	46.2	52.0	47.8	n.a.
1996		xxxxx	54.3	21.1	80.3	67.0	80.9	74.1	76.4	74.8	48.6	n.a.
1997			xxxxx	60.5	65.2	53.6	61.3	49.5	57.6	51.5	79.7	n.a.
1998				xxxxx	27.7	15.5	26.2	12.0	25.6	14.0	52.5	n.a.
1999					xxxxx	76.9	85.0	78.7	77.2	62.8	61.3	n.a.
2000						xxxxx	71.0	70.0	62.9	54.2	53.6	n.a.
2001							xxxxx	76.8	81.2	64.7	63.3	n.a.
2002								xxxxx	82.5	80.2	43.2	n.a.
2003									xxxxx	73.7	56.0	n.a.
2004										xxxxx	46.6	n.a.
2005											xxxxx	n.a.

Table 4.14. Abundance of biomass dominant copepod species in the Elephant Island area during various cruises 1981-2006. 1981-1990 data provided by John Wormuth (TAMU). Dashes indicate that data are not available.

SURVEY PERIOD	TAXON No. per 1000 m^3	*Calanoides acutus*	*Calanus propinquus*	*Metridia gerlachei*	*Rhincalanus gigas*	*Pleuromamma robusta*	*Paraeuchaeta antarctica*	*Haloptilus ocellatus*	*Heterorhabdus austrinus*	Copepodites	Other Copepods	Total Copepods
Jan-Feb 89	Mean	429.7	93.6	1639.0	---	---	---	---	---	---	---	---
N=48	STD	676.8	104.3	3488.0	---	---	---	---	---	---	---	---
	Median	80.5	45.5	57.0	---	---	---	---	---	---	---	---
Jan 90	Mean	302.5	354.4	981.3	---	---	---	---	---	---	---	1700.2
N=23	STD	405.8	365.8	1620.7	---	---	---	---	---	---	---	2003.7
	Median	170.1	243.6	192.3	---	---	---	---	---	---	---	656.7
Jan 99	Mean	335.4	109.1	340.5	---	---	---	---	---	---	---	927.0
N=40	STD	1009.5	161.9	512.7	---	---	---	---	---	---	---	1590.8
	Median	28.9	52.0	66.0	---	---	---	---	---	---	---	332.9
Jan 01	Mean	241.0	50.4	488.4	20.2	5.5	0.2	0.0	---	---	197.5	1003.2
N=60	STD	392.0	85.9	1103.3	74.8	21.0	0.6	0.0	---	---	527.3	1582.4
	Median	117.7	12.5	45.5	0.0	0.0	0.0	0.0	---	---	41.8	252.2
Jan 02	Mean	2931.3	1862.2	350.8	141.6	1.4	122.7	0.0	---	30.2	44.2	5484.3
N=44	STD	8293.0	5659.2	467.6	381.0	6.3	185.6	0.0	---	154.1	89.0	14585.6
	Median	876.4	502.7	130.3	16.4	0.0	57.7	0.0	---	0.0	11.0	2174.9
Jan 03	Mean	75.6	80.1	241.2	11.1	1.8	0.0	0.2	---	0.1	41.0	541.0
N=38	STD	67.9	65.0	639.3	23.4	10.9	0.0	1.0	---	0.9	34.9	798.6
	Median	52.0	55.1	6.7	1.9	0.0	0.0	0.0	---	0.0	27.8	317.0
Jan 04	Mean	77.4	73.2	293.6	9.7	24.1	16.4	0.0	---	0.1	0.0	494.5
N=46	STD	97.2	63.8	706.6	19.0	41.0	25.0	0.0	---	0.9	0.0	796.1
	Median	42.7	57.1	25.4	0.2	7.8	7.6	0.0	---	0.0	0.0	208.7
Jan 05	Mean	39.0	26.4	220.0	12.6	1.4	0.6	0.0	0.0	0.0	49.1	364.6
N=48	STD	62.7	41.8	614.4	21.0	7.0	2.6	0.0	0.0	0.0	57.9	687.3
	Median	16.1	9.5	3.9	4.7	0.0	0.0	0.0	0.0	0.0	35.2	126.4
Jan 06	Mean	948.0	284.2	1157.1	292.7	1.6	0.5	15.3	0.0	0.0	644.1	3677.8
N=48	STD	1526.1	358.1	2000.0	414.4	5.8	1.5	30.9	0.0	0.0	722.8	3563.5
	Median	260.3	141.1	254.3	165.9	0.0	0.0	0.0	0.0	0.0	390.1	2279.8

SURVEY PERIOD	TAXON No. per 1000 m^3	*Calanoides acutus*	*Calanus propinquus*	*Metridia gerlachei*	*Rhincalanus gigas*	*Pleuromama robusta*	*Pareuchaeta antarctica*	*Haloptilus ocellatus*	*Heterorhabdus austrinus*	Copepodites	Other Copepods	Total Copepods
Mar 81	Mean	4786.9	5925.8	2402.5	---	---	---	---	---	---	---	---
N=10	STD	5482.2	6451.6	3321.4	---	---	---	---	---	---	---	---
	Median	2197.7	2048.7	609.5	---	---	---	---	---	---	---	---
Feb-Mar 84	Mean	25.5	121.7	1154.4	---	---	---	---	---	---	---	---
N=13	STD	29.6	134.4	2999.9	---	---	---	---	---	---	---	---
	Median	16.2	51.4	23.1	---	---	---	---	---	---	---	---
Feb 89	Mean	161.4	194.9	3189.3	---	---	---	---	---	---	---	---
N=25	STD	240.9	151.5	4017.2	---	---	---	---	---	---	---	---
	Median	88.0	162.0	1051.0	---	---	---	---	---	---	---	---
Feb 99	Mean	511.8	300.9	521.1	---	---	---	---	---	---	---	1557.9
N=39	STD	1395.6	630.6	699.0	---	---	---	---	---	---	---	2337.8
	Median	70.7	70.8	216.9	---	---	---	---	---	---	---	621.6
Feb 00	Mean	1846.3	741.8	3051.7	1089.0	100.0	107.3	1.5	---	---	1171.4	8019.1
N=60	STD	3177.2	1546.5	4783.5	2456.5	34.7	249.1	7.8	---	---	28232.0	11824.4
	Median	225.2	193.3	1249.7	79.9	0.0	11.0	0.0	---	---	297.6	3478.0
Feb-Mar 01	Mean	2540.2	247.1	1450.0	32.4	3.7	74.7	0.4	---	116.1	37.0	4501.5
N=57	STD	6921.6	402.9	2966.0	129.1	13.6	137.9	2.7	---	343.8	188.4	8072.4
	Median	111.5	122.2	140.1	0.0	0.0	20.8	0.0	---	23.2	0.0	1518.0
Feb-Mar 02	Mean	9569.2	3827.4	2515.1	1226.4	30.0	169.3	14.8	---	5.2	116.0	17473.4
N=44	STD	12553.1	4288.9	3124.5	1952.7	97.2	269.2	66.0	---	22.5	337.2	20036.9
	Median	4855.6	2037.2	1183.6	346.2	0.0	52.5	0.0	---	0.0	0.0	7563.8
Feb 03	Mean	138.1	68.2	1092.8	39.0	5.9	3.8	0.5	---	0.0	205.0	1674.3
N=48	STD	114.2	70.2	2239.6	45.9	17.5	10.0	1.7	---	0.0	235.4	2593.6
	Median	119.3	47.9	197.3	17.9	0.0	0.0	0.0	---	0.0	130.2	737.5
Feb-Mar 04	Mean	1821.7	1113.3	1791.8	1209.3	7.7	168.9	15.1	88.2	0.3	89.7	6303.1
N=47	STD	7439.2	3524.0	3902.9	5315.2	25.3	195.3	53.6	552.6	2.2	195.0	17739.5
	Median	277.0	324.3	368.9	117.3	0.0	68.4	0.0	0.0	0.0	5.9	2233.5
Feb-Mar 05	Mean	144.2	22.6	708.9	54.0	2.2	1.1	0.2	0.9	0.0	54.2	1022.1
N=48	STD	385.5	45.1	1075.7	54.2	9.7	3.0	1.1	5.2	0.0	64.7	1254.5
	Median	47.8	9.9	76.7	31.6	0.0	0.0	0.0	0.0	0.0	32.3	344.3

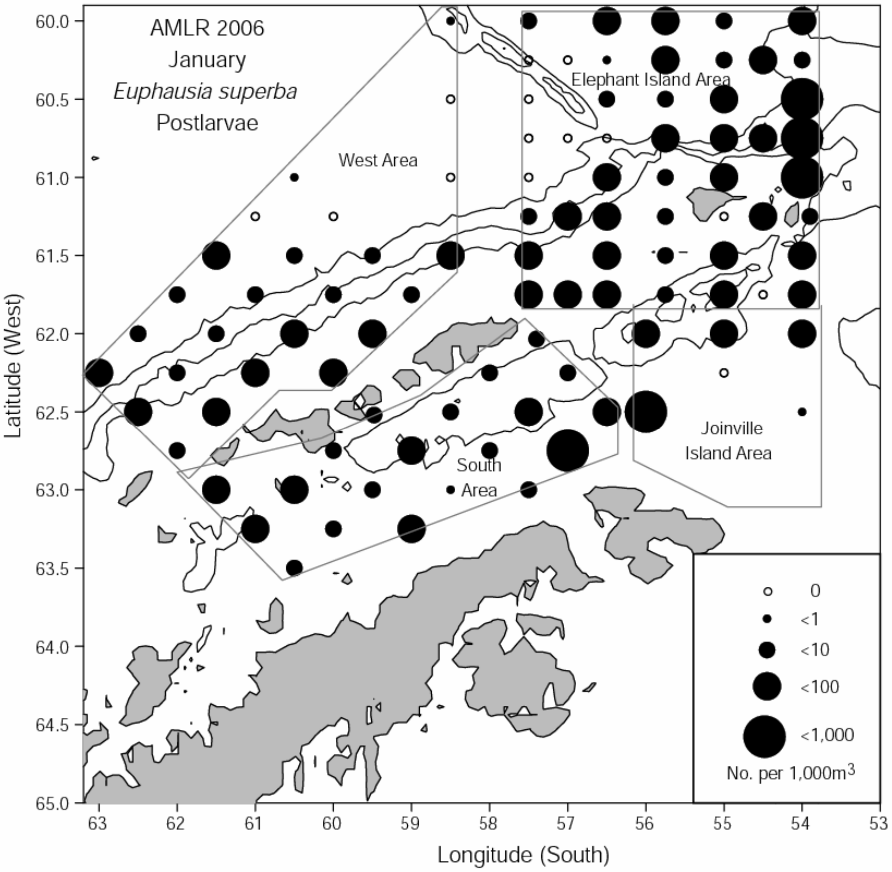

Figure 4.1 Postlarval krill abundance in IKMT samples collected during January 2006 Survey A. The outlined stations included in the Elephant Island Area are used for between-year comparisons. West, South and Joinville Island Area stations are indicated.

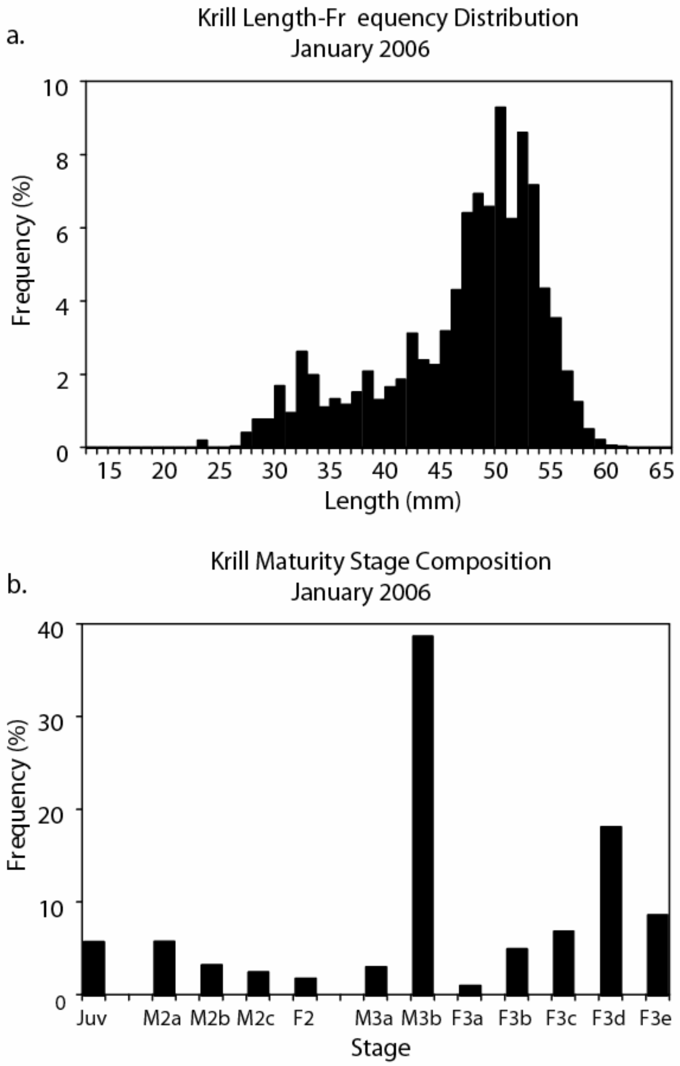

Figure 4.2 Length-frequency distribution and maturity stage composition of postlarval krill represented across the entire survey area during January 2006.

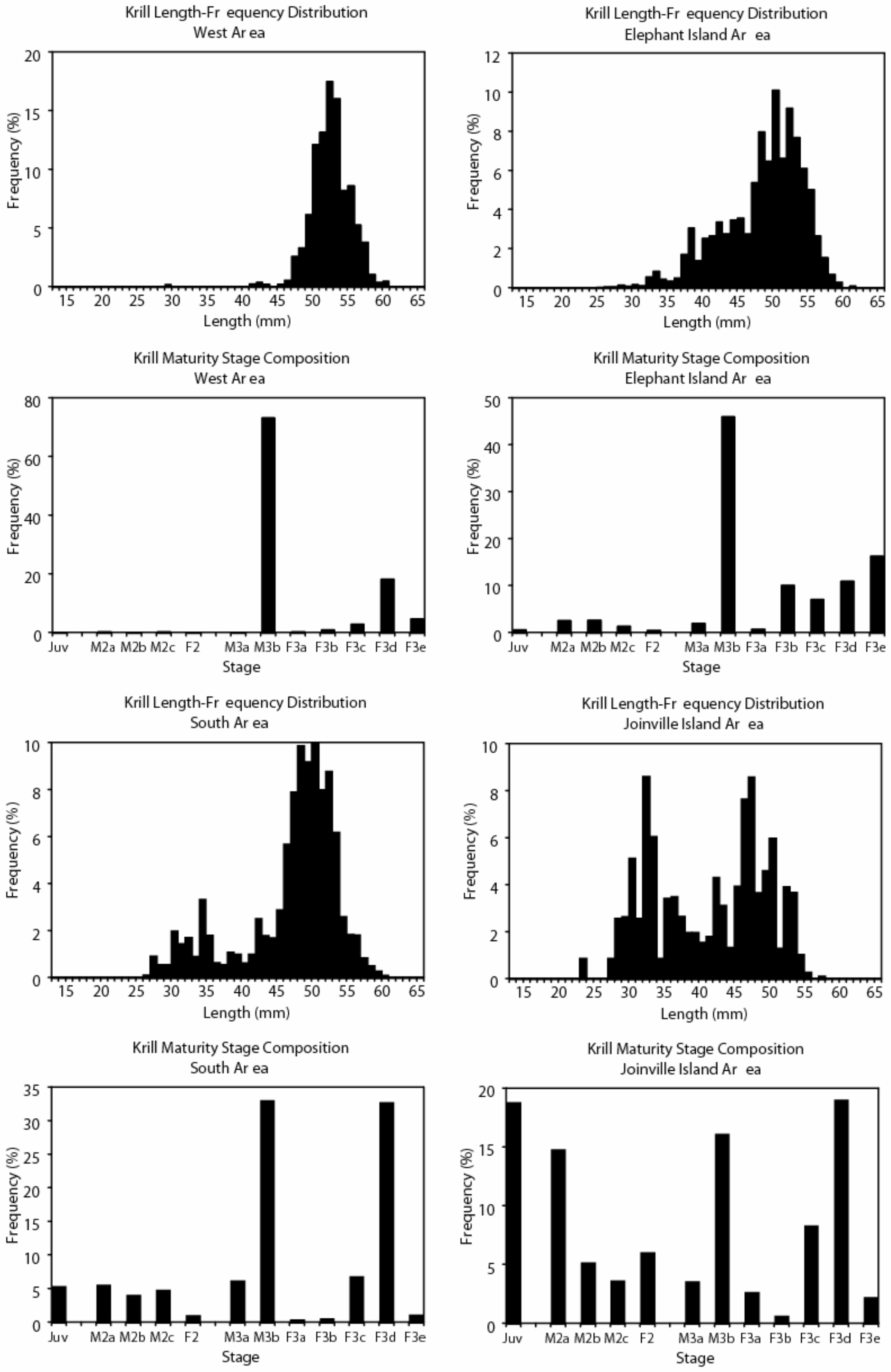

Figure 4.3 Length-frequency distribution and maturity stage composition of postlarval krill in the West, Elephant Island, South and Joinville Island Areas during January 2006.

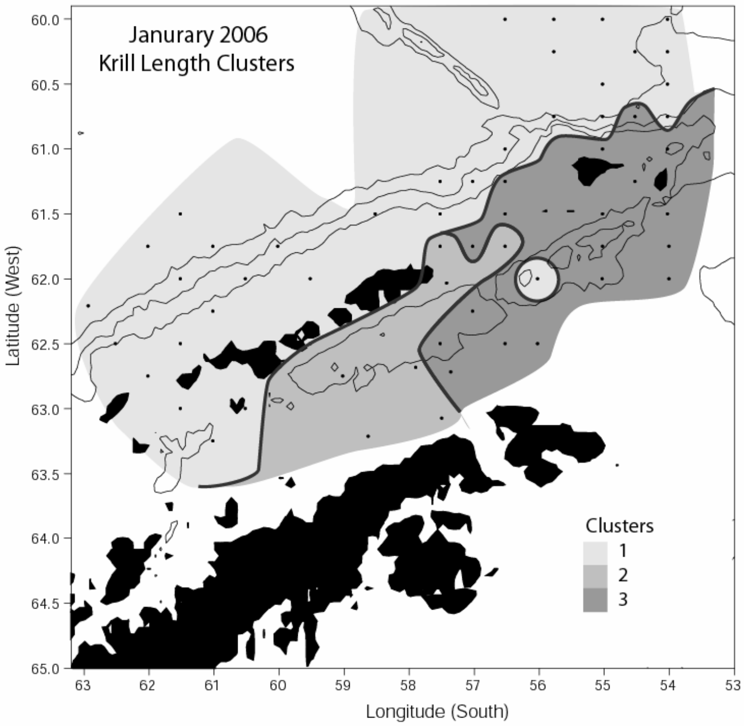

Figure 4.4 Distribution patterns of postlarval krill belonging to three length categories (Clusters) during January 2006.

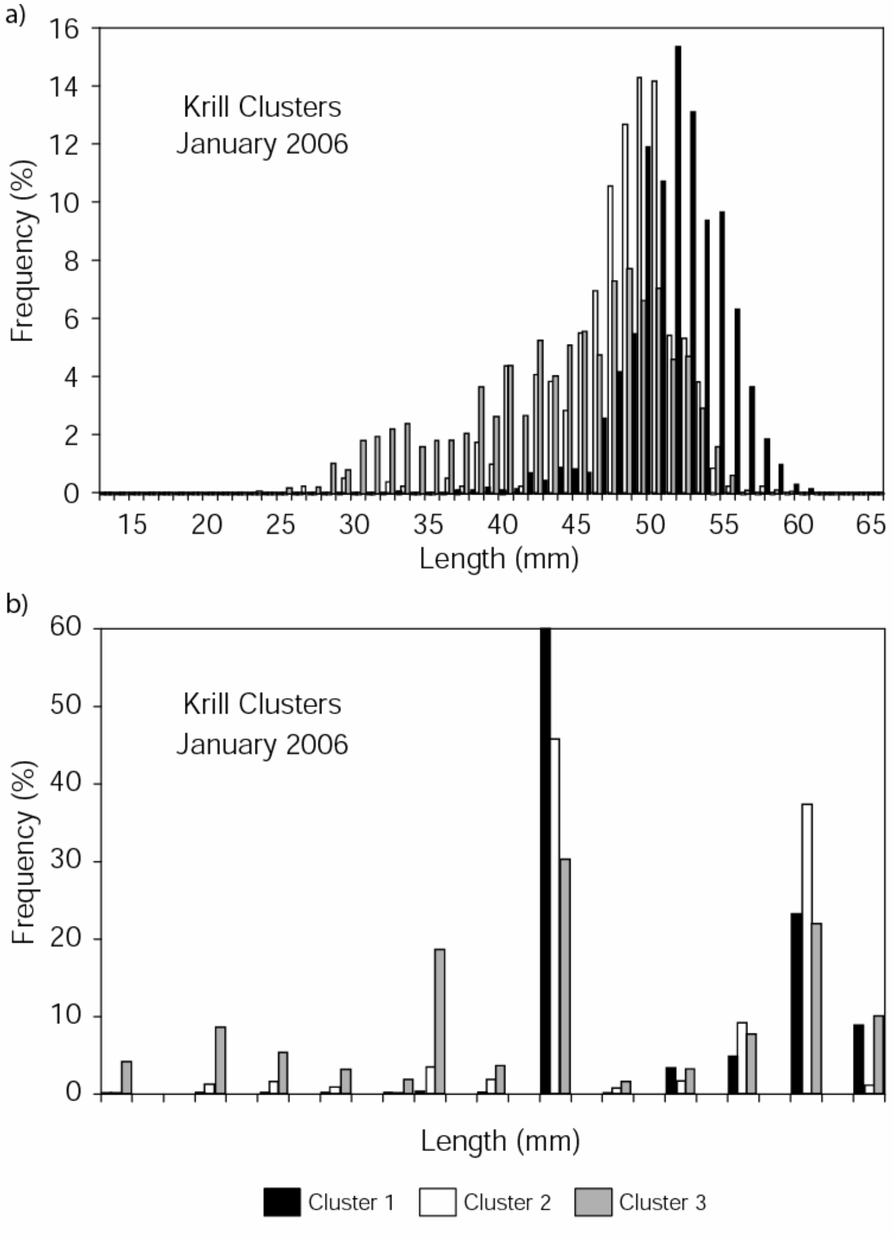

Figure 4.5 Length-frequency distribution and maturity stage composition of postlarval krill belonging to Clusters 1, 2 and 3 during January 2006.

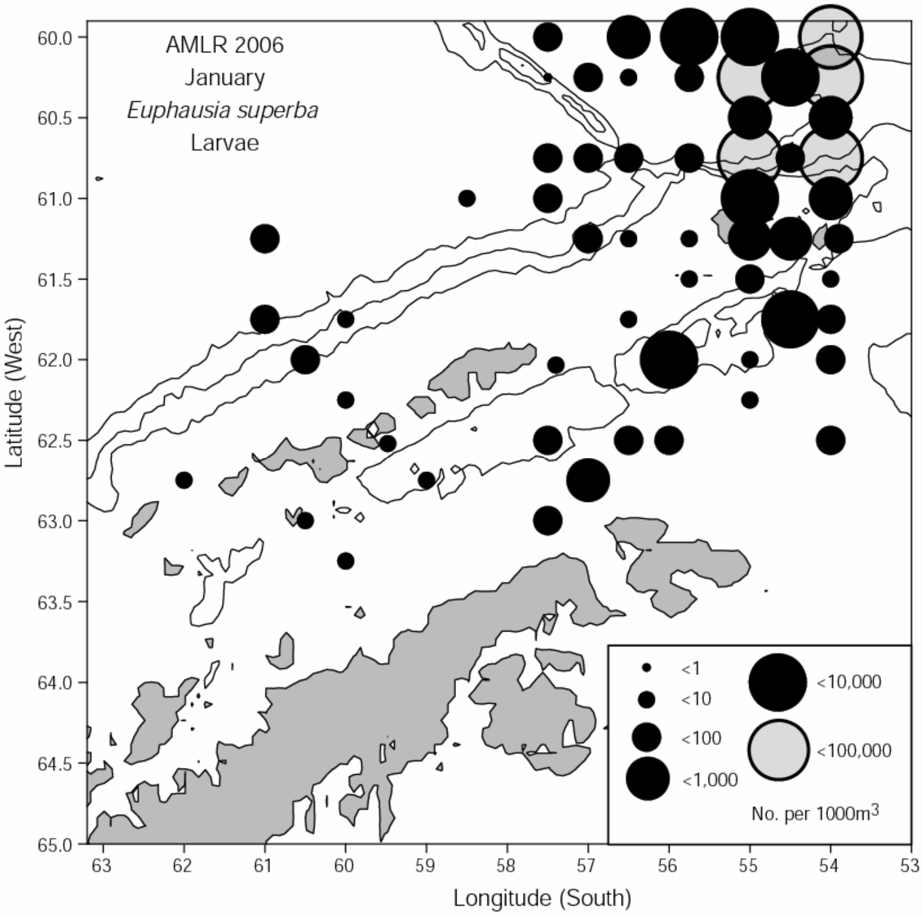

Figure 4.6 Distribution and abundance of krill larvae during January 2006.

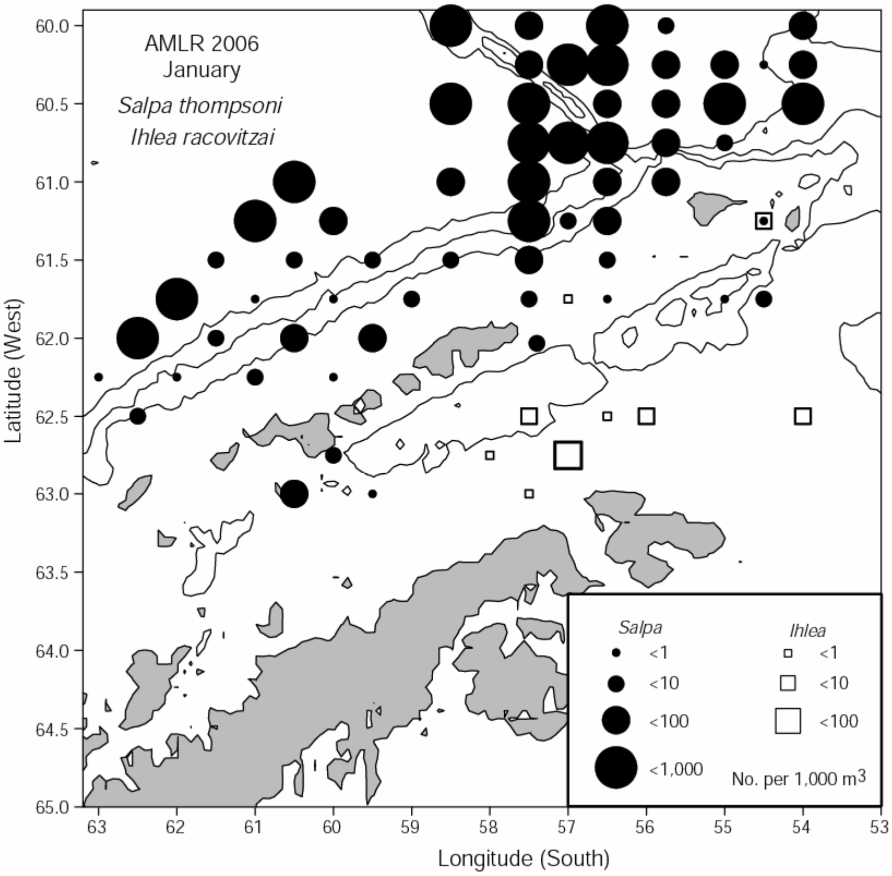

Figure 4.7 Distribution and abundance of the salps *Salpa thompsoni* and *Ihlea racovitzai* during January 2006.

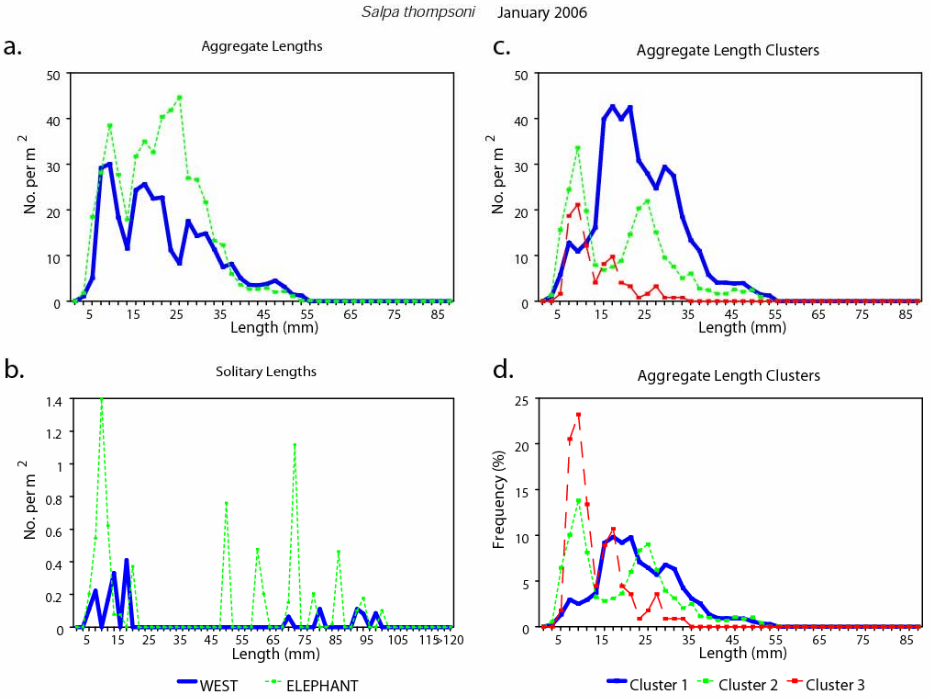

Figure 4.8 Length-frequency distributions of (A) aggregate and (B) solitary stage *Salpa thompsoni* in the West and Elephant Island Areas during January 2006. Length-frequency distributions of aggregate salps belonging to three clusters expressed as (C) numbers per 1 m^2 and (D) frequency of occurrence.

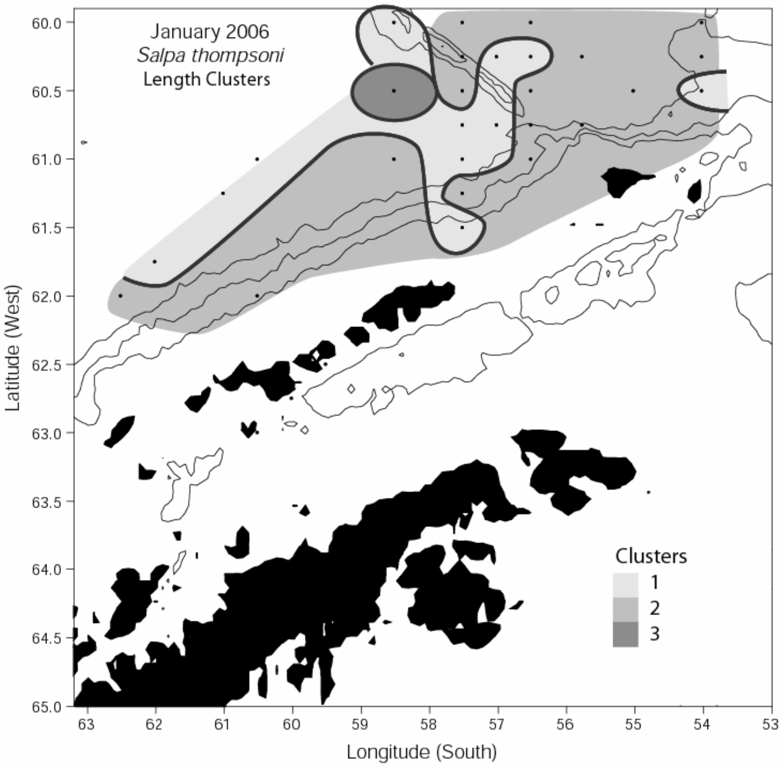

Figure 4.9 Distribution of aggregate salps belonging to three length clusters during January 2006.

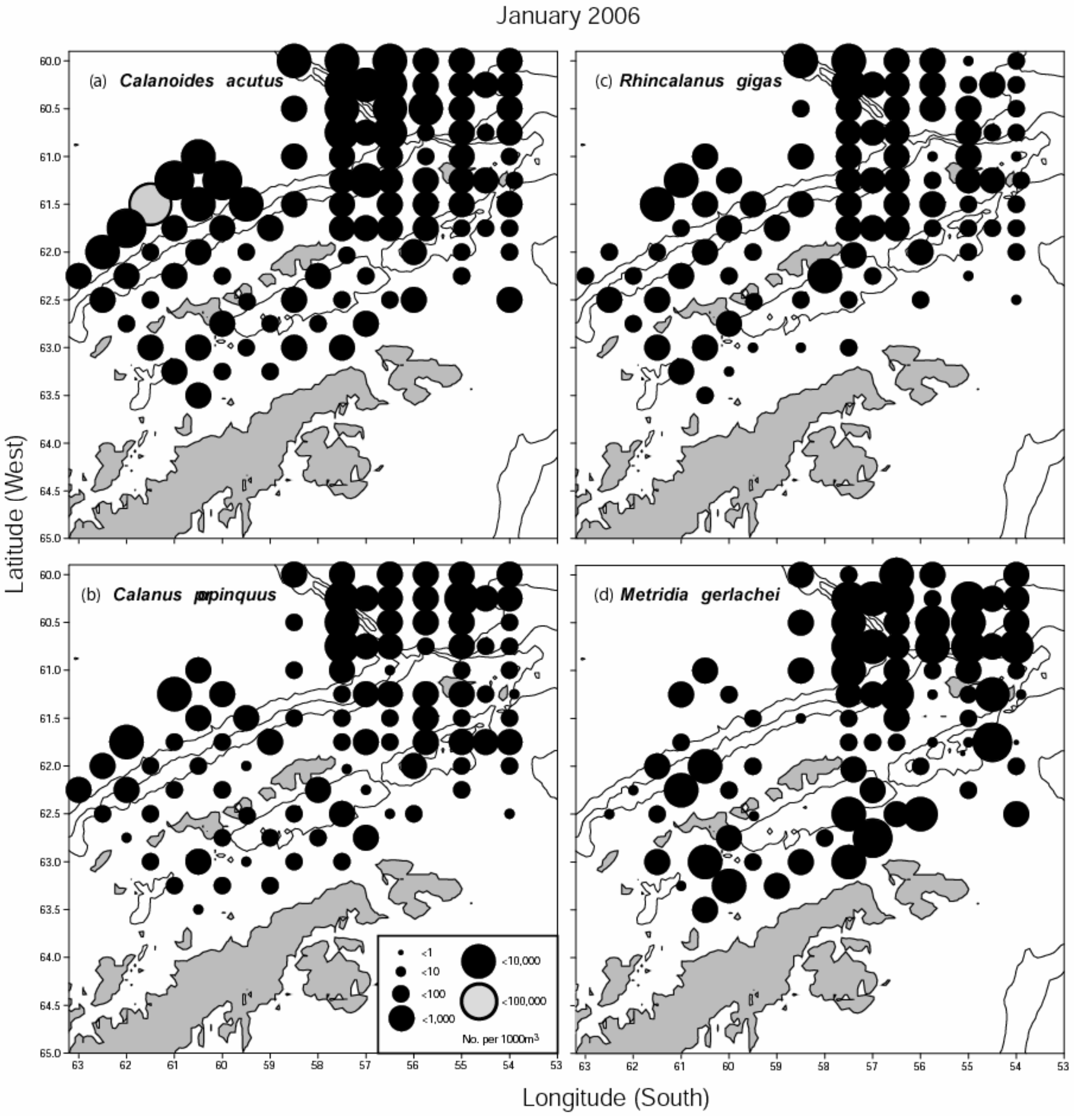

Figure 4.10 Distribution and abundance of dominant copepod species during January 2006: (A) *Calanoides acutus*; (B) *Calanus propinquus*; (C) *Rhincalanus gigas*; and (D) *Metridia gerlachei.*

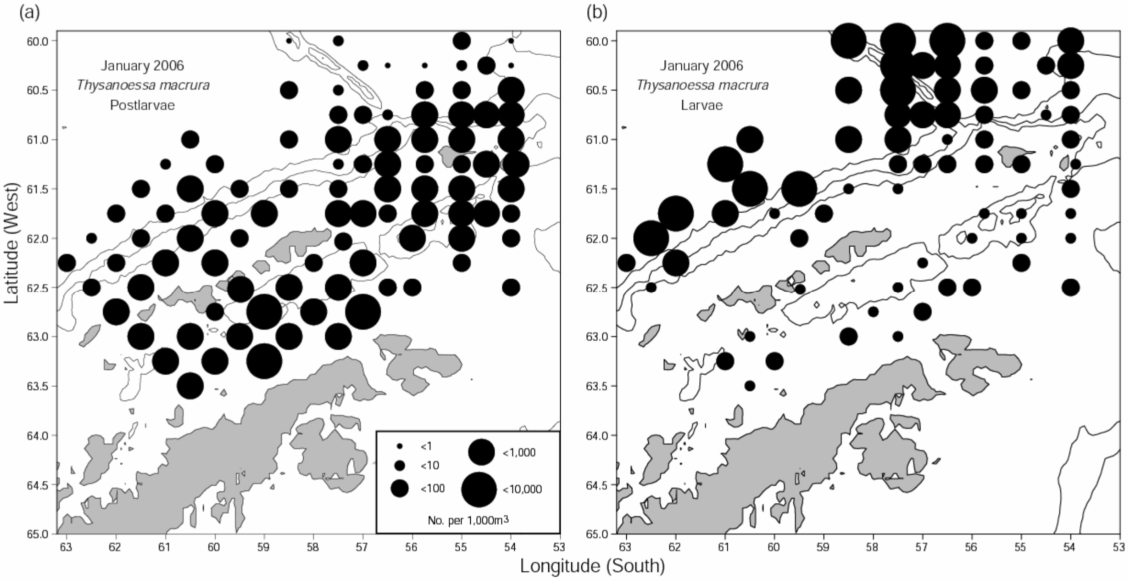

Figure 4.11 Distribution and abundance of (A) postlarval and (B) larval *Thysanoessa macrura* during January 2006.

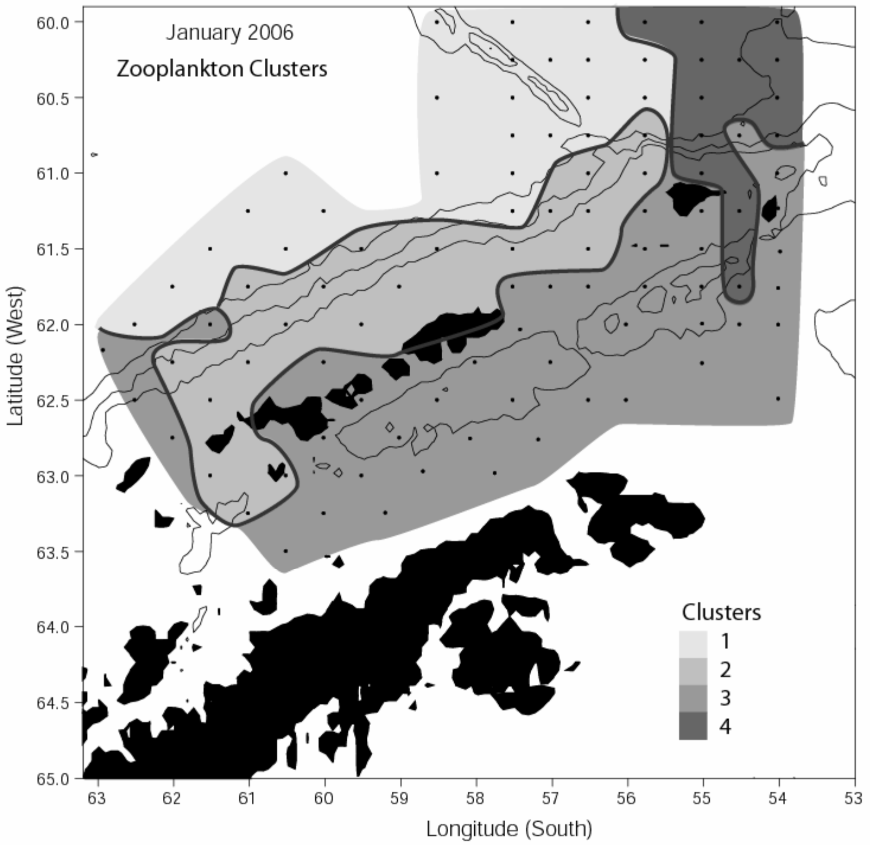

Figure 4.12 Distribution patterns of zooplankton taxa belonging to different station groupings (Clusters 1-4) during January 2006.

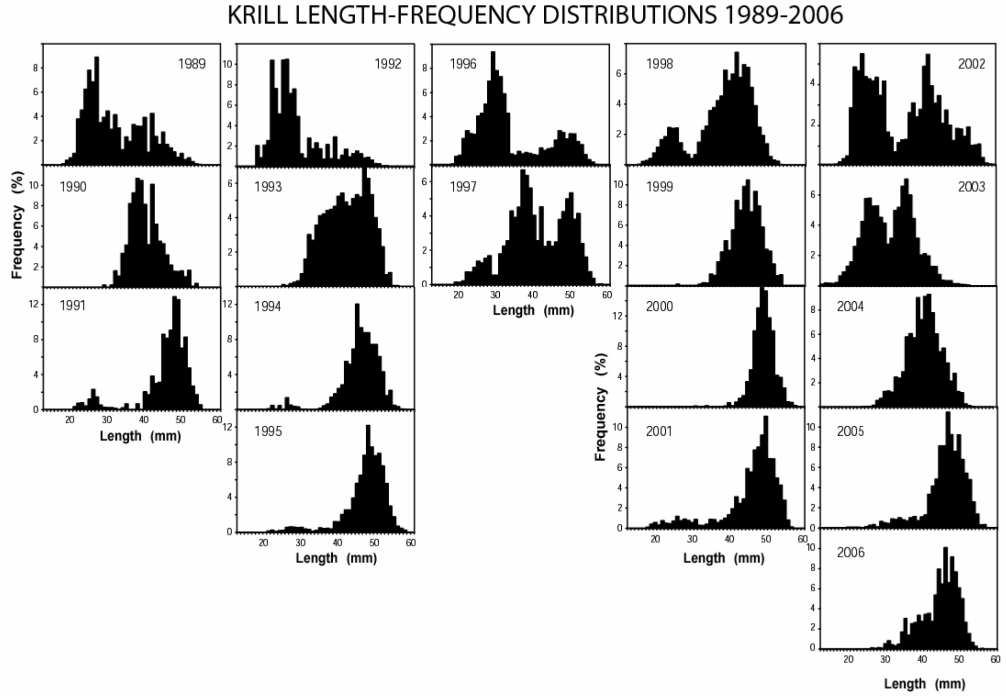

Figure 4.13 Krill length-frequency distributions represented in the Elephant Island Area during 1989-2006 showing temporal sequences of good and poor recruitment success. January-February surveys are used for all years except 2000.

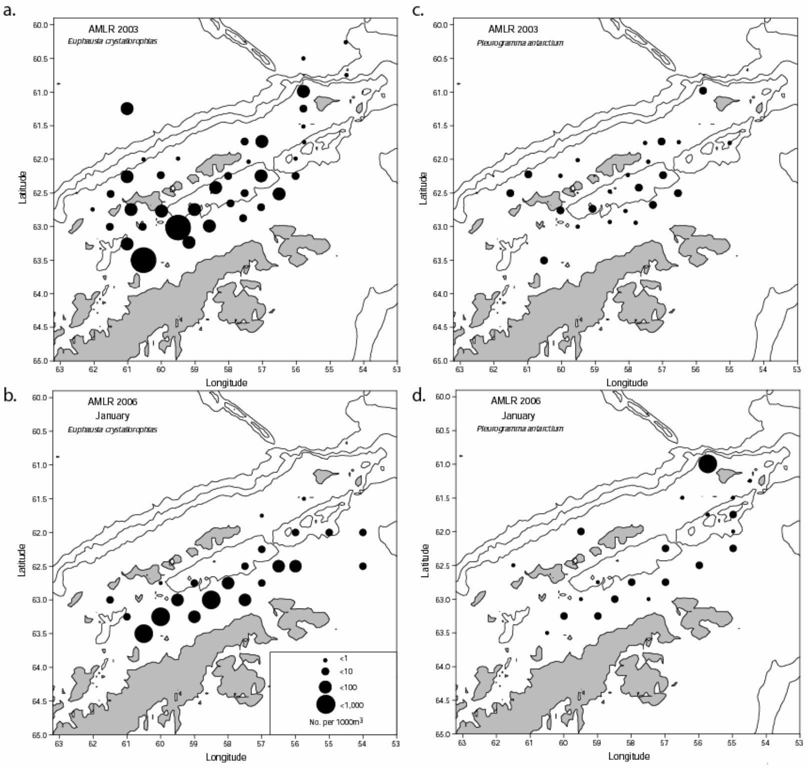

Figure 4.14 Distribution and abundance of *Euphausia crystallorophias* and *Pleuragramma antarcticum* during 2003 (A,B) and 2006 (C,D). Mean January and February-March values are used for 2003 while only January values are available for 2006.

5. Demersal Finfish Survey of the Northern Antarctic Peninsula; submitted by Christopher Jones, Cassandra Brooks, Bill Detrich, Kim Dietrich, Ryan Driscoll, Jacob Kendrick, Karl-Hermann Kock, Darci Lombard, Tom Near, and Sunhild Wilhelms.

5.1 Objectives: Commercial exploitation of finfish was conducted off the northern Antarctic Peninsula (CCAMLR Subarea 48.1) from 1978/79 through 1989, primarily on grounds north of Joinville/D'Urville Islands. At the end of the 1989/90 fishing season, CCAMLR imposed a moratorium on all commercial finfish fishing in Subarea 48.1. Unlike the peri-Antarctic South Shetland Islands opposite the Bransfield Strait, the Antarctic Peninsula Joinville/D'Urville Islands are high-Antarctic regions of CCAMLR Subarea 48.1. The primary target commercial species fished in this region was *Chaenodraco wilsoni*, with a by-catch species *Chionodraco rastrospinosus* also landed (CCAMLR, 1990a, 1990b). The historical characterization of the demersal finfish fishery around Joinville-D'Urville Islands presented by Kock *et al*. (2004) indicates that the fishery and extent of exploitation was primarily dependent on the formation and of concentrations of *Chaenodraco wilsoni*. Species other than *C. wilsoni* and *C. rastrospinosus* noted in relatively high abundance in this region, based primarily on five research hauls taken in 2002 by the *RV Polarstern* (Kock *et al*., 2004) included *Notothenia coriiceps*, *Gobionotothen gibberifrons*, and *Lepidonotothen nudifrons*.

To characterize the current level of stock biomass, collect information on the distribution, biology, ecology, live history characteristics, and determine whether shelf areas can be re-opened to possible finfish exploitation, the first random, depth-stratified bottom trawl survey of the northern Antarctic Peninsula was undertaken during Leg II of the 2006 AMLR field season. Information derived from this survey characterizes demersal finfish stock demographics, and helps elucidate the position and inter-species relationships of demersal finfish within the Antarctic ecosystem.

Although there have been some collections of fish in this region (Kock *et al*., 2004), as well as experimental fishing trials (Sosinski and Trella, 2001), research hauls have been limited to single digit deployments. This survey represents the first comprehensive scientific characterization of demersal fish along the fishable and accessible shelf regions of the northern Antarctic Peninsula region of Subarea 48.1.

The AMLR program initiated the bottom trawl survey component during the 1996/1997 Austral summer, when 7 hauls were conducted in the South Shetland Islands (Subarea 48.1). During the 1997/1998 Austral summer, the first large-scale bottom trawl survey was initiated. The AMLR Program has since conducted periodic bottom trawl surveys in other regions of the Southern Scotia Arc (CCAMLR Subareas 48.1 & 48.2). The AMLR program has conducted three other finfish surveys in the South Shetland Islands region of Subarea 48.1.

The survey objectives included estimation of abundance, species composition, size composition, demographic structure, and diet composition of finfish species within the 500m isobath of the northern Antarctic Peninsula and Joinville/D'Urville Islands. Several other sampling efforts and biological experiments were conducted during the course of this survey, including otolith sampling for age and growth studies, buoyancy measurements, DNA collections, and other tissue collections for biological and physiological experiments. Other components of the Antarctic Peninsula shelf ecosystem examined during leg II included underway acoustic sampling of krill swarms (Chapter 3), characterization of benthic invertebrate by-catch (Chapter 6), acoustic classification of seabed types (Chapter 3), and CTD casts (Chapter 1). The overall goals of this leg were to collect information to be used toward an ecosystem based assessment of the biomass and spatial distribution of demersal fish of the Northern Antarctic Peninsula and Joinville/D'Urville Islands; to acoustically classify habitat characteristics of seabeds, to characterize feeding guilds; and to examine relationships between benthic and pelagic components of the Antarctic ecosystem and how these features may influence demersal finfish resources.

5.2 Methods:

5.2.1 Bottom Trawling: The at-sea protocols used to conduct the trawl survey were based on those used during previous AMLR bottom trawl surveys. The fishing gear used was the "Hard Bottom Snapper Trawl" with vented V-Doors (Net Systems, Inc. Bainbridge Island, WA). Diagrams of the net, doors, and rigging can be obtained from the AMLR program upon request. The trawl is deployed from a 6'6" wide X 12'7" diameter net reel, an 11'9" long 12" diameter stern roller, two trawl winches, instrumented trawl blocks, and a third wire slip ring winch. The headrope transducer platform of the trawl was instrumented with a SimRad FS25 Trawl sonar system used to monitor the geometry of the mouth of the trawl as it is deployed and record when it makes contact with the bottom. The net sonar is also used to measure the trawl mouth dimensions in real time while sampling the station.

Trawling operations were conducted aboard the R/V *Yuzhmorgeologiya* 19 February, 2006 through 16 March, 2006 (Table 5.1). There were a total of 63 hauls completed along the Antarctic Peninsula and Joinville/D'Urville Islands, and 2 hauls north of Livingston Island the South Shetland Islands (Figure 5.1). The sampling strategy along the Peninsula was based on random depth-stratified survey design, and stations were positioned to account for as wide a geographic range as time, sea, and ice conditions determined. There were six targeted designated depth strata: 50-100m, 100-200m, 200-300m, 300-400m and 400-500m. Hauls taken in the sixth strata, between 700-800m, were included on an exploratory, opportunistic basis to increase collections of rare deep sea notothenioid species for taxonomic and physiological studies.

The numbers of hauls within the six depth strata were 3, 16, 18, 14, 11, and 3, respectively. In all cases, a haul was taken only after initial acoustic reconnaissance verified that bottom conditions were suitable for trawling. All final decisions regarding sampling operations during the survey were made by the chief scientist in consultation with the fishing master and ship captain. The initial survey design called for seven additional hauls within the 50-100m depth range within the surveyed areas. However, due to heavy concentrations of icebergs and growlers grounded and otherwise present, these stations were abandoned for safety reasons. Several other initially planned stations were inaccessible due to heavy ice concentrations. However, these were successfully located in the same general shelf region within the same targeted depth strata. The realized locations of almost all hauls varied to some degree from the initially planned coordinates due to sea, wind, bottom, and ice conditions. Nevertheless, for the majority of target strata, the planned survey design was completed successfully.

All hauls with the exception of those taken in the sixth strata were conducted during daylight hours with a targeted haul time of 30 minutes. Trawling started as soon as the footrope made contact with the bottom. Once contact with the bottom was made, time, geographic coordinate, ship speed, bearing, headrope depth, bottom depth, and net mouth geometry (via real-time trawl imaging from the net sonar's computer on the bridge), were recorded. Recordings were made every five minutes thereafter through the course of the haul. The area of seabed sampled during the haul was determined by the latitude longitude coordinates taken with GPS from the start to the end of bottom trawling, and the average of the trawl mouth width recorded while on the bottom. Supplementary data collected for each haul included ship course, air temperature, wind direction and speed, weather, cloud conditions, sea state, light and ice conditions. All haul and cruise specific information is stored in hardcopy format and in computer database maintained by the U.S. AMLR program.

5.2.2 Haul Processing: After a successful haul, the contents of the trawl were emptied onto the deck and transferred to a sorting table, where fish were identified, separated into species, and placed into individual species baskets. Organisms other than fish (benthic invertebrates) were processed separately (See Chapter 6). Baskets were weighed to obtain total catch weights by species. Where catches of a single species were very large, a subsample of the catch was taken (see Subsampling Protocol).

There were 2 categories of haul processing. Category 1 included length (nearest cm below), sex, and gonad maturity stage. Length types were collected as total length (length from tip of snout to end of caudal fin) for all species except myctophids, where length was measured in mm as standard length (length from tip of snout to end of caudal peduncle). Maturity was classified on a scale of 1 to 5 (immature, maturing virgin or resting, developing, gravid, spent) according to the method of Kock and Kellermann (1991). The gonado-somatic index GSI (Kock, 1989) was collected from several species to describe the individual developmental stage of the gonads and to estimate the time of spawning. Category 2 processing included full biometric data including length, weight, sex, maturity, gonad (ovary or testis) weight, diet composition, eviscerated weight, and otolith sampling. All weights were measured as total fresh weight to nearest gram.

An examination of the diet composition for 3752 stomachs of 34 species of finfish was conducted across all regions of the shelf. Of the stomachs examined, 2608 individuals of 33 species contained stomach content material. Stomach content information included content weight (to the nearest g); a measure of the filling degree according to a scale of 0-5 (empty, 25% full, 50% full, 75% full, 100% full, regurgitated); and a measure of the degree of digestion according to a scale of 1-3 (fresh, moderately digested, fully digested). Dietary items were identified to species whenever possible, and to general common taxonomic groupings when material was digested or difficult to verify. The relative volume of each species present within a stomach was recorded by assigning each dietary component a proportion from 0-10, with the total score for each stomach added to 10.

Otoliths were taken from 223 fish of three species for age and growth work. Otoliths will be used primarily to estimate age and construct age-length keys, which will allow age-based models to be used in assessing the population biology and stock status of each species.

5.2.3 Sub-sampling Protocol: Where yields of a species were too large to process in their entirety due to time constraints, sub-sampling was performed using randomized techniques for either Category 1 or Category 2 processing. When using a straightforward simple random sampling with each fish as an independent sampling unit was logistically impractical, we used full baskets of fish as primary sampling units (PSUs). Two forms of sampling strategies were then used: *cluster sampling*, where all fish within a basket were sampled, and *multi-stage sampling*, were only some of the fish within a basket were sampled at random. Sampling effort was adjusted for each haul to allow sampling to be completed before the next haul was on deck. Additional details on these methods and statistical rationale is provided in Ashford and Jones (2001).

5.3 Results and Tentative Conclusions:

5.3.1 Yields and Catch Rates: A total of 1,918kg (7,990 individuals) of 52 finfish species were processed from all hauls (Table 5.2). The dominant element of the Antarctic fish fauna both in terms of biomass and numbers was within the suborder Notothenioidei (Perciformes). The highest standardized densities of combined finfish occurred at stations along a relatively narrow band north of Joinville Island (Figure 5.2A). The highest mean densities for finfish species combined were within the 100-200 m depth strata, those these were not significantly different than those in the 200-300 m depth strata ($P<.0001$, t-test assuming unequal variances).

Prominent finfish species in hauls (defined here as over 100 individuals) included *Chaenodraco wilsoni, Chionodraco rastrospinosus, Cryodraco antarcticus, Gobionotothen gibberifrons, Gymnoscopelus nicholsi*, *Lepidonotothen larseni, L. nudifrons, L. squamifrons, Notothenia coriiceps, Pleuragramma antarcticum, Trematomus eulepidotus,* and *T. newnesi.*

The species with the greatest nominal catch in numbers was *Gobionotothen gibberifrons* (2374 individuals, 719kg), followed by *Trematomus newnesi* (1135 individuals, 133 kg), and *Pleuragramma antarcticum* (30kg, 829 individuals). The greatest yield in kilograms was *G. gibberifrons* followed by *Chionodraco rastrospinosus* (290kg, 727 individuals) and *Trematomus eulepidotus* (157kg, 768 individuals).

The spatial distribution of standardized finfish densities demonstrated substantial contrast. The mean density of undifferentiated finfish biomass for all stations pooled was 3.4 tonnes/nmi^2 (σ=3.5). The greatest standardized density of fish at a single station was 17.4 tonnes/nmi^2 at Station 79 north of Joinville Island (Figure 5.1; 5.2A) at a depth of 291m. This station was dominated by *G. gibberifrons* (69%), with 14 other species making up the remaining percentage. Other stations with substantial densities of finfish were in the same geographic region. Station 81 (132m) was also dominated by *G. gibberifrons*, (51%), *Chionodraco rastrospinosus* (15%) and 10 other species. Nearby Station 46 (149m) was notable in that it was dominated by a large prespawning aggregation of *Trematomus newnesi* (96%).

The number of species encountered at each station (Figure 5.2B) ranged from 2 to 17, with an average of 10 species per haul. The benthic fish fauna consists of two elements: the low – Antarctic and the high – Antarctic fauna. This feature is observed as well to some degree around the South Shetland Islands, but is exacerbated along the northern Antarctic Peninsula due to the confluence of faunal assemblages associated with Weddell Sea and Bransfield Strait. The most ubiquitous species was *C. rastrospinosus* (encountered at 59 of the 64 stations). Other species frequently encountered were *G. gibberifrons* (56 stations), *T. eulepidotus* (49 stations), and *C. wilsoni* (42 stations). All other species occurred in less than 50% of hauls.

5.3.2 Results – Abundant Finfish Species:

Chaenodraco wilsoni: The channichthyid *C. wilsoni*, a species that was formerly targeted by the commercial fishery in the region, was encountered on a relatively frequent basis throughout the survey. A nominal total of 78kg (412 individuals) were captured from 42 stations (Table 5.2), and the overall average standardized density was 132 kg/nmi^2. *C. wilsoni* were encountered at depths from 118 to 755m (Figure 5.3), though the greatest densities were observed between 100 and 350m. The spatial distribution of biomass (Figure 5.4A), demonstrates the majority of the *C. wilsoni* occurring north of Joinville Island, which roughly corresponds with the historical fishing grounds for this species. Fish were encountered within all depth strata, with the greatest mean densities occurring within 100-300m depth (Table 5.3).

The length frequency distribution of *C. wilsoni* demonstrated a large mode around 26 – 34cm, likely comprised of 1 or 2 age classes (Figure 5.5A). A small number of juveniles (7cm) were also encountered. Otoliths of *C. wilsoni* and will be processed and read by colleagues in Italy.

Gonads of *C. wilsoni* were almost entirely in resting stage (stage 2). A small proportion (< 2%) of the fish had gonads in transition from stage 5 (spent) to stage 2 which indicates that spawning had been completed by early January. There were also immature (stage 1) modes detected at 7 and 27cm, along with occasional stage 3 specimens.

A total of 338 *C. wilsoni* stomachs from were analyzed for diet composition. Feeding intensity was relatively high, with 269 (80%) having stomach contents. Krill constituted 100% of the overall diet for all individuals examined (Figure 5.6).

***Chionodraco rastrospinosus*:** The channichthyid *C. rastrospinosus* is a true high Antarctic species that occurs regularly throughout Subarea 48.1 on both sides of the Bransfield Strait. A total of 290kg (727 individuals) were captured, and the overall average standardized density was 515 kg/nm^2. This species was the most ubiquitous amongst all finfish occurring at 59 stations of the 62 stations (Table 5.2) within all depth strata sampled (Figure 5.3). The highest densities were encountered north of Joinville Island (Figure 5.4B) and within 100-300m depth strata (Table 5.3).

The size distribution of *C. rastrospinosus* ranged from 7 to 36cm (Figure 5.5B), with several modes occurring. Age class 1+ of *C. rastrospinosus* (14 – 17cm) was caught for the first time on record. Together with age class 0+ fish (5 – 8cm) which are found regularly as by – catch in the krill fishery (Iwami *et al*., 1996) they will allow to better verify age determinations of the species from otoliths. A large fraction of *C. rastrospinosus* were caught in pre – spawning, spawning and post – spawning condition (Figure 5.5B) which suggested that the species was in the middle of the spawning season. Oocyte diameter of running ripe fish was 4.7 – 4.9mm.

Of the 577 stomachs examined for diet, only 263 (46%) contained material. The proximity of the spawning season likely prevented many *C. rastrospinosus* from feeding. Post-spawning fish were found to prey on krill and fish (both mesopelagic and benthic). The average diet composition consisted mainly of krill (Figure 5.5).

***Cryodraco antarcticus*:** A relatively large number of the high Antarctic channichthyid, *Cryodraco antarcticus* was encountered during the course of the survey (78kg, 257 individuals, from 34 stations). *C. antarcticus* is similar in size and morphology to *C. aceratus*, which is frequently encountered around the South Shetland Islands. Kock and Jones (2002) suggested that *C. antarcticus* replace *C. aceratus* in deeper water. It is likely as well that *C. antarcticus* serve to replace the ecological role of *C. aceratus* at higher latitudes. This is evidence that the Bransfield Strait is an important transition zone between 'low Antarctic' and 'high Antarctic' finfish faunal assemblages.

Fish were encountered in all depth strata except the most shallow (Figure 5.3; Table 5.3). The greatest mean densities of *C. antarcticus* (1,560kg/nmi^2) were encountered near the shelf break north of Joinville/D'Urville Islands in the 300-400m depth strata (Figure 5.4C). The lengths of fish encountered ranged from 6cm to 62cm (Figure 5.5C), with a major length mode around 36-38cm.

The majority of fish were juvenile stage 1 (57%), with 31%, 10%, 1%, and 1% for stages 2-5, respectively. Given that most *C. antarcticus* were represented by fish less than 45cm long which were either juvenile fish or males in an early stage of maturation, this indicates that the maturation process takes longer than one year as has been described also for *C. aceratus* in the low – Antarctic (Everson *et al*., 1997) which occupies the same ecological niche. The few males in pre – spawning and spawning condition were all larger than 45cm. The few adult females were longer than 53cm. They were either in pre- spawning condition (stage 3) or were spent already (stage 5). This was consistent with previous results which pointed at February – March as the spawning season for *C. antarcticus* (Kock and Jones, 2002).

A total of 249 stomachs from were analyzed for diet composition, although only 80 fish had some stomach contents. The average diet composition consisted mainly of fish (85%; Figure 5.5. The proportion of empty stomachs was high, and there was evidence that some stomach contents were regurgitated. Individuals < 30cm fed primarily on krill while larger individuals took *Pleuragramma antarcticum* and benthic nototheniids and a small proportion of krill.

Gobionotothen gibberifrons: As in other regions of Subarea 48.1, nototheniid *G. gibberifrons* was the most abundant demersal finfish species, and one of the most frequently encountered. A total of 719kg (2,374 individuals) were captured from 56 stations (Table 5.2), and the overall average standardized density was 1,295 kg/nm^2. Fish were encountered in all depth strata (Figure 5.3; Table 5.3), with the highest standardized densities occurring in the 100-200m strata. The majority of catches occurred north of Joinville Island, largely along a north-south orientated band between 100 and 300m (Figure 5.4D).

The size distribution ranged from 6 to 47cm, with modes occurring 16, 22, 28 and 35cm (Figure 5.5D). Fish were immature or in resting stage gonads. Most fish (61%) were stage 1, and stage 2 (32%), with 7% immature. Gonads of *G. gibberifrons* in resting stage confirm observations from other areas in the southern Scotia Arc that the species is spawning in austral winter (August – September).

Of the 881 *G. gibberifrons* stomachs analyzed, 860 (98%) had at least 25% full stomachs. As has been demonstrated in other regions of the Southern Scotia Arc, *G. gibberifrons* demonstrated the highest degree of variability in diet composition of all finfish encountered. *G. gibberifrons* is primarily a benthic browser, and thus has a varied diet (Figure 5.6). Polychaetes accounted for one of the most abundant identifiable prey items in their stomachs (19%), though their diet was dominated by largely digested benthic invertebrates (49%), followed by amphipods (10%), krill (9%), ophiroids (5%), salps (3%), isopods (3%), fish (2%), and echinoderms (1%).

***Gymnoscopelus nicholsi*:** The pelagic myctophid *G. nicholsi* was captured opportunistically during the course of the survey. This species, along with *Electrona antarctica* and *Pleuragramma antarcticum* constitutes an important prey item after krill for several species of finfish, land based birds, and mammals, and are one of the most important finfish species of the Antarctic ecosystem. Other species myctophid species encountered included *G. braueri*, *G. opisthopterus*, and *K. anderssoni*.

A total of 10kg (258 individuals) of *G. nicholsi* were captured from 13 stations. Catches occurred at offshore stations in waters deeper than 300 meters (Figure 5.3; 5.4E). The size distribution of *G. nicholsi* ranged from 125 and 172mm (Figure 5.5E), with several length modes. The limited number of *G. nicholsi* staged for maturity demonstrated immature stage 1 gonads.

A small sample of total *G. nicholsi* stomachs (n=14) were analyzed for diet composition. All had some stomach contents present, which consisted entirely of krill (Figure 5.6).

***Lepidonotothen larseni*:** The nototheniid *L. larseni* is small but relatively abundant, and is an important prey item to fish eating demersal finfish. A total of 9kg (206 individuals) were captured from 39 stations (Table 5.2), and the overall average standardized density was 16 kg/nm^2. Unlike most other species, the majority of catches were not north of Joinville Island, but along the peninsula region (Figure 5.4F). The greatest densities of this species were encountered between 200 and 400 meters (Figure 5.3; Table 5.3). The size distribution of *L. larseni* ranged from 11 to 20cm, with a well-defined mode at 18cm (Figure 5.5F).

Gonads of *L. larseni* were in an early stage of maturation. Most fish were either stage 2 (43%), or stage 3 (38%), with 18% immature. This suggests that spawning will not commence before late June.

A total of 202 stomachs from *L. larseni* were analyzed. Most fish (77%) had at least 25% full stomachs. The diet was composed largely of krill (64%; Figure 5.6) and miscellaneous benthic invertebrate material (28%). In addition, their diet consisted of salps (3%), amphipods (2%), mysids 2%, and isopods (1%).

***Lepidonotothen nudifrons*:** The nototheniid *L. nudifrons* is a small regularly occurring demersal species which rarely exceeds 21cm in size, and often serves as prey for several finfish species. A total of 8.7kg (228 individuals) were captured from 34 stations, and the overall average standardized density was 16.8 kg/nm^2. This species has a shallow water distribution (Figure 5.3), with the greatest densities in the 100-200 meter strata (Table 5.3). Greatest densities were observed in northern stations within this stratum (Figure 5.4G). The size distribution of *L. nudifrons* ranged from 9 to 19cm, with a well defined mode at 15cm and a smaller mode of juvenile fish at 11cm (Figure 5.5G).

A large fraction of the sample was sexually mature and gravid (37% and 15%, respectively), as well a relatively large number of immature and developing (32% and 15%, respectively). The mature and gravid fish were likely to commence spawning in 3 – 6 weeks time.

A total of 212 stomachs from *L. nudifrons* were analyzed for diet composition. Most fish (138) had least 25% full stomachs. This species has a varied diet (Figure 5.5). Much of their diet consisted of partially digested benthic invertebrate species (37%).

Lepidonotothen squamifrons**:** A relatively large number of the nototheniid *L. squamifrons* was encountered during this survey. A total of 43kg (119 individuals) were captured from 13 stations (Table 5.2), and the overall average standardized density was 68 kg/nm^2. Catches occurred in deepwater stations, with highest densities in the easternmost stations (Figure 5.4H) northeast of Joinville Island. As observed in other parts of Area 48, the highest average densities were encountered in the deeper strata (300-500m; Figure 5.3; Table 5.3). The size distribution of *L. squamifrons* ranged from 17 to 46cm, with a well defined mode at 30cm.

Fish were found at four stages of maturity, with 69% juveniles, and 18%, 8%, and 4% observed at maturity stages 2, 3, and 5, respectively. The small fraction of spent individuals suggests *L. squamifrons* was just commencing their spawning season.

A total of 114 stomachs from *L. squamifrons* were analyzed for diet composition. All but 1 fish examined had at least 25% full stomachs. The diet of *L. squamifrons* was relatively complex, though comprised mainly of krill and jellyfish (Figure 5.6). Also observed in the diet were unidentified benthic invertebrates, fish, salps, isopods, amphipods, polychaetes, pycnogonids, and ophiuroids, mostly digested.

Notothenia coriiceps: The nototheniid *N. coriiceps* is an important representative of the demersal finfish community found throughout shallow shelf areas of the Scotia Sea. A total of 126kg (112 individuals) was captured from 30 stations (Table 5.2), and the overall average standardized density was 244 kg/nm^2. Fish were found in most shallow stations along the survey area, with the highest densities north of the tip of the Peninsula and Joinville/D'Urville Islands stations. Concentrations of *N. coriiceps* were found primarily in shallow waters less than 200m (Figure 5.3), with the greatest average densities between in the 100 and 200 meters (Table 5.3). The size distribution ranged from 27 to 55cm, with a mode appearing at around 38cm (Figure 5.5I).

Most individuals (84%) encountered were stage 3 (sexually mature); with the remaining at stage 2 (though close to 3). Maturation of most gonads appears to be synchronized. This species likely spawns over a comparatively short period of time, commencing in about 3 – 6 weeks time from the time of this survey.

A total of 106 stomachs from *N. coriiceps* were analyzed for dietary composition, 82 of which had at least 25% full stomachs. *N. coriiceps* demonstrated a near omnivorous diet (Figure 5.6), though was dominated by krill (46%) and fish (41%). Other components included salps, unidentified benthic invertebrates, isopods, amphipods, octopus, ophiuroids, mysids and benthic algae.

Pleuragramma antarcticum: A surprisingly large number of the mesopelagic species *Pleuragramma antarcticum* were captured opportunistically during course of the survey. This species, along with *G. nicholsi* and *Electrona antarctica* constitutes an important prey item after krill for several species of finfish, land based birds, and mammals, and are one of the most important finfish species of the Antarctic ecosystem. We captured 30kg (829 individuals) at 15 stations.

Catches occurred at offshore stations along the survey area (Figure 5.4J), in waters deeper than 400 meters (Figure 5.3; Table 5.3). The size distribution of *P. antarcticum* ranged from 6 to 29cm (Figure 5.5J), with a strong mode at 16cm. A very limited number of specimens were staged for maturity (n=57), and showed fish equally immature or developing (stage 1 and 2).

A total of 49 small sample of *P. antarcticum* stomachs were sampled for dietary composition, 28 of which had at least 25% full stomachs. Diet (Figure 5.6) was comprised primarily of krill (74%), miscellaneous invertebrates (22%), and some hyperid amphipods (4%), mostly digested.

Trematomus eulepidotus: A relatively large number of the high – Antarctic nototheniid *T. eulepidotus* was encountered during this survey. A total of 157kg (768 individuals) were encountered from 49 stations (Table 5.2), and the overall average standardized density was 254 kg/nm^2. The species was present in all depths except the most shallow (Figure 5.3), with the highest standardized densities occurring in the 400-500m stratum (Table 5.3). The spatial pattern of *T. eulepidotus* density demonstrated a markedly increase from the southern to the northernmost stations (Figure 5.4K).

The size distribution ranged from 13 to 37cm, with modes at 21cm and 27cm (Figure 5.5K). Most fish (60%) were immature, along with 14% and 25%, observed at maturity stages 2 and 3 respectively. Those observed at stage 3 were relatively advanced, and likely to commence spawning in 3 – 6 weeks time.

Results from the diet analysis indicated that *T. eulepidotus* fed primarily on krill (65%) as well as miscellaneous invertebrates, including jellyfish (23%), fish, salps, amphipods, polychaetes, and isopods (Figure 5.6).

***Trematomus newnesi**:* A large number of the high – Antarctic nototheniid *T. newnesi* was encountered during this survey, including a station where a pre-spawning aggregation was forming. A total of 133kg (1135 individuals) were encountered from 28 stations (Table 5.2), and the overall average standardized density was 237 kg/nm^2. The species was present in all depth strata sampled (Figure 5.3), with the highest standardized densities occurring in the 100-200m stratum (Table 5.3), though this was likely heavily influenced by the sampling of a dense aggregation at station 46. The highest densities of *T. newnesi* were north of the tip of the peninsula, and north of Joinville in shallow strata, though they were found throughout the southerly shallower stations of the entire survey area (Figure 5.4L).

The size distribution ranged from 13 to 27cm, with a strong mode at 19cm (Figure 5.5L). Fish were overwhelmingly mature (66%), along with 13%, 21, and 1% observed at maturity stages 1, 2, and 4 respectively. Those observed at stage 3 were relatively advanced, and small fraction of spawning individuals suggests *T. newnesi* was just commencing their spawning season.

Results from the diet analysis indicated that *T. newnesi* was similar to *T. eulepidotus*, though with a substantially higher proportion of fish in the diet. They fed primarily on krill (53%), fish (37%) as well as miscellaneous invertebrates, including jellyfish (6%), salps, amphipods, and isopods (Figure 5.6).

Notes on Other Species: The other two families of the suborder Notothenioidei, the Bathydraconidae (dragon fish) and the Artedidraconidae (plunderfish), were less represented in samples during the course of the survey. The bathydraconids encountered were *Gymnodraco acuticeps*, *Parachaenichthys charcoti* and *Gerlachea australis*. Artedidraconids were represented by *Artedidraco skottsbergi* and members of the genus *Pogonophryne*, including *P. barsukovi*, *P. marmorata*, *P. permitini*, *P. scotti*, and *P. squamibarbata*.

Other faunal elements present in catches included pelagic myctophids other than *G. nicholsi* (*Electrona antarctica* and *Krefftichthys anderssoni*) and the zoarcids (*Pachycara brachycephalum*, *Ophthalmolycus amberensis*), skates (*Bathyraja eatonii*, *B. maccaini*, *B. sp.* 2) and snailfishes (Liparididae) of the genus *Paraliparis*. They are either of non – Antarctic origin or form separate species in the Southern Ocean.

5.4 Other finfish-related research during conducted during AMLR 2006:

5.4.1 Collection of Features Toward Antarctic Finfish Habitat Characterization and Spatial Aspects of Demersal Finfish Dietary Constituents: Information on several characteristics of the pelagic and seafloor components of shelf areas around the Antarctic Peninsula and Joinville/D'Urville Islands survey area were collected in an effort to further elucidate the role of mesohabitat features (Auster, 1998) on demersal fish assemblages. Further detail on habitat-related collections are provided in Chapter 3 of this report, and Chapter 6 of this report (benthic invertebrate mega epifaunal composition).

Shelf areas of the Antarctic Peninsula and Joinville/D'Urville Islands consist of a number of contrasting features, including significant diversity in depth, pelagic prey distribution, seabed composition, and benthic invertebrate communities. These features likely play a role in the dietary composition of demersal finfish in a spatial context. During the course of this survey, we were able to characterize the stomach contents of 3,752 individual finfish across all areas of the shelf region (2,608 of these had at least 25% full stomachs; Figure 5.6A). Further analysis of these and other factors influencing spatial distribution of demersal finfish communities, biomass, and presence/absence is ongoing

5.4.2 Biodiversity, buoyancy variation, and systematics of notothenioid fishes: The 38 species of notothenioid demersal fish encountered during the course of the AMLR 2006 survey was by far the largest tally for any AMLR bottom trawl survey. Over 300 tissue biopsies and preserved carcasses were collected for genetic studies. These specimens will be cataloged in the

Yale Peabody Museum of Natural History. Projects resulting from specimens that we have collected on AMLR are outlined below.

5.4.3 Buoyancy variation among notothenioid species: Work on buoyancy variation is demonstrating that closely related notothenioid species can have significantly different buoyancy measurements. This is hypothesized to reflect water column habitat use with more buoyant species being less benthic. Most species of teleost fishes use a swim bladder to regulate buoyancy. All notothenioid fishes lack a swim bladder; however, there has been substantial variation in buoyancy detected among notothenioid species. The buoyancy of a specimen (percent of the weight in air divided by the weight in water) was measured and tissues were taken for 255 specimens from 38 notothenioids for genetic analyses. To determine the weight in water, specimens were suspended completely in seawater by a silk suture attached to a triple beam balance. Further analysis of geographic variation in buoyancy among notothenioid species is ongoing.

The AMLR 2006 trawl survey captured five specimens of *Aethotaxis mitopteryx*, a rare circum-Antarctic notothenioid species. From these specimens, it was possible to confirm that this species is neutrally buoyant. Further analysis of these findings is ongoing.

5.4.4 Systematics of rare notothenioid species: Traditional morphometric data are being employed to assess the systematics and taxonomy of rare notothenioid species. Species of particular interest collected during AMLR 2006 include *Trematomus tokarevi*, *Aethotaxis mitopteryx*, and *Pogonophyrne squamibarbata*. It is interesting to note that the AMLR 2006 specimen of *P. squamibarbata* is only the third specimen of this rare species ever collected.

5.5 Disposition of Data: Data collected from the trawl survey were documented on hardcopy datasheets and entered into an MS-ACCESS computer database. The U.S. AMLR program maintains these hardcopies and computer databases.

5.6 References:

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Table 5.1. Station and nominal finfish catch information for the 2005/06 AMLR bottom trawl survey of the northern Antarctic Peninsula.

Station	Haul Number	Date	Latitude (ºS)	Longitude (ºW)	Depth Strata	Avg. Depth	Number Finfish Species	Finfish Catch (Kg)	Total Number Finfish
7	1	19-Feb-06	63º25.37	59º42.87	1	95	9	30.88	66
1	2	19-Feb-06	63º27.54	60º03.73	2	112	9	28.09	113
5	3	20-Feb-06	63º14.07	59º46.83	3	234	8	9.24	34
4	4	20-Feb-06	63º12.78	59º52.90	4	342	5	1.8	9
6	5	20-Feb-06	63º14.37	59º34.33	5	460	14	31.12	178
14	6	21-Feb-06	63º04.98	58º36.69	2	126	11	54.21	165
12	7	21-Feb-06	63º14.82	59º04.53	4	334	11	6.46	47
8	8	21-Feb-06	63º14.66	59º26.48	6	755	10	4.13	55
16	9	22-Feb-06	63º00.51	58º50.02	4	353	10	57.2	109
15	10	22-Feb-06	63º03.00	58º46.95	3	222	8	27.33	70
19	11	22-Feb-06	63º00.02	58º05.01	3	235	14	51.24	208
17	12	22-Feb-06	62º52.84	58º13.81	5	505	7	5.4	48
21	13	23-Feb-06	62º58.57	57º37.11	2	118	8	18.29	40
24	14	23-Feb-06	62º47.90	57º20.48	2	163	13	33.71	111
26	15	23-Feb-06	62º42.23	57º00.79	3	229	10	16.28	78
23	16	24-Feb-06	62º43.05	57º18.84	5	462	12	15.32	111
33	18	25-Feb-06	62º36.78	56º36.61	3	231	15	72.82	252
35	19	25-Feb-06	62º28.90	56º17.25	4	344	7	29.76	78
34	20	25-Feb-06	62º21.66	56º06.54	5	410	16	37.41	121
36	21	25-Feb-06	62º20.85	56º00.20	4	352	8	10.25	37
37	22	26-Feb-06	62º18.41	55º40.88	4	332	9	48.28	116
46	23	26-Feb-06	62º32.72	55º21.95	2	149	7	121.25	996
41	24	26-Feb-06	62º38.57	55º37.44	2	171	11	16.01	104
40	25	26-Feb-06	62º36.60	55º25.80	2	142	10	53.79	189
38	26	27-Feb-06	62º22.14	55º37.15	3	258	6	15.87	62
47	27	27-Feb-06	62º15.30	55º18.18	4	345	7	14.76	52
48	28	1-Mar-06	62º10.35	55º09.58	5	440	14	33.88	418
73	29	1-Mar-06	62º17.18	55º01.72	5	439	12	71.11	350
50	30	1-Mar-06	62º24.14	54º29.09	4	384	13	47.97	168
49	31	1-Mar-06	62º08.91	54º33.41	6	773	11	37.44	191
74	32	2-Mar-06	61º48.83	53º60.00	3	291	7	42.53	74
27	33	3-Mar-06	62º45.90	56º51.74	2	178	8	5.97	29
75	34	3-Mar-06	62º47.28	56º42.99	2	169	12	19.19	60
76	35	3-Mar-06	62º49.00	56º39.48	2	108	6	24.78	58
77	36	3-Mar-06	62º38.94	56º47.57	3	231	5	4.05	13
78	37	4-Mar-06	62º26.21	55º56.40	3	291	11	23.7	116
79	38	4-Mar-06	62º22.62	55º17.94	3	291	15	166.35	569
80	39	4-Mar-06	62º27.53	55º16.55	3	211	11	33.96	129
81	40	5-Mar-06	62º37.77	55º14.50	2	132	12	117.83	341

Table 5.1. (continued)

Station	Haul Number	Date	Latitude (ºS)	Longitude (ºW)	Depth Strata	Avg. Depth	Number Finfish Species	Finfish Catch (Kg)	Total Number Finfish
45	41	5-Mar-06	62º43.53	55º11.22	2	167	9	15.1	61
43	42	5-Mar-06	62º45.30	55º41.82	1	88	6	35.81	101
42	43	5-Mar-06	62º43.85	55º32.73	2	139	10	72.77	148
82	44	6-Mar-06	62º22.56	54º36.98	4	363	6	5.2	18
83	45	6-Mar-06	62º20.01	54º19.56	4	390	9	23.49	71
84	46	7-Mar-06	62º24.12	54º12.86	5	413	10	30.66	201
52	47	7-Mar-06	62º29.32	54º25.49	4	308	2	1.4	4
51	48	8-Mar-06	62º29.94	54º48.36	3	273	6	12.33	62
55	49	8-Mar-06	62º43.99	54º57.85	2	161	9	33.02	135
85	50	8-Mar-06	62º35.78	55º35.49	2	155	8	12.33	38
86	51	9-Mar-06	62º25.88	55º33.83	3	246	10	38.59	170
39	52	9-Mar-06	62º30.87	55º58.88	3	238	10	12.94	43
31	53	10-Mar-06	63º03.84	57º09.27	3	253	6	4.5	18
87	54	10-Mar-06	62º44.85	57º33.03	5	430	13	7.19	53
88	55	11-Mar-06	63º20.19	60º33.53	5	483	13	6.74	45
89	56	12-Mar-06	62º23.86	60º44.91	1	81	4	5.28	17
90	57	12-Mar-06	62º16.44	60º46.87	3	289	6	2.15	18
53	58	14-Mar-06	62º32.94	54º58.82	3	257	14	45.7	163
91	59	14-Mar-06	62º28.76	55º12.57	3	222	11	13.46	55
20	60	15-Mar-06	62º52.28	57º53.02	4	358	14	11.71	68
92	61	15-Mar-06	62º49.26	57º26.85	2	132	8	33.59	104
93	62	15-Mar-06	62º47.35	57º36.33	5	443.7	9	11.66	166
94	63	15-Mar-06	62º40.64	57º42.63	6	730	17	9.84	132
95	64	16-Mar-06	62º26.01	56º14.34	5	403	15	13.98	99
96	65	16-Mar-06	62º30.06	56º28.85	4	330	9	18.59	35

Table 5.2. Total nominal weight (kg), numbers and biological information recorded for finfish by species from the 2005/06 AMLR bottom trawl survey of the northern Antarctic Peninsula.

Species	Total Catch (kg)	Total Number	Number Stations Species Occurred	Length, Sex, and Maturity Collected	Weights Collected	Evisc. Weights Collected	Gonad Weights Collected	Diet Collected	Otoliths Collected
Aethotaxis mitopteryx	0.21	5	3	5	5	-	-	-	-
Artedidraco skottsbergi	0.028	3	2	3	3	-	-	-	-
Bathylagus antarcticus	0.029	1	1	0	1	-	-	-	-
Bathyraja eatonii	15.925	5	3	5	5	-	-	-	-
Bathyraja maccaini	89	21	13	21	21	-	-	-	-
Bathyraja species 2	1.974	10	7	10	9	-	-	-	-
Chaenocephalus aceratus	9	12	4	12	12	10	2	12	-
Chaenodraco wilsoni	78	412	42	412	348	331	-	338	105
Champsocephalus gunnari	4.613	16	4	16	16	5	-	16	-
Chionodraco myersi	0.341	2	2	2	2	-	-	2	-
Chionodraco rastrospinosus	290	727	59	727	586	521	129	577	-
Cryodraco antarcticus	78	257	34	255	255	243	26	249	111
Dacodraco hunteri	0.003	1	1	1	1	-	-	-	-
Dissostichus mawsoni	20	8	5	8	8	8	-	8	7
Electrona antarctica	0.446	47	10	24	24	-	-	-	-
Gerlachea australis	0.083	1	1	1	1	1	1	1	-
Gobionotothen gibberifrons	719	2374	56	2102	967	867	37	881	-
Gymnodraco acuticeps	10	60	34	57	59	50	3	56	-
Gymnoscopelus braueri	0.107	9	2	9	9	-	-	-	-
Gymnoscopelus nicholsi	10	258	13	233	111	15	-	14	-
Gymnoscopelus opisthopterus	0.038	1	1	1	1	-	-	-	-
Krefftichthys anderssoni	0.003	1	1	-	1	-	-	-	-
Lepidonotothen larseni	9	206	39	207	207	180	43	202	-
Lepidonotothen nudifrons	8.663	228	34	228	226	201	82	212	-
Lepidonotothen squamifrons	43	119	13	119	119	113	9	114	-
Macrourus whitsoni	27	130	2	-	1	-	-	-	-
Magnisudis prionosa	1.21	17	2	-	-	-	-	-	-
Myctophidae	0.005	2	2	2	2	-	-	-	-

Table 5.2. (continued)

Species	Total Catch (kg)	Total Number	Number Stations Species Occurred	Length, Sex, and Maturity Collected	Weights Collected	Evisc. Weights Collected	Gonad Weights Collected	Diet Collected	Otoliths Collected
Neopagetopsis ionah	7.02	6	6	6	6	-	2	5	-
Notothenia coriiceps	126	112	30	112	112	106	88	106	-
Notothenia rossii	5	6	5	6	6	3	-	3	-
Ophthalmolycus amberensis	2	20	9	20	20	3	-	3	-
Pachycara brachycephalum	2	13	9	12	13	1	-	1	-
Pagetopsis macropterus	6	37	17	36	36	17	1	35	-
Parachaenichthys charcoti	10	36	12	36	36	32	-	34	-
Paraliparis species	1.44	16	3	3	3	-	-		-
Pleuragramma antarcticum	30	829	15	546	437	48	-	49	-
Pogonophryne barsukovi	0.668	6	5	5	5	-	-	4	-
Pogonophryne marmorata	0.243	3	2	3	3	-	-	2	-
Pogonophryne permitini	0.227	2	2	2	2	-	-	2	-
Pogonophryne scotti	1.13	2	2	2	2	-	-	2	-
Pogonophryne squamibarbata	0.041	1	1	1	1	-	-	-	-
Pogonophryne species a	0.029	2	1	2	2	-	-	-	-
Racovitzia glacialis	0.198	1	1	1	1	-	-	-	-
Trematomus bernacchii	6.79	17	8	17	17	9	2	12	-
Trematomus eulepidotus	157	768	49	745	534	505	118	517	-
Trematomus hansoni	5	11	8	11	11	6	3	9	-
Trematomus loennbergii	0.257	1	1	1	1	-	-	1	-
Trematomus newnesi	133	1135	28	492	262	244	140	258	-
Trematomus pennellii	4	12	7	12	12	4		10	-
Trematomus scotti	0.493	11	8	11	11	5	1	8	-
Trematomus tokarevi	4	10	7	11	11	3	2	9	-
Total	**1917.62**	**7990**	**-**	**6553**	**4544**	**3531**	**689**	**3752**	**223**

Table 5.3. Standardized densities (kg/nm^2) of finfish species by depth strata from the 2006 AMLR survey of the Antarctic Peninsula.

Species	Depth Strata					
	1	2	3	4	5	6
A. mitopteryx				3.6		9.0
A. skottsbergi		1.0	2.3			
B. antarcticus						2.4
B. eatonii			699.8	463.5		
B. maccaini	1370	807.4	1074.5	85.4	617.1	
Bathyraja sp.2				26.6	37.4	
C.aceratus	272.3	237.4				
C. wilsoni		116.0	396.4	128.6	69.3	31.1
C.gunnari	77.5	149.0				
C. myersi					16.9	
C.rastrospinosus	481.4	782.6	836.5	237.2	181.4	283.2
C. antarcticus		13.5	205.0	320.8	236.7	63.8
D. hunteri						0.6
D. mawsoni			288.0	114.3	542.6	
E. antarctica			1.0	2.2	4.1	8.3
G. australis			8.7			
G. gibberifrons	2311	2155.3	1664.1	1166.5	583.5	71.3
G. acuticeps	23.1	50.5	24.3	29.5	32.4	11.2
G. braueri					4.9	
G. nicholsi			32.8	41.6	87.5	37.6
G. opisthopterus				4.1		
K. anderssoni					0.3	
L. larseni	8.8	28.1	23.3	33.6	22.4	
L. nudifrons	23.1	47.5	24.7	10.9		
L. squamifrons				343.4	327.2	
M. whitsoni						1303.1
M. prionosa						52.1

Species	Depth Strata					
	1	2	3	4	5	6
Myctophidae			0.3		0.1	
N. ionah		222.3	132.4		66.6	112.8
N. coriiceps	644	751.2	254.5	90.6		
N. rossii		99.1	103.6			
O. amberensis			27.7	7.8	18.9	
P. brachycephalum			5.4	20.8	19.5	12.7
P. macropterus		51.0	41.6	5.9		
P. charcoti	66.7	141.4	49.2			
Paraliparis sp.					20.5	52.6
P.antarcticum			0.9	4.7	293.4	94.9
P.barsukovi				8.0	14.1	13.7
P. marmorata				12.6		
P. permitini				9.6	11.3	
P. scotti			88.9	21.6		
P. squamibarbata						3.4
P. sp. A						2.4
R. glacialis					20.5	
T. bernacchii		113.6	129.2	93.1		
T. eulepidotus		79.3	284.0	352.4	557.1	275.2
T. hansoni			72.5	72.2	21.5	94.4
T. loennbergii					26.5	
T. newnesi	190.4	912.0	21.1	17.0	8.2	2.9
T. pennellii		81.5	88.8			
T. scotti			6.9	5.7	6.2	
T. tokarevi		34.6	11.3	18.7	94.8	

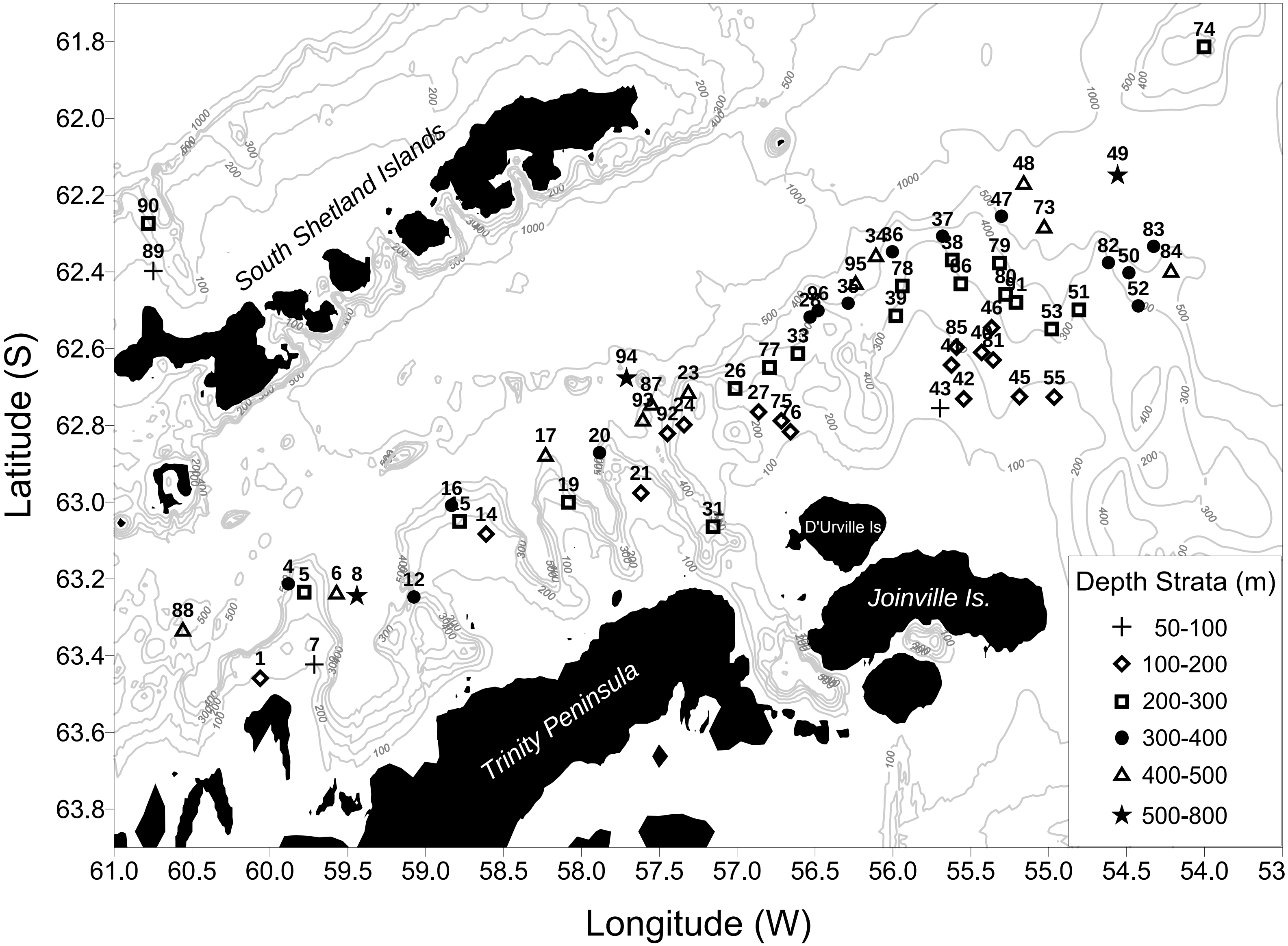

Figure 5.1. Station locations by depth strata for the 2006 AMLR finfish survey of the Antarctic Peninsula and Joinville Island.

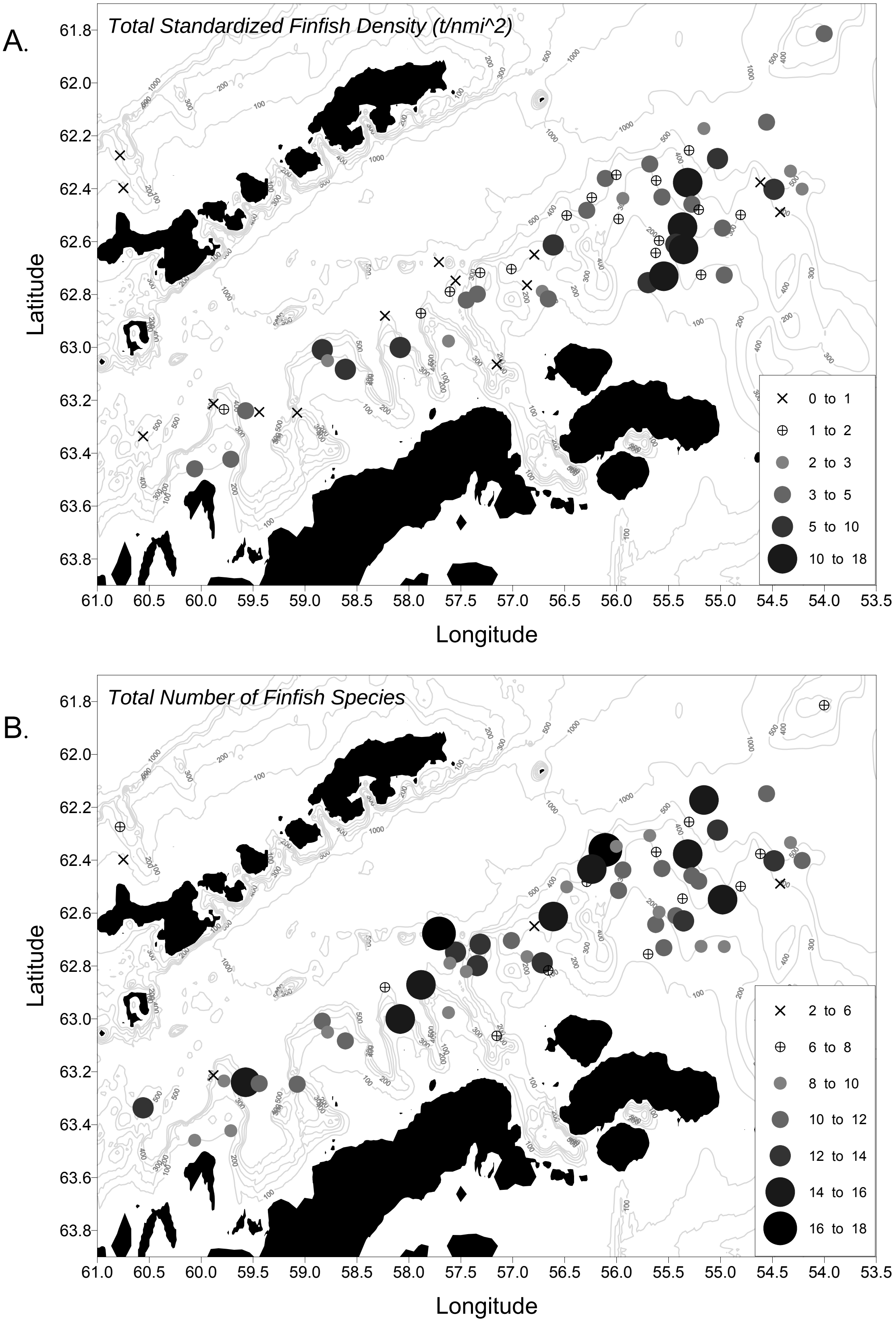

Figure 5.2. A) Total standardized finfish density in tonnes/nmi^2, and B) total number of species from the 2006 AMLR finfish survey of the Antarctic Peninsula and Joinville Island.

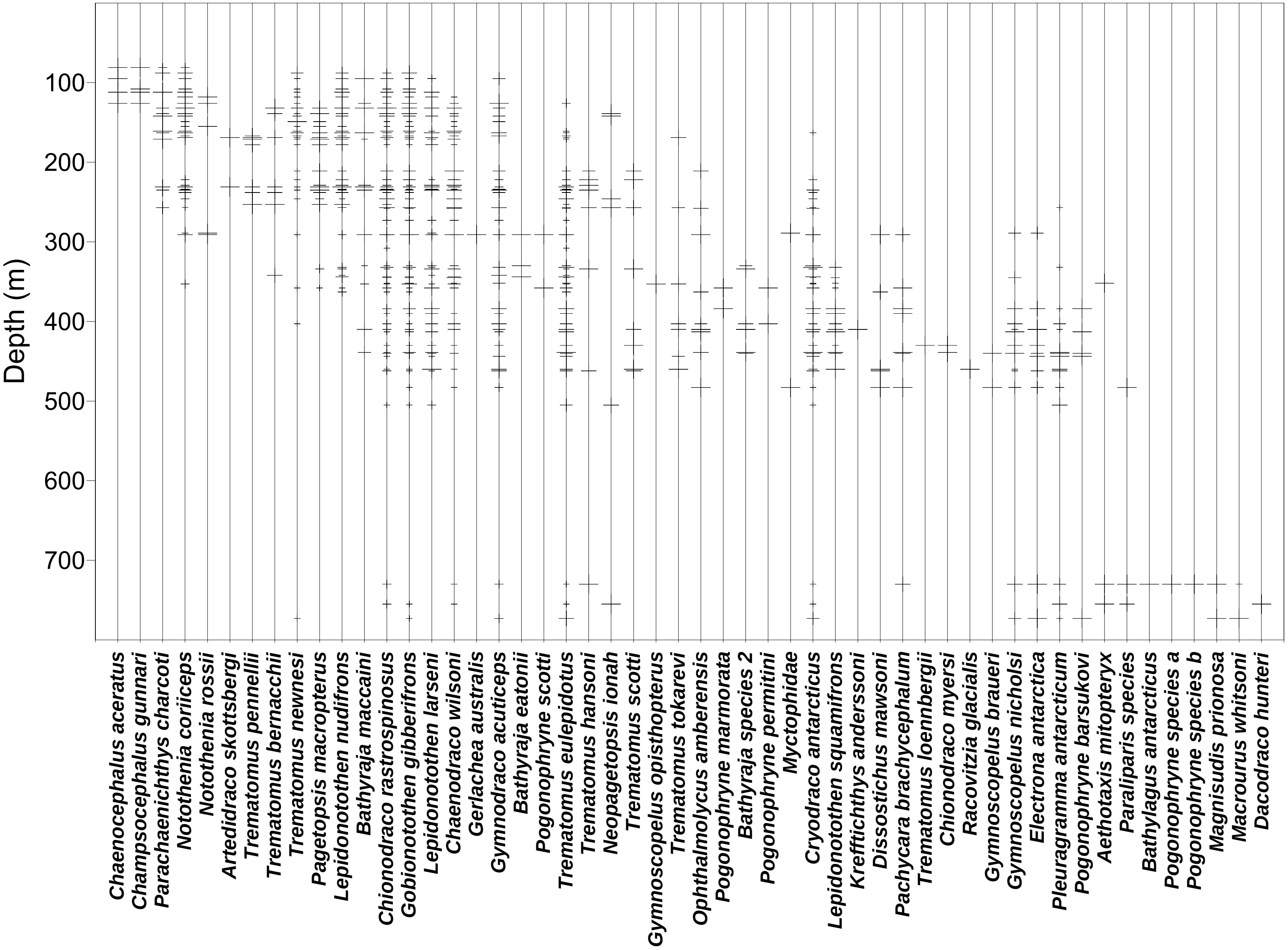

Figure 5.3. Relative standardized densities by depth of finfish encountered during the 2006 AMLR finfish survey. Horizontal lines are proportional to density of station swept area (kg/nm^2) by species relative to species specific overall density.

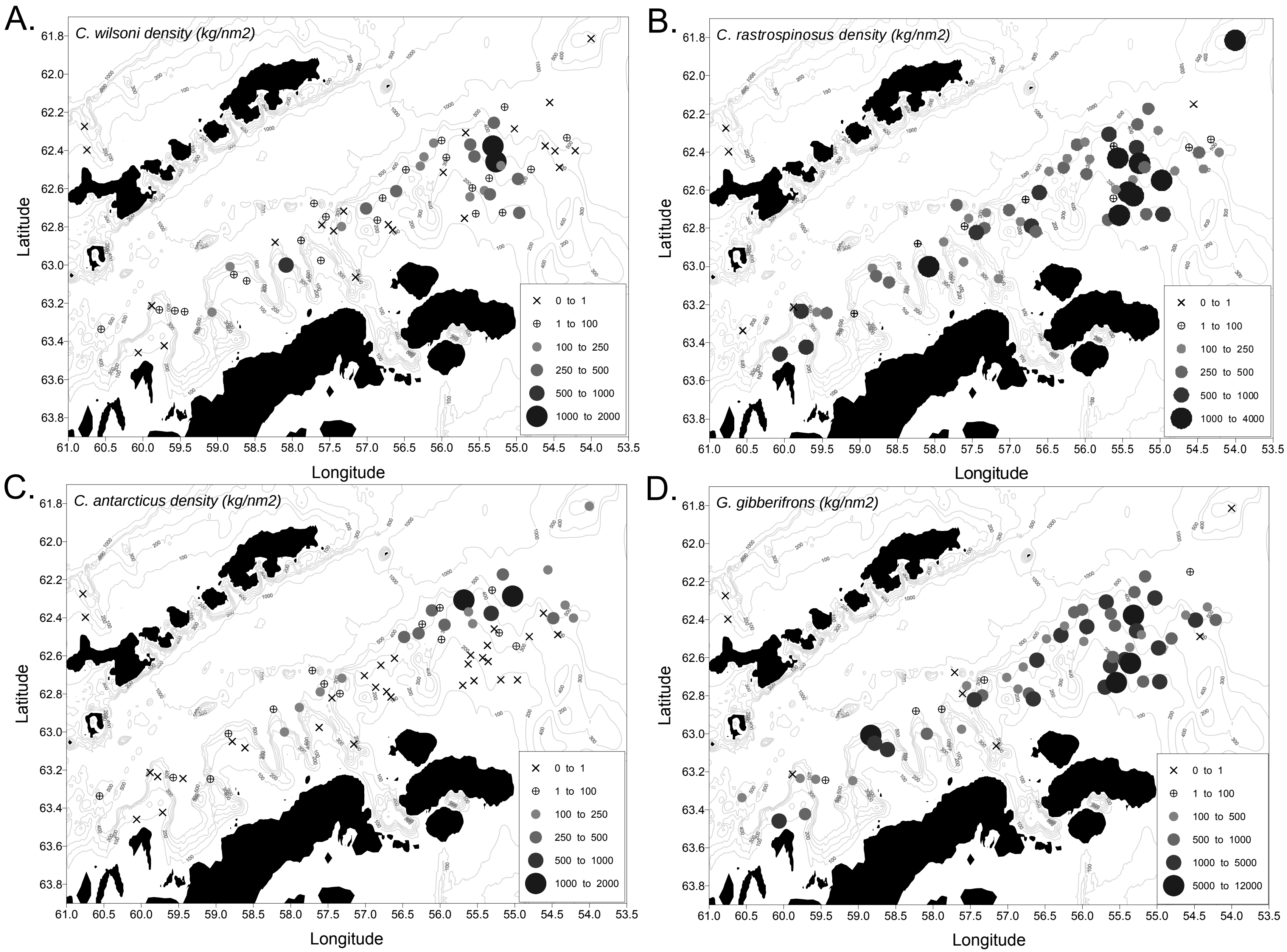

Figure 5.4. Standardized density (kg/nmi2) for A) *C. wilsoni*; B) *C. rastrospinosus*; C) *C. antarcticus*; and D) *G. gibberifrons*.

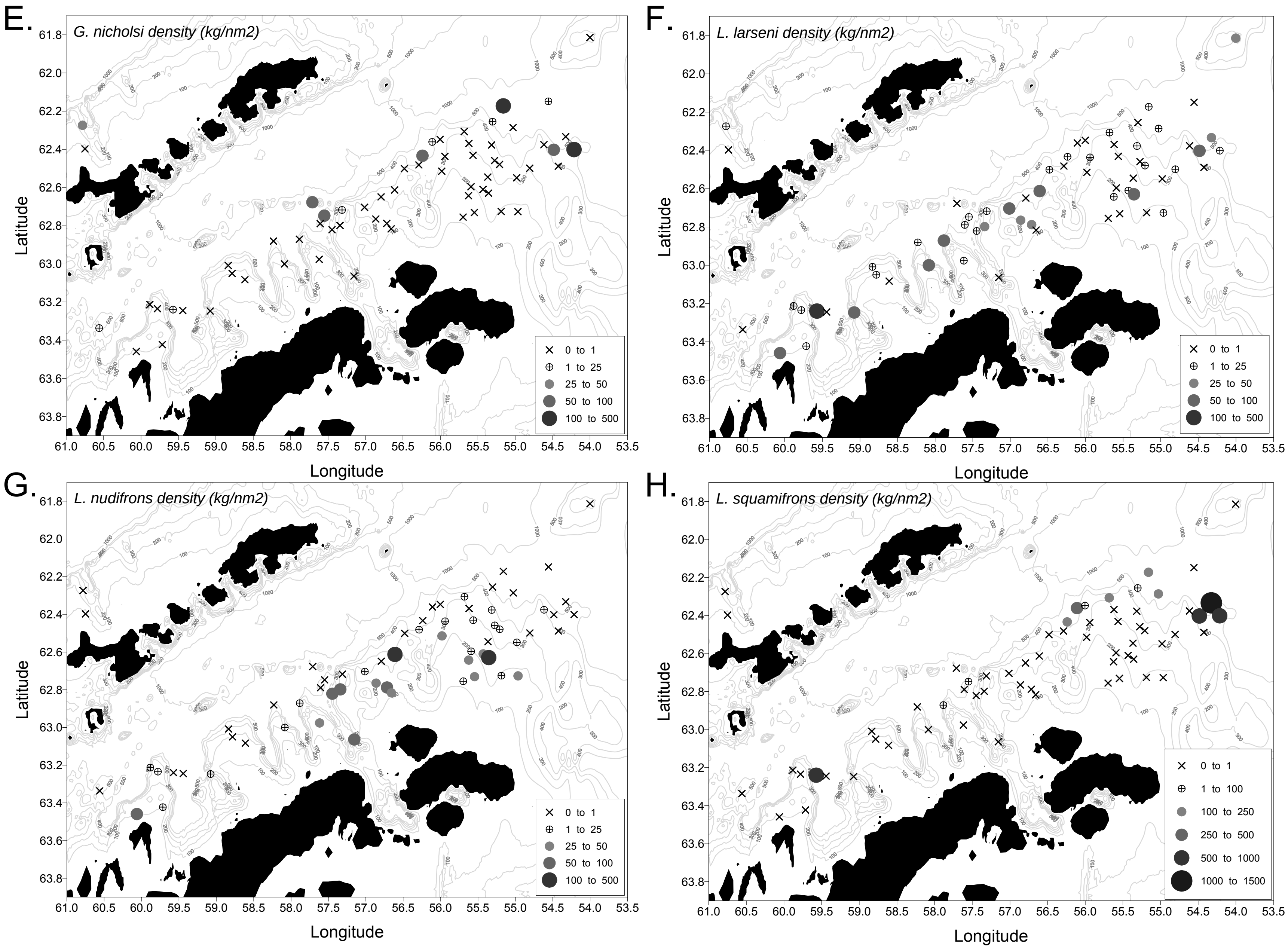

Figure 5.4. continued for E) *G. nicholsi*; F) *L. larseni*; G) *L. nudifrons*; and H) *L squamifrons*.

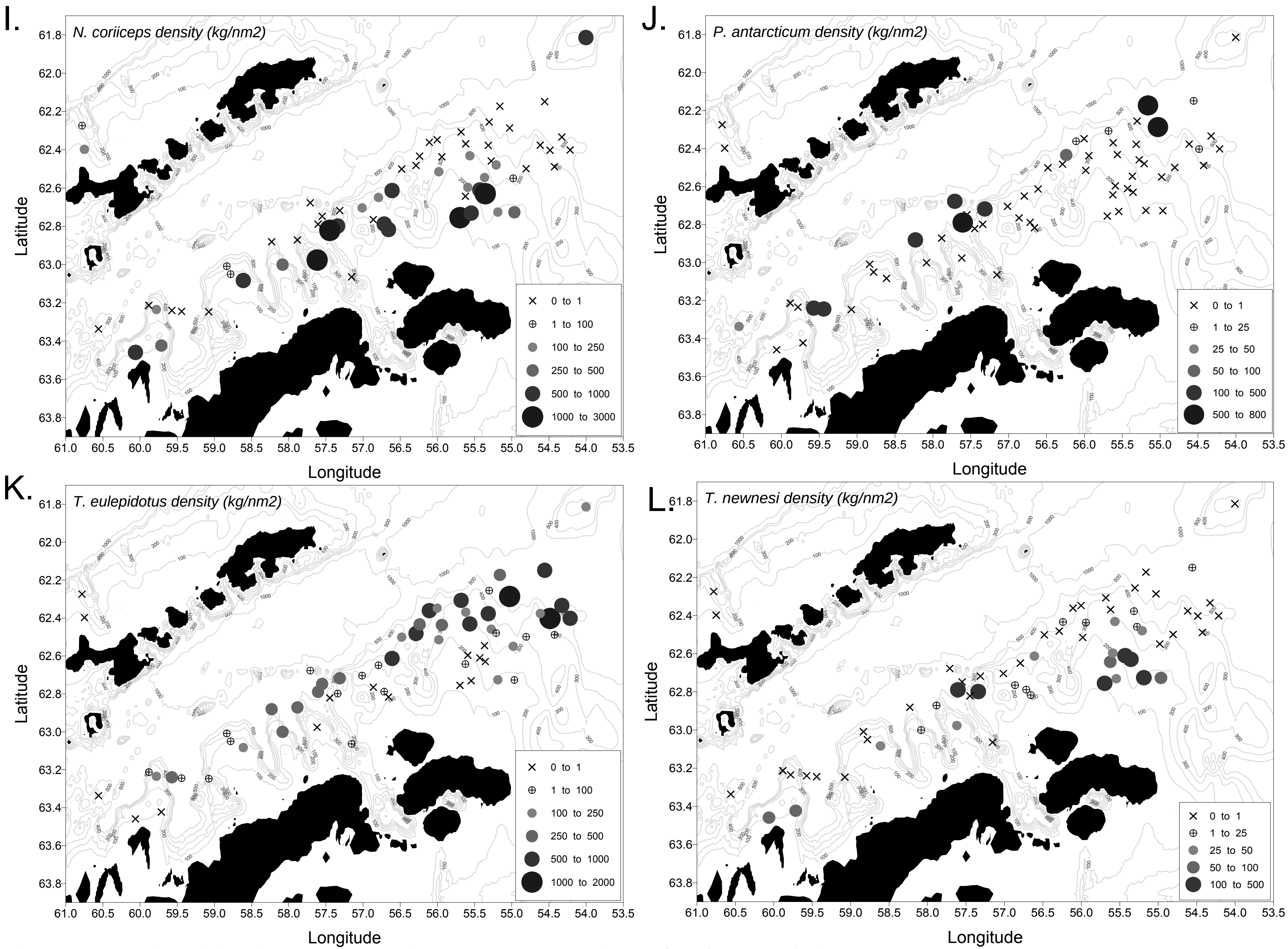

Figure 5.4. continued for I) *N. coriiceps*; F) *P. antarcticum*; G) *T. eulepidotus*; and H) *T. newnesi*.

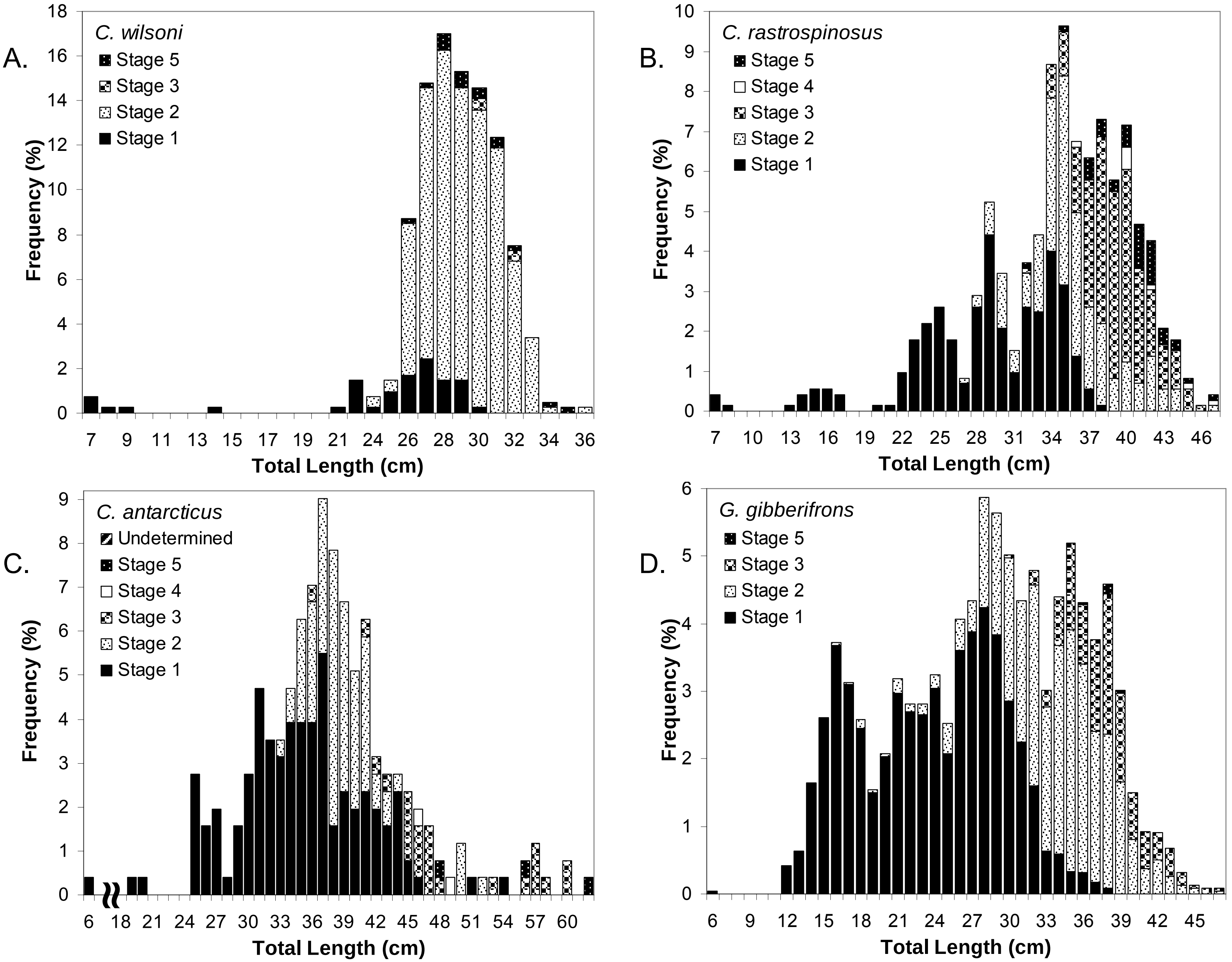

Figure 5.5. Catch-weighted length frequencies for A) *C. wilsoni*; B) *C. rastrospinosus*; C) *C. antarcticus*; and D) *G. gibberifrons*.

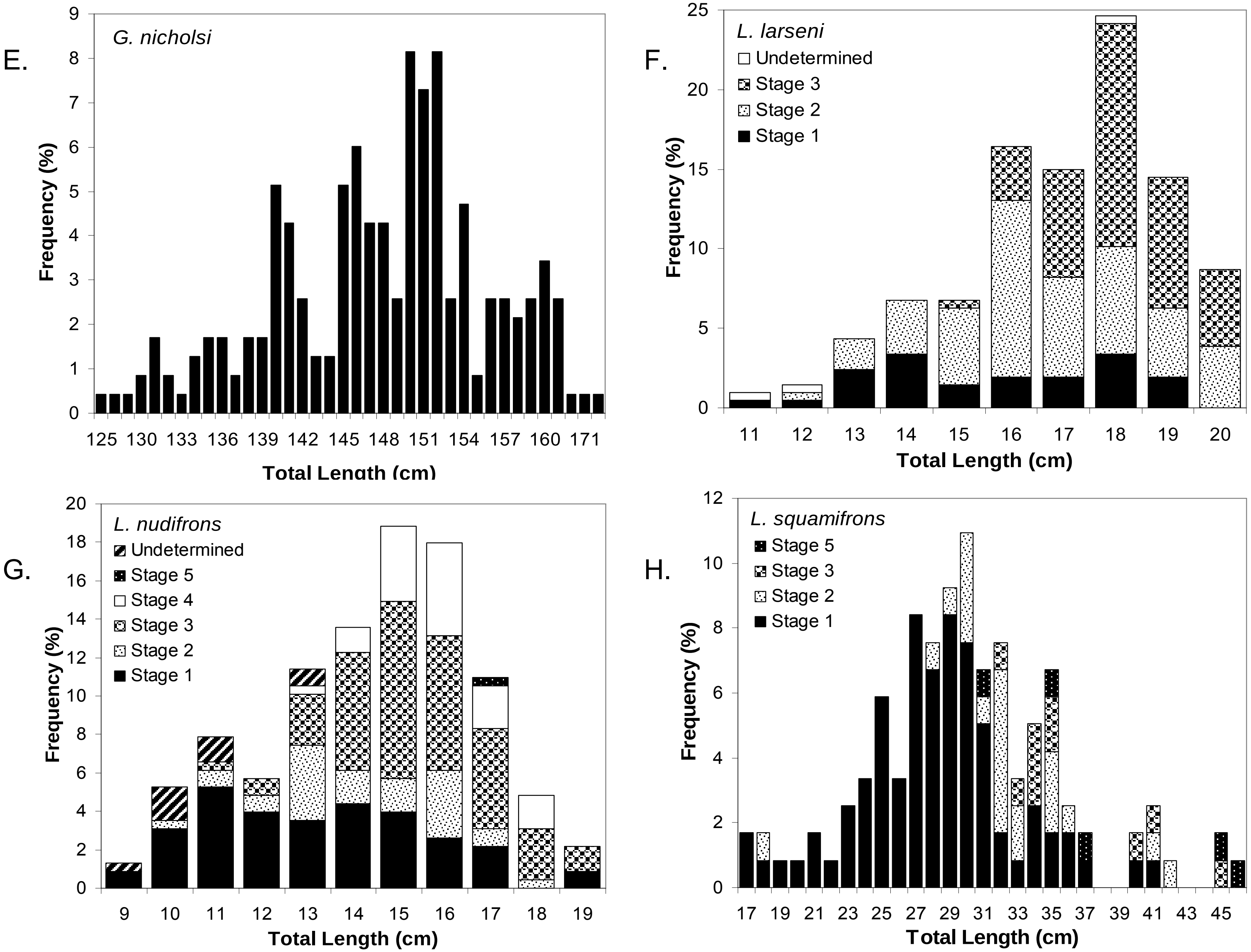

Figure 5.5. continued for E) *G. nicholsi*; F) *L. larseni*; G) *L. nudifrons*; and H) *L squamifrons*.

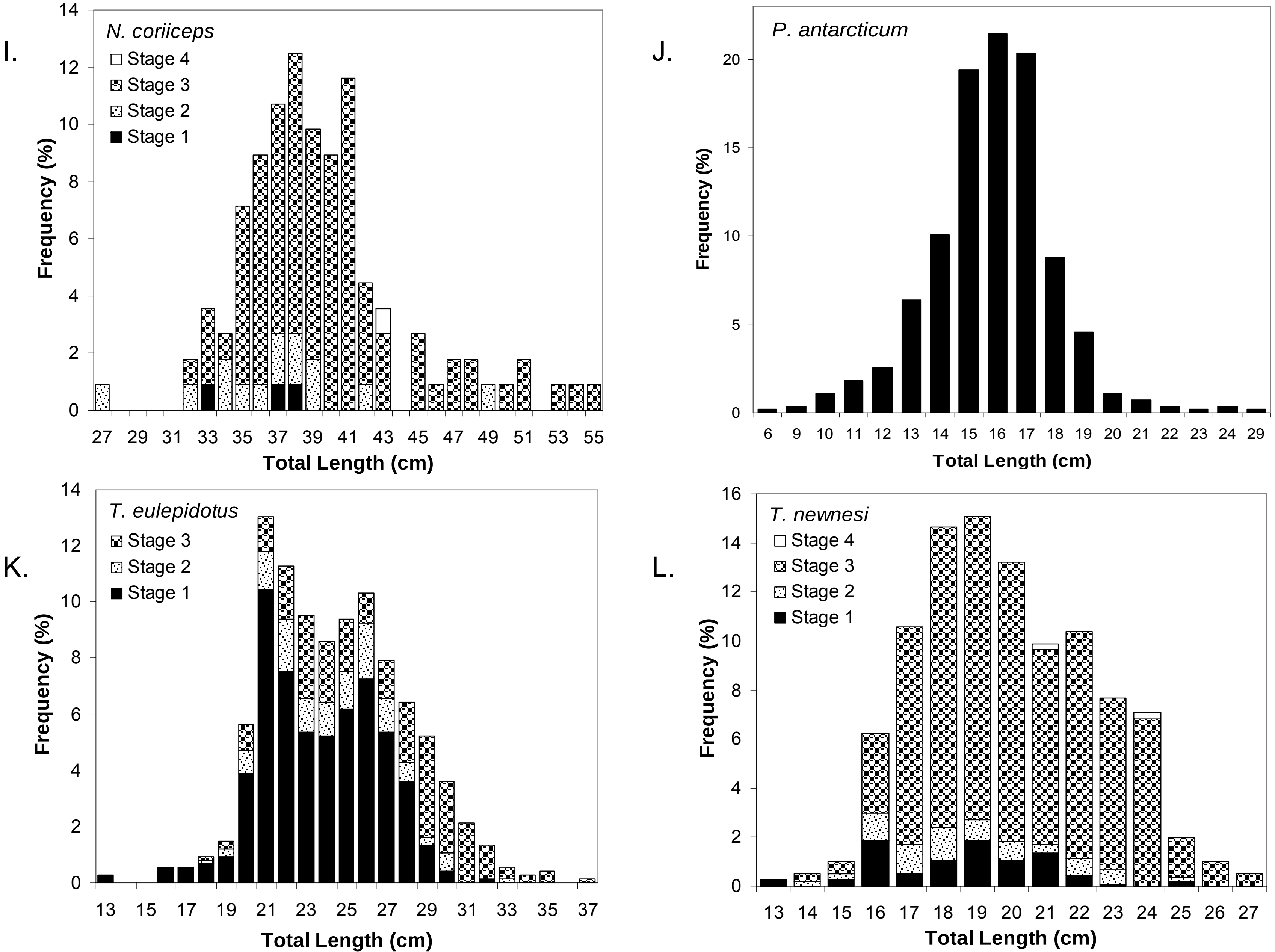

Figure 5.5. continued for I) *N. coriiceps*; F) *P. antarcticum*; G) *T. eulepidotus*; and H) *T. newnesi*.

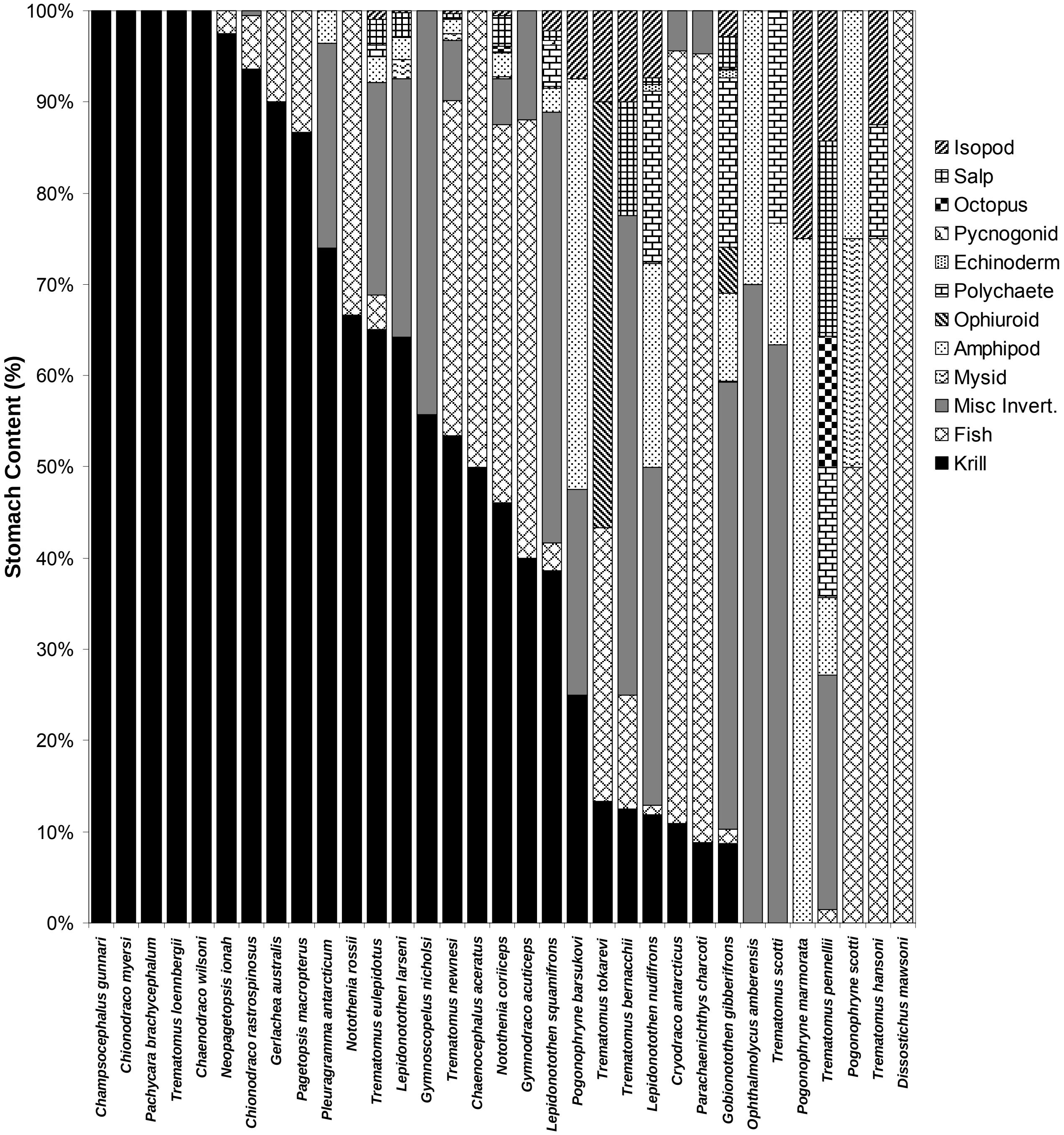

Figure 5.6. Summary of diet composition of 33 species of finfish, based on mean stomach content scores and sorted by % krill, from the 2006 AMLR finfish survey of the Antarctic Peninsula and Joinville/D'Urville Island.

6. Benthic Invertebrate Bycatch Composition and Characterization of the Northern Antarctic Peninsula; submitted by Susanne Lockhart & Christopher Jones.

6.1 Objectives: Benthic invertebrate bycatch composition and habitat characterization was conducted concurrent with the bottom trawl survey and demersal finfish research (Chapter 5 of this report). It is important to investigate the characteristics of the benthic communities with which these fish are associated in order to better understand the Antarctic ecosystem and the relationships of its components. The invertebrate megafauna and benthic habitats of the Antarctic are among the least well known of the world's oceans. A greater understanding of the benthic environment is essential for successful, and faithful, monitoring of the Antarctic ecosystem and its resources. To this end, the objectives for Leg II included composition analysis (identification and quantification) of the benthic invertebrate bycatch component of the bottom trawls in order to characterize the seafloor habitats associated with finfish populations and to examine relationships between the benthic and pelagic elements of this important ecosystem. In addition, sampling of various invertebrate groups of interest was conducted on behalf of specialists in the U.S. and around the world with an ultimate goal of increasing knowledge of the region's biodiversity.

6.2 Methods: Bottom trawling was conducted primarily along the northern Antarctic Peninsula shelf. Fifty-nine successful hauls were conducted on this shelf to depths of up to 500m. An additional three hauls of greater depth were conducted off the shelf in the Bransfield Strait, and another two taken at shelf depths north of Livingston Island, South Shetland Islands. Specifics on trawling activities and techniques are described in Chapter 5 of this report, which includes details of each haul (Table 5.1) and a map illustrating station locations (Figure 5.1).

Once the trawl catch was secured on deck it was shoveled into fish baskets and moved to the sorting area. The contents of each basket were emptied onto the sorting tables, the fish removed and the bycatch material then sorted or, as necessary, returned to the baskets for weighing and subsampling. Frequently, the biomass of the hauls was so great that only a portion of the bycatch could feasibly be put into baskets for weighing. In these cases, fish were removed on the back deck as the bycatch was shoveled into baskets. Up to 20 baskets of bycatch were moved to the sorting area for weighing, while any additional baskets were counted and discarded. In this way, an average weight per basket could be calculated for extrapolation. In cases where it was not feasible to sort all baskets of bycatch that made it to the sorting area, those baskets were first weighed and a subsample (usually 5 baskets) randomly chosen.

The benthic invertebrates were sorted into 44 feasible taxonomic groupings, weighed, and counted where appropriate. Any dead or unsortable organic matter was weighed and, where possible, characterized (e.g. 60% bryozoan fragments, 30% brittle star arms, 10% organic matter). Algae were also weighed. Pelagic invertebrates and inorganic matter were only weighed in the cases where subsampling was necessary. For meso-scale comparisons of benthic invertebrate composition between stations, weights were pooled within each phylum to calculate the percentage of each phylum within a catch. For visual simplicity, composition data from stations in close proximity, and at similar depths, were pooled as detailed in Table 6.1. These calculations excluded the dead uncharacterizable portion of the unsortable organic matter as described above, as well as inorganic matter, pelagics and algae. Calculations of total biomass at each station were standardized from the actual swept area of the trawl to one squared nautical mile and excluded only inorganic matter, pelagics and algae.

6.3 Results & Discussion: A geographic pattern is revealed when total standardized benthic invertebrate biomass at each station is mapped (Figure 6.1). With the exception of some of the deeper hauls, stations along the Trinity Peninsula shelf, and those directly north of D'Urville and Joinville Islands, show great amounts of biomass indicating long- and well-established benthic communities. In stark contrast however, are the stations further north of Joinville Island, which indicate a more sparsely populated seafloor in this region. This pattern is particularly evident at those stations located beyond the easterly limits of Joinville's coast, the majority of which support less than half a metric ton of benthos per nautical mile squared. By comparison, stations located along the coast support communities of benthos larger by a magnitude or more, many with over 100 t/nm^2 of invertebrate biomass. The biomass at these Peninsula shelf stations also far exceed those north of Livingston Island and those in deeper waters of Bransfield Strait. The likely explanation for this broad pattern in the density of benthic communities lies with the different oceanographic conditions experienced. Those stations to the far north east of Joinville Island are those most likely to be affected by Weddell Sea gyre currents and the icebergs that this major system carries with it in its clockwise circulation. Antarctic shelf communities are known to reflect patterns of disturbance by ice scouring (e.g. Gutt *et al*., 1996; Brey *et al*., 1999; Gutt, 2000). Icebergs are believed to regularly cause disturbance to a depth of up to 500m (Peck *et al*., 1999). That stations on shelf areas located to the west of the region likely influenced by Weddell Sea currents support the greatest biomass of benthos lends support to this hypothesis. In contrast, the northern shelf of Livingston Island (see also Kim *et al*., 2003) exhibits low benthic densities similar to the region exposed to currents from the Weddell Sea. The northern coastline of the South Shetland Islands forms the southern border of Drake Passage. Thus, exposure to the powerful Antarctic Circumpolar Current that flows, greatly restricted, through this Passage could well result in shelf communities of this region exhibiting characteristics of disturbance similar to those north east of Joinville Island. The Bransfield Strait, on the other hand, is relatively protected. An alternative explanation, though, may lie in the degree to which these 2 coastlines have been affected by historical commercial fishing activities. The shelf north west of Joinville Island, at irregular intervals, was exploited from 1978 to 1989 (Kock *et al*., 2004). Likewise, commercial bottom trawl fishing activities once occurred along the northern coast of the South Shetland Islands (Kock, 1992). In contrast, the shelf regions shown to support the greatest biomass of benthos are also those that have escaped focused commercial activities.

The density distribution illustrated in Figure 6.1 also indicates a relationship with depth. To explore this further, standardized benthic biomass was plotted as a function of depth (Figure 6.2). An exponential regression model best described the relationship between depth and biomass. However, the relationship was shown to be surprisingly weak ($R^2 = 0.182$). The same data, plotted on a logarithmic scale (Figure 6.3), clearly points to 3 outliers. These correspond to Stations 51 and 52, northeast of Joinville Island (the southernmost low density points illustrated in Figure 6.1 for this region), and also Station 89 immediately north of Livingston Island. Removal of these three data points greatly strengthened the exponential regression relationship between depth and biomass (Figure 6.4; $R^2 = 0.311$). That these 3 stations are located in regions of high exposure to currents and disturbance by iceberg scouring, lend support to the hypothesis proposed above to explain the geographic pattern in benthic community density illustrated in Figure 6.1.

Furthermore, the geographic and depth patterns indicated by the density data are reflected in the invertebrate composition of these benthic communities (Figure 6.5). Those regions along the northern Antarctic Peninsula shelf afforded protection within Bransfield Strait support a seabed dominated by impressive sponge communities. In particular, the massive hexactinellid (glass) sponges, observed in many of the hauls here, are indicative of a stable Antarctic environment (Gutt *et al*., 2000). For these very slow growing hexactinellids (Dayton, 1978) - individuals of which filled the equivalent of 3-4 fish baskets – to have reached the enormous proportions observed, their communities must have remained relatively free of disturbance (whether from icebergs or commercial exploitation) for a substantial period of time. The dominance of Porifera at many stations is such that the contribution of other taxa to the faunal assemblage along this shelf is obscured. Vast, and diverse, communities of tunicates were also encountered at shelf stations along the northern Antarctic Peninsula. Beyond the protection of the Bransfield Strait, however, invertebrate composition changes dramatically. With the exception of the northeastern most illustrated (U in Figure 6.5), dominance by sessile filter feeders weakens eastward and is replaced by assemblages dominated instead by highly mobile taxa, particularly echinoderms (O, P and particularly T in Figure 6.5). Again, the seabed habitat encountered north of Livingston Island presents similar characteristics to those northeast of Joinville Island. Here, sponges contribute relatively little to biomass, with communities strikingly dominated by diverse echinoderm assemblages, and other highly mobile taxa such as crustaceans.

Community composition also changes with bathymetry. Shallower shelf stations are most commonly dominated by sponges and tunicates while at deeper stations (D, H & F in Figure 6.5) members of the phylum Cnidaria increase in relative importance. Specifically, the abundance, and size, of anemones encountered increases as dense sessile filter feeding invertebrate assemblages decrease with depth.

The general geographic patterns described above are additionally reflected in observed diversity of benthic communities. Stations 51 and 52 (outliers in terms of biomass as a function of depth) were two of the least diverse communities sampled, with four and six phyla, respectively, represented. The low invertebrate diversity at these stations was also reflected in the observed number of taxonomic groupings utilized in this study (9 and 8 respectively). Station 20, north of the Trinity Peninsula, proved to be the most diverse, with 11 phyla, and 36 taxonomic groups, recorded. Similarly, Gutt and Starmans (1998) found a positive correlation between the abundance of large sponges and the number of other taxa in the Weddell Sea.

The benthic invertebrate assemblages encountered along the majority of the northern Antarctic Peninsula's shelf are indicative of a stable environment that has largely escaped disturbance frequently experienced by much of Antarctica's shelf communities. Evidence for this is seen in terms of high biomass and high diversity, as well as in long- and well-established communities of slow growing sessile filter feeders such as hexactinellid sponges. Typically, as a result of disturbance, Antarctic benthic invertebrate assemblages exhibit a patchiness whereby one particular species dominates a localized area as seen in similar studies (Kim *et al*., 2003; Jones *et al*., 2004). The more exposed regions sampled during the present survey show evidence of such recent disturbance in the form of low biomass, low diversity, and a dominance of highly mobile invertebrates with their greater ability to colonize newly disturbed habitats. In contrast, fish population density appears to be lower in the more stable environments and highest in the more exposed regions. A more detailed analysis is required before this relationship can be confirmed or explained. A comparison of individual fish species population densities with different components of the invertebrate communities is currently underway.

6.4 Disposition of Data & Samples: Benthic invertebrate data collected during the trawl survey were recorded on hardcopy datasheets and entered into an Excel computer file. The U.S. AMLR program maintains these hardcopies and computer databases. The majority of invertebrate samples collected for further taxonomic and genetic analyses will be deposited and housed at the California Academy of Sciences (San Francisco, CA). Additional samples collected by request for taxonomic and genetic research will be sent to the Smithsonian National Museum of Natural History (Washington D.C.), Auburn University (Alabama), Tromso Museum (Norway) and the Museum of Victoria (Australia).

6.5 Acknowledgements: This research could not have been conducted without the assistance of many on-board, whose cheerful and untiring assistance in sorting the large amounts of bycatch is gratefully acknowledged. In particular, much thanks goes to Vic Smith, Darci Lombard, Kim Dietrich, Ryan Driscoll, Cassandra Brooks, Marcel van den Berg, Tony Cossio and Jennifer Van Dommelen.

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Table 6.1. Stations pooled for benthic invertebrate composition analysis across sampled region. Letter codes refer to composition pie graphs illustrated in Figure 6.5.

Pie graph	Stations	Depth Strata (m)
A	4, 6, 88	300-500
B	1, 5	100-300
C	7	50-100
D	8	500-800
E	12, 16	300-400
F	14, 15	100-300
G	17, 20	300-500
H	94	500-800
I	23, 87, 93	400-500
J	19, 21	100-300
K	24, 92	100-200
L	31	200-300
M	26, 27, 33, 75, 76, 77	100-300
N	34, 35, 36, 95, 96	300-500
O	37, 47, 48, 73	300-500
P	38, 39, 51, 53, 78, 79, 80, 86, 91	200-300
Q	40, 41, 42, 45, 46, 55, 81, 85	100-200
R	43	50-100
S	49	500-800
T	50, 52, 82, 83, 84	300-500
U	74	200-300
V	90	200-300
W	89	50-100

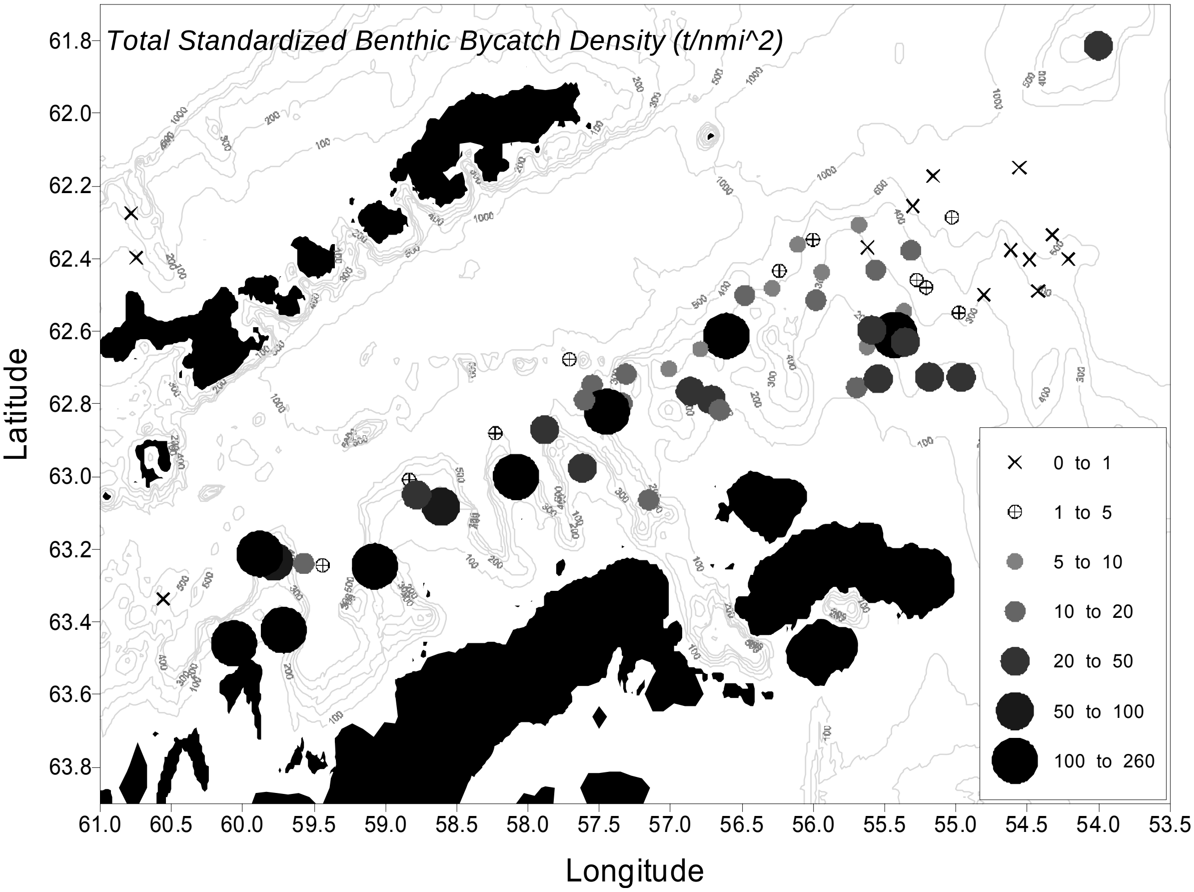


Figure 6.1. Total standardized benthic bycatch density (t/nm^2) at each station sampled during the 2006 bottom trawl finfish survey.

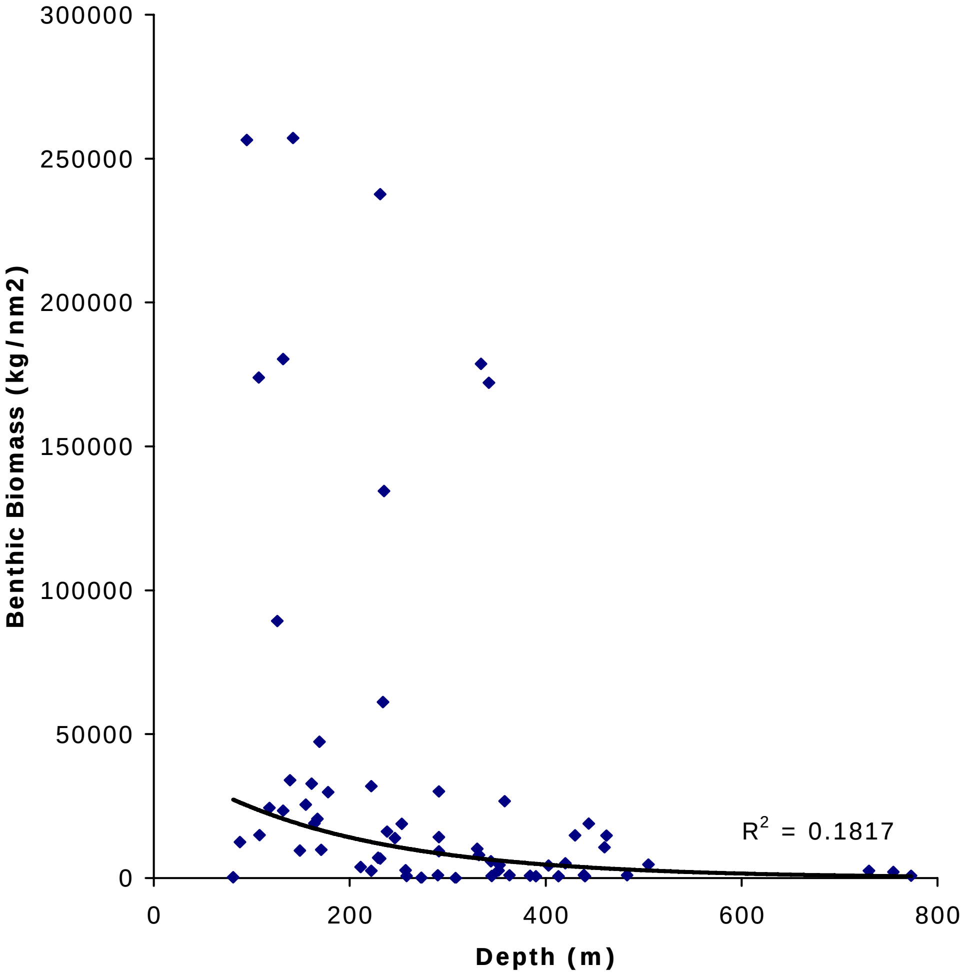


Figure 6.2. Total standardized benthic biomass as a function of depth. Exponential regression line shown.

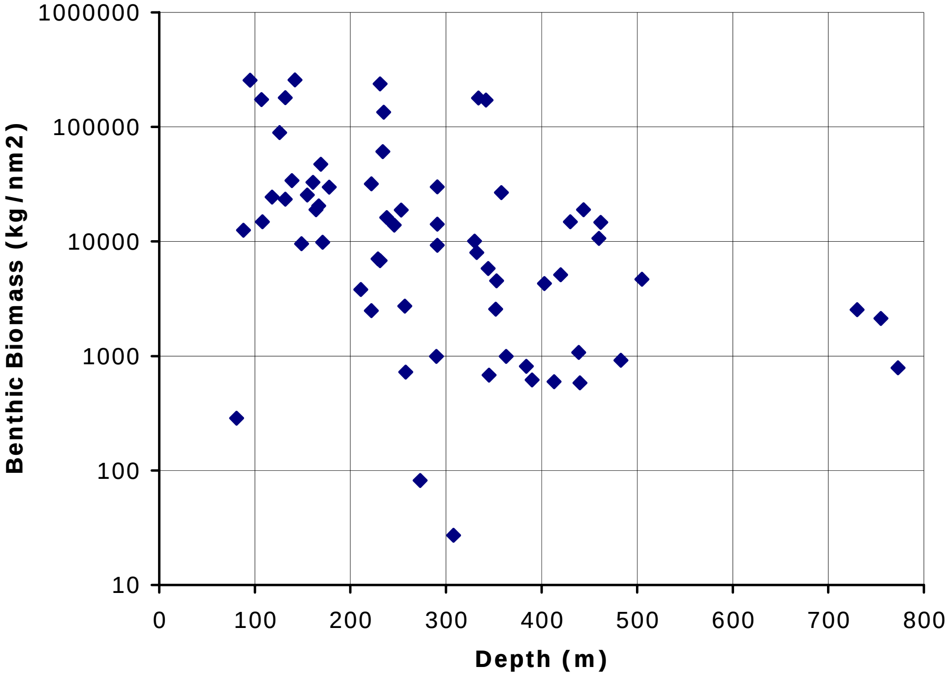


Figure 6.3. Total standardized benthic biomass (logarithmic scale) as a function of depth. The lower three points correspond (from left to right) to Stations 89, 51 and 52.

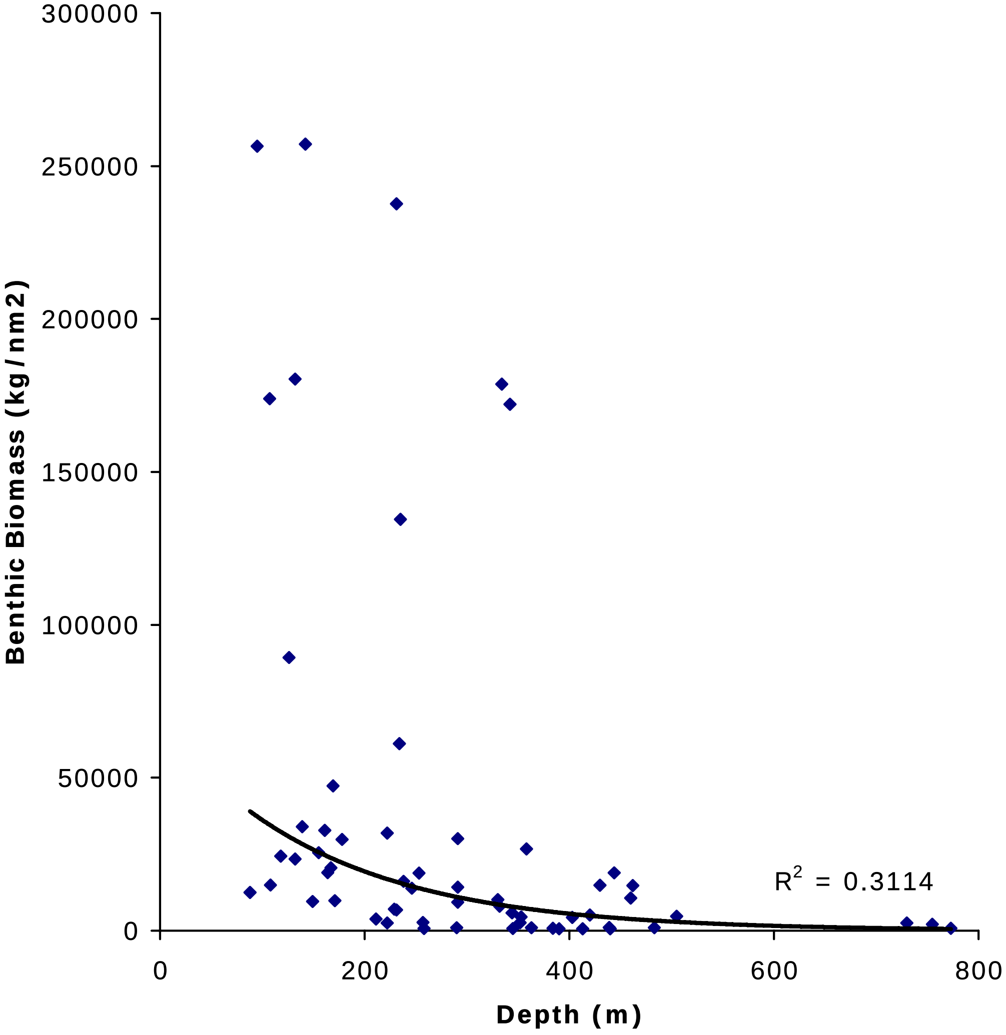


Figure 6.4. Total standardized benthic biomass as a function of depth after the removal three outliers station points identified in Figure 6.3. The exponential regression relationship is improved.

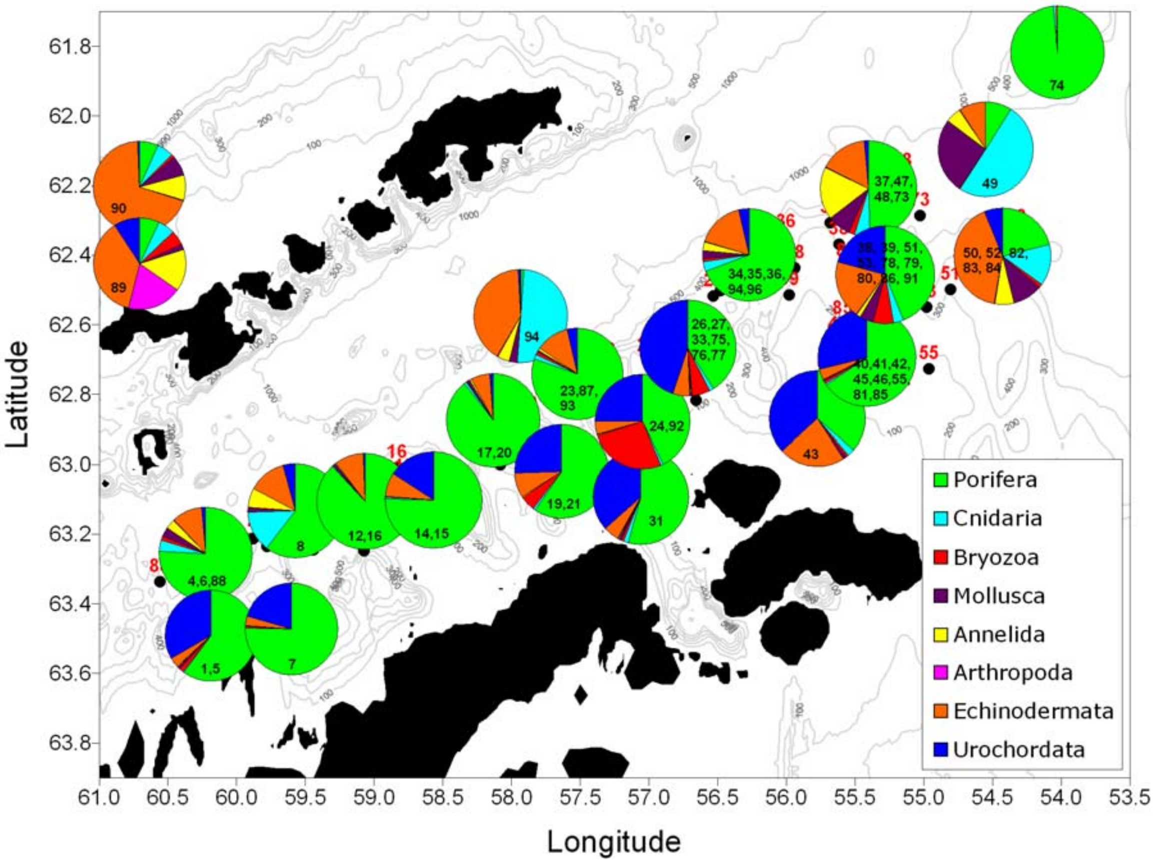


Figure 6.5. Relative contributions by invertebrate phyla to benthic community composition along the northern Antarctic Peninsula. For visual simplicity, data from certain stations have been pooled. Table 6.1 lists the stations relevant to each letter-coded pie graph and its corresponding depth stratum. Only those phyla represented by at least 1% (after rounding) are graphically represented here. Individual stations are mapped in Figure 5.1. (Latitude is South and longitude is West).

7. Nearshore Acoustical Survey Near Cape Shirreff, Livingston Island; submitted by Joseph D. Warren (Leg I), Martin Cox (Leg I), Steve Sessions (Leg I), Adam Jenkins (Leg I), Derek Needham (Leg I) and David A. Demer.

7.1 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 7.1). 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 7.2). An additional modified zodiac (R/V *Roald*) conducted a bathymetric and water column survey using a multibeam acoustic system (Figure 7.1). This survey focused on the western edge of the eastern canyon, that is, the waters immediately east of Cape Shirreff. The multibeam system project is a joint effort between: The UK Royal Society / NERC (Natural Environment Research Council); Simrad, USA; the U.S. AMLR Program; and SWFSC's Advanced Survey Technologies Program. Five instrumented buoys were 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 (Figure 7.1). 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.

7.2 Methods and Accomplishments: Over 264km were surveyed using *Ernest* from 3 to 8 February 2006 (Figure 7.2). *Ernest* is a Mark V 19-ft Zodiac powered by a 55-hp Johnson (Figure 7.1). The *Ernest* is equipped with multiple GPS, EPIRB, 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 vessel. A surface temperature and conductivity sensor (SeaBird MicroCAT) was mounted to the transducer arm and collected measurements at a depth of roughly 1m 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 (2- 12 V marine batteries), the ES60 echosounder processing unit, an DC/AC power inverter, and a 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.

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 locates the transducer approximately 1m below the water line. The transducer can also be raised out of the water for quicker transit or rough sea state.

The nearshore survey was scheduled to begin on 1 February 2006, however a strong gale came through the area during this time period so operations were delayed until 3 February. Additionally, a strong low pressure system was thought to be approaching on the afternoon of 8 February 2006 so the decision was made to recover instruments and personnel a day early so the nearshore operations were completed by 8 February 2006 instead of 9 February as originally scheduled. Despite the loss of multiple days from the survey period, operations were quite successful during the survey as weather conditions were generally favorable and no other time was lost due to equipment failures or poor surveying conditions. The R/V *Ernest* was deployed from *Yuzhmorgeologiya* on 3 February 2006 at approximately 1000 GMT and transferred personnel and equipment to Cape Shirreff field camp. *Ernest* was then taken into the Cape Shirreff cove anchorage location where mooring tackle was set-up, the WeatherPak installed and data acquisition systems tested. Around 1300, the boat was taken out of the anchorage location and the acoustic system was calibrated in 30m of water using a 38.1mm Tungsten Carbide sphere. We were able to acquire strong target returns from the sphere on the echosounder unit; however it was difficult to ascertain whether the sphere was centered in the acoustic beam given the nature of the calibration technique (lowering the sphere on a monofilament line from the side of the boat). After the calibration, the vessel began the survey.

Subsequent operations were based from the field camp on Cape Shirreff. Surveys were conducted 4-8 February 2006. Boat operations began each day between 1000 and 1200 and concluded around 1800. Sea states were generally 1-2m when close to shore or in the lee of Cape Shirreff, however offshore survey tracks occasionally encountered sea states of 3-4m. Due to time limitations and the opportunity to conduct parallel surveys with the R/V *Roald*, the western canyon was again not surveyed this year; however two full surveys were completed of the eastern canyon.

During the late morning on 5 and 8 February 2006 all three vessels (*Yuzhmorgeologiya*, *Ernest*, and *Roald*) conducted a joint survey of the eastern canyon area nearest to Cape Shirreff. Portions of the Y6 transect line were surveyed by the *Yuzhmorgeologiya* with the *Ernest* and *Roald* approximately 50-100m behind and slightly port or starboard to avoid the ship's wake. After approximately 30 minutes, the *Ernest* and *Roald* moved ahead of the *Yuzhmorgeologiya* and continued along the transect line. While scattering patches were sparse, there were at least a few aggregations that were surveyed by all three vessels (using three different acoustic systems).

On 8 February 2006, the *Ernest* was again taken into approximately 30m of water and another acoustic calibration was conducted. The calibration sphere produced more numerous echoes than the pre-survey calibration, but again the location of the sphere in the beam pattern is somewhat unknown. The *Ernest* was brought aboard the *Yuzhmorgeologiya* around 2400.

During the nearshore survey, the *Yuzhmorgeologiya* conducted 25 CTD casts and Isaacs-Kidd Midwater Trawls to collect zooplankton samples (Figure 7.2). The survey effort this year yielded the excellent coverage of the nearshore waters of Livingston Island with minimal time lost to sea state and weather conditions and no survey time was lost due equipment failures or malfunctions.

7.2.1 Instrumented Buoys: Upon arrival at Cape Shirreff on 15 January 2006, five instrumented buoys were deployed along the 90m isobath of the western edge of the canyon east of Cape Shirreff (Table 7.1). The five instrument buoys each contained a 900MHz spread-spectrum radio modem, GPS, radar reflector, strobe light, batteries, wind generator and power control circuitry. Two contained 38 and 200kHz echosounders and three contained 300kHz Acoustic Doppler Current Profilers (ADCP's). The buoys were set to activate themselves for three minutes and switch themselves off for twelve minutes. This cycle was offset between the five buoys, allowing all five to have four three minute time slots per hour. A shore radio, antenna and logging PC were setup at the base on Cape Shirreff where the five buoys started logging data, under the watch of Russell Haner. The buoys were deployed one at a time with a 40 minute wait between deployments as each buoy was brought on line and checked for leaks, before the next one was deployed. Buoy 3 (mooring 5) had to be retrieved and reset as it didn't come alive at its set time.

The radio signal strengths were good, even on the ends of the line. There was a 50 degree arc between the two buoys on either end of the line. Personnel were returned to the R/V *Yuzhmorgeologiya* so the large area survey could begin. Buoys were checked on through communication with R. Haner at the Cape Shirreff field camp. On 16 January, he reported that buoy 5 was not pinging although it was awake. He was unable to communicate with the buoy via the radio-link software. On 20 January via email, we were informed that radio communication had been established again with the buoys, but buoy 4 was off-line and buoy 5 was again on-line but not pinging. It was hypothesized that the buoys were running out of power due to low wind speeds such that they were note recharging the batteries during their "off" cycle. It was decided to reduce the duty-cycle of the buoys from 3/12 (on/off) to 3/27 so that the buoys would have more time to recharge their batteries.

On 22 January, we were emailed that buoy 1 was working; buoy 2 was working but battery voltage was low so duty cycle was switched to 3/27; buoy 3's control software had locked up and needed to be rebooted; buoy 4 had no communication with the shore station; and buoy 5 was active but not pinging. On 27 January, the shore station was unable to communicate with any of the buoys, although buoy 2 was still acquiring data at that point. Inadvertently buoy 2 was shut down while trying to reboot buoy 3.

We returned to Cape Shirreff on the evening of 2 February and had the *Yuzhmorgeologiya* approach the buoy array. Buoy 1 was present and floating sideways in the water due to the loss of the bottom half of the buoy. The frame of buoy 1 was also bent and damaged suggesting contact with icebergs or growlers. Buoy 2 was visible and upright, but none of the other buoys were visible from the bridge of the ship or on their radar screen. On the morning of 3 February, a shore team went to Cape Shirreff and recovered the shore station equipment and the zodiac was deployed with S. Sessions, J. Warren, and M. van Den Berg to recover the buoys aboard the *Yuzhmorgeologiya*. Buoys 3, 4, and 5 were not present, nor was the surface float that connected the buoys to the ground tackle.

After analysis of the data that was received on the shore station, it is believed that there were two major difficulties that lead to the amount of data that were collected by the buoys. The first was a power issue such that the wind generators atop each buoy were unable to supply enough power to recharge the system's batteries during the off period of the duty cycle. The ADCP buoys used much less power than the GPS echosounder equipped buoys, however they too suffered from a lack of power. Unusually low wind speeds were recorded at Cape Shirreff during the deployment period, which proved to be insufficient to maintain the charge of the batteries on the two buoys containing echosounders. Thus the weather conditions that were "good" for the survey and boat operations were "bad" for the buoy's power systems.

The other factor we believe to be responsible for the loss of the buoys is impact or contact with icebergs, growlers, or other floating ice. Buoy communications occur via a line-of-sight radio link that had very strong signal strength when the buoys were initially deployed. Radio contact was intermittent with the buoys partially due to power issues, but also would be eliminated if an iceberg was between the buoys and the shore station. While there were only a few, large icebergs present when the buoys were deployed, shore personnel observed some icebergs moving from one side of the eastern canyon to the other during the January-February deployment period. By examining the data and GPS locations from some of the buoys we can hypothesize that an iceberg struck buoy 3 (mooring 5) and dragged it toward buoy 5 (mooring 4). GPS locations for buoy 3 show it drifting to the northeast out over the canyon at which point contact was lost possibly by exceeding the range of the radio communications link. As the buoy at mooring 4 was already non-responsive we can not be certain that the same berg took out both moorings although it is definitely possible. Mooring 3 was in the same position until 24 January; however the batteries were too low after that point to communicate with the shore station so we are not able to determine when it was lost.

The R/V *Yuzhmorgeologiya* returned to Cape Shirreff on 2 February 2006 to discover that only one of the buoys was left intact, one was severely damaged and three of the buoys were missing, complete with their moorings, leading to the conclusion that icebergs had dragged off the three inshore moorings.

7.2.2 Multibeam Survey: R/V *Roald*, tasked with multi-beam operations, was equipped with a Simrad SM20 multi-beam echosounder (MBE). 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 and the 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*.

Nearshore multibeam operations commenced on the afternoon of 3 February 2006 with a patch test. This was performed to allow compensation for sensor position and timing bias during bathymetry post processing. Following this a test line was run to check gain and power settings for water column targets.

From 4 February 2006 and 8 February 2006 surveying took place following a systematic line transect plan. Each transect was 2.5km long, with a line spacing of 120m. The survey area extents were: 62.44ºS, 60.80ºW; 62.42ºS, 60.74ºW; 62.45ºS, 60.66ºW and 62.46ºS, 60.80ºW. Table 7.2 summarizes daily multi-beam activity.

Multi-beam operations were curtailed on 4 Feb due to a power supply failure and on 5 February due to GPS failure. Despite these problems 41 transects and two tie-lines were run successfully. Additionally several multi-vessel transects were completed.

7.3 Results and Tentative Conclusions: Initial results from the 2006 nearshore survey support the hypothesis that the nearshore waters are productive environments. There were many large aggregations of scatterers at the edges of the canyons often in waters between 100 and 150m in depth. From video observations from the *Ernest*, 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 (Figure 7.3). 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 (Brierley *et al*., 1998). 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 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.

During the survey, an attempt was made to determine the spatial extent of a particularly large krill patch. The survey area was expanded by running concentric circles with an increasing diameter, after numerous expansions of the area, the krill swarm was still present so the vessel proceeded to run due west to determine the east-west dimension (Figure 7.4). This krill swarm was contiguous throughout this survey of its spatial extent, although the thickness and depth of the layer changed quite a bit. The east-west dimension of this krill layer was approximately 7.5km and the north-south dimension was approximately 0.9km.

From the 2006 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 over the course of the survey (Figure 7.2). The stations in the western (Y2 survey line) and eastern (Y8 survey line) canyons were each surveyed twice during the survey, while only one sample was collected along the mid-canyon (Y5 survey line) transect. Due to the presence of ice, the Y5 line was shifted off-shore by one station location from the planned survey. 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 (Prezelin *et al*., 2000). The CTD data had hydrographic characteristics of Circumpolar Deep Water (CDW) as defined by Klinck *et al*. (2004) (Figure 7.5). 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) support the hypothesis that deep water is migrating up the canyons and causing upwelling at the canyon heads (Figure 7.6). Hydrographic data from the *Ernest* was collected from a depth of 1m and shows that the near-surface waters are well mixed by wind and wave action, although there are differences (primarily in salinity) between the mid-canyon waters and those in very shallow depths. The nearshore waters of the eastern canyon had temperatures that varied greatly, however surface salinities showed the presence of freshwater in the southeast corner of the survey area which is likely the result of glacial runoff.

IKMT net tow data were collected at almost all stations along the western, middle, and eastern canyon transects (Figure 7.1). As expected, euphausiids, copepods, larval fish, chaetognaths, and salps (primarily at one station) were the most common animals found (Figure 7.7 and 7.8) and occurred in numerical densities up to several animals per cubic meter (copepods, krill, and chaetognaths). The most common species for various zooplankton types were: krill (*E. superb, T. macrura, and E. frigida)*, copepods (*M. gerlachei, C. acutus, C. propinquus*, *R. gigas* and *Pareuchaeta 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 7.7). Salps were only found in large numbers (~ $1 / m^3$) at only one off-shore, mid-canyon station. Chaetognaths were more abundant than in previous years with a distribution concentrated in the canyons and off-shore stations, which may be a result of their preference for deeper waters. The distribution of the different copepod species showed differences in their distribution as well (Figure 7.8). *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 and were more abundant in the deeper offshore locations. This year a large number of copepods were unidentified and showed a uniform distribution across the nearshore waters.

Weather conditions were fair during the 3 – 8 February 2006 survey period (Figure 7.9). The gale that blew through on 2 February 2006 was the strongest winds experienced during the nearshore survey as weather conditions were atypically mild. Much of the survey period had partially cloudy or sunny skies which aided the observation of predators from the vessel. Rain and fog also occurred at various points during the survey period. 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*. The humidity sensor often gave readings > 100% and is believed to have a 10-15% offset. 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 5-kts and an average of 7-8 hours per day were spent on the water.

A new addition to the data collected during the survey period aboard the R/V *Ernest* were observations of higher-trophic level predators in the krill ecosystem. Observations were recorded whenever possible during survey (not transit) operations. Seabirds were the most abundant animals seen (consisting of Antarctic tern, giant petrel, black-browed albatross, grey headed albatross, Wilson's storm petrel, and skua) throughout the survey area (Figure 7.10). Chinstrap penguins were the next most frequently seen predator, and were concentrated along the eastern edges of the eastern canyon. Their presence in this area is not surprising since there is a large chinstrap penguin colony on Desolation Island which is east of the canyon-head. Humpback whales (both solitary animals and groups) were seen during the survey as well. They were distributed primarily due east of Cape Shirreff along the edges of the canyons. An occasional Antarctic fur seal was also observed.

The MBE deployed from R/V *Roald* successfully observed swarms of Antarctic krill. The 3D structure of krill swarms for a portion of three transects is shown in Figure 7.11. These swarms were identified using the Sonardata cruise-scanning 3D detection algorithm implemented in Echoview v3.50. For a sub-set of four transects of krill swarm detections the median descriptive metrics are given in Table 7.3.

Despite being on effort for 36 of the 41 transects and the two tie lines only 48 air-breathing predator groups were encountered. This is interesting as krill aggregations were frequently encountered, suggesting that predators either transit through or avoid the study site. As with R/V *Ernest* predator observations, seabirds were the most frequently encountered predator group, making up 75% of sightings. Three humpback whale and one minke whale groups were seen feeding close to the surface. Antarctic fur seals made up the other sightings.

Acoustic detections of Antarctic krill swarms by the SM20 MBE demonstrate that a small boat is a viable platform for multibeam 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.

7.4 Disposition of Data: Data are available from David A. Demer, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA; phone/fax: +1 (858) 546-5603/5608; email: David.Demer@noaa.gov or Joseph D. Warren, Marine Sciences Research Center, Stony Brook University, 239 Montauk Hwy, Southampton, NY 11968, phone/fax: +1 (631) 287-8390/631-287-8419; email: joe.warren@stonybrook.edu.

7.5 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. 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: Andrew Brierley, The UK Royal Society / NERC (Natural Environment Research Council); 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.

7.6 References:

Brierley, A.S., Ward, P., Watkins, J.L., and Goss, C. 1998. Acoustic discrimination of Southern Ocean zooplankton. *Deep Sea Research II* 45: 1155-1173.

Klinck, J.M., Hofmann, E.E., Beardsley, R.C., Salihoglu, B., and Howard, S. 2004. Water-mass properties and circulation on the west Antarctic Peninsula Continental Shelf in Austral Fall and Winter. *Deep-Sea Research II* 51: 1925-1946.

Prézelin, B.B., Hofmann, E.E., Mengelt, C., and Klinck, J.M. 2000. The linkage between Upper Circumpolar Deep Water (UCDW) and phytoplankton assemblages on the west Antarctic Peninsula continental shelf. *Journal of Marine Research* 58(2): 165-202.

Table 7.1. Mooring positions and types.

Mooring No.	Buoy No.	Buoy Type	TDR Fitted	Mooring Lat	Mooring Long
1	1	ADCP		62 26.256	60 43.903
2	4	GPT	TDR	62 26.603	60 42.777
3	2	ADCP	TDR	62 26.949	60 41.650
4	5	GPT	TDR	62 27.296	60 40.524
5	3	ADCP		62 27.642	60 39.397

Table 7.2. Nearshore multi-beam transect disposition.

Date	No. of transects run	Other activities
4 Feb 06	4	None
5 Feb 06	3	2 transects run with R/V Ernest & Yuzhmorgeologiya
6 Feb 06	15	None
7 Feb 06	17	None
8 Feb 06	0	2 tie-lines run with R/V Ernest

Table 7.3. Median 3D krill swarm descriptive metrics for a subset of four transects.

Metric	Median value	Coefficient of variation (%)
height	15.3 m	28
volume	4,208 m^3	106
center depth	60	13
north-south length	64.4	60
east-west length	72.4	54

Figure 7.1 The R/Vs *Ernest* (left, background) and *Roald* (left, foreground) at anchor by Cape Shirreff. The five instrumented buoys (right) are laid out on deck before being deployed on 15 Jan 2006. Photos by Steve Sessions.

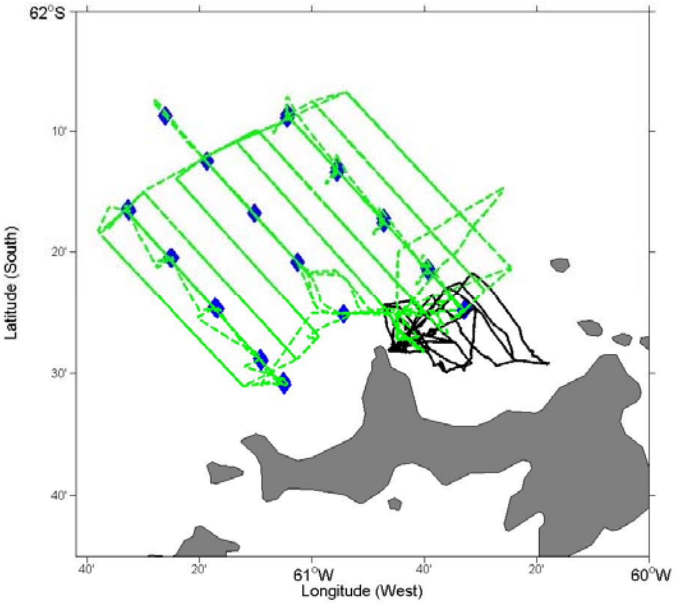


Figure 7.2 Cruise-tracks of the R/V *Yuzhmorgeologiya* (dashed offshore lines) and R/V *Ernest* (solid inshore lines). Diamonds represent locations of CTD casts and IKMT net tows.

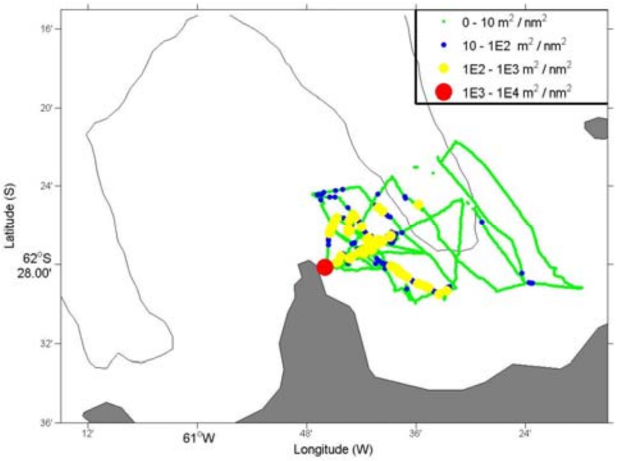
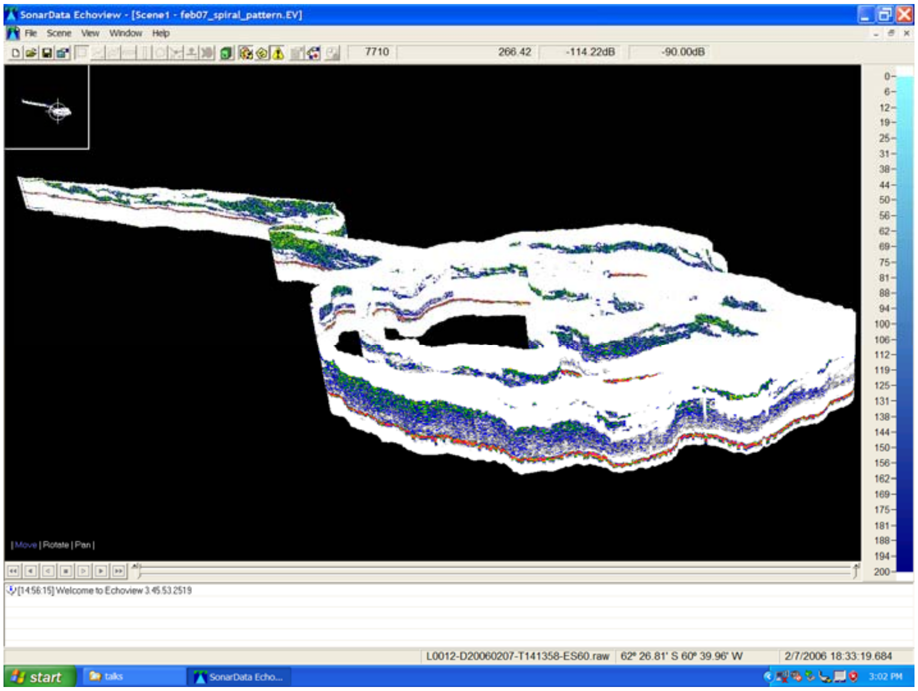


Figure 7.3 Volume backscattering coefficients at 200kHz integrated from 5m depth to either 3m above the bottom or 500m if no bottom present and averaged over 0.1 n.mi. bins (Sa). Elevated backscatter (indicative of the presence of krill) occurred in the areas immediately east and southeast of Cape Shirreff and throughout the canyon region particularly along the canyon boundaries. The 200m isobath is a thin black line.



[14:56:15] Welcome to Echoview 3.45.53.2519

L0012-D20060207-T141358-ES60.raw | 62° 26.81' S 60° 39.96' W | 2/7/2006 18:33:19.684

Figure 7.4 Screen capture of a 3-D representation of a contiguous krill swarm surveyed on 7 February 2006. The trackline represents our attempt to determine the spatial extent of this krill patch. The east-west and north-south dimensions of this patch are roughly 7.5km and 0.9km. respectively.

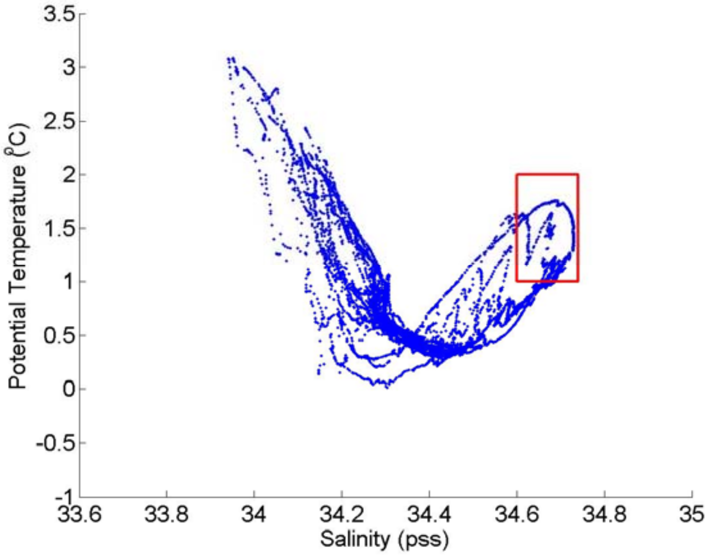


Figure 7.5 Theta-S plot for the CTD casts from the R/V *Yuzhmorgeologiya* during the nearshore survey. The box indicates water that meets the criteria of Circumpolar Deep Water (CDW) as specified by Klinck *et al*., (2004). CDW was mostly found at the CTD stations furthest from the island, along the 500m isobath.

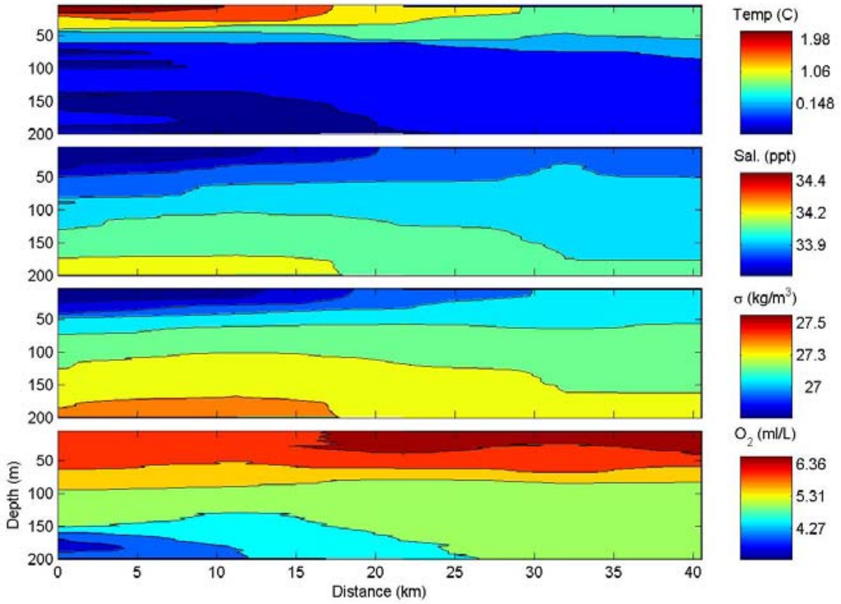


Figure 7.6 Hydrographic profiles along transect Y8-A (the western canyon). Distance is measured from the furthest offshore station.

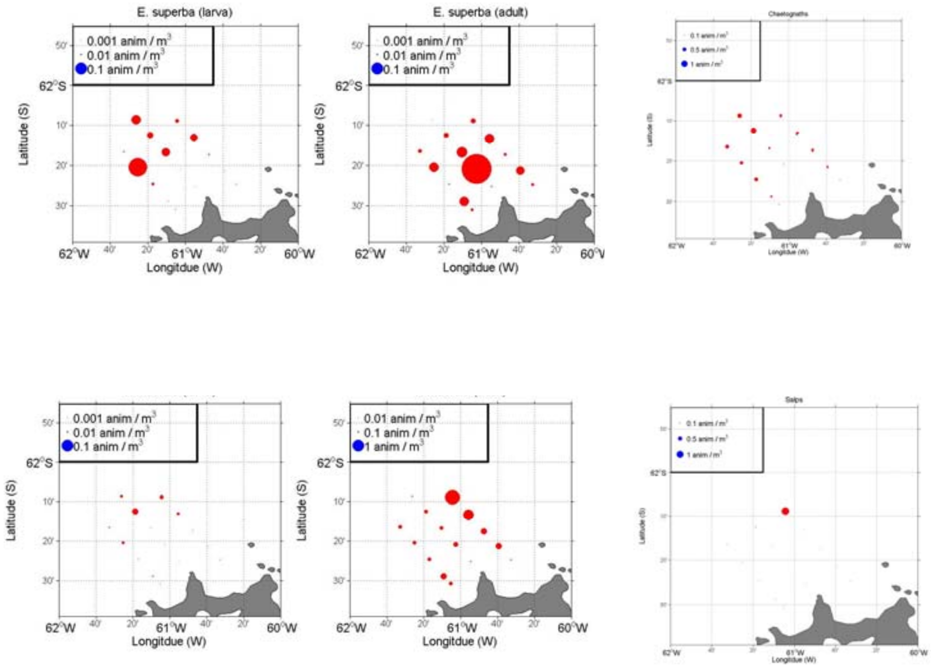


Figure 7.7 Distribution of *E. superba* larvae (top left), *E. superba* adult (top middle), chaetognaths (top right), *T. macrura* larvae (bottom left), *T. macrura* adult (bottom middle), and salps (bottom right) from IKMT new samples collected by the R/V *Yuzhmorgeologiya* during the 2006 nearshore 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.

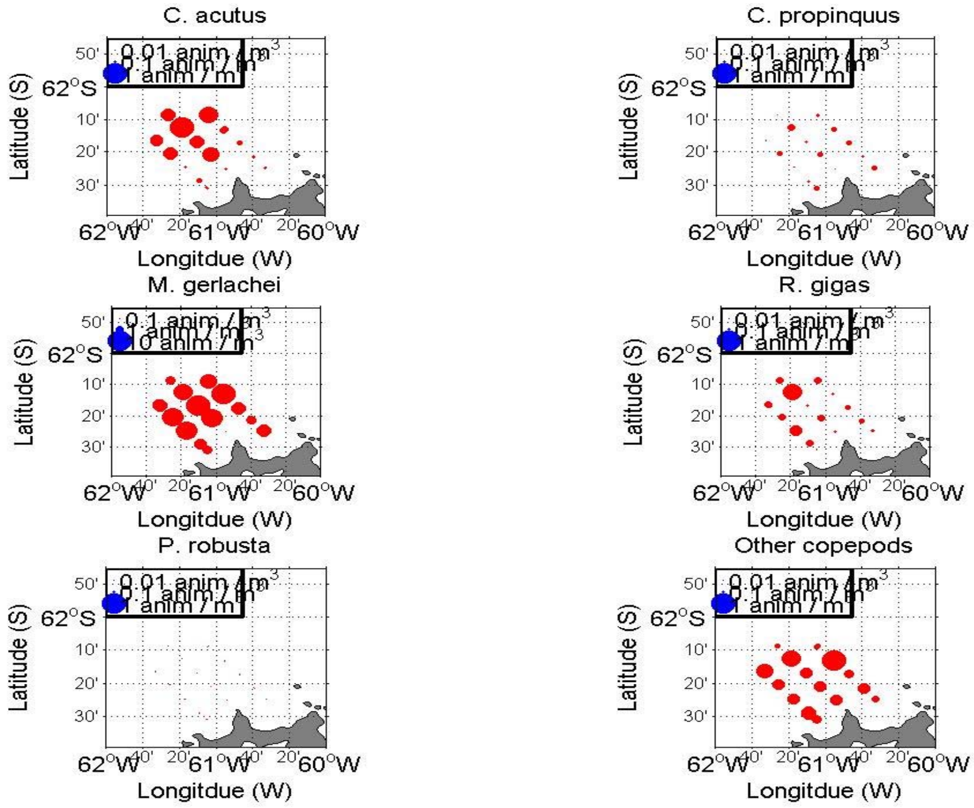


Figure 7.8 Distribution of copepod species collected during the 2006 nearshore survey. *M. gerlachei* were the most abundant copepods followed by *C. acutus*, *R. gigas*, and *C. propinquus*. It appears that copepod distribution is not uniform and differs for the different species.

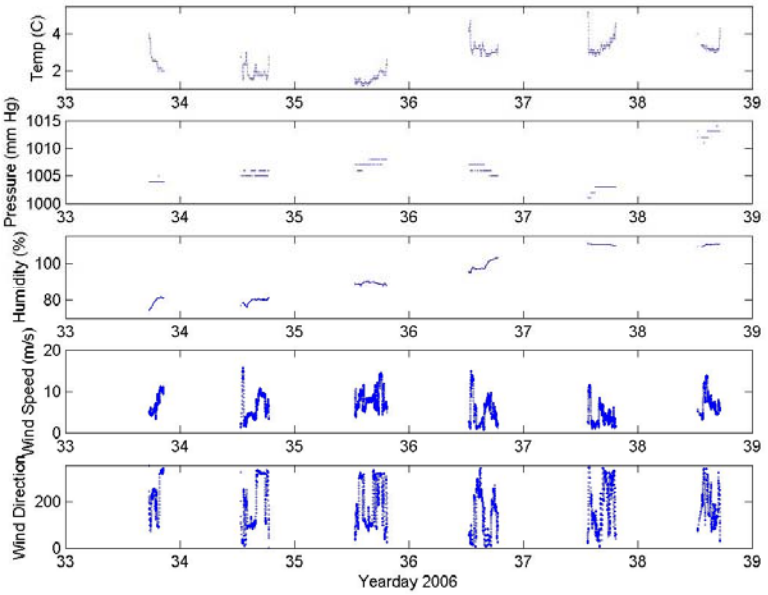


Figure 7.9 Meteorological data from R/V *Ernest* during the nearshore survey. The humidity sensor readings are likely offset 10-15% high. Mean wind speed was 5 m/s with a peak gust recorded of 15 m/s. Most frequent wind direction was from the SW and NW. Compared to previous surveys, these weather conditions were mostly favorable and mild.

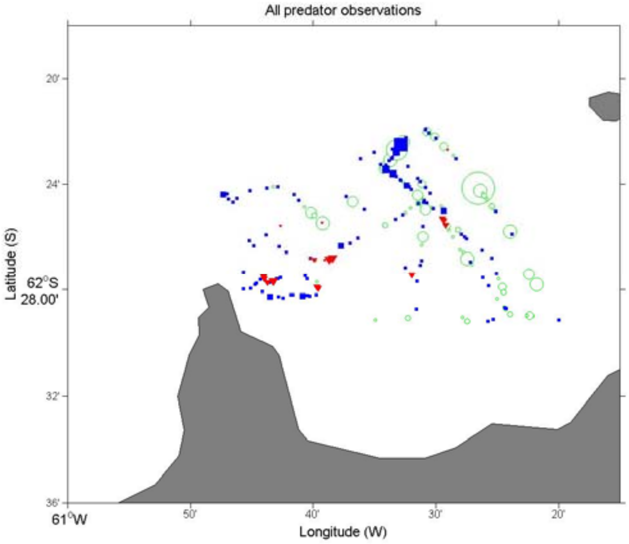


Figure 7.10 Predator observations made from the R/V *Ernest* during the survey. Size of symbol is proportional to number of animals observed. Circles represent penguins (almost entirely chinstrap), squares represent sea birds, and triangles represent marine mammals (primarily humpback whales). The largest aggregation was of 12 chinstrap penguins (large circle on easternmost transect).

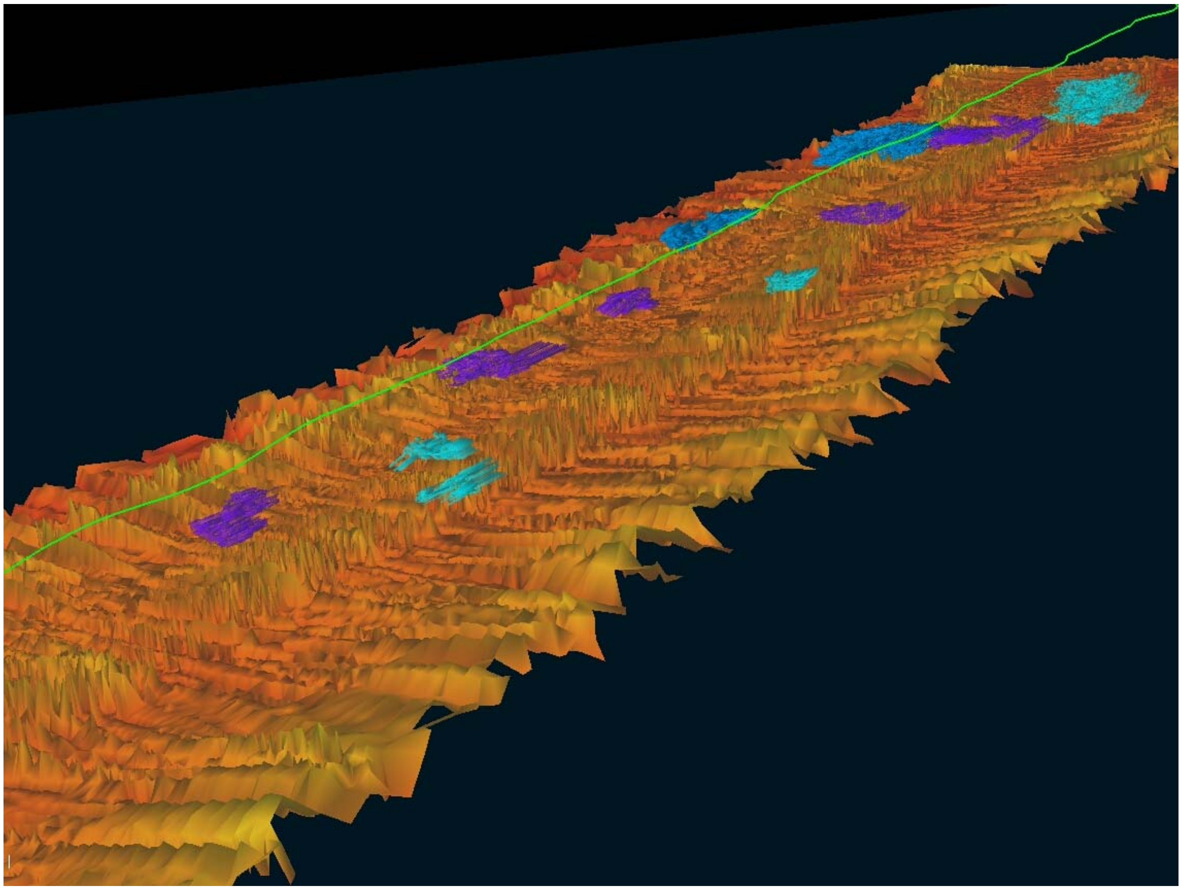


Figure 7.11 Krill swarms observed in 3D using an SM20 multibeam echosounder. Detections are from three adjacent transects. The krill swarm observations from each transect are color coded. The vessel track line for one transect is shown in green. The sounder detected bottom surface is shown in orange/brown, mean depth approximately 50m.

8. Pinniped research at Cape Shirreff, Livingston Island, Antarctica, 2005/06; submitted by Michael E. Goebel, Birgitte I. McDonald, Russell G. Haner, Douglas J. Krause, Scott Seganti, Jessica D. Lipsky, Jennifer Van Dommelen, and Rennie S. Holt.

8.1 Objectives: 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 Scotia Sea, Antarctic fur seals, 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^o28'S, 60^o46'W) are to monitor population demography and trends, reproductive success, and status of pinnipeds throughout the summer months. The Antarctic fur seal, *Arctocephalus gazella*, 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.

The 2005/06 field season began with the arrival at Cape Shirreff of a five person field team via the R/V *Laurence M. Gould* on 7 November 2005. Research activities were initiated soon after and continued until closure of the camp on 12 March 2006. Our specific research objectives for the 2005/06 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 collecting mass measures for a random sample of 100 fur seal pups every two weeks throughout the research period beginning 30 days after the median date of births;

C. Document fur seal pup production at designated rookeries on Cape Shirreff and assist when necessary Chilean colleagues in censuses of fur seal pups for the entire Cape and the 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 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. Record any pinnipeds carrying marine debris (i.e., entanglement); and

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

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

A. Female Fur Seal Attendance Behavior: 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. Measuring changes in attendance behavior (especially the duration of trips to sea) is one of the standard indicators of a change in the foraging environment and availability of prey resources. 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 28 lactating females from 2-21 December 2005. The study was conducted according to CCAMLR protocol (CCAMLR 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 every 30 minutes for 30 seconds for the first six trips to sea 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 28 January. No females lost their pups to leopard seal predation before completion of six trips to sea.

The mean trip duration for the combined first six trips to sea this year was 2.79 days (±0.08, $N_{Females}$=28, N_{Trips}=168, range: 0.35-5.88; Table 8.1, Figure 8.1). The mean duration for the first six, non-perinatal visits was 1.69 days (±0.05, $N_{Females}$=28, N_{Visits}=166, range: 0.96-4.77) (Table 8.1, Figure 8.1). Two females lost their pups while on their sixth trip and their subsequent visit was 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 49.7kg (±1.03, N=28; Figure 8a). The mass-to-length ratio (arc-sin transformed), was 382.4g/cm (±6.72, N=28; Figure 8.2b).

An additional seven females, 4-5 years of age were instrumented 0-1d postpartum for a study of age-related maternal investment and reproductive success. Two of the seven 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 (8 Dec 2005) and ending 21 February (four bi-weekly samples; collection dates: 7 Jan, 22 Jan, 6 Feb, and 21 Feb). 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 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 17 November 2005 through 10 January 2006. The maximum number counted (live plus cumulative dead) for the combined four beaches in 2005/06 was 2146 on 4 January 2006 (Figure 8.3). The median date of parturition was 8 December (since 1997/98, the median date of parturition has varied by four days: 7-10 Dec).

Neonate mortality was lower than in the previous four years. We recorded the number of new pup carcasses on our census beaches at each count and calculated a cumulative mortality every other day (i.e. at each census) from around the start of births (17 November this year) until the last of pupping (10 January this year). Pup mortality for 2005/06 was 3.1%; last year's pup mortality was 4.5 percent. The long-term average (based on eight years of data (1998-2005) is 4.4% ±0.76). Pup mortality for the same time period for past years was: **97/98:** 1.8%; **98/99:** 2.5%; **99/00:** 2.8%; **00/01:** 3.0%; and **01/02:** 5.5%; **02/03:** 9.0%; **03/04:** 4.9% and **04/05:** 4.5%.

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. However, 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. Since remains are rare, evidence of this type of mortality is more difficult to quantify. 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, calculated 23 February, 77 days after the median date of pupping, was based on daily tag resights of adult females. By that date 24.2% of pups were lost to leopard seals. Similar calculations last year indicated 63.4% of pups were lost to leopard seal predation by the same date.

D. Diet Studies: Information on fur seal diet was collected using three different sampling methods: collection of scats, enemas, and fatty acid signature analysis of milk. In addition to scats and enemas, an occasional regurgitation is found in female suckling areas. Regurgitations often provide whole prey that is only minimally digested. Scats are collected from around suckling sites of females or from captured animals that defecate while captive. All females that are captured to remove a time-depth recorder or satellite-linked transmitter (PTT) are given an enema to collect fecal material containing dietary information. In addition to diet information from captive animals, 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.

In total, we collected and processed 111 scats from 23 December 2005-3 March 2006. Diet samples that could not be processed within 24 hours of collection were frozen. All samples were processed by 3 March. Up to 25 krill carapaces were measured from each sample that contained krill. Otoliths were sorted, dried, identified to species. The number of squid beaks were counted and preserved in 70% alcohol for later identification. A total of 2,716 krill carapaces were measured. Most scats, 99.1% (110/111) collected contained krill. In addition, 744 otoliths were collected from 20.7% of the scats collected. Most (98.0%, 729 otoliths) were from two species of myctophid fish (*Electrona antarctica*, n=188 and *Gymnoscopelus nicholsi*, n=541; plus an additional 15 (2.0%) eroded and unidentified otoliths). No *Electrona carlsbergi* otoliths were found in 2005/06. A total of three squid beaks (*Brachioteuthis picta*) were collected from 1.8% of the scats.

The proportions of krill, fish and squid were different every year ($X^2=36.5$, d.f.=9, $P<0.0005$). Results for 2005/06 showed similar trends to past years in regards to an increasing proportion of fish and squid from December through February (Figure 8.4). 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 8.5).

The length and width of krill carapaces found in fur seal scats were measured in order to determine 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*., 2006) was applied to the carapace length (CL) and width (CW) to determine 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*. (2006) were applied to calculate total length (TL) from the carapace length:

$$\text{Females: } TL = 11.6 + 2.13(CL)$$

$$\text{Males: } TL = 0.62 + 3.13(CL)$$

A total of 2,716 carapaces were measured from 110 scats in 2005/06. Summary statistics are presented in Table 8.2. Data from 1999/00 through 2003/04 are also presented for comparison. Krill consumed by fur seals in 2005/06 was on average larger than last year (Table 8.2; ANOVA, $F_{1,212} = 49.26$, $P<0.0001$). The length distributions (in 2mm increments) for the last four years are presented in Figure 8.6. As in previous years, weekly comparisons showed changes in length frequency distributions (Figure 8.7) and in the overall mean length of krill (Figure 8.8). No consistent intra-seasonal trends were evident (Figure 8.8).

E. Fatty Acid Signature Analysis of Milk: In addition to scats, we collected 105 milk samples from 52 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 trans-esterification of fatty acids. Of the 105 samples, 30 were collected from perinatal females and 38 were collected from females that had dive data for the foraging trip prior to milk collection.

F. Diving Studies: Fourteen of our 28 females transmittered for attendance studies also received a time-depth recorder (TDR, Wildlife Computers Inc., Mark 9s, 66 x 18 x 18mm, 31g) on their first visit to shore. Three of the 4-5 year old females used for studies of age-related reproductive success also had TDRs. All but one female carried their TDR for at least their first six trips to sea (one of the 4 year old females failed to return). In addition, all other females captured for studies of at-sea foraging locations also received a TDR. A total of 27 dive records were collected from 26 females in 2005/06. Four TDRs were lost this season.

G. Adult Female Foraging Locations: We instrumented 15 females with satellite-linked transmitters (ARGOS-linked Platform Terminal Transmitters or PTTs) from 21 December – 28 February. Only four 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, three carried a PTT for four trips, six for five trips, one for six trips and one for eight trips. Results of fur seal foraging location data analysis and interannual comparisons are pending. One PTT attachment failed and the lost PTT was not recovered.

H-J. Demography and Tagging: Together Chilean and U.S. researchers tagged 495 fur seal pups (251 females, 244 males) from 17 January – 8 March 2006. All tags placed at Cape Shirreff were Dalton Jumbo Roto tags with white tops and orange bottoms. Each pup was tagged on both fore-flippers with identical numbers. Series numbers for 2005/06 were 4501-4999. All pups were tagged on study beaches on the east side of the Cape from Playa Marko to Ballena Norte beach. No pups were tagged at Loberia beach on the northwest side of the Cape in 2005/06.

In addition to the 495 pups tagged, we also retagged ten adult lactating females (381-390).

Last year we added 30 adult females to our tagged population. These 30, when added to the females that returned in the previous season (N=221) gave an expected known tagged population of 251 for 2005/06 (Table 8.3). Of these, 217 (86.5%) returned in 2005/06 to Cape Shirreff and 182 (83.9%) returned pregnant (Figure 8.9).

This was the first year since our monitoring program began in 1997/98 that we did not observe any yearlings tagged as pups. The yearling return rate declined for the second year in a row. Table 6.4 presents observed tag returns for four cohorts in their first year. Tag deployment, the total number placed and re-sighting effort for all six 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 or other factors) 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 8.5). 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, *etcetera* may vary for different cohorts. Given similar re-sighting effort the seven cohorts presented have return rates in the first two years that are very different (Figure 8.10). 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 was presented in the 1999/00 annual report. This year we took a single post-canine tooth from only 12 previously tagged female. The mean age of the sample was 11.3 years (± 0.99, N=12).

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 14 November 2005 to 5 March 2006. 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 once at each 15-minute interval and stored. 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.

M. Entangled pinnipeds: No fur seals were observed this season with entanglements around their neck.

N. Other pinnipeds: Southern elephant seals. No tagged elephant seals were recorded this year. However, US-AMLR in collaboration with University of California researchers tagged 21 elephant seal pups (10 males, 10 females, and one of unknown sex) and 11 adult females. The adult females were captured post-molt and were also instrumented with satellite-linked transmitters for post-molt dispersal at sea.

8.3 Preliminary Conclusions: Fur seal pup production in 2005/06 at U.S. AMLR study beaches declined over last year. Early season neonate mortality (3.1%) was below the long-term average of 4.4%. We also recorded a mid-season decrease in Leopard seal predation over last year. The median date of pupping based on pup counts was one day earlier than last year and our tag returns of adult females confirm a 2d change in the parturition date. Over winter survival for adult females, however, declined for the second consecutive year (86.5 vs. 89.8%). The natality rate also declined (83.9 vs. 84.8%). However, mean foraging trip duration (2.79 days ±0.08) decreased over last year and was the second lowest recorded in nine years of data collection at Cape Shirreff. Visit duration (1.69 days ±0.05) showed a similar trend and like trip durations were reflective of favorable summer foraging conditions. We recorded poor over winter juvenile survival for 2005 similar to the trend in adult female survival. This was the first year on record that we did not observe any yearlings (i.e. tagged pups from the 2004/05 cohort. The 1999/00 and the 2001/02 cohorts even with decreased survival for 2005 continued to dominate tag returns as in previous years. Fur seal diet studies for second year in a row recorded a total absence of *Electrona carlsbergi*. In general summer conditions were favorable resulting in better than average performance for summer indices; however, winter conditions in 2005 resulted in below average performance.

8.4 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.

8.5 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 a broader temporal spatial scale. Yet these data suggest that post-weaning environments are 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 8.5, Figure 8.10) offer one of the best examples of this. Recent technology in 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 cannot 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.

8.6 Acknowledgements: The National Science Foundation provided support and transportation to the Cape Shirreff field site for the opening camp crew. We thank the captain, crew and science staff of the November cruise of the R/V *Laurence M. Gould*. We are grateful to our Chilean colleagues: Romeo Vargas, Claudio Vero, 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, Elaine Leung, and Rachael Orben for their help with pinniped studies. We are, likewise, grateful to Adam Jenkins, the AMLR personnel, and the Russian crew of the R/V *Yuzhmorgeologiya* for their invaluable support and assistance to the land-based AMLR personnel. All pinniped research at Cape Shirreff was conducted under Marine Mammal Protection Act Permit No. 774-1649 granted by the Office of Protected Resources, National Marine Fisheries Service.

8.7 References:

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Table 8.1. 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 – 2005/06.

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)
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)

Table 8.2. Krill length (mm) in fur seal diet from 1999/00 - 2005/06. Data are derived from measuring length and width of krill carapaces found in fur seal scats and applying a discriminant function to first determine sex before applying independent regression equations to calculate total length.

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

Table 8.3. Tag returns and natality rates for adult female fur seals at Cape Shirreff, Livingston Island, 1998/99 – 2005/06.

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

[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 8.4. A comparison of first year tag returns for seven cohorts: 1997/98 – 2004/05. 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)

Table 8.5. Tag returns and minimum percent survival for six cohorts, 1997/98 – 2003/04 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.

	1997/98			**1998/99**			**1999/00**			**2000/01**			**2001/02**			**2002/03**			**2003/04**		
	?	**?**	**Total**	**?**	**?**	**Total**	**?**	**?**	**Total**	**?**	**?**	**Total**	**?**	**?**	**Total**	**?**	**?**	**Total**	**?**	**?**	**Total**
Sightings:																					
Sighted in Year 1:	12	10	22	1	5	6	11	15	26	3	6	9	12	11	23	9	4	13	5	4	9
Additional Tags Sighted in Year 2:	20	10	32	6	7	13	53	40	93	13	2	15	28	26	54	13	9	22	3	0	3
Minimum survival in year 1:	32	20	54[1]	7	12	19	64	55	119	16	8	24	40	37	77	22	13	35	8	4	12
Tag loss:																					
Unknown tag status:	2	1	3	0	2	2	1	3	4	0	1	1	4	2	6	1	0	1	0	0	0
Both tags present:	14	13	29	6	6	12	48	42	90	11	5	16	29	27	56	9	4	13	6	4	10
Missing 1 tag:	16	6	22	3	2	5	15	10	25	5	2	7	7	8	15	4	4	8	1	0	2
Probability of missing one tag:	0.53	0.32	0.43	0.33	0.25	0.29	0.24	0.19	0.22	0.29	0.29	0.30	0.19	0.23	0.21	0.31	0.50	0.38	0.14	0.00	0.17
Probability of missing both tags[2]:	0.28	0.10	0.19	0.11	0.06	0.09	0.06	0.04	0.05	0.08	0.08	0.09	0.04	0.05	0.04	0.09	0.25	0.15	0.02	0.00	0.03
Survival estimates:																					
Minimum % Survival 1st year:	12.80	8.00	10.8	2.8	4.8	3.8	27.6	20.6	23.8	6.0	3.4	4.8	15.3	15.5	15.4	8.4	5.5	7.0	3.1	1.7	2.4
Adj. Min. % Survival for year 1[3]:	16.44	8.80	**12.8**	3.1	5.1	**4.1**	29.2	21.4	**25.0**	6.6	3.8	**5.3**	15.9	16.4	**16.1**	9.2	6.8	**8.0**	3.13	1.68	**2.47**

[1] Includes two sightings of seals of unknown sex.

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

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

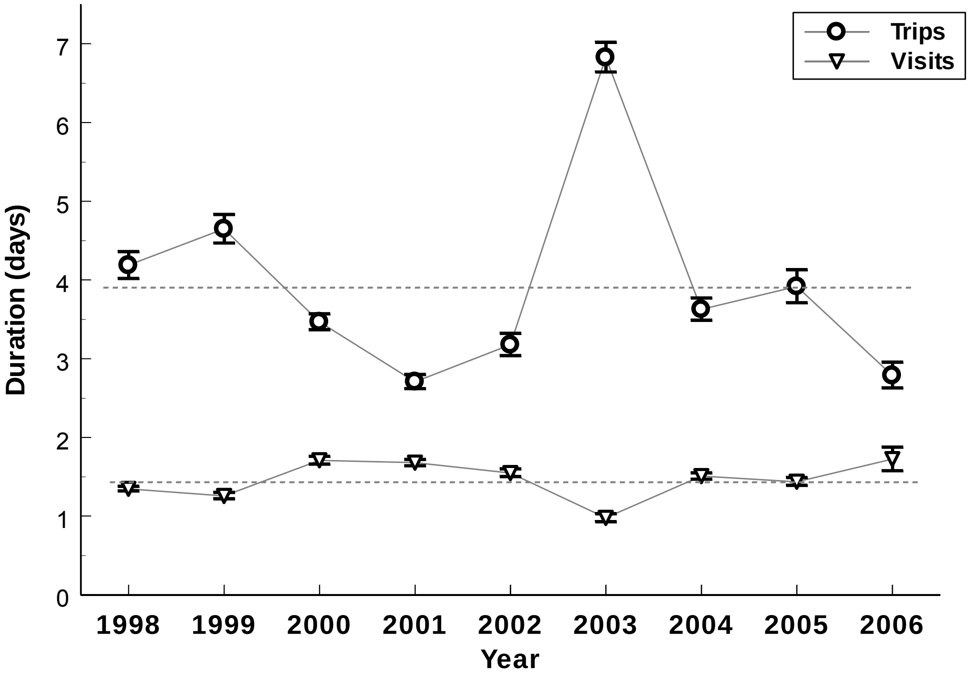

Figure 8.1. Antarctic fur seal mean trip and visit durations (with standard error) for females rearing pups at Cape Shirreff, Livingston Island. Data plotted are for the first six trips to sea and the first six non-perinatal visits following parturition for eight years (See Table 8.1 for sample sizes). Long-term means are plotted as dashed gray lines.

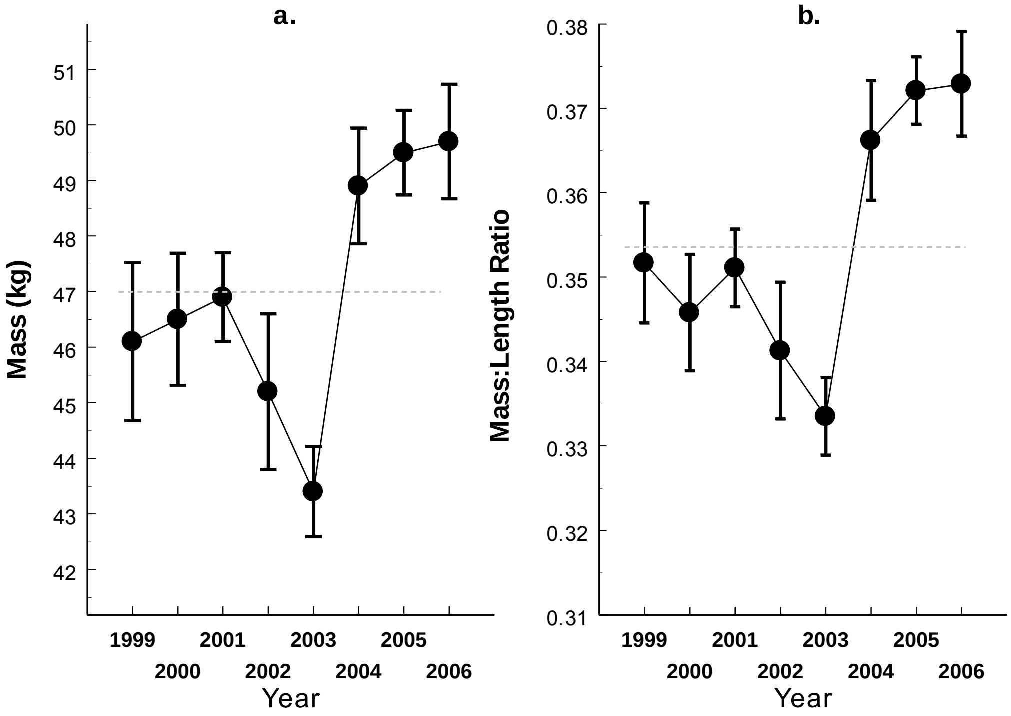

Figure 8.2. The mean mass (a.) and mass:length ratio (b.) for females at parturition 1998/99 – 2005/06 **(98/99**: N=32, **99/00**: N=23, **00/01, 04/05**: N=29, **01/02-03/04, 05/06**: N=28). Long-term average is plotted as a gray dashed line, mass: 47.0 ±0.78; mass:length ratio: 0.354 ±0.005.

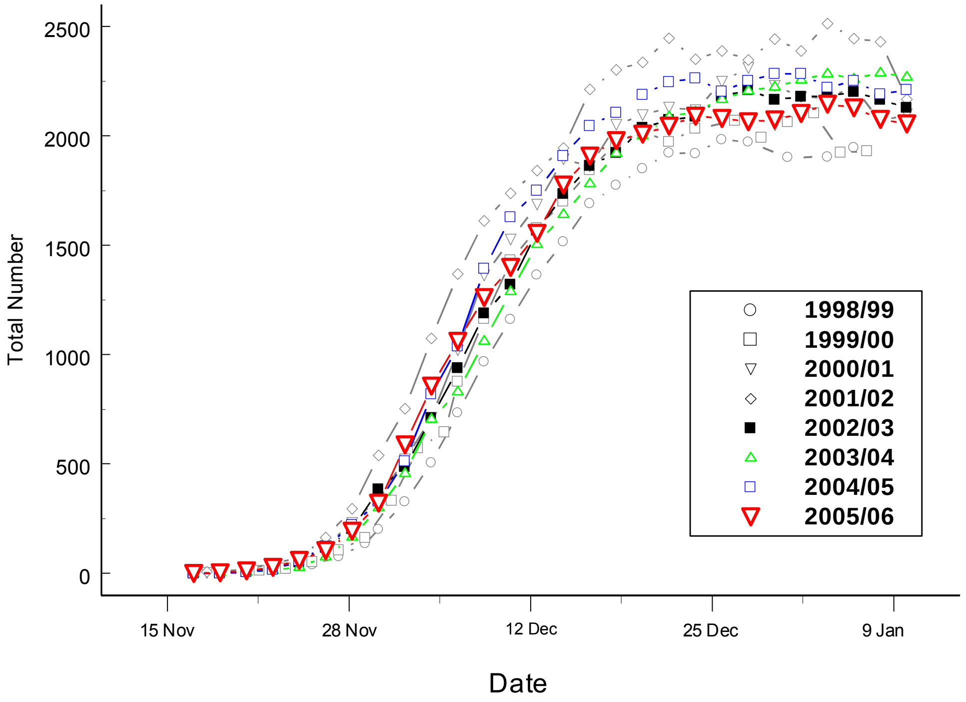

Figure 8.3. Antarctic fur seal pup production at U.S. AMLR study beaches, Cape Shirreff, Livingston Island, 1998/99-2005/06.

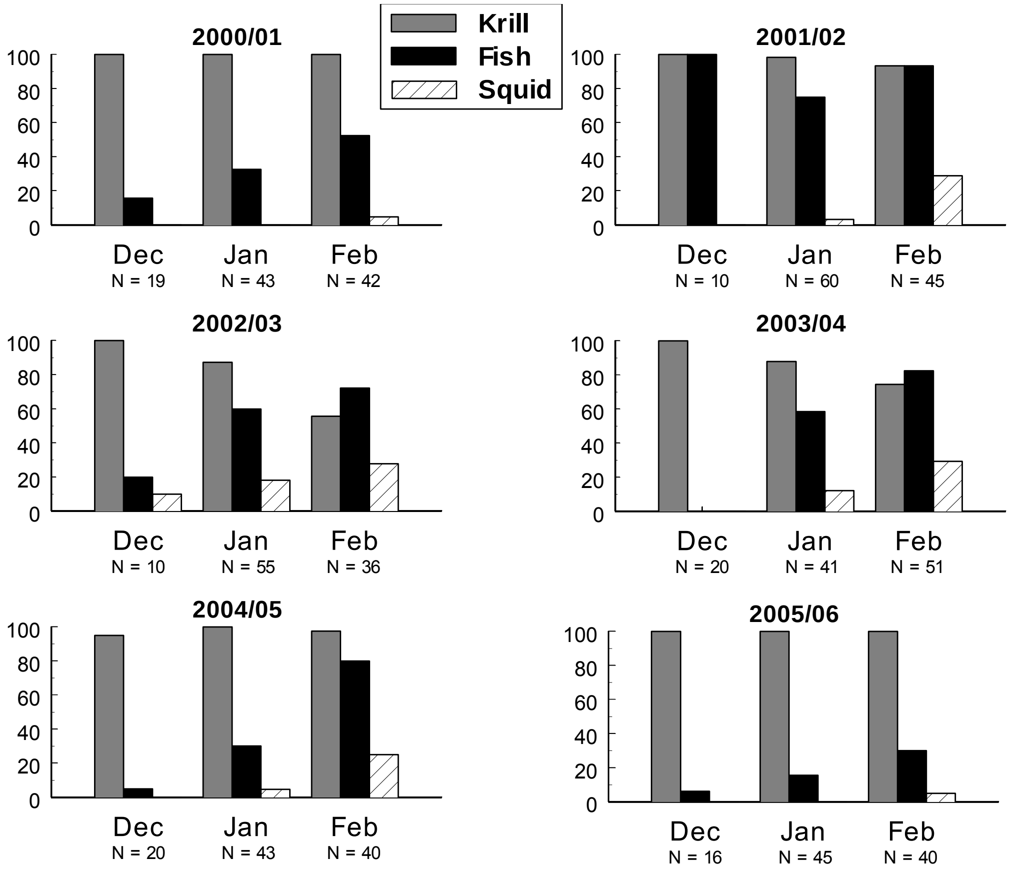

Figure 8.4. The percent occurrence of primary prey types (krill, fish, and squid) from December through February for Antarctic fur seal scats collected from female suckling areas and enemas from females carrying time-depth recorders at Cape Shirreff, Livingston Island for 2000/01 through 2004/05.

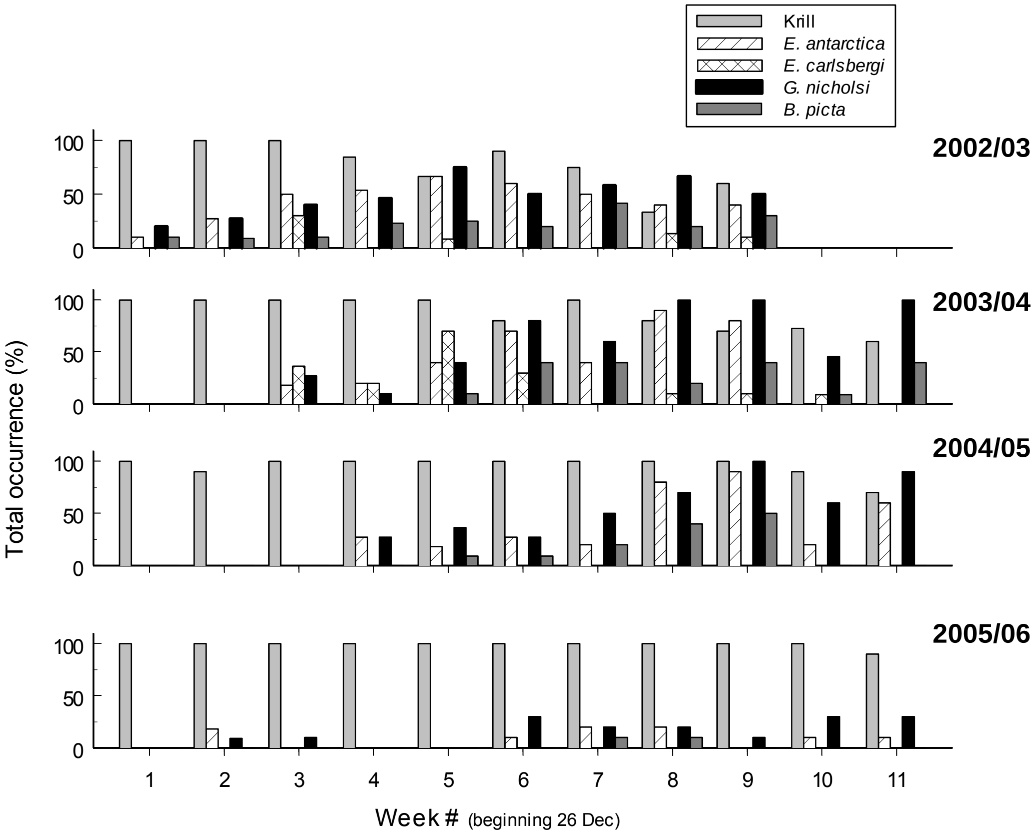

Figure 8.5. The weekly percent occurrence of five primary prey species found in fur seal diets at Cape Shirreff, Livingston Island from 2002/03-2005/06. The five species are krill (*Euphausia superba*), *Electrona antarctica*, *Electrona carlsbergi*, *Gymnoscopelus nicholsi*, and *Brachioteuthis picta*. The first three non-krill species are myctophid fish (lantern fish) and the fourth species is a cephalopod (squid).

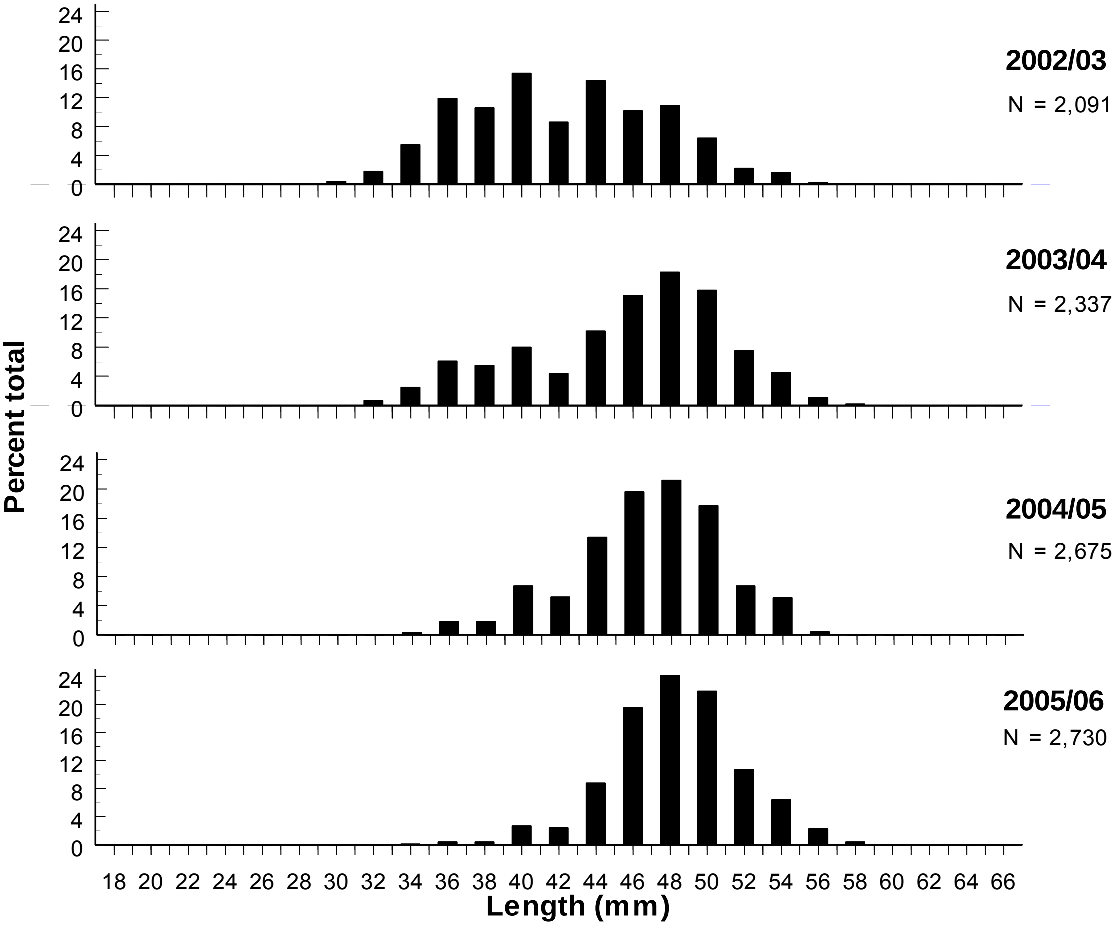

Figure 8.6. The size distribution of krill in Antarctic fur seal diet at Cape Shirreff, Livingston Island from 2002/03 through 2005/06. Data for past years were recalculated using discriminant functions and sex-specific regression equations derived from South Shetlands collected krill (see Goebel *et al.* in press).

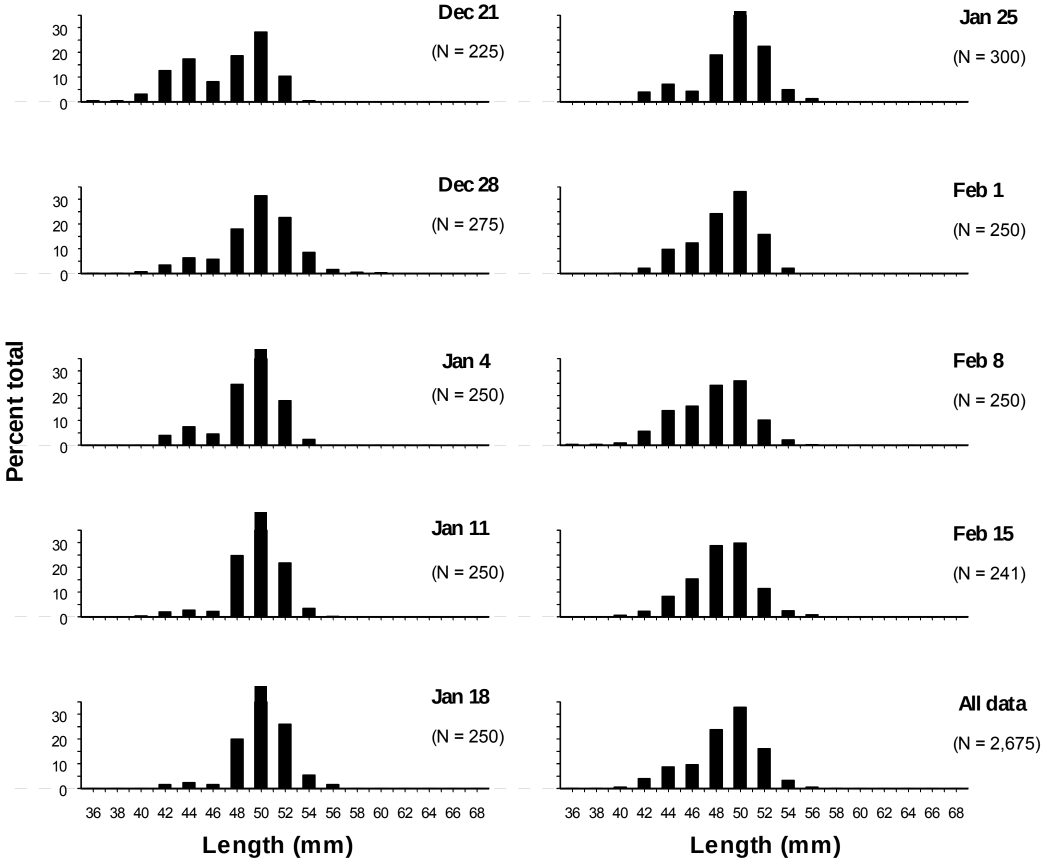

Figure 8.7. Weekly size distribution of krill (*Euphausia superba*) in Antarctic fur seal diet at Cape Shirreff, Livingston Island in 2005/06. Each plot represents one week of krill carapace measurements. The date on each plot is the last day of the week (e.g. Jan 1: the week 26 Dec 2004 - 1 Jan 2005). The number of krill carapaces measured for each week is given in parentheses.

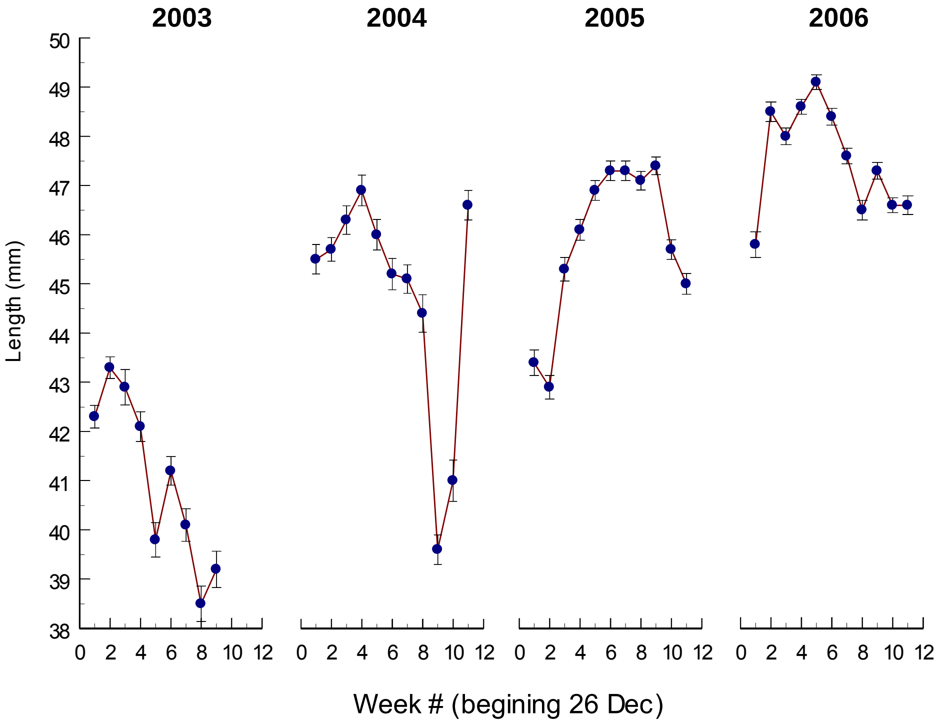

Figure 8.8. Weekly mean length of krill (*Euphausia superba*) in Antarctic fur seal diet at Cape Shirreff, Livingston Island from 2002/03 through 2005/06.

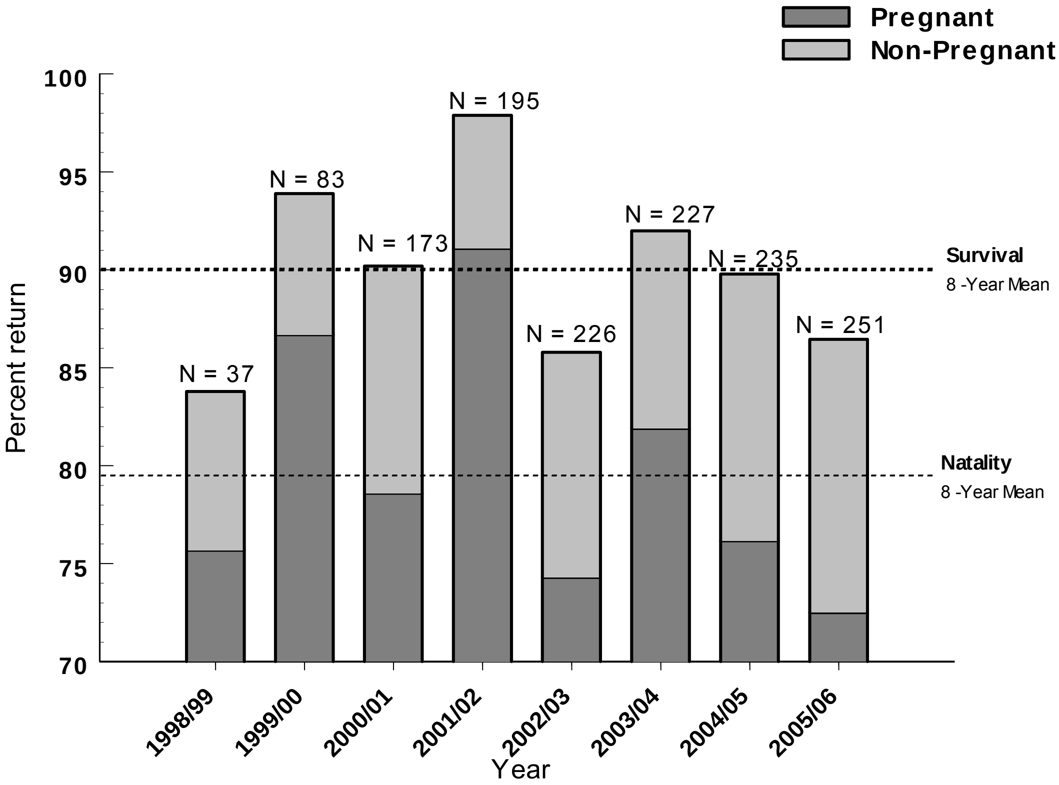

Figure 8.9. Adult female Antarctic fur seal tag returns for seven years (1998/99-2005/06) of study at Cape Shirreff, Livingston Island.

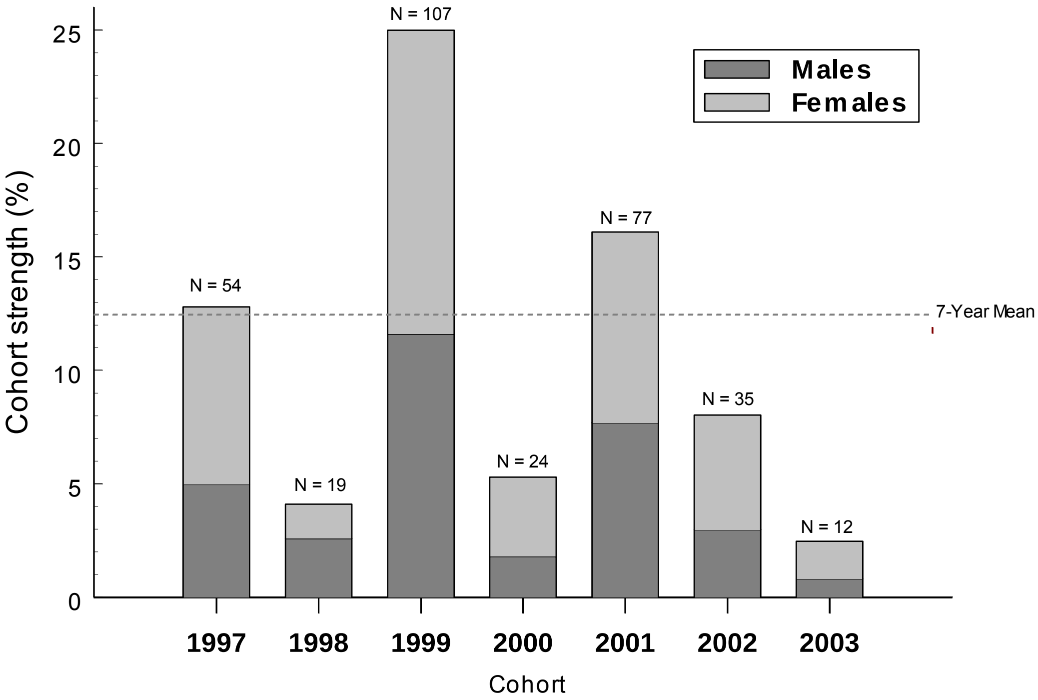

Figure 8.10. Minimum survival to age-1 based on tag returns for the first two years for four cohorts (97/98-03/04) of fur seals tagged as pups at Cape Shirreff, Livingston Island. Not all pups that survive their first year return as yearlings or two year olds, thus our estimates represent a minimum survival. There were no differences in tag re-sight effort among years.

9. Seabird research at Cape Shirreff, Livingston Island, Antarctica, 2005/06; submitted by Elaine S.W. Leung, Rachael A. Orben and Wayne Z. Trivelpiece.

9.1. Objectives: The U.S. Antarctic Marine Living Resources (AMLR) program conducted its ninth 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 2005/06. Cape Shirreff is a Site of Special Scientific Interest (SSSI) and long-term monitoring of predator populations are conducted in support of U.S. participation in the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR).

We arrived at Cape Shirreff on November 11, 2005 via the National Science Foundation vessel R/V *Laurence M. Gould* and conducted research until we closed camp on March 12, 2006. The AMLR chartered vessel R/V *Yuzhmorgeologiya* provided logistical support and transit back to Punta Arenas, Chile at the end of the field season. The objectives of the seabird research for the 2005/06 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 future 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).

9.2 Results:

9.2.1 Breeding biology studies: The penguin rookery at Cape Shirreff consisted of 22 sub-colonies of gentoo and chinstrap penguins during the 2005/06 breeding season. We conducted nest censuses for gentoo penguins on November 17 and for chinstrap penguins on November 25, 2005. Both censuses were conducted approximately one week after mean clutch initiation. A total of 807 gentoo penguin nests were counted; this is comparable to the 2004/05 season of 818 nests, but is below the mean of the previous eight seasons of 842 nests (Figure 9.1). There were 4,849 chinstrap penguin nests; this is a 1% decrease from the previous year but denotes the seventh continuous year of decline in this population (Figure 9.2).

Chick censuses were conducted for gentoo penguins on January 26 and for chinstrap penguins on February 10, 2006. We censused 1,158 gentoo penguin chicks; this is one of the highest chick counts recorded at Cape Shirreff (Figure 9.1). The chinstrap penguin count was 5,247 chicks, representing an 18% increase from the previous season but it was 27% below the mean from the prior eight years (Figure 9.2).

Based on census data, gentoo penguin fledging success was 1.43 chicks/nest. This is the highest fledging success recorded in the nine years data have been collected at Cape Shirreff. Chinstrap penguins fledged 1.08 chicks/nest. This is comparable to the eight year mean and is a 23% increase from the 2004/05 season. Reproductive success was also measured by following a sample of 50 pairs of breeding gentoo penguins and 99 pairs of breeding chinstrap penguins from clutch initiation through crèche formation (Std. Methods 6a, b & c). Based on data from our reproductive study, gentoo penguins fledged 1.52 chicks/nest and chinstrap penguins fledged 1.06 chicks/nest.

We banded a sample of 200 gentoo and 500 chinstrap penguin chicks for future demographic studies. Banded chicks that survive and return to the colony as adults will be observed for age-specific survival and reproductive success in future years.

We collected fledging weights from gentoo and chinstrap penguin chicks and found that this season, the gentoo penguins had the highest average mass in all the years of study while chinstrap penguin fledglings had a mass comparable to the previous eight year mean. Because gentoo penguin chicks are still provisioned by their parents after they begin making trips to sea, it is not possible to obtain definitive fledgling weights by catching and weighing chicks as they depart to sea. Alternatively, we weigh a sample of gentoo penguin chicks 85 days after the mean gentoo penguin clutch initiation date; this approximates the age at which other *Pygoscelis* chicks fledge. We weighed 181 gentoo penguin chicks on February 3, 2006. The average mass was 4,547g (S.D.=493.2); this represents a 15% increase from the previous season. Chinstrap penguin chicks do not typically return to the sub-colonies after they depart to sea and are caught on beaches before they make their first trip. We collected chinstrap penguin fledge weights from February 17-21, 2006, during the peak fledging period. We weighed 178 chinstrap penguin fledglings, with an average mass of 3,121g (S.D.=331.3). This corresponds to an 8% increase in mean mass from last season.

9.2.2 Foraging ecology studies: Diet samples were collected from 20 gentoo and 40 chinstrap penguins via the wet-offloading technique from January 5 through February 11, 2006. 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. All of the diet samples consisted almost entirely of Antarctic krill (*Euphausia superba*). Some diet samples contained small amounts of fish while the amount of marine invertebrates found in the samples was negligible.

In the 2005/06 season, 25% of gentoo penguin diet samples contained evidence of fish; this is significantly lower than the previous eight year average of 74%. For gentoo penguins, fish comprised 1% by mass of the diet samples; this is significantly lower than last year's average of 18% and the previous eight year average of 25%. Evidence of fish was found in 32% of the chinstrap penguin diet samples; this is comparable to the previous eight year mean of 29%. Similar to the previous eight years of diet sampling, fish comprised 1% by mass of 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 in penguin diets. The majority of the krill measured in the gentoo and chinstrap penguin diet samples were 51-55mm in length; this is the fourth year in a trend towards increasingly larger krill seen in the diet (Figure 9.3). The sex distribution of the krill sub-sampled was 80% female and 20% male; this is similar to the distribution recorded last season with 79% female, 21% male and <1% juvenile. This represents the fourth year of increasing proportions of females and decreasing proportions of male and juvenile krill, similar to the first four years of diet sampling (Figure 9.4).

Beginning in the 2004/05 season, we collected only the fresh portion of diet samples from gentoo penguins so chick meal mass could not be evaluated. The average meal mass for chinstrap penguins was 544.1g (S.D.=170.7); this is 11% lower than the previous eight year mean of 611.7g (S.D.=55.5) and is the second lowest mass recorded. The ratio of fresh to digested portions in the diet was comparable to the previous eight seasons.

We deployed 18 radio transmitters on adult chinstrap penguins on January 2, 2006 to measure their foraging trip durations during the chick rearing phase. We logged their transmissions until March 3 with a remote receiver and data collection computer set up at our observation blind. The majority of foraging trips (69%) were between 4-10 hours long. The mean trip duration was 9.7 hours long (n=628, S.D.=5.4), compared to the average trip duration from last season of 12.4 hours. This continues a trend of decreasing foraging trip times with increasing krill size in the diets.

Time-depth recorders (TDRs) were deployed on five chinstrap and four gentoo penguins on January 11 and 12 for approximately 10 days. These instruments collected data on diving behavior during the chick rearing stage. Dive data are awaiting analysis.

We instrumented penguins with satellite transmitters (PTTs) for two deployments of approximately 10 days each in mid-January and the end of January. These PTTs provided geographic data on foraging trips during the chick rearing period. The timing of the first deployment coincided with the AMLR oceanographic survey and the second deployment overlapped with the AMLR nearshore hydroacoustic survey. In the first deployment, we put out nine PTTs on chinstrap penguins and seven PTTs on gentoo penguins. For the second deployment, we instrumented 10 chinstrap penguins and seven gentoo penguins with PTTs. Satellite transmitters were also deployed on seven post-molt chinstrap penguins on March 5. These PTTs will allow us to track where the penguins forage during the winter.

Temperature tags were super-glued on 40 post-molt gentoo penguins on March 1 and 4. These small tags will be left on over-winter and will record temperature at 90 minute intervals. These data denote the amount of time these penguins spend on land versus at sea and future analysis of these data will provide a record of foraging trip durations throughout the winter.

9.2.3 Other seabirds: We monitored breeding success of all reproductive skuas at Cape Shirreff, as well as at an additional breeding site at Punta Oeste. This season, there were 24 pairs of territory holders. All of these were brown skuas (*Catharacta lonnbergi*) with the exception of one pair that appear to be hybrid brown-South Polar skuas. At this point, we have insufficient data to determine whether this pair are indeed hybrid skuas as only one member of the pair was captured and measured. Of all the territory holders, 23 pairs initiated egg clutches and overall fledging success for the 2005/06 season was 0.87 fledglings/pair. This is a 63% increase from the previous season's fledging success of 0.53 fledglings/pair and a 13% increase from the previous 8-year mean of 0.77 fledglings/pair.

We followed the reproductive performance of kelp gulls (*Larus dominicanus*) opportunistically throughout the season. Fifty-three nests were initiated on Cape Shirreff but none were observed at Punta Oeste. Overall fledging success was 1.17 fledglings/pair; this is the highest recorded fledging success in all the years of study.

9.3 Tentative Conclusions: Our ninth complete consecutive 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 penguin breeding population declined marginally from the previous season and is the third lowest population size in the 10 years of census data. The chinstrap penguin breeding population has been declining for the past seven years and is at its lowest size in the 10 years of study. Gentoo penguin fledging success was the highest recorded in all the years of study. The fledging success for chinstrap penguins was noticeably higher during the 2005/06 season than in the previous season and was slightly higher than the previous eight year mean. The gentoo penguin fledge weights for this season were the highest recorded in all the years of study. Chinstrap penguin fledge weights increased slightly from the 2004/05 season and were close to the previous eight year mean. Both gentoo and chinstrap penguin diets were comprised mainly of adult female Antarctic krill, the majority of which were 51-55mm in length. This is a continuation of a four year trend with increasing proportions of female krill and increasingly larger krill. Chinstrap penguin total chick meal mass was lower than almost all of the previous eight years of diet sampling; however, foraging trip durations were shorter than during the 2004/05 season. This may indicate that the provisioning rate of chicks by adults may have been higher, which would account for this difference. This interpretation may be aided by analysis of foraging location and diving behavior data to be done at a later date.

9.4 Acknowledgements: We would like to sincerely thank Mike Goebel, Gitte McDonald, Scott Seganti, Russell Haner, Douglas Krause, and Rennie Holt for their invaluable assistance in the field. We would also like to thank the Chilean research team: Romeo Vargas, Claudio Vera, Daniel Torres Jr., Gisele Hernandez and the Chilean logistics officer, Cesar Cifuentes, 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 and for their help with camp opening, and to the crew of the AMLR chartered research vessel *Yuzhmorgeologiya* for their efforts in resupplying our camp and for providing transit back to Punta Arenas, Chile.

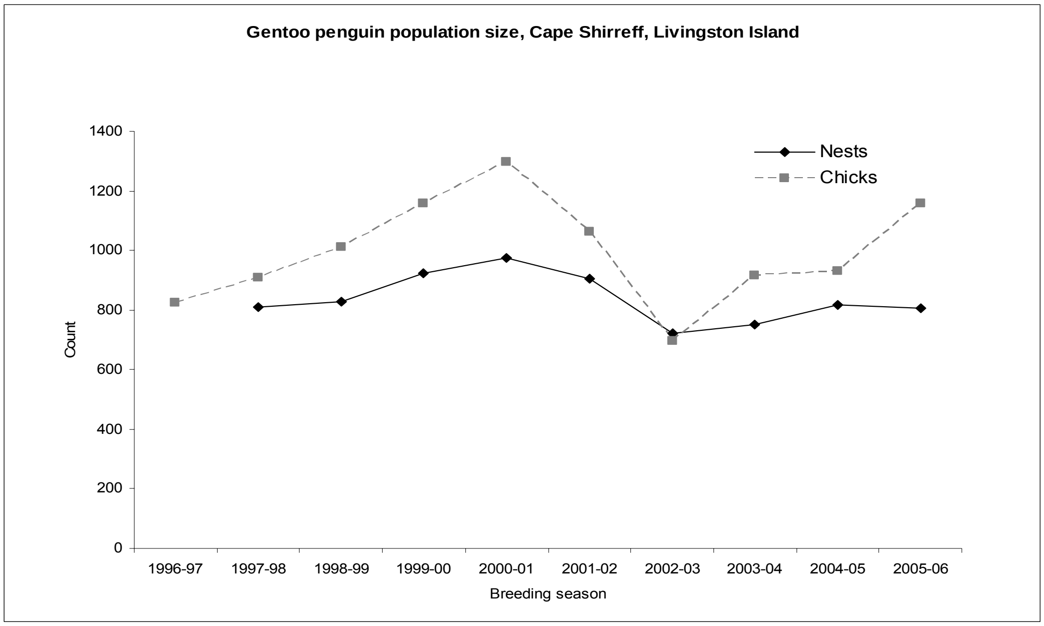

Figure 9.1. Gentoo penguin population size based on census data at Cape Shirreff, Livingston Island, Antarctica, 1996-2006.

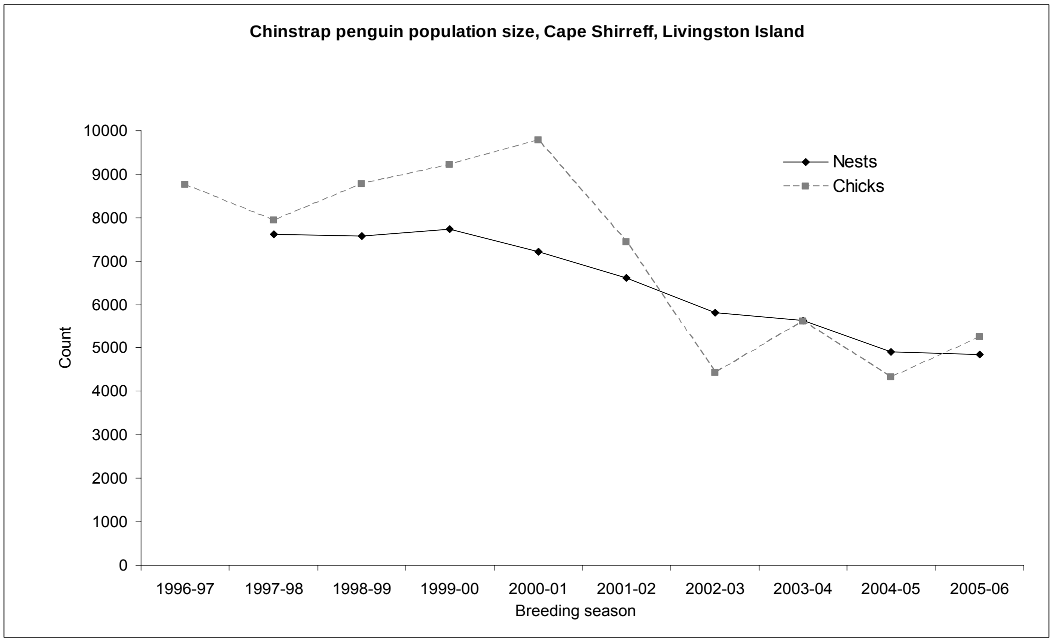

Figure 9.2. Chinstrap penguin population size based on census data at Cape Shirreff, Livingston Island, Antarctica, 1996-2006.

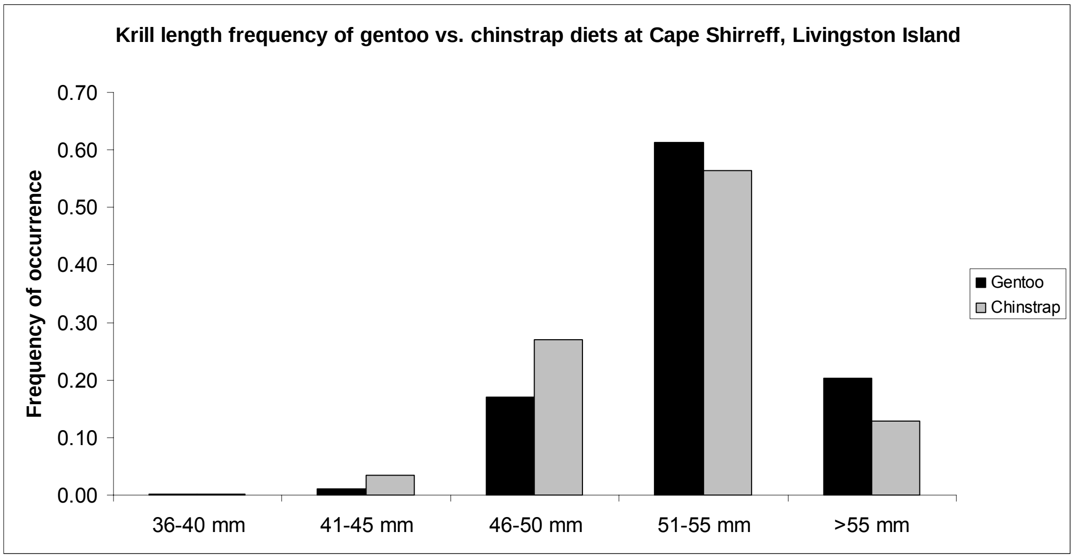

Figure 9.3. Krill length-frequency distribution in gentoo and chinstrap penguin diet samples at Cape Shirreff, Livingston Island, Antarctica, 2005/06.

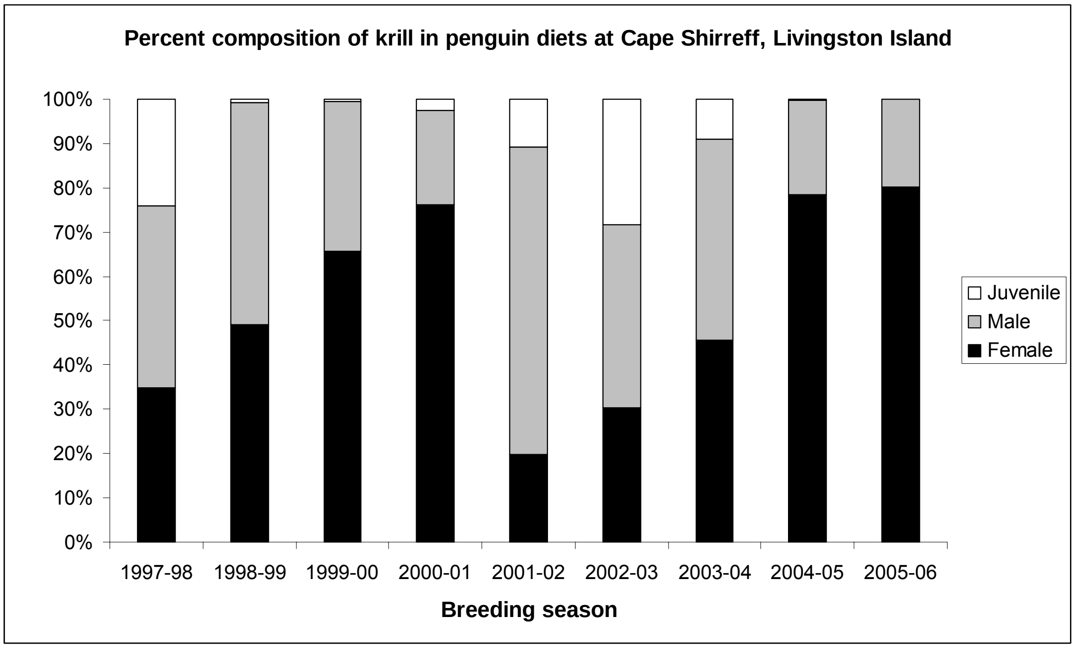

Figure 9.4. Percent composition of Antarctic krill (*Euphausia superba*) in gentoo and chinstrap penguin diet samples at Cape Shirreff, Livingston Island, Antarctica, 1997-2006.

10. Distribution, Abundance, and Behavior of Seabirds and Mammals at Sea, During the 2005/06 AMLR Survey; submitted by Jarrod A. Santora, Michael P. Force, Kimberly Dietrich, Darci Lombard, Christian Reiss and Anthony Cossio.

10.1 Objectives: This investigation focuses on the at sea abundance and behavior of pelagic predators as a response to hydrographic boundaries and prey aggregations. The primary objectives were to map the behavior and abundance of seabirds and mammals at sea during 2005/06 AMLR survey to investigate:

1. The effect of climate change on predator foraging in the Antarctic Peninsula region.
2. The inter-annual spatial distribution of feeding aggregations.
3. Community structure and habitat selection by predators.
4. Simultaneous satellite and ship-based survey of foraging penguins.
5. Interactions of seabirds with research fishing activities.

10.2 Methods-Seabird and Mammal Observations: Data on predator abundance and behavior were collected using binoculars while underway between stations during daylight hours. During the AMLR 2005/06 field season data were collected from the flying bridge of the *R/V Yuzhmorgeologiya* inside the observation platform. Surveys followed strip transect methods and counts were made within an arc of 300m directly ahead and to one side of the ship (Tasker *et al*., 1984). 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 that were flying or porpoising were assigned a direction based on an 8-point compass. Data recorded for mammals included traveling direction, distance from ship and behavior.

We had a unique opportunity to investigate the interaction of seabirds with research fishing activities during the fish stock assessment cruise. Estimates of the number of seabirds (by species) within a 300-meter hemisphere astern of the vessel were made approximately every 30 minutes during non-fishing periods and every 5 minutes during trawling in order to assess a change in seabird abundance during fishing and non-fishing periods. In addition, we also recorded age of albatross species as either sub-adult or adult. There were 4 activities in which data were collected: Net Deploy, Tow, Retrieve, and Non-fishing. Afterwards, we determined whether seabird attraction differed among fishing activities.

10.3 Accomplishments: The amount of space surveyed in each AMLR strata is presented in Table 10.1. Every day during daylight hours data were collected without any problems. In total, 69 transects were collected during Leg I representing approximately 2,197.7 km of sampling effort. Predator densities per AMLR strata are presented in Table 10.2. A total of 594 observations were collected during the investigation of seabird attraction to fishing activities during 2/21/2006 to 3/15/2006.

10.4 Results and Tentative Conclusions:

10.4.1 Large Area Survey: Seabird community composition was similar to the 2003-2005 AMLR field seasons (Santora and Mitra, 2003; Santora, 2004; Santora *et al*., 2005), and primarily composed of the following species: Chinstrap Penguin (*Pygoscelis antarctica*), Black-browed Albatross (*Thalassarche melanophrys*), Southern Giant Petrel (*Macronected giganteus*), Cape Petrel (*Daption capense*), Southern Fulmar (*Fulmarus glacialoides*), White-chinned Petrel (*Procellaria aequinoctialis*), Black-bellied Storm Petrel (*Fregetta tropica*), Wilson's Storm Petrel (*Oceanites oceanicus*), and Prions (*Pachyptila spp.),* (Table 10.2). We have found that there are distinct differences in the abundance of local and non-locally breeding species in the survey area, which may be linked to availability of krill around Elephant Island (Santora and Reiss *in prep*). Briefly, the abundance of local predators does not fluctuate annually but non-locally breeding predators do. We will continue to explore these phenomena.

The spatial distribution of (a) total seabird abundance (#/hour) and (b) feeding aggregation abundance (#/hour) of recorded during Leg I of AMLR 2005/06 is presented in Figure 10.1. As in past AMLR surveys the majority of petrel and albatross aggregations were located offshore and along the shelf break north of the South Shetlands and Elephant Island (see Figure 10.1a). Feeding activity was very low, and the largest feeding aggregations occurred to the southwest and west of King George Island (see Figure 10.1b). These aggregations were primarily composed of Cape Petrels and Black-browed Albatross.

Humpback Whales (*Megaptera novaeangliae*) were the most abundant whales recorded during the AMLR 2005/06 survey. The distribution of Humpbacks was fairly restricted to the waters of Bransfield Strait (see Figure 10.1c). Observations of whales tended to occur in groups of 3-5, and on a few occasions there were aggregations of 8+ whales, which seemed be feeding (i.e. repeated diving in same locality) in the waters south of Livingston and King George Islands (see Figure 10.1c). A large group of Killer Whales (*Orciuns orca*) numbering approximately 12-15 individuals were observed within 25km from the north coast of Livingston Island during surveys in the West Area. Another small pod was also observed outside the entrance to Admiralty Bay, King George Island. Photographs of the pod near Livingston Island were taken and are available.

10.4.2 Assessment of Seabird Attraction to Fishing Operations: Summary of seabird observations performed from 2/21 to 3/2/06: Sixteen species were observed in the observation zone including Black-browed, Grey-headed (*Thalassarche chrysostoma)* Wandering albatrosses (*Diomedea exulans*), Giant Petrels (*Macronectes spp.*), Cape Petrel, Snow Petrel (*Pagodroma nivea*) and Antarctic Fulmars. A maximum of 105 birds occurred in the observation zone. Deployment periods and non-fishing periods with discard were also similar (~9.8). Black-browed albatross and Cape petrels were the most ubiquitous although Cape petrels were more common during fishing periods. More black-browed albatross were seen during non-fishing periods and times when we were discarding fish.

Seabird observations from 3/3 to 3/10/06: Thirteen seabird species were observed in the 300-meter observation zone astern. The average number of birds sighted per observation during non-fishing and non-discarding periods was 2.6. Trawl deployment, tow and retrieval periods were similar (2.8, 3.1 and 3.3, respectively). Non-fishing periods with discards were slightly lower this week (5.1). A maximum of 31 birds occurred in the observation zone. Wilson's storm petrels, cape petrels and black-browed albatrosses were the most prevalent species.

There was no difference in the mean number of total birds among fishing events (ANOVA, F = 1.28, P = 0.27). Furthermore, the mean number of black-browed albatross among fishing events also was not significantly different (F = 1.25, P = 0.28). However, Cape Petrels were more abundant during net deployment than any other fishing event (F = 4.5, P = 0.006, see Figure 10.2). This indicates that when the net is deployed for a fishing event, Cape Petrels were more likely to be attracted to the vicinity of the ship.

10.5 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

10.6 Acknowledgements: The underway predator observation team would like to thank the captain, crew and AMLR program for providing an outstanding observation platform on the flying bridge. This platform enabled data collection with much comfort and style while providing an excellent 360-degree view of the surrounding ocean, and we therefore have infinite gratitude. Heartfelt thanks to Valerie Loeb, Adam Jenkins (cruise leader), Christian Reiss, Anthony Cossio, Jessica Lipsky and the members of the zooplankton team for their support, understanding, and interest.

10.7 Reference:

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Table 10.1. Survey effort (# of km) for seabird and mammal observations during AMLR 2005/06.

Stratum	km
Elephant Island	**1162.8**
West	**558.4**
South	**347.3**
Joinville Island	**123.2**
TOTAL	**2191.7**

Table 10.2. Predator densities recorded for Leg I AMLR 2005/06. Densities are presented as # / km per stratum (see Table 10.1)

		AMLR Strata				
Common Name	**Latin Name**	**Elephant**	**Joinville**	**South**	**West**	**Total**
Gentoo Penguin	*Pygocelis papua*	0.00008	0	0.3	0	0.04
Chinstrap Penguin	*Pygocelis antarctica*	0.61	0.07	1.31	0.14	0.6
Wandering Albatross	*Diomedea exulans*	0.0009	0	0	0.02	0.0009
Royal Albatross	*Diomedea epomorpha*	0.00034	0	0	0.0004	0.0003
Black-browed Albatross	*Thalassarche melanophrys*	0.07	0.02	0.03	0.3	0.11
Grey-headed Albatross	*Thalassarche chrysostoma*	0.0009	0	0	0.05	0.02
Light-mantled Sooty Albatross	*Phoebetria palpebrata*	0.0003	0	0	0	0.0001
Southern Giant Petrel	*Macronectes giganteus*	0.034	0.02	0.02	0.02	0.03
Northern Giant Petrel	*Macronectes halli*	0	0.0008	0.0006	0.0002	0.0002
Southern Fulmar	*Fulmarus glacialoides*	0.22	0.5	1.5	0.5	0.5
Cape Petrel	*Daption capense*	0.67	0.61	0.8	0.95	0.8
Soft-plumaged Petrel	*Pterodroma mollis*	0.01	0	0	0	0.0006
White-chinned Petrel	*Procellaria aequinoctialis*	0.03	0	0	0.03	0.022
Antarctic Prion	*Pachyptila desolata*	0.1	0	0.0003	0.06	0.066
Slender-billed Prion	*Pachyptila belcheri*	0.00008	0	0	0	0.00004
Unknow prion	*Pachytila sp.*	0.0005	0	0	0.0004	0.0004
Blue Petrel	*Halobaena caerulea*	0.07	0	0	0.4	0.13
Wilson's Storm Petrel	*Oceanites oceanicus*	0.07	0.4	0.12	0.09	0.09
Black-bellied Storm Petrel	*Fregetta tropica*	0.2	0.08	0.07	0.2	0.2
Common Diving Petrel	*Pelacanoides urinatrix*	0.00008	0	0	0	0.00004
Brown Skua	*Catharacta antarctica*	0.0003	0.0008	0.0006	0	0.0003
South Polar Skua	*Catharacta maccormicki*	0.0007	0.03	0.06	0.0002	0.014
Kelp Gull	*Larus dominicanus*	0	0	0.0009	0	0.0001
Antarctic Tern	*Sterna vittata*	0.01	0	0.03	0	0.013
Antarctic fur seal	*Artcocephalus gazella*	0.01	0.02	0.03	0.0002	0.014
Humpback whale	*Megaptera novaeangliae*	0.0009	0.05	0.25	0.0007	0.05

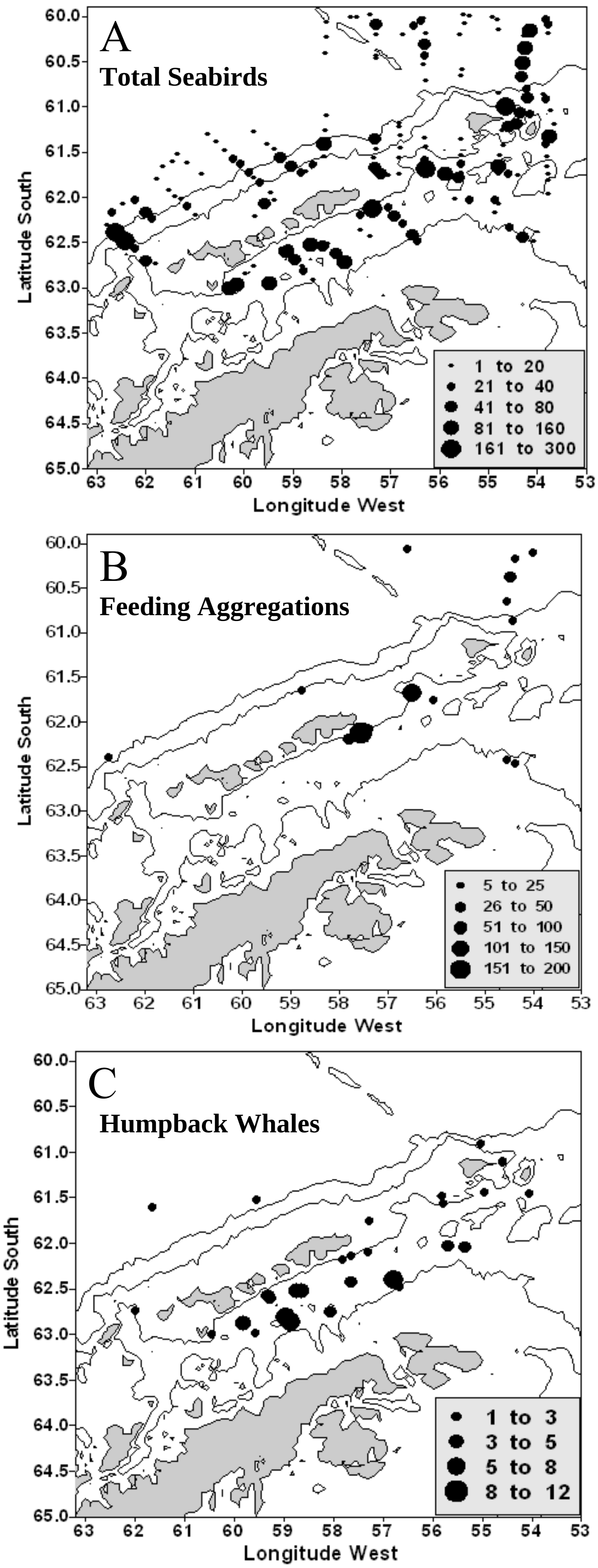

Figure 10.1. Distribution and abundance (#/hour) of pelagic predators: (a) total seabirds, (b) seabird feeding aggregations, and humpback whales (*Megaptera novaeangliae*).

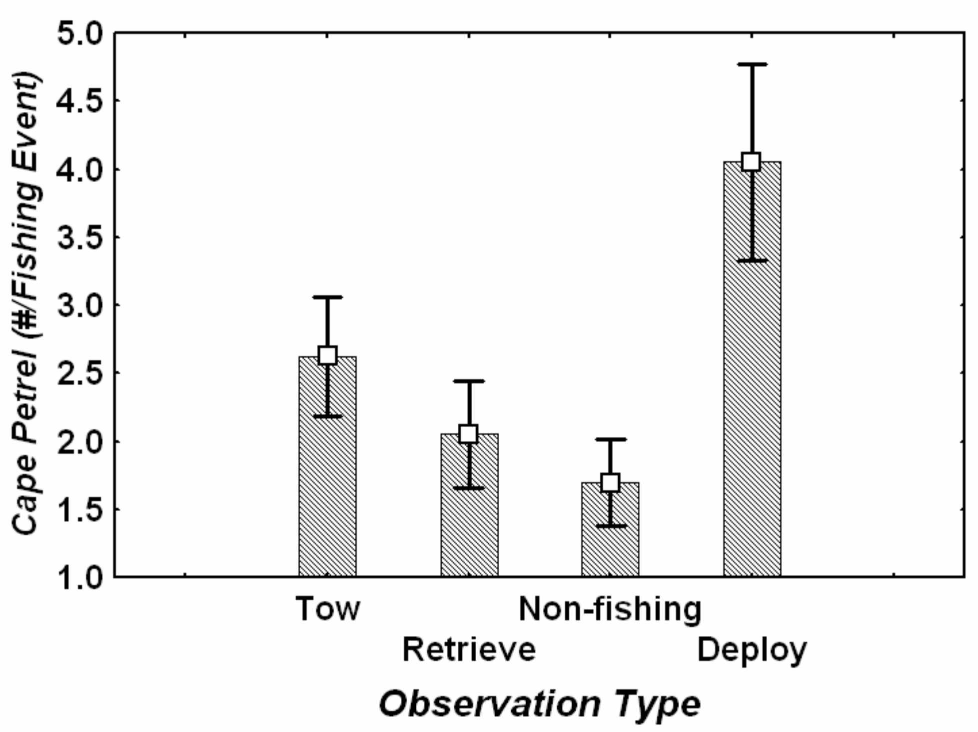

Figure 10.2. Synthesis of fishing activities and attraction of cape petrel (*Daption capense*) to the R/V *Yuzhmorgeologiya* during the fish stock assessment survey (Leg II). Cape petrels were significantly more likely to be attracted to the ship during net deployment.

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