UNITED STATES
AMLR ANTARCTIC MARINE LIVING RESOURCES PROGRAM

AMLR 2002/2003 FIELD SEASON REPORT

Objectives, Accomplishments and Tentative Conclusions

Edited by
Jessica D. Lipsky

November 2003

NOAA-TM-NMFS-SWFSC-355

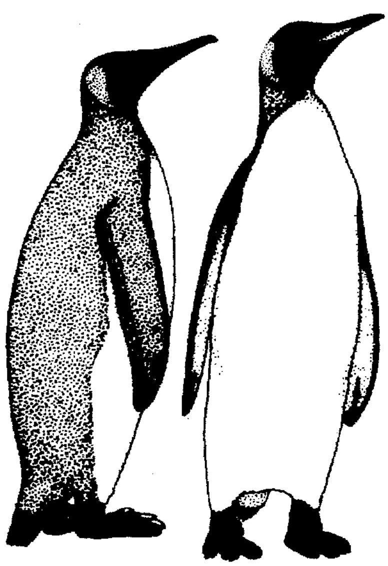
Southwest Fisheries Science Center
Antarctic Ecosystem Research Division

The National Oceanic and Atmospheric Administration (NOAA), organized in 1970, has evolved into an agency which establishes national policies and manages and conserves our oceanic, coastal, and atmospheric resources. An organizational element within NOAA, the Office of Fisheries is responsible for fisheries policy and the direction of the National Marine Fisheries Service (NMFS).

In addition to its formal publications, the NMFS uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series, however, reflect sound professional work and may be referenced in the formal scientific and technical literature.

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.

Inquiries should be addressed to:



Antarctic Ecosystem Research Division
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, California, USA 92037

Telephone Number: (858) 546-5600
E-mail: Jessica.Lipsky@noaa.gov

UNITED STATES AMLR ANTARCTIC MARINE LIVING RESOURCES PROGRAM

AMLR 2002/2003 FIELD SEASON REPORT

Objectives, Accomplishments and Tentative Conclusions

Edited by
Jessica D. Lipsky

November 2003

NOAA-TM-NMFS-SWFSC-355

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center
Antarctic Ecosystem Research Division
8604 La Jolla Shores Drive
La Jolla, California, U.S.A. 92037

TABLE OF CONTENTS

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 and 2003.

This is the 15th issue in the series of AMLR field season reports.

SUMMARY OF 2003 RESULTS

The Russian R/V *Yuzhmorgeologiya* was chartered to support the U.S. AMLR Program during the 2002/03 field season. Shipboard operations included: 1) two region-wide surveys of krill and oceanographic conditions in the vicinity of the South Shetland Islands (Legs I & II) (See Figure 2 for station locations); 2) calibration of acoustic instrumentation at the beginning and end of survey operations; 3) underway bird and mammal observations; 4) a finfish bottom trawl survey (Leg III); and 5) 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 Drakes Passage water to the north from Bransfield Strait water to the south. At the beginning of Leg I, this frontal zone was at its typical northern extent. The location was similar to last year (AMLR 2001/02) but more clearly defined in 2002/03. At the end of Leg I, the zone had shifted further south and remained in this location through the beginning of Leg II. By the end of Leg II this zone had extended even further south and had become less defined. It was difficult during Leg I to define the water zones due to a large ice field in the eastern portion of the survey area (Figure 2). Zone II (Transition Water) was seldom seen in the survey area during Leg I with only small patches in the southwestern corner and northern edge. Zone IV (Bransfield) water was evident forming a coastwise parallel buffer between the Weddell and the Antarctic Circumpolar Current (ACC). Additionally, during Leg I Zone III water was not identified. During Leg II the water zones conformed more closely with previous years. The ACC dominated the western and northern areas, running parallel to the continental shelf. Bransfield water (Zone IV) filled the Straits and extended northeasterly into the southern Elephant Island Area. Predominant winds on Leg I were from the east and southeast, but shifted to the northwest during Leg II.

Chlorophyll concentrations generally increased between Legs I and II. Although concentrations were low for all areas in the AMLR survey, chlorophyll concentrations did increase slightly during Leg II. In general however, chlorophyll concentrations were well below the 12-year average for all areas. Twenty drifter buoys were released this year during the AMLR oceanographic survey, 10 for each of Legs I and II. A primary purpose for these releases was to examine how the Shackleton Fracture Zone (SFZ) interrupted the eastward flow of the Antarctic Circumpolar Current (ACC). It was seen that the SFZ marks a major obstruction in the flow of the ACC. In the beginning of Leg II a SeaWiFS image indicated that a bloom has recently developed and the drifter buoy data indicated that this bloom was associated with a frontal system between Bransfield Strait and Drake Passage. The data lend additional support to the suggestion that the bloom occurred at a front with mixing between waters of Water Zones I and IV. It is likely that the formation of this bloom in the waters between King George Island and Elephant Island was due to injection of iron into the euphotic zone by upwelling generated along a frontal system in shelf and shelf-break waters.

During both surveys krill median abundance in the Elephant Island Area was the highest recorded over the 1992-2003. January abundance values were about three times greater than the highs recorded in 1995/96. This resulted from two successive years of strong recruitment success (i.e., the 2000/01 and 2001/02 year classes). These were associated with average (2001) and prolonged (2002) periods of elevated sea ice extent. Krill demography during 2002/03 was characterized by extraordinarily low proportions of large and reproductively active krill. Their reproductive condition resembled 1991/92, 1992/93 and 1997/98 when spawning appeared to be delayed or deferred, possibly due to poor feeding conditions. The unprecedented paucity of large krill (i.e., >43mm and $\geq$4 years old) may be due to (a) age-related mortality and low recruitment success following the 1995/96 year class and/or (b) delayed southward ontogenetic migration associated with prolonged sea ice cover during 2002. A small juvenile size group (13-22mm) was present during both surveys and comprised about 11% of total krill collected during January. Small juveniles were also noted during the 1991/92, 1995/96, 1996/97, 1997/98 and 2001/02 AMLR surveys. Given their reported pack ice and Weddell Sea associations the presence of these individuals may result from interannual variations of production within, and/or advection from, higher latitude source areas. Larval krill abundance was relatively low with mean values one to two orders of magnitude less than during the previous four years (1999-2002). The developmental stage composition reflected an early pulse and later resumption of seasonal spawning activity.

Larval survival and recruitment success will depend on advective processes, food availability and sea ice dynamics but, given the low abundance and timing in the current seven-year sea ice cycle, is not likely to match that of the past two years. *Salpa thompsoni* abundance was constant across the survey period with values only slightly larger than the lows encountered in 1994/95 and 1995/96. Observations of abundant aggregate forms in Bransfield Strait during Leg III suggested a late-season pulse of chain production which, in conjunction with low winter sea ice development, would likely favor a large overwintering seed population and potential for a substantially increased population during 2004. Overall zooplankton abundance in the Elephant Island Area during the February-March seasonal peak was greatly reduced from the previous three years and comparable to low values observed during 1996-1999. This was in large part due to low numbers of copepods (*C. acutus, C. propinquus* and *M. gerlachei*) and chaetognaths. Extremely large, widespread concentrations of postlarval *T. macrura* during 2002/03, like 1996-1998, appeared to result from elevated larval abundance during years with prolonged and/or extensive sea ice development (i.e., 1995-1996 and 2001-2002). These results support the anticipated sequence of enhanced sea ice development, decreased salp abundance, strong krill recruitment success and population growth following the 1998/99 transition. The results also suggest that 2002/03 represents a transition back to a less productive, salp-dominated ecosystem not favorable for krill population growth.

This year independent seabird and marine mammal observers joined the survey to collect data on the spatial distribution and abundance of seabirds and marine mammals. The importance of seabirds and mammals as indicators of the marine environment is unquestionable and the data collected at sea in collaboration with the 2002/03 AMLR survey, will provide insight on how pelagic predators respond to changes in of the distribution of Antarctic krill and the position of oceanographic features.

A total of 6,218kg (17,011 individuals) of 46 finfish species was processed from all hauls from Elephant Island and the lower South Shetlands Islands. Species that were caught in substantial numbers, defined as >500kg or >500 individuals, included *Gobionotothen gibberifrons, Notothenia coriiceps, Champsocephalus gunnari, Chaenocephalus aceratus, Chionodraco rastrospinosus, Gymnoscopelus nicholsi, Lepidonotothen larseni, Chionodraco rastrospinosus, Lepidonotothen squamifrons and Pleurogramma antarcticum.* As with the 2000/01 survey, the greatest combined yields occurred at stations on the western and northwestern shelf of Elephant Island and north of King George Island. The highest average densities were within the 200-300m depth strata. The species with the greatest yield in weight was *Gobionotothen gibberifrons* (1,633kg, 2,082 individuals), followed by *Notothenia coriiceps* (1,363kg, 838 individuals), and *Champsocephalus gunnari* (917kg, 4,056 individuals). Similar to the 2000/01 survey, the greatest catch in numbers was *C. gunnari* followed by the myctophid *Gymnoscopelus nicholsi* (116kg, 3,662 individuals) and *G. gibberifrons*. The number of species encountered at each station ranged from 4 to 19, with an average of 10 species per haul. The highest diversity of finfish species occurred at stations to the north and southwest of Elephant Island and at stations around Livingston Island. The most frequently encountered species was *C. aceratus*, which was found within catches at 87% of the stations. Other species frequently encountered in the hauls were *C. gunnari* (84%), *G. gibberifrons* (78%), *L. larseni* (77%), *N. coriiceps* (68%), and *C. rastrospinosus* (66%). All other species occurred in less than 50% of hauls.

The benthic community sampled by bottom trawling at depths between 50 and 500m around Elephant and the South Shetland Islands showed no statistically significant similarities between stations. Individual tows were strongly dominated by single taxa, but there was no significant correlation in biomass, abundance, or dominance with depth or geographical location. Trends in species distributions were a general transition down the island chain from sponge-biomass dominated benthic communities to the northeast, to echinoderm-biomass dominated communities to the northwest. The biomass of octopus and bryozoans also became increasingly important north of the western South Shetland Islands. At a finer scale, sponges were particularly prominent to the northeast of King George Island and northeast of the eastern tip of Elephant Island. A difference in the composition of benthic invertebrates caught by the Little BIT compared to those caught by the bottom trawl illustrates the need for a more intensive investigation of the data. Further analysis comparing the two pieces of collecting equipment, with ground-truthing by quantitative analysis of the photographic and video transects, is underway.

The 2002/03 year was the 7th season of data collection at Cape Shirreff allowing us to compare annual indices of predator parameters at this site across all years. Breeding population size and reproductive success of chinstrap and gentoo penguins alike fell below levels previously observed at this site. Fledging weights of chicks of both chinstrap and gentoo penguins were also low. However, chinstrap penguin adult mass at egg laying and egg measurements of both chinstrap and gentoo penguins did not differ from previous years, implying that the condition of returning breeders was normal. Elevated foraging trip durations and a high frequency of occurrence of fish may suggest that krill were less abundant in 2002/03 compared to prior seasons, at least within the foraging ranges of the penguins during chick rearing. The apparent inconsistency represented by above average stomach sample masses in both penguin species may be related to an age-specific effect. During years with poor reproductive success, younger, less experienced birds are more prone to failure than older, experienced birds. This removes less experienced birds from the population and increases the proportion of older experienced penguins in the diet samples collected. Further analysis of TDR (time depth recorder) and PTT (satellite linked transmitter) data will provide additional insights into the linkages among penguin diets, food load sizes, foraging ranges and behaviors. Future research plans include the use of PTTs and TDRs in the study of penguin over-wintering strategies and metapopulation dynamics.

The 2002/03 season was the poorest on record for Antarctic fur seals at Cape Shirreff since our monitoring studies began in 1997/98. Fur seal pup production at U.S.-AMLR study beaches decreased by 12.1% over last year, the first decrease recorded. Pup mortality (9.0%) was also higher than in any other year and attendance studies indicated that a significant proportion of early pup mortality was attributed to unusually long maternal foraging trips. The median date of pupping based on pup counts was two days later this year. The mean arrival and parturition dates for our tagged female population was also two days later than last year. Over winter survival for adult females was lower than in the last three years (85.8%). The natality rate (86.6%) was also lower than in any other year. Foraging trip duration was longer than in any other year (mean: 6.83 days ±0.73) and visit duration the shortest (0.98 days ±0.51). This was the first year that we have ever recorded the proportion of fish in the diet exceeding that of krill (for February). Fish and squid both were in greater proportions than in previous years. The krill that were present in fur seal diet were smaller than in previous years. The 1999/00 cohort continued to dominate tag returns as in previous years.

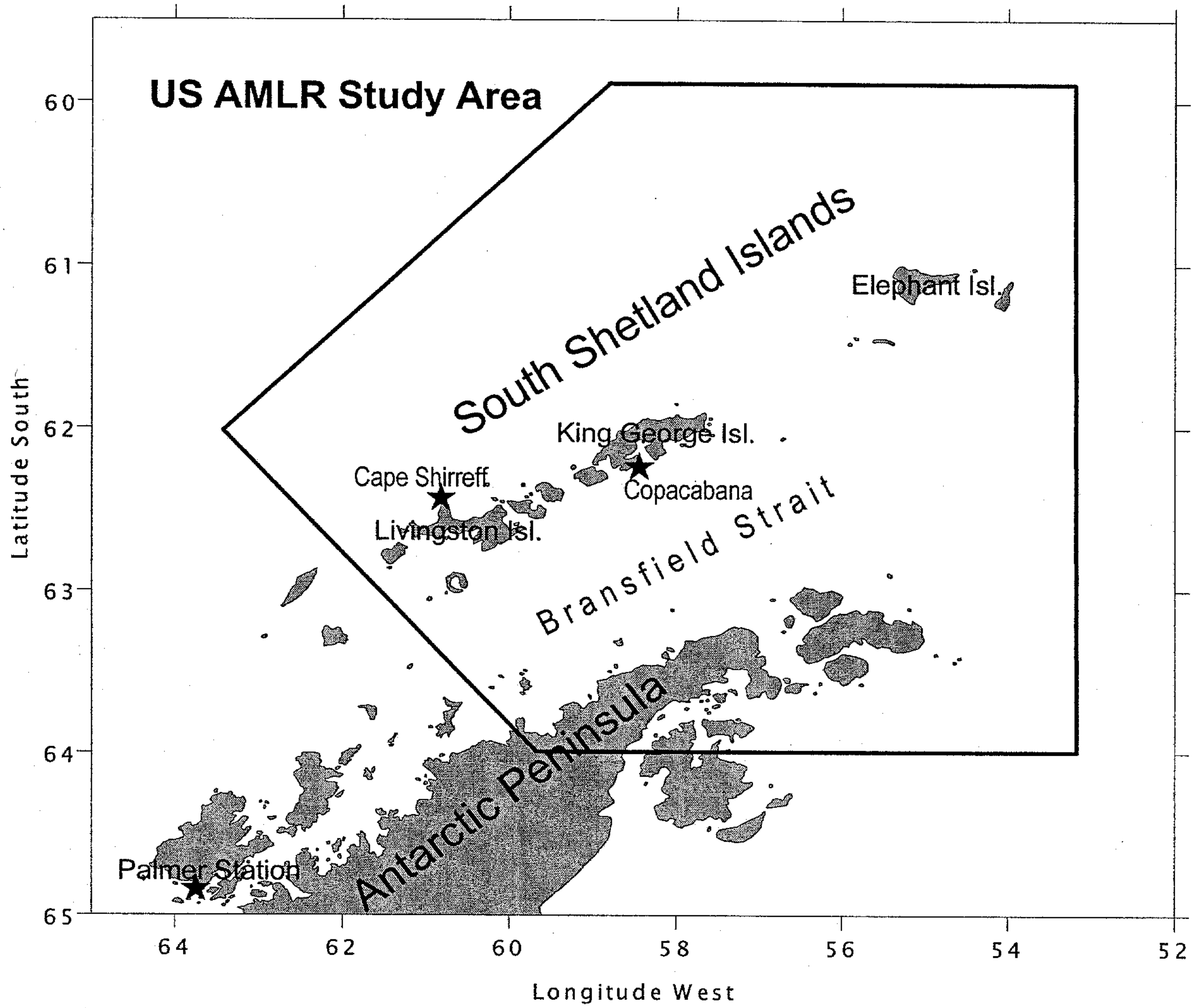


Figure 1. Locations of the U.S. AMLR field research program: AMLR study area, Cape Shirreff, Livingston Island and Copacabana, King George Island.

OBJECTIVES

Shipboard Research:

1. Conduct a survey in the AMLR study area during Legs I and II 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 sturdy area.
3. Calibrate the shipboard acoustic system in Admiralty Bay, King George Island near the beginning of Leg I, and again at Admiralty Bay near the end of Leg II.
4. Conduct underway bird observations during Legs I and II.
5. 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 during Leg III.

6. 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.
7. Deploy WOCE drifter buoys during Legs I and II.
8. 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. Document Antarctic fur seal pup production for Cape Shirreff and assist Chilean colleagues with censuses of fur seal pups for the entire Cape and the San Telmo Islands.
12. Monitor female Antarctic fur seal attendance behavior.
13. Collaborate with Chilean researchers in collecting Antarctic fur seal pup mass for 100 pups every two weeks through the season.
14. Collect 10 Antarctic fur seal scat samples every week for diet studies.
15. Collect a milk sample at each female Antarctic fur seal capture for fatty acid signature analysis and diet studies.
16. Record at-sea foraging locations for female Antarctic fur seals using Platform Terminal Transmitters (PTT).
17. Deploy time-depth recorders (TDR) on female Antarctic fur seals for diving studies.
18. Tag 500 Antarctic fur seal pups for future demographic studies.
19. Collect teeth from selected Antarctic fur seals for age determination and other demographic studies.
20. 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 eighth consecutive year, the cruise was conducted aboard the chartered research vessel R/V *Yuzhmorgeologiya*.

Leg I:	Depart Punta Arenas	10-12 January 2003
	Resupply & transfer personnel to Cape Shirreff	12 January
	Calibrate in Admiralty Bay, King George Island	13 January
	Large-area survey (Survey A)	14-30 January
	Transfer personnel from Copacabana & retrograde trash	31 January
	Transfer personnel from Cape Shirreff	01 February
	Transit to Punta Arenas	02-04 February
Leg II:	Depart Punta Arenas	07-09 February
	Transfer supplies at Cape Shirreff	10 February
	Large-area survey (Survey D)	11-27 February
	Close Cape Shirreff	28 February
	Close Copacabana and Calibrate in Admiralty Bay	01 March
	Transit to Punta Arenas	02-04 March
Leg III:	Depart Punta Arenas	08-10 March
	Bottom trawl survey, bottom typing and CTDs	11 March- 01 April
	Transit to Punta Arenas	02-04 April

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, 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 demographics, physical oceanography and phytoplankton observations. Survey A consisting of 83 (out of 104 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, 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 (see Figure 2).

4. A series of 12 extra stations were conducted along three transects in the vicinity of the Shackleton Fracture Zone (Figure 3).

5. A small scale-survey consisting of three acoustic transects and two net sampling stations was conducted in the vicinity of the shelf break north of Cape Shirreff (see Section 10 for maps).

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

7. A total of 10 WOCE drifter buoys were deployed at various positions north of Livingston and King George Islands (see Section 2 for map of release points and tracks).

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. Survey D consisting of 97 (out of 104 planned) CTD and net sampling stations, separated by acoustic transects, was conducted in the vicinity of the South Shetland Islands (Figure 2). The field of icebergs was less extensive and allowed the conduct of most of the survey except for some stations in the Joinville Island Area and northwestern Weddell Sea. However, the positions of several stations at the southern ends of the transects had to be adjusted by as much as 5 km because of the presence of icebergs.

3. An extra station was conducted north of King George Island where an area of high surface chlorophyll had been detected on the SeaWiFS imagery (Figure 3).

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

5. A total of 10 WOCE drifter buoys were deployed at various positions north of Livingston and King George Islands (see Section 2 for map of release points and tracks).

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

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

8. 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.

Leg III

1. The R/V *Yuzhmorgeologiya* departed Punta Arenas, Chile via the eastern end of the Straits of Magellan. After transiting across the Drake Passage, the ship arrived at the South Shetland Islands for the first trawl station.

2. A total of 71 hauls were conducted within the 500m isobath of the South Shetland Islands (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, 28 days of continuous underway measurements of meteorological and sea surface conditions, and CTD casts.

4. At the end of Leg III, operations ceased and the R/V *Yuzhmorgeologiya* transited across the Drake Passage to the Straits of Magellan en route to Punta Arenas, Chile.

Land-based Research:

1. A four-person field team (M. Goebel, J. Lyons, L. Shill and M. Antolos) arrived at Cape Shirreff, Livingston Island, on 7 November 2002 via the R/V *Lawrence M. Gould*. Equipment and provisions were also transferred from the R/V *Lawrence M. Gould* to Cape Shirreff.

2. Two additional personnel (R. Holt and D. Krause), along with supplies and equipment, arrived at Cape Shirreff via the R/V *Yuzhmorgeologiya* 12 January 2003.

3. The annual censuses of active chinstrap and gentoo penguin nests were conducted on 28 and 30 November 2002. 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 2003 and remained on until their chicks fledged in late February 2003. 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. Four satellite-linked transmitters (PTTs) were deployed on adult chinstrap penguins and

four on adult gentoo penguins during the time each species was feeding chicks in early January. The PTTs were removed and placed on eight new birds in mid-January to coincide with the time when the annual AMLR 2002/03 marine survey was adjacent to Cape Shirreff during Leg I.

6. Diet studies of chinstrap and gentoo penguins during the chick-rearing phase were initiated on 8 January 2003 and continued through 8 February 2003. Chinstrap and gentoo adult penguins were captured upon returning from foraging trips, and their stomach contents were removed by lavaging.

7. Counts of all chinstrap and gentoo penguin chicks were conducted on 20 January and 5-6 February 2003, respectively. Fledging weights of 206 chinstrap penguin chicks were collected between 20 and 26 February 2003. Two hundred gentoo penguin chicks were also weighed on 17 February 2003.

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 10-12 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 redeployed on four birds of each species in late January.

11. Antarctic fur seal pups and female fur seals were counted at four main breeding beaches every other day from 17 November 2002 through 10 January 2003.

12. Attendance behavior of 28 lactating female Antarctic fur seals was measured using radio transmitters. Females and their pups were captured, weighed, and measured from 5 December 2002 to 16 December 2002.

13. U.S. researchers assisted Chilean scientists in collecting data on Antarctic fur seal pup growth. Measurements of mass for a random sample of 100 pups were begun 30 days after the median date of pupping on 8 January 2003 and continued every two weeks until 22 February 2003.

14. 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.

15. Twenty-five Antarctic fur seals were instrumented with time-depth recorders (TDR's) for diving behavior studies.

16. Seventeen Antarctic fur seal females were instrumented with ARGOS satellite-linked transmitters for studies of at-sea foraging locations from 20 December 2002 to 13 February 2003.

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

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

19. A single post-canine tooth was extracted from 30 tagged female fur seals for aging and demography studies. Studies of the effects of tooth extraction on attendance and foraging behavior were initiated.

20. One team member (M. Goebel) left Cape Shirreff via the R/V *Yuzhmorgeologiya* on 1 February 2003.

21. The Cape Shirreff field camp was closed for the season on 1 March 2003; all U.S. personnel (R. Holt, D. Krause, L. Shill, M. Antolos and J. Lyons), garbage, and equipment were retrieved by the R/V *Yuzhmorgeologiya*.

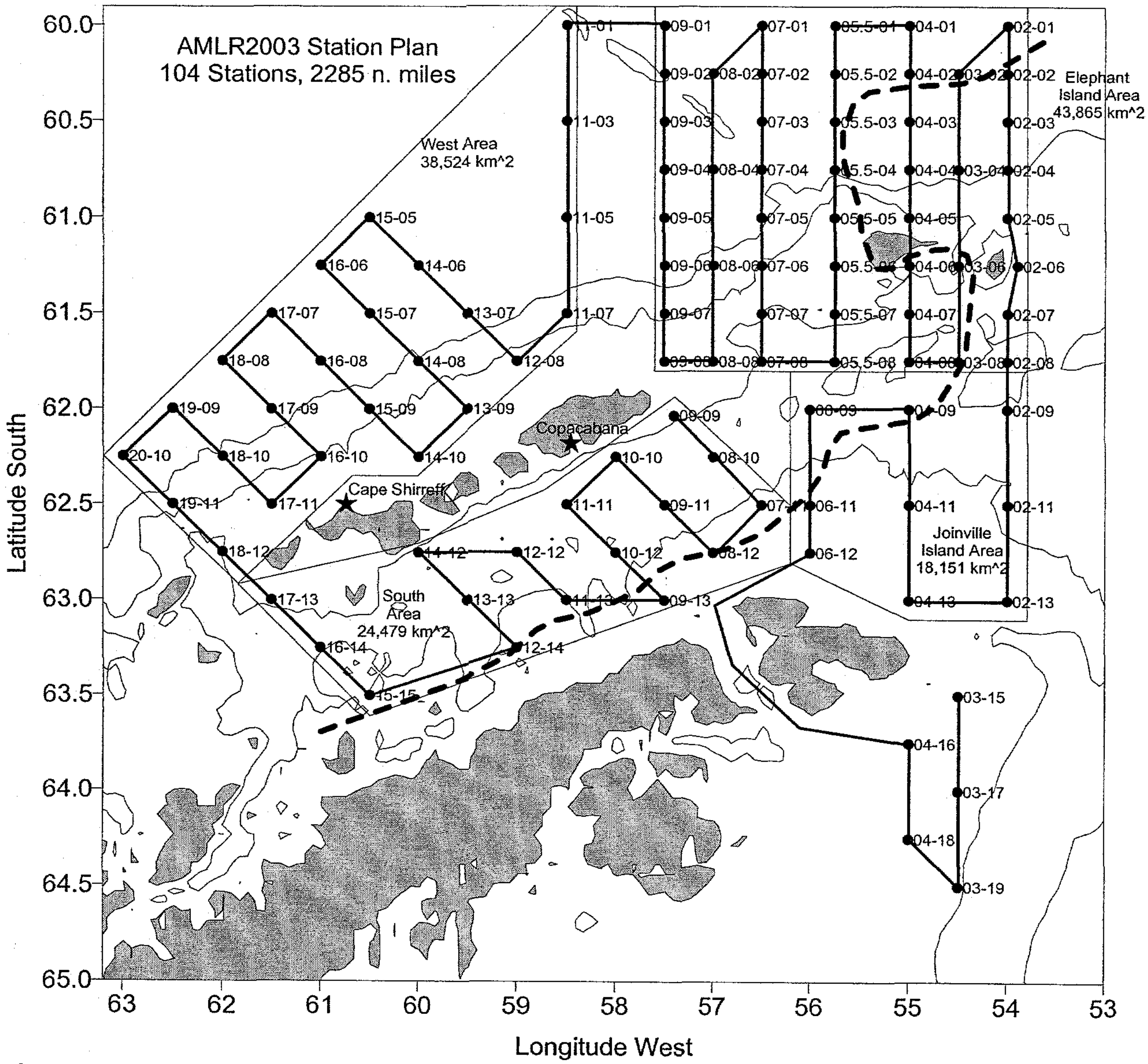


Figure 2. The planned survey for AMLR 2003 (Survey A and D) in the vicinity of the South Shetland Islands; field camp locations indicated by★. The survey contained four strata: the stratum containing stations in the western portion of the survey area north of Livingston and King George Islands was designated 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. The heavy dashed line indicates the western and northern limit of an extensive field of icebergs emanating from the northwestern Weddell Sea during Leg I that precluded survey operations to the south and east. Planned stations south of the Joinville Island Area in the northwestern Weddell Sea were not conducted on either leg due to extensive icebergs in the area. Locations of stations and transects in the South Area were changed slightly from Leg I to Leg II.

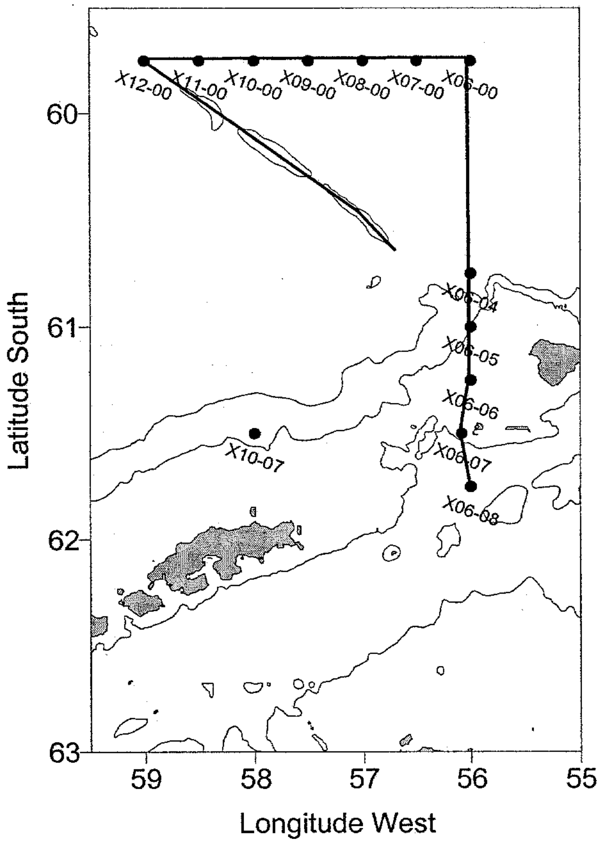


Figure 3. Extra stations conducted during Legs I and II.

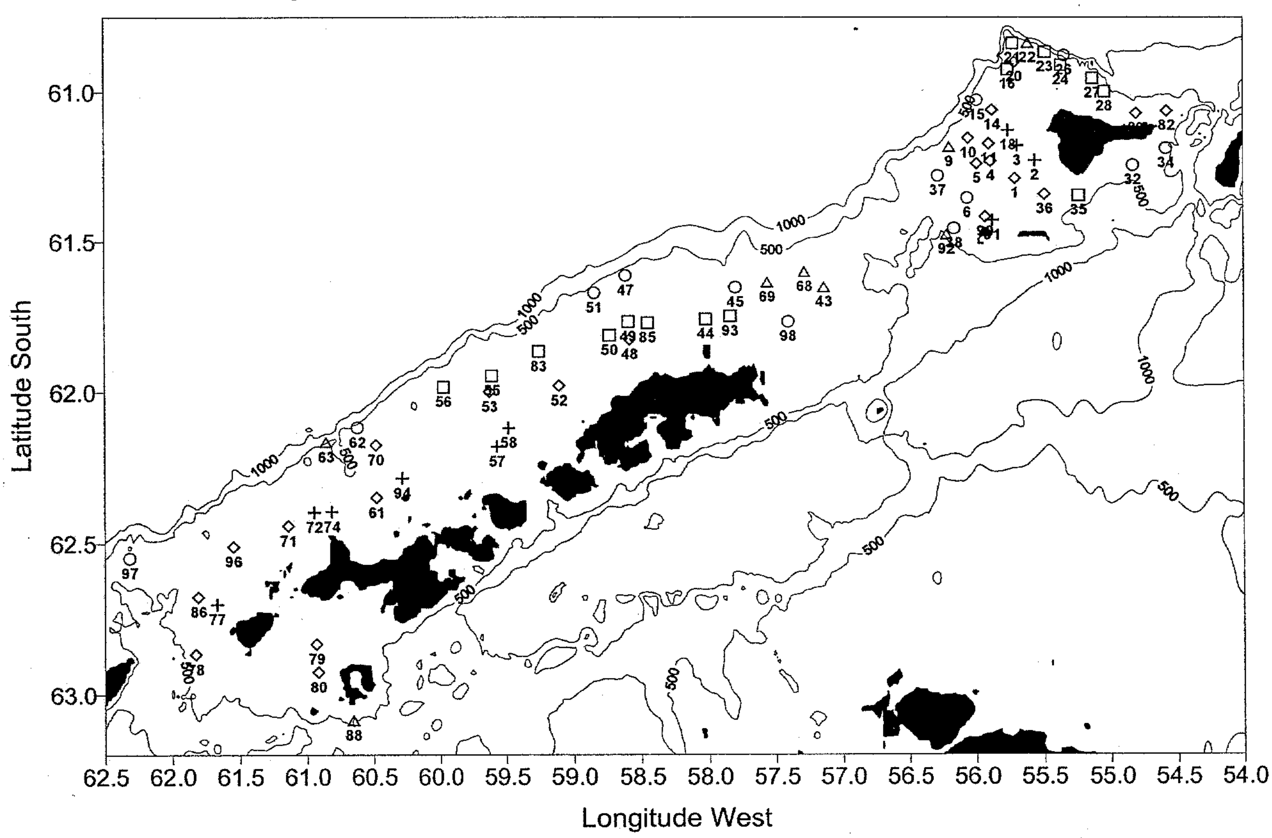


Figure 4. Station locations by depth strata for the 2003 AMLR finfish bottom trawl survey.

SCIENTIFIC PERSONNEL

Cruise Leader:
Roger P. Hewitt, Southwest Fisheries Science Center (Leg I)
Adam Jenkins, Southwest Fisheries Science Center (Leg II)
Christopher D. Jones, Southwest Fisheries Science Center (Leg III)

Physical Oceanography:
Derek Needham, Sea Technology Services (Legs I & II)
Mark Prowse, Sea Technology Services (Leg I)
Marcel van den Berg, Sea Technology Services (Leg II)
Susanne Lockhart, University of California at Santa Cruz (Leg III)

Phytoplankton:
Christopher D. Hewes, Scripps Institution of Oceanography (Legs I & II)

Bioacoustic Survey:
Andrew Dizon, Southwest Fisheries Science Center (Leg I)
Roger P. Hewitt, Southwest Fisheries Science Center (Leg I)
Daniel Doolittle, Virginia Institute of Marine Science (Legs II & III)

Krill and Zooplankton Sampling:
Valerie Loeb, Moss Landing Marine Laboratories (Legs I & II)
Kim Dietrich, University of Washington, (Leg II)
Michael Force (Legs I & II)
Nancy Gong, University of California at Santa Cruz (Legs I & II)
Adam Jenkins, Southwest Fisheries Science Center (Leg I)
Jonathan Reum, University of California at Santa Cruz (Legs I & II)
Rob Rowley, Moss Landing Marine Laboratories (Legs I & II)
Catherine Ware, U.S. House Resources Committee (Leg I)
Stephanie Wilson, Virginia Institute of Marine Science (Legs I & II)

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

Seabird and Marine Mammal Observation Studies:
Jarrod A. Santora, College of Staten Island
Shaibal S. Mitra, College of Staten Island

Bottom Trawl Survey:
Christopher D. Jones, Southwest Fisheries Science Center (Leg III)
Julian Ashford, Old Dominion University (Leg III)
Art DeVries, University of Illinois (Leg III)
Kim Dietrich, University of Washington (Leg III)

Stuart Hanchet, National Institute of Water and Atmospheric Research (Leg III)
Karl-Herman Kock, Sea Fisheries Research Institute (Leg III)
Tom Near, University of California at Davis (Leg III)
Teresa Turk, Northwest Fisheries Science Center (Leg III)
Sunhild Wilhelms, Bundesamt fuer Seeschiffahrt und Hydrographie (Leg III)

Invertebrate Bycatch Studies:
Stacy Kim, University of California at Santa Cruz (Leg III)
Susanna Lockhart, University of California at Santa Cruz (Leg III)
Valerie Loeb, Moss Landing Marine Laboratory (Leg III)
Rich Mooi, California Academy of Sciences (Leg III)
Rob Rowley, Moss Landing Marine Laboratory (Leg III)
Andrew Thurber, Moss Landing Marine Laboratory (Leg III)

Cape Shirreff Personnel:
Michael E. Goebel, Camp Leader, Southwest Fisheries Science Center (11/3/02 to 2/1/03)
John Lyons (11/3/02 to 3/1/03)
Laina Shill (11/3/02 to 3/1/03)
Michelle Antolos (11/3/02 to 3/1/03)
Rennie S. Holt, Southwest Fisheries Science Center (1/12/03 to 3/1/03)
Douglas Krause, Southwest Fisheries Science Center (1/12/03 to 3/1/03)

DETAILED REPORTS

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

1.1 Objectives: Objectives were to 1) collect and process physical oceanographic data in order to identify and map oceanographic frontal zones; and 2) collect and process environment data underway 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: Eighty-one of the 104 planned CTD/carousel casts were made on Leg I (Survey A, Stations A02-01 to A20-10). No casts were cancelled because of bad weather, but 23 stations were cancelled due to an extensive field of icebergs, which invaded the entire eastern portion of the survey area. Extra stations A03-07 and A06-10 were inserted during the survey after the eastern stations were abandoned bringing the total casts during the survey to 83. Station A07-08 was re-sampled (Station suffix B) after the main survey and five extra stations (X06-08 to X06-04) were sampled during the northward transit to a line of seven extra stations at 59°45'S (X06-00 to X12-00). A total of 13 extra stations were sampled.

A total of 98 out of a possible 108 casts were completed during Leg II, 95 being stations on the planned survey grid, one "blue water" station (D-CWZ-01) on the transit from Punta Arenas, one ad-hoc station (X10-07) as a result of a high chlorophyll peak identified by the SeaWiFS satellite and one repeat station (D15-09B) due to problems with the CTD winch's sea cable.

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. See Figure 2 in the Introduction for station locations. The new Guideline Portasal which replaced the troublesome Autosal used in previous years, proved to be much easier to use and more consistent. Samples from all stations were analysed on board and good agreement between CTD-measured salinity and the Portasal values was obtained with an average error of less than 0.02%. The final CTD/Portasal correlation produced an r^2=0.9929 (n=448) and an r^2=0.9992 (n=458) for Legs I and II respectively.

Underway comparison of the Seabird TSG salinity data with 7m CTD salinity data showed agreement (average 0.08% difference), while the sea temperature showed the TSG to be on average 0.68°C higher than the CTD 7m data which agrees with the 0.6°C measured in 2001 and 2002. This can be attributed to the heating effects of positioning the temperature sensor downstream of the seawater pump.

The older model SBE 13-02-B dissolved oxygen sensor has replaced with a type SBE 43 for Leg II. 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.

1.2.2 Underway Environmental Observations: Environmental and vessel positional data were collected for a total of 26 days each for both Legs I and II via the Scientific Computer System (SCS) software package (Software Version 3.2) running under Windows 2000 on a Pentium III (450mHz) PC. A Coastal Environmental Company Weatherpak system was installed on the port side of the forward A-frame in front of the bridge and was 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.

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. The 11^{th} bottle allowed for an additional 15m sample to be collected. Profiles were limited to a depth of 750 meters or 5 meters above the sea bottom when shallower and a Data Sonics altimeter was used to stop the CTD above the bottom on the shallow casts. Standard sampling depths were 750m, 200m, 100m, 75m, 50m, 40m, 30m, 20m, 15m, 10m and 5m. A Dissolved Oxygen (DO) sensor (Beckman 13-02-B for Leg I and a SBE 43 for Leg II), a Wetlabs fluorometer, a Seatech transmissometer and a Biospherical 2pi PAR sensor provided additional water column data during Legs I and II. Scan rates were set at 24 scans /second during both down and up casts. Sample bottles were only triggered during up casts. Plots of the down traces were generated and stored with the CTD cast log sheets and a copy given to the phytoplankton person, together with CTD mark files (reflecting data from the cast at bottle triggering depths) and processed up and down traces in 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 Vs 5.22 and the data processed using SBE Data Processing Vs 5.22. The dual screen configuration of the PC and Windows-based Seasave allowed additional windows of information to be displayed during the CTD casts, which greatly improved the information available to the operator (this included real-time T-S plots). Downcast data was re-formatted using a SAS script and then imported into Ocean Data View 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). 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 output in a serial format by the SeaBird SBE21 thermosalinograph (TSG) were also integrated into the logged data. Ships position and heading were provided in NMEA format via a Furuno GPS Navigator and Guiys Gyro respectively. No underway transmissometer and fluorometer measurements were made during the routine survey. Serial data lines were interfaced to the logging PC via a Digi-ports 16/EM serial multiplexor.

1.4 Results and Tentative Conclusions:

1.4.1 Oceanography: The position of the polar frontal zone, identified mainly by sea temperature change and minor salinity variation, was located from underway logged data during all four transits to and from Punta Arenas and the South Shetland survey area. This zone is normally found between 57-58°S. During the south transit for Leg I, the front was centered around 58°25'S, at the northern extent of the normal location (encompassed by 58-

59°S). This is similar to south bound transit during Leg I of AMLR 2001/02, which was between 58°05'S and 58°45'S, but more clearly defined this year. On the northern transect the front shifted further south, becoming less clearly defined between 58°30'S to 59°S. On the south bound transit for Leg II the front had a similar location as the north bound transect of Leg I, laying between 58°20'S and 59°S. On the return north bound transit at the end of Leg II, the zone had extended and became less defined and was located between 58°S and 59°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 Matlab program written during AMLR 2000/01 was used to confirm field classification according to the criteria in Table 1.1, thus attempting to reduce any subjective influence on the classification of water zones (see AMLR 2000/01 Field Season Report for details).

The tentative classifications according to the criteria in Table 1.1 were sometimes prone to ambiguity, particularly in the coastal regions around King George and Livingston Islands and in the south and southeast of Elephant Island. Classifications of Zone IV and Zone V waters in these areas could change if other oceanographic data such as density are considered. For the purpose of this report in which we report only tentative conclusions, only the criteria contained in the table were used. This was done to ensure consistency with past cruises.

Water zoning during Leg I was made difficult by the serious ice barrier in the eastern survey area and the accompanying Weddell influence. The Weddell intrusion between the islands of the archipelago and extending parallel to the shelf edge can be seen in (Figure 1.2), which is the result of the Matlab water-zoning algorithm. This was substantiated by the subjective application of the field criteria (Table 1.1). Little evidence of Zone II water (Transition) was seen in the whole survey area, other than a small patch on the south-western corner and northern edge. Bransfield water (Zone IV) was evident extending from the southern Bransfield Strait before being cut-off by the Weddell intrusion. The Bransfield water extended north of King George Island forming a coastwise-parallel buffer between the Weddell and the Antarctic Circumpolar Current (ACC) water in the north. The ACC extended eastward until it was diverted northward by the Weddell influence in the eastern four lines of the survey area. Zone II water was less prevalent than in previous years, and once again, Zone III water was not identified, although it is speculated that some Zone III water could have occurred had different criteria been applied.

Leg II conformed more closely to the normal water zone distributions; the ACC dominated the western and northern area, running parallel with the continental shelf edge. Bransfield water (Zone IV) completely filled the Straits, except for a token appearance of Weddell water at the entrance to the Antarctic Sound. It extended north-easterly into the southern Elephant Island Area and the northern coastal waters of the islands. The narrow mixing area of Zone II Transition water, first seen at the south-western edge of the West Area, clearly followed the shelf edge, meandered and became broader through the north-eastern quadrant of the survey area. A possible eddy-like feature, containing Zone II water occupied the north-western quadrant of the Elephant Island Area in the vicinity of the Shetland Fracture Zone. The extent of the Weddell influence seen during Leg I was clearly reduced, with no significant ice or Zone V water seen north of the islands. The south-eastern edge of the survey area was Zone V (Weddell) water until the survey was blocked by ice in the Joinville Island Area. When comparing the wind data of the two legs, the predominately east and south-easterly winds of the first leg, shifted to predominantly north-westerly winds during the second leg, which may have also contributed to the retreat of the ice and Weddell Sea influence in the eastern boundary area.

Drifter buoys were deployed during both these legs to measure currents in the survey area and these data should be referred to in conjunction with the above reporting (see Phytoplankton Chapter 2 of this report).

Three vertical temperature transects were chosen for plotting using ODV (Ocean Data View) software – the same transects that were plotted for the 2000/01 and 2001/02 reports were chosen for comparative reasons. (Figure 1.3) These transects were W05 in the West Area and EI03 and EI07 in the Elephant Island Area of the survey. During Leg I the transect EI07 was not completed due the extensive icebergs in the area and has been omitted.

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 (except for TSG data which are not available for transits in the Strait of Magellan). Very short periods of data were lost periodically while the logging PC was routinely reset and during the period when the PC was suffering self-induced rebooting attacks. Processed data were averaged and filtered over 5-minute intervals to reduce the effects of transients, particularly in data recorded from the thermosalinograph, which was sometimes prone to the effects of aeration (Figures 1.4 and 1.5).

Comparisons between the weather conditions experienced during Legs I and II during the surveys show significant differences, primarily between wind direction and speed (Figure 1.6). When comparing the wind data of the two legs, the predominately east and south-easterly winds of the first leg, shifted to predominantly north-westerly winds during the second leg, with wind speeds averaging around 20 knots during Leg I and with increases in wind speeds during Leg II to average at around 25 knots.

There was a noticeable increase in the number of icebergs seen in the survey in comparison with the AMLR 2000/01 and 2001/02 surveys, as noted in the altered survey plan.

1.5 Disposition of Data: Data are available from Roger P. Hewitt, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA, 92037; phone/fax (858) 546-5602/ (858) 546-5608; email: Roger.Hewitt@noaa.gov.

1.6 Acknowledgements: The cooperation and assistance of the Russian technical support staff was always outstanding. All requests for assistance were dealt with efficiently and in a thoroughly professional manner.

1.7 Problems and Suggestions: The CTD system performed well, with the usual maintenance attention having to be given to the underwater connectors. Very little data or time was lost during the 194 casts. The underwater units were switched over during the port call as two of the bulkhead connectors were showing signs of corrosion. CTD communication problems and blown deck-unit fuses on Leg II were traced to an intermittent short in the sea-cable's underwater connector and a low impedance path at the winch slip-rings.

The originally fitted Beckman 13-02-B dissolved oxygen sensor failed on Leg I and was replaced with the spare Beckman 13-02-B unit. The bulkhead connector on this spare unit, and its underwater cable, where also replaced on a later dip when a leak caused both to corrode. This older Beckman 13-02-B dissolved oxygen sensor was replaced with a SBE 43 dissolved oxygen sensor for Leg II. This necessitated the changing of the Seasave and Seasoft data processing configuration files as well as the SAS script for converting data to ODV format.

Upgrading to the newer SBE 43 DO sensors should be considered, as Seabird now considers the Beckman 13-02-B as obsolete. The new type sensor also minimizes the historesis effect that occurs during the down and up casts. 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.

The SBE Carousel and General Oceanics Niskin bottles worked relatively well, with only a few lanyard snags causing lost samples. The problem of not being able to trigger some casts from the PC's keyboard can be attributed to a PC problem, rather than an SBE hardware problem. This problem should be resolved when the PC is upgraded. The new Niskin bottles are being damaged on their bottom sealing areas by their springs. General Oceanics should be contacted to discuss the option of using rubbers instead of springs.

The fluorometer developed a small leak through a broken bulkhead connector and corroded the internal cabling, necessitating it to be removed for a few stations while it was repaired.

The SCS/CTD PC should be replaced as it frequently reboots itself, "crashes" or becomes too sluggish to keep pace with the CTD data upload rate. It is using 100% of its CPU resources when running the Seasave software with the SCS in the background.

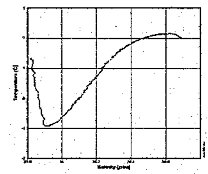
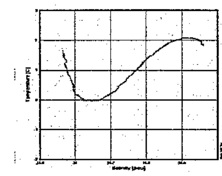
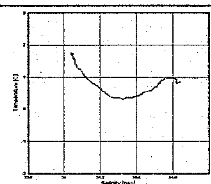
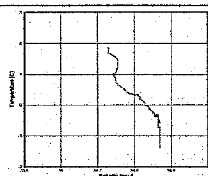
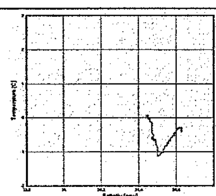
The TSG pump and debubbler system had to be periodically stopped and cleaned due to clogging by krill, seaweed and other biologicals.

The CTD/SCS logging PC, currently an older Pentium 450mHz, is prone to gradual slowing down during the cruise and required periodic re-booting to improve this (See details in AMLR 2001/02 report). It was previously recommended that this be upgraded to a faster processor and this is re-iterated in this report. This PC is logging SCS data continuously, CTD data during casts and is also used for CTD data analysis and routine survey administration. A further problem was noted when the PC began rebooting unexpectedly during routine operation.

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 during AMLR 2003.

	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	

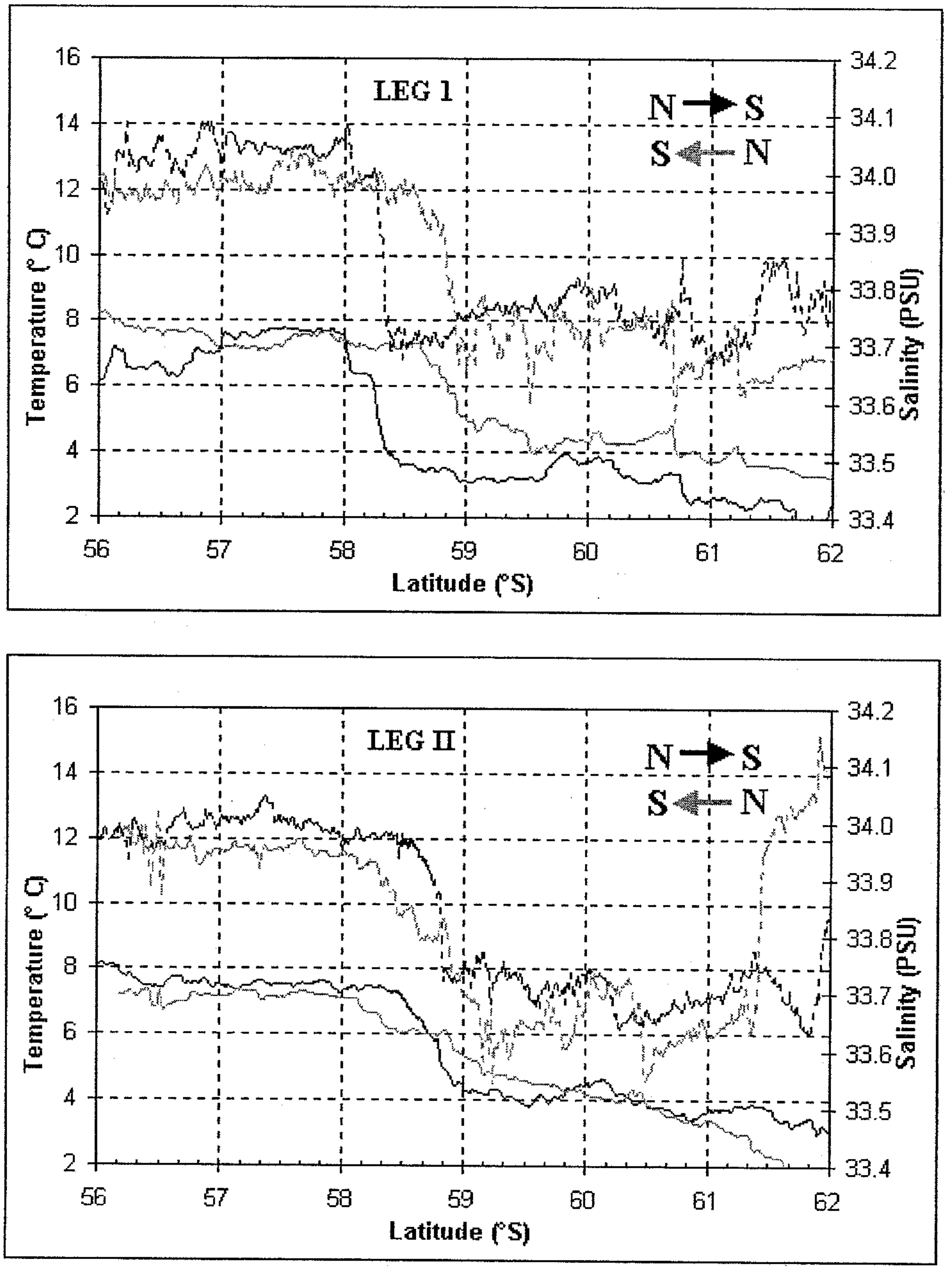


Figure 1.1. The position of the polar fronts as determined for AMLR 2002/03 Legs I (top) and II (bottom), from measurements of sea surface temperature (solid line) and salinity (broken line) for the south and north transits to and from the South Shetland Islands survey area.

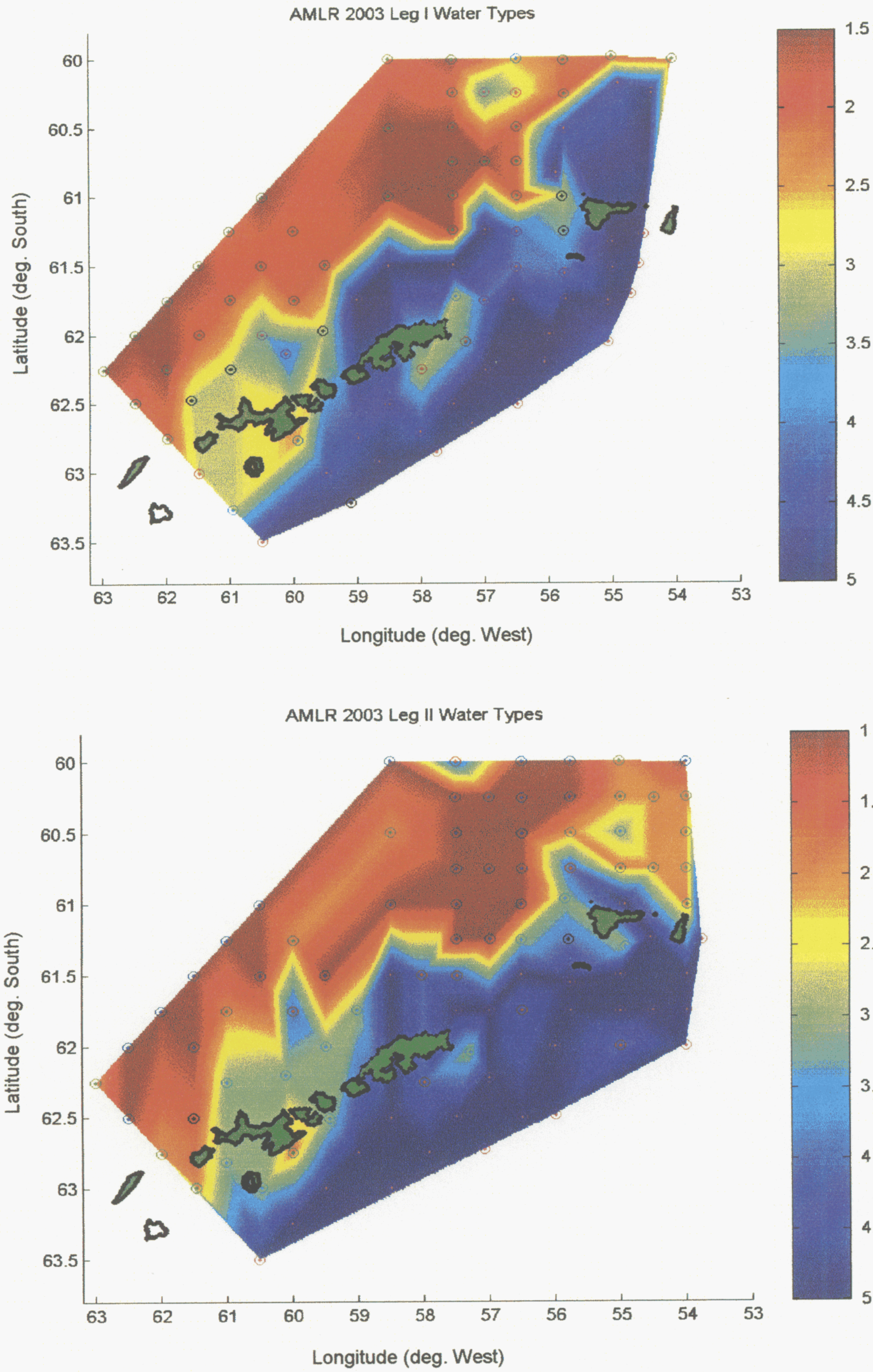


Figure 1.2. Classification of water zones for Legs I & II (top and bottom panels respectively) for AMLR 2002/03, as determined by the MATLAB classification routine developed during the AMLR 2000/01 survey. The colored bar on the right represents Water Zones I-V.

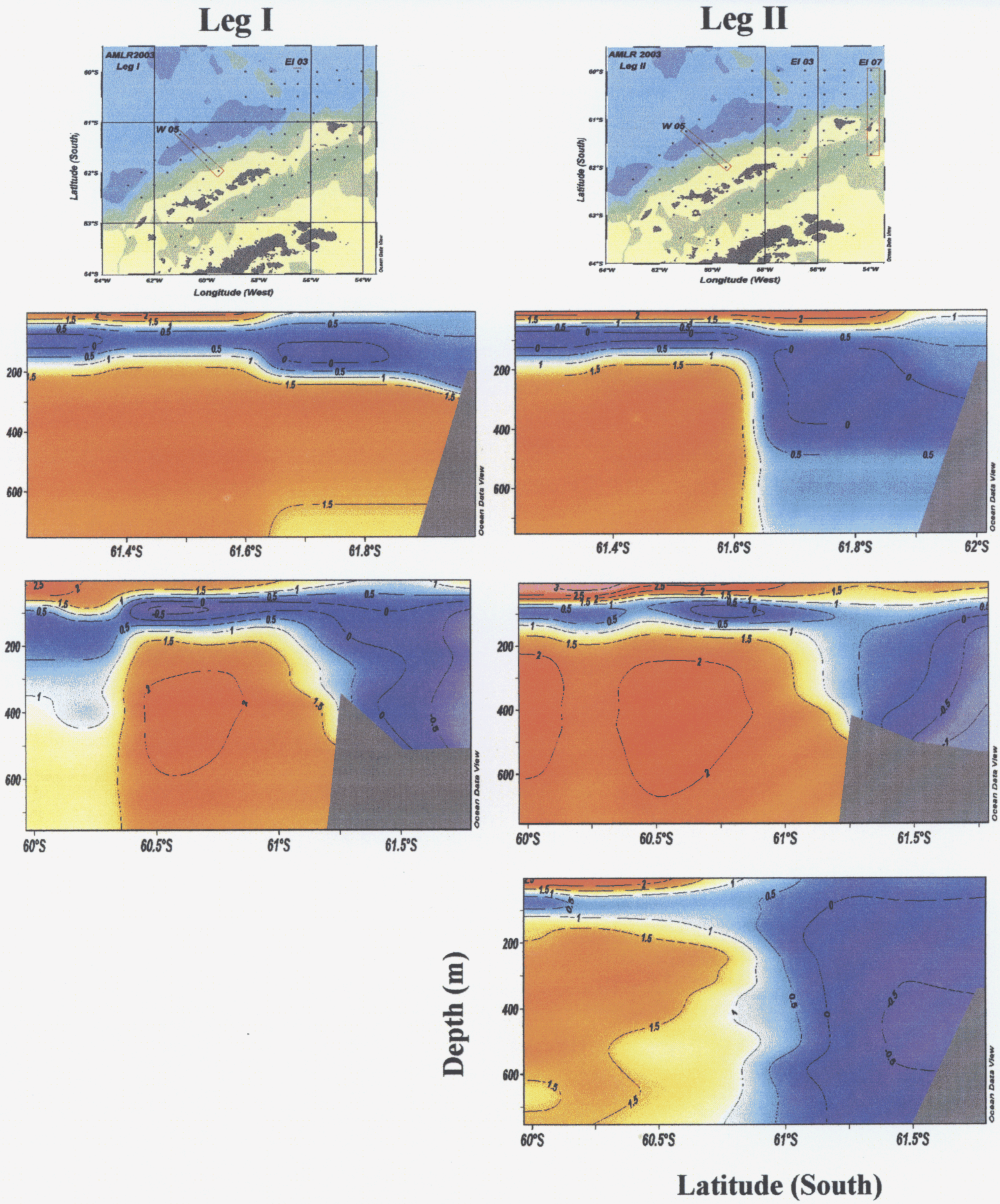


Figure 1.3. Vertical temperature ^{0}C profiles derived from CTD data recorded on three transects, W05 (top), EI03 (middle) and EI07 (bottom), during Legs I (left column) and II (right column) of the AMLR 2002/03 South Shetland Island survey. Transect EI07 not completed during Leg I due to icebergs in vicinity.

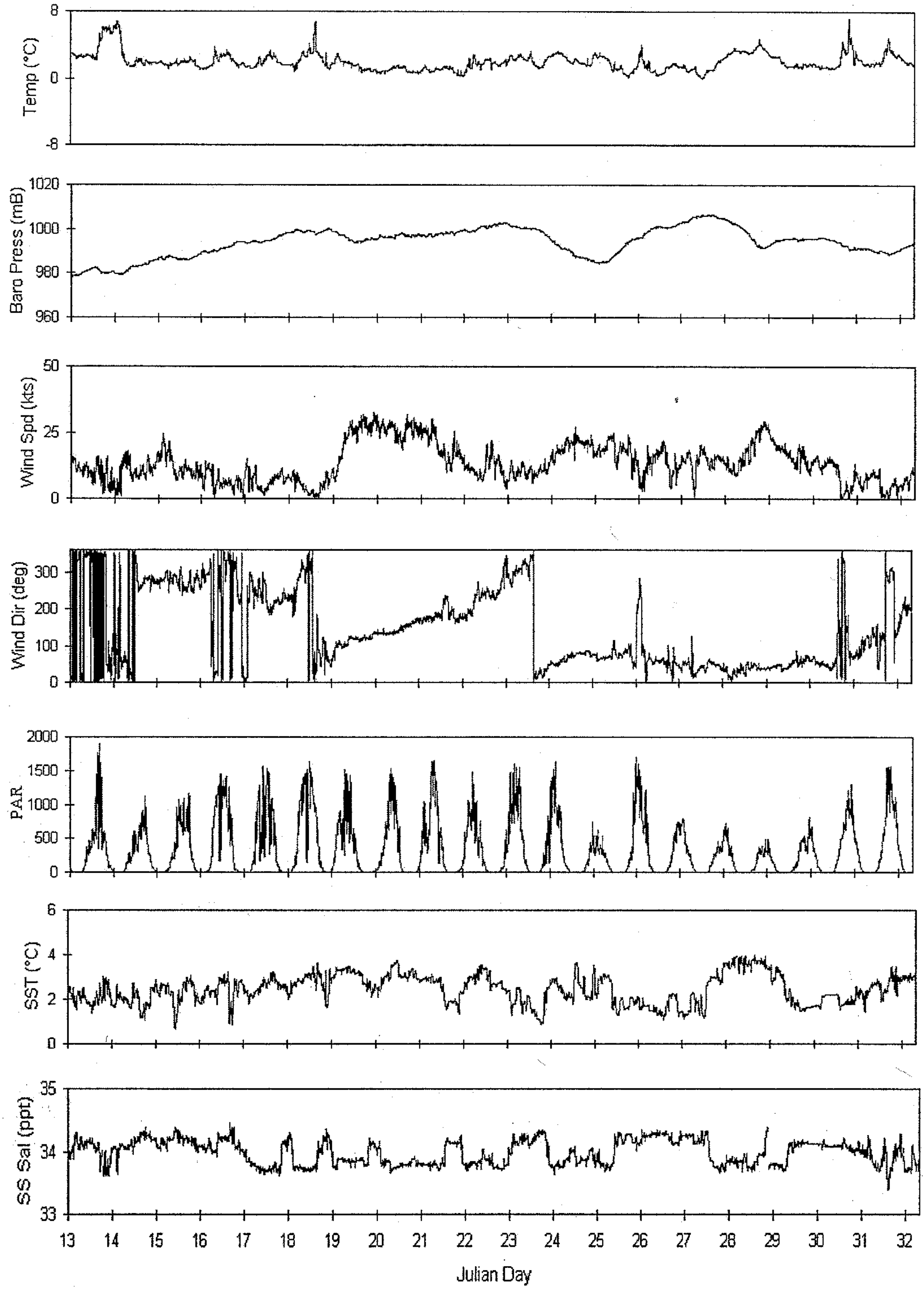


Figure 1.4. Meteorological data (5 minute averages) recorded between January 13th and February 2nd during Leg I (survey only) of the AMLR 2002/03 cruise. (PAR is photo-synthetically available radiation).

AMLR 2003 – Leg II

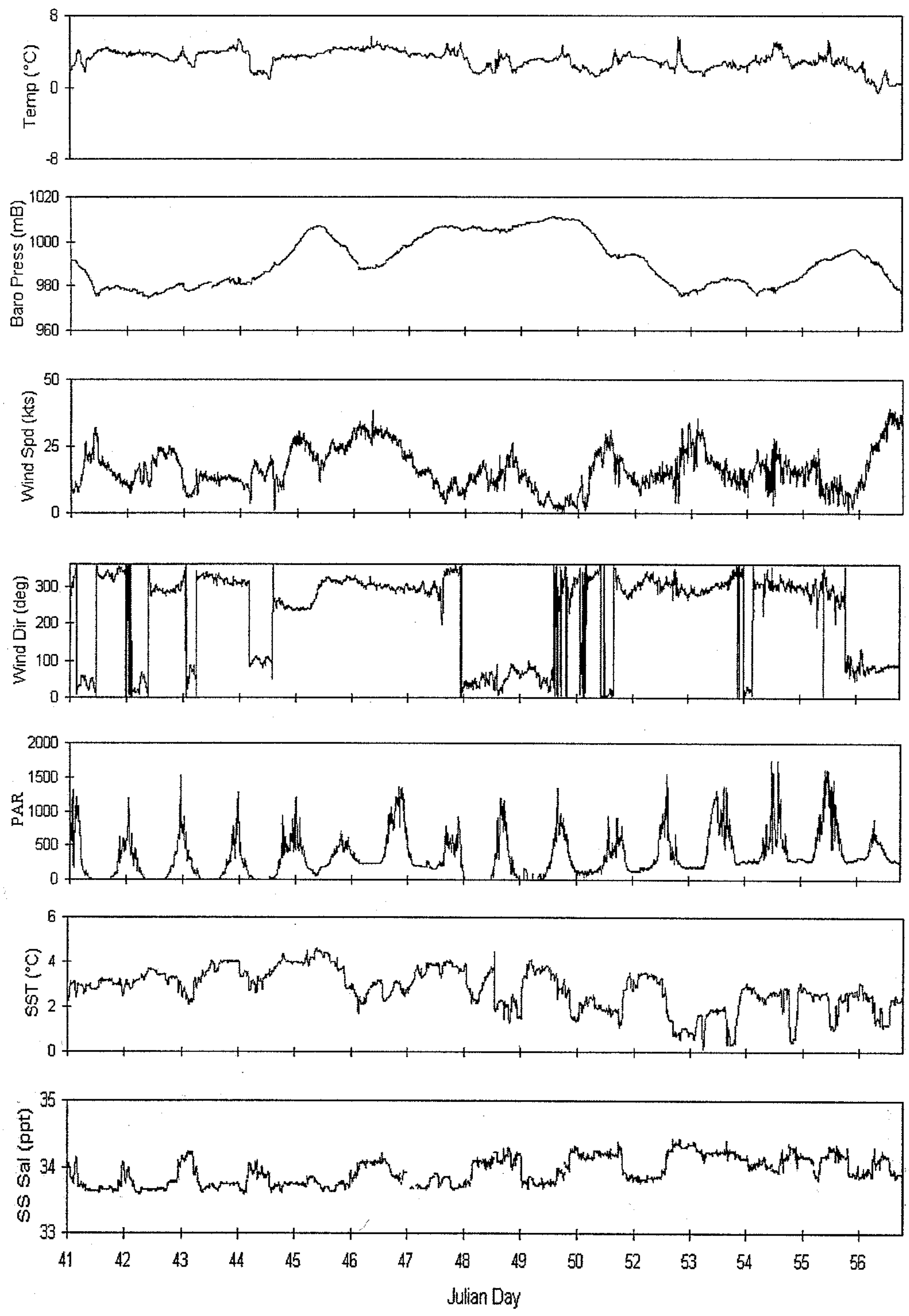


Figure 1.5. Meteorological data (5 minute averages) recorded between February 10th and February 25th during Leg II (survey only) of the AMLR 2002/03 cruise. (PAR is photo-synthetically available radiation).

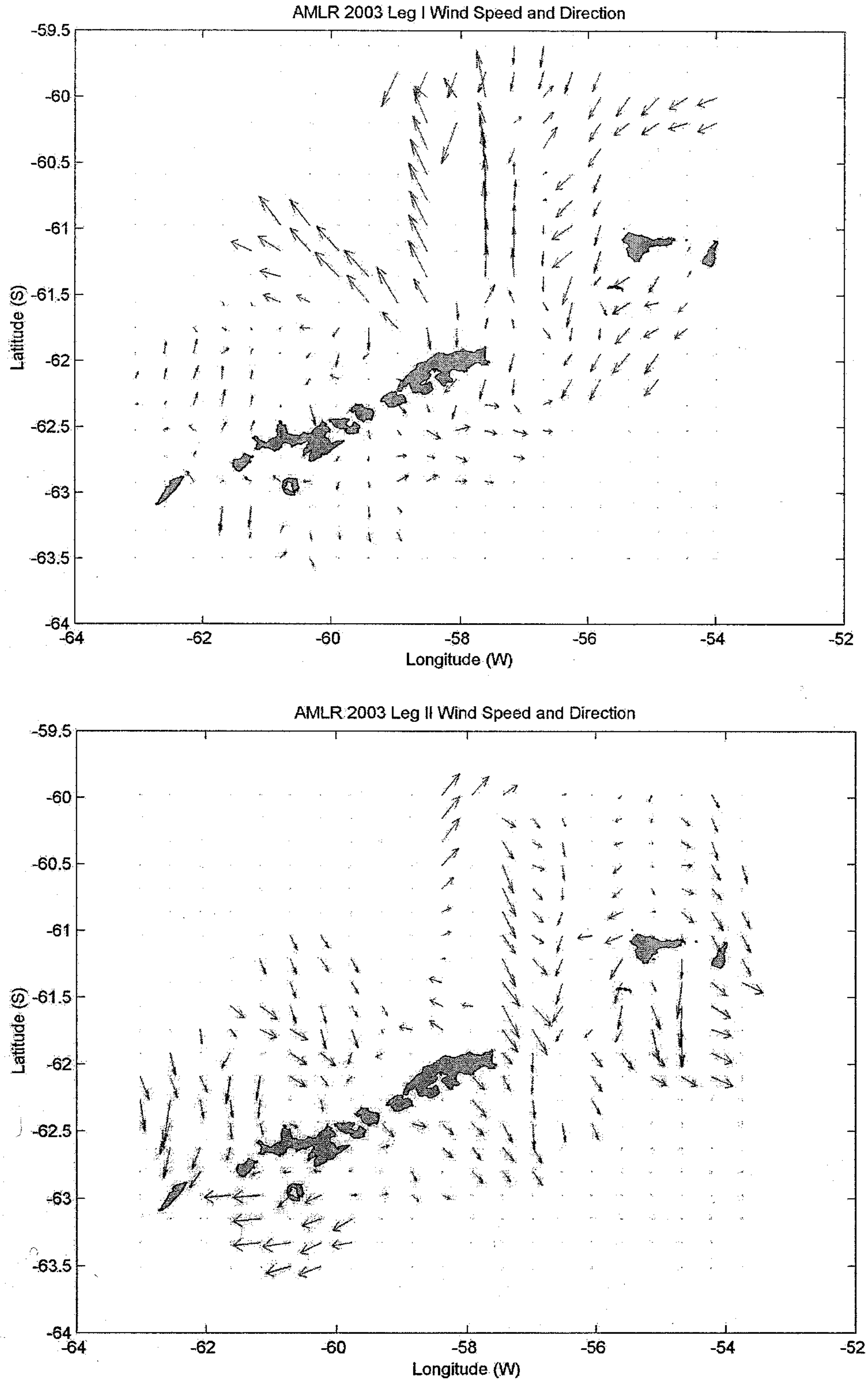


Figure 1.6. Vectors representing wind speed and direction for Legs I (top) and II (bottom) derived from data recorded by the SCS logging system during AMLR 2002/03 survey of the South Shetland Islands.

2. Chlorophyll-*a* Concentrations in the Upper Water Column of the AMLR Sampling Grid; submitted by Christopher D. Hewes (Legs I & II, SIO), Meng Zhao, (UMB) Ryan Dorland (UMB), B. Greg Mitchell (SIO), Mati Kahru (SIO), and Osmund Holm-Hansen (SIO).

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 objective of our work was to determine the distribution and biomass of phytoplankton in the upper water column (surface to 200m), with emphasis on the upper 100m, and in conjunction with the NASA SIMBIOS program, (1) to determine the concentrations of all the major cellular photosynthetic pigments by High Pressure Liquid Chromatography (HPLC), from which one can estimate the relative proportions of various phylogenetic groups of phytoplankton and (2) to calibrate satellite imagery of spectral reflectance to surface chlorophyll concentrations. However, the distribution of phytoplankton is dependent upon local currents as well as availability of growth promoting factors (light or nutrients), both of which are conditioned by physical and chemical properties of the upper water column. In order to better understand mixing processes in our study area, this year we deployed drifter buoys to examine direction and speed of surface currents.

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: The CTD carousel and independent profiling units were used to obtain samples of the water column for analyses as well as to obtain data from various profiling sensors as listed below:

A. For both Legs, water samples were obtained from 10-liter Niskin bottles (with Teflon covered springs) which were closed at 10 standard depths (5, 10, 15, 20, 30, 40, 50, 75, 100, and 200m) from every station upcast of the CTD/rosette unit.

B. For both Legs, a Sea Tech transmissometer was used to determine the attenuation of collimated light (by both scattering and absorption) during CTD casts.

C. For both Legs, a Sea Tech profiling fluorometer was used to measure in situ chlorophyll fluorescence.

D. For both Legs, a Biospherical QCP200L profiling PAR (photosynthectically available radiation) sensor was used to measure the in situ light regime.

2.2.2 Measurements and Data Acquired:

(A) <u>Chlorophyll-*a* concentrations</u>: Chl-*a* concentrations in the water samples were determined by measurement of chl-*a* fluorescence after extraction in methanol. Sample volumes of 100mL 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 spectrophotometrically determined chl-*a* concentrations of a prepared standard (Sigma). Stability of the fluorometer was verified daily by use of a fluorescence standard (Turner Designs #7000-994).

(B) Measurement of photosynthetic pigment concentrations: HPLC samples will be used for the analysis of various chlorophylls and associated pigments. Samples from 5-meter bottle samples at 184 CTD stations were obtained by filtering 1L water through 25mm GF/F filters. Samples were frozen and stored in liquid nitrogen until their analyses can be made at SIO. The ratio of chlorophyll and associated pigments will be used to determine the proportions of algal classes contained in the phytoplankton community.

(C) Measurement of beam attenuation: A Sea Tech transmissometer (660nm, 25cm path) was fixed onto the Seabird CTD carousel for deployment at all stations. Previous studies have shown that beam attenuation (660nm) coefficients can be used to estimate total particulate organic carbon in Antarctic waters (Villafañe *et al.*, 1993). This calculation assumes that there is a negligible load of inorganic sediment in the water, a condition that is apparently satisfied throughout much of the study area.

(D) Measurement of chlorophyll fluorescence: A Sea Tech profiling fluorometer was used to obtain measures of chlorophyll fluorescence intensity in the water column. These data will be used (in conjunction with the measurement of *in situ* PAR) to estimate chlorophyll concentrations in the water column, using the algorithm of Holm-Hansen *et al.* (2000) as applied specifically for the AMLR survey region.

(E) Measurement of *in situ* light: A Biospherical Instruments cosine PAR (photosynthetically available radiation, 400-700nm) sensor (Model #QCP-200L) was used to measure light attenuation profile in the water column. This sensor is also used in conjunction with the SeaTech fluorometer to estimate chlorophyll concentrations *in situ*, and to provide a parameter to measure the variability of photophysiological responses of phytoplankton.

(F) Satellite Oceanography: SeaWiFS chlorophyll images were obtained for 8-day and monthly average composites from NASA archives (http://eosdata.gsfc.nasa.gov/). These data were sufficient to evaluate the time-dependence and distribution of chl-*a* within our study region. Additional LAC (local area coverage) data giving high resolution, single day images of chlorophyll distribution for segments of the AMLR survey area have also been obtained.

(G) Drifter buoy deployment: In cooperation with the Global Drifter Program (P. Nieler, SIO), we deployed 20 drifter buoys (10 each for Leg I and Leg II) to determine paths and rates of ocean currents in the AMLR study area.

(H) Non-routine CTD stations: Time permitted us to obtain additional data during both Legs I and II in regions of specific interest to describe the distribution of phytoplankton. At the end of Leg I, a transect including seven CTD stations along 59.75°S between 56 and 59°W was followed by a transect along the Shackleton Fracture Zone to measure bathymetry. On the return to Cape Shirreff at the beginning of Leg II, one CTD cast was made in the Drake Passage (Station CWZ). These CTD casts included measurements of PAR, transmissometer, and fluorometer, and included chlorophyll measurements from water bottle samples. One additional station during Leg II, X10-07, was made to fill in a gap for a station transect in which a phytoplankton bloom had developed. These data will be used to study processes involved with bloom dynamics.

2.3 Tentative Results and Conclusions:

2.3.1 Overview of Phytoplankton Distributions in the AMLR Survey Areas January-March:

West Area. Chlorophyll-*a* concentrations at 5m averaged 0.51 ± 0.88 mg Chl m^{-3} (n = 49), and values integrated to 100m were 32 ± 25 mg Chl m^{-2}. For this area, chlorophyll concentrations were well below our 12-year average (5 meter being 0.85 ± 0.33 mg Chl m^{-3}; 100m integrated being 56 ± 22 mg Chl m^{-2}).

Elephant Island Area: Chlorophyll-*a* concentrations at 5m averaged 0.59 ± 0.52 mg Chl m^{-3} (n = 93), and values integrated to 100m were 40 ± 23 mg Chl m^{-2}. For this area, chlorophyll concentrations were well below our now 13-year average (5 meter being 0.93 ± 0.43 mg Chl m^{-3}; 100m integrated being 57 ± 24 mg Chl m^{-2}).

Joinville Island and South Areas: For the Joinville Island Area, too few stations were made to make any historical comparisons (5m chlorophylls were 0.64 ± 0.19 mg Chl m^{-3} for 7 stations). For the South Area, chlorophyll-*a* concentrations at 5 m averaged 0.87 ± 0.42 mg Chl m^{-3} (n = 36), and values integrated to 100 m were 45 ± 16 mg Chl m^{-2}. For this area, chlorophyll concentrations were well below our 12-year average (5 meter being 1.75 ± 0.74 mg Chl m^{-3}; 100m integrated being 84 ± 41 mg Chl m^{-2}).

Chlorophyll concentrations generally increase between Legs I and II (Table 2.1). Although concentrations were low for all areas in the AMLR survey area, chlorophyll concentrations did increase slightly during Leg II (Figure 2.1). Satellite imagery (Figure 2.2) shows this same trend, with moderate chlorophyll concentrations in the AMLR survey area (and Bellingshausen/Scotia Seas) during December, 2002, that decreased during January, 2003; chlorophyll concentrations increased again somewhat during February to subside during March, the end of the austral summer

2.3.2 Ocean Surface Currents and Circulation: Twenty drifter buoys were released this year during the AMLR oceanographic survey, 10 for each of Legs I and II. A primary purpose for these releases was to examine how the Shackleton Fracture Zone (SFZ) interrupted the eastward flow of the Antarctic Circumpolar Current (ACC). Patterns of the drifter tracks were generalized into five categories (Figure 2.3).

Buoys released north of the shelf break in the Antarctic Circumpolar Current (ACC) drifted east northeastward and either were:

1) deflected southeastward towards the north of Elephant Island (Figure 2.3A) or
2) deflected northwestward (Figure 2.3B).

In both cases, after passing the SFZ, these drifter buoys were realigned to the general east northeastward flow of the ACC.

3) Buoys released within the shelf (<500m) and shelf-break (500-1000m) region between King George and Elephant Islands (Figure 2.3C) were either caught in a southwest current north of King George Island (blue trace), a southeast current that hugged the southern shores of Elephant Island (red trace), or a southeast current into the Bransfield Strait (green trace); these drifters were eventually captured by an east northeasterly current.

4) Three drifters released at the shelf-break north of King George Island took a southwest direction (Figure 2.3D) with two (red and blue traces) entering the Bransfield Strait via the Nelson Strait (between Nelson and Robert Islands). One of these (blue trace) left the Bransfield Strait north of King George Island and was entrained by the general east northeasterly flow of the ACC.

5) Two drifter buoys released in the shelf region north of Livingston Island took a west southwest course (Figure 2.3E), with one drifter entering the Bransfield Strait south of Snow Island (blue trace).

From the collected tracks of these 20 drifter buoys, a description of the general pattern of current flow within the AMLR survey area for the 2002/03 field season can be made (Figure 2.3F). The SFZ marks a major obstruction in the flow of ACC as stated by others (see Stein, 1988). Drifter buoys exited the Bransfield Strait north of King George Island to flow southwest along the northern shores of the South Shetland Islands (Stein, 1988). Some of this current re-entered the Bransfield Strait between King George and Livingston Islands, and a remainder entered the Bransfield Strait south of Snow Island. Bransfield Strait water (e.g., Water Zone IV) originates at the southwest entrance of the strait as a complex blend of Bellingshausen and Weddell Seas water as well as coastal waters (Stein, 1988; Hofmann *et al.*, 1996). Stein also described an eddy (e.g. his Figure 10) southeast of Elephant Island, similar in locality to where one of our drifters became entrained for about two months (green trace, Figure 2.3C).

Several of the drifter buoys survived passage through the Scotia Sea (Figure 2.2A). Although at the time of this writing the drifters had reached ¾ of the distance to South Georgia, the distances traveled shown in Figure 2.2A took between 43 and 86 days. Drifter buoys released in the ACC ranged between 11-15 km d^{-1} east northeast in speed by straight line distance. Drifter 39141 traveled 900km in 65 days, which would extrapolate to the distance between Elephant Island and South Georgia in less than 100 days. There have been efforts made to determine whether krill found in the South Georgia Island area might originate from the South Shetland Island area (Hofmann *et al.*, 1998; Fach *et al.*, 2002). From modeling, these authors suggested that krill might be transported across the Scotia Sea in 3-4 months. The direct results of our drifter buoy data indicate this is a reasonable estimate of time for krill transport.

2.3.3 Analysis of Bloom Development: On February 14, 2003, a high-resolution, local area coverage (LAC) SeaWiFS image of chlorophyll distribution (taken four days prior) was received on board ship. This image (Figure 2.4A) indicated that this bloom (labeled "bl" in Figure 2.4A) had recently developed in this area. An additional CTD station (X10-07 at 61.5°S and 58°W) was occupied on February 14, 2003, to obtain more data on this bloom. Drifter buoy data (see Figure 2.4B-D) indicated that this bloom was associated with a frontal system between Bransfield Strait and Drake Passage waters.

Data relevant to this phytoplankton bloom are shown in Figure 2.5 (temperature, density, and oxygen) and Figure 2.6 (extracted chl-*a*, fluorometric, and transmissometry). These data lend additional support to the suggestion that this bloom (measuring >1 mg Chl m^{-3}) did occur at a front with mixing between waters of Water Zones I and IV. It should be noted that for Figures 2.5A-D and 2.6A-D, the series of stations taken from the shelf and southward was sampled approximately 7-8 days after the northern portion of the transect; for Figures 2.5E-H and 2.6E-H, stations were sampled over a 9-day period. A latitudinal section made through the bloom area (labeled "bl" in Figure 2.6B), corresponded to 1 mg chl m^{-3} at 5m measured at station D09-06.

This section shows the ACC (e.g., Water Zone I; Amos and Lavender, 1991; Demer *et al.*, 2001) to the north, characterized by warm surface waters (>2°C; Figure 2.5B) and a layer of Winter Water (labeled "ww" in Figure 2.5B) with low temperature (~-1°C) and salinity (<34°/₀₀) at about 75m (Figures 2.7B-D). This is in contrast to water of the Bransfield Strait that lies to the south (Figure 2.5B), having cooler (<2°C) and saltier (~34°/₀₀) surface waters with temperatures approaching -1°C below ~300m (Figures 2.7B-D). Water Zones II and III are mixtures of Bransfield Strait and ACC waters (Amos and Lavender, 1991; Demer *et al.*, 2001). Water Zone II is similar to Water Zone I in Temperature/Salinity space (Figure 2.7B) and water column profiles (Figure 2.7C-F), but has a higher temperature minimum (-1-0°C) with corresponding higher salinity (>34°/₀₀). Water Zone III was found over the shallow sill of the Loper Channel (between Elephant Island and King George) and north to the shelf break. It was characterized by having a modest temperature minimum (~0°C; "Bloom" in Figure 2.7B, C). A longitudinal section (Figures 2.5E and 2.6E) through the bloom area (labeled "bl" in Figure 2.6F) included values of 1.7 mg chl m^{-3} at station X10-07 and 2.3 mg chl m^{-3} at station D11-07 (see Figure 2.7A for locations of these stations). Both temperature and salinity profiles (Figure 2.7B-D) show that ACC waters lay to the west of this section and Bransfield Strait waters lay at the eastern edge of the plot. Water Zone III was also found over the sill and westward to the shelf-break in this section.

The sections for water density (Figure 2.5C & G) indicate that denser water had welled up at the juncture of ACC and Water Zone III. This also corresponded with much lower oxygen concentrations below ~60m (Figures 2.5D & H) as compared with surrounding waters and the northern and western boundaries of the bloom (Figure 2.6B-D & F-H). Highest oxygen concentrations were in near surface waters that most likely corresponded to increased photosynthesis of the bloom, as well as in Winter Water of the ACC.

The temperature minimum at station D09-06 (labeled "pk" in Figure 2.5B) of -1.08°C was at 55m (heavy green line in Figure 2.7C) and had a salinity of 34.06 (heavy green line in Figure 2.7D). The temperature verses salinity relationship (Figure 2.7B) indicated that this was of Water Zone I (e.g., ACC) water. However, blooms are not typical for this water zone (Holm-Hansen *et al.*, 1997), and this station had >1 mg chl m^{-3} at 5m. Station D09-06 was also unusual in that: 1) it had a temperature minimum at approximately 20 meters shallower than is typical of Water Zone I (Figure 2.5B); and 2) the oxygen concentration at this temperature minimum was 6.55 ml/liter. The Winter Water in ACC is much richer in oxygen concentration (see Figures 2.5D & H).

Our biological data (Figures 2.6B-D) indicated that this pocket of cold water at station D09-06 was probably derived from Winter Water. Winter Water in the ACC for the AMLR survey area is characterized by a chlorophyll fluorescence maximum (labeled "fm" in 2.Figures 6C & G) near the temperature minimum (see Figures 2.7B & E; Holm-Hansen *et al.*, 1997). Although this fluorescence maximum does correspond to a chlorophyll maximum, the *in vivo* fluorescence yield per unit chlorophyll (in proportion to *in situ* PAR) is two to three times higher for ACC than of other water zones in the survey area (Holm-Hansen *et al.*, 2000). Our data indicated that the *in vivo* fluorescence yield per unit chlorophyll relative to PAR for 40- and 50-m samples at station D09-06 were not significantly different than those of Winter Water and were higher than those of Bransfield Strait water.

We think it likely that the formation of this bloom in the waters between King George Island and Elephant Island was due to injection of iron into the euphotic zone by upwelling generated along a frontal system in shelf and shelf-break waters. This interpretation would be consistent with previous data from AMLR studies which have shown the enhancement of phytoplankton biomass in a frontal system to the north of Elephant Island (Helbling *et al.*, 1993) and also that addition of iron to ACC waters results in an increase of phytoplankton biomass (Helbling *et al.*, 1991; Holm-Hansen *et al.*, 1994).

2.4 Disposition of the Data: All chlorophyll and CTD-interfaced sensor data obtained during these cruises have been archived with AERD, Southwest Fisheries Science Center. HPLC samples will be processed by Dr. B.G. Mitchell under his NASA SIMBIOS project, and made available to AMLR participants.

2.5 Problems and Suggestions: It should be noted that the phytoplankton component of the AMLR program has not received adequate funding for the calibration, repair, or replacement of field equipment (both laboratory equipment and *in situ* sensors) used in these annual surveys beginning with the 1999/00 season. Several instruments devoted to this program (some originally obtained from other funding agencies) need to be replaced, and the situation is now critical. Additional NOAA funding needs to be made available in order to maintain and/or replace such instruments, since this affects the scope and quality of our data. Funds obtained from NOAA for phytoplankton studies this year did not cover the full expense required of the field season work.

2.6 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 field season. 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. HPLC pigment samples will be analyzed through the NASA SIMBIOS Project Award to B. Greg Mitchell, NAS5-01002. Peter Nieler (SIO) arranged getting drifter buoys for our study through the "Global Drifter Program", NA17RJ1231, JIMO Task Number 2. This report was funded in part to O. Holm-Hansen from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, under JIMO grant NA17RJ1231. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its sub-agencies.

2.7 References:

Amos, A.F., and Lavender, M.K. 1991. AMLR program, Water masses in the vicinity of Elephant Island. *Antarctic Journal of the United States* 26: 210-213.

Demer, D.A., Hewitt, R.P., Loeb, V., Malan, P., and Rowley, R. 2001. Physical oceanography. Pages 17-25 in (Jessica Lipsky, *ed.*) AMLR 1999/2000 Field Season Report: Objectives, Accomplishments and Tentative Conclusions. March 2001. NOAA-TM-NMFS-SWFSC-302.

Fach, B.A., Hofmann, E.E., and Murphy, E J. 2002. Modeling studies of Antarctic krill *Euphausia superba* survival during transport across the Scotia Sea. *Marine Ecology Progress Series* 231: 187-203.

Helbling, E.W., Villafañe, V.E., and Holm-Hansen, O. 1991. Effect of Fe on Productivity and Size Distribution of Antarctic Phytoplankton. *Limnology and Oceanography* 36: 1879-1885.

Helbling, E.W., Amos, A.F., Silva, S.N., Villafañe, V.E., and Holm-Hansen, O. 1993. Phytoplankton distribution and abundance as related to a frontal system north of Elephant Island, Antarctica. *Antarctic Science* 5: 25-36

Hofmann, E.E., Klinck, J.M., Lascara, C.M., and Smith, D.A. 1996. Water mass distribution and circulation west of the Antarctic Peninsula and including Bransfield Strait. Pages 61-80, in (Ross, R.M., E.E. Hofmann, and L.B. Quetin, eds.) Foundations for Ecological Research West of the Antarctic Penninsula. Antarctic Research Series Vol. 70. American Geophysical Union, Washington, D.C.

Hofmann, E.E., Klinck, J.M., Locarnini, R., Fach, B., and Murphy, E. 1998. Krill transport in the Scotia Sea and environs. *Antarctic Science* 10(4): 406-415.

Holm-Hansen, O., Lorenzen, C.J., Holmes, R.W., and Strickland, J.D.H. 1965. Fluorometric determination of chlorophyll. *Conseil permanent international pour L'Exploration de la Mer* 30: 3-15.

Holm-Hansen, O., and Riemann, B. 1978. Chlorophyll a determination: Improvements in methodology. *OIKOS* 30: 438- 447.

Holm-Hansen, O., Amos, A.F., Silva, S.N., Villafañe, V.E., and Helbling, E.W. 1994. *In situ* evidence for a nutrient limitation of phytoplankton growth in pelagic Antarctic waters. *Antarctic Science* 6: 315-324.

Holm-Hansen, O., Hewes, C.D., Helbling, E.W., Villafañe, V.E., and Amos, A.F. 1997. Phytoplankton biomass and distribution in relation to water masses around Elephant Island, Antarctica. *Polar Biology* 18: 145-153.

Holm-Hansen, O., Amos, A.F., and Hewes, C.D. 2000. Reliability of estimating chlorophyll-*a* concentrations in Antarctic waters by measurement of in situ chlorophyll-*a* fluorescence. *Marine Ecology Progress Series* 196: 103-110.

Mitchell, B.G. and Holm-Hansen, O. 1991. Bio-optical properties of Antarctic Peninsula waters: differentiation from temperate ocean models. *Deep-Sea Research I* 38(8/9): 1009-1028.

Schlitzer, R. 2002. Ocean Data View. http://www.awi-bremerhaven.de/GEO/ODV.

Stein, M. 1988. Variation of geostrophic circulation off the Antarctic Peninsula and in the southwest Scotia Sea, 1975-1985. Pages 81-91, in (Sahrhage, D., ed.) Antarctic Ocean and Resources Variability. Springer-Verlag, Berlin, Heidelberg. 304p.

Villafañe, V.E., Helbling, E.W., and Holm-Hansen, O. 1993. Phytoplankton around Elephant Island, Antarctica: distribution, biomass and composition. *Polar Biology* 13: 183-191.

Table 2.1. Comparison of surface and integrated (100-meter) chlorophyll concentrations in the three different AMLR survey regions between 2003 and the 1990-2002 mean (median) seasonal values. For all regions and both legs, 2003 chlorophyll concentrations were below average.

	No. of Years	Area	Average Number of Stations	Mean Surface, mg Chl m^{-3}	Median Surface, mg Chl m^{-3}	Mean Integrated, mg Chl m^{-2}	Median Integrated, mg Chl m^{-2}
Leg I	13	EI	58 ± 14	0.75 ± 0.31	0.63 ± 0.25	48 ± 17	44 ± 15
	11	SA	11 ± 4	1.27 ± 0.6	1.14 ± 0.52	66 ± 23	59 ± 20
	11	WA	17 ± 11	0.69 ± 0.29	0.57 ± 0.35	47 ± 15	45 ± 19
		2003 EI	45	0.44 ± 0.35	0.32	37 ± 19	40
		2003 SA	17	0.81 ± 0.38	0.73	43 ± 15	37
		2003 WA	25	0.23 ± 0.23	0.10	26 ± 16	18
Leg II	13	EI	57 ± 13	1.04 ± 0.6	0.80 ± 0.49	66 ± 35	55 ± 29
	11	SA	11 ± 5	1.89 ± 1.65	1.91 ± 1.94	106 ± 93	92 ± 78
	11	WA	18 ± 13	0.99 ± 0.48	0.78 ± 0.59	65 ± 34	58 ± 32
		2003 EI	48	0.73 ± 0.62	0.49	43 ± 26	38
		2003 SA	19	0.92 ± 0.46	0.79	47 ± 16	41
		2003 WA	24	0.79 ± 1.18	0.14	38 ± 30	26

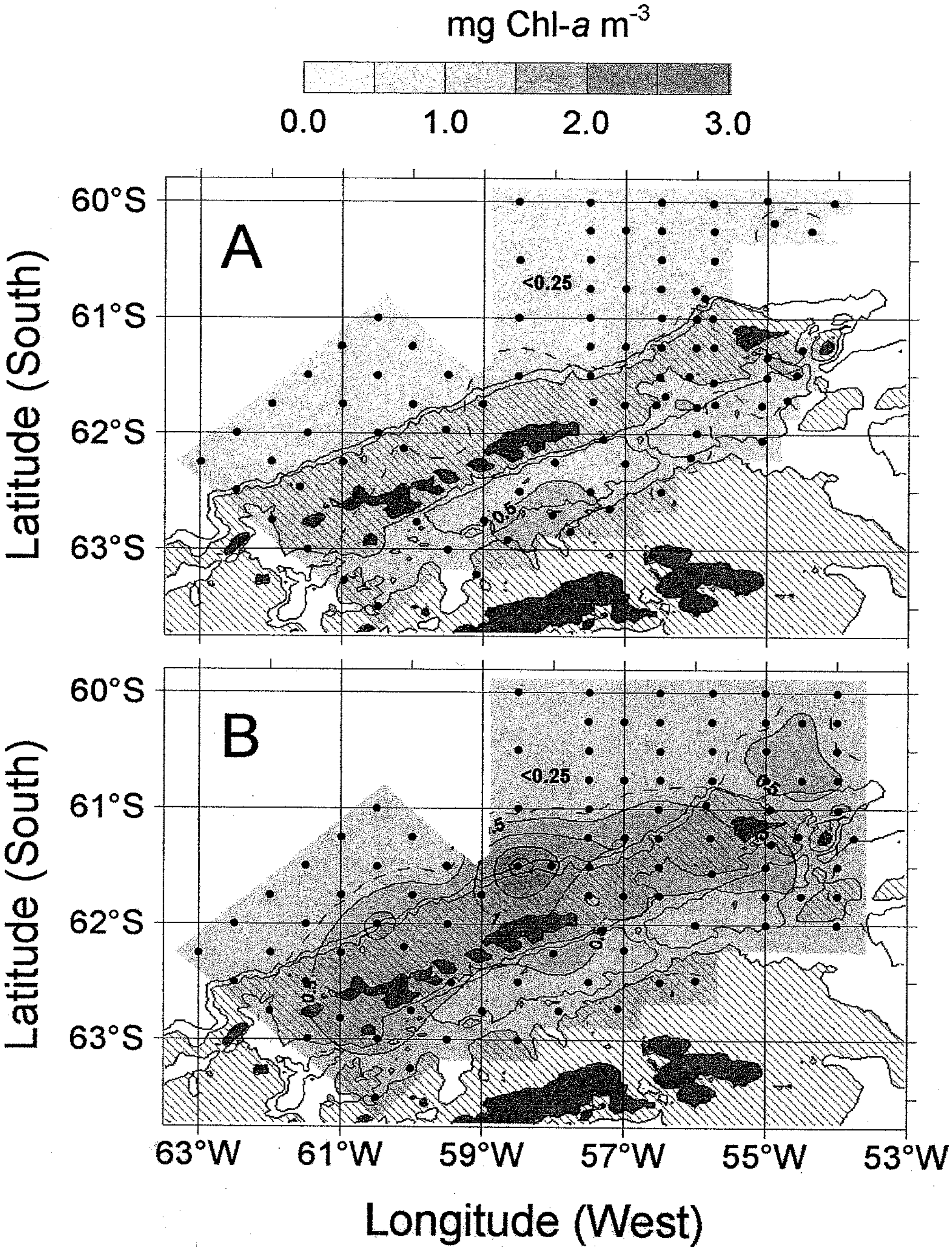


Figure 2.1. Distribution of 5 meter chlorophyll concentrations (methanol extraction) and positions of stations (filled circles) for (A) Leg I and (B) Leg II of the AMLR 2002/03 ship survey. The 0.25 mg Chl-*a* m^{-3} contour is shown as a broken line. The cross hatched areas are shelf waters with depths <500 meters. The 1000 meter depth contour is also shown (continuous line).

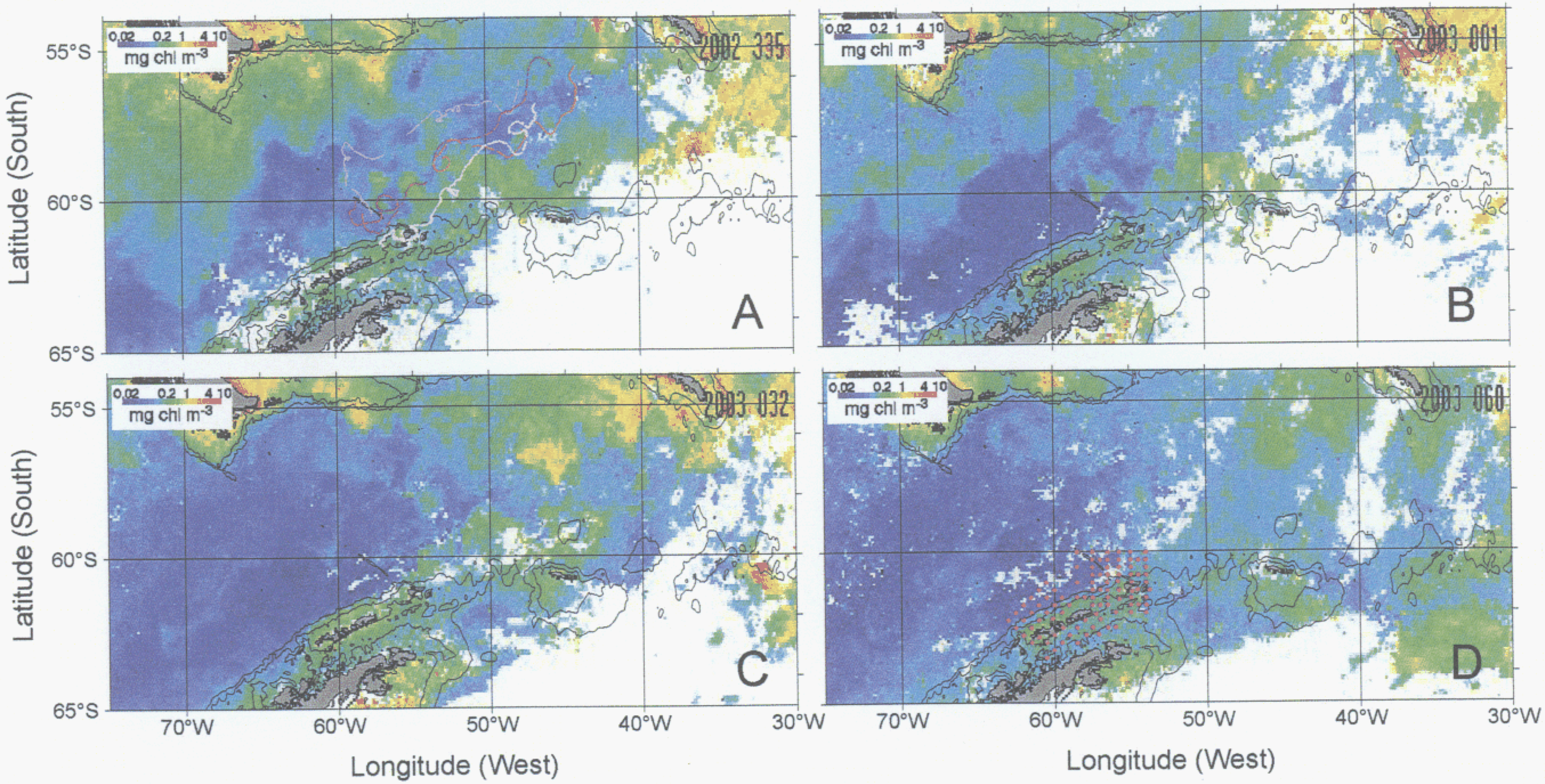


Figure 2.2. Monthly averages of surface chlorophyll (derived by SeaWiFS OC4v4 algorithm) distribution in the Bellingshausen and Scotia Seas obtained by SeaWiFS satellite for (A) December, 2002, (B) January, 2003, (C) February, 2003, and (D) March, 2003. In (A), tracks are shown of four drifter buoys released in January and distance traveled through mid-April (~4 months). In (D), station positions (pink squares) are shown for Leg II of the 2003 survey.

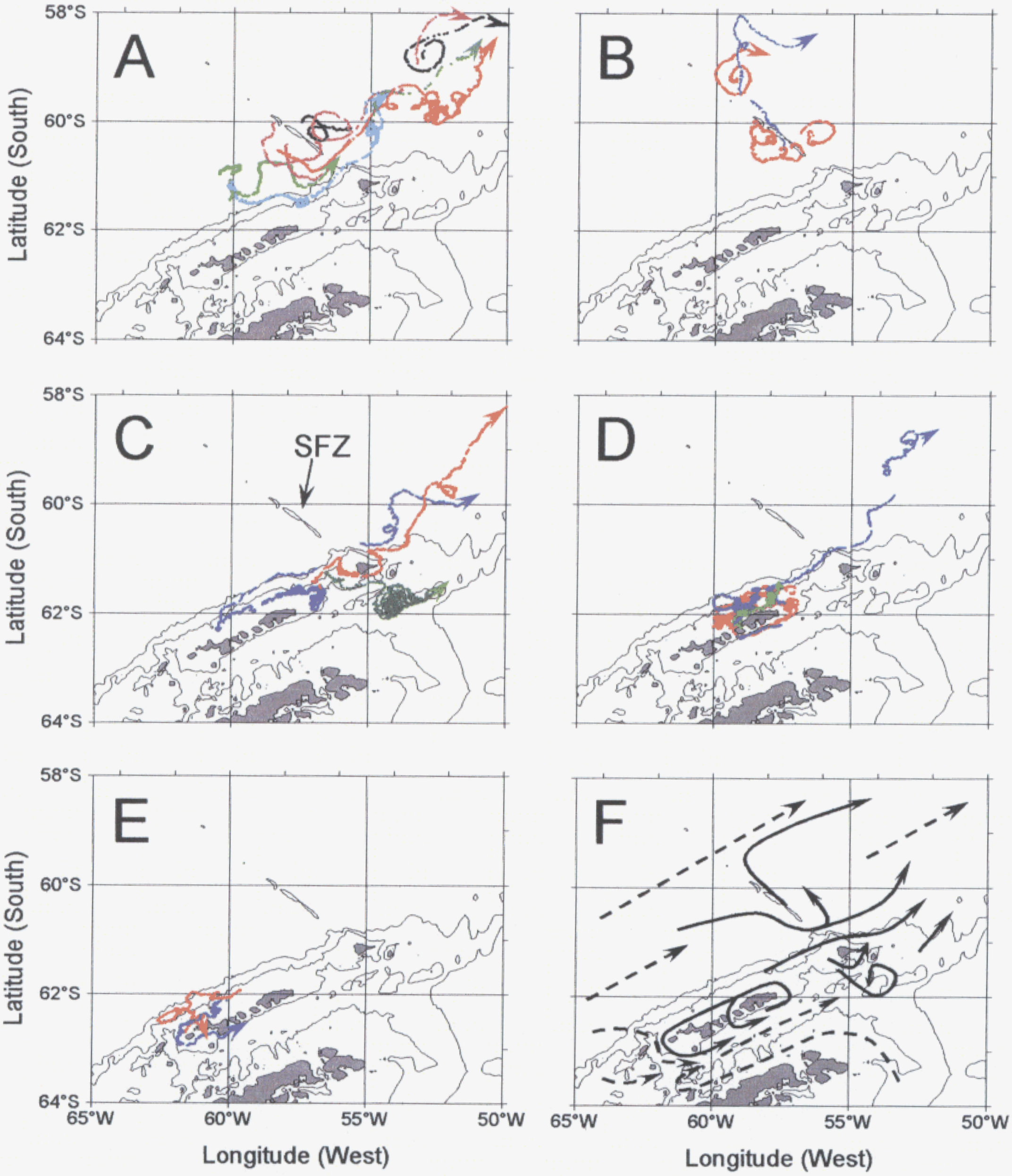


Figure 2.3. Tracks of buoys released January-March, 2003. Drifter buoys generally moved in an east northeast direction, but their tracks could be grouped into five patterns. (A) Releases north of the shelf-break in the ACC were apparently deflected by the Shackleton Fracture Zone (SFZ) so that the buoys passed between the SFZ and Elephant Island. (B) Releases near the SFZ moved northwestward. (C) Releases between King George and Elephant Island in shelf and shelf-break waters were entrained in a northeastward flowing current. In addition, one buoy entered the Bransfield Strait and apparently remained within an eddy southeast of Elephant Island. (D) Releases similar to (C) but nearer to King George Island flowed southwest and entered the Bransfield Strait between Livingston and King George Islands. (E) Releases in shelf and shelf-break waters north of Livingston Island flowed southwest and entered the Bransfield Strait south of Livingston Island. (F) Generalized patterns of surface currents (solid lines with arrows indicating direction) from this study. Broken lines with arrows indicate the general pattern of currents in the AMLR survey area interpreted from Stein (1988) and Hofmann *et al.* (1996).

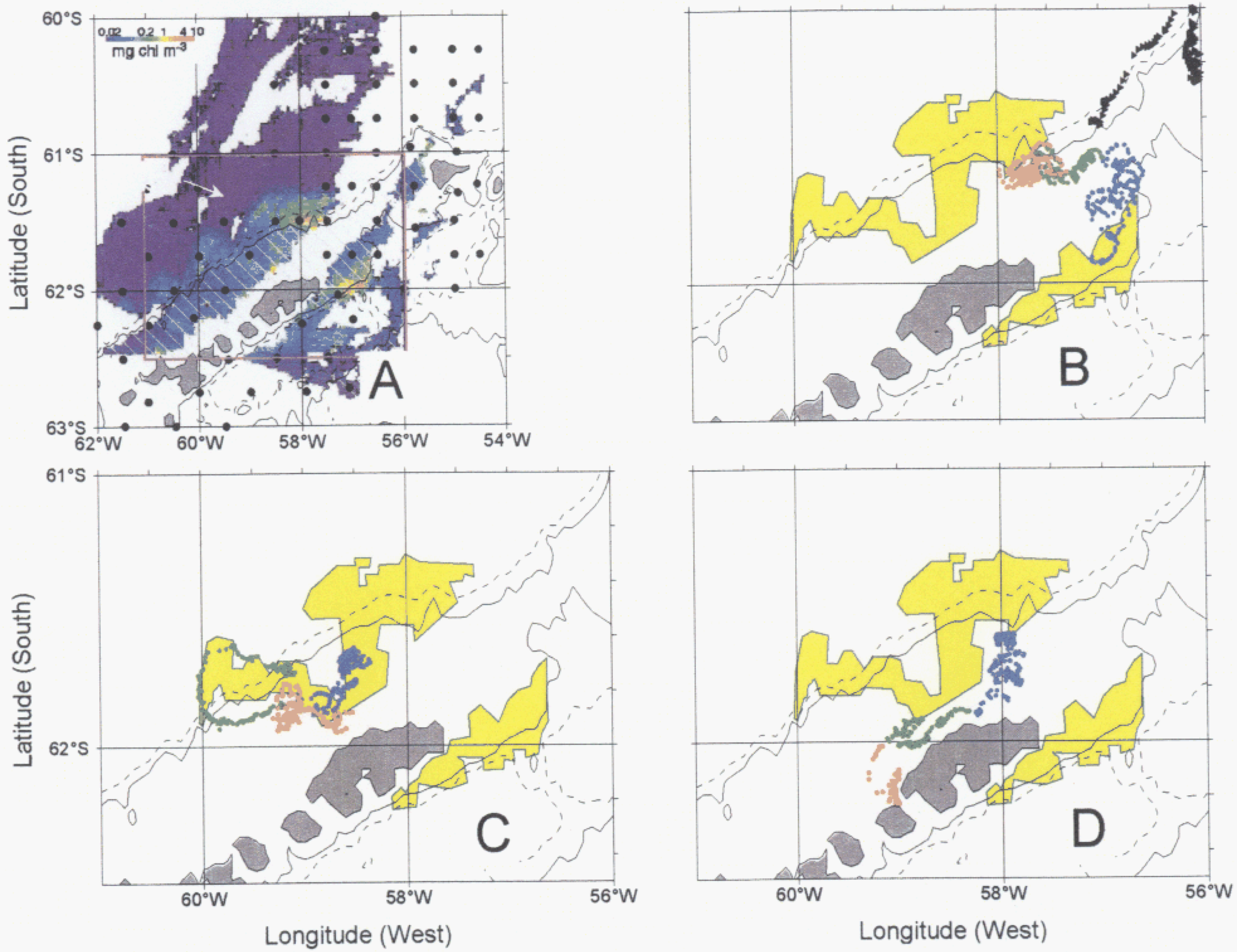


Figure 2.4. Surface currents as indicated by drifter buoy tracks in relation to location of a phytoplankton bloom in shelf waters between King George Island and Elephant Island. (A) High-resolution local area coverage (LAC) SeaWiFS image for February 10, 2003 (Julian day 41) that shows two blooms (the southern bloom is separated from the northern by a strip of low chlorophyll containing water). The bloom discussed in the text is indicated by bl. Non-colored areas are where no data were obtained due to cloud cover, and filled circles show station positions. (B, C, D) Enlarged area indicated as pink box in (A), showing buoy drifter tracks in relation to regions showing of elevated chl-a concentrations (shown in yellow). The time periods of the drifter tracks are shown as a function of time, with blue being Julian days 26-35, green for Julian days 36-45, and red for Julian days 46-55. Drifter 39110 is shown in (B), in addition to drifter 39096, the path of which (black trace) is shown for Julian days 26-35 as it drifted toward Elephant Island. Path of drifter 39131 is shown in (C). Path of drifter 39119 is shown in (D). Contour lines represent 500 (hatched area in A) and 1000 meter depth.

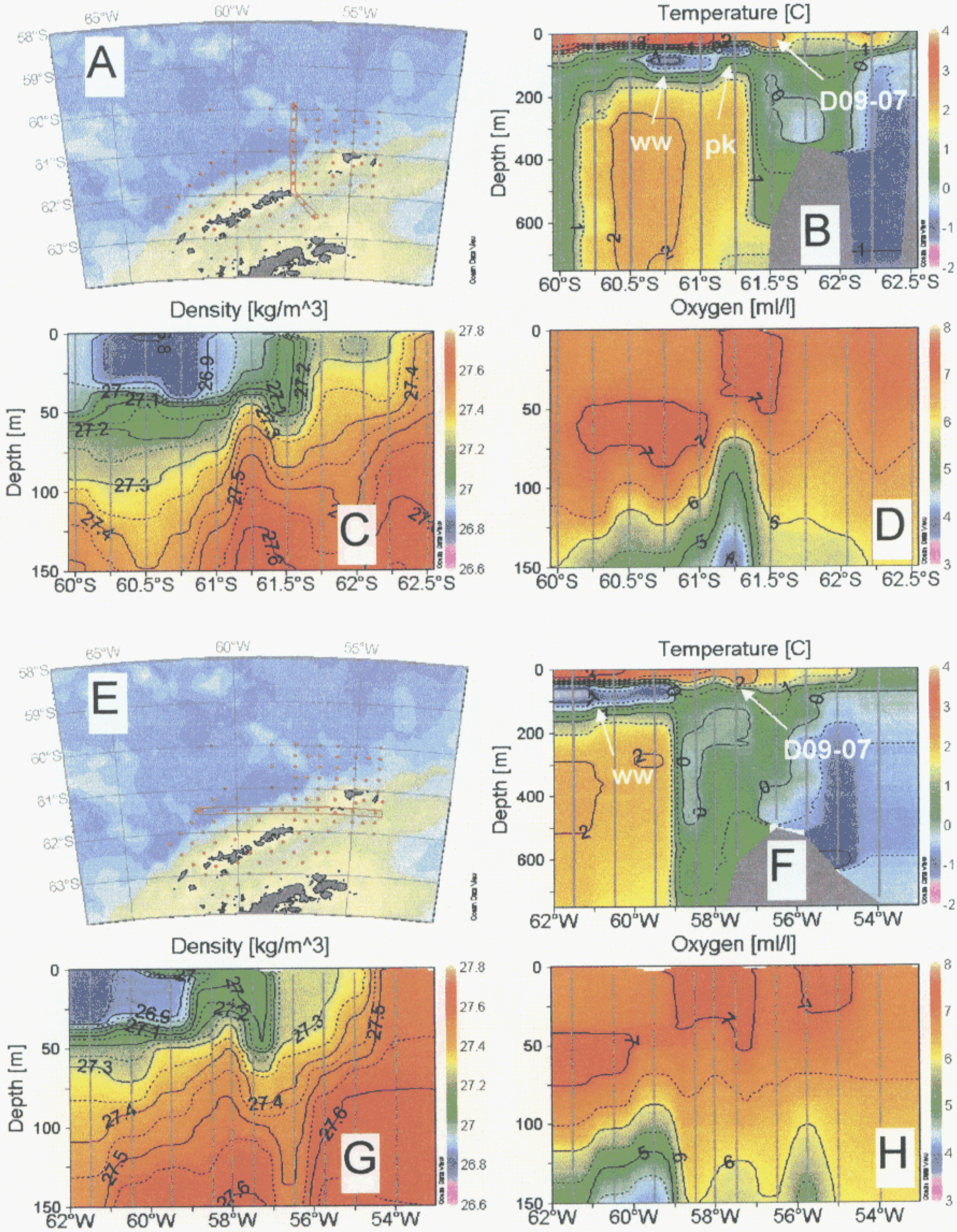


Figure 2.5. Interpolated (generated by Ocean Data View; Schlitzer, 2002) temperature (°C), density (sigma-theta, kg/m^3) and oxygen (ml/L) data of latitudinal (A-D) and longitudinal (E-H) sections through a bloom. The juncture of these sections occurred at station D09-07. Winter Water (ww) characteristic of Water Zone I (ACC) and station D0906 (pk) as discussed in the text are shown. See Figure 2.6 for phytoplankton concentrations relating to these sections.

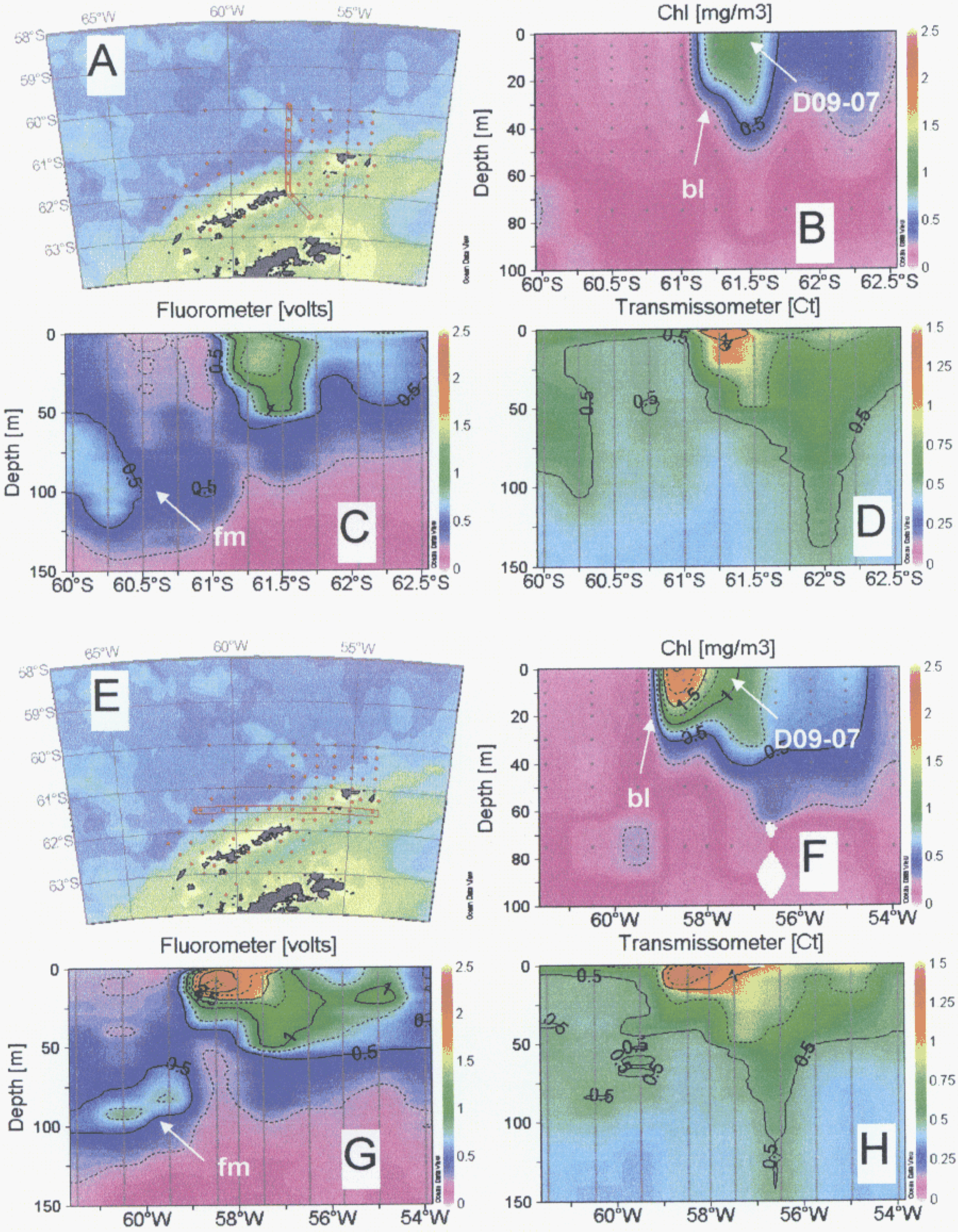


Figure 2.6. Interpolated (generated by Ocean Data View; Schlitzer, 2002) chlorophyll (from bottle samples, mg m^{-3}), fluorometric (volts) and beam transmission (C_t) data of latitudinal (A-D) and longitudinal (E-H) sections through a bloom (bl). The juncture of these sections occurred at station D09-07. Winter Water characteristic of Water Zone I (ACC) is shown with a chlorophyll fluorescence maximum (fm). See Figure 2.5 for physical properties relating to these sections

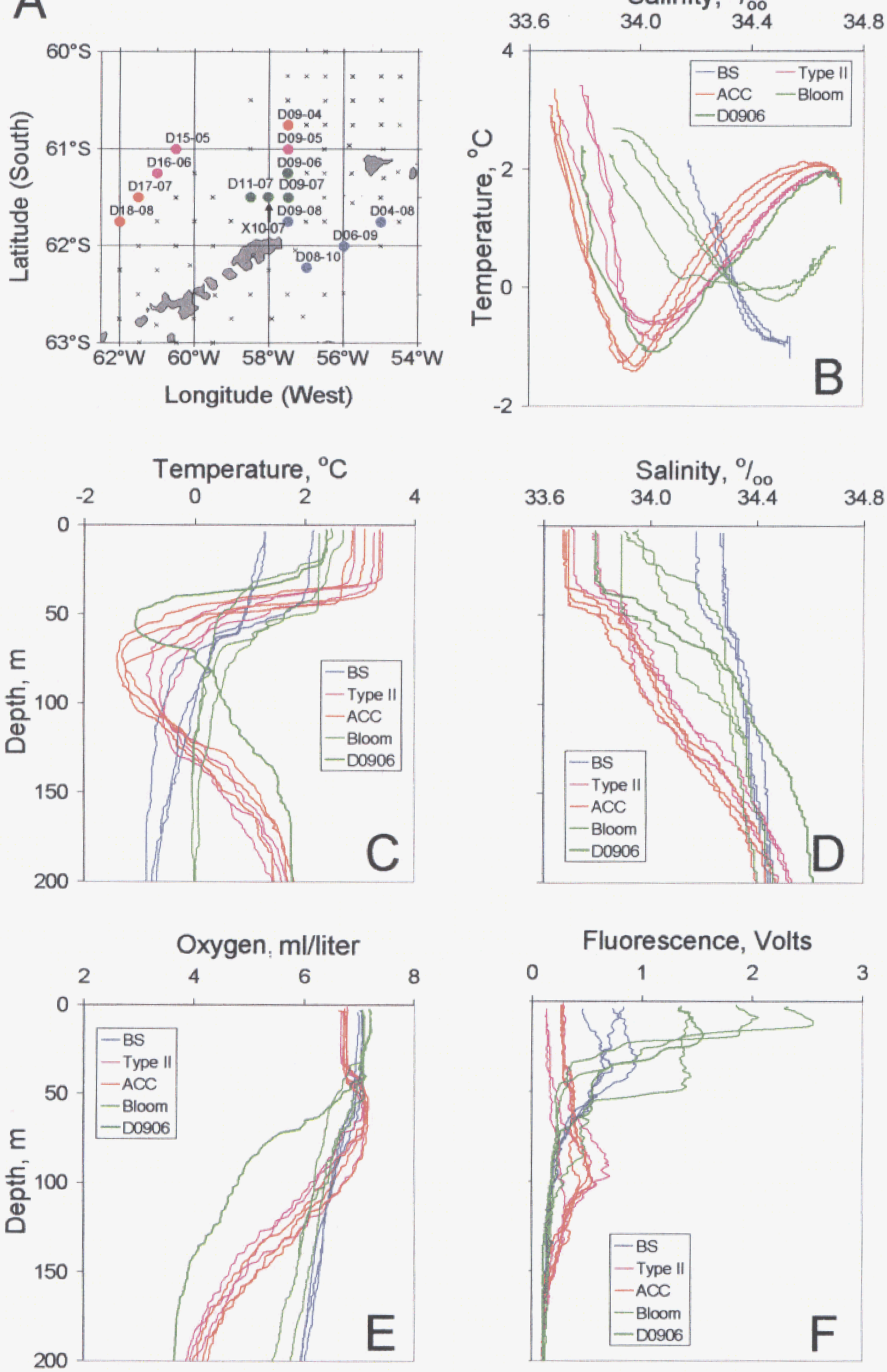


Figure 2.7. Water column characteristics at selected stations in the AMLR survey area (A) for Bransfield Strait (blue), ACC (Water Zone I, red), Water Zone II (pink) and four stations encompassing the bloom (green), with other stations indicated as X. Temperature verses salinity relationship in (B), with profiles for (C) temperature, (D) salinity, (E) oxygen, and (F) chlorophyll fluorescence. In B-F, colors represent waters as in (A), with station D09-06 (pk in Figures 2.5, 2.6) with the heavy green line. Note the different shapes of fluorescence profiles for Water Zones I and II compared with bloom and Bransfield Strait Water.

3. Bioacoustic survey; submitted by Jennifer H. Emery, Roger P. Hewitt (Leg I), Andrew Dizon (Leg I), and Daniel Doolittle (Legs II & III).

3.1 Objectives: The primary objectives during Legs I and II were to map the meso-scale dispersion of krill in the vicinity of the South Shetland Islands; to estimate their biomass; and to determine their association with predator foraging patterns, water mass boundaries, spatial patterns of primary productivity, and bathymetry. In addition, efforts were made to map the distribution of myctophids and determine their relationship with water mass boundaries and zooplankton distribution. The focus of the acoustic program during Leg III was to estimate krill abundance at each bottom trawl location.

3.2 Methods and Accomplishments: Acoustic data were collected using a multi-frequency echo sounder (Simrad EK500) configured with down-looking 38, 120, and 200 kilohertz (kHz) transducers mounted in the hull of the ship. System calibrations were conducted before and after the surveys using standard sphere techniques while the ship was at anchor in Admiralty Bay, King George Island. During the surveys, pulses were transmitted every 2 seconds at 1 kilowatt for 1 millisecond duration at 38kHz, 120kHz, and 200kHz. Geographic positions were logged every 60 seconds. Ethernet communications were maintained between the EK500 and one Windows 2000 workstation and one Windows XP workstation. Both workstations were running SonarData EchoLog. One unit was used for primary system control, data logging, processing with SonarData Echoview software, and archiving while the other logged data for use in seabed classification.

Acoustic surveys of the waters surrounding the South Shetland Islands were conducted on Legs I and II. These surveys were divided into four areas (see Figure 2 in Introduction section) (1) a 43,865 km^2 area centered on Elephant Island (Elephant Island Area) was sampled with seven north-south transects; (2) a 38,524 km^2 area along the north side of the southwestern portion of the South Shetland archipelago (West Area) was sampled with six transects oriented northwest-southeast and one north-south transect; (3) a 24,479 km^2 area south of King George Island in the Bransfield Strait (South Area) was sampled with six transects oriented northwest-southwest; (4) and a 18,151 km^2 area in the vicinity of Joinville Island (Joinville Island Area). Due to extensive sea ice accumulation, only four transects in the Elephant Island Area were completed during Leg I (Survey A) and no transects were completed in the Joinville Island Area during Leg II (Survey D). Acoustic data were continuously collected during bottom trawling operations throughout Leg III.

3.2.1 Krill Delineation (Legs I & II, Surveys A & D): Krill densities were 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). This method reduced the inclusion of other euphausiid species and myctophid fish in the biomass estimate. A ΔMVBS (mean volume backscattering strength) window of 4 to 16 was set as the acceptable difference between the 120kHz and 38kHz data for labeling acoustic target as krill. However, this preset criteria allowed the inclusion of a small amount of myctophids in the final krill density estimate. Therefore a second ΔMVBS window of –4 to 2 was established as the acceptable difference between the 120kHz and 200kHz transducer data in which backscattering values would be attributed to krill. The combined application of these two windows (three-frequency method) eliminated all acoustic targets not classified as Antarctic krill. The window ranges were selected based on models of krill backscattering strength at each frequency (Demer, in press).

3.2.2 Myctophid Delineation (Legs I & II, Surveys A & D): 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 38kHz and 120kHz. The use of the three-frequency method to further delineate myctophids was unnecessary. The two-frequency method sufficiently reduced the acoustic data to include myctophid targets only.

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):

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

Where

$$\text{NASC} = 4\pi (1852)^2 \int_0^{500} S_v \qquad (\text{m}^2/\text{n.mi.}^2)$$

And f_i = the relative frequency of krill of standard length l_i.

For each area in each survey, mean biomass density attributed to krill and its variance were calculated by assuming that the mean density along a single transect was an independent estimate of the mean density in the area (Jolly and Hampton, 1990).

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

3.3 Tentative Conclusions:

3.3.1 Leg I (Survey A): During Survey A, high abundances of krill were observed along the shelf break north of Livingston and northwest King George Islands, with the third and fourth northwestern transects exhibiting the highest krill densities (Figure 3.1). An area of greater krill abundance also extended from the northeast end of King George Island to the northeast of Elephant Island, and along the westernmost transect in the Bransfield Strait. Krill densities were calculated to be 28.58, 24.48, and 13.10 g/m^2 for the West, Elephant Island, and South Areas respectively (Table 3.1). Density estimates by transect are listed in Table 3.2.

The distribution of mean nautical area scattering coefficients (NASC) of myctophids was mapped and found to be highest along the 2000m isobath (Figure 3.2). More specifically, areas of greater abundance were observed northwest of Livingston Island, north of King George Island, west and northwest of Elephant Island. There appears to be some correlation between locations of myctophids and krill during Survey A. No obvious correlation was observed during Survey D.

3.3.2 Leg II (Survey D): A shift in the locations of high krill density areas was observed for Survey D. Krill density was relatively low in the West Area (Figure 3.1). Krill abundance was highest in most of the Elephant Island Area. Densities were calculated as 36.71, 16.86, and 20.34 g/m^2 for the West, Elephant Island, and South Areas based on the three-frequency method, respectively.

Myctophid NASC distribution remained similar to that observed during Survey A, most abundant near the 2000m isobath. However, overall NASC was less than that observed during Survey A.

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. Seabed classified datasets consume approximately 75 MB. The data are available from Jennifer H. Emery or Roger Hewitt, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037; phone/fax – (858) 546-5602/546-5608; e-mail: Roger.Hewitt@noaa.gov.

3.5 References:

Demer, D.A. In press. An estimate of error for the CCAMLR 2000 estimate of krill biomass. *Deep Sea Research II, Special Issue.*

Greene, G.H., Yoklavich, M.M., Starr, R.M., O'Connell, V.M., Wakefield, W.W., Sullivan, D.E., McRea Jr., J.E., and Cailliet, G.M. 1999. *Oceanologica Acta* 22: 663-678.

Hewitt, R.P., and Demer, D.A. 1993. Dispersion and abundance of Antarctic krill in the vicinity of Elephant Island in the 1992 austral summer. *Marine Ecology Progress Series* 99: 29-39.

Hewitt, R.P., Demer, D.A., and Emery, J.H. 2003. An eight year cycle in krill biomass density inferred from acoustic surveys conducted in the vicinity of the South Shetland Islands during the austral summers of 1991/92 through 2001/02. *Aquatic Living Resources* 16(3): 205-213.

Jolly, G.M. and Hampton, I. 1990. A stratified random transect design for acoustic surveys of fish stocks. *Canadian Journal of Fisheries and Aquatic Science* 47: 1282-1291.

Maclennan, H., and Fernandes, P. Definitions, units and symbols in fisheries scounstics. Draft 3/4/00. Contr FAST Working Group Meeting, Haarlem, April 2000. 6pp.

Maduriera, L.S.P., Ward, P., and Atkinson, A. 1993. Differences in backscattering strength determined at 120 and 38 kHz for three species of Antarctic macroplankton. *Marine Ecology Progress Series* 99: 17-24.

Table 3.1. Mean krill biomass density for surveys conducted from 1992 to 2003. 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 values are not available due to lack of data. Data values are based on the three-frequency krill delineation method (2-16dB difference between 120 and 38kHz and –4-2dB difference between 200 and 120kHz). See Figure 2 in the Introduction Section for description of each survey.

*Density measurements are based on data collected during both day and night hours. All other density measurements are based on data collected during daylight hours

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	1119	29.0
D (early March)	Elephant Island	17.00	41,673	708	36.0
1997 A (late January)	Elephant Island	50.04	41,673	2085	21.4
1998 A (late January)	Elephant Island	60.22	41,673	2509	19.4
	West	75.39	34,149	2575	30.5
	South	29.35	8,102	238	27.1
D (late February)	Elephant Island	20.84	41,673	868	16.3
	West	75.03	34,149	2563	28.7
	South	37.87	8,102	307	12.4
1999 A (late January)	Elephant Island	14.84	41,673	619	38.1
	West	16.92	34,149	578	31.6
	South	15.52	8,102	126	14.8
D (late February)	Elephant Island	13.37	41,673	557	39.8
	West	16.18	34,149	552	35.7
2000 D (late February)	West	32.51	34,149	1110	37.43
	Elephant Island	34.57	41,673	1441	28.6
	South	19.83	8,102	161	4.0
2001 A (late January)	West	4.70	34,149	161	16.4
	Elephant Island	6.65	41,673	277	19.1
	South	6.50	8,102	53	20.9
D (late February)	West	7.83	34,149	268	42.8
	Elephant Island	5.99	41,673	250	10.4
	South	2.77	8,102	22	40.1
2002 A (late January)	West	2.29	38,524	88	117.6
	Elephant Island	3.34	43,865	147	78.7
	South	2.11	24,479	351	53.3
	Joinville Island	1.05*	18,151	19	9.2
D (late February)	West	1.69	38,524	65	19.3
	Elephant Island	1.17	43,865	51	23.5
	South	1.05	24,479	26	32.9
	Joinville Island	0.51*	18,151	9	73.3
2003 A (late January)	West	28.58	38,524	1101	13.9
	Elephant Island	24.48	43,865	1044	0.2
	South	13.10	24,479	331	0.3
D (late February)	West	36.71	38,524	1414	19.3
	Elephant Island	16.86	43,865	739	23.5
	South	20.34	24,479	498	13.09

Table 3.2. Krill density estimates by area and transect for Surveys A and D, (Legs I and II). n = 1 interval = 1 nautical mile.

Elephant Island Area				
		Survey A		Survey D
	n	krill density	n	krill density
Transect 1	82	22.36	83	11.74
Transect 2	86	21.52	0	0.00
Transect 3	78	19.22	67	13.77
Transect 4	70	41.55	69	9.50
Transect 5	21	19.97	70	33.16
Transect 6	34	16.74	80	16.83
Transect 7	0	0.00	92	12.33
West Area				
		Survey A		Survey D
	n	krill density	n	krill density
Transect 1	51	28.47	21	7.98
Transect 2	30	18.42	44	62.95
Transect 3	41	48.09	36	28.64
Transect 4	53	39.78	43	63.12
Transect 5	53	26.22	20	2.18
Transect 6	35	24.02	74	24.77
Transect 7	98	20.44	80	38.92
South Area				
		Survey A		Survey D
	n	krill density	n	krill density
Transect 1	42	7.05	2	7.56
Transect 2	0	0.00	0	0.00
Transect 3	37	12.55	0	0.00
Transect 4	14	6.16	47	18.58
Transect 5	42	24.37	8	13.23
Transect 6	16	6.68	23	27.49

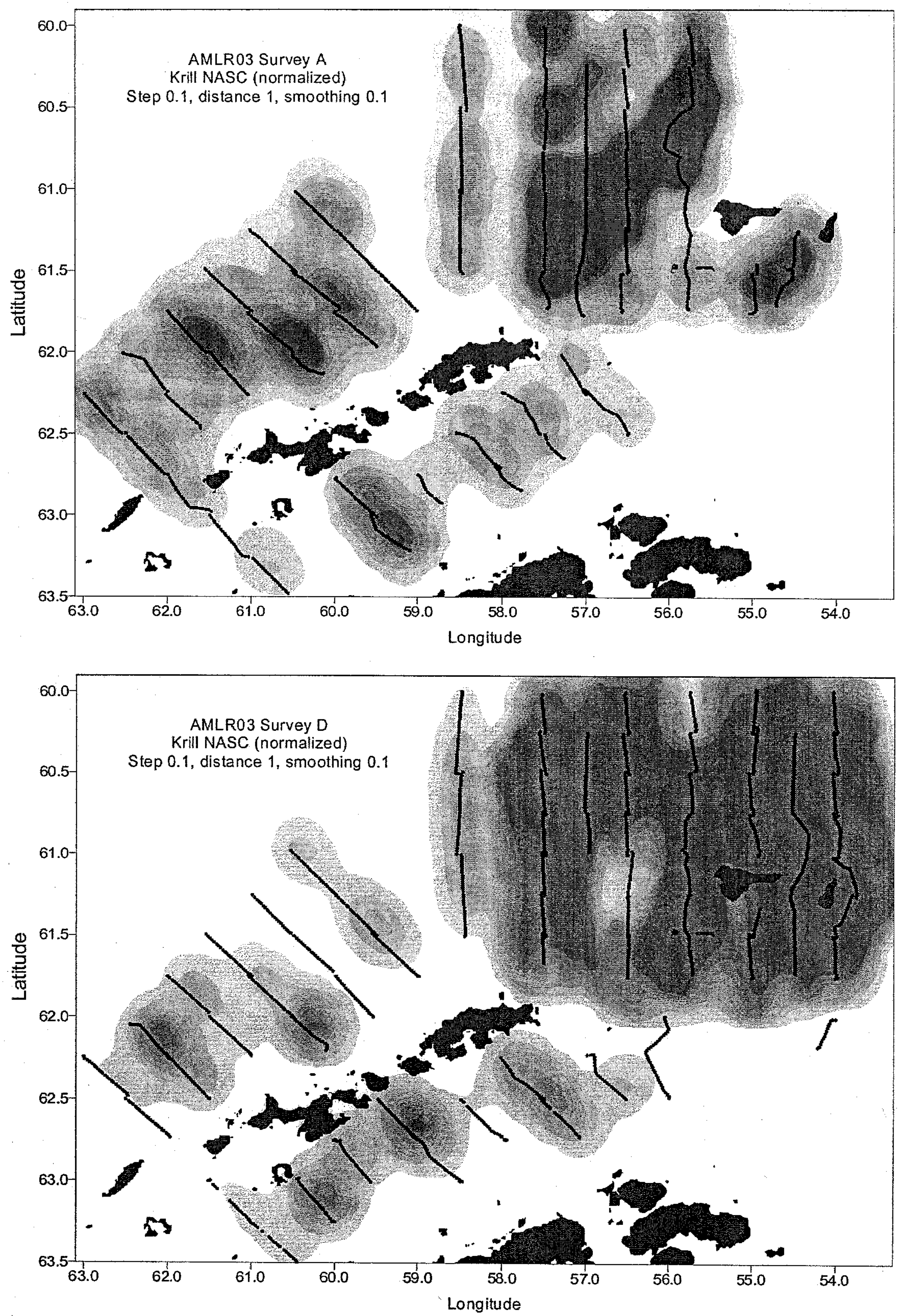


Figure 3.1. Normalized krill density for Surveys A and D at 120kHz. (Latitude is south and longitude is west).

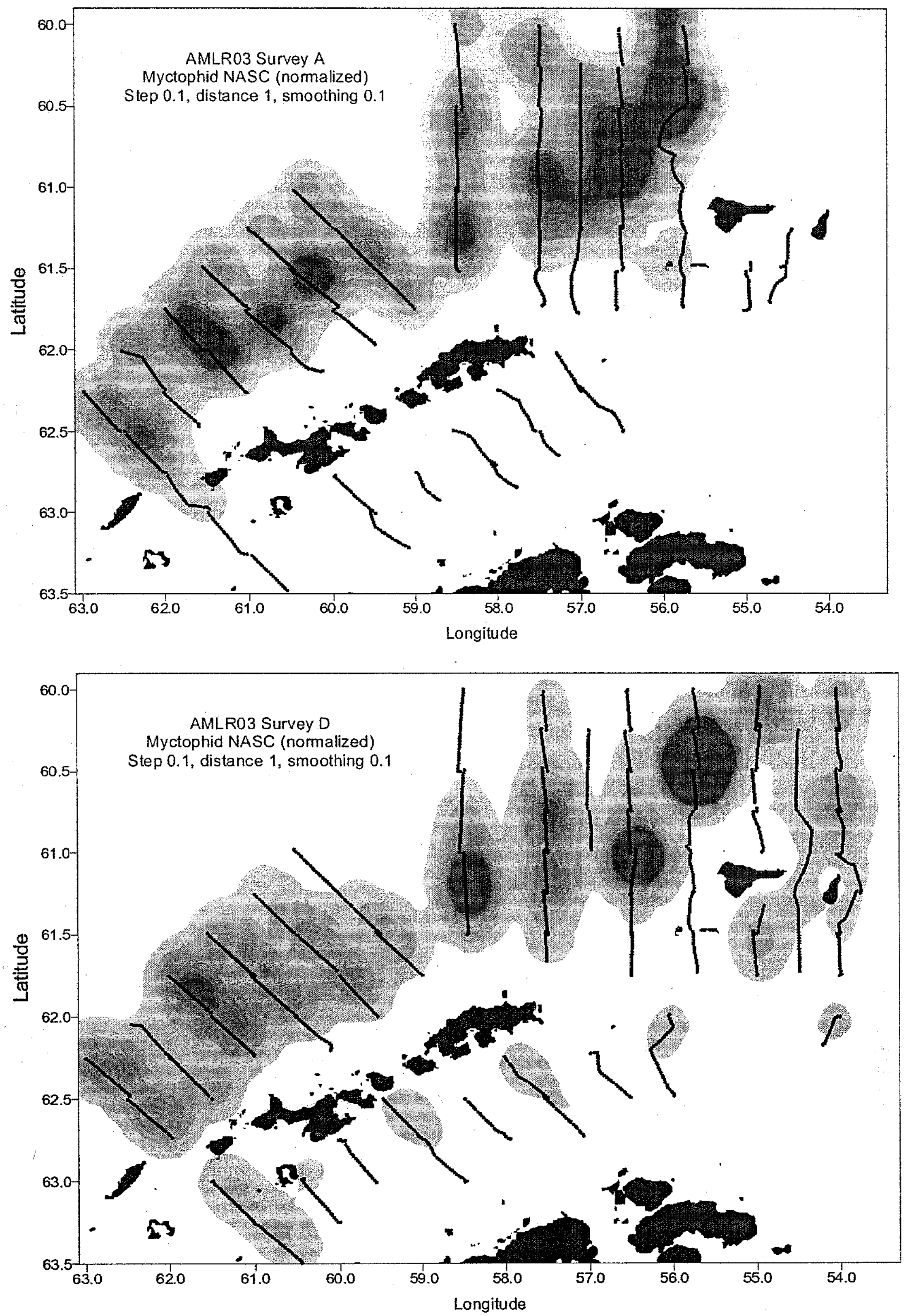


Figure 3.2. Normalized myctophid density for Surveys A and D at 120kHz. (Latitude is south and longitude is west).

4. Net Sampling: Krill and Zooplankton; submitted by Valerie Loeb (Legs I &II), Kimberly Dietrich (Leg II), Michael Force (Legs I & II), Nancy Gong (Legs I & II), Adam Jenkins (Legs I & II), Jonathan Reum (Legs I & II), Rob Rowley (Legs I & II), Catherine Ware (Leg I) and Stephanie Wilson (Legs I & II).

4.1 Objectives: Information is presented 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 and Livingston Islands. Essential krill demographic information includes length, sex ratio, maturity stage composition and reproductive condition. Information useful for determining the relationships between krill and zooplankton distribution patterns and ambient environmental conditions was derived from net samples taken at established CTD/phytoplankton stations. The salp, *Salpa thompsoni*, and biomass dominant copepod species receive special attention because their interannual abundance variations may reveal underlying hydrographic processes influencing the Antarctic Peninsula ecosystem. Results are compared to those from previous AMLR surveys to assess between-year differences in krill demography and zooplankton composition and abundance over the 1992-2003 period. Additional historical data from the Elephant Island Area are used to examine copepod species abundance and abundance relations between 1981 and present.

4.2 Accomplishments:

4.2.1 Large-Area Survey Samples: Krill and zooplankton were obtained using a 6' Isaacs-Kidd Midwater Trawl (IKMT) fitted with a 505µm mesh plankton net. Flow volumes were measured using a calibrated General Oceanics flow meter mounted on the frame in front of the net. All tows were fished obliquely from a depth of 170m or to ca. 10m above bottom in shallower waters. Real-time tow depths were derived from a depth recorder mounted on the trawl bridle. Tow speeds were ca. 2kts. Samples were collected at Large-Area survey stations during both cruise legs. Four regionally distinct groups of stations are considered (Lipsky *et al.*, this volume; Figures 4.1A & B). 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 to predator populations at Cape Shirreff and to the krill fishery that operates in this area during summer months. 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 in association with 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. Abundance information is presented for the Elephant Island, West, South and Joinville Island Areas, and for the total survey area.

(A) Krill. Krill were removed and counted prior to other sample processing. All krill from samples containing <100 individuals were analyzed. For larger samples, generally 100-200 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).

(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 $\leq$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 $\geq$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. After analysis the zooplankton samples (without salps and adult fish) 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, recent survey grid expansions into higher latitudes incorporate zooplankton taxa not encountered by earlier surveys. Most notable are areas influenced by Weddell Sea shelf water (Weddell Sea and Joinville Island) and by outflow from Gerlache Strait. Use of a more protective cod-end starting in 2002 also increased the numbers of previously unidentifiable delicate taxa such as jellies and pteropods.

4.2.3 Statistical Analyses: Data from the total survey area and four subareas are analyzed here for between-cruise and between-year comparisons. Analyses include a variety of parametric and nonparametric techniques. Among these are Analysis of Variance (ANOVA and MANOVA), 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 0.40 to 0.60. Clusters based on size characteristics utilize proportional length-frequency distributions in each sample with at least 17 krill or 50 salps. Zooplankton clusters are based on log transformed sample abundance data (N+1) for the most frequently occurring taxa. Statistical analyses were performed using *Statistica* software (StatSoft).

4.3 Results and Preliminary Conclusions:

4.3.1 Survey A, January 2003

4.3.1.1 Krill:

Frequency and Abundance (Table 4.1A, Figure 4.1A)

Postlarval krill were present in 77 of 83 (93%) samples and relatively high mean and median abundance values (respectively, 193 and 13.8 per 1000 m^3) reflect their broad distribution across the survey area. Moderately large concentrations (e.g., >500 per 1000 m^3) occurred in all areas but, among the three adequately sampled areas, abundance was greatest in the Elephant Island Area (mean and median respectively 318 and 31 per 1000 m^3). The largest concentration here (>8680 per 1000 m^3) occurred near the offshore gyral northwest of Elephant Island. Other comparatively large concentrations occurred over island shelf areas and within Bransfield Strait resulting in somewhat lower and similar abundance values within the South and West Areas (87 and 38 per 1000 m^3 means, 1 and 8 per 1000 m^3 medians).

Length and Maturity Stage Composition (Table 4.2; Figures 4.2A & B; 4.3A-D; 4.4A-D)

Krill lengths ranged from 13-54mm. Overall length distribution was a bell curve centered around 30-33mm with 50% of individuals 26-33mm. Only 10% were 40-50mm and individuals >50mm were scarce. In contrast, 11% were 13-22mm which constitutes a relatively large contribution by extraordinarily small krill. In accordance with the length distribution, juveniles comprised 45% and immature stages 40% of the total catch indicating strong recruitment success of the 2001/02 and 2000/01 year classes. Mature krill comprised only 14% of the catch. Spawning activity appeared to be seasonally delayed with sexually mature males (3b) and advanced female stages (3c-3e) together comprising only 3% of the total. The gaunt appearance of mature krill suggested that delayed spawning may have been due to poor feeding conditions.

Length and maturity stage composition differed among the four areas. Small krill ($\leq$35mm) constituted 90% of the South and Joinville Island Area catches; here <23mm individuals comprised 12-18% of the total and few if any individuals >40mm were caught. South Area lengths centered around a strong 30-33mm mode. Juveniles and immature stages dominated here comprising, respectively, 66% and 31% of the total in the Joinville Island Area and 48% and 49% in the South Area. Much broader size and maturity categories were represented in the West and Elephant Island Areas. The West Area length-frequency distribution was polymodal (19, 32, 35, 37, 40 and 44mm modes) and the 37mm median length was large relative to the other areas (29-32mm); immature (45%) and mature (36%) stages predominated here. Elephant Island Area krill were characterized by: a bimodal length-frequency distribution around 25-28mm and 35-37mm; similar numbers of juvenile and immature stages (39-42%); 19% mature forms. Although less abundant <23mm individuals constituted 7% and 8% of West and Elephant Island Area krill.

Distribution Patterns (Figures 4.5A; 4.6A,B)

Cluster analysis performed on krill lengths at 55 stations represented by $\geq$17 individuals each yielded two groups. These groups had broad, overlapping size distributions but with distinctly different distribution centers and age/maturity structures. Cluster 1 and 2 lengths, respectively, centered around 30-32mm (1-year old) and 39-42mm (2-year old) modes. Accordingly, the majority of Cluster 1 krill were juveniles (53%) and small immature stages (33%) while the majority of Cluster 2 individuals were mature (56%) and more advanced immature stages (35%). These clusters reflect strong numerical dominance of the past two year classes (2000/01 and 2001/02), and paucity of older year classes, across the survey area. Cluster 2 krill, present at 21 stations, had a fairly restricted, predominantly offshore distribution adjacent to the Shackleton Fracture zone gyre. Widely spread Cluster 1 krill occurred at 34 stations inshore of this and within Bransfield Strait.

Larval Krill Distribution, Abundance and Stage Composition (Table 4.3; Figure 4.7A)

Larval krill were present in low abundance in all four areas. Highest mean abundance was in the West and Elephant Island Areas (3.6 and 4.7 per 1000 m^3) where greatest concentrations were generally in Bransfield Strait and/or over island shelves. Only calyptopis stage 1 (C1) larvae were collected in South and Joinville Island Areas. In the Elephant Island Area C1 and C2 predominated (90% and 9%) while C1 and C3 stages predominated in the West (78% and 20%). These results indicate that, although reproductively active krill were rare in Survey A samples, spawning had begun ca. six weeks earlier (i.e., early December; Ross *et al.*, 1988) and some segment of the population was participating in normal seasonal spawning activity.

4.3.1.2 *Salpa thompsoni*:

Frequency and Abundance (Table 4.1A; Figure 4.8A)

Salpa thompsoni was present in 68 (82%) of Survey A samples with mean and median abundance values, respectively, 63 and 9.7 per 1000 m^3. The four largest catches had 1200-2400 individuals (420-775 per 1000 m^3); two were in western Bransfield Strait, two well offshore of Elephant Island. Large standard deviations associated with mean and median abundance values in the South (79 and 2.4 per 1000 m^3) and Elephant Island Areas (52 and 8.7 per 1000 m^3) reflect increased patchiness there relative to the West (mean 59 and median 34 per 1000 m^3). More even salp distribution occurred within Zone 1 ("oceanic") water offshore of the South Shetland Islands.

Composition, Size and Distribution (Figure 4.9)

Only 2% of all salps collected were the overwintering solitary stage. Fewest solitaries (1%), all large individuals >95mm, were in the South; greatest numbers of solitaries (>2%), almost all recently spawned individuals <20mm, were in the Elephant Island Area. Aggregate lengths ranged between 4 and 53mm with a 26mm median. Largest sizes were in the West Area where the median length was 30mm compared to 26mm in the Elephant Island Area and 20mm in the South. Given an estimated 0.44mm per day growth rate, peak aggregate chain production occurred between the last week of November (West) and mid-December (South). Cluster analyses performed on length distributions in all samples with >60 salps but no coherent or meaningful spatial patterns were observed.

4.3.1.3 Zooplankton and Micronekton Assemblage:

Overall Composition and Abundance (Tables 4.4, 4.5A)

The 83 Survey A samples yielded a total of 103 taxonomic categories. Diversity was slightly less in the West vs. other Areas (median 21 vs. 24 taxa per sample). Copepods and the euphausiid *Thysanoessa macrura* were present in all samples, ranked 1 and 2 in mean abundance and together comprised 2/3 of total mean abundance. Among the copepods coastal species *Metridia gerlachei* had greatest mean abundance and alone contributed 27% of total mean zooplankton abundance. However *M. gerlachei* was extremely patchy and had a low median abundance value (6.6 per 1000 m^3) relative to *Calanoides acutus* and *Calanus propinquus* (38 and 51 per 1000 m^3). Krill and salps followed *T. macrura* in mean abundance, respectively contributing 15% and 5% of the total. Other relatively abundant and frequent taxa were the pteropod *Limacina helicina*, chaetognaths and "ice krill" *Euphausia crystallorophias*.

Copepods, specifically *M. gerlachei,* contributed the most to total mean zooplankton abundance in all four areas; among the copepod species greatest median abundance was exhibited by *C. acutus* in the South and Joinville Island Areas and *C. propinquus* in the West and Elephant Island Areas. Relatively large concentrations of postlarval *T. macrura* were fairly evenly distributed across the entire region and median abundance of this species exceeded that of total copepods in the South and West Areas. Mean abundance of postlarval krill and *T. macrura,* respectively, ranked 2 and 3 within the Elephant and Joinville Island Areas and 4 and 2 within West and South Areas. Abundance relations of other species reflected coastal vs. offshore source areas: higher mean abundance (rank 3 or 4) was exhibited by *S. thompsoni* in the West and Elephant Island Areas, *E. crystallorophias* in the South and *L. helicina* in the Joinville Island Area. Significant area abundance differences were primarily exhibited by coastal species: *E. crystallorophias, Beroe forskalli, Diphyes antarctica* and sipunculids all had significantly greater concentrations in the South vs. West and Elephant Island Areas (ANOVA, $P<0.05$). The amphipod *Themisto gaudichaudii* was significantly more abundant in the West vs. South and Elephant Island Areas ($P<0.01$).

Distribution Patterns (Table 4.6; Figures 4.10A & B, 4.11)

Cluster analysis applied to frequent taxa ($\geq$20% of samples) resulted in three distinct groups. These were represented at 27 coastal (primarily Bransfield Strait) stations, 34 oceanic (primarily Drake Passage) and 22 intermediate (transition) stations over or downstream of island shelves. Overall mean abundance of the transition group was an order of magnitude greater than the others. Major contributors were *M. gerlachei* (41%), *T. macrura* (16%) and krill (15%). Within this cluster, *T. macrura, S. thompsoni, C. propinquus, M. gerlachei,* other copepods, *Euphausia frigida, Cyllopus lucasii* and *Beroe forskalli* abundance was significantly higher than in coastal and oceanic clusters (ANOVA, $P<0.01$). Coastal assemblage dominants were krill (26%), *C. acutus* (16%), *E. crystallorophias* (11%), *T. macrura* (10%) and *L. helicina* (7%). Ocean assemblage dominants were *T. macrura* (45%), *S. thompsoni* (10%), *C. propinquus* (8%) and *C. acutus* (7%). Amphipod species abundance within the ocean cluster (*Themisto gaudichaudii, Primno macropa, Vibilia antarctica* and *Cyllopus magellanicus*) was significantly higher than in the coastal cluster (ANOVA, $P<0.05$). In contrast, pteropod (*L. helicina, Clione limacina*), siphonophore (*Diphyes antarctica*) and sipunculid abundance in the coastal cluster was significantly higher than offshore. Drifter movements during the survey period suggest that elevated abundance of transition cluster taxa may result from complex circulation patterns over and downstream of the South Shetland Island shelf area (i.e., localized concentration and retention by gyres and fronts)

4.3.2 Survey A Between-Year Comparisons:

Krill (Tables 4.3, 4.7, 4.8, 4.9; Figure 4.12)

January 2003 krill abundance in the Elephant Island Area was the highest ever recorded during AMLR surveys with mean and median values ca. three times the highs of 1996 and one to two orders of magnitude larger than the 1995 and 1999 lows. The size and maturity stage composition indicates that this extraordinarily high abundance results from two successive years of strong recruitment success. The length-frequency distribution was most similar to that of 1996 (D_{max}=19) while the overall demographic composition (i.e., proportions of juvenile, immature and mature stages) was most like 1996 and 1992 (PSI's 79 and 75). Mean krill carbon biomass in the Elephant Island Area, attributed to 1 and 2 year-old individuals, was four to six times the highs of 1996 (small 1 year-old juveniles) and 2001 (mature 45-60mm individuals).

The low proportions of large (i.e., >50mm) and reproductively active krill (i.e., stage 3c-e females and 3b males) are also unprecedented in AMLR collections. These observations suggest that seasonal onshore migrations and reproductive behavior were delayed relative to other years. This is possibly related to the extensive and prolonged (May to mid-November) winter sea ice cover during 2002.

Although typically uncommon, similar proportions of very small juveniles (9-11% <23mm) were observed in all four areas during 2002 and primarily the West Area (13%) during 1998. Smaller proportions (4-6%) were observed in 1992, 1996 and 1997. Krill of approximately this size characterize 1 year-old juveniles in the south-east and north-west Weddell Sea during austral summer (Siegel 1987; Siegel *et al.*, 2002), apparently associated with pack-ice. As Brinton (1991) surmised, their variable presence in the AMLR survey area could result from advective processes favoring enhanced input from the Weddell Sea. It is also possible that this size group is becoming more frequent and, in addition to advective processes, is reflecting variable recruitment success of a developing Western Weddell Sea spawning stock associated with retreat of the Larsen ice shelf. Interestingly, small juveniles were also observed in the Bellingshausen Sea (LTER) area during 1996, 1997 and 2002 (Siegel *et al.*, 2002) suggesting production within, and advection from, higher latitude source areas there.

Larval krill mean abundance was similar to that of January 1996 and 1998; these values were an order of magnitude greater than the 1998 low and one to two orders of magnitude less than during the 1999-2002 surveys. Substantially greater proportions of C1 vs. later stages during 2003 may reflect a delayed or pulsed spawning season relative to 2001 and 2002.

Salps (Tables 4.7, 4.9; Figure 4.13)

Salpa thompsoni mean and median abundance values in the Elephant Island Area were an order of magnitude smaller than observed during 1997-2002 surveys. These and similar January 1992 values were slightly larger than the lows encountered in 1995 and 1996. The overall aggregate stage length-frequency distribution was quite similar to that during January 2001 (D_{max}=4) suggesting similar production periods with a late November to mid-December peak. In both years largest sizes and earliest seasonal production was in the West (predominantly oceanic) Area suggesting an offshore source.

Salp carbon biomass was of the same order of magnitude as during January 1995 and 1996 and, like abundance, was one to two orders of magnitude less than during the 1997-2002 period. The extremely low salp:krill biomass ratio (0.03) was the same as during 1995.

Zooplankton and Micronekton (Tables 4.7, 4.10, 4.11A, 4.12, 4.13A)

Copepods typically dominate AMLR zooplankton samples. Notable exceptions were in 1993, 1994 and 1998 when salps were the most abundant taxon during January-February surveys. With the exception of January 2002, when copepods were extremely abundant, their median value and proportion of total mean zooplankton abundance in the Elephant Island Area during copepod-dominated periods have been fairly consistent at 250-400 per 1000 m^3 and 40-60% total mean abundance. These values are markedly higher than during salp years (<25 per 1000 m^3, <5% total mean abundance). Coastal *M. gerlachei* typically contributes the greatest proportion of mean copepod abundance in this area and has a relatively high median abundance; the median value during January 2003 was notably small reflecting an extremely patchy distribution compared to *C. acutus* and *C. propinquus*.

The large contribution of postlarval krill to total mean zooplankton abundance (25% and second only to total copepods) is unprecedented in the AMLR data set. Postlarval *T. macrura* similarly followed krill in overall mean abundance during 1996. While absolute abundance values of this euphausiid species were the largest observed over the 1992-2003 period they, along with relative abundance (19%), were not markedly higher than those during the 1998 salp year. Also like 1998, larval *T. macrura* were virtually absent from January 2003 samples. As with abundance the relative contribution by salps to total mean zooplankton abundance in 2002 and 2003 (ca. 5%, rank 3-4) was slightly greater than during January-February 1995 and 1996 (ca. 2%, rank 5-6). Unusually large proportions of coastal *Limacina helicina* (>2%, rank 5) were also observed in January 1996 and likewise are associated with extensive sea ice the preceding winter.

Relatively low PSI values (e.g., <70) indicate that taxonomic composition and abundance relations in the Elephant Island Area during Survey A differed from previous years; greatest similarity was with 1996 and 1997 (PSIs 64-67).

4.3.3 Extra January Stations:

Subsequent to large Survey A 12 additional samples were collected along transects crossing the Elephant Island shelf (n=5) and offshore Shackleton fracture zone gyre northwest of Elephant Island (n=7). The samples were processed and data logged. Results are not presented here because (a) the data collected from the Elephant Island Area cannot be included as part of the synoptic survey effort and (b) the numbers of offshore samples are not sufficient to provide meaningful results relative to the circulation system. These data are available on request.

4.3.4 Survey D, February-March 2003

4.3.4.1 Krill:

Frequency and Abundance (Table 4.1B, Figure 4.1B)

Postlarval krill were present in 86 (90%) of Survey D samples with respective mean and median values of 152 and 9 per 1000 m^3. Greatest concentrations were in the South Area where four samples (southern Bransfield Strait) had estimated abundance >1000 per 1000 m^3 and the mean and median values were 412 and 34 per 1000 m^3. The West and Elephant Island Areas had similar means (ca. 94 per 1000 m^3) but median catch size was larger in the West vs. Elephant Island Area (21 vs. 9 per 1000 m^3) due to a more even (less patchy) distribution.

Length and Maturity Stage Composition (Table 4.2; Figures 4.14, 4.15A-D, 4.16A-D)

Lengths ranged from 15-54mm with a 33mm median and 90% of individuals <45mm. Most krill were immature (46%) or juvenile (32%); mature forms made up only 22%. Like Survey A, these results indicate strong 2000/01 and 2001/02 year class success. Very few krill were reproductively active: <2% were gravid and spent (3d and 3e stage) females and 7% were 3b males. The paucity of large mature krill could result from a combination of: (a) attrition due to age-related mortality of the highly successful 1995/96 year class (now 7 years-old); (b) poor recruitment success of subsequent (i.e., 1996/97 through 1999/00) year classes; and (c) delayed onshore migration of older krill. The gaunt appearance observed during Survey A persisted through Survey D and the few gravid females collected appeared to have made only minor investments in egg production. These results suggest a continuation of poor local feeding conditions and minimal spawning activity.

Largest krill were in the West where the median was 43mm and 24% of individuals were >47 mm. Over 64% of the West Area catch was represented by mature krill and reproductively active females (9% stage 3d and 3e) and males (30% 3b) were primarily located here. Small forms prevailed in the South and Joinville Island Areas where median lengths were 29-30mm and ca. 90% were <40mm. Juveniles and immature stages dominated and were similarly represented (each 42-48% total krill). Elephant Island Area krill had a median length of 35mm with 90% of individuals <44mm in length. Immature stages were by far the most abundant category (52%) followed by mature (27%) and juvenile (21%) stages. In contrast to the West Area <10% of krill here were reproductively active.

Distribution Patterns (Figures 4.5B, 4.6C & D)

Cluster analysis applied to krill length data from 57 stations yielded three groups more or less demonstrating a coastal-oceanic separation of size/maturity categories. Median lengths within Clusters 1, 2 and 3, respectively, were 29, 36 and 44mm. Cluster 1 represented primarily juvenile (55%) and immature (35%) krill and was distributed in areas influenced by Bransfield Strait water. Large Cluster 3 krill were predominantly mature forms (5% advanced female and 34% male 3b stages) located within or adjacent to oceanic (Zone 1) water. Intermediate sized Cluster 2 krill, mostly (58%) immature individuals, appeared to be associated with gyres and eddies over and around island shelf regions.

Larval Krill Distribution, Abundance and Stage Composition (Table 4.3; Figure 4.7B)

Small numbers of larval krill were again encountered in all four areas. Excluding sparsely sampled Joinville Island Area, larvae were most frequent (42% of samples) and abundant (mean of 6.1 per 1000 m^3) in the Elephant Island Area. Only calyptopis stage 1 (C1) larvae were collected in the West and Joinville Island Areas; C1 (79%) and C2 (21%) stages were present in the South Area. Although C1 and C2 stages also predominated in the Elephant Island Area (63% and 23%) the presence of Furcilia 1 and 2 stages here (14%) suggests discontinuous spawning activity after an early pulse initiated around early December.

4.3.4.2 *Salpa thompsoni*:

Abundance (Table 4.1B; Figure 4.8B)

Salpa thompsoni was present in 77% of Survey D samples with overall mean and median values of 79 and 7 per 1000 m^3, respectively. Greatest frequency of occurrence (88%) and mean and median abundance (133 and 20 per 1000 m^3) were in the West Area; the South and Elephant Island Areas were characterized by lower and similar values (67-75% of samples, means 61 per 1000 m^3 and medians 2-7 per 1000 m^3). Largest concentrations (1145-3186 individuals, 436-1237 per 1000 m^3) were primarily located offshore of island shelves.

Maturity Stages, Size and Age (Figure 4.9)

Aggregates comprised 93% and solitaries 7% of the total salp catch. Solitaries were proportionally most abundant in the South where they made up 13% of the total compared to 5-8% in the West and Elephant Island Areas. South Area solitaries were represented by a broad size range; 25% were >50mm in length suggesting a late seasonal presence of mature forms in surface waters relative to West and Elephant Island Areas. This could presage a late-summer pulse of aggregate production and consequent production of an elevated overwintering seed population in Bransfield Strait. Elevated concentrations of predominantly small solitaries in the West and Elephant Island Areas (respectively, 50% and 72% ≤ 25mm) resulted from recent spawning by the aggregates. Overall aggregate lengths ranged from 4-63mm with a 33mm median. Generally smaller sizes predominated in the West Area (30mm median, 80% ≤36mm) suggesting a prolonged period of elevated chain production here relative to the other two areas. Aggregate length distribution in the South Area (17-63mm range, 37mm median) suggests minimal chain production during the previous month. As for Survey A cluster analysis applied to length distributions in samples with ≥60 salps did not produce meaningful spatial patterns.

4.3.4.3 Zooplankton and Micronekton Assemblage:

Overall Composition and Abundance (Tables 4.4, 4.5B; Figures 4.10C & D)

A total of 98 taxonomic categories were collected during Survey D. Copepods dominated and comprised 69% of total mean abundance. *Metridia gerlachei* was by far the most abundant copepod species with mean and median values of 1,024 and 164 per 1000 m^3. "Other" small copepods, *C. acutus* and a small form tentatively identified as *Racovitzanus antarcticus* were also relatively abundant. Postlarval *T. macrura* ranked second to total copepods and, with mean and median values of 293 and 202 per 1000 m^3, it rivaled *M. gerlachei* as the numerically dominant species. Postlarval krill, chaetognaths and salps followed in overall mean abundance.

Total copepod abundance in the West Area was surprisingly small relative to the other areas, and concentrations of *C. acutus* and *C. propinquus* there were significantly smaller than in the Elephant Island Area (ANOVA, $P<0.05$). Taxonomic diversity in the West (20 taxa per tow) was also significantly lower than in the South and Elephant Island Areas (22-23 taxa per tow; $P<0.05$). While postlarval *T. macrura* abundance ranked second to copepods across the survey area, their abundance in the South was significantly greater than in the Elephant Island Area ($P<0.05$). Larval *T. macrura* were scarce in all four areas. *Euphausia crystallorophias* concentrations in the South were again significantly greater than in the West and Elephant Island Areas ($P<0.01$).

Distribution Patterns

Cluster analysis resulted in two distinct groupings, however their complex distribution patterns, along with abundance and composition differences, suggested a strong bias by diel vertical migrations. This is supported by the fact that all but seven of the 62 stations represented by Cluster 1 were sampled during the day while 26 of 33 stations represented by Cluster 2 were sampled at night. Significant day-night abundance differences were observed for postlarval *T. macrura, M. gerlachei, C. propinquus*, *Pareuchaeta antarctica,* other copepods, *E. frigida, E. triacantha* (all with larger night concentrations; ANOVA, $P<0.05$) and *E. frigida* larvae (greater day concentrations; $P<0.05$).

4.3.5 Survey A and D 2003 Comparisons:

Krill (Tables 4.2, 4.3; Figures 4.1, 4.5, 4.6, 4.7)

Krill demonstrated a slight overall abundance decrease, geographical and length-frequency distribution and maturity stage composition shifts between Surveys A and D that are associated with seasonal ontogenetic migration from Drake Passage and the Elephant Island Area to higher latitude, coastal environments. Greatest concentrations relocated from the Elephant Island to South and West Areas as larger, older individuals moved southward across, and small juveniles migrated away from, the survey area. Decreased abundance of <23mm individuals was associated with this migration, especially in the West Area where they contributed <1% vs. 7% of total krill the previous month. Modest proportions of these persisted in South, Elephant and Joinville Island Areas (5-8%).

Most dramatic changes in length-frequency distribution and maturity stage composition occurred in the West Area which included significantly greater proportions of 40-55 mm krill (D_{max}=38.9, P=0.05) and substantially increased proportions (64 vs. 36%) of mature stages during Survey D. Although overall spawning activity remained minimal across the survey period the proportions of advanced female stages in the West Area increased from 10 to 31% with the seasonal influx of large mature individuals. While area-wide larval krill abundance did not demonstrate a seasonal abundance increase the greater frequency of occurrence, increased mean abundance and developmental advances in the Elephant Island and South Areas balanced losses from the West and reflect some degree of local reproductive success.

Salpa thompsoni (Tables 4.4, 4.7, 4.9; Figures 4.8, 4.9)

Total salp abundance was remarkably stable across the survey period; the only apparent seasonal difference was a shift in increased patchiness from the South to West Area from Survey A to D. Mean and median values within the Elephant Island Area were virtually identical between the two surveys. Greatest changes occurred through enhanced seasonal production of small overwintering solitaries (particularly in the South Area), late seasonal appearance of large mature solitaries in the South Area, and significantly larger aggregate length-frequency distribution across the entire survey area (D_{max}=28.1; P<0.01). The primary modal length of aggregates increased from 25 to 36mm, an increase of 11 mm, over the 29 days between survey median dates. This provides a 0.38mm per day estimated growth rate. As a consequence of increased salp length and decreased krill abundance in the Elephant Island Area the salp:krill carbon biomass value increased an order of magnitude (from 0.03 to 0.20) between the two surveys.

Zooplankton and Micronekton (Tables 4.4, 4.7, 4.11; Figure 4.10)

Total zooplankton abundance exhibited a significant seasonal increase (ANOVA; P<0.01) due to increased numbers of copepods (specifically *M. gerlachei, R. gigas* and "others") and chaetognaths. Significant decreases occurred for overall diversity (numbers of taxa per tow) and abundance of pteropods *Limacina helicina* and *Clione limacina,* amphipods *Hyperiella dilatata* and *Cyllopus lucasii* and *Lepidonotothen larseni* larvae (P<0.05 in all cases). *Cyllopus magellanicus* and *E. frigida* had significant abundance increases during Survey D, the latter probably due to its diel migratory behavior and longer periods of darkness. Copepods increased from 48 to 69%, and *M. gerlachei* alone from 27 to 46%, of total mean zooplankton abundance. Postlarval *T. macrura* and krill remained second and third most abundant taxa after copepods, but abundance relations of other common taxa changed. These abundance shifts resulted in moderately low PSI (percent similarity index) values of 77 (pooled copepods) and 73 (individual copepod species).

4.3.6 Survey D Between-Year Comparisons:

Krill (Tables 4.3, 4.7, 4.8, 4.9)

Although mean krill abundance in the Elephant Island Area ranked third behind February-March 1998 and 1996 individuals were more evenly distributed and the resulting median value was the highest recorded since 1992. Overall maturity stage composition resulting from two successive years of good recruitment success was most similar to that of 1993 (PSI=82) due to the large contribution by two year old immature stages (ca. 50% of the total), however it also resembled that of 1992 due to the relatively large proportions of one year old juveniles (PSI=75). In terms of reproductive condition, with relatively small proportions of actively spawning individuals, this season resembled 1992, 1993 and 1998 when spawning appeared to be delayed or deferred. The relative abundance of large krill is the lowest in the time series: only 11% of the Elephant Island krill were >43mm (≥4 years old) compared to previous lows of 28-32% in 1992, 1993 and 2002. This may in large part be due to age-related mortality and poor recruitment success following the 1995/96 year class; however, delayed or reduced southward migration into the Elephant Island Area may also be a factor.

Larval krill mean abundance in the Elephant Island Area was slightly greater than the low observed during 1998. As with 2002 Survey D, relatively large proportions were furcilia stages resulting from an early and successful pulse of seasonal spawning activity. However, based on the time-series, neither larval abundance nor development appears to offer predictive ability for recruitment success. Extremely large concentrations of predominantly calyptopis larvae encountered in 2000 and relatively large proportions of furcilia larvae during 1996 both yielded minimal recruitment. Obviously other factors such as food availability, sea ice development and advective processes have major impacts on larval survival and year class success. Both 2001 and 2002 D surveys were characterized by moderate larval krill abundance (means 50-72 per 1000 m^3); furcilia stages were relatively more abundant in 2002 (14% vs. 2%). The 2001/02 year class experienced prolonged, extensive and dynamic sea ice conditions extending from June to mid-November; the 2000/01 year class had moderate sea ice extent over a more normal July to September period. Based on the proportions of juveniles during 2002 and 2003 Survey A, the two year classes appear to have had similar recruitment success.

Salps (Tables 4.7, 4.9; Figure 4.13)

Salpa thompsoni abundance in the Elephant Island Area was slightly larger than the lows observed in 1995 and 1996. Like those years it did not demonstrate much, if any, seasonal change. The relative proportions of aggregate and solitary stages (92 and 8%) are typical for this season. The overall length-frequency distribution centered around ca. 36 mm was most similar to those of 1994 and 2000 (D_{max}= 14.1 and 9.2, respectively) and reflect peak chain production in late November-early December. The estimated growth rate was slightly lower than previous estimates which ranged from 0.39-0.46mm per day.

Zooplankton and Micronekton (Tables 4.7, 4.10B, 4.11B, 4.12, 4.13B)

Despite the marked seasonal increase overall zooplankton abundance in the Elephant Island Area was extremely low compared to the previous three years and resembled the levels observed during 1996-1999. This was in large part due to copepods: mean and median abundance of total copepods ranked sixth over the past 10 years; mean and median abundance of dominant species *C. acutus, C. propinquus* and *M. gerlachei* were among the lowest in the eight years for which we have data. Widely distributed elevated concentrations of postlarval *T. macrura* during 2003, like those of 1996-1998, followed a two-year period of elevated larval abundance (i.e., 1995-1996 and 2001-2002); both 2003 and 1998 were characterized by extremely low numbers of *T.*

macrura larvae. As with copepods, low chaetognath abundance was similar to 1996-1999. Despite reports that myctophids were scarce in predator diets during the 2002/03 field season individual and pooled species mean abundance values were typical for this time of year. Overall zooplankton composition and abundance relations during Survey D were similar to those of 1994, 2001 and 2002 (PSIs=80-82) primarily due to strong dominance by total copepods (74-82%) relative to other taxa.

4.4 AMLR 2002/03 Cruise Summary: During the past 14 summer field seasons, the AMLR Program has observed a multi-year cycle of physical and biological conditions in the Elephant Island Area. The annual reproductive success of krill follows this cycle and results in variations in population demographics and abundance (Siegel and Loeb, 1995; Loeb *et al.*, 1997; Siegel *et al.*, 1997). The multi-year nature of these cycles offers the promise of predictive capability. Within the context of this multi-year cycle, the 1998/99 season marked a transition between a period of low sea-ice development, when the pelagic community was dominated by salps, and a period of above-average sea-ice when a richer, more diverse copepod-dominated zooplankton community prevailed. This had profound implications for krill reproductive success and population growth as indicated in the following summary.

1. During both surveys krill median abundance in the Elephant Island Area was the highest recorded over the 1992-2003 data base. January abundance values were about three times greater than the highs recorded in 1996. This resulted from two successive years of strong recruitment success (i.e., the 2000/01 and 2001/02 year classes). These were associated with average (2001) and prolonged (2002) periods of elevated sea ice extent.

2. Krill demography during 2003 was characterized by extraordinarily low proportions of large and reproductively active krill. The reproductive condition resembled 1992, 1993 and 1998 when spawning appeared to be delayed or deferred, possibly due to poor feeding conditions. The unprecedented paucity of large krill (i.e., >43mm and $\geq$4 years old) may be due to (a) age-related mortality and low recruitment success following the 1995/96 year class and/or (b) delayed southward ontogenetic migration associated with prolonged sea ice cover during 2002.

3. A small juvenile size group (13-22mm) was present during both surveys and comprised about 11% of total krill collected during January. Small juveniles were also noted during the 1992, 1996, 1997, 1998 and 2002 AMLR surveys. Given their reported pack ice and Weddell Sea associations the presence of these individuals may result from interannual variations of production within, and/or advection from, higher latitude source areas.

4. Larval krill abundance was relatively low with mean values one to two orders of magnitude less than during the previous four years (1999-2002). The developmental stage composition reflected an early pulse and later resumption of seasonal spawning activity. Larval survival and recruitment success will depend on advective processes, food availability and sea ice dynamics but, given the low abundance and timing in the current seven year sea ice cycle, is not likely to match that of the past two years.

5. *Salpa thompsoni* abundance was constant across the survey period with values only slightly larger than the lows encountered in 1995 and 1996. Observations of abundant aggregate forms

in Bransfield Strait during Leg III suggested a late-season pulse of chain production which, in conjunction with low winter sea ice development, would likely favor a large overwintering seed population and potential for a substantially increased population during 2004.

6. Overall zooplankton abundance in the Elephant Island Area during the February-March seasonal peak was greatly reduced from the previous three years and comparable to low values observed during 1996-1999. This was in large part due to low numbers of copepods (*C. acutus, C. propinquus* and *M. gerlachei*) and chaetognaths. Extremely large, widespread concentrations of postlarval *T. macrura* during 2003, like 1996-1998, appear to result from elevated larval abundance during years with prolonged and/or extensive sea ice development (i.e., 1995-1996 and 2001-2002).

The results presented here support the anticipated sequence of enhanced sea ice development, decreased salp abundance, strong krill recruitment success and population growth following the 1998/99 transition. The results also suggest that 2002/03 represents a transition back to a less productive, salp dominated ecosystem not favorable for krill population growth.

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 Roger Hewitt (Southwest Fisheries Science Center). Frozen krill and myctophids were provided to Mike Goebel (Southwest Fisheries Science Center) for chemical analyses. Preserved krill samples were saved for Adina Paytan (Stanford University) also for chemical analyses.

4.6 Problems and Suggestions: Again it was helpful to have the expert assistance of CTD technicians at sea. Hydrographic information provided by drifter buoys deployed during Legs I and II was interesting and inclusion of this work during future field seasons would be quite advantageous. However, acknowledging the focus on offshore circulation, it would of great value to have additional drifters deployed within Bransfield Strait. Alternatively, it would be extremely beneficial to have information provided by an acoustic Doppler current profiler.

The zooplankton van would benefit from modifications making it more comfortable and more easily maintained. Improvements would include (a) replacing storage areas with microscope benches allowing assistants to be seated while performing sample analyses and (b) installation of stainless steel counters to allow efficient and effective cleaning.

We greatly appreciated having the large outdoor aquarium for maintaining live krill, fish and other net-collected animals for extended periods of time. The clean flow-through sea water system and spacious accommodations allowed us to photograph and video these animals in as natural a state as possible while on board the ship.

4.7 References:

Brinton, E. 1991. Distribution and population structures of immature and adult *Euphausia superba* in the western Bransfield Strait regions during the 1986-87 summer. *Deep-Sea Research* 38: 1169-1193.

Makarov. R.R. and Denys, C.J.I. 1981. Stages of sexual maturity of *Euphausia superba*. BIOMASS Handbook 11.

Ross, R.M., Quetin, L.B., and Kirsch, E. 1988. Effect of temperature on developmental times and survival of early larval stages of *Euphausia superba* Dana. *Journal of Experimental Marine Biology and Ecology* 121: 55-71.

Siegel, V. 1987. Age and growth of Antarctic Euphausiacea (Crustacea) under natural conditions. *Marine Biology* 96: 483-495.

Siegel, V. 1988. A concept of seasonal variation of krill (*Euphausia superba*) distribution and abundance west of the Antarctic Peninsula. Pp. 219-230 *In*: D. Sahrhage (ed.) Antarctic Ocean and Resources Variability. Springer-Verlag, Berlin.

Siegel, V., Ross, R.M., Quetin, L.B. 2002. Are krill recruitment indices from meso-scale surveys representative for larger areas? CCAMLR WG-EMM-02/20. 13 pp.

Table 4.1. AMLR 2003 Large-area survey IKMT station information. Double lines denote subarea divisions. Time represents local area time at when samples were collected.

A. SURVEY A

STATION #	DATE	TIME START (LOCAL)	END	DIEL	TOW DEPTH (m)	FLOW VOL. (m3)	KRILL ABUNDANCE TOTAL	KRILL ABUNDANCE #/1000M3	SALP ABUNDANCE TOTAL	SALP ABUNDANCE #/1000M3
SOUTH AREA:										
A09-09	14/01/03	0833	0906	D	171	3141.6	5	1.5	56	17.8
A08-10	14/01/03	1140	1208	D	170	2665.6	0	0.0	1	0.4
A07-11	14/01/03	1505	1533	D	170	2665.6	3	1.1	0	0.0
A08-12	14/01/03	1830	1903	D	170	3141.6	9	2.8	13	4.1
A09-11	14/01/03	2102	2137	D	170	3332.0	0	0.0	6	1.8
A10-10	15/01/03	0038	0107	T	170	2760.8	0	0.0	210	76.1
A11-11	15/01/03	0419	0450	D	170	2951.2	1	0.3	8	2.7
A10-12	15/01/03	0748	0818	D	170	2856.0	2	0.7	0	0.0
A09-13	15/01/03	1024	1055	D	170	2396.1	1474	615.2	0	0.0
A11-13	15/01/03	1525	1556	D	170	2930.3	0	0.0	4	1.4
A12-12	15/01/03	1806	1834	D	170	2878.0	1683	584.8	7	2.4
A14-12	16/01/03	0845	0912	D	170	2572.4	17	6.6	39	15.2
A13-13	16/01/03	1213	1241	D	170	2779.9	424	152.5	0	0.0
A12-14	16/01/03	1511	1543	D	170	3004.1	311	103.5	0	0.0
A15-15	16/01/03	2039	2109	D	170	3014.3	42	13.9	27	9.0
A16-14	16/01/03	2337	0008	N	170	3088.3	2	0.6	2393	774.9
A17-13	17/01/03	0253	0324	T	170	2901.6	1	0.3	1287	443.5
WEST AREA:										
A18-12	17/01/03	0623	0652	D	169	2765.8	80	28.9	213	77.0
A19-11	17/01/03	0940	1010	D	171	2861.6	408	142.6	213	74.4
A20-10	17/01/03	1307	1338	D	171	2743.7	12	4.4	1	0.4
A19-09	17/01/03	1658	1725	D	171	2784.9	18	6.5	23	8.3
A18-10	17/01/03	2035	2103	D	170	2476.6	15	6.1	376	151.8
A17-11	17/01/03	2320	2355	T	170	3379.9	6	1.8	0	0.0
A16-10	18/01/03	0300	0331	T	170	2947.8	1	0.3	2	0.7
A17-09	18/01/03	0630	0658	D	170	2546.2	5	2.0	366	143.7
A18-08	18/01/03	0953	1021	D	170	2659.7	44	16.5	47	17.7
A17-07	18/01/03	1325	1356	D	170	3006.3	24	8.0	103	34.3
A16-08	18/01/03	1705	1735	D	171	2683.7	52	19.4	109	40.6
A15-09	18/01/03	2027	2055	D	170	2511.3	87	34.6	0	0.0
A14-10	18/01/03	2249	2316	N	171	2686.5	1	0.4	103	38.3
A13-09	19/01/03	0155	0222	T	170	2405.7	17	7.1	32	13.3
A14-08	19/01/03	0515	0542	D	170	2993.1	162	54.1	466	155.7
A15-07	19/01/03	0851	0919	D	172	2717.0	1	0.4	481	177.0
A16-06	19/01/03	1232	1258	D	170	2677.3	0	0.0	102	38.1
A15-05	19/01/03	1600	1624	D	171	2353.9	24	10.2	144	61.2
A14-06	19/01/03	1924	1949	D	172	2592.0	151	58.3	547	211.0
A13-07	19/01/03	2322	2348	N	170	2547.7	1096	430.2	514	201.8
A12-08	20/01/03	0234	0305	T	171	2996.9	150	50.1	0	0.0
A11-07	20/01/03	0628	0652	D	170	2117.3	3	1.4	34	16.1
A11-05	20/01/03	1105	1130	D	174	2247.4	125	55.6	60	26.7
A11-03	20/01/03	1553	1621	D	174	2653.2	6	2.3	0	0.0
A11-01	20/01/03	2042	2109	D	169	2396.7	33	13.8	0	0.0
ELEPHANT ISLAND AREA:										
A09-01	21/01/03	0204	0232	N	171	2847.8	106	37.2	1197	420.3
A09-02	21/01/03	0537	0604	D	170	2579.6	66	25.6	0	0.0
A09-03	21/01/03	0904	0937	D	171	2766.3	125	45.2	0	0.0
A09-04	21/01/03	1206	1234	D	171	2981.1	115	38.6	0	0.0
A09-05	21/01/03	1459	1527	D	171	2657.8	15	5.6	0	0.0
A09-06	21/01/03	1803	1831	D	171	2470.2	41	16.6	343	138.9
A09-07	21/01/03	2054	2122	D	170	2576.9	409	158.7	107	41.5
A09-08	21/01/03	2320	2352	N	171	2594.5	691	266.3	289	111.4
A08-08	22/01/03	0204	0233	N	170	2910.5	35	12.0	140	48.1
A08-06	22/01/03	0645	0714	D	170	2649.5	20	7.5	233	87.9
A08-04	22/01/03	1110	1139	D	170	2774.6	1	0.4	5	1.8
A08-02	22/01/03	1541	1608	D	171	2453.7	89	36.3	15	6.1
A07-01	22/01/03	1913	1939	D	172	2600.5	35	13.5	11	4.2
A07-02	22/01/03	2143	2214	D	171	2757.7	29	10.5	4	1.5
A07-03	23/01/03	0033	0101	N	170	2811.9	24416	8683.2	16	5.7
A07-04	23/01/03	0327	0353	T	170	2349.6	130	55.3	105	44.7
A07-05	23/01/03	0623	0657	D	170	3087.2	76	24.6	150	48.6
A07-06	23/01/03	0903	0931	D	170	2809.4	19	6.8	7	2.5

Table 4.1 (Cont.)

A. SURVEY A

STATION #	DATE	TIME START (LOCAL)	END	DIEL	TOW DEPTH (m)	FLOW VOL. (m3)	KRILL ABUNDANCE TOTAL	KRILL #/1000M3	SALP ABUNDANCE TOTAL	SALP #/1000M3
A07-07	23/01/03	1204	1233	D	171	2995.4	26	8.7	20	6.7
A07-08	23/01/03	1442	1508	D	170	2446.6	231	94.4	8	3.3
A05.5-08	23/01/03	1829	1858	D	170	2837.4	6	2.1	29	10.2
A05.5-07	23/01/03	2040	2110	D	171	2891.9	17	5.9	22	7.6
A05.5-06	23/01/03	2347	0009	N	110	1885.0	69	36.6	453	240.3
A05.5-05	24/01/03	0202	0230	T	155	2652.0	34	12.8	34	12.8
A05.5-04	24/01/03	0431	0500	D	170	3876.1	810	209.0	215	55.5
A05.5-03	24/01/03	0809	0839	D	170	2702.0	430	159.1	173	64.0
A05.5-02	24/01/03	1058	1125	D	169	2385.4	236	98.9	2	0.8
A05.5-01	24/01/03	1347	1417	D	170	2784.7	121	43.5	1	0.4
A04-01	24/01/03	1741	1806	D	170	2535.8	152	59.9	111	43.8
A04-02	24/01/03	2034	2101	D	170	2735.3	63	23.0	290	106.0
A02-01	25/01/03	0246	0312	N	170	2529.5	1	0.4	1794	709.2
A03-02	25/01/03	0712	0735	D	170	2377.8	54	22.7	213	89.6
A04-08	26/01/03	0442	0510	D	170	2508.7	1770	705.5	2	0.8
A04-07	26/01/03	0742	0808	D	170	2625.9	2176	828.7	20	7.6
A04-06	26/01/03	1014	1042	D	169	2722.0	10	3.7	20	7.3
A03-06	26/01/03	1249	1318	D	171	2874.6	0	0.0	28	9.7
A03-08	26/01/03	1858	1919	D	171	2551.1	602	236.0	32	12.5
A03-07	26/01/03	1553	1624	D	170	3045.9	262	86.0	7	2.3
JOINVILLE ISLAND AREA:										
A04-09	26/01/03	2317	2344	N	170	2646.8	6	2.3	106	40.0
A06-09	27/01/03	1135	1203	D	171	2631.5	3800	1444.0	5	1.9
A06-10	27/01/03	1443	1513	D	171	2701.1	162	60.0	0	0.0

		KRILL TOTAL	KRILL #/1000M3	SALP TOTAL	SALP #/1000M3
SURVEY A:					
N=83		43951		14194	
	AVG		193.1		63.0
	STD		962.0		134.3
	MEDIAN		13.8		9.7
WEST AREA:					
N=25		2521		3936	
	AVG		38.2		59.3
	STD		85.8		69.0
	MEDIAN		8.0		34.3
ELEPHANT ISLAND AREA:					
N=38		33488		6096	
	AVG		317.9		51.9
	STD		1386.1		132.7
	MEDIAN		30.9		8.7
JOINVILLE ISLAND AREA:					
N=3		3968		111	
	AVG		502.1		14.0
	STD		666.5		18.4
	MEDIAN		60.0		1.9
SOUTH AREA:					
N=17		3974		4051	
	AVG		87.3		79.4
	STD		191.8		202.4
	MEDIAN		1.1		2.4

Table 4.1 (Cont.)

B. SURVEY D

STATION #	DATE	TIME START (LOCAL)	END	DIEL	TOW DEPTH (m)	FLOW VOL. (m3)	KRILL ABUNDANCE TOTAL	KRILL ABUNDANCE #/1000M3	SALP ABUNDANCE TOTAL	SALP ABUNDANCE #/1000M3
WEST AREA:										
D18-12	10/02/03	1705	1734	D	170	2725.0	227	83.3	26	9.5
D19-11	10/02/03	2045	2113	D	173	2618.9	12	4.6	616	235.2
D20-10	11/02/03	0025	0054	N	170	2502.9	1888	754.3	266	106.3
D19-09	11/02/03	0356	0424	N	170	2854.2	9	3.2	80	28.0
D18-10	11/02/03	0853	0919	D	170	2374.7	16	6.7	218	91.8
D17-11	11/02/03	1201	1224	D	130	2090.9	985	471.1	57	27.3
D16-10	11/02/03	1506	1536	D	170	2876.6	125	43.5	18	6.3
D17-09	11/02/03	1841	1909	D	170	2724.8	46	16.9	1	0.4
D18-08	11/02/03	2214	2242	N	170	2585.0	0	0.0	50	19.3
D17-07	12/02/03	0133	0203	N	170	2789.0	892	319.8	56	20.1
D16-08	12/02/03	0513	0538	T	170	2390.3	3	1.3	223	93.3
D15-09	12/02/03	0848	0915	D	169	2507.9	327	130.4	39	15.6
D14-10	12/02/03	1409	1434	D	142	2141.6	0	0.0	0	0.0
D13-09	12/02/03	1737	1807	D	160	2779.7	21	7.6	24	8.6
D14-08	12/02/03	2122	2153	N	170	2752.3	104	38.1	55	20.0
D15-07	13/02/03	0102	0130	N	172	2525.7	157	62.2	623	246.7
D16-06	13/02/03	0458	0528	T	170	2683.2	1	0.4	134	49.9
D15-05	13/02/03	0835	0903	D	171	2576.2	4	1.6	3186	1236.7
D14-06	13/02/03	1230	1258	D	170	2603.9	12	4.6	577	221.6
D13-07	13/02/03	1621	1649	D	170	2635.8	284	107.7	50	19.0
D12-08	13/02/03	1945	2014	D	170	2461.0	105	42.7	8	3.3
D11-07	14/02/03	0257	0327	N	170	2738.4	391	142.8	132	48.2
D11-05	14/02/03	0734	0800	D	170	2392.8	139	58.1	1936	809.1
D11-03	14/02/03	1245	1314	D	170	2781.8	59	21.2	0	0.0
D11-01	14/02/03	1825	1856	D	170	2679.7	1	0.4	0	0.0
ELEPHANT ISLAND AREA:										
D09-01	14/02/03	2319	2344	N	170	2602.1	152	58.4	199	76.5
D09-02	15/02/03	0222	0251	N	170	2427.6	511	210.5	42	17.3
D09-03	15/02/03	0545	0620	D	170	3104.6	1	0.3	0	0.0
D09-04	15/02/03	0902	0929	D	170	2535.0	94	37.1	0	0.0
D09-05	15/02/03	1208	1236	D	170	2410.7	8	3.3	134	55.6
D09-06	15/02/03	1528	1555	D	170	2226.9	21	9.4	93	41.8
D09-07	15/02/03	1848	1912	D	169	2179.2	216	99.1	6	2.8
D08-06	16/02/03	1728	1757	D	170	2713.9	3	1.1	0	0.0
D08-04	17/02/03	0100	0127	N	170	2495.0	7	2.8	4	1.6
D08-02	17/02/03	0522	0549	T	171	2536.1	3	1.2	3	1.2
D07-01	17/02/03	0903	0931	D	170	2490.2	21	8.4	0	0.0
D07-02	17/02/03	1159	1227	D	171	2391.2	9	3.8	0	0.0
D07-03	17/02/03	1456	1524	D	170	2399.5	0	0.0	0	0.0
D07-04	17/02/03	1802	1828	D	170	2231.5	0	0.0	0	0.0
D07-05	17/02/03	2107	2136	N	169	2401.9	0	0.0	582	242.3
D07-06	18/02/03	0006	0032	N	168	2122.6	39	18.4	56	26.4
D07-07	18/02/03	0241	0310	N	170	2490.6	363	145.7	510	204.8
D07-08	18/02/03	0539	0612	D	172	3235.1	29	9.0	6	1.9
D05.5-08	18/02/03	0900	0927	D	170	2547.5	23	9.0	0	0.0
D05.5-07	18/02/03	1115	1142	D	170	2287.1	5	2.2	2	0.9
D05.5-06	18/02/03	1403	1422	D	115	1701.9	83	48.8	4	2.4
D05.5-05	18/02/03	1640	1710	D	173	2601.6	400	153.7	71	27.3
D05.5-04	18/02/03	1911	1940	D	168	2519.9	493	195.6	11	4.4
D05.5-03	18/02/03	2158	2225	N	172	2614.8	3423	1309.1	1243	475.4
D05.5-02	19/02/03	0046	0115	N	170	2428.2	32	13.2	58	23.9
D05.5-01	19/02/03	0328	0354	N	171	2343.7	0	0.0	1	0.4
D04-01	19/02/03	0719	0743	D	171	2104.6	0	0.0	716	340.2
D04-02	19/02/03	1032	1101	D	170	2534.4	263	103.8	53	20.9
D04-03	19/02/03	1339	1404	D	170	2210.0	32	14.5	1	0.5
D04-04	19/02/03	1631	1655	D	170	2075.3	1	0.5	33	15.9
D04-05	20/02/03	1916	1942	D	170	2508.1	61	24.3	51	20.3
D04-06	20/02/03	0030	0057	N	171	2325.7	46	19.8	23	9.9
D04-07	20/02/03	0250	0321	N	171	2950.3	22	7.5	222	75.2
D04-08	20/02/03	0540	0609	D	172	2549.3	1	0.4	6	2.4
D03-08	20/02/03	0845	0913	D	168	2685.7	0	0.0	0	0.0
D03-06	20/02/03	1308	1335	D	170	2393.3	2328	972.7	0	0.0
D03-04	20/02/03	1800	1825	D	171	2290.7	2	0.9	223	97.4
D03-02	20/02/03	2227	2252	N	170	2623.6	791	301.5	1145	436.4

Table 4.1 (Cont.)

B. SURVEY D

STATION #	DATE	TIME START (LOCAL)	END	DIEL	TOW DEPTH (m)	FLOW VOL. (m3)	KRILL ABUNDANCE TOTAL	KRILL ABUNDANCE #/1000M3	SALP ABUNDANCE TOTAL	SALP ABUNDANCE #/1000M3
D02-01	21/02/03	0216	0242	N	170	2252.4	21	9.3	951	422.2
D02-02	21/02/03	0511	0538	T	171	2277.6	1	0.4	320	140.5
D02-03	21/02/03	0811	0840	D	170	2427.2	3	1.2	62	25.5
D02-04	21/02/03	1124	1151	D	169	2588.6	6	2.3	25	9.7
D02-05	21/02/03	1419	1445	D	170	2148.9	191	88.9	4	1.9
D02-06	21/02/03	1723	1748	D	170	2056.7	1	0.5	0	0.0
D02-07	21/02/03	2027	2053	N	170	2355.4	3	1.3	2	0.8
D02-08	21/02/03	2322	2347	N	172	2323.4	1189	511.7	90	38.7
D08-08	23/02/03	0326	0353	N	170	2404.5	372	154.7	120	0.0
D09-08	23/02/03	0623	0652	D	171	2615.8	2	0.8	0	0.0
JOINVILLE ISLAND AREA:										
D02-09	22/02/03	0222	0253	N	170	2865.3	72	25.1	148	51.7
D04-09	22/02/03	0827	0856	D	169	2619.9	51	19.5	3	1.1
D06-09	22/02/03	1245	1315	D	171	2895.6	28	9.7	2	0.7
D06-11	22/02/03	1724	1751	D	170	2475.1	135	54.5	0	0.0
SOUTH AREA:										
D07-11	22/02/03	1941	2006	D	170	2327.4	1106	475.2	0	0.0
D08-10	22/02/03	2320	2345	N	170	2257.9	2785	1233.4	12	5.3
D09-09	23/02/03	0950	1015	D	170	2363.3	2	0.8	7	3.0
D10-10	23/02/03	1342	1402	D	170	2165.3	5	2.3	0	0.0
D09-11	23/02/03	1708	1735	D	170	2528.4	424	167.7	1	0.4
D08-12	23/02/03	2004	2031	D	171	2392.6	3504	1464.5	0	0.0
D10-12	23/02/03	2345	0010	N	170	2234.9	5010	2241.7	3	1.3
D11-11	24/02/03	0321	0348	N	170	2496.9	66	26.4	9	3.6
D13-11	24/02/03	0712	0742	D	170	2438.0	14	5.7	96	39.4
D12-12	24/02/03	1038	1105	D	170	2412.3	2	0.8	1	0.4
D11-13	24/02/03	1406	1433	D	171	2332.9	949	406.8	0	0.0
D13-13	24/02/03	1846	1914	D	171	2516.5	12	4.8	0	0.0
D14-12	24/02/03	2224	2254	N	169	2647.7	21	7.9	306	115.6
D16-12	25/02/03	0232	0300	N	170	2443.7	104	42.6	150	61.4
D15-13	25/02/03	0615	0642	D	170	2426.9	18	7.4	1872	771.3
D14-14	25/02/03	0948	1016	D	171	2504.6	2561	1022.5	25	10.0
D15-15	25/02/03	1321	1348	D	170	2685.7	798	297.1	0	0.0
D17-13	25/02/03	1956	2023	D	170	2534.4	6	2.4	228	90.0

		KRILL TOTAL	KRILL #/1000M3	SALP TOTAL	SALP #/1000M3
SURVEY D AREA :					
N=95		34753		18347	
	AVG		151.6		78.9
	STD		358.9		188.2
	MEDIAN		9.4		7.4
WEST AREA:					
N=25		5808		8375	
	AVG		92.9		132.6
	STD		172.8		279.0
	MEDIAN		21.2		20.1
ELEPHANT ISLAND AREA:					
N=48		11272		7072	
	AVG		94.9		62.3
	STD		240.2		121.9
	MEDIAN		8.7		3.6
JOINVILLE ISLAND AREA:					
N=4		286		153	
	AVG		27.2		13.4
	STD		16.7		22.1
	MEDIAN		22.3		0.9
SOUTH AREA:					
N=18		17387		2710	
	AVG		411.7		61.2
	STD		632.3		175.5
	MEDIAN		34.5		2.2

Table 4.2. Maturity stage composition of krill collected in the large survey area and four subareas during January-March 2003. Advanced maturity stages are proportions of mature females that are 3c-3e in January and 3d-3e in February.

	Euphausia superba January 2003				
Area	Survey A	West	Elephant I.	Joinville I.	South
Stage	%	%	%	%	%
Juveniles	45.5	19.0	42.4	66.4	48.3
Immature	40.4	45.2	39.1	31.4	49.4
Mature	14.1	35.8	18.5	2.2	2.3
Females:					
F2	13.1	10.2	12.3	6.4	23.5
F3a	8.8	21.0	11.7	2.1	1.4
F3b	0.7	0.6	1.3	0.0	0.1
F3c	0.9	1.2	1.6	0.0	0.0
F3d	0.0	0.0	0.0	0.0	0.0
F3e	0.2	1.2	0.0	0.0	0.0
Advanced Stages	10.1	10.2	11.2	0.9	0.0
Males:					
M2a	16.3	11.1	13.6	19.1	23.1
M2b	8.1	16.7	10.2	4.0	2.2
M2c	2.9	7.1	3.1	2.0	0.6
M3a	1.2	4.2	1.1	0.0	0.7
M3b	2.3	7.6	2.9	0.0	0.1
Male:Female	1.3	1.4	1.2	2.9	1.1
No. measured	4206	1037	2466	211	492

	February 2003				
Area	Survey D	West	Elephant I.	Joinville I.	South
Stage	%	%	%	%	%
Juveniles	31.7	9.5	20.6	41.7	45.0
Immature	46.2	26.7	52.4	45.4	48.2
Mature	22.1	63.8	27.0	12.9	6.8
Females:					
F2	17.8	7.7	21.4	17.0	18.5
F3a	8.1	9.4	13.4	5.0	4.6
F3b	1.2	2.5	2.5	0.9	0.0
F3c	2.0	7.9	2.3	0.7	0.0
F3d	0.9	5.0	0.3	0.0	0.0
F3e	0.8	3.9	0.6	0.3	0.0
Advanced Stages	13.1	31.0	4.7	4.3	0.0
Males:					
M2a	13.6	5.8	12.0	11.6	16.9
M2b	11.6	8.0	14.9	11.8	10.7
M2c	3.2	5.1	4.2	5.0	2.1
M3a	2.3	5.0	2.0	1.0	1.6
M3b	6.8	30.2	5.8	5.0	0.6
Male:Female	1.2	1.5	0.9	1.4	1.4
No. measured	4494	1349	1936	241	968

Table 4.3. Larval krill stage composition in (A) Large Survey areas, 1996-2003, and (B) total and individual areas, 2000-2003. Only pooled calyptopis and furcilia stages provided for 1996-1999. Individual stages provided for 2000-2002 surveys. Shaded area denotes stage composition of Euphausia spp. larvae in the A02 Joinville Island Area.

(A) Large Survey Area

Stage %	A96	A97	A98	A99	A00	A01	A02	A03
Calyptopis Total	100	93	68	100	n.a.	100	70	100
Furcilia Total	---	7	32	---	n.a.	---	30	---

Stage %	D96	D97	D98	D99	D00	D01	D02	D03
Calyptopis Total	86	100	99	97	97	98	85	89
Furcilia Total	14	---	1	3	3	2	15	11

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

Survey	A00				A01				A02					A03				
Stage %	n.a.				Total	West	Eleph	South	Total	West	Eleph	South	Joinvl	Total	West	Eleph	South	Joinvl
C1	---	---	---	---	24.0	17.6	68.4	95.3	37.3	50.0	40.3	13.9	5.0	87.5	77.7	89.7	100	100
C2	---	---	---	---	66.3	72.7	22.1	---	15.8	50.0	16.3	7.0	2.9	9.6	1.9	8.8	---	---
C3	---	---	---	---	9.7	9.7	9.3	---	17.4	---	20.3	---	52.5	3.6	20.4	1.5	---	---
Unid.	---	---	---	---	---	---	0.2	4.7	---	---	---	---	---	---	---	---	---	---
Calyptopis Total	---	---	---	---	100	100	100	100	70.5	100	76.9	20.9	60.4	100	100	100	100	100
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	---	---	---	---	---

Survey	D00				D01				D02					D03				
Stage %	Total	West	Eleph	South	Total	West	Eleph	South	Total	West	Eleph	South	Joinvl	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	---	67.7	100	63.4	78.8	100
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	21.2	---	22.8	21.2	---
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	1.1	---	1.3	---	---
F2	1.2	---	1.2	---	---	0.1	---	---	3.4	---	7.4	---	12.1	10.0	---	12.5	---	---
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	---	---	---	---	---

Table 4.4. Composition and abundance of zooplankton assemblages sampled in large Survey A and D Areas, January-March, 2003. F(%) is frequency of occurrence in samples. R is rank and % is percent of total mean abundance represented by L and J denote larval and juvenile stages.

AMLR 2003	SURVEY A (N=83)						SURVEY D (N=95)					
TAXON	F (%)	R	%	MEAN	STD	MEDIAN	F (%)	R	%	MEAN	STD	MEDIAN
Copepods	100.0	1	48.1	609.2	1114.5	182.8	100.0	1	68.8	1533.7	2640.1	610.3
Calanoides acutus	98.8		6.5	82.3	137.5	38.1	97.9		4.8	106.8	100.5	74.1
Calanus propinquus	98.8		5.4	68.5	68.5	50.8	96.8		2.5	55.1	61.4	37.6
Other copepods	96.4		3.6	45.3	85.5	20.3	98.9		8.6	191.7	254.4	121.5
Metridia gerlachei	84.3		26.9	340.3	964.1	6.6	95.8		46.0	1024.3	2400.9	164.0
Racovitzanus antarcticus?	71.1		4.9	62.4	116.5	10.6	86.3		5.3	117.1	153.4	60.5
Rhincalanus gigas	56.6		0.7	9.2	19.9	1.1	71.6		1.4	30.4	47.7	11.2
Pleuromama robusta	3.6		0.1	1.0	7.5	0.0	15.8		0.2	3.9	13.7	0.0
Haloptilus ocellatus	2.4		0.0	0.1	0.7	0.0	4.2		0.0	0.2	1.3	0.0
Copepodites	2.4		0.0	0.1	0.8	0.0	1.1		0.0	0.0	0.4	0.0
Pareuchaeta simillus?	1.2		0.0	0.0	0.0	0.0	1.1		0.0	0.9	8.6	0.0
Pareuchaeta antarctica?	0.0		0.0	0.0	0.0	0.0	33.7		0.1	3.2	9.9	0.0
Thysanoessa macrura	100.0	2	19.2	243.5	345.1	123.3	100.0	2	13.2	293.3	317.2	201.8
Chaetognaths	94.0	6	2.5	31.3	94.1	7.1	96.8	4	3.7	83.1	114.5	35.4
Euphausia superba	92.8	3	15.3	193.0	962.1	13.8	90.5	3	6.8	151.5	358.8	9.7
Primno macropa	85.5	10	0.4	5.2	5.6	4.0	73.7	8	0.3	6.7	10.7	2.9
Salpa thompsoni	81.9	4	5.0	63.0	134.3	9.7	76.8	5	3.5	77.8	186.4	9.7
Themisto gaudichaudii	74.7		0.6	7.8	14.6	2.7	93.7	9	0.3	6.4	8.4	3.2
Tomopteris spp.	74.7		0.3	3.4	8.4	1.0	49.5		0.1	1.9	3.6	0.0
Vibilia antarctica	74.7		0.2	2.3	3.0	1.0	63.2		0.1	1.9	3.6	0.4
Limacina helicina	68.7	5	2.5	31.9	45.1	9.2	36.8		0.1	1.5	4.1	0.0
Hyperiella dilatata	65.1		0.1	0.8	1.1	0.4	37.9		0.0	0.4	1.1	0.0
Spongiobranchaea australis	57.8		0.1	1.4	3.4	0.4	54.7		0.1	1.3	3.0	0.4
Clione limacina	54.2		0.2	2.9	11.5	0.4	18.9		0.0	0.3	1.0	0.0
Lepidonotothen larseni (L)	48.2		0.1	1.5	2.6	0.0	15.8		0.0	0.5	2.3	0.0
Radiolaria	47.0		0.2	2.2	4.0	0.0	46.3		0.1	2.3	4.4	0.0
Ostracods	45.8	9	0.5	6.8	15.0	0.0	48.4	7	0.4	9.0	24.2	0.0
Electrona spp. (L)	44.6		0.1	1.5	3.4	0.0	55.8		0.1	2.5	5.1	0.4
Euphausia frigida	39.8	8	0.9	10.9	29.5	0.0	58.9	6	1.4	31.3	70.2	2.1
Cyllopus magellanicus	37.3		0.0	0.5	0.9	0.0	45.3		0.1	2.2	6.8	0.0
Diphyes antarctica	33.7		0.0	0.5	0.9	0.0	29.5		0.0	0.4	1.1	0.0
Euphausia superba (L)	32.5		0.3	3.4	12.1	0.0	27.4		0.2	3.9	10.5	0.0
Cyllopus lucasii	31.3		0.0	0.5	1.5	0.0	17.9		0.0	0.2	0.4	0.0
Euphausia crystallorophias	30.1	7	2.3	29.7	164.7	0.0	31.6	10	0.2	4.9	11.5	0.0
Beroe forskalii	30.1		0.0	0.4	1.1	0.0	3.2		0.0	0.0	0.1	0.0
Sipunculids	26.5		0.0	0.2	0.5	0.0	15.8		0.0	0.1	0.4	0.0
Thysanoessa macrura (L)	21.7		0.1	1.0	3.3	0.0	25.3		0.0	1.1	2.8	0.0
Rhynchonereella bongraini	18.1		0.0	0.5	1.6	0.0	16.8		0.0	1.0	3.0	0.0
Dimophyes arctica	16.9		0.0	0.1	0.3	0.0	9.5		0.0	0.1	0.6	0.0
Notolepis coatsi (L)	16.9		0.0	0.1	0.2	0.0	23.2		0.0	0.2	0.6	0.0
Clio pyramidata antarctica	15.7		0.1	1.7	7.1	0.0	6.3		0.0	0.2	1.2	0.0
Pleuragramma antarcticum (L)	15.7		0.0	0.4	1.3	0.0	15.8		0.0	0.2	0.8	0.0
Lepidonotothen kempi (L)	15.7		0.0	0.2	0.6	0.0	35.8		0.0	0.6	1.1	0.0
Callianira antarctica	14.5		0.0	0.1	0.6	0.0	13.7		0.0	0.3	0.9	0.0
Ihlea racovitzai	13.3		0.0	0.2	0.9	0.0	10.5		0.0	0.5	2.3	0.0
Larval Fish	12.0		0.0	0.4	1.4	0.0	17.9		0.0	0.7	2.1	0.0
Euphausia triacantha	10.8		0.1	0.7	3.0	0.0	30.5		0.1	1.8	4.5	0.0
Isopods	10.8		0.0	0.4	1.3	0.0	12.6		0.0	0.5	1.7	0.0
Cyllopus spp.	10.8		0.0	0.2	1.5	0.0	9.5		0.0	0.4	2.6	0.0
Acanthophyra pelagica (L)	10.8		0.0	0.1	0.2	0.0	3.2		0.0	0.1	0.8	0.0
Decapods	9.6		0.0	0.1	0.4	0.0	1.1		0.0	0.0	0.4	0.0
E. frigida (L)	8.4		0.0	0.4	1.9	0.0	18.9		0.0	1.0	2.9	0.0
Amphipod	8.4		0.0	0.1	0.6	0.0	3.2		0.0	0.1	0.7	0.0
Beroe cucumis	8.4		0.0	0.1	0.6	0.0	4.2		0.0	0.0	0.2	0.0
Clio pyramidata sulcata	7.2		0.0	0.1	0.3	0.0	1.1		0.0	0.0	0.1	0.0
Pegantha martagon	7.2		0.0	0.0	0.2	0.0	8.4		0.0	0.1	0.2	0.0
Hyperiids	6.0		0.0	0.1	0.6	0.0	1.1		0.0	0.0	0.0	0.0
Hyperiella macronyx	6.0		0.0	0.1	0.5	0.0	1.1		0.0	0.0	0.1	0.0
Hyperiella spp.	6.0		0.0	0.0	0.1	0.0	5.3		0.0	0.2	1.7	0.0
Orchomene rossi	6.0		0.0	0.0	0.1	0.0	4.2		0.0	0.2	1.4	0.0
Hyperoche medusarum	6.0		0.0	0.0	0.1	0.0	4.2		0.0	0.0	0.1	0.0
E. triacantha (L)	4.8		0.2	2.8	16.9	0.0	2.1		0.0	0.0	0.3	0.0
E. crystallorophias (L)	4.8		0.0	0.2	0.9	0.0	2.1		0.0	0.0	0.4	0.0

Table 4.4 (Contd.)

TAXON	F (%)	%	MEAN	STD	MEDIAN	F (%)	%	MEAN	STD	MEDIAN
Eusirus antarcticus	4.8	0.0	0.0	0.1	0.0	3.2	0.0	0.0	0.1	0.0
Chionodraco rastrospinosus (L)	4.8	0.0	0.0	0.1	0.0	1.1	0.0	0.0	0.0	0.0
Atolla wyvillei	4.8	0.0	0.0	0.1	0.0	4.2	0.0	0.0	0.1	0.0
Gammarids (unid.)	3.6	0.0	0.4	3.2	0.0	1.1	0.0	0.1	0.9	0.0
Notocrangon antarcticus(?)	3.6	0.0	0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Siphonophora	3.6	0.0	0.1	0.6	0.0	1.1	0.0	0.0	0.3	0.0
Gastropods	3.6	0.0	0.1	0.5	0.0	2.1	0.0	0.2	1.3	0.0
Fish Eggs	3.6	0.0	0.1	0.3	0.0	5.3	0.0	0.2	1.4	0.0
Larvaceans	3.6	0.0	0.1	0.4	0.0	1.1	0.0	0.0	0.2	0.0
Unid. Eggs	3.6	0.0	0.0	0.2	0.0	1.1	0.0	0.0	0.2	0.0
Ctenophora	3.6	0.0	0.0	0.2	0.0	4.2	0.0	0.0	0.2	0.0
Cumaceans	2.4	0.0	0.3	2.1	0.0	0.0	0.0	0.0	0.0	0.0
Orchomene spp.	2.4	0.0	0.1	0.5	0.0	1.1	0.0	0.0	0.0	0.0
Notolepis spp. (L)	2.4	0.0	0.0	0.3	0.0	6.3	0.0	0.1	0.3	0.0
Decapods (L)	2.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Calycopsis borchgrevinki	2.4	0.0	0.0	0.1	0.0	6.3	0.0	0.0	0.1	0.0
Pleurobrachia pileus	2.4	0.0	0.0	0.1	0.0	1.1	0.0	0.0	0.1	0.0
Notolepis annulata (L)	2.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Orchomene plebs	2.4	0.0	0.0	0.1	0.0	3.2	0.0	0.0	0.3	0.0
Leusia sp.	1.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Scina spp.	1.2	0.0	0.0	0.1	0.0	4.2	0.0	0.1	0.8	0.0
Periphylla periphylla	1.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Cryodraco antarctica (L)	1.2	0.0	0.0	0.1	0.0	1.1	0.0	0.0	0.0	0.0
Krefftichthys anderssoni (L)	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eusirus spp.	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cephalopods	1.2	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.1	0.0
Mitrocomella brownei	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electrona carlsbergi	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyperia antarctica	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maupasia coeca	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Atolla sp.	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vogtia serrata	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Staurophora mertensi ?	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electrona antarctica	1.2	0.0	0.0	0.0	0.0	9.5	0.0	0.1	0.4	0.0
Gymnoscopelus braueri	1.2	0.0	0.0	0.0	0.0	7.4	0.0	0.1	0.3	0.0
Epimeriella macronyx	1.2	0.0	0.0	0.0	0.0	2.1	0.0	0.1	0.9	0.0
Russelia mirabilis	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artededraco mirus (L)	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Modeeria rotunda	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bathylagus sp. (L)	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polychaetes	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.3	1.6	0.0
Euphausia spp. (L)	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.1	0.6	0.0
Hydromedusae	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.1	0.5	0.0
Euphausia spp.	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.2	1.0	0.0
Harpagifer antarcticus (L)	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.2	0.0
Cyphocaris richardi	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.1	0.0
Protomyctophum bolini	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.2	0.0
Champsocephalus gunnari (L)	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.1	0.0
Eusirus properdentatus	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.1	0.0
Mysids	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.2	0.0
Bylgides pelagica	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0
Botrynema brucei	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0
Gymnoscopelus nicholsi	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0
Pseudochaenichthys georgianus	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0
TOTAL			1265.6014	1596.4	555.9			2228.5	3022.9	1410.8
TAXA	103		23.1	4.5	23	98		21.9	4.1	22

Table 4.5. Composition and abundance of zooplankton assemblages sampled in four subareas, during (A) January and (B) February 2003. F(%) is frequency of occurrence in samples. R is rank and % is percent of total mean abundance represented by each taxon. L and J denote larval and juvenile stages.

A.

SURVEY A	WEST AREA (N=25)						ELEPHANT ISLAND AREA (N=38)						SOUTH AREA (N=17)						JOINVILLE ISLAND AREA (N=3)					
TAXON	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Copepods	100	1	56.4	702.4	1523.8	149.0	100	1	42.5	541.0	798.6	317.0	100	1	41.7	452.1	698.7	72.3	100	1	66.5	1586.6	1715.4	737.2
Metridia gerlachei	92.0		40.1	499.5	1360.6	8.7	86.8		19.0	241.2	639.3	6.7	64.7		15.5	168.6	380.8	1.7	100		52.1	1242.2	1725.1	41.8
Calanus propinquus	100		5.4	67.6	79.5	40.8	100		6.3	80.1	65.0	55.1	94.1		4.2	45.2	55.4	14.4	100		2.6	61.6	40.6	66.5
Calanoides acutus	96.0		4.3	53.6	73.3	23.4	100		5.9	75.6	67.9	52.0	100		12.9	140.1	262.8	35.9	100		3.2	77.3	49.7	74.1
Racovitzanus antarcticus?	96.0		3.8	47.9	77.2	13.0	81.6		7.1	89.8	138.1	32.2	5.9		0.3	3.3	13.2	0.0	100		7.1	170.5	201.2	48.7
Other copepods	100		2.3	28.4	33.1	16.4	97.4		3.2	41.0	34.9	27.8	94.1		7.7	83.4	170.9	28.6	66.7		1.0	24.4	32.5	3.0
Rhincalanus gigas	40.0		0.4	5.4	9.8	0.0	65.8		0.9	11.1	23.4	1.9	58.8		1.0	10.3	22.6	1.1	66.7		0.4	10.5	14.1	1.1
Pleuromama robusta	0.0		0.0	0.0	0.0	0.0	2.6		0.1	1.8	10.9	0.0	5.9		0.1	0.7	2.8	0.0	0.0		0.0	0.0	0.0	0.0
Haloptilus ocellatus	0.0		0.0	0.0	0.0	0.0	2.6		0.0	0.2	1.0	0.0	5.9		0.0	0.1	0.3	0.0	0.0		0.0	0.0	0.0	0.0
Copepodites	0.0		0.0	0.0	0.0	0.0	2.6		0.0	0.1	0.9	0.0	5.9		0.0	0.3	1.2	0.0	0.0		0.0	0.0	0.0	0.0
Eucalanus sp.	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Thysanoessa macrura	100	2	26.2	326.8	342.7	188.6	100	3	18.8	239.0	405.3	103.9	100	2	13.4	145.3	141.1	110.9	100	3	6.8	162.6	67.1	126.6
Salpa thompsoni	80.0	3	4.8	59.3	69.0	34.3	89.5	4	4.9	61.9	132.7	8.7	70.6	5	7.3	79.4	202.4	2.4	66.7		0.6	14.0	18.4	1.9
Euphausia superba	96.0	4	3.1	38.2	85.8	8.0	97.4	2	25.1	318.8	1386.0	30.9	76.5	4	8.0	87.3	191.8	1.1	100	2	20.5	489.8	674.8	23.0
Chaetognaths	96.0	5	1.9	24.2	34.6	9.8	94.7	6	1.5	19.3	33.6	5.3	94.1	6	6.5	71.1	192.0	6.3	66.7		0.7	17.1	22.1	3.0
Themisto gaudichaudii	100	6	1.5	18.6	21.9	10.3	86.8		0.3	4.4	5.8	2.2	23.5		0.1	0.6	1.6	0.0	0.0		0.0	0.0	0.0	0.0
Limacina helicina	48.0	7	1.3	16.6	29.8	1.1	63.2	5	2.6	32.5	55.2	1.3	100	7	4.2	45.4	29.1	33.5	100	4	3.2	75.4	21.3	86.5
Euphausia frigida	32.0	8	1.0	12.9	37.2	0.0	36.8	7	0.8	10.6	27.3	0.0	52.9	8	0.9	9.6	23.2	0.7	33.3		0.3	6.3	8.9	0.0
Euphausia triacantha (L)	16.0	9	0.7	9.2	29.9	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Ostracods	48.0	10	0.4	5.5	9.9	0.7	52.6	8	0.5	6.7	14.6	0.4	23.5	9	0.9	9.3	21.5	0.0	33.3		0.1	3.2	4.5	0.0
Primno macropa	96.0		0.4	5.3	4.7	4.5	89.5	9	0.4	5.6	5.8	4.3	64.7		0.4	4.3	6.6	1.0	66.7		0.2	4.9	3.7	5.7
Tomopteris spp.	88.0		0.4	5.0	13.7	1.3	73.7		0.2	2.6	4.3	0.9	58.8		0.3	3.3	4.6	0.7	66.7		0.1	1.9	1.6	1.9
Euphausia superba (L)	36.0		0.3	3.6	7.5	0.0	36.8	10	0.4	4.7	16.8	0.0	11.8		0.1	1.0	3.1	0.0	66.7		0.0	0.0	0.0	0.0
Vibilia antarctica	88.0		0.2	2.7	2.8	1.4	71.1		0.2	2.4	3.5	0.8	64.7		0.1	1.4	2.1	0.6	66.7		0.1	2.2	2.0	1.9
Electrona spp. (L)	52.0		0.2	2.3	3.9	0.3	50.0		0.1	1.6	3.7	0.2	23.5		0.0	0.4	1.1	0.0	33.3		0.0	0.1	0.2	0.0
Radiolaria	40.0		0.1	1.7	2.9	0.0	50.0		0.2	2.6	4.9	0.3	58.8		0.2	1.8	2.8	0.8	33.3		0.1	2.1	3.0	0.0
Lepidonotothen larseni (L)	44.0		0.1	1.6	2.5	0.0	42.1		0.1	1.0	1.7	0.0	64.7		0.2	1.7	2.0	1.2	33.3		0.2	5.1	7.2	0.0
Thysanoessa macrura (L)	8.0		0.1	1.2	4.7	0.0	31.6		0.1	1.2	2.7	0.0	17.6		0.1	0.7	2.3	0.0	0.0		0.0	0.0	0.0	0.0
Euphausia triacantha	12.0		0.1	1.2	4.0	0.0	10.5		0.1	0.7	3.0	0.0	5.9		0.0	0.1	0.3	0.0	33.3		0.0	0.3	0.4	0.0
Spongiobranchaea australis	60.0		0.1	1.1	2.1	0.4	68.4		0.1	1.9	4.6	0.4	35.3		0.1	0.7	1.8	0.0	33.3		0.0	0.1	0.2	0.0
Hyperiella dilatata	68.0		0.1	0.8	1.3	0.4	57.9		0.1	0.7	1.0	0.4	82.4		0.1	1.3	1.1	1.4	33.3		0.0	0.2	0.3	0.0
Cyllopus magellanicus	52.0		0.1	0.7	0.9	0.0	34.2		0.0	0.5	0.9	0.0	35.3		0.1	0.5	1.0	0.0	0.0		0.0	0.0	0.0	0.0
Pleuragramma antarcticum (L)	8.0		0.0	0.6	2.0	0.0	7.9		0.0	0.1	0.6	0.0	41.2		0.1	0.9	1.4	0.0	0.0		0.0	0.0	0.0	0.0
Clione limacina	28.0		0.0	0.5	1.1	0.0	50.0		0.1	1.5	3.7	0.2	94.1	10	0.8	9.1	23.7	3.0	100		0.2	5.0	1.7	3.8
Rhynchonereella bongraini	8.0		0.0	0.4	1.9	0.0	26.3		0.0	0.6	1.6	0.0	11.8		0.0	0.1	0.3	0.0	33.3		0.1	1.9	2.7	0.0
Cyllopus lucasii	32.0		0.0	0.3	0.7	0.0	26.3		0.1	0.8	2.2	0.0	41.2		0.0	0.3	0.4	0.0	33.3		0.0	0.3	0.4	0.0
Euphausia crystallorophias	8.0		0.0	0.3	1.1	0.0	15.8		0.1	1.8	6.7	0.0	94.1	3	12.9	140.4	342.1	3.5	66.7		0.0	1.1	0.8	1.5
Decapods	16.0		0.0	0.3	0.7	0.0	5.3		0.0	0.0	0.1	0.0	11.8		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Larval Fish	12.0		0.0	0.3	0.9	0.0	15.8		0.0	0.6	2.0	0.0	5.9		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0
Lepidonotothen kempi (L)	20.0		0.0	0.2	0.7	0.0	21.1		0.0	0.2	0.7	0.0	5.9		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Euphausia spp. (L)	0.0		0.0	0.2	0.8	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
Cyllopus spp.	8.0		0.0	0.2	0.5	0.0	7.9		0.0	0.0	0.2	0.0	17.6		0.1	0.8	3.1	0.0	0.0		0.0	0.0	0.0	0.0
Polychaetes	0.0		0.0	0.1	0.5	0.0	0.0		0.0	0.1	0.4	0.0	17.6		0.0	0.3	0.7	0.0	0.0		0.0	0.0	0.0	0.0
Fish Eggs	4.0		0.0	0.1	0.5	0.0	5.3		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

SURVEY A	WEST AREA (N=25)						ELEPHANT ISLAND AREA (N=38)						SOUTH AREA (N=17)						JOINVILLE ISLAND AREA (N=3)					
TAXON	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Acanthophyra pelagica (L)	8.0		0.0	0.1	0.4	0.0	2.6		0.0	0.0	0.1	0.0	23.5		0.0	0.1	0.2	0.0	66.7		0.0	0.4	0.3	0.4
Amphipod	12.0		0.0	0.1	0.3	0.0	7.9		0.0	0.2	0.8	0.0	5.9		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Beroe forskalii	12.0		0.0	0.1	0.3	0.0	26.3		0.0	0.3	0.6	0.0	58.8		0.1	1.1	2.1	0.3	66.7		0.0	0.5	0.5	0.4
Unid. Eggs	8.0		0.0	0.1	0.3	0.0	2.6		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
Diphyes antarctica	8.0		0.0	0.1	0.2	0.0	28.9		0.0	0.4	0.9	0.0	70.6		0.1	1.1	1.2	0.4	66.7		0.0	0.8	0.8	0.4
Euphausia frigida (L)	4.0		0.0	0.1	0.4	0.0	13.2		0.1	0.8	2.6	0.0	5.9		0.0	0.3	1.1	0.0	0.0		0.0	0.0	0.0	0.0
Dimophyes arctica	8.0		0.0	0.0	0.2	0.0	15.8		0.0	0.1	0.3	0.0	35.3		0.0	0.3	0.5	0.0	0.0		0.0	0.0	0.0	0.0
Pegantha martagon	8.0		0.0	0.0	0.2	0.0	10.5		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
Hyperiids	8.0		0.0	0.0	0.2	0.0	5.3		0.0	0.1	0.6	0.0	5.9		0.0	0.2	1.0	0.0	0.0		0.0	0.0	0.0	0.0
Hydromedusae	0.0		0.0	0.0	0.2	0.0	0.0		0.0	0.1	0.2	0.0	5.9		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Hyperiella macronyx	4.0		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	17.6		0.0	0.4	1.1	0.0	0.0		0.0	0.0	0.0	0.0
Calycopsis borchgrevinki	4.0		0.0	0.0	0.2	0.0	2.6		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	8.0		0.0	0.0	0.1	0.0	10.5		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
Callianira antarctica	8.0		0.0	0.0	0.1	0.0	23.7		0.0	0.3	0.8	0.0	0.0		0.0	0.0	0.0	0.0	33.3		0.0	0.3	0.4	0.0
Orchomene rossi	8.0		0.0	0.0	0.1	0.0	2.6		0.0	0.0	0.1	0.0	5.9		0.0	0.1	0.2	0.0	33.3		0.0	0.1	0.2	0.0
Notolepis coatsi (L)	4.0		0.0	0.0	0.1	0.0	18.4		0.0	0.1	0.2	0.0	29.4		0.0	0.1	0.2	0.0	33.3		0.0	0.1	0.2	0.0
Hyperoche medusarum	8.0		0.0	0.0	0.1	0.0	7.9		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
Sipunculids	4.0		0.0	0.0	0.1	0.0	26.3		0.0	0.2	0.4	0.0	52.9		0.0	0.5	0.7	0.3	66.7		0.0	1.0	0.8	1.1
Hyperiella spp.	8.0		0.0	0.0	0.1	0.0	2.6		0.0	0.0	0.1	0.0	11.8		0.0	0.1	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Gammarids	4.0		0.0	0.0	0.1	0.0	5.3		0.1	0.8	4.8	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Eusirus antarcticus	4.0		0.0	0.0	0.1	0.0	2.6		0.0	0.0	0.1	0.0	5.9		0.0	0.0	0.1	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
Mitrocomella brownei	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
Beroe cucumis	4.0		0.0	0.0	0.1	0.0	13.2		0.0	0.2	0.9	0.0	5.9		0.0	0.1	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Ihlea racovitzai	4.0		0.0	0.0	0.1	0.0	13.2		0.0	0.4	1.3	0.0	29.4		0.0	0.4	0.6	0.0	0.0		0.0	0.0	0.0	0.0
Ctenophora	0.0		0.0	0.0	0.1	0.0	2.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	33.3		0.0	0.5	0.7	0.0
Bolinopsis infundibulus	4.0		0.0	0.0	0.1	0.0	7.9		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
Notocrangon antarcticus(?)	4.0		0.0	0.0	0.1	0.0	5.3		0.0	0.3	1.5	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Cumaceans	0.0		0.0	0.0	0.0	0.0	5.3		0.0	0.6	3.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Isopods	0.0		0.0	0.0	0.0	0.0	7.9		0.0	0.3	1.3	0.0	35.3		0.1	1.0	1.8	0.0	0.0		0.0	0.0	0.0	0.0
Euphausia crystallorophias(L)	0.0		0.0	0.0	0.0	0.0	7.9		0.0	0.2	1.2	0.0	0.0		0.0	0.0	0.0	0.0	33.3		0.1	1.4	2.0	0.0
Orchomene spp.	0.0		0.0	0.0	0.0	0.0	5.3		0.0	0.2	0.8	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	5.3		0.0	0.1	0.6	0.0	5.9		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Notolepis spp. (L)	0.0		0.0	0.0	0.0	0.0	5.3		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Clio pyramidata antarctica	0.0		0.0	0.0	0.0	0.0	5.3		0.0	0.0	0.2	0.0	64.7		0.8	8.3	13.8	1.0	0.0		0.0	0.0	0.0	0.0
Leusia sp.	0.0		0.0	0.0	0.0	0.0	2.6		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
Scina spp.	0.0		0.0	0.0	0.0	0.0	2.6		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
Pleurobrachia pileus	0.0		0.0	0.0	0.0	0.0	5.3		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
Decapods (L)	0.0		0.0	0.0	0.0	0.0	2.6		0.0	0.0	0.1	0.0	5.9		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Cryodraco antarctica (L)	0.0		0.0	0.0	0.0	0.0	2.6		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
Krefftichthys anderssoni (L)	0.0		0.0	0.0	0.0	0.0	2.6		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
Pleuragramma antarcticum	0.0		0.0	0.0	0.0	0.0	2.6		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 spp.	0.0		0.0	0.0	0.0	0.0	2.6		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
Gastropods	0.0		0.0	0.0	0.0	0.0	2.6		0.0	0.0	0.1	0.0	11.8		0.0	0.3	1.2	0.0	0.0		0.0	0.0	0.0	0.0
Electrona carlsbergi	0.0		0.0	0.0	0.0	0.0	2.6		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
Notolepis annulata (L)	0.0		0.0	0.0	0.0	0.0	2.6		0.0	0.0	0.1	0.0	5.9		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0

SURVEY A	WEST AREA (N=25)						ELEPHANT ISLAND AREA (N=38)						SOUTH AREA (N=17)						JOINVILLE ISLAND AREA (N=3)					
TAXON	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Pasiaphaea sp. (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.1	0.0	5.9		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Orchomene plebs	0.0		0.0	0.0	0.0	0.0	2.6		0.0	0.0	0.1	0.0	5.9		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Maupasia coeca	0.0		0.0	0.0	0.0	0.0	2.6		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
Vogtia serrata	0.0		0.0	0.0	0.0	0.0	2.6		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
Staurophora mertensi ?	0.0		0.0	0.0	0.0	0.0	2.6		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
Gymnoscopelus braueri	0.0		0.0	0.0	0.0	0.0	2.6		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 antarctica	0.0		0.0	0.0	0.0	0.0	2.6		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
Russelia mirabilis	0.0		0.0	0.0	0.0	0.0	2.6		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
Euphausiids	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	11.8		0.1	0.8	2.3	0.0	0.0		0.0	0.1	0.2	0.0
Siphonophora	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	17.6		0.0	0.3	1.2	0.0	0.0		0.0	0.0	0.0	0.0
Chionodraco rastrospinosus (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	23.5		0.0	0.1	0.3	0.0	0.0		0.0	0.0	0.0	0.0
Atolla wyvillei	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	17.6		0.0	0.1	0.2	0.0	33.3		0.0	0.1	0.2	0.0
Periphylla periphylla	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.1	0.3	0.0	0.0		0.0	0.0	0.0	0.0
Epimeriella macronyx	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Artededraco mirus (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Modeeria rotunda	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Bathylagus sp. (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Hyperia antarctica	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	33.3		0.0	0.1	0.2	0.0
Atolla 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	33.3		0.0	0.1	0.2	0.0
TOTAL				1245.54	1657.6	555.9				1272.09	1746.4	558.6				1085.57	908.9	802.4				2385.53	1684.8	2371.3
TAXA	62			21.4	3.5	21	89			23.6	5.0	24	74			24.5	4.2	24	40			23.3	4.1	24

Table 4.5 (Contd.)

B.

SURVEY D	WEST AREA (N=25)						ELEPHANT ISLAND AREA (N=48)						SOUTH AREA (N=18)						JOINVILLE ISLAND AREA (N=4)					
TAXON	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Copepods	100.0	1	52.0	682.2	951.3	388.1	100.0	1	73.7	1674.3	2593.6	737.5	100.0	1	66.3	2170.9	3707.5	855.5	100.0	1	84.1	2300.6	3181.8	666.2
Calanoides acutus	96.0		24.5	321.6	584.7	51.9	95.8		48.1	1092.8	2239.6	197.3	94.4		49.1	1609.1	3657.3	224.8	100.0		71.8	1962.6	2969.2	380.8
Metridia gerlachei	96.0		16.1	211.0	347.4	92.2	100.0		9.0	205.0	235.4	130.2	100.0		4.6	149.2	139.0	129.7	100.0		3.8	103.6	102.0	51.9
Other copepods	100.0		4.6	60.2	50.7	44.1	97.9		6.1	138.1	114.2	119.3	94.4		3.1	102.9	90.9	66.4	100.0		1.4	39.4	17.6	43.5
Calanus propinquus	72.0		2.6	34.3	42.9	16.0	87.5		5.3	121.0	161.3	56.7	100.0		7.1	232.3	168.5	213.2	100.0		2.5	69.3	49.2	49.8
Racovitzanus antarcticus?	96.0		2.1	27.3	20.7	25.7	97.9		3.0	68.2	70.2	47.9	94.4		1.6	52.8	49.9	37.9	100.0		3.0	81.8	94.3	42.1
Rhincalanus gigas	40.0		1.5	20.0	60.4	0.0	83.3		1.7	39.0	45.9	17.9	83.3		0.7	22.0	28.8	10.7	75.0		1.1	29.3	21.3	31.8
Pleuromamma robusta	20.0		0.3	3.5	10.2	0.0	18.8		0.3	5.9	17.5	0.0	5.6		0.0	0.2	0.9	0.0	0.0		0.0	0.0	0.0	0.0
Pareuchaeta antarctica?	4.0		0.3	3.4	16.5	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
Pareuchaeta simillus?	16.0		0.1	0.7	2.2	0.0	39.6		0.2	3.8	10.0	0.0	44.4		0.1	2.4	7.7	0.0	25.0		0.5	14.6	25.2	0.0
Copepodites	4.0		0.0	0.2	0.9	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Haloptilus ocellatus	0.0		0.0	0.0	0.0	0.0	8.3		0.0	0.5	1.7	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Thysanoessa macrura	100.0	2	21.7	284.6	196.0	262.2	100.0	2	10.2	232.6	271.3	156.0	100.0	2	14.2	465.9	485.5	300.6	100.0	2	11.0	300.6	165.1	343.4
Salpa thompsoni	88.0	3	10.1	132.7	279.0	20.1	75.0	5	2.7	60.7	119.7	7.0	66.7	5	1.9	61.2	175.5	2.2	75.0		0.5	13.4	22.1	0.9
Euphausia superba	88.0	4	7.1	92.8	172.6	21.2	87.5	4	4.2	94.9	240.2	8.7	100.0	3	12.6	411.7	632.3	34.5	100.0		1.0	27.2	16.7	22.3
Chaetognaths	96.0	5	4.3	56.7	90.9	18.2	97.9	3	4.5	103.2	130.6	56.3	94.4	4	2.3	76.0	95.0	34.5	100.0	3	1.4	39.5	56.0	10.7
Euphausia frigida	48.0	6	1.2	15.9	29.3	0.0	68.8	6	2.2	50.9	92.0	11.5	50.0	10	0.2	6.1	9.4	0.7	50.0		0.2	6.4	10.8	0.2
Themisto gaudichaudii	96.0	7	0.7	9.7	10.0	6.0	93.8	10	0.2	4.5	6.9	2.0	94.4	9	0.2	7.7	8.7	4.6	75.0		0.1	1.7	1.8	1.0
Ostracods	48.0	8	0.6	7.3	17.4	0.0	47.9	9	0.2	5.4	10.4	0.0	55.6	6	0.6	20.8	46.4	3.5	25.0		0.3	9.3	16.2	0.0
Euphausia crystallorophias	20.0	9	0.4	4.6	14.6	0.0	14.6		0.0	1.1	4.4	0.0	88.9	7	0.5	15.4	13.8	11.6	50.0		0.2	5.4	6.6	2.8
Cyllopus magellanicus	64.0	10	0.3	3.7	11.6	0.4	39.6		0.1	2.1	4.2	0.0	38.9		0.0	1.0	1.7	0.0	25.0		0.0	0.1	0.2	0.0
Vibilia antarctica	80.0		0.3	3.3	5.7	1.0	62.5		0.1	1.6	2.4	0.4	38.9		0.0	1.1	2.0	0.0	75.0		0.0	0.5	0.5	0.4
Primno macropa	68.0		0.2	2.7	3.5	1.2	75.0	7	0.4	8.1	12.6	3.8	77.8	8	0.3	9.0	11.2	4.1	75.0		0.1	3.8	4.9	1.6
Euphausia triacantha	36.0		0.2	2.6	5.5	0.0	29.2		0.1	2.0	4.8	0.0	0.0		0.0	0.2	0.4	0.0	25.0		0.0	0.1	0.2	0.0
Tomopteris spp.	60.0		0.1	1.8	3.1	0.4	45.8		0.1	1.8	3.5	0.0	38.9		0.1	2.2	4.0	0.0	75.0		0.1	3.0	4.7	0.4
Spongiobranchaea australis	40.0		0.1	1.3	3.9	0.0	62.5		0.0	0.7	1.0	0.4	55.6		0.1	2.5	4.6	0.4	50.0		0.0	1.3	1.7	0.5
Radiolaria	32.0		0.1	1.2	3.3	0.0	58.3		0.1	3.3	4.9	0.6	27.8		0.0	0.3	0.7	0.0	75.0		0.2	5.6	7.6	1.9
Rhynchonereella bongraini	20.0		0.1	0.9	2.1	0.0	16.7		0.0	0.9	2.9	0.0	16.7		0.0	1.5	4.3	0.0	0.0		0.0	0.0	0.0	0.0
Electrona spp. (L)	44.0		0.1	0.9	1.4	0.0	68.8		0.2	4.1	6.7	1.6	50.0		0.0	1.2	1.9	0.2	0.0		0.0	0.0	0.0	0.0
Larval Fish	20.0		0.1	0.8	1.7	0.0	18.8		0.0	0.9	2.6	0.0	16.7		0.0	0.3	1.0	0.0	0.0		0.0	0.0	0.0	0.0
Thysanoessa macrura (L)	20.0		0.1	0.8	1.7	0.0	31.3		0.1	1.3	3.0	0.0	16.7		0.0	1.3	3.7	0.0	25.0		0.0	0.1	0.2	0.0
Hyperiella dilatata	44.0		0.0	0.6	1.6	0.0	33.3		0.0	0.4	0.9	0.0	38.9		0.0	0.2	0.3	0.0	50.0		0.0	0.4	0.4	0.2
Lepidonotothen kempi (L)	28.0		0.0	0.5	1.2	0.0	41.7		0.0	0.6	0.9	0.0	33.3		0.0	0.6	1.2	0.0	25.0		0.0	0.1	0.2	0.0
Euphausia spp.	8.0		0.0	0.4	1.7	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.3	1.1	0.0	0.0		0.0	0.0	0.0	0.0
Amphipod	12.0		0.0	0.3	1.3	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Acanthophyra pelagica	4.0		0.0	0.3	1.6	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
Pleuragramma antarcticum (L)	12.0		0.0	0.3	1.1	0.0	4.2		0.0	0.1	0.4	0.0	55.6		0.0	0.7	1.1	0.4	0.0		0.0	0.0	0.0	0.0
Hydromedusae	8.0		0.0	0.3	1.0	0.0	4.2		0.0	0.0	0.2	0.0	5.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Gastropods	4.0		0.0	0.2	1.0	0.0	0.0		0.0	0.0	0.0	0.0	5.6		0.0	0.6	2.6	0.0	0.0		0.0	0.0	0.0	0.0
Clione limacina	16.0		0.0	0.2	0.6	0.0	18.8		0.0	0.3	1.0	0.0	16.7		0.0	0.5	1.2	0.0	50.0		0.0	1.1	1.7	0.2
Limacina helicina	16.0		0.0	0.2	0.8	0.0	39.6		0.1	1.4	2.8	0.0	44.4		0.1	2.7	7.7	0.0	100.0		0.1	3.9	1.1	3.9
Cyllopus lucasii	20.0		0.0	0.2	0.4	0.0	14.6		0.0	0.1	0.5	0.0	22.2		0.0	0.2	0.4	0.0	25.0		0.0	0.1	0.2	0.0
Lepidonotothen larseni (L)	20.0		0.0	0.2	0.4	0.0	4.2		0.0	0.3	1.8	0.0	33.3		0.0	1.1	3.9	0.0	50.0		0.1	2.0	2.3	1.2
Euphausia crystallorophias(L)	4.0		0.0	0.1	0.7	0.0	0.0		0.0	0.0	0.0	0.0	5.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Electrona antarctica	8.0		0.0	0.1	0.6	0.0	10.4		0.0	0.1	0.3	0.0	11.1		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Decapods	4.0		0.0	0.1	0.7	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0

B.

SURVEY D	WEST AREA (N=25)						ELEPHANT ISLAND AREA (N=48)						SOUTH AREA (N=18)						JOINVILLE ISLAND AREA (N=4)					
TAXON	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Gymnoscopelus braueri	12.0		0.0	0.1	0.4	0.0	8.3		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Notolepis coatsi (L)	20.0		0.0	0.1	0.3	0.0	25.0		0.0	0.3	0.7	0.0	27.8		0.0	0.3	0.5	0.0	0.0		0.0	0.0	0.0	0.0
Diphyes antarctica	16.0		0.0	0.1	0.3	0.0	29.2		0.0	0.6	1.5	0.0	33.3		0.0	0.2	0.3	0.0	100.0		0.1	1.4	0.9	1.4
Euphausia superba (L)	4.0		0.0	0.1	0.6	0.0	41.7	8	0.3	6.1	13.0	0.0	16.7		0.1	2.8	9.1	0.0	50.0		0.2	4.8	7.9	0.4
Protomyctophum bolini	8.0		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Orchomene plebs	4.0		0.0	0.1	0.4	0.0	2.1		0.0	0.0	0.1	0.0	5.6		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0
Pegantha martigon	8.0		0.0	0.1	0.3	0.0	10.4		0.0	0.1	0.2	0.0	0.0		0.0	0.0	0.0	0.0	25.0		0.0	0.1	0.2	0.0
Sipunculids	12.0		0.0	0.1	0.2	0.0	12.5		0.0	0.1	0.5	0.0	11.1		0.0	0.2	0.6	0.0	100.0		0.0	0.7	0.2	0.7
Euphausia frigida (L)	4.0		0.0	0.1	0.3	0.0	27.1		0.1	1.7	3.8	0.0	22.2		0.0	0.9	2.1	0.0	0.0		0.0	0.0	0.0	0.0
Hyperoche medusarum	12.0		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
Calycopsis borchgrevinki	8.0		0.0	0.0	0.2	0.0	8.3		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	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
Atolla wyvillei	4.0		0.0	0.0	0.2	0.0	4.2		0.0	0.0	0.1	0.0	5.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Ctenophora	8.0		0.0	0.0	0.1	0.0	2.1		0.0	0.0	0.1	0.0	5.6		0.0	0.1	0.5	0.0	0.0		0.0	0.0	0.0	0.0
Pleurobrachia pileus	4.0		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Callianira antarctica	8.0		0.0	0.0	0.1	0.0	14.6		0.0	0.2	0.6	0.0	22.2		0.0	0.8	1.8	0.0	0.0		0.0	0.0	0.0	0.0
Hyperiella spp.	4.0		0.0	0.0	0.1	0.0	2.1		0.0	0.0	0.1	0.0	16.7		0.0	1.1	3.9	0.0	0.0		0.0	0.0	0.0	0.0
Notolepis spp. (L)	4.0		0.0	0.0	0.1	0.0	10.4		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Euphausia spp. (L)	4.0		0.0	0.0	0.1	0.0	6.3		0.0	0.2	0.6	0.0	5.6		0.0	0.2	0.7	0.0	0.0		0.0	0.0	0.0	0.0
Orchomene rossi	4.0		0.0	0.0	0.1	0.0	6.3		0.0	0.3	2.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Vanadis antarctica	4.0		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0	11.1		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0
Cyllopus spp.	0.0		0.0	0.0	0.0	0.0	16.7		0.0	0.8	3.6	0.0	5.6		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0
Polychaetes	0.0		0.0	0.0	0.0	0.0	8.3		0.0	0.6	2.2	0.0	0.0		0.0	0.0	0.0	0.0	25.0		0.0	0.2	0.3	0.0
Isopods	0.0		0.0	0.0	0.0	0.0	10.4		0.0	0.4	1.5	0.0	33.3		0.0	1.4	2.9	0.0	25.0		0.0	0.4	0.7	0.0
Clio pyramidata antarctica	0.0		0.0	0.0	0.0	0.0	6.3		0.0	0.4	1.7	0.0	5.6		0.0	0.0	0.1	0.0	50.0		0.0	0.4	0.5	0.2
Fish Eggs	0.0		0.0	0.0	0.0	0.0	6.3		0.0	0.3	1.9	0.0	11.1		0.0	0.2	0.8	0.0	0.0		0.0	0.0	0.0	0.0
Ihlea racovitzai	0.0		0.0	0.0	0.0	0.0	12.5		0.0	0.2	0.9	0.0	16.7		0.1	1.9	4.8	0.0	25.0		0.0	0.2	0.3	0.0
Scina spp.	0.0		0.0	0.0	0.0	0.0	6.3		0.0	0.2	1.1	0.0	5.6		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Epimeriella macronyx	0.0		0.0	0.0	0.0	0.0	4.2		0.0	0.2	1.2	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Gammarids	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.2	1.3	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Dimophyes arctica	0.0		0.0	0.0	0.0	0.0	14.6		0.0	0.2	0.8	0.0	0.0		0.0	0.0	0.0	0.0	50.0		0.0	0.5	0.7	0.2
Bolinopsis infundibulus	0.0		0.0	0.0	0.0	0.0	8.3		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
Euphausia triacantha (L)	0.0		0.0	0.0	0.0	0.0	4.2		0.0	0.1	0.4	0.0	27.8		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Beroe cucumis	0.0		0.0	0.0	0.0	0.0	6.3		0.0	0.1	0.2	0.0	5.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Larvaceans	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.3	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Eusirus antarcticus	0.0		0.0	0.0	0.0	0.0	4.2		0.0	0.0	0.1	0.0	5.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Cephalopods	0.0		0.0	0.0	0.0	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
Harpagifer antarcticus (L)	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.1	0.0	11.1		0.0	0.1	0.4	0.0	0.0		0.0	0.0	0.0	0.0
Hyperiella 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	0.0		0.0	0.0	0.0	0.0
Champsocephalus gunnari (L)	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.1	0.0	5.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Eusirus properdentatus	0.0		0.0	0.0	0.0	0.0	2.1		0.0	0.0	0.1	0.0	5.6		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Hyperiids	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
Bylgides pelagica	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
Siphonophora	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.6		0.0	0.1	0.6	0.0	0.0		0.0	0.0	0.0	0.0
Eggs	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.6		0.0	0.1	0.5	0.0	0.0		0.0	0.0	0.0	0.0

B.

SURVEY D	WEST AREA (N=25)						ELEPHANT ISLAND AREA (N=48)						SOUTH AREA (N=18)						JOINVILLE ISLAND AREA (N=4)					
TAXON	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN	F(%)	R	%	MEAN	STD	MEDIAN
Cyphocaris richardi	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	16.7		0.0	0.1	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Mysids	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.6		0.0	0.1	0.4	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	0.0		0.0	0.0	0.0	0.0	5.6		0.0	0.0	0.2	0.0	0.0		0.0	0.0	0.0	0.0
Pseudochaenichthys georgianus (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Cryodraco antarctica (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Chionodraco rastrospinosus (L)	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Orchomene spp.	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
Gymnoscopelus nicholsi	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.6		0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.0	0.0
TOTAL				1311.7	998.3	1088.4				2271.6	2927.6	1197.9				3274.6	4386.7	1724.5				2734.7	3300.4	1154.1
TAXA	65			19.8	3.4	20.0	79			22.5	4.0	22.5	72			23.2	4.3	23.0	38			23.5	3.4	22.5

Table 4.6. Taxonomic composition of zooplankton clusters during January 2003. R and % are rank and proportions of total abundance represented by each taxon.

SURVEY A JANUARY 2003	CLUSTER 1 (COASTAL) N=27					CLUSTER 2 (TRANSITION) N=22					CLUSTER 3 (OCEANIC) N=34				
TAXON	R	%	MEAN	STD	MEDIAN	R	%	MEAN	STD	MEDIAN	R	%	MEAN	STD	MEDIAN
Metridia gerlachei	9	3.0	22.3	57.1	2.2	1	41.3	1213.7	1568.1	519.7	6	5.5	27.8	64.5	4.8
Thysanoessa macrura	4	10.4	78.3	68.1	63.2	2	15.9	468.4	478.2	318.8	1	45.3	229.1	290.8	124.9
Euphausia superba	1	25.6	192.2	341.6	13.9	3	15.2	445.8	1800.5	12.4	5	6.0	30.1	37.8	15.2
Salpa thompsoni	13	0.9	6.5	10.8	2.4	4	5.2	153.8	223.5	46.4	2	9.7	49.1	59.8	30.5
Calanus propinquus	8	5.1	38.0	33.1	29.8	5	5.0	147.7	79.1	142.3	3	8.2	41.6	32.1	31.7
Calanoides acutus	2	15.7	118.2	212.8	38.2	6	3.8	113.0	91.7	96.7	4	6.7	33.8	28.2	24.5
Pareuchaeta antarctica	11	1.0	7.8	18.5	0.0	7	3.7	108.4	106.3	81.6	8	3.9	19.7	37.0	6.2
Other copepods	6	7.2	53.8	138.4	17.4	8	2.2	65.2	42.8	61.8	7	5.1	25.7	27.4	16.9
Limacina helicina	5	7.2	54.4	39.6	33.5	9	1.8	52.2	56.7	43.6		0.2	0.9	1.7	0.0
Chaetognaths	7	6.7	50.6	156.0	4.6	10	1.6	46.2	43.0	40.5	11	1.2	6.3	7.0	3.5
Euphausia frigida		0.1	0.8	2.0	0.0	11	1.3	38.5	47.2	21.1		0.2	1.1	4.0	0.0
Ostracods		0.2	1.3	2.8	0.0	12	0.7	19.7	23.4	14.0	13	0.5	2.7	6.2	0.0
Rhincalanus gigas	10	2.1	15.6	26.3	2.9	13	0.4	12.7	21.3	4.0	15	0.4	1.8	5.7	0.0
Euphausia superba (L)		0.0	0.2	1.0	0.0	14	0.3	9.7	21.8	0.0	14	0.4	2.1	3.9	0.0
Tomopteris spp.	15	0.3	2.5	3.6	0.8	15	0.3	7.9	14.8	2.5		0.3	1.3	1.5	0.8
Euphausia crystallorophias	3	11.3	85.1	280.2	1.0		0.3	7.4	21.4	0.0		0.0	0.2	1.0	0.0
Primno macropa	14	0.4	3.2	3.4	2.2		0.2	5.5	7.1	1.7	10	1.3	6.6	5.5	5.1
Themisto gaudichaudii		0.1	0.7	1.1	0.0		0.1	3.9	4.2	2.9	9	3.1	15.9	19.8	8.8
Radiolarians		0.3	2.4	3.6	1.0		0.1	3.2	5.9	0.0		0.3	1.3	2.0	0.0
Spongiobranchaea australis		0.1	0.9	2.0	0.0		0.1	3.1	5.9	1.0		0.1	0.6	0.9	0.4
Vibilia antarctica		0.1	1.0	1.3	0.3		0.1	2.7	3.4	1.6	12	0.6	3.0	3.4	1.5
Lepidonotothen larseni (L)		0.2	1.8	3.2	0.7		0.1	1.9	2.7	0.5		0.2	0.9	1.7	0.0
Electrona spp. (L)		0.2	1.2	4.0	0.0		0.1	1.7	4.0	0.0		0.3	1.7	2.2	0.4
Cyllopus lucasii		0.0	0.2	0.3	0.0		0.0	1.3	2.7	0.2		0.1	0.3	0.6	0.0
Clione limacina	12	1.0	7.6	19.3	3.0		0.0	1.3	1.5	1.0		0.0	0.2	0.5	0.0
Hyperiella dilatata		0.1	1.0	0.7	0.8		0.0	1.1	1.4	0.4		0.1	0.5	1.2	0.3
Beroe forskalii		0.0	0.2	0.4	0.0		0.0	1.1	2.0	0.0		0.0	0.1	0.3	0.0
Thysanoessa macrura (L)		0.2	1.4	4.7	0.0		0.0	1.0	3.3	0.0		0.2	0.8	1.6	0.0
Cyllopus magellanicus		0.0	0.2	0.5	0.0		0.0	0.7	1.1	0.0		0.2	0.8	1.0	0.0
Diphyes antarctica		0.1	1.0	1.2	0.4		0.0	0.4	0.8	0.0		0.0	0.1	0.2	0.0
Sipunculids		0.1	0.4	0.5	0.3		0.0	0.3	0.7	0.0		0.0	0.0	0.1	0.0
TOTAL			750.8					2939.4					506.0		

Table 4.7. Abundance of krill and other dominant zooplankton taxa collected in the Elephant Island area during January-February and February-March surveys, 1992-2003. Zooplankton data are not available for February-March 1992 or January 2000.

	Euphausia superba January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N	63	70	63	71	72	71	61	40	n.a.	60	44	38
Mean	23.7	28.8	34.5	9.5	82.1	29.6	27.1	5.3	---	18.9	39.0	318.8
SD	78.0	64.4	94.2	20.6	245.1	80.5	42.3	8.1	---	32.7	93.3	1386.0
Med	5.7	8.2	3.1	3.6	11.4	5.6	10.2	1.7	---	6.0	7.5	30.9
Max	594.1	438.9	495.9	146.1	1500.6	483.2	175.0	35.1	---	217.7	458.6	8683.2
	February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N	67	67	70	71	72	16	61	39	60	57	44	48
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
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
Med	7.1	3.0	0.4	1.2	4.1	4.6	4.5	0.8	3.3	4.6	0.4	8.7
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

	Salpa thompsoni January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N	63	70	63	71	72	71	61	40	n.a.	60	44	38
Mean	94.3	1213.4	931.9	20.2	25.5	223.2	939.7	197.5	---	622.8	410.0	61.9
SD	192.3	2536.7	950.2	46.5	36.3	336.4	1556.3	191.6	---	576.4	614.6	132.7
Med	14.0	245.8	582.3	1.6	10.5	87.1	348.9	159.1	---	449.3	85.8	8.7
Max	1231.1	16078.8	4781.7	239.9	161.6	2006.3	8030.4	873.4	---	3512.4	2816.8	420.3
	February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N	n.a.	67	70	71	72	16	61	39	60	57	44	48
Mean	---	1585.9	495.1	20.6	33.2	1245.5	977.3	309.1	912.8	452.4	570.4	60.7
SD	---	2725.5	579.4	66.5	85.7	1224.6	1496.5	376	3395.1	501.2	782.3	119.7
Med	---	605.9	242.6	0.7	5.6	521.0	553.8	160.7	262.9	312.1	250.9	7.0
Max	---	16662.5	2377.5	391.9	659.4	4348.3	10712.9	1550.2	24031.9	2416.8	2903.7	475.4

Table 4.7. (Contd.)

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

	Copepods January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N	n.a.	70	63	71	72	71	61	40	n.a.	60	44	38
Mean	---	73.5	32.4	741.0	897.5	656.4	41.2	928.2	---	1003.2	5484.3	541.0
SD	---	302.7	92.2	1061.3	1726.4	799.1	55.1	1590.8	---	1582.4	14585.6	798.6
Med	---	0.0	0.0	346.0	338.2	399.7	21.5	333.0	---	252.2	2174.9	317.0
Max	---	2312.6	465.3	7047.5	10598.0	4090.0	276.0	7524.8	---	6909.7	96514.5	4390.2
	February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N	n.a.	n.a.	70	71	72	16	61	39	60	57	44	48
Mean	---	---	3453.3	3707.3	1483.7	1267.8	110.4	1558.4	8019.1	4501.5	17473.4	1674.3
SD	---	---	8190.8	5750.3	2209.2	1755.6	170.3	2337.5	11824.4	8072.4	20036.9	2593.6
Med	---	---	172.4	1630.9	970.2	659.8	50.9	621.6	3478.0	1518.0	7563.8	737.5
Max	---	---	37987.2	40998.5	16621.0	7289.2	901.1	10786.6	57498.5	39800.7	90224.5	15990.9

Table 4.7. (Contd.)

	Euphausia superba Larvae January-February											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N	n.a.	n.a.	n.a.	71	72	71	61	40	n.a.	60	44	38
Mean	---	---	---	172.1	3.4	19.3	0.4	175.1	---	32.8	35.8	4.7
SD	---	---	---	969.4	8.3	27.0	1.6	795.5	---	86.2	64.6	16.8
Med	---	---	---	0.0	0.0	6.4	0.0	4.3	---	9.0	0.0	0.0
Max	---	---	---	8076.1	42.7	96.5	11.4	5083.2	---	654.0	356.3	95.5
	February-March											
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N	n.a.	n.a.	n.a.	71	72	16	61	39	60	57	44	48
Mean	---	---	---	4593.4	14.1	25.0	2.5	67.2	3423.2	71.9	49.9	6.1
SD	---	---	---	20117.0	44.0	81.4	18.3	146.0	8974.1	176.9	140.9	13.0
Med	---	---	---	268.6	3.3	0.0	0.0	12.3	248.7	5.1	0.0	0.0
Max	---	---	---	167575.6	368.5	339.0	144.1	692.5	44478.2	1197.7	728.6	56.1

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

Table 4.7. (Contd.)

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

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

Table 4.8. Maturity stage composition of krill collected in the Elephant Island Area during 2003 compared to 1992-2002. Advanced maturity stages are proportions of mature females that are (A) 3c-3e in January-February and (B) 3d-3e in February-March. Data are not available for January-February, 2000.

A. SURVEY A	*Euphausia superba* JANUARY-FEBRUARY											
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
Immature	19.1	30.7	18.8	4.0	18.3	30.6	31.7	11.7	---	6.2	9.0	39.1
Mature	43.9	62.2	77.2	91.4	26.7	54.2	49.9	87.9	---	84.1	44.7	18.5
Females:												
F2	0.8	7.8	2.3	0.1	1.1	6.3	9.1	1.6	---	0.2	0.4	12.3
F3a	0.6	11.7	18.0	0.2	0.0	3.5	21.4	1.7	---	0.9	0.5	11.7
F3b	12.3	14.3	19.3	1.2	0.2	0.6	9.0	1.8	---	14.6	2.3	1.3
F3c	9.2	5.1	20.1	15.3	1.9	6.9	1.0	14.7	---	13.2	13.7	1.6
F3d	0.4	1.2	2.3	17.7	0.7	6.1	0.3	23.9	---	7.4	10.0	0.0
F3e	0.0	0.0	0.0	3.7	11.6	7.4	0.7	9.2	---	1.3	6.2	0.0
Advanced Stages	42.7	19.5	37.5	96.3	98.3	83.2	6.2	93.2	---	58.5	91.6	11.2
Males:												
M2a	8.7	6.8	0.3	0.9	14.6	14.6	8.5	2.2	---	2.1	3.0	13.6
M2b	7.3	11.9	9.4	1.5	2.1	8.2	8.4	3.9	---	2.1	4.0	10.2
M2c	2.3	4.2	6.8	1.5	0.5	1.5	5.7	4.1	---	1.7	1.5	3.1
M3a	2.8	3.7	4.3	4.4	1.4	1.5	3.1	1.7	---	2.1	1.7	1.1
M3b	18.7	26.2	13.2	48.9	10.9	28.1	14.4	34.9	---	44.6	10.4	2.9
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
No. measured	2472	4283	2078	2294	4296	3209	3600	751	---	2063	1437	2466

B. SURVEY D	FEBRUARY-MARCH											
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Stage	%	%	%	%	%	%	%	%	%	%	%	%
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
No. measured	3646	3669	1155	1271	2984	560	3153	1176	1371	1739	558	1936

Table 4.9. Salp and krill carbon biomass (mg C per m^2) in the Elephant Island Area during 1995-2003 surveys. N is number of samples. Salp:Krill ratio is based on median values.

	January-February																	
	1995		1996		1997		1998		1999		2000		2001		2002		2003	
Biomass	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
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
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
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
N	57	71	72	72	71	71	61	60	40	40	---	---	60	60	44	44	38	38
Salp:Krill Ratio	0.03		0.1		2.4		4.0		6.4		n.a.		3.1		3.4		0.03	

	February-March																	
	1995		1996		1997		1998		1999		2000		2001		2002		2003	
Biomass	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
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
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
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
N	71	71	72	72	16	16	61	60	39	39	60	60	57	57	44	44	48	48
Salp:Krill Ratio	0.1		0.1		10.1		12.0		28.0		5.6		4.7		121.1		0.2	

Table 4.10. Zooplankton and nekton taxa present in the large survey area samples during (A) January 2003 and (B) February-March 2003 compared to 1995-2003 surveys. F is the frequency of occurrence (%) in (N) tows. Mean is number per 1000 m^3. Dashes indicate that taxon were not identified and/or enumerated. (L) and (J) denote larval and juvenile stages.

A. SURVEY A	JANUARY-FEBRUARY																	
	2003 N=83		2002 N=95		2001 N=101		2000 n.a.		1999 N=75		1998 N=105		1997 N=105		1996 N=91		1995 N=90	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean			F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Copepods	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
Thysanoessa macrura	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
Chaetognaths	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
Euphausia superba	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
Primno macropa	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
Salpa thompsoni	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
Themisto gaudichaudii	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	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.	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
Limacina helicina	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
Hyperiella dilatata	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
Spongiobranchaea australis	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
Clione limacina	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 larseni (L)	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
Radiolaria	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	-----	-----
Ostracods	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
Electrona spp. (L)	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
Euphausia frigida	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
Cyllopus magellanicus	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
Diphyes antarctica	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
Euphausia superba (L)	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
Cyllopus lucasii	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
Euphausia crystallorophias	30.1	29.7	12.6	16.5	1.0	0.0	---	---	9.3	0.1	---	---	---	---	---	---	4.4	0.0
Beroe forskalii	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	-----	-----
Sipunculids	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
Thysanoessa macrura (L)	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
Rhynchonereella bongraini	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
Dimophyes arctica	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
Notolepis coatsi (L)	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
Lepidonotothen kempi (L)	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
Clio pyramidata antarctica	15.7	1.7	2.1	0.0	-----	-----	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Table 4.10 (Contd.)

SURVEY A	JANUARY-FEBRUARY																	
	2003		2002		2001		2000		1999		1998		1997		1996		1995	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	n.a.		F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Pleuragramma antarcticum (L)	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
Callianira antarctica	14.5	0.1	-----	-----	-----	-----	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ihlea racovitzai	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
Larval Fish	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
Euphausia triacantha	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 spp.	10.8	0.2	3.2	0.0	2.0	0.0	---	---	28.0	0.4	1.0	0.0	1.0	0.0	-----	-----	-----	-----
Acanthophyra pelagica (L)	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
Euphausia frigida (L)	8.4	0.4	-----	-----	-----	-----	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Beroe cucumis	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
Clio pyramidata sulcata	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
Pegantha martagon	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
Hyperiella spp.	6.0	0.0	11.6	0.1	5.9	0.1	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Hyperiids	6.0	0.1	4.2	0.5	12.9	0.7	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Hyperiella macronyx	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
Hyperoche medusarum	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 rossi	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
Euphausia triacantha (L)	4.8	2.8	-----	-----	-----	-----	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Euphausia crystallorophias (L)	4.8	0.2	-----	-----	-----	-----	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Chionodraco rastrospinosus (L)	4.8	0.0	2.1	0.0	-----	-----	---	---	1.3	0.0	1.9	0.0	1.0	0.0	-----	-----	-----	-----
Bolinopsis infundibulus	4.8	0.0	1.1	0.0	-----	-----	---	---	5.3	0.0	1.9	0.0	-----	-----	-----	-----	-----	-----
Eusirus antarcticus	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
Atolla wyvillei	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
Notocrangon antarcticus(?)	3.6	0.1	-----	-----	-----	-----	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Gastropods	3.6	0.1	2.1	0.0	-----	-----	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Siphonophora	3.6	0.1	2.1	0.0	3.0	0.3	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ctenophora	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
Gammarids	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	-----	-----
Fish Eggs	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
Orchomene spp.	2.4	0.1	-----	-----	-----	-----	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Decapods (L)	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	-----	-----
Pleurobrachia pileus	2.4	0.0	2.1	0.0	-----	-----	---	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Cumaceans	2.4	0.3	2.1	2.7	1.0	0.0	---	---	-----	-----	-----	-----	3.8	0.4	1.1	0.0	-----	-----
Orchomene plebs	2.4	0.0	1.1	0.0	-----	-----	---	---	-----	-----	1.0	0.0	2.9	0.0	1.1	0.0	4.4	0.0
Calycopsis borchgrevinki	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
Notolepis spp. (L)	2.4	0.0	0.0	0.0	2.0	0.0	---	---	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----
Notolepis annulata (L)	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

Table 4.10 (Contd.)

SURVEY A	JANUARY-FEBRUARY																	
	2003		2002		2001		2000		1999		1998		1997		1996		1995	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	n.a.		F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Mitrocomella brownei	1.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Russelia mirabilis	1.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Leusia sp.	1.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Atolla sp.	1.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Electrona antarctica	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
Bathylagus sp. (L)	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
Modeeria rotunda	1.2	0.0	2.1	0.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Electrona carlsbergi	1.2	0.0	2.1	0.0	2.0	0.0	-----	-----	2.7	0.0	1.0	0.0	10.5	0.1	-----	-----	-----	-----
Staurophora mertensi ?	1.2	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Gymnoscopelus braueri	1.2	0.0	1.1	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Hyperia antarctica	1.2	0.0	1.1	0.0	1.0	0.0	-----	-----	0.0	0.0	0.0	0.0	1.9	0.0	-----	-----	-----	-----
Artededraco mirus (L)	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
Krefftichthys anderssoni (L)	1.2	0.0	1.1	0.0	0.0	0.0	-----	-----	0.0	0.0	0.0	0.0	1.9	0.0	-----	-----	-----	-----
Maupasia coeca	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	-----	-----
Cephalopods	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
Epimeriella macronyx	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
Scina spp.	1.2	0.0	0.0	0.0	1.0	0.1	-----	-----	0.0	0.0	0.0	0.0	4.8	0.1	-----	-----	-----	-----
Periphylla periphylla	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
Vogtia serrata	1.2	0.0	0.0	0.0	0.0	0.0	-----	-----	1.3	0.0	0.0	0.0	3.8	0.1	-----	-----	-----	-----
Cryodraco antarctica (L)	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	-----	-----
Eusirus spp.	1.2	0.0	0.0	0.0	0.0	0.0	-----	-----	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----
Hydromedusae	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
Polychaetes	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	-----	-----
Euphausia spp. (L)	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	-----	-----
Lepidonotothen nudifrons (L)	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
Prionodraco evansii (J)	0.0	0.0	4.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Trematomus newnesi (L)	0.0	0.0	4.2	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mysids	0.0	0.0	3.2	0.1	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Chromatonema rubra	0.0	0.0	2.1	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Zanclonia weldoni	0.0	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Notothenia spp. (L)	0.0	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Vanadis antarctica	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
Schyphomedusae	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	-----	-----
Clione antarctica	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Spongiobranchaea sp.	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Lepidonotothen larseni (J)	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Table 4.10 (Contd.)

SURVEY A	JANUARY-FEBRUARY																	
	2003		2002		2001		2000		1999		1998		1997		1996		1995	
TAXON	F(%)	Mean	F(%)	Mean	F(%)	Mean	n.a.		F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Crustacean larvae	0.0	0.0	1.1	0.8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Parachaenechthys charcoti (L)	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Schizobrachium polycotylum	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pasiaphaea sp. (L)	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Trematomus lepidorhinus (L)	0.0	0.0	1.1	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Trematomus scotti (L)	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pelagobia longicirrata	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	-----	-----
Electrona subaspera	0.0	0.0	1.1	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Gobionotothen gibberifrons (L)	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
Hyperiella antarctica	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
Gymnoscopelus nicholsi	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
Chaenodraco wilsoni (L)	0.0	0.0	0.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Botrynema brucei	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
Eusirus perdentatus	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
Patagonitothen b. guntheri (J)	0.0	0.0	0.0	0.0	0.0	0.0	-----	-----	1.3	0.0	-----	-----	-----	-----	-----	-----	-----	-----
Bylgides pelagica	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
Notothenia coriiceps (L)	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
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	2.2	0.0
Travisiopsis coniceps	0.0	0.0	0.0	0.0	0.0	0.0	-----	-----	0.0	0.0	0.0	0.0	1.0	0.0	-----	-----	-----	-----
Arctapodema ampla	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	-----	-----
Cyphocaris richardi	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
Bolinopsis sp.	0.0	0.0	0.0	0.0	0.0	0.0	-----	-----	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----
Eusirus microps	0.0	0.0	0.0	0.0	0.0	0.0	-----	-----	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0
Chaenocephalus aceratus (L)	0.0	0.0	0.0	0.0	0.0	0.0	-----	-----	0.0	0.0	3.8	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	1.1	0.0	-----	-----
Artededraco skottsbergi (L)	0.0	0.0	0.0	0.0	0.0	0.0	-----	-----	0.0	0.0	1.0	0.0	1.0	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	3.3	0.0
Oediceroides calmani	0.0	0.0	0.0	0.0	0.0	0.0	-----	-----	0.0	0.0	0.0	0.0	1.0	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	1.1	0.0
Phalacrophorus pictus	0.0	0.0	0.0	0.0	0.0	0.0	-----	-----	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	-----	-----
Thyphloscolex muelleri	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	-----	-----
Chorismus 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	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	1.0	0.0	-----	-----	-----	-----
Hyperia macrocephala	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
Krefftichthys anderssoni	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	-----	-----
Travisiopsis levinseni	0.0	0.0	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
Gymnoscopelus opisthopteris	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
TOTAL		1264.92		11143.1		3812.2		---		1294.2		1172.7		1015.2		1408.9		1052.2
TAXA	88		89		63		---		65		63		70		66		68	

Table 4.10 (Contd.)

B. SURVEY D	FEBRUARY-MARCH																	
	2003 N=95		2002 N=94		2001 N=97		2000 N=97		1999 N=67		1998 N=104		1997 N=16		1996 N=91		1995 N=89	
TAXON	F (%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean	F(%)	Mean
Copepods (Total)	100.0	1533.7	100.0	15904.8	99.0	5915.7	99.0	7038.7	100.0	1454.5	97.1	119.0	100.0	1267.8	98.9	1387.0	100.0	3189.1
Thysanoessa macrura	100.0	293.3	79.8	112.8	86.5	639.0	92.8	41.5	98.5	93.1	100.0	177.4	100.0	181.3	91.2	143.3	93.3	161.3
Chaetognaths	96.8	83.1	97.9	880.1	77.1	164.5	91.8	632.8	91.0	127.4	61.5	10.7	75.0	18.2	93.4	64.1	100.0	296.4
Themisto gaudichaudii	93.7	6.4	97.9	30.2	79.2	4.3	83.5	7.2	32.8	0.2	32.7	0.3	87.5	2.9	91.2	2.5	74.2	3.6
Euphausia superba	90.5	151.5	57.4	281.6	79.2	59.0	77.3	21.0	61.2	24.4	89.4	133.5	68.8	30.4	86.8	106.7	78.7	5.7
Salpa thompsoni	76.8	77.8	80.9	621.6	100.0	392.1	96.9	726.2	100.0	248.1	98.1	689.1	100.0	1245.5	62.6	28.2	59.6	16.5
Primno macropa	73.7	6.7	57.4	28.2	28.1	1.5	44.3	3.2	65.7	2.6	49.0	1.9	18.8	0.5	63.7	3.5	31.5	0.4
Vibilia antarctica	63.2	1.9	46.8	22.2	99.0	10.9	95.9	20.2	98.5	3.6	96.2	8.0	81.3	8.1	48.4	1.0	23.6	0.2
Euphausia frigida	58.9	31.3	66.0	80.0	50.0	42.0	67.0	49.9	64.2	20.0	29.8	9.3	68.8	44.8	54.9	9.0	60.7	16.7
Electrona spp. (L)	55.8	2.5	20.2	2.2	12.5	0.8	43.3	4.0	20.9	0.3	10.6	0.2	12.5	0.1	38.5	0.9	62.9	5.2
Spongiobranchaea australis	54.7	1.3	47.9	1.3	70.8	4.1	68.0	2.7	65.7	1.0	38.5	0.8	43.8	2.8	68.1	1.4	60.7	0.4
Tomopteris spp.	49.5	1.9	18.1	1.1	19.8	0.4	23.7	2.3	55.2	2.8	8.7	0.0	31.3	0.5	38.5	0.9	57.3	1.3
Ostracods	48.4	9.0	22.3	42.6	20.8	10.1	45.4	25.1	80.6	14.0	43.3	5.4	56.3	4.8	47.3	10.1	75.3	43.4
Radiolaria	46.3	2.3	36.2	7918.3	32.3	216.2	40.2	531.4	40.3	6.3	28.8	1.0	12.5	0.7	34.1	0.9	27.0	0.4
Cyllopus magellanicus	45.3	2.2	34.0	2.8	70.8	2.9	87.6	10.0	95.5	4.8	81.7	5.6	93.8	3.3	46.2	2.1	25.8	0.7
Hyperiella dilatata	37.9	0.4	38.3	2.6	30.2	0.4	22.7	0.4	56.7	1.2	34.6	0.4	25.0	0.2	52.7	0.8	24.7	0.1
Limacina helicina	36.8	1.5	5.3	0.6	33.3	1.8	45.4	205.4	26.9	1.9	37.5	0.8	0.0	0.0	24.2	1.9	4.5	0.0
Lepidonotothen kempi (L)	35.8	0.6	18.1	0.3	19.8	0.2	29.9	0.3	16.4	0.1	22.1	0.2	6.3	0.2	39.6	0.4	48.3	0.4
Euphausia crystallorophorias	31.6	4.9	11.7	65.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Euphausia triacantha	30.5	1.8	22.3	2.2	16.7	1.2	25.8	1.9	22.4	1.8	11.5	0.6	43.8	0.9	22.0	0.8	28.1	1.6
Diphyes antarctica	29.5	0.4	8.5	0.2	20.8	0.2	21.6	0.4	31.3	0.3	29.8	0.4	6.3	0.3	7.7	0.1	23.6	0.4
Euphausia superba (L)	27.4	3.9	28.7	61.0	64.6	683.4	80.4	2129.6	80.6	49.8	12.5	1.6	37.5	25.0	62.6	13.9	93.3	3690.0
Thysanoessa macrura (L)	25.3	1.1	96.8	1111.5	91.7	718.3	82.5	883.9	74.6	137.4	13.5	2.6	50.0	10.8	87.9	414.4	79.8	276.9
Notolepis coatsi (L)	23.2	0.2	12.8	0.2	2.1	0.0	6.2	0.0	0.0	0.0	4.8	0.0	0.0	0.0	18.7	0.1	36.0	0.2
Euphausia frigida (L)	18.9	1.0	19.1	53.4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Clione limacina	18.9	0.3	4.3	0.1	16.7	0.9	5.2	0.0	3.0	0.0	10.6	0.1	12.5	0.0	15.4	0.2	-----	-----
Cyllopus lucasii	17.9	0.2	30.9	3.0	96.9	26.6	4.1	0.0	29.9	0.2	57.7	1.6	93.8	2.4	34.1	0.2	23.6	0.5
Larval Fish	17.9	0.7	1.1	0.0	1.0	0.0	6.2	0.6	14.9	0.7	1.9	0.1	0.0	0.0	1.1	0.0	-----	-----
Rhynchonereella bongraini	16.8	1.0	0.0	0.0	2.1	0.0	5.2	0.6	31.3	2.3	1.0	0.0	0.0	0.0	5.5	0.1	20.2	0.1
Lepidonotothen larseni (L)	15.8	0.5	11.7	1.8	14.6	0.2	3.1	0.0	11.9	0.0	13.5	0.1	0.0	0.0	13.2	0.3	10.1	0.0
Pleuragramma antarcticum (L)	15.8	0.2	5.3	0.2	5.2	0.1	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	1.1	0.0	2.2	0.0
Sipunculids	15.8	0.1	4.3	1.5	12.5	0.3	12.4	0.1	11.9	0.0	4.8	0.1	6.3	0.0	8.8	0.1	9.0	0.0
Callianira antarctica	13.7	0.3	0.0	0.0	5.2	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ihlea racovitzai	10.5	0.5	5.3	0.3	3.1	0.3	13.4	0.6	26.9	5.1	61.5	51.5	-----	-----	-----	-----	-----	-----
Cyllopus spp.	9.5	0.4	13.8	0.9	0.0	0.0	25.8	2.9	0.0	0.0	24.0	0.7	24.0	0.7	-----	-----	-----	-----

Table 4.10 (Contd.)

B. SURVEY D	FEBRUARY-MARCH																	
	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
Electrona antarctica	9.5	0.1	12.8	0.1	5.2	0.0	15.5	0.1	6.0	0.0	8.7	0.0	31.3	0.2	20.9	0.2	15.7	0.1
Dimophyes arctica	9.5	0.1	8.5	0.1	15.6	0.2	15.5	0.6	0.0	0.0	16.3	0.4	12.5	0.1	13.2	0.1	13.5	0.3
Pegantha margaton	8.4	0.1	3.2	0.1	27.1	0.3	13.4	0.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Gymnoscopelus braueri	7.4	0.1	6.4	0.1	7.3	0.0	8.2	0.1	7.5	0.1	-----	-----	-----	-----	-----	-----	-----	-----
Clio pyramidata antarctica?	6.3	0.2	4.3	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Calycopsis borchgrevinki	6.3	0.0	4.3	0.0	6.3	0.0	13.4	0.2	19.4	0.4	4.8	0.0	6.3	0.0	6.6	0.0	11.2	0.0
Notolepis spp. (L)	6.3	0.1	1.1	0.0	1.0	0.2	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0
Hyperiella spp.	5.3	0.2	12.8	0.2	0.0	0.0	9.3	0.3	9.0	0.1	1.0	0.0	-----	-----	-----	-----	-----	-----
Hydromedusae	5.3	0.1	5.3	0.0	4.2	0.0	23.7	0.5	40.3	0.3	12.5	0.2	12.5	0.2	3.3	0.1	5.6	0.0
Euphausia spp. (L)	5.3	0.1	3.2	4.4	1.0	0.4	11.3	4.3	13.4	1.5	-----	-----	-----	-----	-----	-----	-----	-----
Polychaetes	5.3	0.3	1.1	0.0	6.3	0.6	18.6	2.6	7.5	0.3	13.5	0.3	0.0	0.0	3.3	0.1	2.2	0.0
Fish Eggs	5.3	0.2	0.0	0.0	3.1	0.0	0.0	0.0	1.5	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Hyperoche medusarum	4.2	0.0	3.2	0.0	10.4	0.1	3.1	0.0	4.5	0.0	0.0	0.0	12.5	0.3	2.2	0.0	12.4	0.0
Scina spp.	4.2	0.1	1.1	0.0	0.0	0.0	1.0	0.0	1.5	0.0	0.0	0.0	6.3	0.5	2.2	0.0	1.1	0.0
Beroe cucumis	4.2	0.0	1.1	0.0	7.3	0.1	2.1	0.0	9.0	0.0	4.8	0.0	0.0	0.0	11.0	0.1	4.5	0.0
Orchomene rossi	4.2	0.2	1.1	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.0	0.0	0.0	0.0	5.5	0.5	6.7	0.0
Atolla wyvillei	4.2	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	-----	-----
Ctenophora	4.2	0.0	0.0	0.0	5.2	0.0	6.2	0.1	4.5	0.0	0.0	0.0	6.3	0.0	1.1	0.0	3.4	0.0
Euphausia spp.	4.2	0.2	0.0	0.0	0.0	0.0	4.1	0.7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Eusirus antarcticus	3.2	0.0	2.1	0.0	5.2	0.1	1.0	0.0	1.5	0.0	1.9	0.0	-----	-----	-----	-----	-----	-----
Cyphocaris richardi	3.2	0.0	2.1	0.0	1.0	0.0	3.1	0.0	1.5	0.0	0.0	0.0	0.0	0.0	1.1	0.0	3.4	0.1
Orchomene plebs	3.2	0.0	2.1	0.0	1.0	0.0	2.1	0.8	0.0	0.0	1.9	0.0	0.0	0.0	2.2	0.0	3.4	0.0
Harpagifer antarcticus (L)	3.2	0.0	2.1	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	-----	-----
Acanthophyra pelagica	3.2	0.1	1.1	0.0	0.0	0.0	0.0	0.0	3.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	5.6	0.0
Beroe forskalii	3.2	0.0	0.0	0.0	10.4	0.0	13.4	0.1	9.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Eusirus properdentatus	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Euphausia crystallorophorias (L)	2.1	0.0	6.4	14.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Cephalopods	2.1	0.0	2.1	0.0	1.0	0.0	2.1	0.0	4.5	0.0	1.9	0.0	0.0	0.0	9.9	0.0	-----	-----
Euphausia triacantha (L)	2.1	0.0	1.1	0.8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Champsocephalus gunnari (L)	2.1	0.0	1.1	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	1.1	0.0
Gastropods	2.1	0.2	0.0	0.0	0.0	0.0	4.1	17.6	6.0	0.5	1.9	0.0	-----	-----	-----	-----	-----	-----
Epimeriella macronyx	2.1	0.1	0.0	0.0	0.0	0.0	2.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	5.6	0.6
Protomyctophum bolini	2.1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pseudochaenichthys georgianus (J)	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Cryodraco antarctica (L)	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Clio pyramidata sulcata	1.1	0.0	5.3	0.2	10.4	0.4	5.2	0.0	13.4	0.1	0.0	0.0	0.0	0.0	3.3	0.0	12.4	0.0

Table 4.10 (Contd.)

B. SURVEY D	FEBRUARY-MARCH																	
	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
Gammarids	1.1	0.1	4.3	2.3	4.2	0.4	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Gymnoscopelus nicholsi	1.1	0.0	2.1	0.0	3.1	0.0	1.0	0.0	1.5	0.0	1.0	0.0	12.5	0.1	3.3	0.0	1.1	0.0
Mysids	1.1	0.0	2.1	0.1	1.0	0.1	1.0	0.0	1.5	0.0	-----	-----	-----	-----	-----	-----	-----	-----
Hyperiella macronyx	1.1	0.0	1.1	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	6.3	0.0	6.6	0.1	13.5	0.0
Hyperiids	1.1	0.0	0.0	0.0	5.2	0.3	8.2	2.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pleurobrachia pileus	1.1	0.0	0.0	0.0	5.2	0.0	0.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Siphonophora	1.1	0.0	0.0	0.0	2.1	0.0	10.3	2.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bylgides pelagica	1.1	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0
Chionodraco rastrospinosus (L)	1.1	0.0	0.0	0.0	1.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Botrynema brucei	1.1	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Orchomene spp.	1.1	0.0	0.0	0.0	0.0	0.0	1.0	1.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Zanclonia weldoni?	0.0	0.0	6.4	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Clytia sp.?	0.0	0.0	4.3	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Trematomus scotti (L)	0.0	0.0	4.3	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Chromatonema rubra?	0.0	0.0	3.2	0.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Modeeria rotunda?	0.0	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bolinopsis spp.	0.0	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Vanadis antarctica	0.0	0.0	2.1	0.0	1.0	0.0	4.1	0.1	1.5	0.0	3.8	0.1	0.0	0.0	1.1	0.0	6.7	0.0
Lepidonotothen nudifrons (L)	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	1.1	0.0	3.4	0.0
Cumaceans	0.0	0.0	1.1	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	-----	-----
Parachaenechthys charcoti (L)	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Arctapodema ampla	0.0	0.0	1.1	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Gerlache australis (L)	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pyrasoma atlanticum	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Trematomus newnesi (L)	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mitrocomella brownei?	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Trematomus centronotus (L)	0.0	0.0	1.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Electrona carlsbergi	0.0	0.0	1.1	0.0	6.3	0.0	1.0	0.0	4.5	0.0	1.9	0.0	-----	-----	-----	-----	-----	-----
Limacina spp.	0.0	0.0	1.1	0.2	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pelagobia longicirrata	0.0	0.0	1.1	0.0	0.0	0.0	5.2	0.6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bathydraco antarcticus (L)	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	3.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----
Periphylla periphylla	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1	0.0
Euphausiid eggs	0.0	0.0	0.0	0.0	19.8	9.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Electrona subaspera	0.0	0.0	0.0	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Laodicea undulata	0.0	0.0	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Gymnoscopelus bolini	0.0	0.0	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Table 4.10 (Contd.)

B. SURVEY D																	FEBRUARY-MARCH
	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
Eusirus perdentatus	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.2	0.0	6.7	0.1
Krefftichthys anderssoni (L)	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----
Notothenia coriiceps (L)	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Schyphomedusae	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	12.5	0.0	19.8	0.1	13.5	0.1
Leusia spp.	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bolinopsis infundibulus	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Gobionotothen gibberifrons (L)	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Solomondella spp.	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pasiaphaea sp. (L)	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Chorismus antarcticus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	-----	-----	-----	-----	-----	-----	-----	-----
Travisiopsis coniceps	0.0	0.0	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	1.1	0.0
Lepidonotothen larseni (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Pagetopsis macropterus	0.0	0.0	0.0	0.0	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
Artedidraco skottsbergi (L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	-----	-----	-----	-----	-----	-----
Chaenodraco wilsoni (J)	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 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	3.3	0.0	10.1	0.0
Rhynchonereella sp.	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 sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	-----	-----	-----	-----	-----	-----
Bathylagus sp. (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	6.3	0.0	1.1	0.0	14.6	0.0
Pagothenia brachysoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	-----	-----	-----	-----	-----	-----
Decapods (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	1.1	0.0	-----	-----
Notolepis annulata (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	6.3	0.0	5.5	0.0	3.4	0.0
Hyperia macrocephala	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	1.1	0.0	5.6	0.0
Eusirus microps	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	-----	-----
Hyperia 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	1.1	0.1	-----	-----
TOTAL		2228.5		27260.8		8910.2		12378.9		2207.6		1224.4		2854.0		2196.4		7713.3
TAXA	82		84		72		72		58		60		37		63		62	

Table 4.11. 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, 1994-2003. Includes the 10 most abundant taxa each year. Radiolarians excluded as a taxonomic category. No samples were collected January-February 2000. Dashes indicate that taxon was not enumerated.

A.	JANUARY-FEBRUARY																			
	2003		2002		2001		2000		1999		1998		1997		1996		1995		1994	
TAXON	%	R	%	R	%	R	n.a.		%	R	%	R	%	R	%	R	%	R	%	R
Copepods	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	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
Thysanoessa macrura	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	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
Limacina helicina	2.55	5	0.03		0.14		---	---	0.07		0.69	8	0.28		2.38	5	0.18		0.03	
Chaetognaths	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	
Euphausia frigida	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
Ostracods	0.53	8	0.09		0.25		---	---	0.13		0.41	9	0.54	9	0.35	8	0.91	9	---	
Primno macropa	0.44	9	0.12		0.10		---	---	0.13		0.06		0.42	10	0.01		0.01		0.05	
Euphausia superba (L)	0.37	10	0.49	7	1.53	6	---	---	10.95	3	0.09		1.49	7	0.19	10	12.80	2	---	
Themisto gaudichaudii	0.35		0.32	10	0.17		---	---	0.02		0.03		0.35		0.34	9	0.46		1.05	6
Tomopteris spp.	0.20		0.03		0.11		---	---	0.15	10	0.11		0.19		0.06		0.40		0.25	10
Vibilia antarctica	0.19		0.06		0.98	8	---	---	0.32	9	1.12	6	0.24		0.04		0.02		1.17	5
Spongiobranchaea australis	0.15		0.02		0.09		---	---	0.09		0.07		0.22		0.13		0.05		0.01	
Thysanoessa macrura (L)	0.09		10.67	2	12.55	3	---	---	7.29	4	0.00		1.67	6	21.82	2	1.50	6	---	
Cyllopus lucasii	0.06		0.02		0.98	9	---	---	0.15		0.16	10	0.37		0.11		0.02		0.62	7
Euphausia triacantha	0.05		0.02		0.10		---	---	0.03		0.02		0.14		0.04		0.14		0.12	
Ihlea racovitzai	0.03		0.02		0.02		---	---	0.15		3.53	4	---		---		---		---	
Clio pyramidata sulcata	0.01		0.46	8	0.08		---	---	0.01		0.02		0.00		0.01		0.50	10	0.53	8
TOTAL	98.61		99.34		99.68		---		98.15		99.32		98.79		99.64		99.26		99.69	

B.	FEBRUARY-MARCH																			
	2003		2002		2001		2000		1999		1998		1997		1996		1995		1994	
TAXON	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R
Copepods	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
Thysanoessa macrura	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
Chaetognaths	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 superba	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
Salpa thompsoni	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
Euphausia frigida	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
Primno macropa	0.35	7	0.21	9	0.03		0.02		0.08		0.11		0.02		0.15	10	0.00		0.00	
Euphausia superba (L)	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	---	
Ostracods	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	---	
Themisto gaudichaudii	0.20	10	0.12		0.07		0.02		0.01		0.01		0.10		0.09		0.01		0.27	8
Electrona spp. (L)	0.18		0.02		0.02		0.03		0.01		0.01		0.01		0.04		0.07	9	0.75	4
Cyllopus magellanicus	0.09		0.02		0.02		0.07		0.17		0.55	9	0.12		0.10		0.01		0.12	
Euphausia triacantha	0.09		0.01		0.02		0.01		0.06		0.04		0.03		0.03		0.02		0.03	
Euphausia frigida (L)	0.07		0.40	5	---		---		---		---		---		---		---		---	
Vibilia antarctica	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
Limacina helicina	0.06		0.00		0.00		2.21	6	0.00		0.03		0.00		0.01		0.00		0.00	
Thysanoessa macrura (L)	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	---	
Ihlea racovitzai	0.01		0.00		0.00		0.00		0.34	10	2.77	5	---		---		---		---	
Euphausia spp. (L)	0.01		0.00		0.01		0.04		0.10		0.00		0.00		0.00		0.00		---	
Cyllopus lucasii	0.01		0.01		0.43	9	0.00		0.01		0.14		0.08		0.01		0.01		0.14	10
TOTAL	99.29		99.72		99.86		99.61		98.76		96.17		99.70		99.56		99.93		98.66	

Table 4.12. Abundance of biomass dominant copepod species in the Elephant Island Area during various cruises 1981-2003. 1981-1990 data provided by John Wormuth. Abundance is numbers per 1000 m^3. Dashes indicate that data are not available.

SURVEY PERIOD	TAXON	*Calanoides acutus*	*Calanus propinquus*	*Metridia gerlachei*	*Rhincalanus gigas*	*Pleuromama robusta*	*Pareuchaeta antarctica?*	*Haloptilus ocellatus*	*Racovitzanus antarcticus?*	Copepodites	Other Copepods	Total Copepods
Jan-Feb 88	Mean	429.7	93.6	1639.0	---	---	---	---	---	---	---	2162.3
N=48	STD	676.8	104.3	3488.0	---	---	---	---	---	---	---	3928.6
	Median	80.5	45.5	57.0	---	---	---	---	---	---	---	618.5
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	1003.2	20.2	5.5	0.2	0.0	---	---	197.5	1003.2
N=60	STD	392.0	85.9	1582.4	74.8	21.0	0.6	0.0	---	---	527.3	1582.4
	Median	117.7	12.5	252.2	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	---	0.2	170.5	0.1	41.0	541.0
N=38	STD	67.9	65.0	639.3	23.4	10.9	---	1.0	201.2	0.9	34.9	798.6
	Median	52.0	55.1	6.7	1.9	0.0	---	0.0	48.7	0.0	27.8	317.0

SURVEY PERIOD	TAXON	*Calanoides acutus*	*Calanus propinquus*	*Metridia gerlachei*	*Rhincalanus gigas*	*Pleuromama robusta*	*Pareuchaeta antarctica?*	*Haloptilus ocellatus*	*Racovitzanus antarcticus?*	Copepodites	Other Copepods	Total Copepods
Mar 81	Mean	4786.9	5925.8	2402.5	---	---	---	---	---	---	---	13115.2
N=10	STD	5482.2	6451.6	3321.4	---	---	---	---	---	---	---	12799.9
	Median	2197.7	2048.7	609.5	---	---	---	---	---	---	---	8466.8
Feb-Mar 84	Mean	25.5	121.7	1154.4	---	---	---	---	---	---	---	1301.6
N=13	STD	29.6	134.4	2999.9	---	---	---	---	---	---	---	3043.9
	Median	16.2	51.4	23.1	---	---	---	---	---	---	---	96.6
Feb 89	Mean	161.4	194.9	3189.3	---	---	---	---	---	---	---	3545.6
N=25	STD	240.9	151.5	4017.2	---	---	---	---	---	---	---	4071.5
	Median	88.0	162.0	1051.0	---	---	---	---	---	---	---	1776.0
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	121.0	0.0	205.0	1674.3
N=48	STD	114.2	70.2	2239.6	45.9	17.5	10.0	1.7	161.3	0.0	235.4	2593.6
	Median	119.3	47.9	197.3	17.9	0.0	0.0	0.0	56.7	0.0	130.2	737.5

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, 1994-2003.

A.	JANUARY-FEBRUARY PSI VALUES								
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003
1994	16.7	16.6	34.2	85.0	20.9	n.a	38.7	14.5	20.9
1995	xxxxx	70.3	76.8	18.7	80.7	n.a.	58.9	71.7	58.7
1996		xxxxx	73.4	19.3	70.0	n.a.	65.9	73.4	64.2
1997			xxxxx	38.4	80.2	n.a.	75.7	71.3	66.6
1998				xxxxx	22.6	n.a.	39.8	15.2	30.9
1999					xxxxx	n.a.	75.1	77.4	54.4
2000						xxxxx	n.a.	n.a.	n.a.
2001							xxxxx	69.2	54.4
2002								xxxxx	53.8

B.	FEBRUARY-MARCH PSI VALUES								
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003
1994	42.4	66.9	60.1	22.9	78.4	61.8	74.9	86.4	80.4
1995	xxxxx	49.1	44.0	10.0	52.4	72.0	48.1	48.9	46.2
1996		xxxxx	54.3	21.1	80.3	67.0	80.9	74.1	76.4
1997			xxxxx	60.5	65.2	53.6	61.3	49.5	57.6
1998				xxxxx	27.7	15.5	26.2	12.0	25.6
1999					xxxxx	76.9	85.0	78.7	77.2
2000						xxxxx	71.0	70.0	62.9
2001							xxxxx	76.8	81.2
2002								xxxxx	82.5

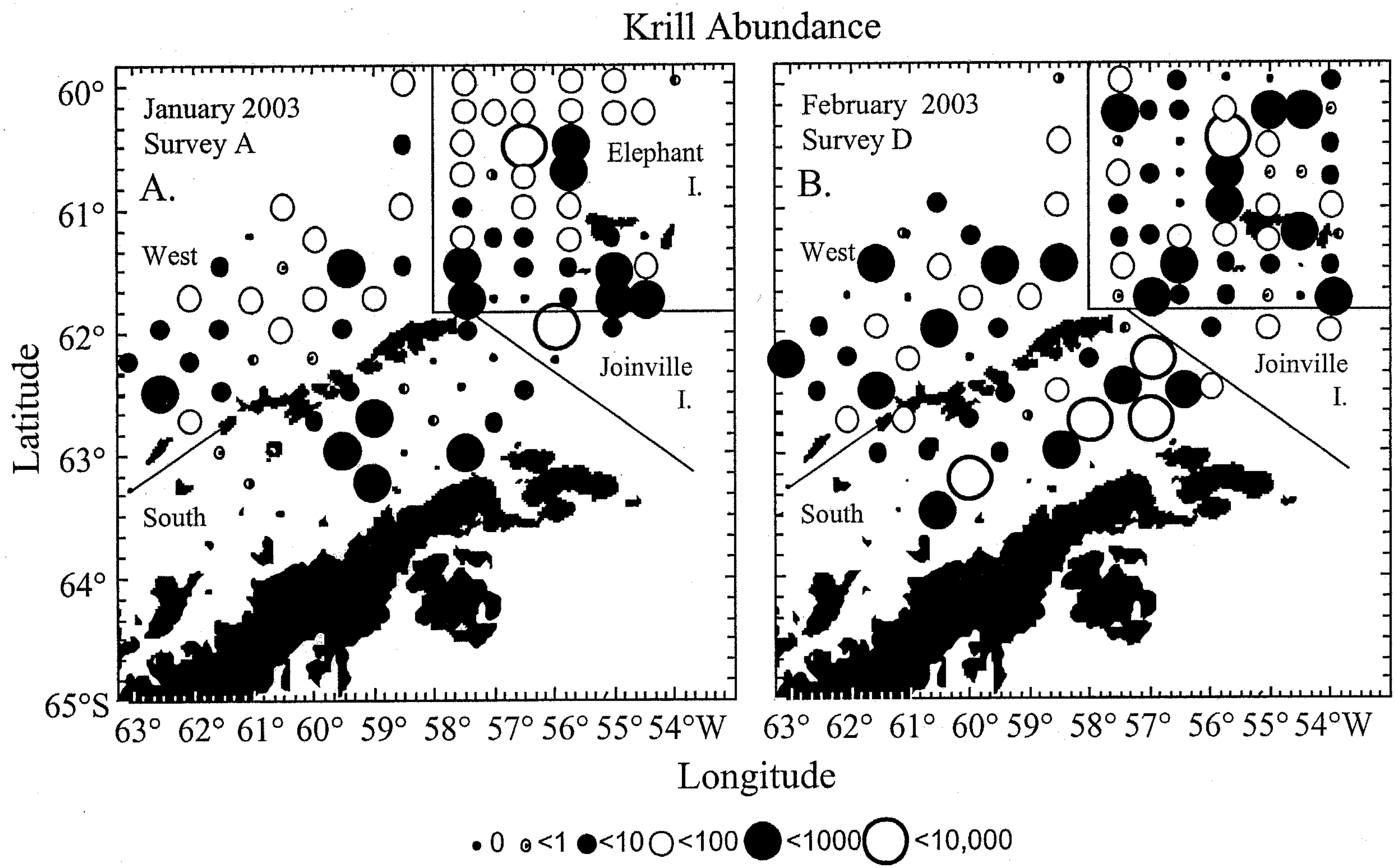


Figure 4.1 Krill abundance in IKMT tows collected during (A) January Survey A and (B) February Survey D. The outlined stations included in the Elephant Island Area are used for between-year comparisons. West, South and Joinville Island Area stations are indicated.

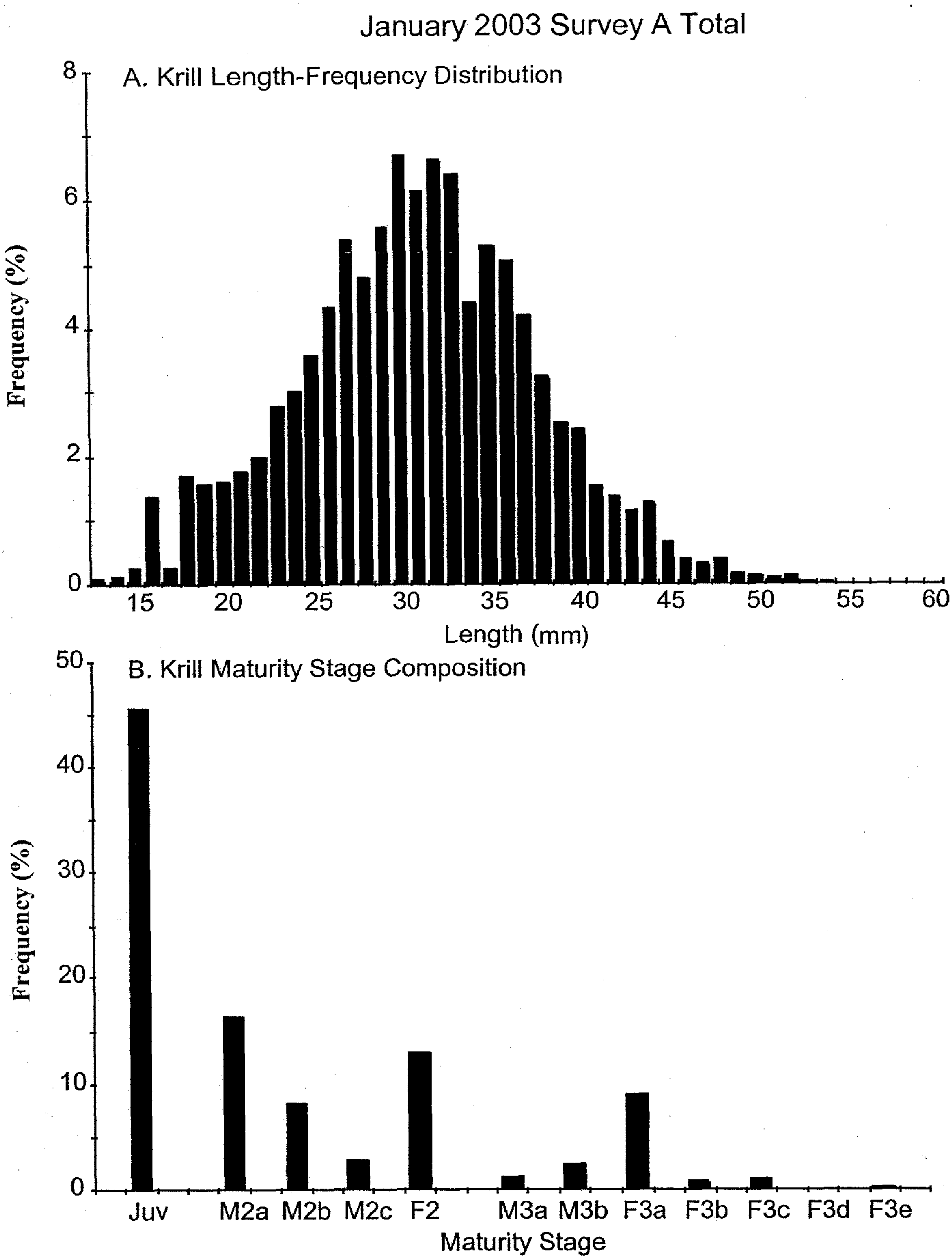


Figure 4.2 Krill (A) length-frequency distribution and (B) maturity stage composition during Survey A.

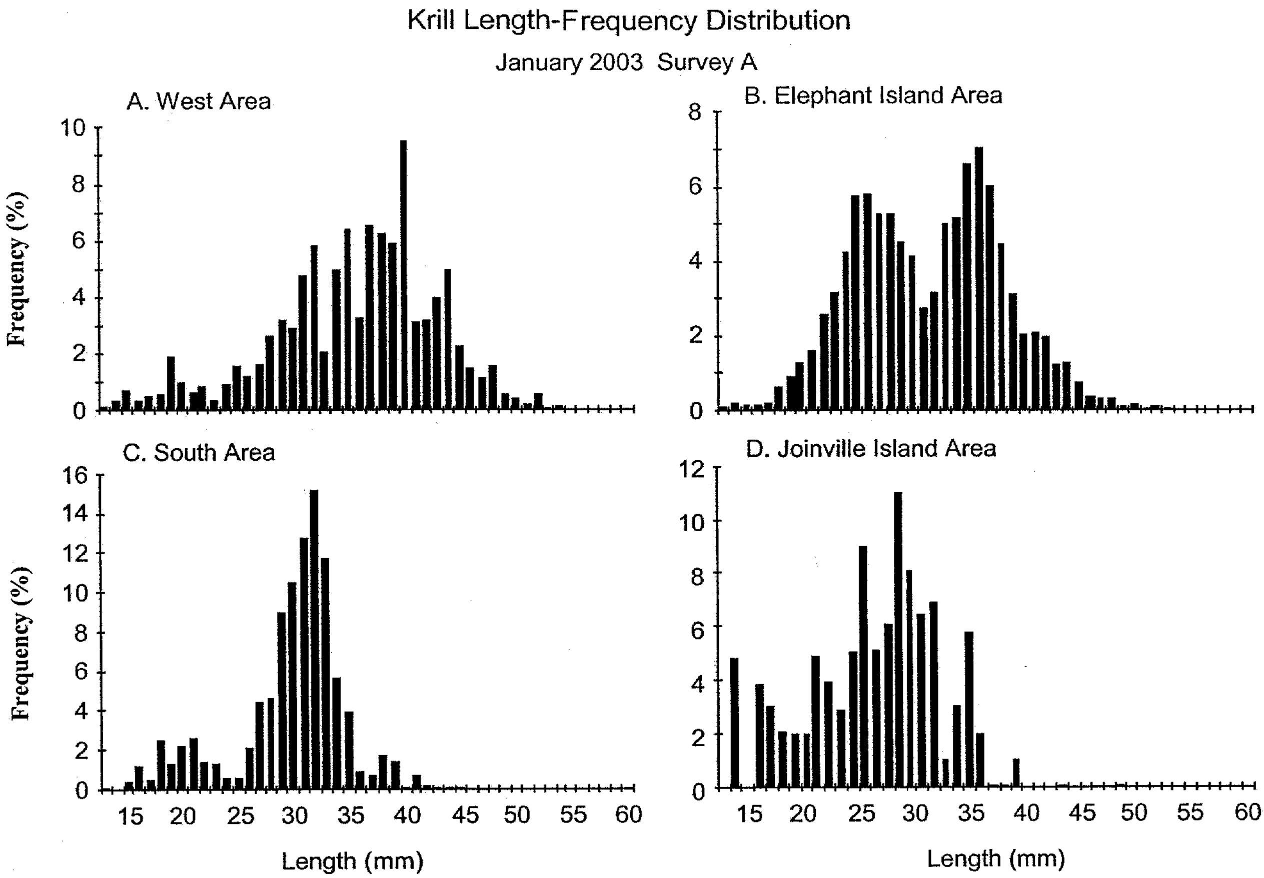


Figure 4.3 Krill length-frequency distribution in the (A) West, (B) Elephant Island, (C) South and (D) Joinville Island Areas during Survey A.

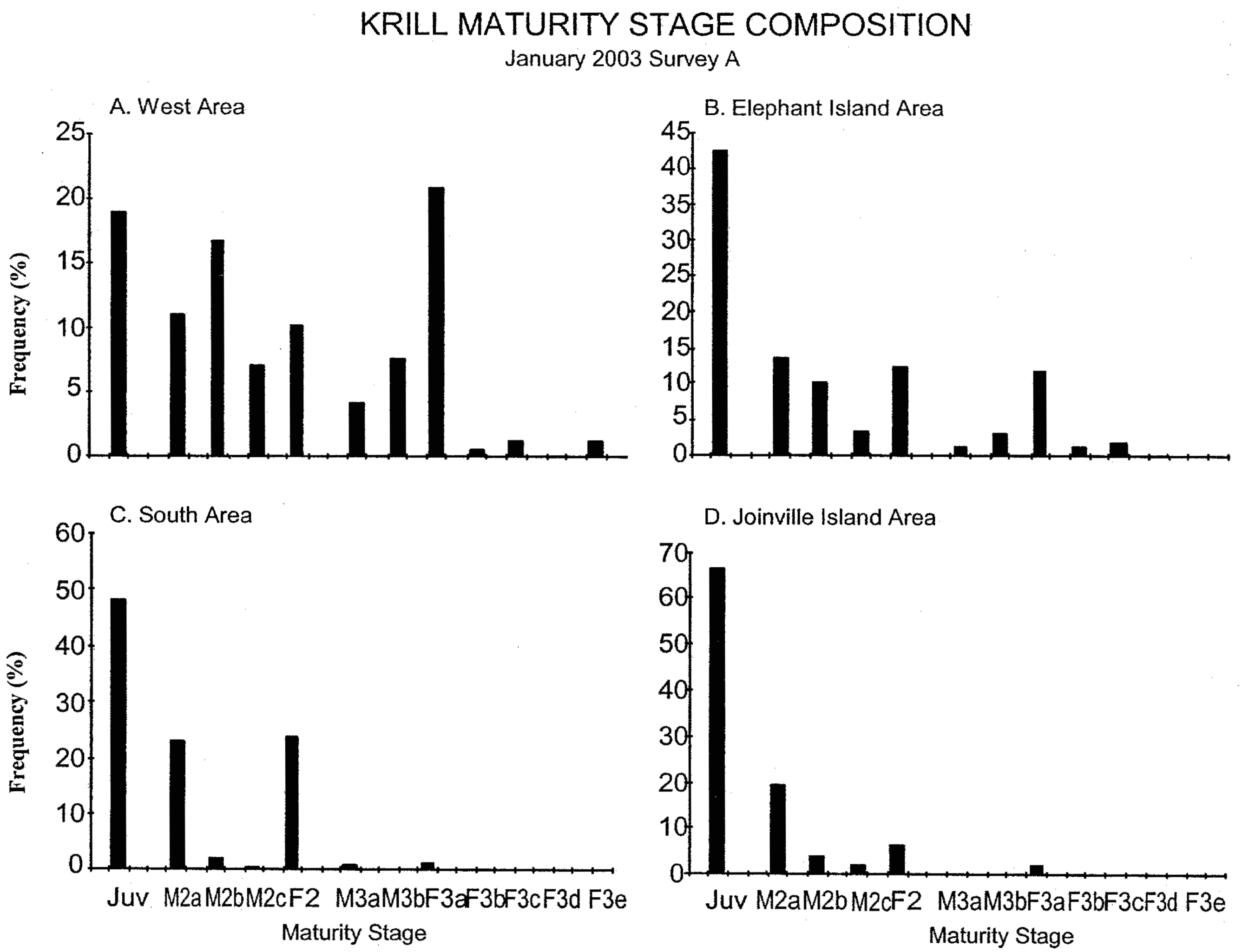
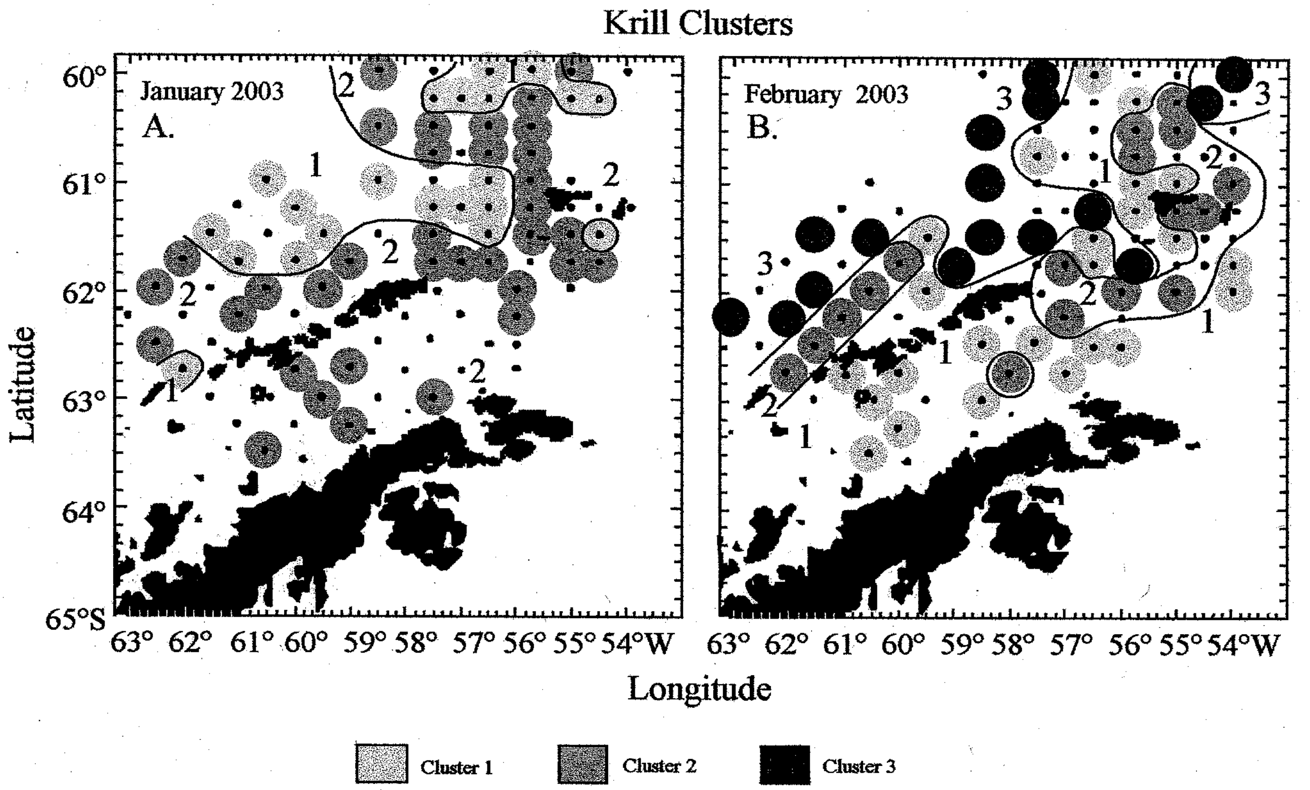
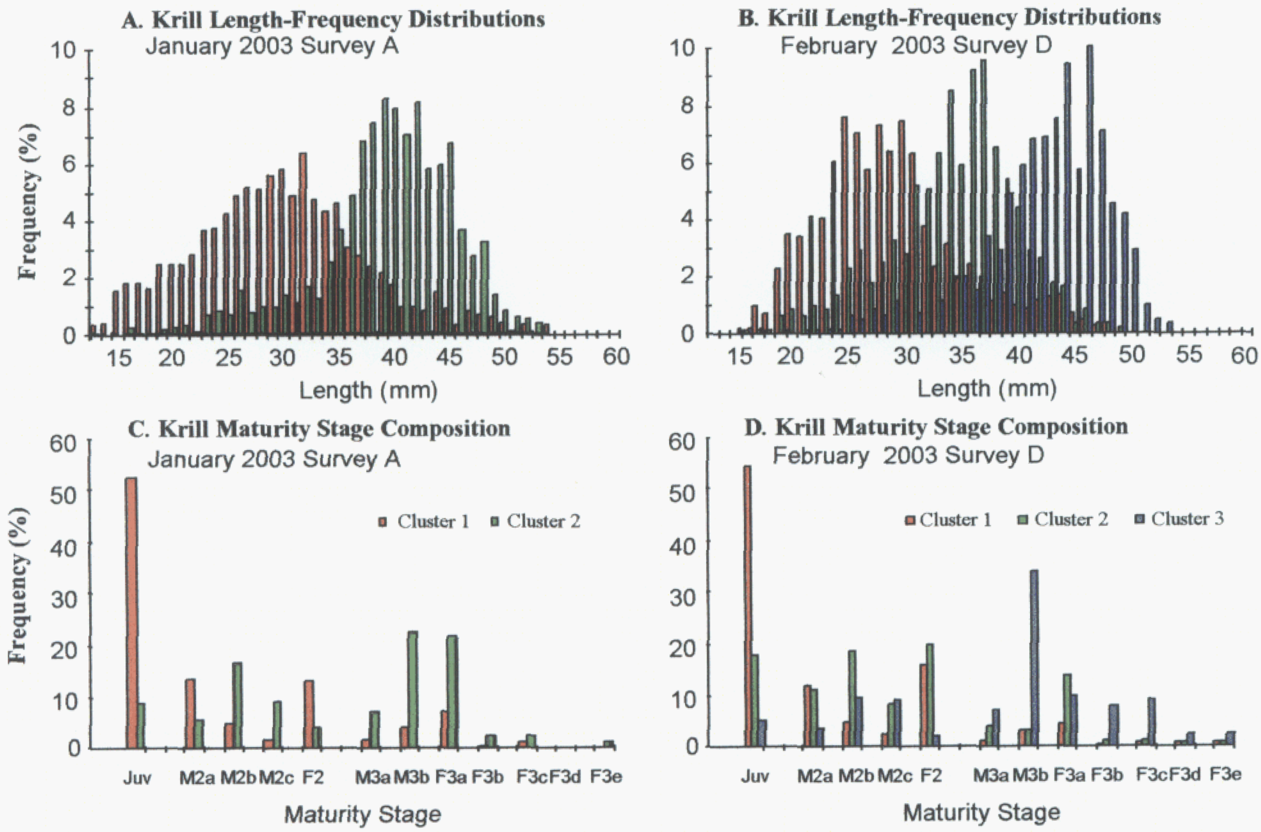


Figure 4.4 Krill maturity stage composition in the (A) West, (B) Elephant Island, (C) South and (D) Joinville Island Areas during Survey A.



4.5 Distribution patterns of krill belonging to length categories (Clusters) within the large survey areas during (A) January Survey A and (B) February Survey D.



4.6 Length-frequency distribution and maturity stage composition of krill belonging to (A,B) Clusters 1 and 2 during Survey A and (C,D) Clusters 1-3 during Survey D.

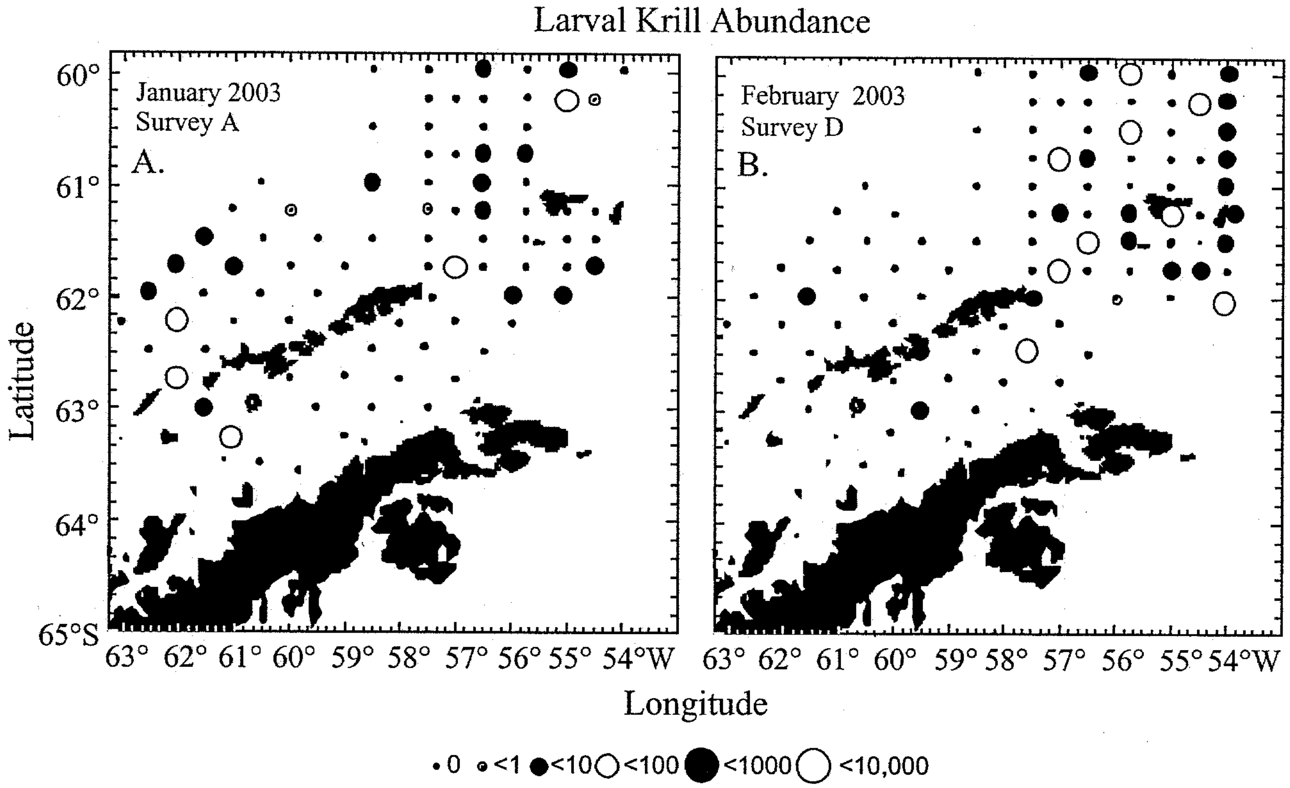


Figure 4.7 Distribution and abundance of larval krill during (A) Survey A and (B) Survey D.

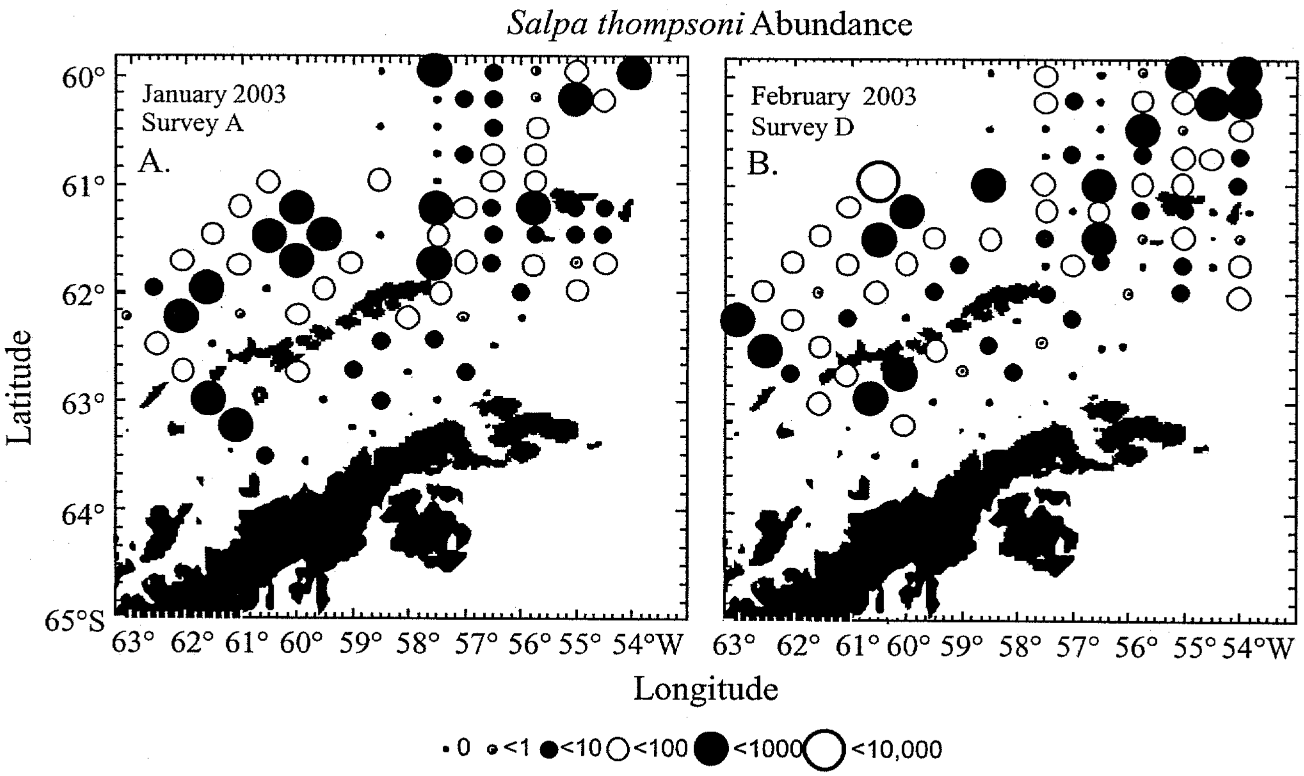


Figure 4.8 Distribution and abundance of *Salpa thompsoni* during (A) Survey A and (B) Survey D.

Aggregate Length Distributions

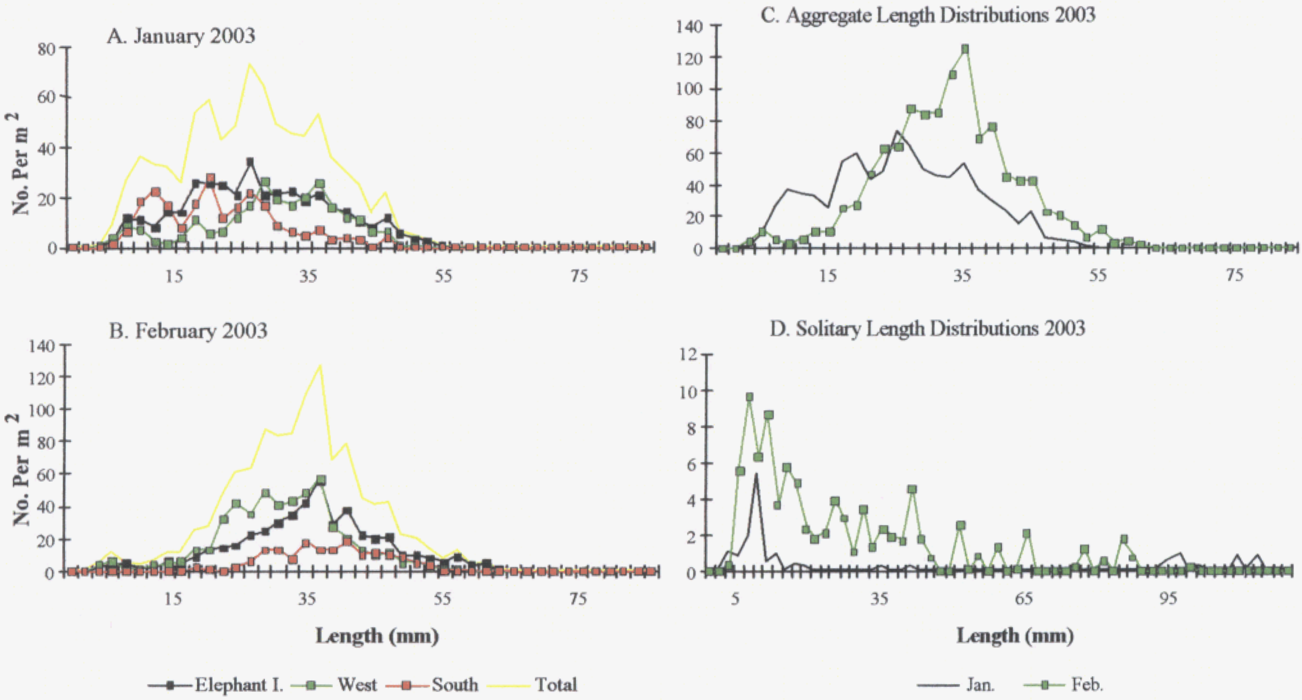


Figure 4.9 Length-frequency distributions of aggregate stage *S. thompsoni* in the large survey area and four subareas (A) January and (B) February and seasonal differences in (C) aggregate stage and (D) solitary stage length-frequency distributions, January-February, 2003.

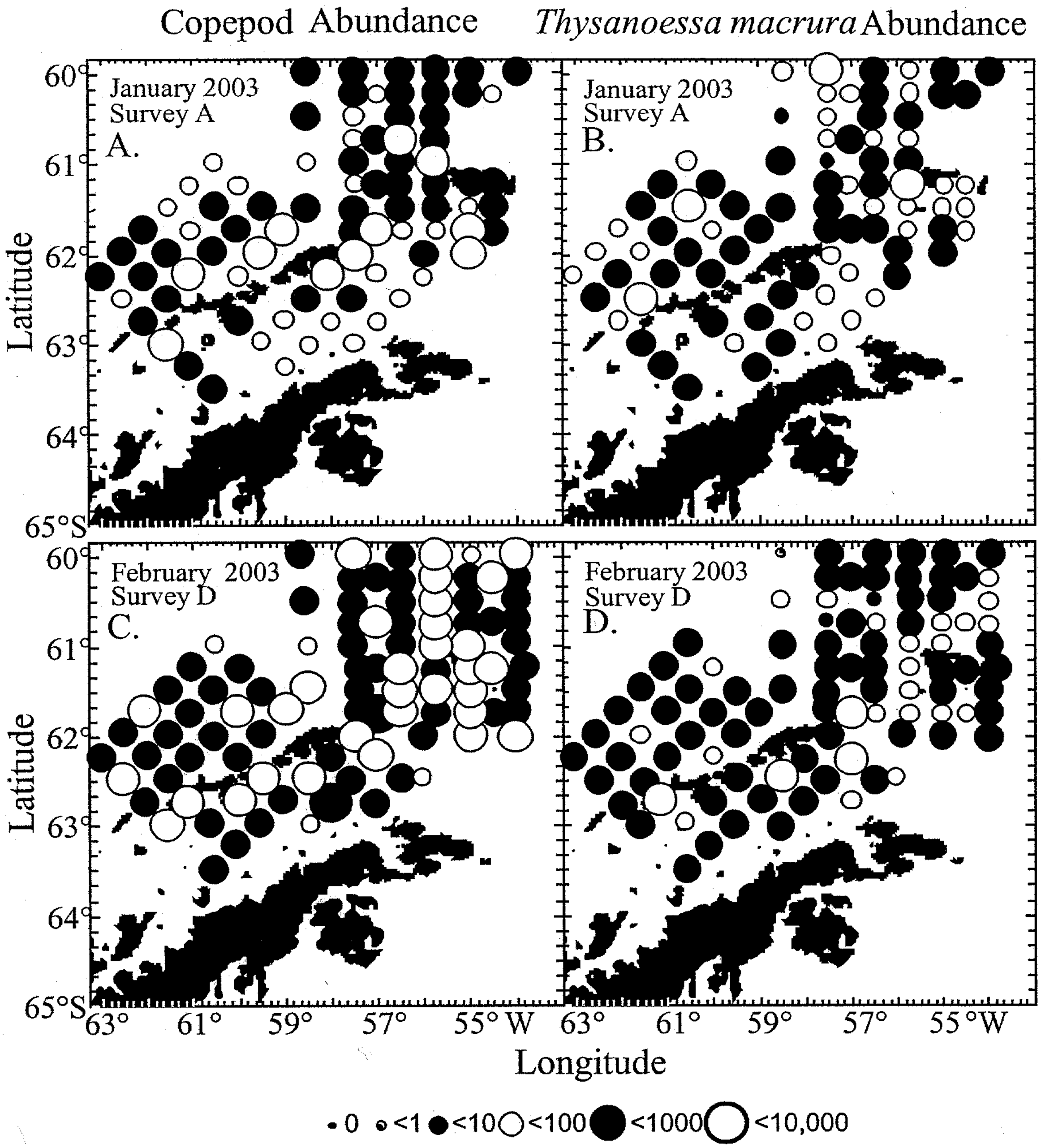
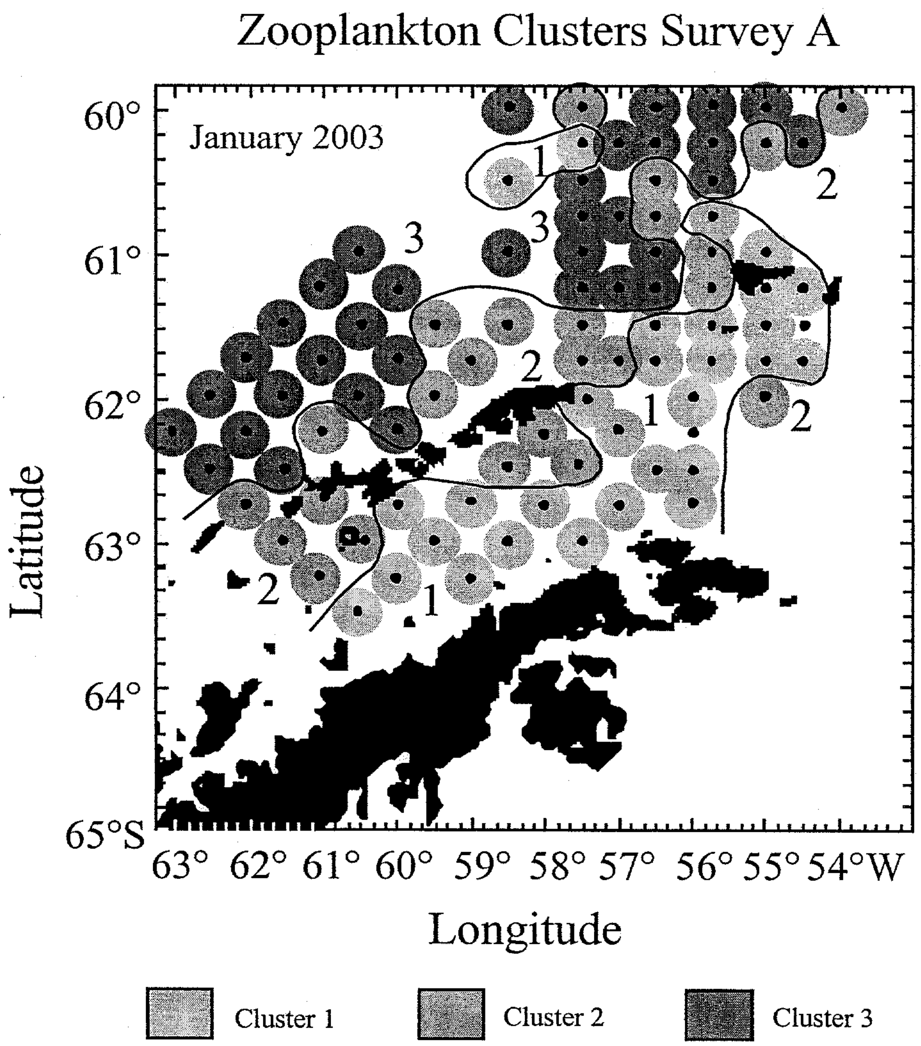
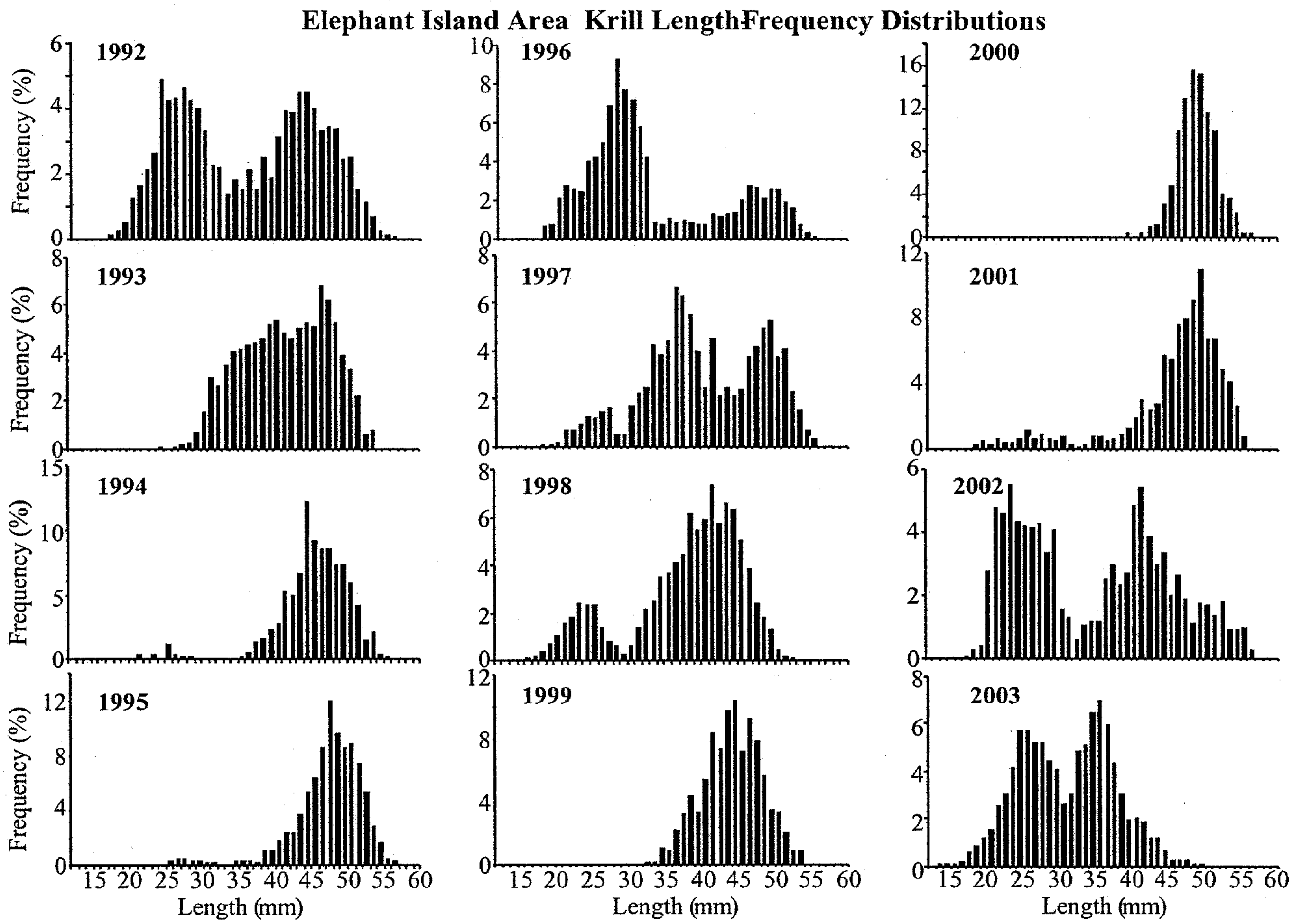


Figure 4.10 Distribution and abundance of copepods and postlarval *Thysanoessa macrura* in the (A,B) Survey A and (C,D) Survey D areas.



4.11 Distribution patterns of zooplankton taxa belonging to different station groupings (Clusters 1-3) during Survey A.



4.12 Krill length-frequency distributions in the Elephant Island Area during January-February surveys, 1992-2003.

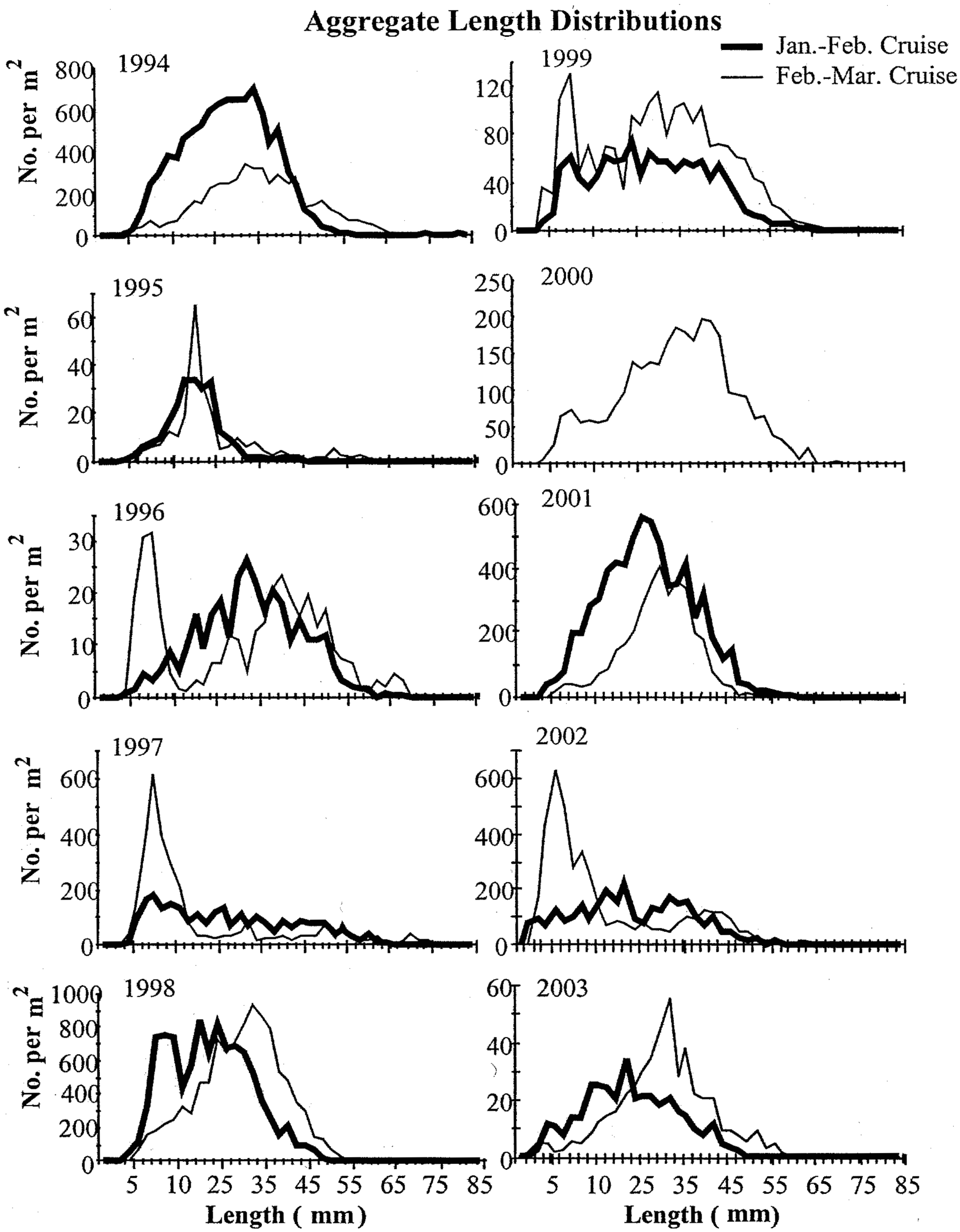
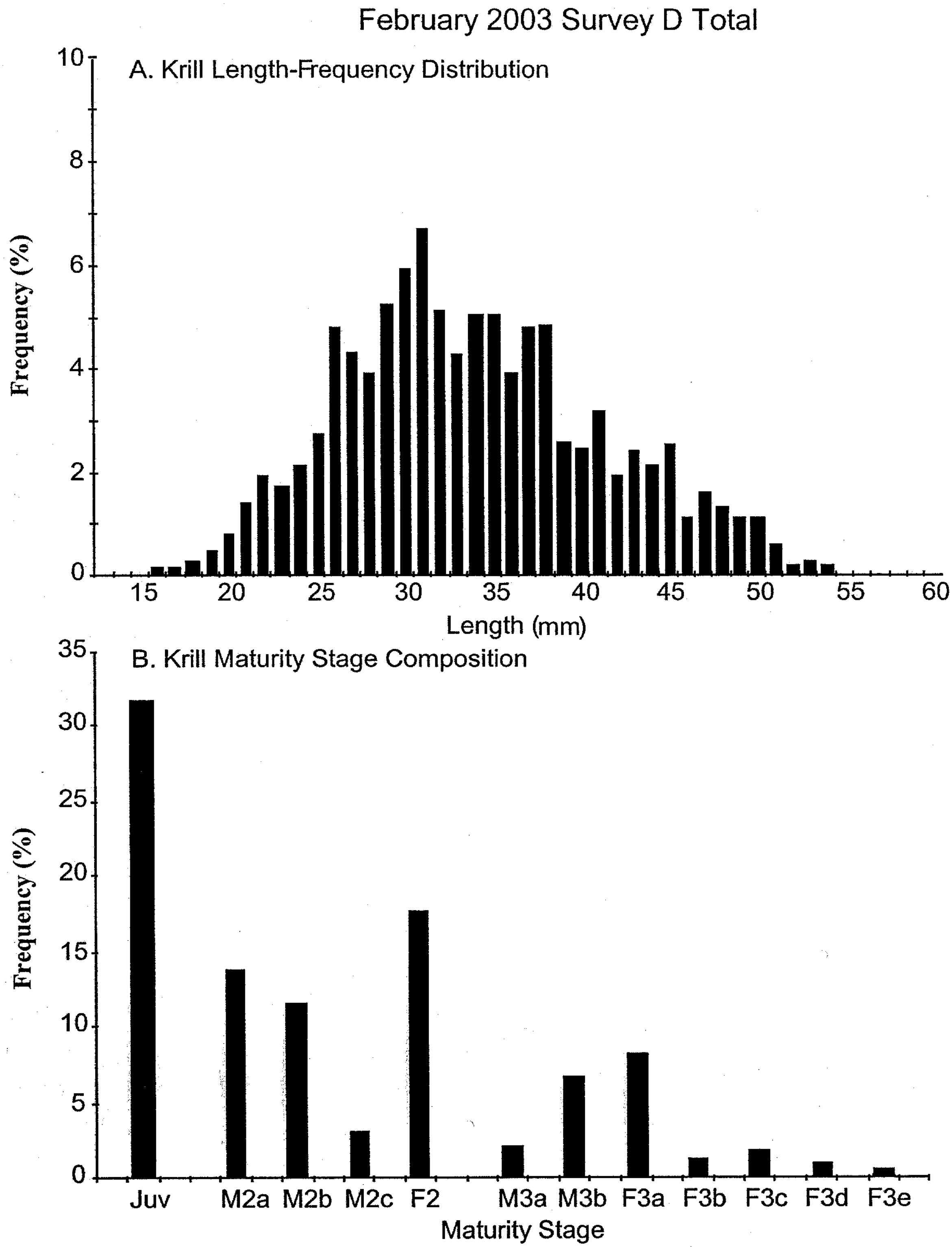
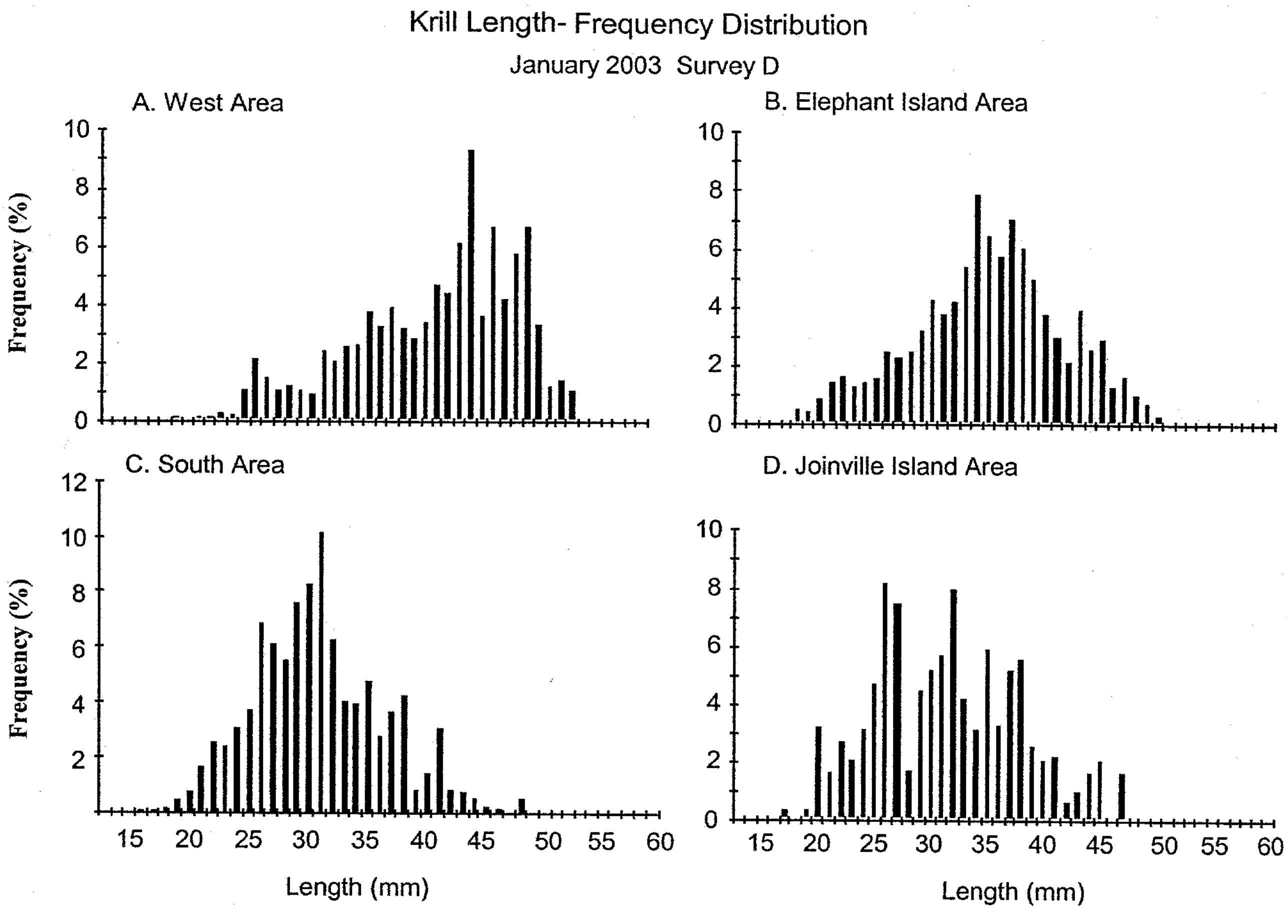


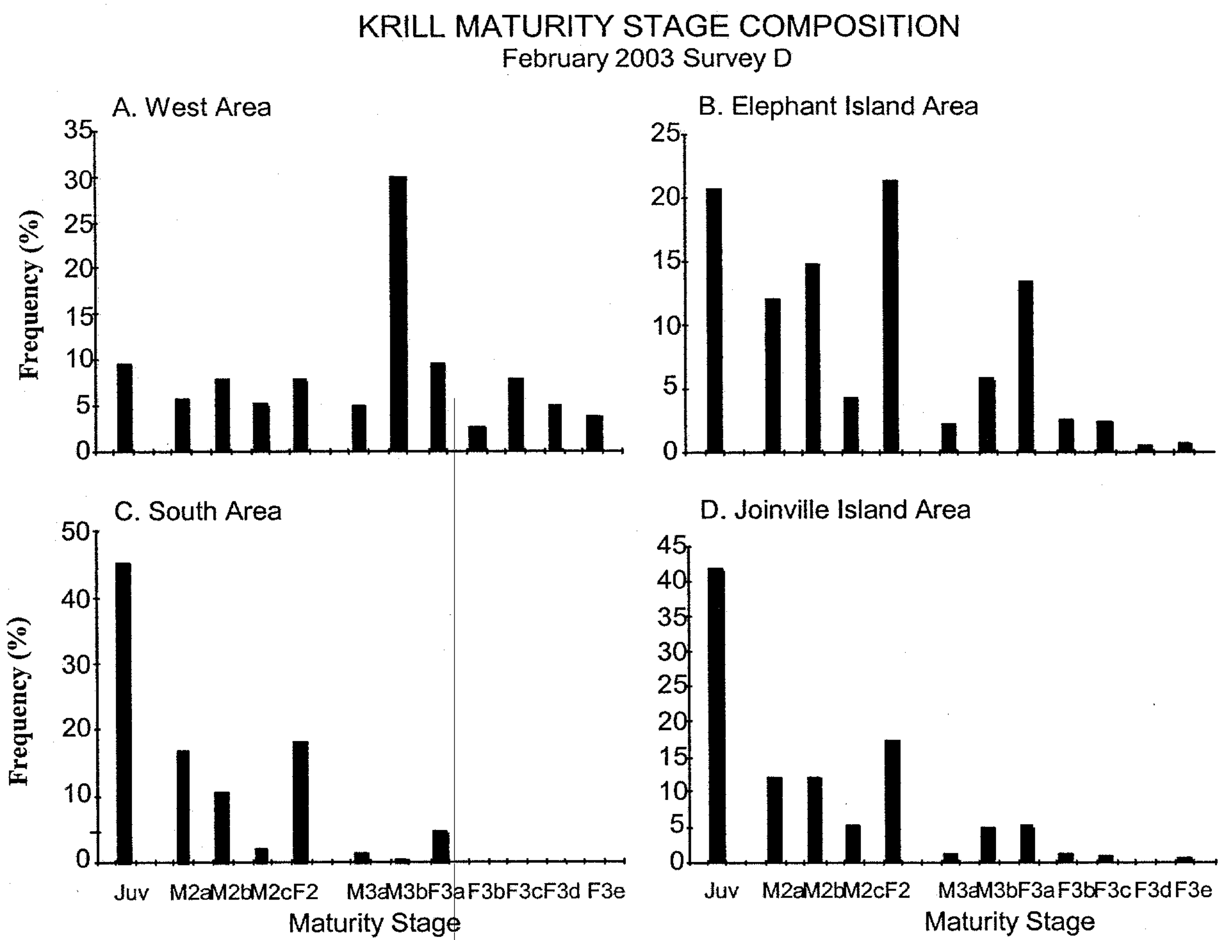
Figure 4.13 Aggregate stage *Salpa thompsoni* length-frequency distributions during January-February and February-March surveys, 1994-2003.



4.14 Krill (A) length-frequency distribution and (B) maturity stage composition during February Survey D.



4.15 Krill length-frequency distribution in the (A) West, (B) Elephant Island, (C) South and (D) Joinville Island Areas, February Survey D.



4.16 Krill maturity stage composition in the (A) West, (B) Elephant Island, (C) South and (D) Joinville Island Areas, February Survey D.

5. Bottom Trawl Survey and Demersal Finfish Research in the South Shetland Islands; submitted by Christopher Jones (Leg III), Julian Ashford (Leg III), Kim Dietrich (Leg II, III), Art DeVries (Leg III), Stuart Hanchet (Leg III), Karl-Hermann Kock (Leg III), Tom Near (Leg III), Teresa Turk (Leg III), and Sunhild Wilhelms (Leg III).

5.1 Objectives: Commercial fishing for finfish in the South Shetland Island chain was conducted from 1978/79 through 1988/89. The main species fished in this region were *Champsocephalus gunnari* and *Notothenia rossii* (Agnew and Nichol, 1996), as well as several bycatch species, including *Gobionotothen gibberifrons*, *Chaenocephalus aceratus*, and *Chionodraco rastrospinosus* (CCAMLR, 1990). Within two years after the fishery was developed, catches substantially declined. This led CCAMLR to impose a moratorium on taking finfish from the South Shetland Islands from 1989/90 to the present. To understand the population dynamics, the position and relationships of species within the Antarctic ecosystem, and to determine whether shelf areas can be re-opened to possible exploitation, it is essential to monitor the biomass of demersal finfish stocks, and to collect information on factors that influence the biology, ecology, and life history characteristics of the finfish species.

The AMLR program initiated the bottom trawl survey component during the 1996/97 austral summer, when seven hauls were conducted in the South Shetland Islands (Subarea 48.1). During the 1997/98 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). This is the third bottom trawl survey of the fishable shelf regions of the South Shetland Islands.

The survey objectives include estimating the abundance, species composition, size composition, demographic structure, and diet composition of finfish species within the 500m isobath of the South Shetlands Islands. Several other sampling efforts and biological experiments were conducted during the course of this survey, including intensive otolith sampling for age and growth studies, buoyancy measurements, DNA collections, and other tissue collections for biological and physiological experiments. Other components of the South Shetlands Islands shelf ecosystem examined during Leg III included underway acoustic sampling of krill swarms and myctophid layers (Chapter 3 of this report), characterization of benthic invertebrate bycatch (Chapter 6 of this report), video/still imagery of the seafloor, acoustic classification of seabed types (Chapter 7 of this report), sampling of seabed substrate for groundtruthing the acoustic classification, and CTD casts. 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 Antarctic demersal fish within the 500m isobath of the South Shetland Islands; to investigate 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 influence demersal finfish resources.

5.2 Methods and Accomplishments:

5.2.1 Bottom Trawling: The at-sea protocols used to conduct the trawl survey were based on those used during the 1997/98 and 2000/01 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 is instrumented with a net sonar system ("Netsweep 325", Ocean Systems Inc.) used to monitor the geometry of the mouth of the trawl as it is deployed and to 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* March 13, 2003 through April 1, 2003 (Table 5.1). The sampling strategy was based on random depth stratified survey design, and stations were positioned to account for a wide geographic range. There were five designated depth strata: 50-100m, 100-200m, 200-300m, 300-400m and 400-500m. There were a total of 68 hauls completed around the South Shetland Islands: 32 around Elephant Island (Table 5.1) and 36 around the lower South Shetlands Islands (Table 5.2). The numbers of hauls within the five depth strata were 10, 22, 16, 13, and 8, respectively. Allocation of hauls within depth strata were proportional to the known areas of seabed (Jones *et al.*, 1999) and previous estimates of abundance in each stratum from the 1997/98 and 2000/01 AMLR South Shetlands Islands survey. 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 three additional hauls within the 50-100m depth range northwest of Elephant Island. However, due to heavy concentrations of grounded icebergs and otherwise present, these stations were abandoned for safety reasons. Several other planned stations were inaccessible due to heavy ice concentrations. However, these were successfully relocated 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.

All hauls were conducted during daylight hours with a targeted haul time of 30 minutes. Any haul less than 20 minutes was considered invalid, and discarded. 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, trawl mouth width, height were recorded from the net sonar's deck unit. Recordings were made every five minutes thereafter, for a total of seven observations for each 30 minute 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 were processed separately (See Chapter 6 "Benthic invertebrate bycatch and characterization"). 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 5.2.3 Subsampling Protocol). In several cases, large yields of finfish were released live after the subsampling protocol.

There were two categories of fish processing. Category 1 included fish measured for length (nearest cm below), sex, and gonad maturity stage. Lengths 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 the nearest gram.

An examination of the contents of 4,129 stomachs of 33 species of finfish was conducted across all regions of the shelf. Of these 2,691 individuals of 28 species contained stomach content material. Stomach content information included whole stomach weight and stomach contents weight; a measure of the filling degree was taken 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 was recorded 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 identify. The relative volume of each species present within a stomach was recorded by assigning each dietary component a proportion from 0-10, with the score for each stomach totaling 10.

Otoliths were taken from 3,457 fish of 22 species for age and growth work to be undertaken at the Center for Quantitative Fisheries Ecology (CQFE) based at Old Dominion University in Virginia. Otolith collections by species are listed in Table 5.3. 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. In addition to age and growth, aspects of life history characteristics will be studied by conducting elemental analysis of otolith and relating this information to water mass signatures.

5.2.3 Subsampling Protocol: Where yields of a species were too large to process in their entirety due to time constraints, subsampling 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*, where 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 6,218kg (17,011 individuals) of 46 finfish species was processed from all hauls from Elephant Island (Table 5.3) and the lower South Shetlands Islands

(Table 5.4). Species that were caught in substantial numbers, defined as >500kg or >500 individuals, included *Gobionotothen gibberifrons, Notothenia coriiceps, Champsocephalus gunnari, Chaenocephalus aceratus, Chionodraco rastrospinosus, Gymnoscopelus nicholsi, Lepidonotothen larseni, Chionodraco rastrospinosus, Lepidonotothen squamifrons and Pleurogramma antarcticum*. As with the 2000/01 survey, the greatest combined yields occurred at stations on the western and northwestern shelf of Elephant Island and north of King George Island. The highest average densities were within the 200-300m depth strata. The species with the greatest yield in weight was *Gobionotothen gibberifrons* (1,633kg, 2,082 individuals), followed by *Notothenia coriiceps* (1,363kg, 838 individuals), and *Champsocephalus gunnari* (917kg, 4,056 individuals). As in the 2000/01 survey, the greatest catch in numbers was *C. gunnari* followed by the myctophid *Gymnoscopelus nicholsi* (116kg, 3,662 individuals) and *G. gibberifrons*.

The standardized finfish density by station demonstrated substantial contrast. The mean density of undifferentiated finfish biomass for all stations pooled was 7.4 tonnes/nmi^2 (σ=11.6). At most stations with high catch rates, yields were dominated by a single species. The greatest standardized density of fish at a single station was 66 tonnes/nmi^2 at station 49 north of King George Island (Figure 5.2A) within the 200-300m depth strata. This station was dominated by a large prespawning aggregation of *Notothenia coriiceps* (79%), with 12 other species making up the remaining percentage. Other parts of the shelf with substantial densities of finfish were west of Elephant Island at station 10 (59 tonnes/nmi^2) within the 100-200m strata in which 60% were *G. gibberifrons* and 31% were *C. aceratus*, and (interestingly) station 91 north of Aspland Island on the southern Elephant Island shelf, (38 tonnes/nmi^2), 80% of which was comprised of *N. coriiceps*. Another notable catch occurred west of Elephant Island at station 11 in the 100-200m strata where a large aggregation of juvenile *C. gunnari* was encountered.

The number of species encountered at each station (Figure 5.2.B) ranged from 4 to 19, with an average of 10 species per haul. The highest diversity of finfish species occurred at stations to the north and southwest of Elephant Island and at stations around Livingston Island. The most frequently encountered species was *C. aceratus*, which was found within catches at 87% of the stations. Other species frequently encountered were *C. gunnari* (84%), *G. gibberifrons* (78%), *L. larseni* (77%), *N. coriiceps* (68%), and *C. rastrospinosus* (66%). All other species occurred in less than 50% of hauls.

5.3.2 Results – Abundant Finfish Species:

Chaenocephalus aceratus: The channichthyid *C. aceratus*, a relatively sluggish sedentary species, was the most frequently encountered finfish species. A nominal total of 643.2kg (1,300 individuals) was captured from 59 stations (Table 5.4), and the overall average standardized density was 748 kg/nmi^2. The spatial distribution of biomass (Figure 5.3A), demonstrates the majority of the *C. aceratus* occurring on the west and southwest shelf areas of Elephant Island, as well as along the central lower S. Shetland Islands. Fish were encountered within all strata, with the greatest average densities occurring within the 100-200m depth strata (1,643 kg/nmi^2). As has been noted in previous AMLR surveys, the size distribution of *C. aceratus* was among the greatest of any species captured, ranging from 8 to 69cm. Relatively well defined modes appear at 16cm, 25cm, 37cm, and 48cm. (Figure 5.4A), with substantially greater fish in the 2nd

mode at both Elephant Island and the South Shetland Islands, and slightly greater numbers of larger fish occurring around Elephant Island.

Fish were found at all stages of maturity. Most fish (66%) were juveniles (maturity stage 1) with 19%, 12%, 0.2%, and 3% observed at maturity stages 2, 3, 4 and 5, respectively. About 47% of the catch was female. Spawning probably started in early March (Table 5.5), as there were a small number of spent females at the start of the survey. The maturation of gonads appears to be more synchronized than in channichthyids such as *C. gunnari*. Consequently the spawning time is likely to be shorter and is unlikely to extend 6 – 8 weeks. The GSIs in females (n = 38) were mostly in the order of 12 – 20 with maximum values at 27 – 31. GSIs in males (n = 42) were 1 – 2 with a maximum of 2.5. Oocyte diameter of females close to spawning was 4.4 – 4.7mm. Eggs close to spawning were sticky and are likely benthic. Maximum lengths investigated were 54cm in males and 68cm in females. This difference provides further evidence of sexual dimorphism observed in growth of males and females.

Feeding intensity of *C. aceratus* was low, with 84% of the stomachs empty. However, it is likely that a significant proportion of the fish regurgitated stomach contents when caught. Krill constituted about 50% of the overall diet for all individuals examined (Figure 5.5). However, the fish fed primarily on krill and mysids (*Antarctomysis maxima*) when they were small (< 30cm). Mysids were likely taken close to the bottom. When *C. aceratus* change to a more sedentary life and sit and wait for prey on the bottom (ambush feeding) fish alter their prey to fish (*C. gunnari*, *L. larseni* etc.) with a smaller proportion of krill taken.

***Cryodraco antarcticus*:** While not generally considered abundant on shelf areas <500m, we encountered a reasonably large number of the high Antarctic channichthyid *Cryodraco antarcticus* (65.193kg, 108 individuals, from 20 stations). *C. antarcticus* is similar in size and morphology to *C. aceratus* although more slender in shape and consequently lighter at the same length. It has been proposed that they to replace *C. aceratus* in deeper water (Kock and Jones, 2002). Its bathymetric range is known to extend deeper than 1,500m. This survey only covered the upper part of the depth range of the species, which extended here to approximately 800m. The greatest mean densities (353 kg/nmi^2) were encountered north of King George Islands in the 300-400m strata (Figure 5.3B). The lengths of fish encountered were similar to *C. aceratus*, ranging from 11cm to 65cm, though they were larger on average (Figure 5.4B).

The majority of fish were juvenile stage 1 (44%), with 39%, 12%, 1%, and 4% for stages 2 – 5, respectively. Spawning appears to start in March as the first spent individuals were found. GSIs were 10 – 18. Ovaries were preserved to estimate absolute and relative fecundity. GSIs were 13 – 17 in females and 3.3 – 3.8 in the two males caught. No female in spawning condition was observed, suggesting that they may move to deeper water for spawning. The species exhibits the same sexual dimorphism in size as observed in *C. aceratus*: the largest male found was 46cm and the largest female observed 65cm long.

A total of 106 stomachs were analyzed for diet composition, although only 30 fish had some stomach contents. The average diet composition consisted mainly of fish (89%; Figure 5.5), as well as krill (11%). Juveniles (< 30cm) are more pelagic and prey on krill and a lesser extent fish. Larger fish depend almost entirely on fish and krill occasionally.

Champsocephalus gunnari: The bentho-pelagic channichthyid species *C. gunnari* was among the most abundant species encountered, with the greatest number of individuals caught. A total of 917kg (4,056 individuals) was encountered at from 57 stations (Tables 5.3 & 5.4), and the overall average standardized density was 1182 kg/nm^2. The highest densities of *C. gunnari* biomass were encountered west of Elephant Island (Figure 5.3C). The trend of increasing biomass with more westerly stations observed during the 2000/01 survey was seen again during this survey. The highest average densities occur within the 100-200m depth strata of both areas. The large catches west of Elephant Island were in patchy concentrations. The size distribution ranged from 12 to 52cm, with strong year-class modes at 22cm, 27cm, 32cm, and 40cm (Figure 5.4C). A substantially greater proportion of older fish were encountered around Elephant Island. However the opposite pattern was observed during the 1997/98 and 2000/01 AMLR surveys where a greater proportion were encountered around the lower South Shetland Islands.

Most fish (44%) were maturity stage 2, with 43%, 9%, and .3% and 3% observed at maturity stages 1, 3, 4 and 5, respectively. About 53% of the catch was female. A large range of GSIs observed suggests that *C. gunnari* spawns over a more extended period of time than other channichthyids (Table 5.5). Spawning appears to have occurred earlier than in 2001. Most sexually mature individuals between Elephant Island and Greenwich Island (lower South Shetland Islands) were spent (stage 5/2). In contrast, most individuals further south (Livingston – Snow Island) were still in prespawning condition (stage 3). As practically no fish were observed in spawning condition during this survey, it is likely that fish move inshore for spawning as observed at South Georgia and Kerguelen Islands. GSIs were 5 – 12 in females (n = 49). GSIs of males (n = 43) were 2 – 3. Eggs found in one female were sticky, suggesting that eggs are benthic and are deposited at the bottom where they stick to the substrate.

Results from the diet analysis indicated that *C. gunnari* fed on about 91% krill (Figure 5.5) for all stomachs examined; with a slightly higher proportion around the Elephant Island Area compared to the lower S. Shetland Islands. Fish (primarily myctophids) were occasionally found. *C. gunnari* smaller than 25cm had a low proportion of *Thysanoessa macrura* and occasionally *Themisto gaudichaudii* and *Euphausia frigida* in their diet. The amount of food taken and the degree of digestion varied considerably between stations and even between individuals caught at one station. Stomach contents weight varied from < 1 to 10 % of the body weight.

Chionodraco rastrospinosus: The channichthyid *C. rastrospinosus* is the only true high Antarctic species that is regularly encountered. A total of 491kg (809 individuals) was captured from 45 stations (Table 5.4), and the overall average standardized density was 613 kg/nm^2. The majority of catches occurred north of King George Island and the most offshore stations north of Elephant Island (Figure 5.3D). As in the 2000/01 survey, the highest densities were encountered within the 200-300m depth strata. The size distribution of *C. rastrospinosus* ranged from 13 to 49cm. Only one well defined mode is apparent at around 40cm (Figure 5.4D).

Fish were found at all stages of maturity. Most fish (52%) were mature stage 3, with 9%, 19%, 13%, and 7% observed at maturity stages 1, 2, 4 and 5, respectively. Sexes were equally represented. The species exhibits a sexual dimorphism in the prespawning and spawning season: males are dark green and blackish in their dorsal parts; females are more uniformly greenish in color. The development of the ovaries was less advanced around Elephant Island. GSI in most females was 15 – 22. GSI in the lower South Shetland Islands was 18 – 24. This suggests an earlier (about 14 days) start of the spawning season in the lower South Shetland Islands. Males had GSIs of 1.8 – 2.5. The synchronized development of most ovaries suggest a comparatively short spawning period of 4 – 6 weeks. Egg diameter was 4.5 – 5.0mm at spawning. Eggs are sticky at spawning and are likely to be attached to the bottom. Maximum lengths were 42cm in males and 49cm in females.

The proximity of the spawning season prevented many *C. rastrospinosus* from feeding. Postspawning fish were found to prey on krill and fish (both mesopelagic and benthic). A total of 410 stomachs from *C. rastrospinosus* were analyzed. At least 34% of fish had stomach contents. The average diet composition consisted mainly of krill (68%; Figure 5.5). In addition, their diet consisted of fish (34%), polychaetes, salps, and unidentified organisms (Σ=3%).

***Dissosstichus mawsoni*:** The nototheniid *D. mawsoni* is a commercially exploited species in other parts of the Southern Ocean (CCAMLR Subarea 88.1, 88.2), is closely related to the economically important and closely related *D. eleginiodes*, and there are continuing uncertainties regarding life history characteristics of this species. Thus, this species warrants special attention during our surveys. A total of 113.1kg (68 individuals) were captured from 33 stations (Table 5.4), and the overall average standardized density was 126 kg/nm^2. This value is heavily skewed by a single specimen captured northwest of Elephant Islands at Station 16 weighing 68.1kg. Without this observation, the average standardized density was 55.4 kg/nm^2; similar to what was encountered during the 2000/01 survey. Fish were relatively evenly distributed across the entire island chain (Figure 5.3E), and present in all strata. The size distribution ranged from 22 to 175cm. Strong modes were observed at around 25 and 47cm (Figure 5.4E).

Most fish (68%) were juvenile stage 1, with the other 30% at the maturing virgin stage 2. The large specimen mentioned above was the only fully mature (stage 3) fish. Stomach contents were examined from 66 individuals, 14% of these had empty stomachs. The composition of the diet for those fish with stomach contents consisted mostly of fish (74%), and krill (25%) (Figure 5.5).

***Gobionotothen gibberifrons*:** As with previous AMLR surveys of the South Shetlands, the nototheniid *G. gibberifrons* was the most abundant demersal finfish in the South Shetlands Islands, and one of the most frequently encountered. A total of 1,633kg (2,082 individuals) was captured from 53 stations (Table 5.4), and the overall average standardized density was 1,813 kg/nm^2. The majority of catches occurred west and northwest of Elephant Island and north of King George Island (Figure 5.3F). Catches were observed at all strata, with the greatest average densities occurring between 100-300 meters (Table 5.4). The size distribution ranged from 17 to 54cm, with a single mode appearing at around 40cm for combined area length distributions (Figure 5.4F). However, when broken down by area, there are two clearly defined modes, one at 36cm at the lower S. Shetlands Islands at 41cm around Elephant Island. Similar patterns were observed during the previous AMLR surveys, supporting evidence that a higher proportion of juvenile *G. gibberifrons* are more likely to be found in the lower S. Shetlands Islands.

Fish were either maturing virgin or had developing gonads. Most fish (52%) were stage 2, and stage 3 (37%), with 10% immature. Most fish mature at 31 – 34cm length. Testes were similar in size to ovaries. Low GSIs of 2.0 – 5.0 in females (n = 72) and 1.5 – 3.0 in males (n = 84) support earlier observations that the species is a winter spawner (July – August) (Kock, 1989). Maximum lengths investigated were 46cm in males and 49cm in females.

This species demonstrated the highest degree of variability in diet composition of all finfish encountered. Of the 422 *G. gibberifrons* stomachs analyzed, 99% had at least 25% full stomachs. *G. gibberifrons* is primarily a benthic browser, and thus has a varied diet (Figure 5.5). Due to a large degree of partially digested benthic invertebrate species, about 37% of the average diet was unidentifiable to species group. The greatest proportion of identifiable species groups were polychaetes (32%), followed by amphipods (13%), ophiroids (12%), salps (11%), isopods (6%), krill (3%), fish (2%), and echinoderms (3.2), and combined pycnogonids, octopus, mysids, echinoderms, and fish eggs (Σ=2%).

Lepidonotothen larseni: The nototheniid *L. larseni* is small but relatively abundant, and is an important demersal prey item. A total of 70.6kg (1,661 individuals) were captured from 52 stations (Table 5.4), and the overall average standardized density was 90 kg/nm^2. The majority of catches occurred in north of Elephant Island and north and east of King George Island (Figure 5.3G). This species was encountered in greatest numbers between 200 and 400 meters (Table 5.4). The size distribution of *L. larseni* ranged from 6 to 25cm, with a well-defined mode at 17cm (Figure 5.4G).

Fish had started the process of gonad maturation. Most fish (48%) were stage 3 (35%), with 18% immature. The still low GSIs of females (n = 60) were 3 – 5 (Table 5.5). This confirmed earlier observations that the species is a winter spawner (July – August) (Kock, 1989). The maximum length investigated was 21cm.

A total of 165 stomachs from *L. larseni* was analyzed. Most fish (85%) had at least 25% full stomachs. The average diet was composed of unidentifiable benthic organisms (60%; Figure 5.5) and krill (28%). In addition, their diet consisted of salps (11%), amphipods (6%), and amphipods, polychaetes, fish, and mysids (Σ=5%).

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 9.9kg (224 individuals) was captured from 32 stations, and the overall average standardized density was 12.6 kg/nm^2. The large concentration of *L. nudifrons* encountered near the eastern tip of Elephant Island in past surveys was observed again (Figure 5.3H). This concentration appears to be associated with the large well developed sponge community in this region (See Chapter 6 of this report). This species has a shallow water distribution, with the greatest densities between 50 and 100 meters (Table 5.4). The size distribution of *L. nudifrons* ranged from 9 to 25cm, with a well defined mode at 16cm, and similar size composition in both areas (Figure 5.4H).

Mostly sexually mature individuals were encountered (69% stage 3), with equal proportions of the remaining stage 1 and 2. Gonads were advanced in development with GSIs of mostly 12 – 16 in females (n = 43). GSIs in males (n = 7) were 1.5 – 2.5. The smallest female observed with developing ovaries was 11cm long. Spawning is likely to start in mid-April. The synchronized development of the gonads points at a comparatively short spawning season of 4 – 6 weeks (Table 5.5). Maximum length was 17cm in males and 21cm in females.

A total of 72 stomachs from *L. nudifrons* was analyzed. Most fish (about 89%) had at least 25% full stomachs. This species has a varied diet (Figure 5.5). Due to a large degree partially digested benthic invertebrate species, about 64% of the average diet was unidentifiable to species group. Other identifiable components included amphipods (27%), pycnogonids (11%), salps (8%), krill (7%), and a very small percentage of isopods and fish.

***Lepidonotothen squamifrons*:** A relatively large number of the nototheniid *L. squamifrons* was encountered during this survey. This species has been commercially exploited in other Antarctic island groups. A total of 208kg (649 individuals) was captured from 23 stations (Table 5.4), and the overall average standardized density was 254 kg/nm^2. Catches occurred in most deepwater stations across the island chain (Figure 5.3I), stations to the north and west of Elephant Island, and north of King George Island (Figure 5.3H). The highest average densities were encountered between 400-500 meters, although there were some catches as well in the 200-400 meter strata (Table 5.4). The size distribution of *L. squamifrons* ranged from 9 to 50cm. Most of the size class modes were mixed (Figure 5.4I), with larger fish encountered around Elephant Island.

Fish were found at four stages of maturity, with 60% juveniles, and 25%, 9%, and 5% observed at maturity stages 2, 3, and 5, respectively. This proportion of maturity stages is almost identical to previous AMLR surveys. The species was in the middle of the spawning season (Table 5.5). As in previous surveys, no individuals in spawning condition (maturity stage 4) were observed, suggesting spawning may occur in waters deeper than 500m. Most GSIs were in the range 6 – 11 (n = 24) and the maximum value was 18.4. The maximum size of females investigated was 47cm.

A total of 282 stomachs from *L. squamifrons* was analyzed for diet composition. About 91% of these fish had at least 25% full stomachs. The diet of *L. squamifrons* was complex, and was comprised mainly of unidentified benthic invertebrates (53%, Figure 5.5), along with krill (20%), fish (15%), salps (14%), isopods (10%), amphipods (8%), pycnogonids, polychaetes, ophiroids, and mysids (Σ=5%).

***Notothenia coriiceps*:** The nototheniid *N. coriiceps* has the second highest biomass in the South Shetlands Islands, after *G. gibberifrons*. A total of 1,363kg (838 individuals) were captured from 46 stations (Table 5.4), and the overall average standardized density was 1,610 kg/nm^2. As in the past two AMLR surveys, the presence of the resident large prespawning aggregation north of King George Island was encountered (Figure 5.3J). The greatest average densities were between 200-300 meters (Table 5.4). The size distribution ranged from 25 to 58cm, with a single mode appearing at around 43cm for combined area length distributions (Figure 5.4J). The size compositions were similar between areas.

Most individuals (85%) encountered were stage 3 sexually mature; with the remaining at stage 2 (though close to 3). Maturation of most gonads appears to be synchronized, and this species spawns over a comparatively short period of time. GSIs were mostly 6 – 12 in females (n = 84). GSIs in males were 5 – 11 (n = 130). This suggests that *N. coriiceps* spawn in 6 - 8 weeks time (Table 5.5). Maximum sizes investigated were 49cm in males and 53cm in females.

A total of 247 stomachs from *C. coriiceps* was analyzed for dietary composition. Most fish (92%) had at least 25% full stomachs. The average diet was comprised mainly of krill (51%) and fish (30%; Figure 5.5). Other components included unidentified benthic invertebrates (13%), salps (9%), isopods (7%), amphipods (4%), octopus (3%), and mysids, and polychaetes (Σ=2%).

Notothenia rossii: The nototheniid *N. rossii* was the primary target species in this area in the late 1970's fishery, and the recovery of this species is being closely monitored. A total of 116kg (97 individuals) were captured from 23 stations (Table 5.4), and the overall average standardized density was 147 kg/nm^2. This density is slightly higher than that observed during the 2000/01 survey, and considerably greater than in the 1997/98 survey. The majority of catches occurred north of Elephant Island and north King George Island (Figure 5.3K). This species was captured in all depth strata, with the highest average densities encountered within 200-300 meters (Table 5.4). The size distribution ranged from 13 to 61cm, with a well defined mode at 43cm (Figure 5.4K).

Most ovaries were still in the juvenile stage (stage 1), while most testes were in an early stage of development (stage 2). This indicated that males mature at a smaller size than females. The maturity composition of sexes combined demonstrated that the majority of fish (36%) were immature, with 32%, 28%, and 4% observed at maturity stages 2, 3, 4 and 5, respectively. The few developing ovaries (n = 5) spanned a wide range: GSIs were 4 – 21. Males (n = 21) had mostly GSIs of 5 – 9 (Table 5.5). Maximum sizes investigated were 46cm in males and 61cm in females.

A total of 93 stomachs from *N. rossii* were analyzed for diet composition. About 96% of these had at least 25% full stomachs. The average diet composition was similar to that of *N. coriiceps*, though slightly less diverse. Their diet consisted mainly of krill (88%; Figure 5.5), fish (10%), salps, amphipods, and unidentified benthic invertebrates (Σ=4%).

Pseudochaenichthys georgianus: A total of 253kg (230 individuals) of the channichthyid *P. georgianus* was captured from 28 stations (Table 5.4). The majority of catches occurred at stations off King George Island, west of Livingston Island, and southwest of Elephant Island (Figure 5.3L). Fish were encountered in all strata, with the highest average densities between 100-300 meters (Table 5.4), and the overall average standardized density was 291 kg/nm^2. The size distribution of *P. georgianus* ranged from 18 to 58cm. There were very well defined modes at 20, 36 and 51cm, and a higher proportion of larger animals were captured off Elephant Island (Figure 5.4L).

Most fish (91%) were mature (Stage 3), with 28%, 19% and 3% observed at maturity stages 1, 2 and 5, respectively. *P. georgianus* spawns at South Georgia in April-May. Almost all individuals had a comparatively low GSI of 4 – 8 (n = 51) although one female with a GSI of 27.0 was observed. Males (n = 35) had GSIs of 1 – 2 with a maximum of 1.8.

A total of 178 stomachs from *P. georgianus* was analyzed for diet composition. About 56% of these had at least 25% full stomachs. The average diet was comprised mainly of krill (61%;

Figure 5.5) and fish 33%. In addition, their diet consisted of mysids, amphipods, and unidentified invertebrates (Σ=6.3%).

Electrona antarctica and ***Gymnoscopelus nicholsi***: Part of this survey included an acoustic characterization of mesopelagic myctophids. These two species are captured opportunistically during our surveys. *E. antarctica* and *G. nicholsi* species constitute important secondary prey items for several species of finfish, birds and mammals, they are one of the most important finfish species of the Antarctic ecosystem. Other species myctophid species captured in lesser numbers included *E. carlsbergi, G. braueri* and *G. opisthopterus*.

A total of 1.84kg (227 individuals) of *E. antarctica* was captured from 16 stations and a total of 116.16kg (3,363 individuals) of *G. nicholsi* was captured from 24 stations. The majority of catches for both species occurred at offshore stations along the length of the islands (Figure 5.3M&N), the majority of both species were encountered in waters deeper than 300 meters (Table 5.4). The size distribution of *E. antarctica* ranged from 46 and 111mm, with no well-defined length modes (Figure 5.4M). The length range for the larger, more abundant *G. nicholsi* was 120 to 192mm (Figure 5.4N). The limited number of *E. antarctica* were staged for sexual maturity; most were immature of maturing virgin (stage 1). Most *G. nicholsi* were also stage 1, with a slightly smaller fraction observed at stage 2.

A total of 9 stomachs from *E. antarctica* and 135 stomachs from *G. nicholsi* was analyzed for diet composition. About half of *E. antarctica* and 92% of *G. nicholsi* had at least 25% full stomachs. The diet of both species consists primarily of krill (Figure 5.5), along with a small number of unidentified species, as well as amphipods.

5.3.3 Notes on Other Species: Several other species were captured in smaller numbers and were processed using the same sampling protocols, including analysis of diet composition (Figure 5.5), as the above species. There were five species in the genus *Trematomus* captured, all in small numbers. The most abundant was *T. eulepidotus*. We captured about 9.8kg (84 individuals) from 29 stations, mostly around Elephant Islands between 300 and 400 meters. We examined the diet of 51 of these individuals, 35 of which (69%) had some contents in the stomach. Their diet consisted mainly of unidentified benthic invertebrates (46%) and krill (33%; Figure 5.5). To a lesser extent, salps (10%), amphipods (7%), and fish (7%) were observed. Also observed were polychaetes, isopods and mysids. The species exhibits a sexual dimorphism in size in that females grow about 7cm larger than males. The GSI observations were limited to two females and three males. GSIs were 14 – 20 in females and 4.0 – 4.9 in males, confirming earlier observations that fish were within 4 weeks of their spawning season.

A surprising number of the mesopelagic species *Pleurogramma antarcticum* was encountered during course of the cruise. We captured 6.9kg (529 individuals) at seven stations. Since these are relatively rare to catch in this area during the trawl survey, a large number of otoliths were collected for elemental signature analysis that will be used to examine distribution of this species as it relates to water mass and physical oceanography. In addition, several specimens were preserved for fatty acid analysis that will be used to examine aspects of land based predator dietary components.

5.4 Other Finfish-Related Research During Conducted During AMLR 2002/03:

5.4.1 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 South Shetland Islands were collected in an effort toward further elucidation of the role of mesohabitat features (Auster, 1998) on demersal fish assemblages. The data collection during this Leg considerably strengthens the information collected during the 2000/01 AMLR finfish survey. Further detail on habitat-related collections are provided in Chapter 3 (krill distribution), Chapter 6 (benthic invertebrate epifaunal composition), and Chapter 7 (seabed composition, benthic habitat imagery), all in this report.

Shelf areas of the South Shetland 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 4,129 individual finfish across all areas of the shelf region (2,691 of these stomachs were at least 25% full; Figure 5.6A).

To examine the importance of different shelf regions on dietary constituents, the means of the proportions of stomach scores allocated to the various major dietary components by each station were pooled for all species regardless of volume. Constituents were grouped by three major dietary components: krill, fish, and benthic invertebrates. Items excluded from this were other pelagic invertebrates (i.e. mysids, salps). To define regions of importance, the grouped stomach scores were smoothed across the stations using a kernel smoothing algorithm (Ball, 2002). A matrix of smoothed, normalized indices of dietary importance was then gridded by kriging and overlaid onto a map of the South Shetland Islands. The results of the analysis for the three groups are presented in Figure 5.6B-5.6D for krill, fish, and benthic invertebrates, respectively.

Primary regions of importance for fish with a high krill dietary component are most of the Elephant Island shelf area, in particular a region west of the island, northeast of King George Island, north of Livingston Islands, and northwest of Deception Island (Figure 5.6B). Regions important to fish with a high fish dietary component are north of King George Islands, north of Livingston Island, and northwest of Elephant Island, and north of Elephant Islands (Figure 5.6C). Regions for fish with a high benthic invertebrate dietary component include west and southwest of Elephant Island, north of Elephant Islands, and several areas along the lower S. Shetland Islands (Figure 5.6D). These analyses will be examined further in the near future to draw relationships among the finfish dietary feeding guilds and both pelagic and benthic faunal composition.

5.4.2 Buoyancy Variation in Antarctic Notothenioid Fishes Collected on AMLR 2002/03: 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, considered as the percent of the weight in air of the weight in water, was measured for 235 specimens sampled from 28 notothenioid species (see formula below). To determine the weight in water, specimens were suspended completely in seawater by a silk suture attached to a triple beam balance. Species of the family Channichthyidae and any rare notothenioid species were targeted for buoyancy measurements.

$$B = \frac{\text{weight in water}}{\text{weight in air}} \times 100$$

Among the 28 species sampled, six (*Artedidraco skottsbergi, Harpagifer antarcticus, Racovitzia glacialis, Chionobathyscus dewitti, Neopagetopsis ionah, and Trematomus tokarevi*) have never been measured for buoyancy. Other species (e.g. *Dissostichus mawsoni*) were targeted for continuing studies of ontogenetic changes in buoyancy in notothenioid species. Preliminary analysis of measurements taken have provided some very interesting results. Figure 5.7 illustrates the overall buoyancy measurements for the species sampled. In this plot, the lower the value, the more neutrally buoyant the species, where less than 0.6 is neutrally buoyant. Interestingly, the near-shore benthic species *Harpagifer antarcticus* is the least buoyant Antarctic notothenioid ever measured. Also, two channichthyid (icefish) species *Chionobathyscus dewitti* and *Neopagetopsis ionah* are among the most buoyant species in this clad. Not surprisingly, the pelagic *Pleurogramma antarcticum* approaches neutral buoyancy for most specimens.

Data collected during AMLR 2000/01 and AMLR 2002/03 will serve as the basis for future research on aspects of evolutionary diversification of buoyancy variation among channichthyid species using a phylogenetic hypothesis and information regarding evolutionary ages of speciation events from molecular clock analyses.

5.4.3 Freezing Avoidance of Antarctic Notothenioids: Correlation Between Geographic Distribution and Freezing Avoidance Using Blood Levels of Antifreeze Glycoproteins as an Indicator?

The present day distribution of the Antarctic notothenioid fishes can be more clearly understood by considering their physiological and biochemical adaptations to the freezing Southern Ocean. Clearly they are cold-adapted at the biochemical level as some species have relatively rapid rates of growth, but one of the most important of the adaptations is their biological antifreeze system where by circulating antifreeze glycoproteins (AFGPs) protect them from freezing. Correlations of freeze avoidance and levels of AFGPs and considerations of their geographical-evolutionary histories may in part help explain present day abundance and distributions.

Representative specimens of most hauls were sampled for blood to determine the level of circulating antifreeze glycoproteins (AFGPs) that have been shown to directly correlate with levels of freezing avoidance. Tissue samples were also collected so that we can eventually estimate the number of AFGP genes and correlate the number of genes with levels of circulating AFGPs.

Analyses of concentrations of blood AFGPs show that among the ice fishes (family: Channichthyidae) levels of AFGPs varied from 3 mg/ml in *Champsocephalus gunnari* to 30 mg/ml in *Neopagetopsis ionah*, the latter comparable to the high-latitude ice fish of McMurdo Sound. The common Notothenia species such as *N. coriiceps*, *N. rossii* and *Gobionotothen* *gibberifrons* all have high levels of AFGP which correlates with the fact that part of their life cycle involves exposure to ice-laden waters of shallow habitats during the winter and early spring. *Lepidonotothen larseni* a deep-water form has an intermediate level of AFGP that is correlated with its absence from shallow-water habitats.

It is of special interest to know whether those notothenioid fishes lacking physiologically significant levels of AFGPs in the blood have completely lost their AFGP genes, if in fact their ancestors had them. If not then they probably invaded the Antarctic secondarily and have managed to survive in the present day ice-free environments such as water deeper than 100m and distant from ice shelves. One species that lacks detectable levels of blood AFGP is *Lepidonothen squamifrons*. Lack of AF most likely restricts this species to deep-water >200m) habitats. It will be of interest to know whether this species has lost its AF genes since its ancestors apparently had the AF genes based on independent phylogenetic studies. The possibility also exists that it has AFGP genes but fails to transcribe them or if transcription is intact, then there may be failure in the process translation into protein.

The few *Trematomus* species (*T. bernacchii, T. hansoni, T. loennbergi*) whose common habitat is primarily the high latitude ice-laden shallow waters of Antarctica showed no difference in AFGPs relative to McMurdo Sound populations. This finding indicates that the slightly warmer waters of the Antarctic Peninsula regions have little effect on antifreeze levels and that the level of circulating AFGPs may be an evolutionary fixed characteristic in these fishes.

Pleurogramma antarcticum, a common circumpolar notothenioid fish has low levels of antifreeze protein at all life stages regardless of whether it is captured in shallow or deep water or in McMurdo Sound vs. water near the South Shetlands in the Peninsula region (this cruise). The abundance of this species in McMurdo Sound, one of the coldest bodies of water in Antarctica, represents a paradox in that this species's level of antifreeze protein is insufficient to protect it in the surface waters, yet it is common at depths of 150 meters even though the water at that depth is close to its freezing point of -1.93°C, and is also common around ice shelves where occasional plumes of ice-laden cold water flow from under the shelf.

Documentation of the circulating levels of AFGPs in the various Antarctic fishes species may in part help explain their geographic distribution, and in conjunction with considerations of their evolutionary origins may better explain the present day distribution of the Antarctic fish fauna. Such information may be helpful in predictions of where a given species may or may not be found because the water temperatures are below their body freezing points.

5.6 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.

5.7 References:

Agnew, D.J. and Nichol, S. 1996. Marine disturbances – commercial fishing. *In*: Ross, R.M., E.E. Hoffman, L.B. Quetin (Eds). Foundations for Ecological Research West of the Antarctic Peninsula. Washington, American Geophysical Union, Antarctic Research Series 70: 417-435.

Ashford, J.R., and Jones, C.D. 2001. Using hierarchical methods for sub-sampling hauls by trawl during fisheries surveys. CCAMLR WG-FSA-01/68.

Auster, P.J. 1998. A conceptual model of the impacts of fishing gear on the integrity of fish habitats. *Conservation Biology* 12(6): 1198-1203.

Ball, I.R. 2002. Defining predator foraging ranges, illustrated using Adélie penguin foraging tracks from Mawson coast. CCAMLR WG-EMM-02/41.

Jones, C.D., Sexton, S.N., Cosgrove III, R.E. 1999. Surface areas of seabed within the 500 m isobath for regions within the South Shetland Islands (Subarea 48.1). *CCAMLR Science* 6: 133-140.

Kock, K.-H. 1989. Reproduction in fish around Elephant Island. *Archiv für Fischereiwissenschaften* 39 (Beiheft 1): 171-210.

Kock, K.-H. and Kellermann, A. 1991. Reproduction in Antarctic notothenioid fish - a review. *Antarctic Science* 3(2): 125-150.

Table 5.1. Station and catch information for the 2002/03 AMLR finfish survey of the South Shetland Islands: Elephant Island Stations.

Station	Haul Number	Date	Latitude	Longitude	Strata	Mean Depth	Number of Species	Total Catch (Kg)	Total Number
27	1	13-Mar-03	60°57.38'	55°08.96'	3	258	8	22.32	135
28	2	13-Mar-03	61°00.00'	55°03.62'	3	259	19	55.39	361
89	3	13-Mar-03	61°04.47'	54°49.59'	2	135	9	86.13	130
82	4	14-Mar-03	61°03.97'	54°34.70'	2	198	10	52.71	273
34	5	14-Mar-03	61°10.78'	54°34.38'	4	328	15	32.81	132
32	6	14-Mar-03	61°14.34'	54°48.66'	4	125	12	34.83	268
35	7	15-Mar-03	61°20.73'	55°12.81'	3	247	9	26.95	180
36	8	15-Mar-03	61°20.59'	55°28.17'	2	142	8	82.92	196
1	9	15-Mar-03	61°17.94'	55°42.76'	2	138	10	90.85	405
2	10	15-Mar-03	61°14.37'	55°33.95'	1	56	5	12.22	16
3	11	15-Mar-03	61°11.41'	55°41.39'	1	76	6	16.13	79
11	12	15-Mar-03	61°10.59'	55°52.90'	2	111	8	179.46	725
18	13	16-Mar-03	61°07.29'	55°46.37'	1	66	6	33.49	152
14	14	16-Mar-03	61°03.93'	55°51.50'	2	133	11	110.44	393
15	15	16-Mar-03	61°02.23'	56°00.06'	4	323	12	16.14	240
16	16	16-Mar-03	60°55.98'	55°46.55'	3	265	12	108.86	129
20	17	16-Mar-03	60°54.02'	55°43.21'	2	169	11	204.66	347
21	18	17-Mar-03	60°50.80'	55°44.39'	3	282	9	109.32	91
22	19	17-Mar-03	60°49.81'	55°37.84'	5	407	14	48.99	62
23	20	17-Mar-03	60°51.71'	55°30.23'	3	258	5	10.26	13
24	21	17-Mar-03	60°54.21'	55°22.92'	3	279	12	348.23	406
26	22	17-Mar-03	60°52.97'	55°21.06'	4	334	15	21.50	220
9	23	18-Mar-03	61°10.27'	56°11.68'	5	414	9	53.21	1232
10	24	18-Mar-03	61°09.06'	56°04.65'	2	156	7	884.15	1037
4	25	18-Mar-03	61°13.32'	55°52.50'	2	130	7	17.94	56
5	26	19-Mar-03	61°13.98'	55°58.37'	2	140	7	26.62	98
6	27	19-Mar-03	61°21.56'	56°02.50'	4	333	14	8.38	42
38	28	19-Mar-03	61°27.45'	56°08.22'	4	342	7	6.95	27
37	29	19-Mar-03	61°17.02'	56°15.32'	4	296	8	20.74	62
90	30	20-Mar-03	61°25.03'	55°54.20'	2	162	8	92.63	133
91	31	20-Mar-03	61°27.08'	55°51.49'	1	86	7	386.66	279
92	32	20-Mar-03	61°28.70'	56°11.58'	5	426	6	12.97	50

Table 5.2. Station information for the 2002/03 AMLR finfish survey of the South Shetland Islands: lower South Shetland Islands stations.

Station	Haul Number	Date	Latitude	Longitude	Strata	Mean Depth	Number of Species	Total Catch (Kg)	Total Number
43	33	21-Mar-03	61°39.26	57°06.44'	5	434	13	37.63	231
68	34	21-Mar-03	61°36.21	57°15.59'	5	410	12	32.85	114
69	35	21-Mar-03	61°38.17	57°32.24'	5	400	13	28.44	102
93	36	21-Mar-03	61°44.74	57°49.10'	3	266	11	139.34	214
45	37	22-Mar-03	61°39.11	57°46.79'	4	315	9	23.69	211
44	38	22-Mar-03	61°45.40	58°00.36'	3	246	9	24.54	51
85	39	22-Mar-03	61°46.12	58°25.60'	3	241	13	284.91	384
49	40	22-Mar-03	61°45.87	58°34.16'	3	260	13	942.36	670
48	41	23-Mar-03	61°49.52	58°33.88'	2	183	8	8.81	16
50	42	23-Mar-03	61°48.36	58°42.88'	3	245	15	118.55	152
47	43	23-Mar-03	61°36.53	58°35.75'	4	349	14	75.06	163
51	44	23-Mar-03	61°39.81	58°49.75'	4	376	12	86.42	427
83	45	24-Mar-03	61°51.46	59°14.20'	3	241	18	149.57	380
52	46	24-Mar-03	61°59.00	59°07.58'	2	154	12	94.75	186
58	47	24-Mar-03	62°06.92	59°29.93'	1	71	7	13.79	26
57	48	24-Mar-03	62°11.06	59°35.50'	1	62	7	18.21	96
55	49	25-Mar-03	61°56.66	59°34.94'	3	229	16	112.78	1163
53	50	25-Mar-03	61°59.98	59°36.04'	2	163	11	137.51	259
56	51	25-Mar-03	61°58.98	59°57.01'	3	269	19	52.84	503
94	52	25-Mar-03	62°16.74	60°15.98'	1	73	4	38.41	287
63	53	26-Mar-03	62°09.92	60°50.45'	5	447	18	24.33	134
62	54	26-Mar-03	62°06.59	60°36.09'	4	334	9	18.30	223
70	55	26-Mar-03	62°10.21	60°27.74'	2	167	13	39.87	111
61	56	26-Mar-03	62°20.78	60°27.17'	2	100	10	30.12	212
74	57	27-Mar-03	62°20.96	60°28.60'	1	75	4	29.13	200
72	58	27-Mar-03	62°23.60	60°50.02'	1	88	6	43.92	174
71	59	27-Mar-03	62°23.58	60°55.51'	2	146	9	18.26	74
96	60	27-Mar-03	62°26.28	61°07.30'	2	124	9	55.37	133
97	61	28-Mar-03	62°30.23	61°31.75'	4	370	11	16.20	131
86	62	28-Mar-03	62°32.73	62°17.59'	2	137	13	73.33	357
77	63	28-Mar-03	62°40.10	61°47.06'	1	86	8	26.00	41
78	64	28-Mar-03	62°41.65	61°38.93'	2	140	7	45.30	163
79	65	29-Mar-03	62°52.24	61°48.54'	2	182	15	50.16	168
80	66	29-Mar-03	62°49.60	60°54.58'	2	172	9	67.91	427
88	67	29-Mar-03	62°54.92	60°54.33'	5	466	11	23.80	521
98	68	1-Apr-03	63°04.94	60°38.18'	4	352	7	21.29	338

Table 5.3: Number of stomachs investigated and otoliths collected by species during the 2002/03 AMLR finfish survey of the South Shetland Islands.

Species	Number of Stomachs Investigated	Number of Stomachs with Content	Percent of Stomachs with Contents	Number of specimens with otoliths collected
Chaenocephalus aceratus	804	126	16	484
Chionodraco wilsoni	5	3	60	-
Champsocephalus gunnari	822	682	83	733
Chionobathyscus dewitti	1	0	0	-
Chionodraco rastrospinosus	410	138	34	384
Cryodraco antarcticus	106	30	28	100
Dissostichus mawsoni	66	57	86	67
Electrona antarctica	9	4	44	43
Gerlachea australis	2	1	50	-
Gobionotothen gibberifrons	422	419	99	415
Gymnoscopelus braueri	-	-	-	16
Gymnoscopelus nicholsi	135	124	92	226
Gymnoscopelus opisthopterus	1	0	0	1
Harpagifer antarcticus	52	45	87	-
Lepidonotothen larseni	165	141	85	29
Lepidonotothen nudifrons	72	64	89	13
Lepidonotothen squamifrons	282	256	91	282
Muraenolepis microps	13	9	69	3
Neopagetopsis ionah	13	10	77	-
Notothenia coriiceps	247	227	92	242
Notothenia rossii	93	89	96	89
Ophthalmolycus amberensis	3	2	67	-
Pachycara brachycephalum	33	19	58	1
Pagetopsis macropterus	3	2	67	-
Parachaenichthys charcoti	50	45	90	18
Pleurogramma antarcticum	70	57	81	141
Pogonophryne scotti	1	1	100	-
Pseudochaenichthys georgianus	178	99	56	159
Racovitzia glacialis	1	0	0	-
Trematomus bernacchii	5	3	60	-
Trematomus eulepidotus	51	35	69	8
Trematomus hansoni	10	3	30	3
Trematomus scotti	3	0	0	-
Trematomus tokarevi	1	0	0	-

Table 5.4. Total nominal weight and numbers of species caught within the 500 m isobath of the South Shetland Islands.

	50-100 m		100-200 m		200-300 m		300-400 m		400-500 m		Total	
Species	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.	Kg.	Num.
Artedidraco skottsbergi					0.01	1					0.01	1
Bathyraja eatonii					10.81	7	10.96	3	2.21	2	23.98	12
Bathyraja maccaini	6.84	7	15.51	3	58.70	10	11.24	2	18.56	4	110.85	26
Bathyraja species 2			0.27	2	10.38	17	3.96	19	2.43	18	17.04	56
Chaenocephalus aceratus	61.13	71	480.45	740	81.94	339	17.69	110	2.00	40	643.21	1300
Chaenodraco wilsoni					0.37	5	0.19	1	0.02	1	0.59	7
Champsocephalus gunnari	75.07	626	768.72	3199	48.40	131	20.20	86	4.54	14	916.94	4056
Chionobathyscus dewitti									0.18	1	0.18	1
Chionodraco rastrospinosus			81.74	140	303.23	480	64.48	110	41.83	79	491.27	809
Cryodraco antarcticus					17.48	24	40.65	68	7.06	16	65.19	108
Dissostichus mawsoni	0.17	1	8.19	31	88.10	23	6.98	7	9.71	6	113.15	68
Electrona antarctica					0.32	30	1.07	158	0.44	39	1.84	227
Electrona carlsbergi							0.02	4			0.02	4
Electrona sp.							0.58	105			0.58	105
Gerlachea australis					0.07	2					0.07	2
Gobionotothen gibberifrons	35.94	45	787.87	965	770.97	1016	23.55	33	14.51	23	1632.83	2082
Gymnodraco acuticeps			0.13	1							0.13	1
Gymnoscopelus braueri							0.17	21	0.02	1	0.18	22
Gymnoscopelus nicholsi					36.14	1004	23.07	611	56.95	1748	116.16	3363
Gymnoscopelus opisthopterus							0.04	2	0.05	1	0.09	3
Gymnoscopelus species					0.01	1					0.01	1
Harpagifer antarcticus	1.04	67			0.02	2					1.06	69
Lepidonotothen larseni			16.58	417	35.61	869	13.46	277	4.92	98	70.57	1661
Lepidonotothen nudifrons	2.32	37	4.14	88	0.77	18	2.66	80	0.04	1	9.92	224
Lepidonotothen squamifrons					22.34	42	113.18	385	72.71	222	208.23	649
Lycodichthys antarcticus			0.04	1			0.06	1			0.11	2
Macrourus species									0.06	1	0.06	1
Magnisudis prionosa							0.05	1			0.05	1
Muraenolepis microps					1.08	2	3.71	7	1.68	6	6.47	15
Neopagetopsis ionah			4.60	4	6.33	6			2.84	3	13.77	13

Table 5.4. Continued... Total nominal weight and numbers of species caught within the 500 m isobath of the South Shetland Islands.

	50-100 m		100-200 m		200-300 m		300-400 m		400-500 m		Total	
Notothenia coriiceps	414.24	287	149.06	120	790.89	425	7.10	5	2.01	1	1363.30	838
Notothenia rossii	5.07	10	13.41	14	86.13	64	3.09	2	7.81	7	115.51	97
Ophthalmolycus amberensis			0.53	7	3.22	35	0.37	5	0.11	1	4.23	48
Pachycara brachycephalum			0.14	2	1.51	21	2.22	28	0.38	5	4.24	56
Pagetopsis macropterus			0.06	1	0.09	2					0.15	3
Parachaenichthys charcoti	6.01	189	1.01	12	0.15	3	0.03	1			7.20	205
Paradiplospinus gracilis							0.12	2			0.12	2
Pleuragramma antarcticum					1.40	129	3.75	305	1.76	95	6.90	529
Pogonophryne scotti			0.52	1							0.52	1
Pseudochaenichthys georgianus	9.57	7	114.09	116	124.54	104	1.54	1	3.72	2	253.46	230
Racovitzia glacialis									0.08	1	0.08	1
Trematomus bernacchii	0.53	2	0.80	2			0.66	2			1.99	6
Trematomus eulepidotus	0.03	1	1.17	25	1.74	9	4.29	40	2.54	9	9.77	84
Trematomus hansoni			0.74	5	3.38	6	1.15	1	1.05	1	6.33	13
Trematomus scotti			0.13	3							0.13	3
Trematomus tokarevi					0.06	5	0.03	1			0.08	6

Table 5.5. Estimated spawning time and gonado-somatic indices (GSI) at spawning in females, GSI in March 2003, and egg size at spawning in abundant nototheniids, and channichthyids in the Elephant Island – South Shetland Island region.

Species	Estimated spawning time	GSI of females at spawning	GSI of females in March 2003*	Egg size (mm)
C. aceratus	March - April	23 - 31	12 - 20	4.4 – 4.7
C. antarcticus	March - April	23 - 28	13 - 17	4.2 – 4.5
C. gunnari	End of Feb - April	23 - 28	5 - 12	3.5 – 3.7
C. rastrospinosus	March - April	25 - 30	18 - 24	4.5 – 5.0
G. gibberifrons	July - August	> 20	< 8	1.7 –2.0
L. larseni	July - August	> 20	3 - 5	1.8 – 2.0
L. nudifrons	April - May	23 - 28	12 - 16	2.5
L. squamifrons	February - April	unknown	6 - 11	probably 1.4
N. coriiceps	May - June	23 - 28	6 - 12	4.4 – 4.7
N. rossii	May - June	20 - 30	4 - 21	4.7 – 5.0
P. georgianus	June - July	23 - 28	4 - 8	4.5 – 4.8
T. hansoni	February - March	> 23	30 (1 ♀ only)	3.2

* Figures may change slightly when all material is analyzed.

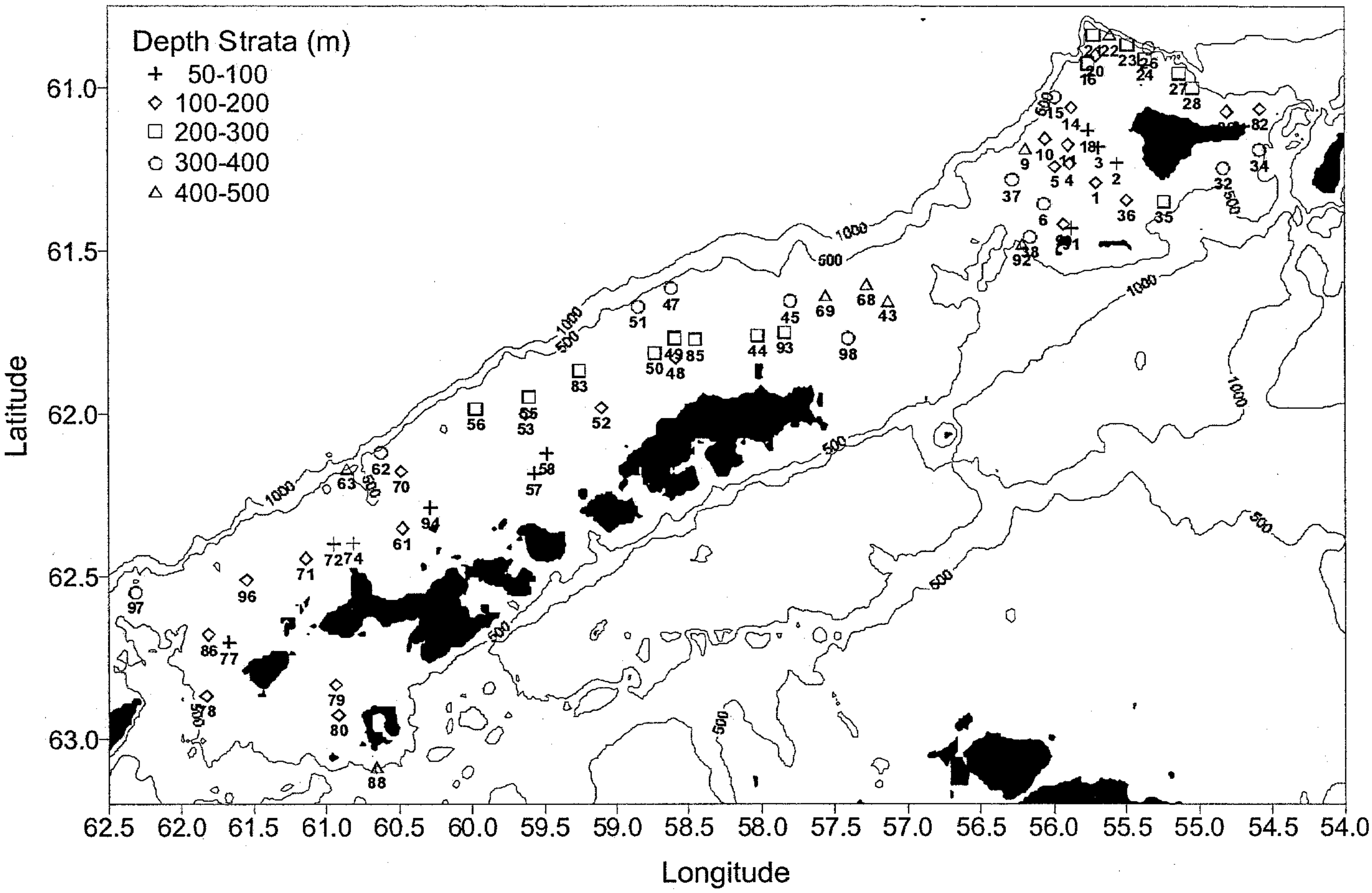


Figure 5.1 Station locations by depth strata for the 2003 AMLR finfish bottom trawl survey. (Latitude is south and longitude is west).

A)

B)

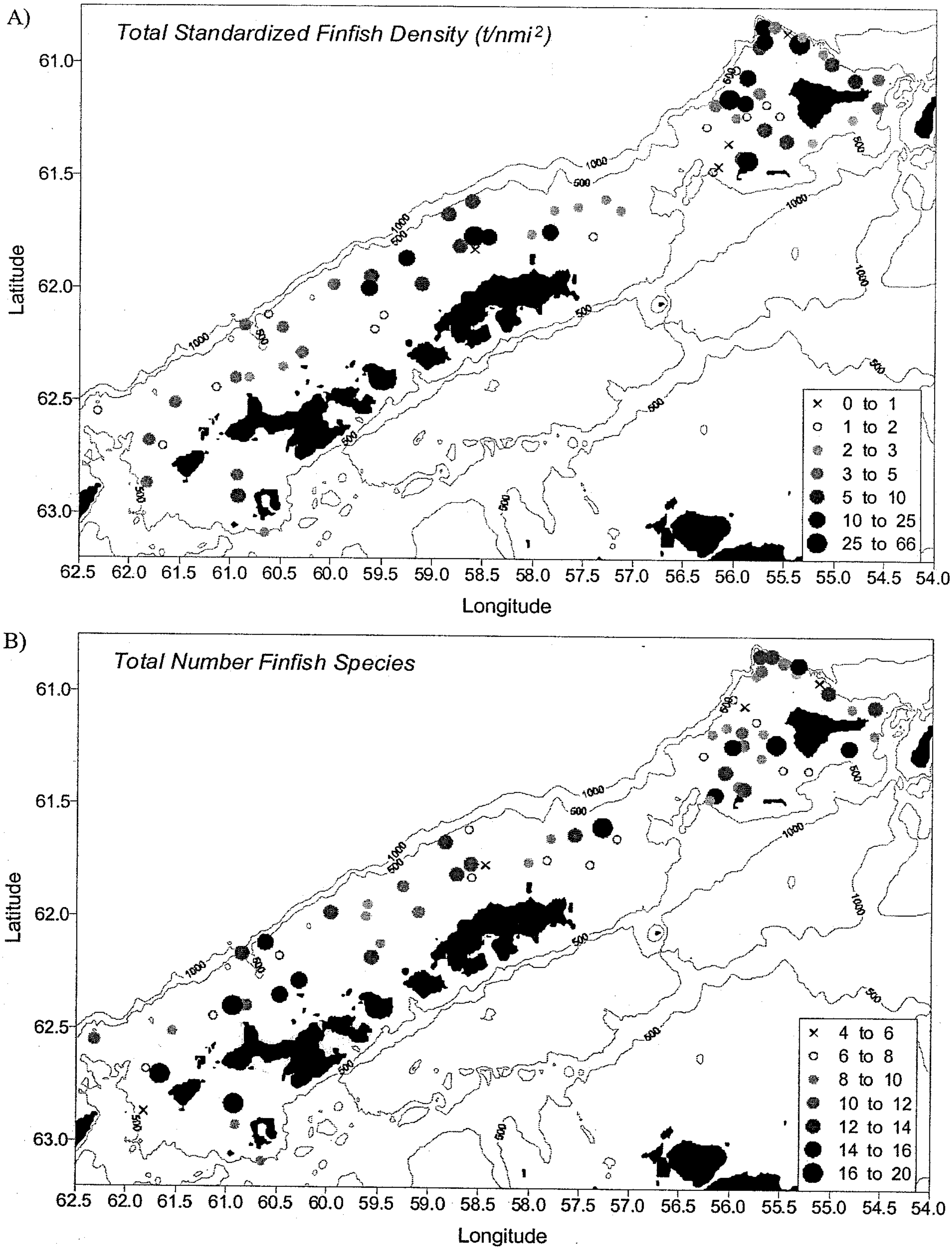


Figure 5.2. A) Total standardized finfish density in tonnes/nmi^2, and B) total number of species from the 2003 AMLR finfish survey of the S. Shetland Islands. (Latitude is south and longitude is west).

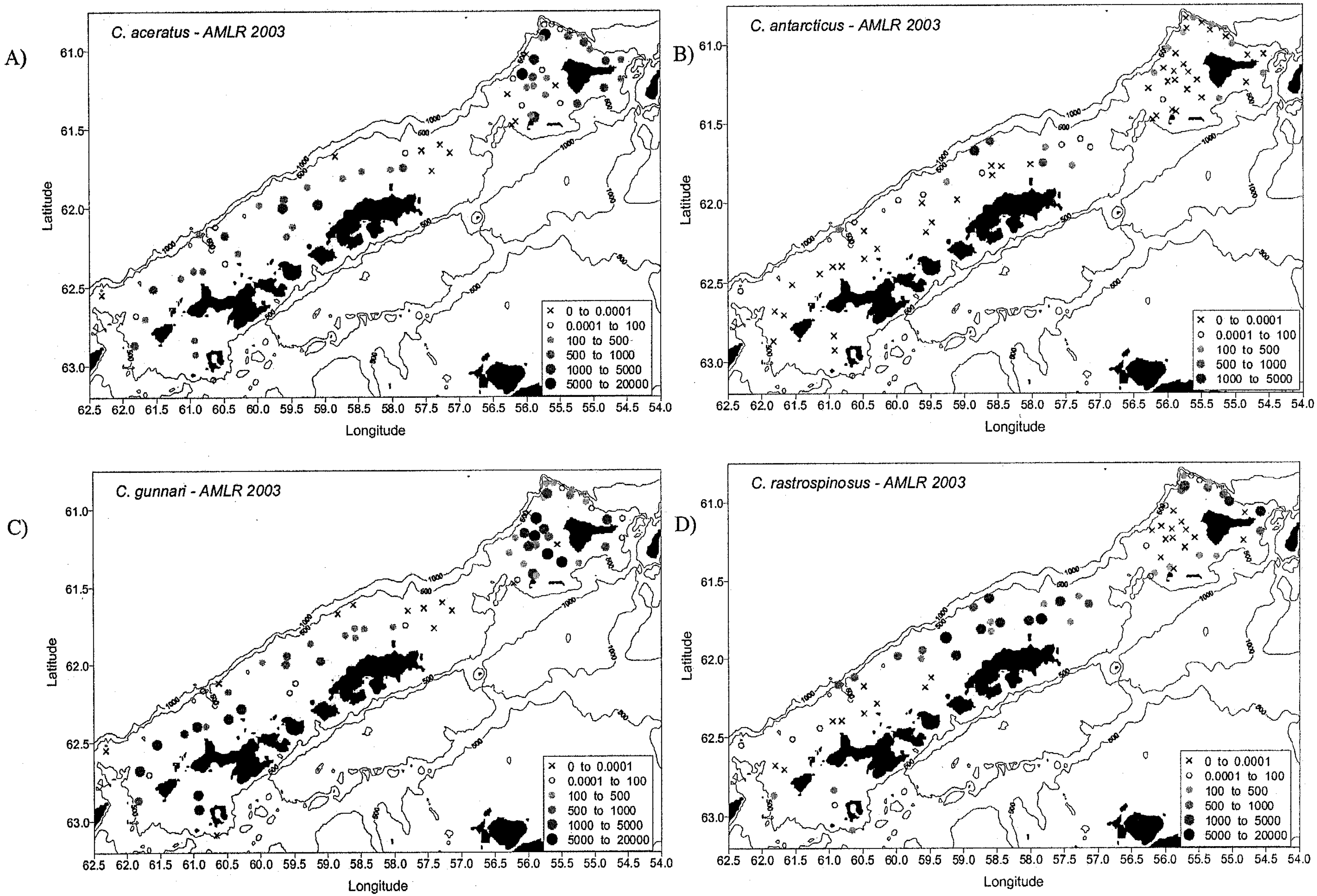


Figure 5.3. Standardized density (kg/nmi^2) for A) *C. aceratus*; B) *C. antarcticus*; C) *C. gunnari*; and D) *C. rastrospinosus* from the 2003 AMLR finfish survey of the South Shetland Islands. (Latitude is south and longitude is west).

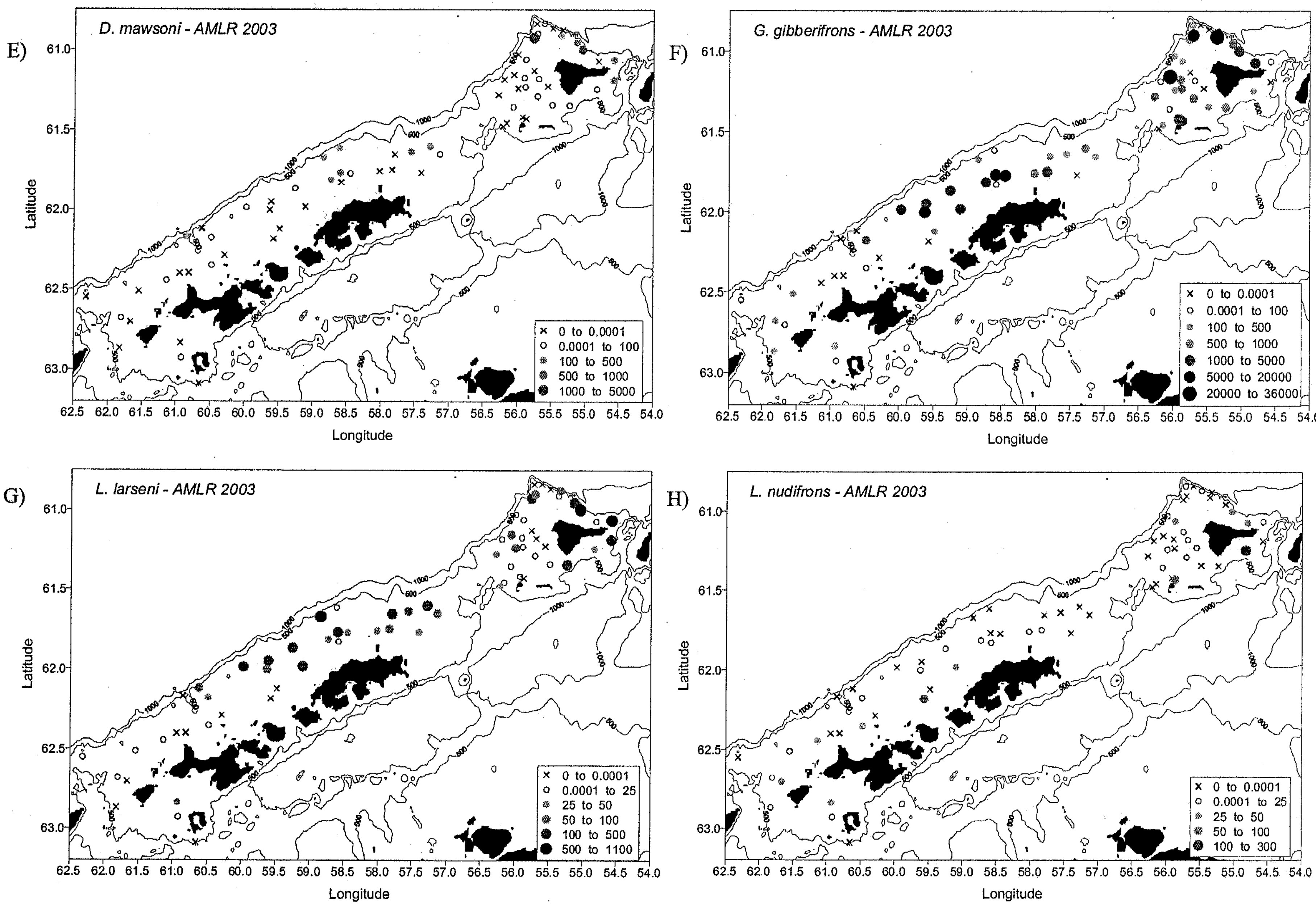


Figure 5.3. Continued. Standardized density (kg/nmi^2) for E) *D. mawsoni*; F) *G. gibberifrons*; G) *L. larseni*; and H) *L. nudifrons* from the 2003 AMLR finfish survey of the South Shetland Islands. (Latitude is south and longitude is west).

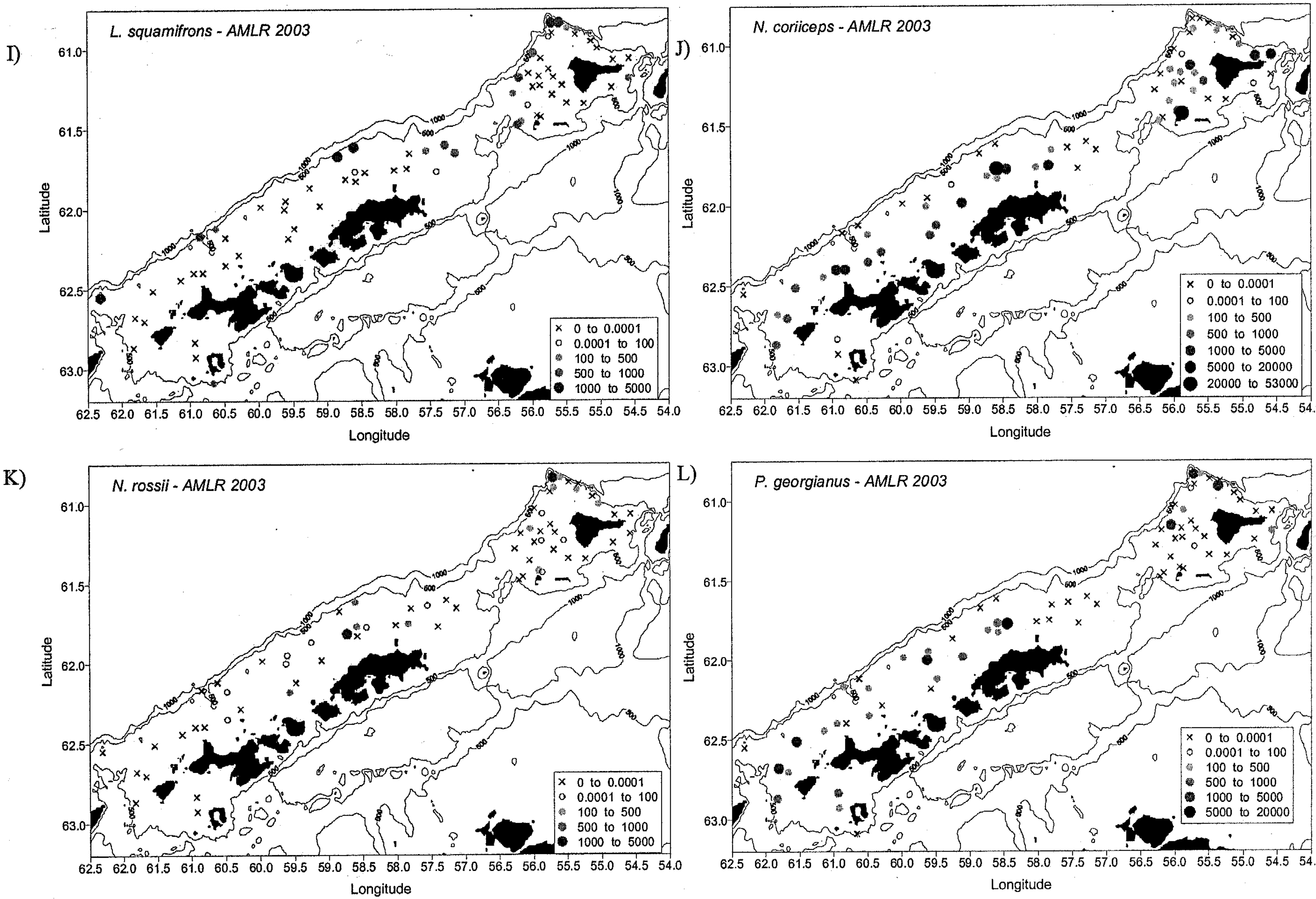


Figure 5.3. Continued. Standardized density (kg/nmi^2) for I) *L. squamifrons*; J) *N. coriiceps*; K) *N. rossii*; and L) *P. georgianus* from the 2003 AMLR finfish survey of the South Shetland Islands. (Latitude is south and longitude is west).

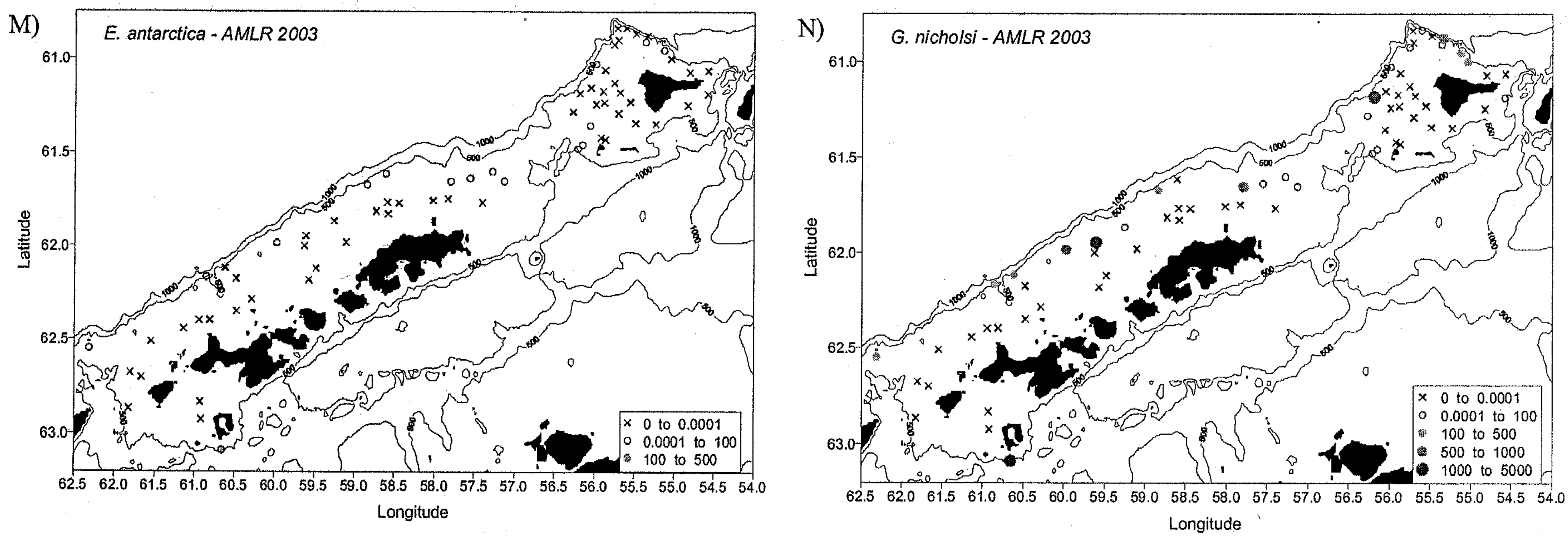


Figure 5.3. Continued. Standardized density (kg/nmi^2) for M) *E. antarctica*; and N) *G. nicholsi* from the 2003 AMLR finfish survey of the South Shetland Islands. (Latitude is south and longitude is west).

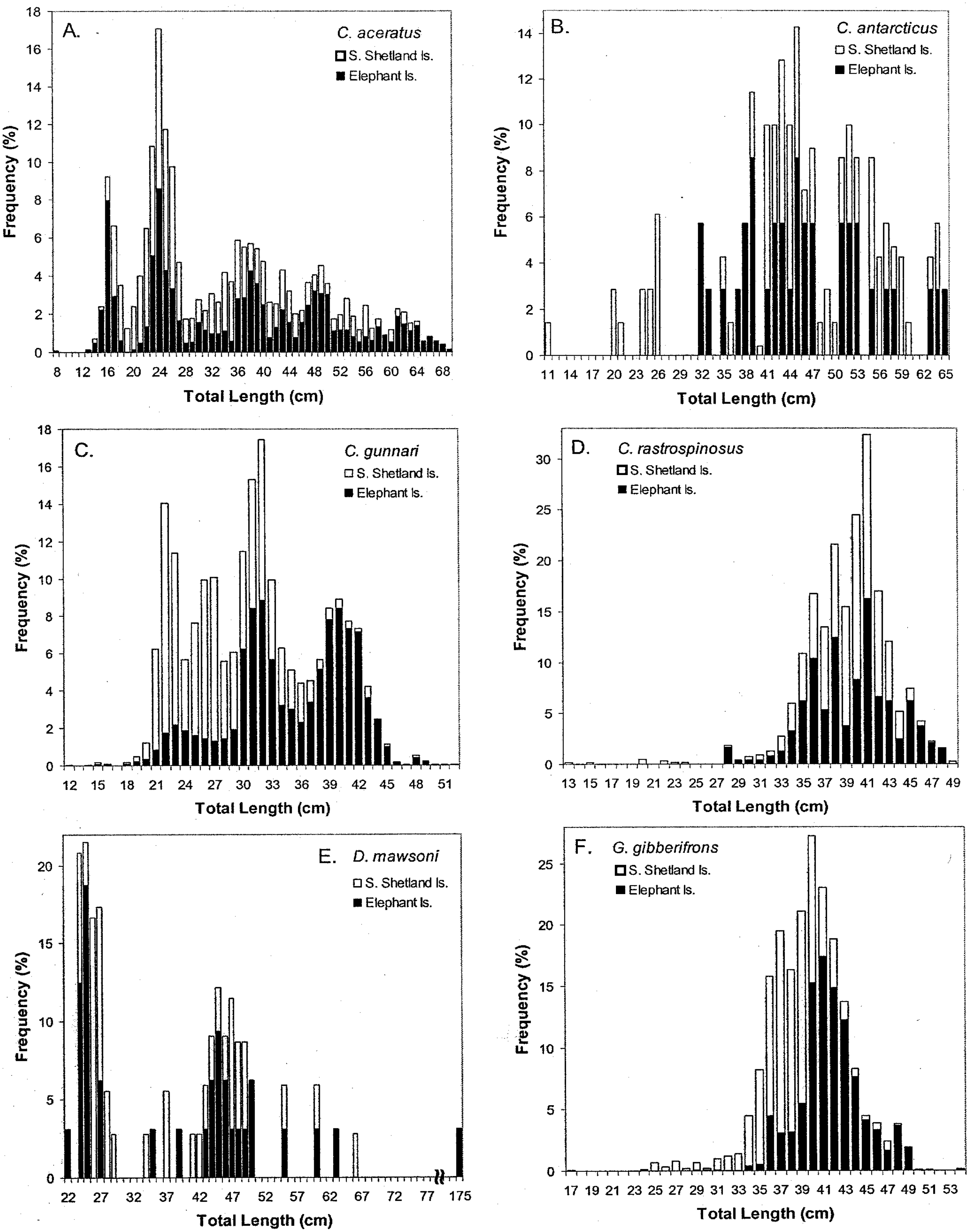


Figure 5.4. Catch weighted length-frequency distribution for A) *C. aceratus*; B) *C. gunnari*; C) *C. rastrospinosus*; D) *C. antarcticus*; E) *D. mawsoni*; and F) *G. gibberifrons*.

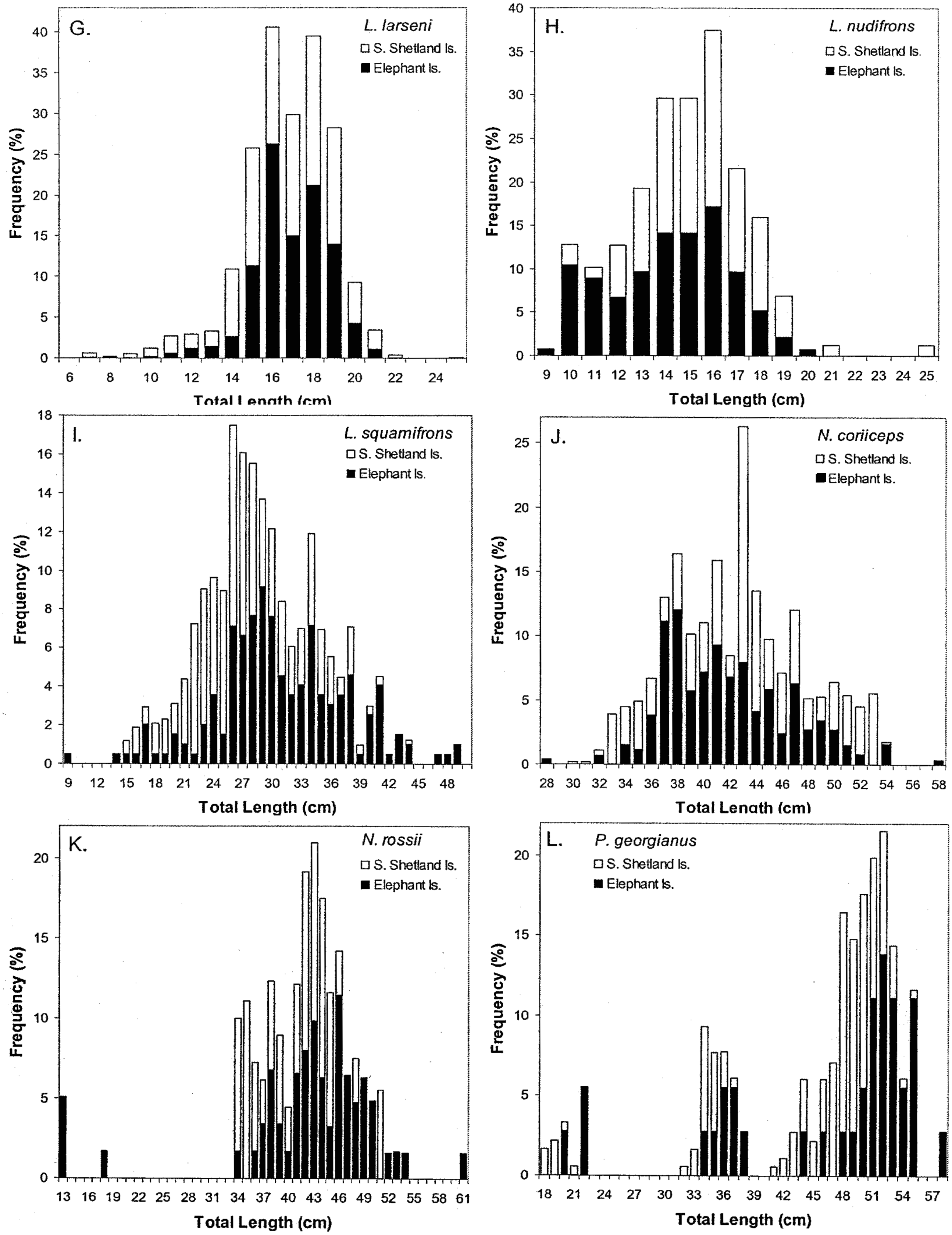


Figure 5.4 (continued). Catch weighted length-frequency distribution for G) *L. larseni*; H) *L. nudifrons*; I) *L. squamifrons*; J) *N. coriiceps*; K) *N. rossii*; and L) *P. georgianus*.

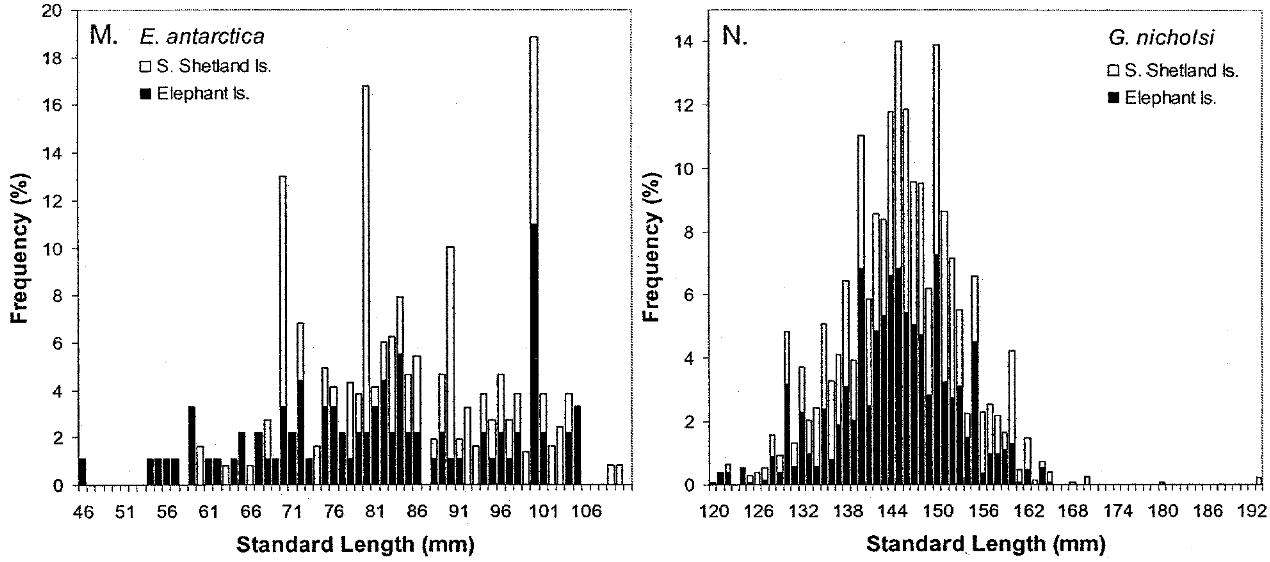


Figure 5.4 (continued). Catch weighted length-frequency distribution for M) *E. antarctica*; and N) *G. nicholsi*.

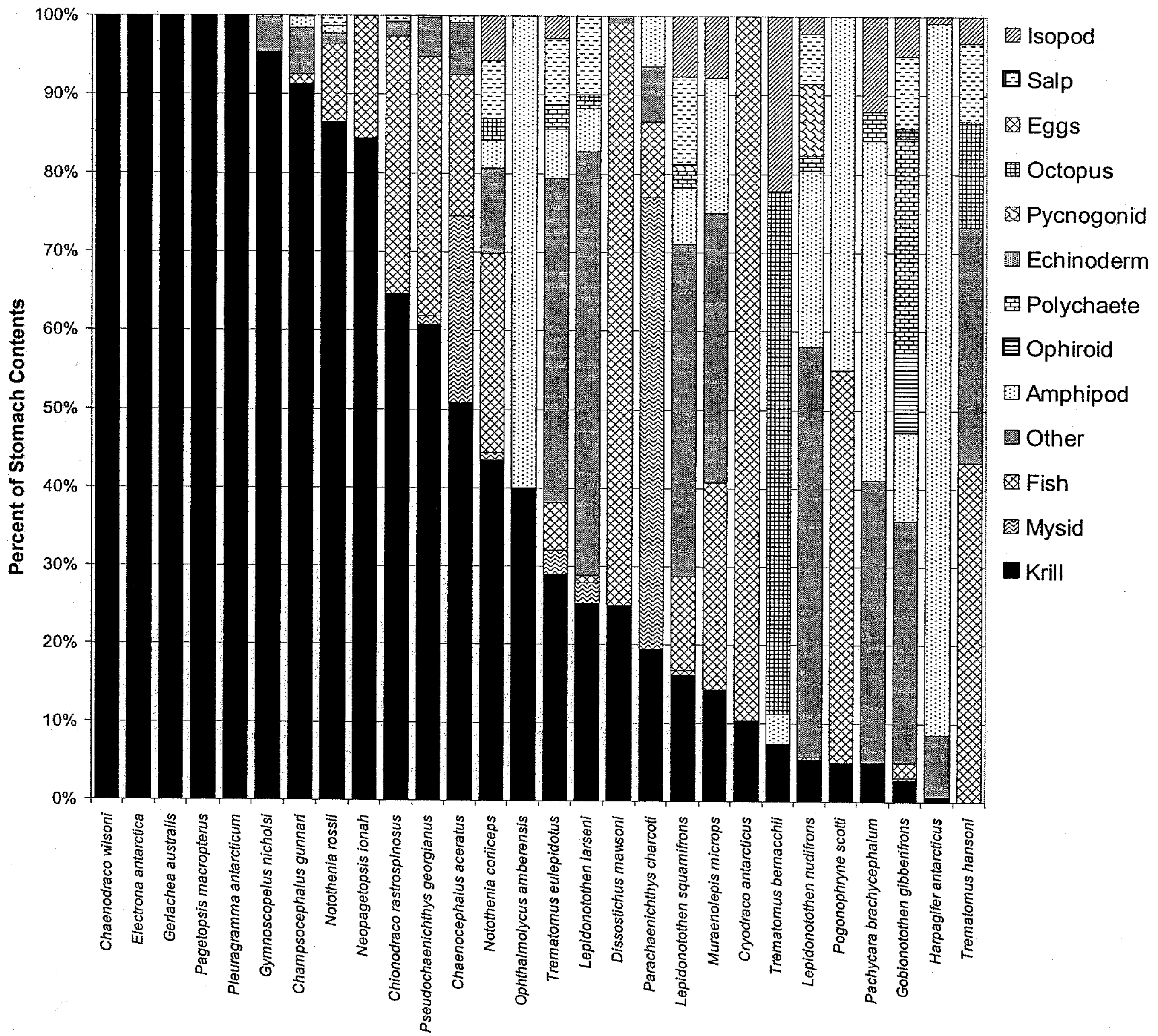


Figure 5.5. Summary of diet composition of 20 species of finfish, based on mean stomach content scores, from the 2001 AMLR finfish bottom trawl survey of the South Shetland Islands.

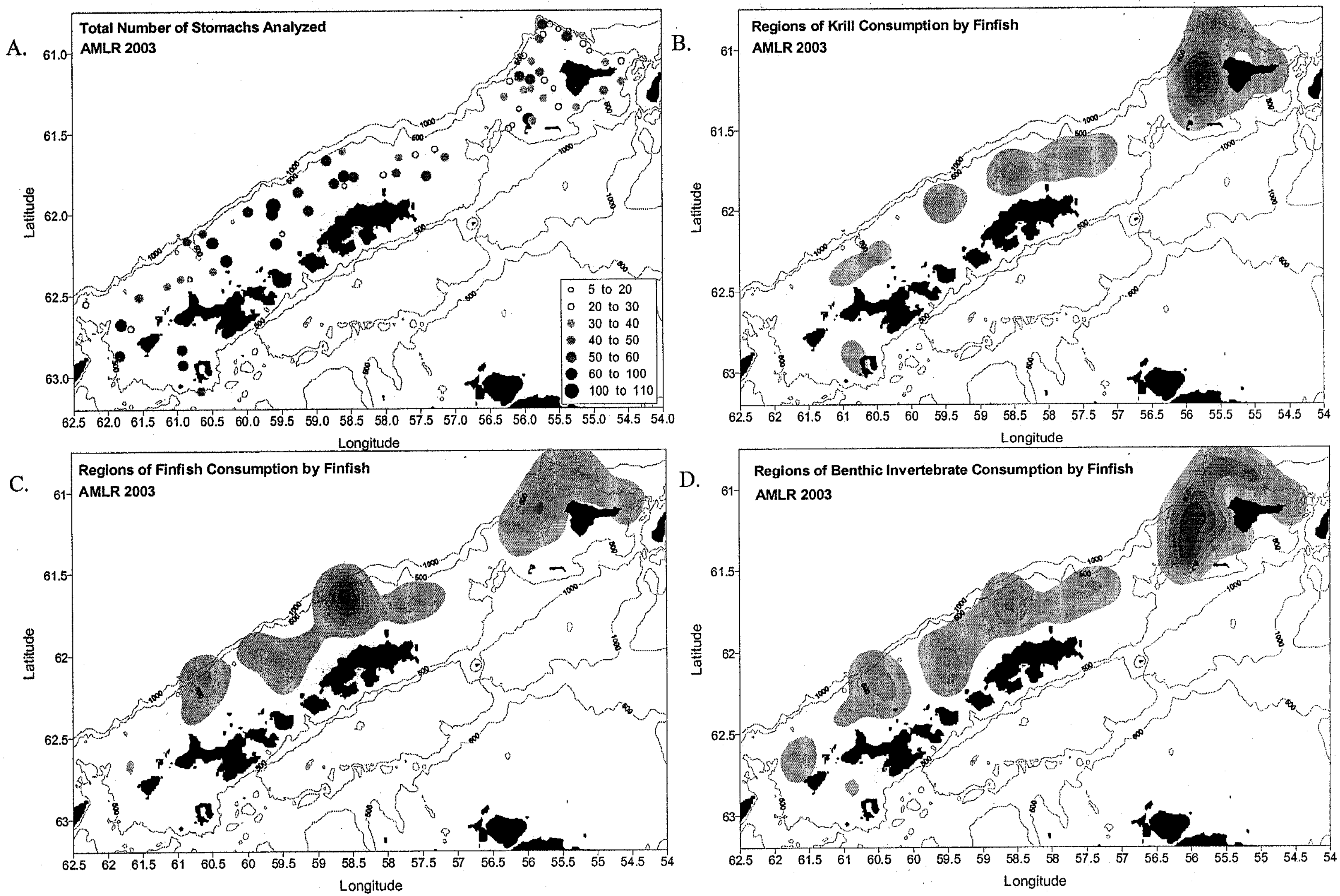


Figure 5.6. Regions of importance for pooled finfish dietary constituents from the 2003 AMLR finfish survey. A) Number of stomachs analyzed; B) regions of krill importance; C) regions of finfish importance; and D) benthic invertebrate importance. (Latitude is south and longitude is west).

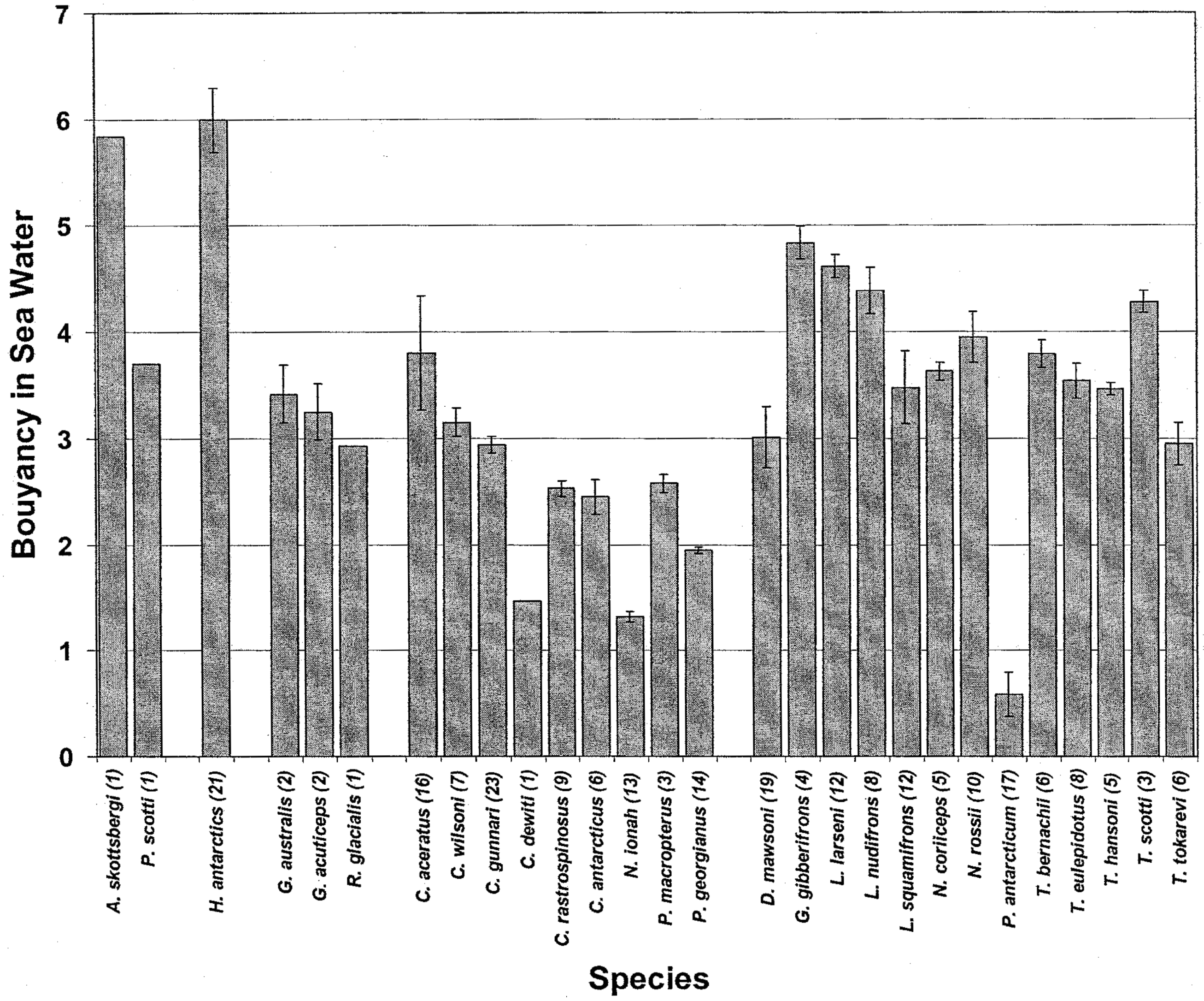


Figure 5.7. Buoyancy measurement for 28 species of notothenioid fish, from the 2003 AMLR survey. Samples sizes are given next to species name.

6. Benthic Invertebrate Bycatch and Characterization; submitted by Stacy Kim (Leg III), Andrew Thurber (Leg III), Richard Mooi (Leg III), Susanne Lockhart (Leg III) and Rob Rowley (Leg III).

6.1 Objectives: The goal of this work was to identify and quantify the invertebrates incidentally captured by the bottom trawl, part of the effort to describe and contrast meso-scale habitat features on different parts of the shelves around the South Shetland Islands. The non-target species captured by a fishery, commonly known as "bycatch", include both vertebrate and invertebrate species. In this section we present data on the invertebrate bycatch from the bottom trawl. Details on the bottom trawl are provided in Chapter 5 of this field season report.

In addition to the data on the invertebrate bycatch brought up in the bottom trawl, we employed a small benthic dredge to sample the infaunal and epifaunal invertebrates. Termed the Little Benthic Invertebrate Trawl (Little BIT), this net was attached to the main trawl's lower bridle, just forward of the mud sweep. It was rigged with eight spectra line bridles, doubled and fastened at four points on the mouth, two at each side of the head- and foot-rope ground tackle. The inner lining mesh measured 3cm, while the outer net material was a nylon mesh of 10cm. The net was protected by fitting the belly with hula chafing. Additional Little BIT dimensions can be found in Table 6.1. Unlike the bottom trawl, which likely had reduced amounts of benthos due to the footrope tire gear configuration, the footrope of the little BIT was not rigged with bobbins, tires, or any other gear, enabling firm contact with the bottom. The two trawls thus are differentially selective in the organisms recovered, and offer a more complete sampling of the benthic community.

The excellent condition of animals collected by the Little BIT, along with improved camera and aquarium equipment available on deck, allowed us to remarkably improve the draft field guide produced during the 2000/01 AMLR field season. A basic field guide (suitable for use by non-specialists) has been compiled and is available on CD by request. Many species remain indistinguishable to the casual observer, as defining characteristics are microscopic or nearly so, or require training in invertebrate morphology to perceive. For species-level classification, a detailed web-based identification guide has been developed.

Finally, still and video camera records of the seafloor, taken in areas close to the trawled areas during the night hours, provided a record of *in situ* biota. Without the collected organisms, most of the species would have been unidentifiable, but in combination the techniques provided an excellent overview of real abundances, and collection efficiency of the bottom trawl and the Little BIT. Aspects of the video and still imagery are described in Chapter 4 of this report.

6.2 Methods: Trawl samples were taken around Elephant Island and the South Shetland Islands. Samples were stratified into five intervals between 50 and 500m. Specifics on trawling activities and techniques are described in Chapter 5 of this report. Hauls covered an average of 1.28 linear nautical mile of seafloor.

Immediately after the trawl was secured on deck, the organisms were put into fish baskets and moved off the back deck. Invertebrates were grouped into visually distinctive taxa; abundant organisms (i.e. Porifera, Echinodermata, and Urochordata) were grouped by species and, for rare or low biomass organisms, larger taxonomic groupings were used (e.g. all gorgonians were quantified together). It was not possible to identify all organisms to species because of time constraints, and we felt that the best use of limited time and resources was to concentrate on the biomass and numerical dominants. Species of Porifera, in particular, remain unidentified in the field as laboratory preparations of internal spicules are necessary to confirm identifications.

The Little BIT was deployed with the bottom trawl at 62 of the 68 stations. The Little BIT was not deployed at some of the stations sampled early in the cruise (stations 1, 2, 28, 34, 35, 82) in order to reduce the work load, allowing the benthic team time to develop the most optimal working routine on deck. Upon being detached from the main trawl, the contents of the Little BIT were dumped onto a table and sorted into taxonomic groupings. Due to the fact that this piece of equipment was collecting, in general, at a much finer scale than the larger bottom trawl, the catch could not be sorted or identified to species in the time available between hauls. However, where a particular taxon was often found to be dominant and was instantly recognizable, it was identified to genus (e.g. the isopod genus *Serolis*, the polychaete genus *Laetmonice*). Often, a significant proportion of the catch was muddy sediment. In order to make sorting possible, such catches were washed clean with seawater before being dumped on the sorting table.

The invertebrates were completely characterized when possible. Occasionally, extremely large biomass made sampling the entire catch unfeasible with the available time and personnel; these samples were subsampled. One-half the catch from stations 89 (haul 3) and 34 (haul 5) was processed. One quarter of the catch from stations 28 (haul 2) and 82 (haul 4) was subsampled. For station 91 (haul 31), 11.8% of the catch was subsampled, and for the largest haul (#6) at station 32, only 2.6% of the total catch was processed.

As with the bottom trawl, hauls of exceptionally large biomass collected by the Little BIT required subsampling. Despite the smaller volume of the latter, the catch was made up of mainly tiny organisms that were time consuming to sort. As a result, 16 of the 62 hauls were subsampled as follows: 1/2 the catch from stations 53, 62 and 72 (hauls 50, 54 and 56 respectively); 1/3 the catch from stations 24 (haul 21) and 78 (haul 64); 1/4 the catch from stations 20, 90, 91, 69, 93, 48, 50 and 61 (hauls 17, 30, 31, 35, 36, 41, 42 and 56 respectively); 1/6 the catch from station 85 (haul 39); 1/8 the catch from stations 83 (haul 45) and 52 (haul 46). However, in these cases, large and conspicuous taxa such as cephalopods, shizasterid echinoids, cidaroid echinoids, *Laetmonice* polychaetes and *Labidiaster* asteroids were sorted from the entire catch, counted and weighed.

After sorting the bottom trawl catch, each invertebrate taxon was weighed and, if the organisms were individuals (i.e. not colonial), they were counted. For each new taxon encountered, a representative sample was fixed appropriately in 70% ethanol for sponges and gorgonians, and in 10% buffered formaldehyde in seawater (Formalin) for all other taxa. At the end of the cruise the samples in formalin were transferred to 70% ethanol for transport to the US.

Each taxonomic group sorted from the Little BIT catch was weighed and counted according to the methods followed for processing the bottom trawl bycatch. In addition to the voucher samples collected and fixed in formalin as described above, a subsample of the benthic invertebrate community was preserved in 95% ethanol and will be housed at the California Academy of Sciences so as to be available for molecular studies.

Fresh specimens were photographed using a Nikon CoolPix 990 against a solid background including a scale. Photography recorded natural colors and textures, key features for identifying species in the field. Soft-bodied organisms that had contracted were first placed in aquariums with running ambient seawater until they expanded to their natural form before being photographed. Because contracted organisms may look completely different from expanded forms, this allowed identification of species in still and video imagery of the seafloor. Photographs of organisms were compiled into a general field guide that can be used to identify many species. Organisms were brought into the lab and photographs of morphological details taken with fiber optic lights and a macro lens for the CoolPix, which showed details clearly to <1 mm. These images and detailed morphological descriptions were compiled into a scientific guide that will be web accessible. Of the three most common phyla, almost all specimens of Echinodermata and Urochordata are completely identified. However, identifications of Porifera remain tentative due to the extensive laboratory processing necessary for confirming species identifications. Voucher specimens will be archived at the California Academy of Sciences.

Data were entered into a MS Excel benthic database and double-checked for accuracy. This database is compatible with and readily portable to the Access database for the fish and other field data. Statistical analysis included multivariate analysis on all species and on larger taxonomic groupings, for both biomass and abundance measures. Statistical tests were conducted using Systat (vs. 10) and Biodiversity Pro.

6.3 Results and Preliminary Conclusions:

6.3.1 Biomass and Diversity: Biomass and diversity were the two main descriptive parameters for the invertebrate communities. Biomass was adjusted relative to the trawled area which ranged from 0.0077 - 0.016nmi^2. Taxon counts for each trawl were not adjusted by area. However, because similarly-sized areas were fished by each trawl, direct comparisons of taxon counts were facilitated.

The maximum biomass recorded from the bottom trawl was 166.8 t/nmi^2 at Station 32 (Elephant Island). This value is 3 orders of magnitude larger than the minimum biomass of 0.3 t/nmi^2 at Station 23. The distribution of biomass values is shown in Figure 6.1; there was no obvious correlation between biomass and bottom depth (R=0.027), however the biomass was generally higher at the Elephant Island stations than at the South Shetland Island stations (Figure 6.2). Porifera made up the majority (68%) of the biomass caught by the bottom trawl, followed by Echinodermata (mostly seastars) and Urochordata (Figure 6.3). There was no clear pattern to the distribution of taxa with depth, but there exists slight trends towards higher biomass of Urochordata and Arthropoda in shallow depths, and Porifera and Cnidaria in deeper waters.

The maximum and minimum biomass caught by the Little BIT was 80.6 t/nmi^2 (station 11, Elephant Is.) and 1.55 t/nmi^2 (Station 94, South Shetland Islands) respectively. The overall pattern of biomass seen in the bottom trawl bycatch was also reflected in the Little BIT catches. The average biomass caught by the Little BIT was 35.5 t/nmi^2 at Elephant Island and 15.5 t/nmi^2

at the South Shetland Islands. On the other hand, Echinodermata made up the majority of the overall biomass collected by the Little BIT (32%), followed closely by Porifera (29%) (Figure 6.4). This difference is a result of the Little BIT's smaller mouth, which either did not encounter or did not collect the patchily distributed, larger sponges.

Species richness ranged from 19 to 111 taxa per bottom trawl haul. Figures 6.5 and 6.6 show how species counts were distributed. Again, there was no clear pattern with depth or location. Though the maximum of 111 was much higher than the maximum of 65 recorded in 2001, suggestive of improvements in taxonomic allocations, it is likely that this is still an underestimate of the true diversity. The diversities reported here are comparable between our sites but should not be directly compared with other values from the literature.

Correlations between overall invertebrate biomass from the bottom trawls and overall fish biomass were not significant (R=0.166). More detailed analysis of specific species associations (i.e. benthic fish species with structure-creating invertebrates) would be productive hypothesis-driven research that will proceed from the existing data set.

No distinctive groupings were found in multivariate analysis. Hierarchical clustering of Bray-Curtis dissimilarity indices on the total data set of all taxa, for both biomass and abundance, revealed no clear pattern. Only some of the taxa were individuals that could be counted; these were often smaller animals that did not contribute greatly to biomass. Because not all taxa were individuals, the abundance comparison was less robust than the biomass analysis and must be interpreted with caution. The same statistical tests on combined data sets of the major taxonomic groupings likewise resulted in poor correlations. Nevertheless, visual inspection of biomass dominants shows trends in spatial structure and are discussed below.

Principle component analyses were performed on biomass of the major invertebrate taxa from the bottom trawls with station location, depth, date, fish biomass and diversity, and total invertebrate biomass and diversity. Pearson correlation coefficients and Bonferroni-adjusted p values for the few significant patterns are presented in Table 6.2. Of the 136 correlations tested, only four were significant. The higher biomass of arthropods and tunicates with higher sponge biomass supports the concept that sponges are providing habitat structure for other species. The higher number of fish species with depth is addressed in Chapter 5 of this report. Correlation of fish and mollusk biomass with depth is possibly due to the similarities in prey species for fishes and octopus, and will be analyzed in detail in another paper.

A single phylum dominated the biomass bottom trawl at each station. The biomass dominants from both the bottom trawl and the Little BIT are listed in Table 6.3, and displayed geographically in Figure 6.7. Because trawl sampling for benthic invertebrates was semi-quantitative, with some animals remaining trapped in the net, no statistical comparison was justified. Nevertheless, a pattern in the bottom trawl data emerges of Asteroidea (seastar) dominating at the southwest stations with Porifera (sponge) becoming dominant towards the northeastern stations. The differences in biomass were sometimes minimal, so this pattern is not seen in the overall statistical analysis. The distributional groupings for the bottom trawl suggest, however, that Elephant Island provides a more stable habitat supporting sessile, long-lived sponges than the South Shetland Islands at which one finds a preponderance of motile forms such as seastars. The results from the Little BIT, on the other hand, indicate that echinoderms dominate at both sites. Again, this is most likely due to exclusion of larger sponges by the small mouth of the Little BIT.

Although the statistical tests conducted on the data thus far reveal few patterns, distinct communities of benthic invertebrates are clearly distinguishable in the field. Over the years, these have become familiar to the AMLR group to the extent that reliable predictions can be made as to the general composition of the benthic fauna at each station before a haul reaches the deck. To better illustrate the meso-scale differences in community structure along the shelves of the islands, we divided the survey area into regions based on finfish diet data. Data on dietary components scored, as proportions, from the stomachs of all benthic browsing fish species were examined using a kernal smoothing algorithm and a map of smoothed, normalized benthic dietary importance was generated. Additional details of this procedure are presented in Chapter 5 of this report. Using this map, the survey area was divided into 10 regions. Bycatch data from stations falling within each of the regions identified were pooled to generate pie graphs of benthic invertebrate composition by biomass which were then overlaid onto the map (Figure 6.8). This process was carried out for both the bottom trawl and the Little BIT.

Figure 6.8 illustrates a transition from sponge dominated benthic communities to the northeast of the island chain to echinoderm dominated communities to the northwest. Sponge dominated communities are particularly prominent to the northeast of King George Island (regions 5 & 6) and around the eastern tip of Elephant Island (regions 1, 2 & 4). Region 3, to the west of Elephant Island, is more complex than this figure can show, and requires further examination on a finer scale.

Comparing the two trawl nets in this format illustrates the different sampling capabilities of each piece of equipment. The bottom trawl data indicates an importance of Mollusca to the north and northwest of the South Shetlands (regions 6, 7, 8 & 9). In contrast, data from the Little BIT suggests an importance of Bryozoa, while mollusks are represented as relatively insignificant. The majority of the high biomass of mollusks caught by the bottom trawl in these regions was due to a large number of octopuses which would be able to dart more easily out of the path of the smaller Little BIT. This latter net, on the other hand, is designed to maintain contact with the bottom and to retain smaller organisms. In addition, as explained above, Porifera were poorly sampled by the Little BIT, relative to the bottom trawl.

6.3.2 Summary: Individual tows were strongly dominated by single taxa, but there was no significant correlation in biomass, abundance, or dominance with depth or geographical location. Trends in species distributions were a general transition down the island chain from sponge-biomass dominated benthic communities to the northeast, to echinoderm-biomass dominated communities to the northwest. The biomass of octopus and bryozoans also became increasingly important north of the western South Shetland Islands. At a finer scale, sponges were particularly prominent to the northeast of King George Island and the eastern tip of Elephant Island. A difference in the composition of benthic invertebrates caught by the Little BIT compared to those caught by the bottom trawl illustrates the need for a more intensive investigation of the data. Further analysis comparing the two pieces of collecting equipment, with ground-truthing by quantitative analysis of the photographic and video transects, is underway.

6.4 Disposition of Data and Samples: The U.S. AMLR Program maintains the electronic data files from this study. Preserved samples are undergoing further taxonomic analysis at the Moss Landing Marine Laboratories (S. Kim), and will ultimately be catalogued and housed at the California Academy of Sciences (R. Mooi). The photographic guide to benthic invertebrates that will be utilized in future bycatch studies is targeted for web accessibility in the near future.

6.5 Acknowledgements: The invertebrate group would like to thank the other members of the Leg III scientific team. We are particularly grateful for the help offered by Kim Dietrich, Teresa Turk, and Valerie Loeb. Adam Jenkins prepared van space on deck that allowed us to work much more comfortably and safely, and we are very appreciative. The crew of the R/V *Yuzhmorgeologiya* were excellent sources of inspiration for getting things done with supplies on hand. Thanks go to those who supported us from shore at Moss Landing Marine Laboratories, especially Dan Malone and the Benthic Lab, and also the California Academy of Sciences, and the Department of Ocean Sciences, University of California, Santa Cruz.

Table 6.1. Dimensions of the Little Benthic Invertebrate Trawl (Little BIT). All measurements are taken with tension in the material.

Foot rope ground tackle (bottom contact)	61cm
Mouth maximum width	71cm
Mouth height (ground tackle to head rope)	56cm
Head rope to cod end length	1.52m
Upper bridle length	1.47m
Lower bridle length	1.35m

Table 6.2. Statistically significant results of principle components analysis on biomass of the major invertebrate taxa caught by the bottom trawl with station location, depth, date, fish biomass and diversity, and total invertebrate biomass and diversity. P values are Bonferroni adjusted.

Correlation	Pearson coefficients	corrected p values
Porifera biomass vs. Arthropoda biomass	0.484	0.003
Porifera biomass vs. Urochordata biomass	0.426	0.034
Depth vs. # of fish species	0.458	0.010
Mollusca biomass vs. # of fish species	0.495	0.002

Table 6.3. Dominant phyla by biomass at each station. Where only a few grams separated the top two dominant phyla, both phyla are indicated.

Station	Dominant Phyla	
	Bottom trawl	Little BIT
1	Echinodermata	
2	Echinodermata	
3	Mollusca	Echinodermata
4	Porifera	Echinodermata
5	Porifera	Echinodermata
6	Echinodermata	Echinodermata
9	Echinodermata	Echinodermata
10	Porifera	Urochordata
11	Porifera	Porifera
14	Echinodermata	Echinodermata
15	Echinodermata	Echinodermata
16	Porifera	Echinodermata
18	Urochordata	Urochordata
20	Porifera	Porifera
21	Porifera	Porifera
22	Cnidaria	Echinodermata/Cnidaria
23	Echinodermata	Cnidaria
24	Porifera	Echinodermata
26	Porifera	Echinodermata
27	Echinodermata	Cnidaria
28	Porifera	
32	Porifera	Porifera
34	Porifera	
35	Echinodermata	
36	Urochordata	Urochordata
37	Echinodermata	Echinodermata
38	Echinodermata	Echinodermata
43	Porifera	Cnidaria
44	Porifera	Porifera
45	Porifera	Echinodermata
47	Porifera	Echinodermata
48	Echinodermata	Porifera
49	Porifera	Bryozoa
50	Mollusca	Echinodermata
51	Cnidaria	Echinodermata/Cnidaria
52	Echinodermata	Echinodermata/Bryozoa
53	Echinodermata	Porifera
55	Echinodermata	Bryozoa
56	Echinodermata	Echinodermata
57	Urochordata	Bryozoa
58	Echinodermata	Echinodermata
61	Urochordata	Urochordata
62	Urochordata	Annelida
63	Mollusca	Echinodermata
68	Porifera	Porifera
69	Porifera	Echinodermata
70	Echinodermata	Urochordata
71	Echinodermata	Echinodermata
72	Echinodermata	Echinodermata
74	Echinodermata	Echinodermata
77	Echinodermata	Echinodermata
78	Echinodermata	Echinodermata
79	Echinodermata	Echinodermata
80	Porifera	Porifera/Echinodermata
82	Porifera	
83	Echinodermata	Echinodermata
85	Echinodermata	Echinodermata
86	Mollusca	Bryozoa
88	Echinodermata	Echinodermata
89	Urochordata	Urochordata
90	Porifera	Echinodermata
91	Urochordata	Porifera
92	Porifera	Porifera
93	Porifera	Porifera
94	Echinodermata	Echinodermata
96	Echinodermata	Porifera
97	Echinodermata	Echinodermata
98	Porifera	Echinodermata

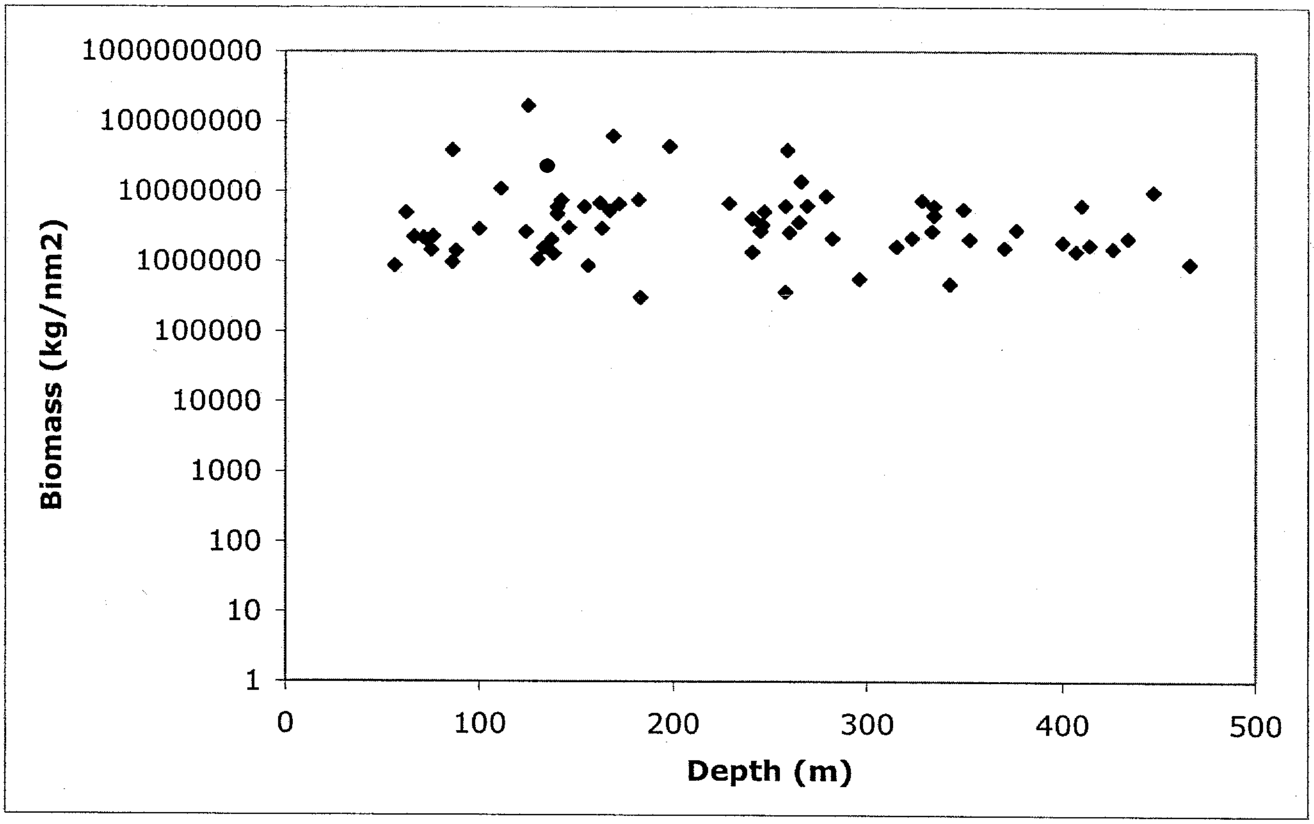


Figure 6.1. Biomass of invertebrates collected at each station by the bottom trawl, arranged by depth.

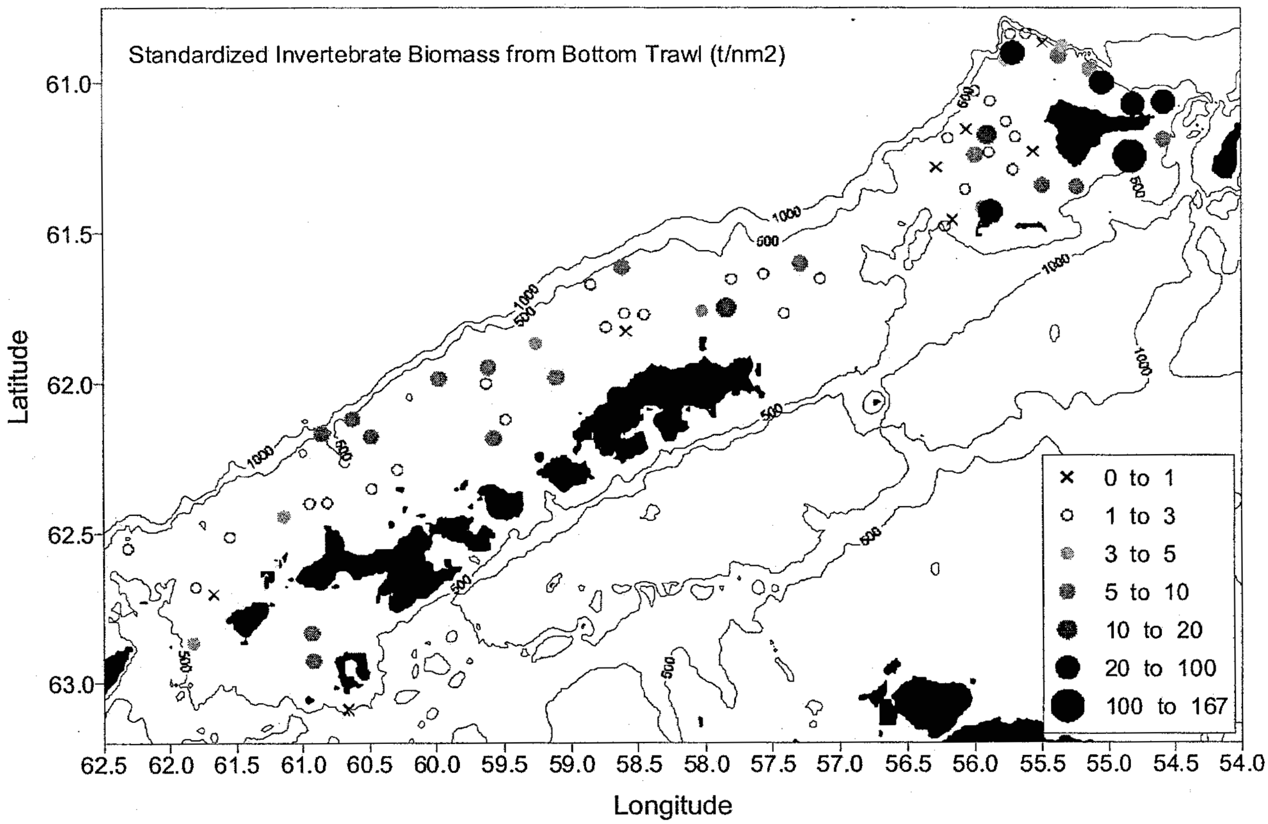


Figure 6.2. Standardized biomass of invertebrates (t/nm^2) collected at each station by the bottom trawl. (Latitude is south and longitude is west).

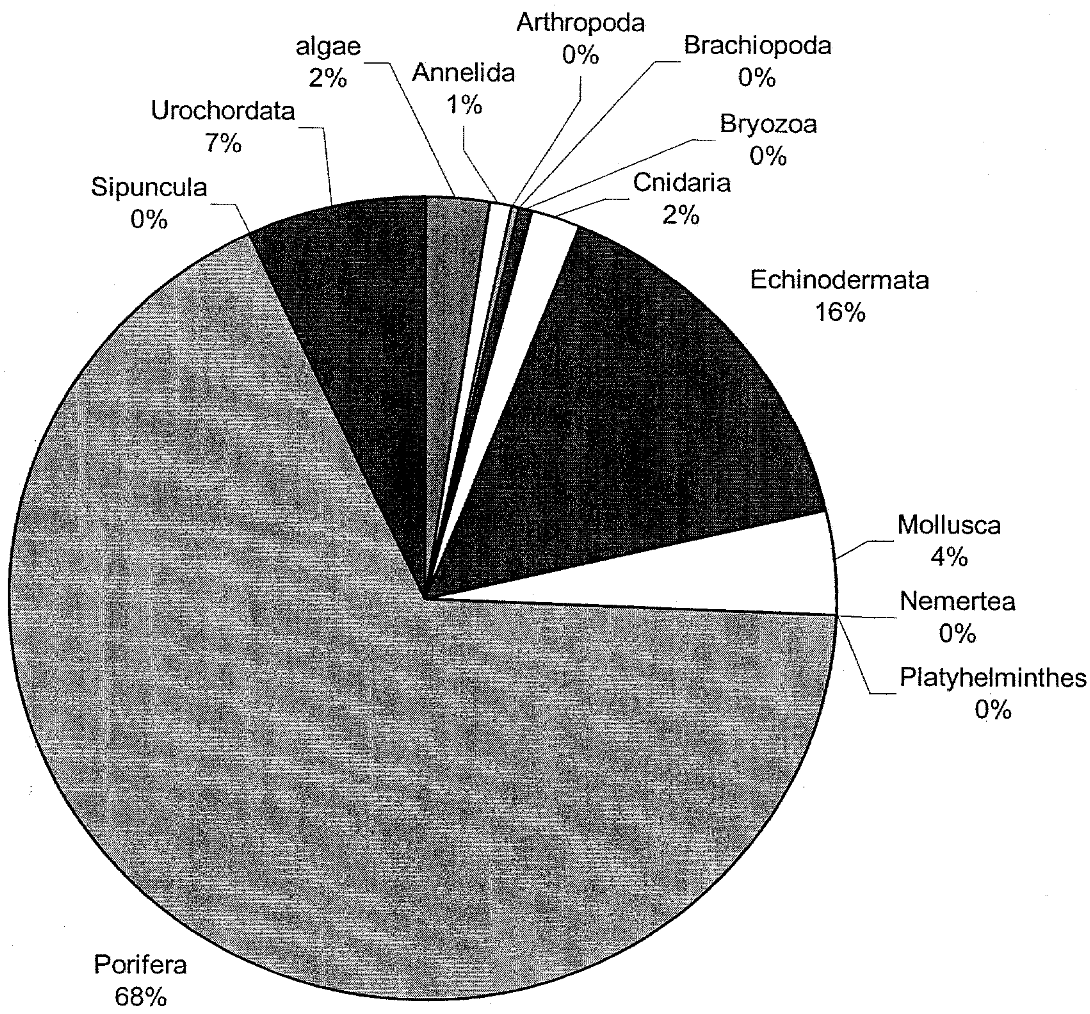


Figure 6.3. Percent catch contributed by each phylum to the overall catch in the bottom trawl net.

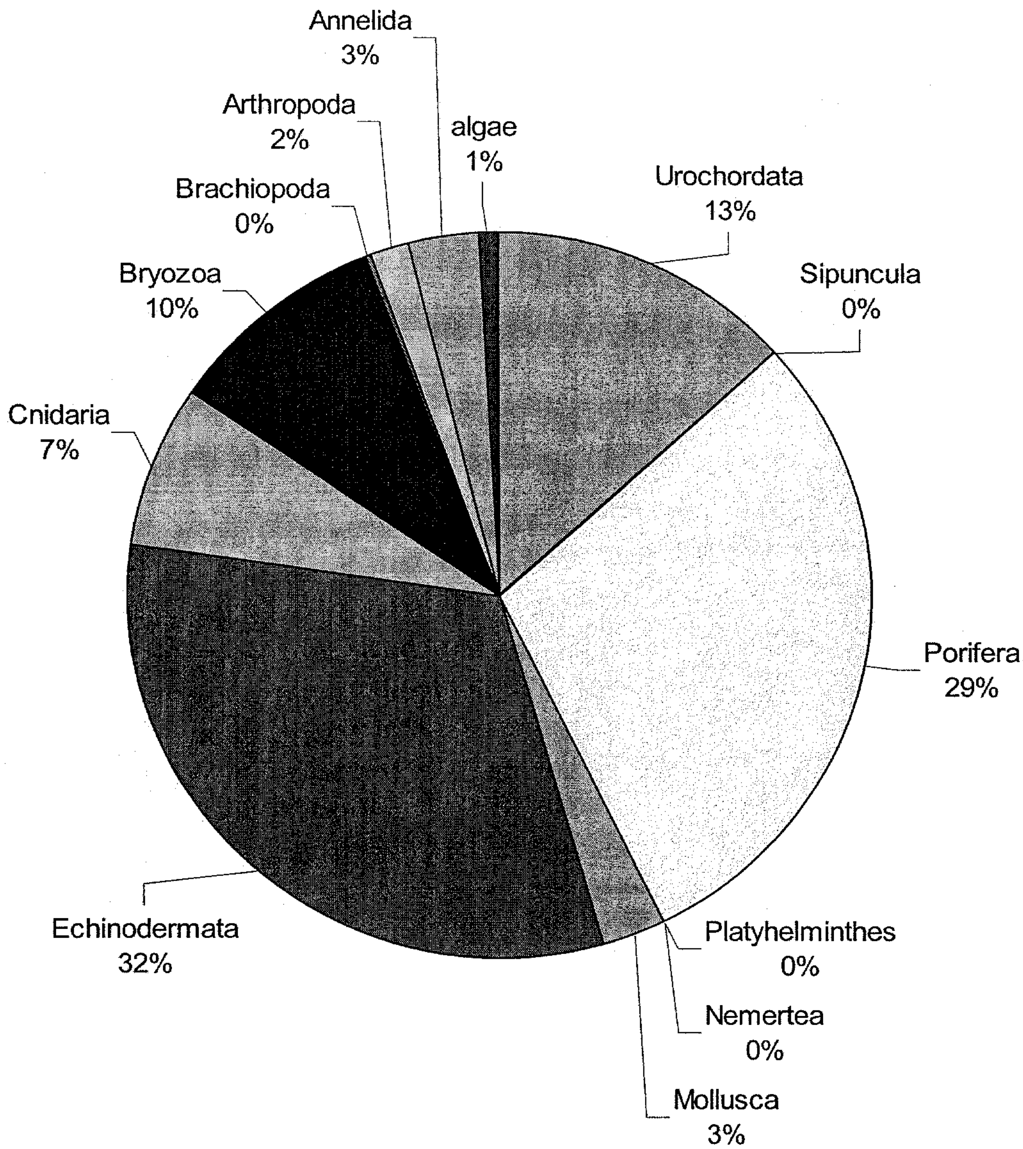


Figure 6.4. Percent catch contributed by each phylum to the overall catch in the Little BIT.

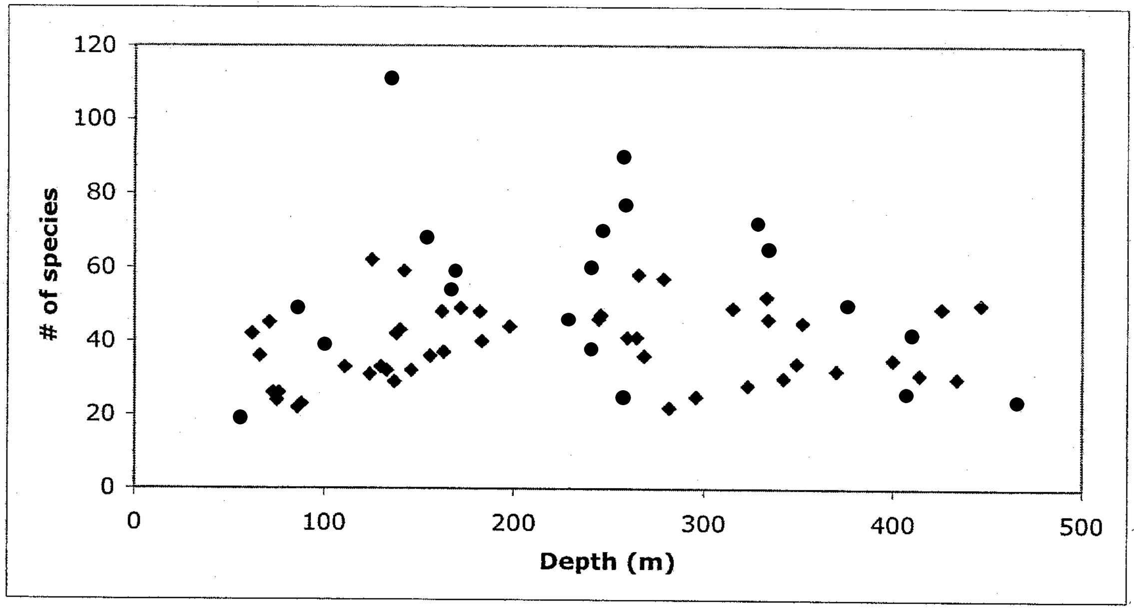


Figure 6.5. Species richness of invertebrates collected by the bottom trawl at each station, arranged by depth.

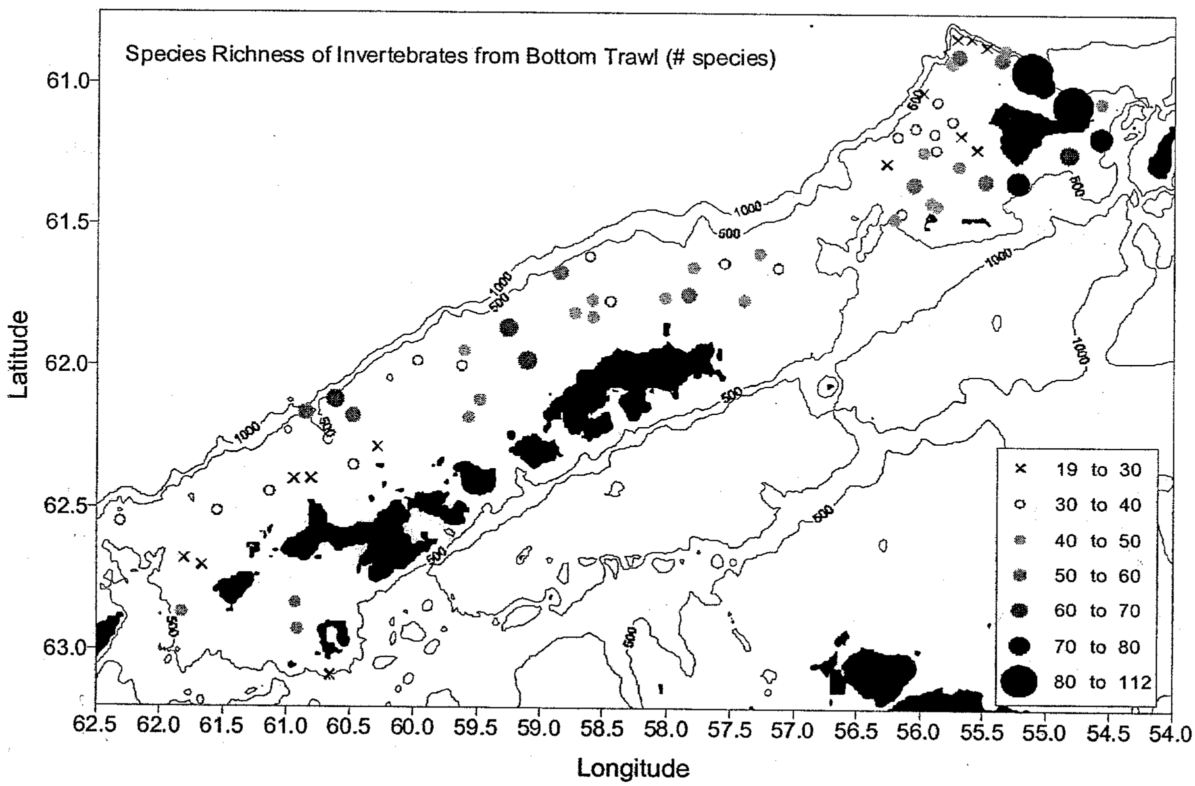
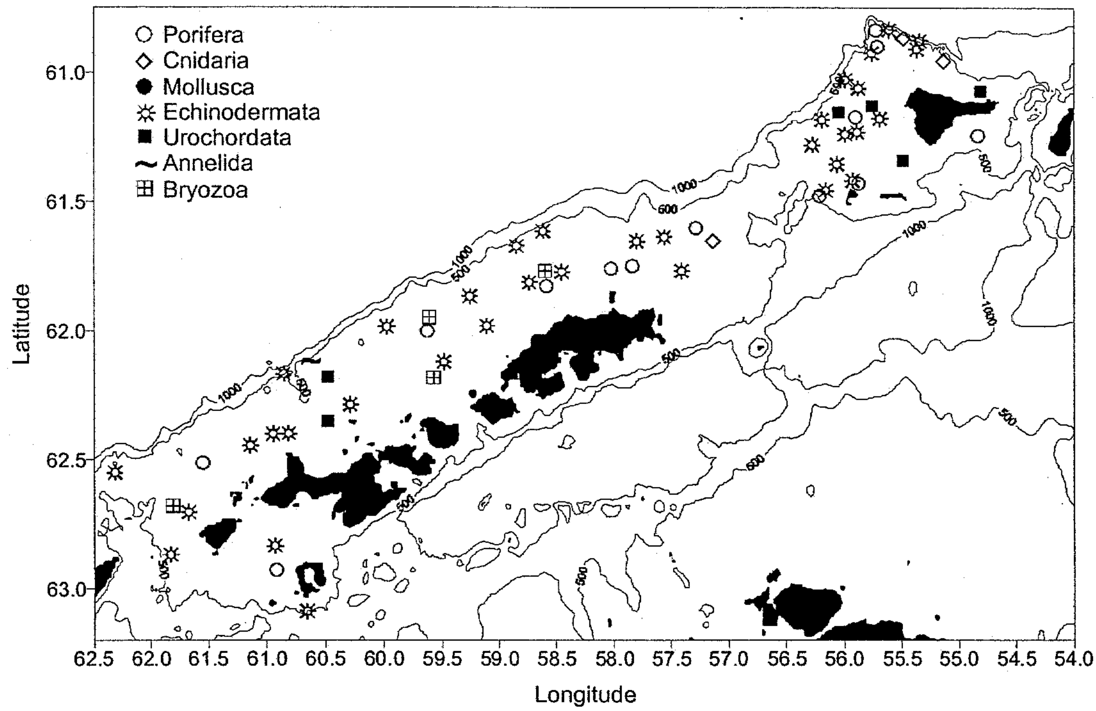


Figure 6.6. Species richness of invertebrates collected by the bottom trawl at each station, displayed geographically. The circles are scaled to number of species, and range from 19 to 111. (Latitude is south and longitude is west).

A)



B)

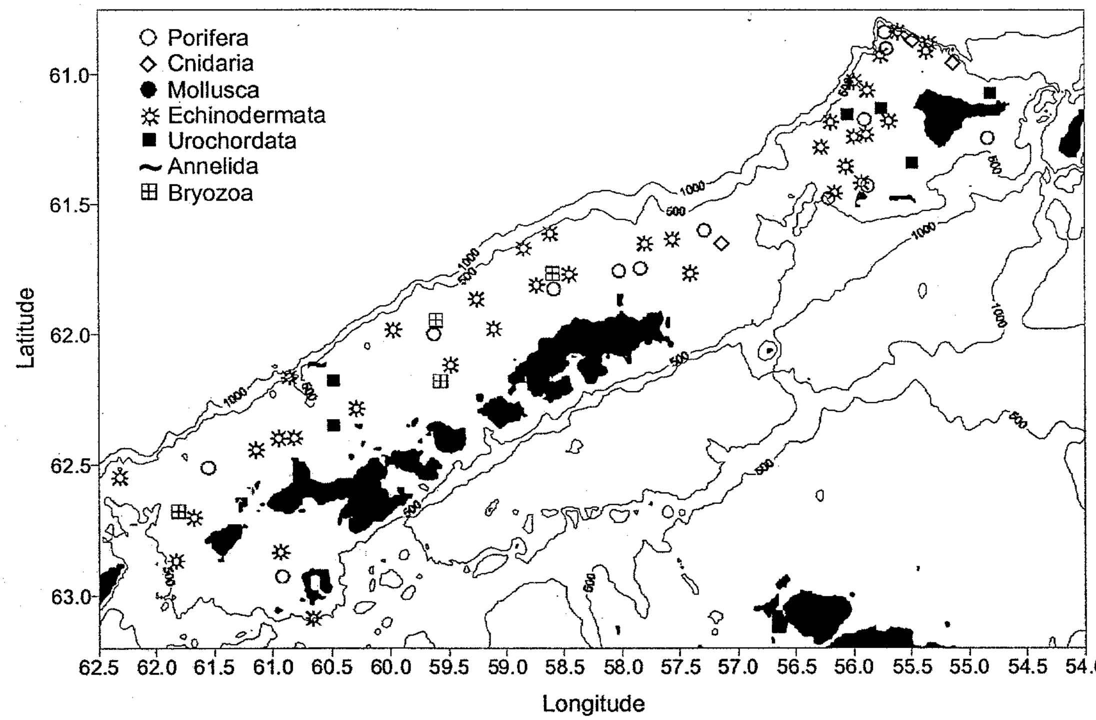


Figure 6.7. Distribution of biomass dominant invertebrate phyla caught by the A) fish bottom trawl and B) Little BIT. (Latitude is south and longitude is west).

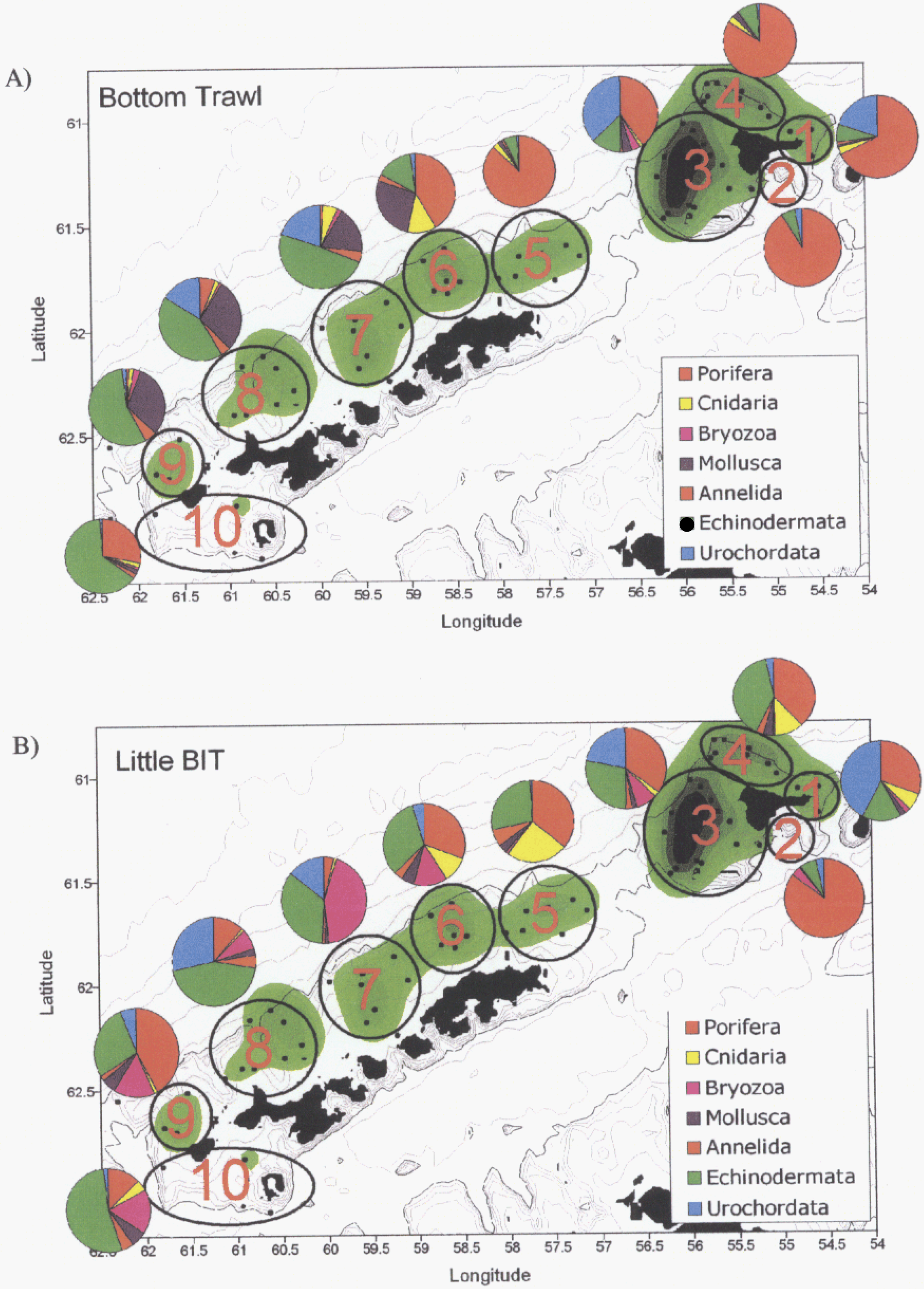


Figure 6.8. Percentage biomass of benthic invertebrates collected by A) the bottom trawl and B) the Little BIT along the South Shetland and Elephant Islands. The survey area is divided into 10 regions based on smoothed, normalized dietary component data of benthic browsing fish species. The most western station, #97, was included in region 10. (Latitude is south and longitude is west).

7. Acoustic seabed characterization and benthic habitat imagery; submitted by Daniel F. Doolittle (Legs II & III), Rich Mooi (Leg III) and Christopher D. Jones (Leg III).

7.1 Objectives: The objectives of the seabed classification program during Leg III are: 1) to acoustically map the surficial sediment types surrounding the South Shetland Islands using Questar Tangent Corporation (QTC) IMPACT seabed classification software, 2) to evaluate video and digital still photography methods for groundtruthing the acoustic sediment classifications, 3) to collect sediment grab samples for additional groundtruthing, and 4) to utilize photographic and video data to describe the epibenthic invertebrate communities.

7.2 Methods and Accomplishments:

7.2.1 Acoustic Data Collection: Acoustic data were collected at three frequencies (38kHz, 120kHz, 200kHz) with a SIMRAD EK500 scientific echo sounder. Acoustic telegrams were simultaneously transmitted, via Ethernet connection, to a Windows XP Professional workstation running Questar Tangent Corporation's (QTC) IMPACT acoustic bottom typing software.

7.2.2 Digital Photography Acquisition: Digital still imagery was obtained utilizing a custom built drop camera system developed by V. Kazachenok aboard the R/V *Yuzhmorgeologiya* (Figure 7.1). The drop camera system is composed of a 3.1 megapixel Sony digital camera and a variable power flash module. Images collected from this system have a resolution of 2100 by 1700 pixels. An electronic control module was constructed aboard the ship for flash and shutter control. This module was not fully operational, so a manual shutter trigger was used during camera deployment on Leg III. The manual trigger consists of a variable length (equal to focal length setting on digital camera) small diameter chain with a machined 14cm diameter, 6kg weight. This weight was painted with contrasting colors at 10cm and 1cm intervals to aid in scaling objects visible in each image.

The 1 m^3 camera frame was equipped with a 200kHz sonar altimeter that allowed good control of the camera altitude above the seafloor. This signal was monitored in real time by the traction winch operator.

7.2.3 Video Acquisition: Video imagery was obtained in conjunction with each still camera deployment. A self-contained video package (Figure 7.1) was flown on 5 and 7m bridles behind the still camera frame assembly. Bridles were made of ¼ inch Spectra line. The video system is composed of a Sony Handycam digital recorder, dual, lithium-ion 12 vdc battery packs and a power control circuit and relay integrated with a mechanical pressure switch. This switch allowed the system to turn on/off when the camera passed through ~ 20m water depth. These components are housed in a 6,000m rated, titanium pressure housing. External to the pressure housing, a Deep Sea Power and Light (DSPL) Multi SeaCam underwater camera and DSPL SeaLight (interchangeable 50 and 100 watt bulbs) and two DSPL SeaLasers, spaced 10cm apart, are integrated within a High Density Poly Ethylene (HDPE) and aluminum mounting frame. This frame is designed to be flown in multiple configurations and attitudes. For this experiment, the frame was flown in a horizontal attitude with camera and lasers and light pointed towards the seafloor. A single 11" trawl float was attached to the dorsal side of the camera frame to provide neutral buoyancy and stability. Two 7.5 inch aluminum trawl floats were attached to the titanium pressure housing. These floats provided enough lift for the canister to remain slightly negatively buoyant.

Camera transects were approximately 1 nautical mile in length and averaged 85 still images and 50 – 75 minutes of digital video tape per transect. Transects were co-located with trawl stations in order to allow comparisons between imagery and trawl catches.

7.2.4 Sediment Sample Collection: Acoustic and visual data were groundtruthed with multiple (n = 9) sediment grabs. Sediment grabs were located along transects whenever possible. The locations of each camera/video transect and grabs are presented in Figure 7.2. Sediment samples were sieved through 3 (5, 10, and 230 micron) brass screens and a percentage composition (boulder, cobble, pebble, gravel, sand, mud/silt/ooze) was computed for each sediment type.

7.2.5 Invertebrate Community Characterization: Photographic data were examined by onboard benthic invertebrate (Rich Mooi) and vertebrate (Stuart Hanchett) taxonomic experts. Each image was examined and species observed were documented. Attempts were made to also document obvious sediment types.

7.3 Results and Tentative Conclusions: Acoustic seabed class data were collected in waters less then 500m depth. Due to an incompatibility issue between the onboard computing operating systems and the QTC Impact software, these data will be post processed at the La Jolla laboratory and are not yet available for publication.

Over the 20 transects completed, 1,705 images were taken of the seafloor and examined by invertebrate taxonomists who are expert with Antarctic and South Shetland Island fauna. Table 7.1 lists conspicuous invertebrate fauna found in each image and the relative occurrence for the 20 transects completed over the AMLR survey area. Table 7.2 reports the relative abundance from photos. Taxa are listed only if a high level of confidence exists for a correct identification. Figure 7.3 depicts a representative sample of imagery collected. Table 7.3 reports the grab sediment data.

7.4 Disposition of Data: Raw and processed acoustic data are deposited with Jennifer Emery at the Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037; (858) 546-5609. Video, still photographic, and sediment grab data are deposited with Christopher D. Jones at the Southwest Fisheries Science Center.

7.5 Problems and Suggestions: Processing of the acoustic data with the QTC software package was hindered by an unreported incompatibility between the Impact software and Window XP Professional operating systems. A patch for this conflict was created by the company and transmitted to the ship. This software conflict prevented timely processing of the acoustic waveform data and thus required significant post-processing of the acoustic data after the field season.

Reliability of the camera was good with only a few evident problems that need to be resolved before the next field season. Significant effort was expended to evaluate the appropriate flash power and camera settings. A matrix of various camera settings which provide the best imagery should be created. As the camera is a commercial off-the-shelf product, continued increases of camera resolution should be integrated into this system as camera hardware becomes available.

The manual trigger for the camera shutter created significant turbidity when it contacted the sea floor. This created visibility reductions for the towed video system. A remote shutter trigger should be developed in order to allow a control signal to be sent from the surface. This would allow the camera and video system to remain at a stable altitude off the sea floor, thus further enhancing video and photographic image quality.

The video system performed well. There were several transects where the video signal was not recorded on the digital tape. This could be due to the stereo plug not having a completely secure mounting and being pulled from its socket during chassis insertion. After this plug was secured with tape, partway through the cruise, no further problems were encountered.

7.6 Acknowledgements: Waldo Wakefield of the Northwest Fisheries Science Center and Scott McEntire of the Alaska Fisheries Science Center are gratefully acknowledged for the loan and technical support of the remote video camera system. Stuart Hanchett, Stacy Kim, and Andrew Thurber spent numerous hours viewing imagery and assisting with species identification. Valeriy Kazachenok provided masterful technical assistance with still camera development, video system troubleshooting, and a steady hand on the winch controls during the deployment of the camera system. Oleg Pivovarchuk and the crew of the R/V *Yuzhmorgeologiya* is to be commended for their professionalism and level of service to the various onboard scientific missions.

Table 7.1. Relative abundance of identified taxa. Abundance is reported as the percentage of individual images which contain an identifiable species.

Taxon	Percentage Relative Abundance
ophiuroid long-armed, disk buried (Ophiuroidea, Echinodermata)	17.3
bryozoan (Bryozoa)	15.2
Astrotoma (Ophiuroidea, Echinodermata)	10.5
schizasterid, mostly *Amphipneustes* (Spatangoida, Echinoidea, Echinodermata)	9.4
pycnogonid (Pycnogonida, Arthropoda)	8.4
comatulid (Crinoidea, Echinodermata)	7.6
tunicate (Ascidiacea, Urochordata)	7.4
pycnogonid (Pycnogonida, Arthropoda)	6.7
mysid (Mysidacea, Crustacea, Arthropoda)	6.3
Ophionotus victoriae (Ophiuroidea, Echinodermata)	5.5
elasipodid holothuroid, possibly *Laetmogone* (Holothuroidea, Echinodermata)	5.4
tunicate (Ascidiacea, Urochordata)	3.8
asteroid (Asteroidea, Echinodermata)	3.6
gorgonian (Octocorallia, Coelenterata)	3.1
Notocidaris new species (Cidaridae, Echinoidea)	2.6
Labidiaster radiosus (Asteroidea, Echinodermata)	2.5
anemone (Anthozoa, Coelenterata)	2.5
Flabellum (Scleractinia, Anthozoa, Coelenterata)	2.3
Serolis (Isopoda, Crustacea, Arthropoda)	2.2
Rhynchocidaris triplopora (Cidaridae, Echinoidea)	2.0
Anthomastus bathyproductus (Anthozoa, Coelenterata)	1.9
hydroid (Hydrozoa, Coelenterata)	1.6
Laetmonices (Polychaeta, Annelida)	1.5
Caryophyllia squiresi (Scleractinia, Anthozoa, Coelenterata)	1.5
Harpovoluta charcoti + *Isosycionis alba* (commensal snail with anemone)	1.4
holothuroid (Holothuroidea, Echinodermata)	1.1
Brachysternaster chesheri (Schizasteridae, Echinoidea)	1.0
Notocidaris gaussensis (Cidaridae, Echinoidea)	0.8
gastropod (Gastropoda, Mollusca)	0.6
Odontaster (Asteroidea, Echinodermata)	0.6
octopus (Cephalopoda, Mollusca)	0.6
Sterechinus (Echinidae, Echinoidea)	0.5
opisthobranch (Gastropoda, Mollusca)	0.3
psolid (Holothuroidea, Echinodermata)	0.3

Ctenocidaris geliberti or *gigantea* (Cidaridae, Echinoidea)	0.2
Bathyplotes (Holothuroidea, Echinodermata)	0.2
Odinella (Asteroidea, Echinodermata)	0.2
ophiuroid (Ophiuroidea,, Echinodermata)	0.2
brachiopod (Articulata, Brachiopoda)	0.1
nudibranch (Gastropoda, Mollusca)	0.1
Astrotoma (Ophiuroidea, Echinodermata)	0.1
Ctenocidaris geliberti or *gigantea* (Cidaridae, Echinoidea)	0.1
Hippasterias (Asteroidea, Echinodermata)	0.1
Laetmonices (Polychaeta, Annelida)	0.1
Leptychaster (Asteroidea, Echinodermata)	0.1
Natatolana (Isopoda, Crustacea, Arthropoda)	0.1
schizasterid, mostly *Amphipneustes* (Spatangoida, Echinoidea, Echinodermata)	0.1
scleractinian coral, branched (Anthozoa, Coelenterata)	0.1

Table 7.2. Percentage of relative occurrence, reported as the percentage of times each taxa appeared in the photo transects.

Taxon	**Percentage Relative Occurrence**
asteroid (Asteroidea, Echinodermata)	90
Astrotoma (Ophiuroidea, Echinodermata)	75
pycnogonid (Pycnogonida, Arthropoda)	75
pycnogonid (Pycnogonida, Arthropoda)	75
bryozoan (Bryozoa)	70
schizasterid, mostly *Amphipneustes* (Spatangoida, Echinoidea, Echinodermata)	70
elasipodid holothuroid, possibly *Laetmogone* (Holothuroidea, Echinodermata)	65
comatulid (Crinoidea, Echinodermata)	60
Labidiaster radiosus (Asteroidea, Echinodermata)	60
Flabellum (Scleractinia, Anthozoa, Coelenterata)	55
Laetmonices (Polychaeta, Annelida)	55
gorgonian (Octocorallia, Coelenterata)	50
anemone (Anthozoa, Coelenterata)	50
mysid (Mysidacea, Crustacea, Arthropoda)	45
tunicate (Ascidiacea, Urochordata)	45
tunicate (Ascidiacea, Urochordata)	40
Rhynchocidaris triplopora (Cidaridae, Echinoidea)	35
Harpovoluta charcoti + *Isosycionis alba* (commensal snail with anemone)	35
octopus (Cephalopoda, Mollusca)	35
ophiuroid long-armed, disk buried (Ophiuroidea, Echinodermata)	30
holothuroid (Holothuroidea, Echinodermata)	30
Notocidaris gaussensis (Cidaridae, Echinoidea)	30
Anthomastus bathyproductus (Anthozoa, Coelenterata)	25
Caryophyllia squiresi (Scleractinia, Anthozoa, Coelenterata)	25
Brachysternaster chesheri (Schizasteridae, Echinoidea)	25
Ophionotus victoriae (Ophiuroidea, Echinodermata)	20
Notocidaris new species (Cidaridae, Echinoidea)	20
Ctenocidaris geliberti or *gigantea* (Cidaridae, Echinoidea)	20
Serolis (Isopoda, Crustacea, Arthropoda)	15
hydroid (Hydrozoa, Coelenterata)	15
gastropod (Gastropoda, Mollusca)	15
Odontaster (Asteroidea, Echinodermata)	15

Sterechinus (Echinidae, Echinoidea)	15
opisthobranch (Gastropoda, Mollusca)	15
Bathyplotes (Holothuroidea, Echinodermata)	15
brachiopod (Articulata, Brachiopoda)	10
nudibranch (Gastropoda, Mollusca)	10
psolid (Holothuroidea, Echinodermata)	5
Odinella (Asteroidea, Echinodermata)	5
ophiuroid (Ophiuroidea, , Echinodermata)	5
Astrotoma (Ophiuroidea, Echinodermata)	5
Ctenocidaris geliberti or *gigantea* (Cidaridae, Echinoidea)	5
Hippasterias (Asteroidea, Echinodermata)	5
Laetmonices (Polychaeta, Annelida)	5
Leptychaster (Asteroidea, Echinodermata)	5
Natatolana (Isopoda, Crustacea, Arthropoda)	5
schizasterid, mostly *Amphipneustes* (Spatangoida, Echinoidea, Echinodermata)	5
scleractinian coral, branched (Anthozoa, Coelenterata)	5

Table 7.3. Sediment grab results. Values indicate relative proportion of each geologic component.

Station	Grab#	Depth	Latitude (°S)	Longitude (°W)	Mud/Silt/Ooze <0.06mm	Sand 0.06-2mm	Gravel 2-4mm	Pebble 4-64mm	Cobble 64-250mm	Boulder > 25cm
10	1	175	61°09.028	56°04.743	0.5	0.5	0.0	0.0	0.0	0.0
91	2	110	61°26.634	55°51.66	0.0	0.5	0.1	0.4	0.0	0.0
45(1)	3	343	61°39.12	57°47.015	0.2	0.7	0.0	0.1	0.0	0.0
45(2)	4	329	61°39.092	57°45.876	0.1	0.3	0.1	0.5	0.0	0.0
83	5	265	61°51.539	59°14.369	0.5	0.4	0.1	0.0	0.0	0.0
53	6	180	62°00.634	59°37.379	0.7	0.3	0.0	0.0	0.0	0.0
61	7	120	62°19.806	60°29.167	0.5	0.5	0.0	0.0	0.0	0.0
97	8	400	62°32.747	62°17.641	0.9	0.1	0.0	0.0	0.0	0.0
78	9	150	62°52.152	61°48.355	0.4	0.5	0.0	0.1	0.0	0.0

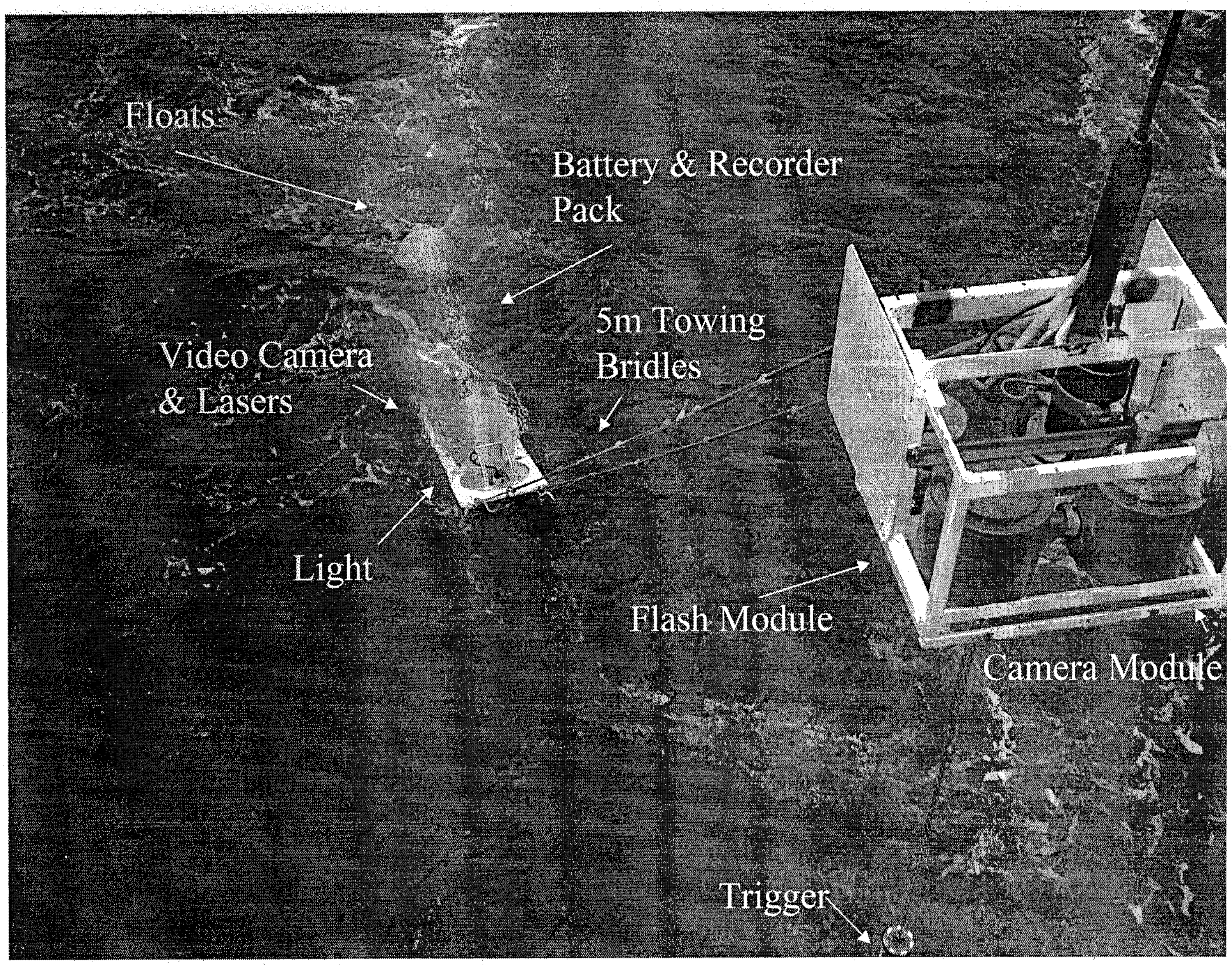


Figure 7.1. Digital still camera and towed video system.

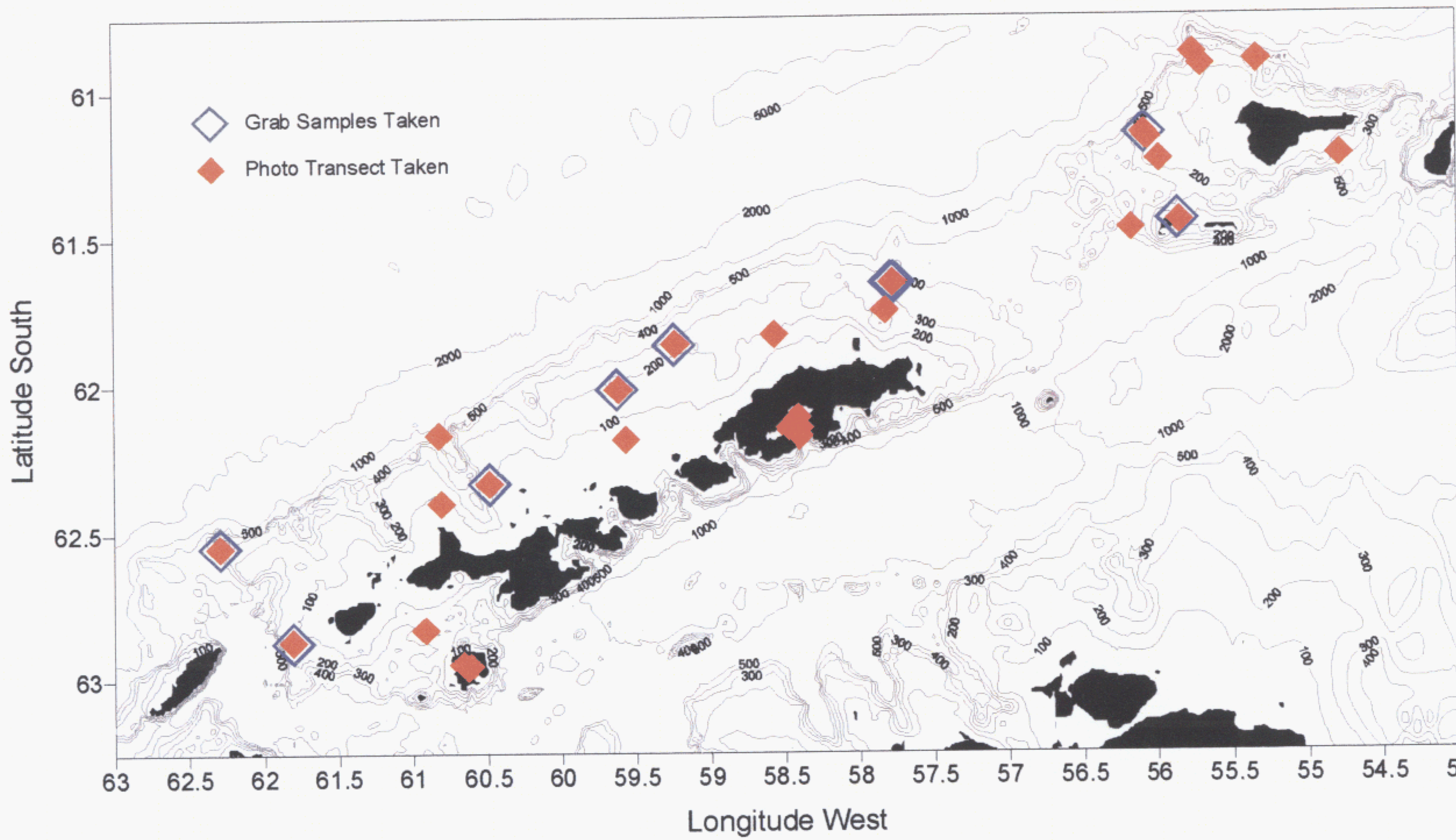


Figure 7.2, Sediment grab data and locations taken during AMLR 03 survey Leg III

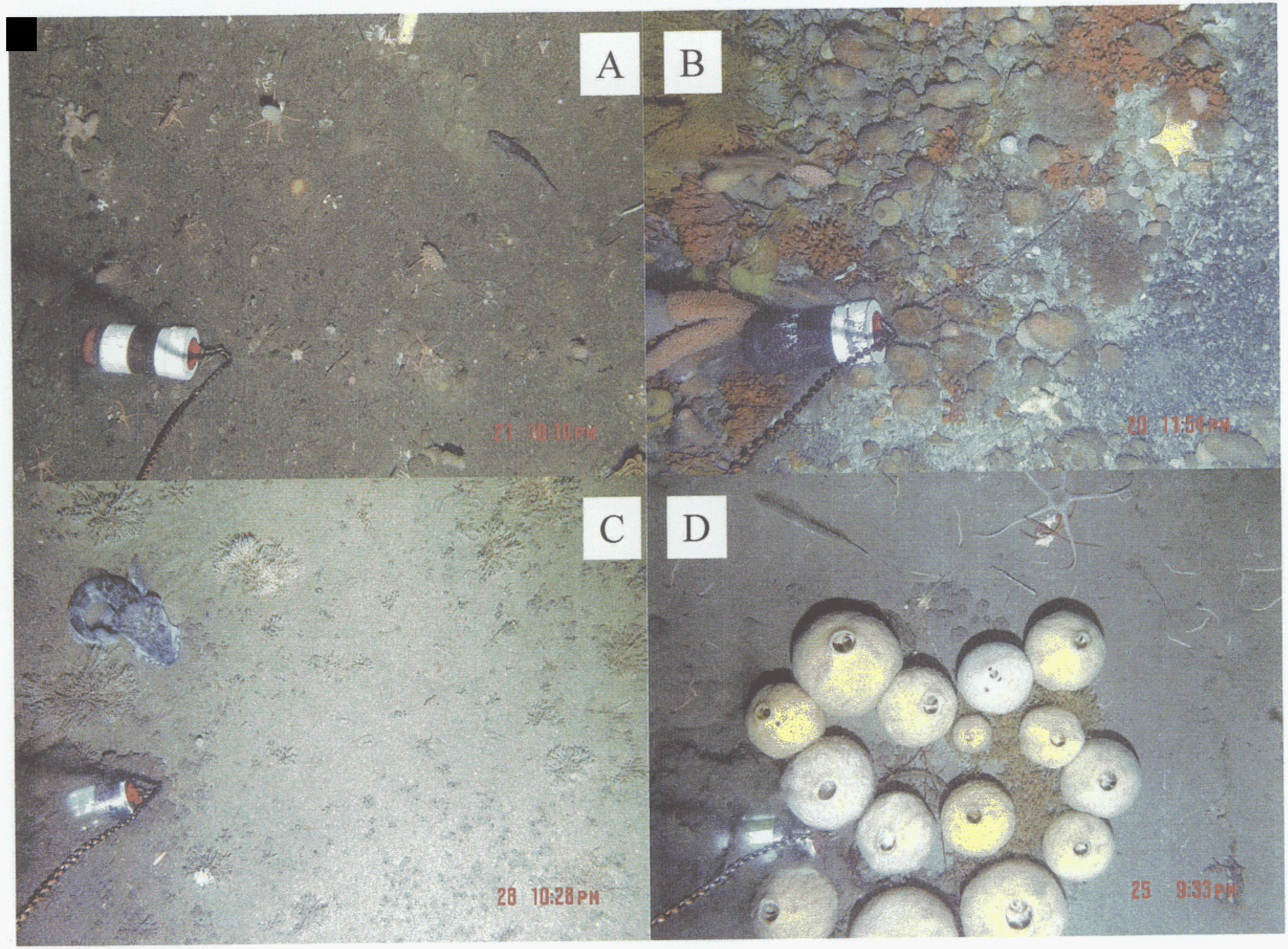


Figure 7.3. Representative sample of digital still photographs taken during Leg III of AMLR 02/03 field season. Sandy sediments can be seen in A, gravel bottom is visible in B, images C and D show soft, silty sediments. Such images, which provide general sediment information, can be further used to calibrate the acoustic bottom typing software.

8. Seabird Research at Cape Shirreff, Livingston Island, Antarctica, 2002-2003; submitted by Laina F. Shill, Michlelle Antolos and Wayne Z. Trivelpiece.

8.1 Objectives: The U.S. Antarctic Marine Living Resources (AMLR) program conducted its seventh consecutive field season of land-based predator research at the Cape Shirreff field camp on Livingston Island, Antarctica (62° 28'S, 60° 46'W), during the austral summer of 2002/2003. Predator populations there were monitored as part of a U.S. contribution to the international research conducted in the Southern Ocean under CCAMLR (Convention for the Conservation of Antarctic Marine Living Resources). Four scientists were transported to Cape Shirreff aboard the National Science Foundation vessel R/V *Lawrence M Gould,* arriving on 7 November 2002. Research commenced immediately and continued through camp closure on 27 February 2003. The AMLR chartered vessel R/V *Yuzhmorgeologiya* provided logistical and scientific support during January and February and transported field personnel back to Punta Arenas, Chile at the field season's conclusion.

The objectives of the seabird research for the 2002/03 season were to collect the following long-term monitoring data:

1. To estimate chinstrap and gentoo penguin breeding population size (Std Method A3);
2. To assess adult annual survival and 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).

8.2 Results and Conclusions:

8.2.1 Breeding Biology Studies: The Cape Shirreff penguin colony consisted of 26 breeding groups (sub-colonies) of gentoo and chinstrap penguins. Chinstrap and gentoo penguin breeding populations were censused on 28 and 30 November 2002, approximately one week following their respective peak of clutch initiation dates, according to CCAMLR Standard Method A3. All sub-colonies were counted in their entirety. The gentoo penguin census found 778 breeding pairs, a 16.6 % decline from last year and 12.3 % below the five-year mean breeding population size (Figure 8.1). The chinstrap penguin census found 5,868 breeding pairs, the third consecutive year of declining numbers at this colony (Figure 8.2). Both populations were at their lowest level since we began studies at this site in 1997/98.

Chick censuses for both gentoo and chinstrap penguins were conducted on 5 and 6 February 2003. At that time, chicks were in crèches and were approximately 5 weeks old. The gentoo penguin chick count was 696 birds, also well below their average of 1027, and a 30% drop from last year (Figure 8.1). Gentoo penguins fledged 0.96 chicks per nest, also well below their mean reproductive success rate of 1.25 chicks fledged per pair for the 1997/98 to 2001/02 years. Chinstrap penguins fledged a total of 4,420 chicks, a 41% decrease in the total number of chicks surviving to fledging compared to last season and a 55% decline in mean numbers of chicks fledged per year over the last 6-years at Cape Shirreff. Chinstrap penguins fledged 0.76 chicks per pair based on our census data comparing total chicks fledged divided by total nesting pairs in all sub-colonies (Std Methods 6a,c; Figure 8.2). Penguin chick numbers, in both species, were depressed by both a decline in the breeding population size and by low reproductive success among breeding pairs in the 2002/03 year.

Reproductive success was also determined by following a sample of 100 breeding pairs of chinstrap penguins and 50 gentoo pairs from clutch initiation through crèche formation (Std. Methods 6b). This methodology allowed us to examine the breeding biology and reproductive success of chinstrap and gentoo penguins in greater detail. Chinstrap penguins hatched 0.82 and fledged 0.61 chicks/pair, while 74% of all hatched chicks survive to fledging. Chinstrap penguin reproductive success was significantly below the five-year mean of .98 chicks fledged per pair. Gentoo penguins had higher reproductive success hatching 0.84 and fledging 0.68 chicks/pair, while 69% of all hatched chicks survived to fledging. Although gentoo penguins fledged more chicks per pair than the chinstrap penguins in 2002/03, their reproductive success was only 56% of the mean reproductive success for this species over the last five seasons (0.68 and 1.21 chicks fledged per pair in 2002/03 versus 1997/98-2001/02, respectively).

We collected chinstrap penguin chick fledging weights between 20 and 26 February 2003 according to Standard Method 7c. The mean fledging weight of 206 chicks captured on the rookery beaches, as they were about to depart to sea was 3,010 grams (s.d. = 429 g). This was approximately 5% below the six-year mean of 3,184 grams, and 240 grams below last year's chinstrap penguin chick mean fledging weight. Gentoo penguin chicks do not fledge in the classic sense, as they are a non-migratory species. However, a random sample of chicks were weighed on 17 February 2003, 85 days following the mean clutch initiation date for gentoo penguins, as derived from the 2002/03 reproductive data. This method provides an annual index of chick mass derived from a time during their growth when their average age is seven weeks, approximately the fledging age of the other *Pygoscelis* penguin species. The 200 gentoo penguin chicks captured and weighed on 17 February had a mean mass of 3,972 grams (s.d. = 587 g), about 7% below the 4,278 mean weights of chicks from the 1997/98 to 2001/02 years.

8.2.2 Foraging Ecology Studies: We conducted diet studies of chinstrap and gentoo penguins during the chick-rearing phase of each species annual cycle. Samples were collected between 8 January and 8 February 2003, mostly concurrent with the AMLR shipboard krill acoustic and net sampling studies. We captured 40 chinstrap and 20 gentoo penguin adults returning from foraging trips to feed their chicks and collected their complete stomach contents using the water-offloading technique. Antarctic krill (*Euphausia superba*) predominated most of the samples and was present in all of them. The mean overall stomach food load sizes were 654g and 631g for chinstrap and gentoo penguins, respectively; equal to or above the previous maximum food loads for these species over the past 5 years. Krill demography was examined by measuring and sexing a total of 50 individual krill from each bird's stomach sample. The krill found in the penguin's diets were 28.3% juveniles, 30.3% females, and 41.5% males, with mean standard lengths of 32mm, 43mm, and 41mm, respectively (Figure 8.3). The juvenile krill component in the 2002/03 penguin diets samples was significantly higher than the 10.7% recorded in the diets in 2001/02. This, in turn, had followed two consecutive seasons (1999/00 & 2000/01), largely devoid of juvenile krill in the diet samples. We found evidence of fish in 61% of chinstrap penguin diet samples. This was well above the mean frequency of occurrence of fish (23%) in the chinstrap penguin diet for the 1997/98 – 2001/02 seasons. However, in spite of the high frequency of occurrence of fish in the 2002/03 chinstrap penguin samples, the contribution of fish matter to total food load mass was negligible. Eighty-one percent of gentoo penguins had evidence of fish present in their diet samples, and the fish component comprised a mean 32% of the food load mass. The fish component in the gentoo penguin diets in 2002/03 was consistent, in both frequency of occurrence and mass, with previous year's results.

We attached 18 radio transmitters to adult chinstrap penguins feeding one week old chicks on 6 and 7 January 2003 and logged their foraging trip durations through mid-February using a remote receiver and DCC (Data Collection Computer) logger at our observation blind. We calculated the departure and arrival times of foraging birds. Unlike the past three seasons, foraging trip durations exhibited a unimodal distribution. Although the peak foraging trip duration fell between 10 and 12 hours, the mean was 12.8 hours. Average foraging trips were approximately 4 hours longer in 2002/03 than in the three previous breeding seasons.

We deployed five time-depth recorders (TDRs) on chinstrap penguins and four on gentoo penguins in early January to collect penguin diving data concurrently with our other foraging parameters. We retrieved the instruments after about 10 days, downloaded the data, and redeployed all but one dysfunctional instrument on another set of birds in late January. Analysis of the dive records will be processed and analyzed over the coming months. We also used PTTs (satellite-linked transmitters) in our foraging studies to provide us with specific time-location data for a sample of chinstrap and gentoo penguins provisioning chicks in January. We affixed four PTTs each to chinstrap and gentoo penguins during early January. One gentoo penguin failed to return, however, the remaining birds all provided some of the first information on the foraging areas used by each species in the marine region around Cape Shirreff. Gentoo penguins generally foraged close to the colony, while chinstrap penguins foraged offshore in the vicinity of the shelf-break and beyond.

We monitored the activity of all skuas on Cape Shirreff, as well as an additional accessible breeding pair on Punta Oeste. Although both Brown (*Catharacta lonnbergi* and South Polar (*C. maccormicki*) skuas breed in the South Shetland Islands, only brown skuas attempted to breed at Cape Shirreff. Nineteen brown skua pairs made breeding attempts this year. Twenty-five percent of these pairs suffered early season egg loss due to snowstorms and made second breeding attempts. The brown skuas fledged a mean 0.53 chicks per pair, well below our six-year mean of 0.88. A brown skua pair established one new breeding territory on Playa Media Luna, this pair successfully fledged one chick. One female brown skua was found dead on its breeding territory. This skua had bred on this territory with the same male for the last four years.

The 2002/03-year was the 7th season of data collection at Cape Shirreff allowing us to compare annual indices of predator parameters at this site across all years. Breeding population size and reproductive success of chinstrap and gentoo penguins alike fell below levels previously observed at this site. Fledging weights of chicks of both chinstrap and gentoo penguins were also low. However, chinstrap penguin adult mass at egg laying and egg measurements of both chinstrap and gentoo penguins did not differ from previous years, implying that the condition of returning breeders was normal. Elevated foraging trip durations and a high frequency of occurrence of fish may suggest that krill were not very abundant in 2002/03 compared to prior seasons, at least not within the foraging ranges of the penguins during chick rearing. The apparent inconsistency represented by above average stomach sample masses in both penguin species may be related to an age-specific effect. During years with poor reproductive success, younger, less experienced birds are more prone to failure than older, experienced birds. This removes less experienced birds from the population and increases the proportion of older experienced penguins in the diet samples collected. Further analysis of TDR and PTT data will provide additional insights into the linkages among penguin diets, food load sizes, foraging ranges and behaviors. Future research plans include the use of PTTs and TDRs in the study of penguin over wintering strategies and metapopulation dynamics.

8.3 Acknowledgments: We are indebted to Mike Goebel for a smoothly run camp and his good humor, to John Lyons for his innovative and copious assistance with the seabird fieldwork, to Doug Krause for his amazing provisions and to Rennie Holt for providing us with the best painted field camp in Antarctica. We would also like to thank the Chilean research team; Olivia Blank, Layla Osman, Romeo Vargas and Claudio Vera for their scientific assistance and personal camaraderie during the season. We are grateful to the crew of the NSF research vessel *Laurence M. Gould* for our transit to Cape Shirreff and assistance with the opening of the camp in November. We also wish to thank the scientific party and crew of the AMLR chartered research vessel *Yuzhmorgeologiya* for their resupply visits and for our safe return to Chile in March. Finally, we thank Stephanie Sexton, for keeping us in touch with the world at large during our 4 months in the field. This research is funded by the US Antarctic Ecosystem Research Division, SWFSC, La Jolla, CA.

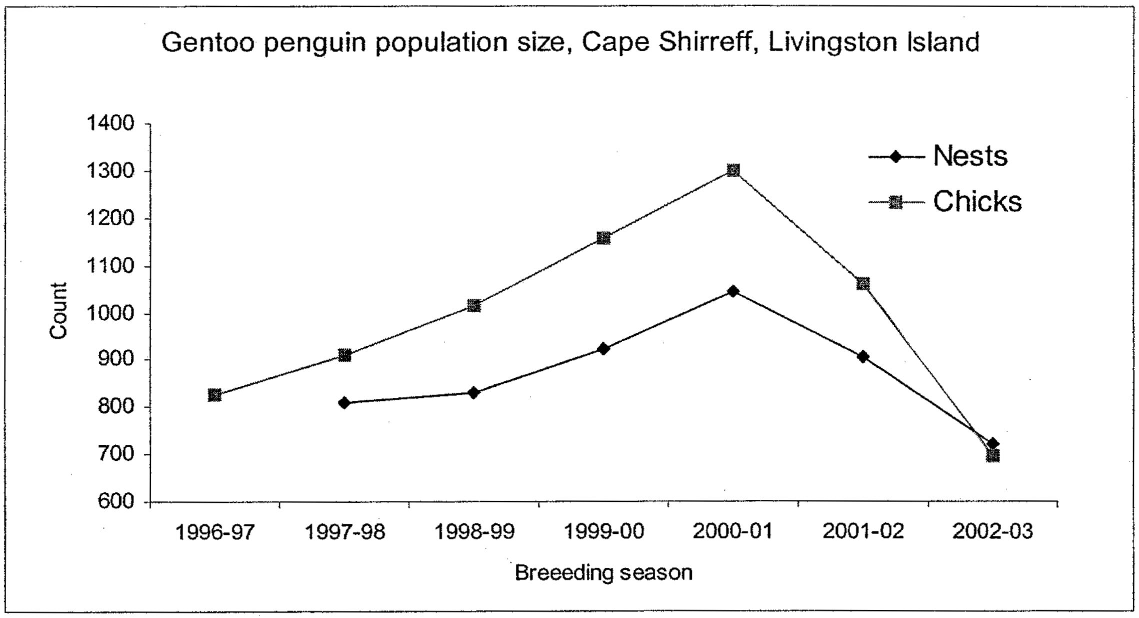


Figure 8.1. Gentoo penguin population trends at Cape Shirreff, Livingston Island, Antarctica, 1996/97 to present. Chicks represented here are fledged.

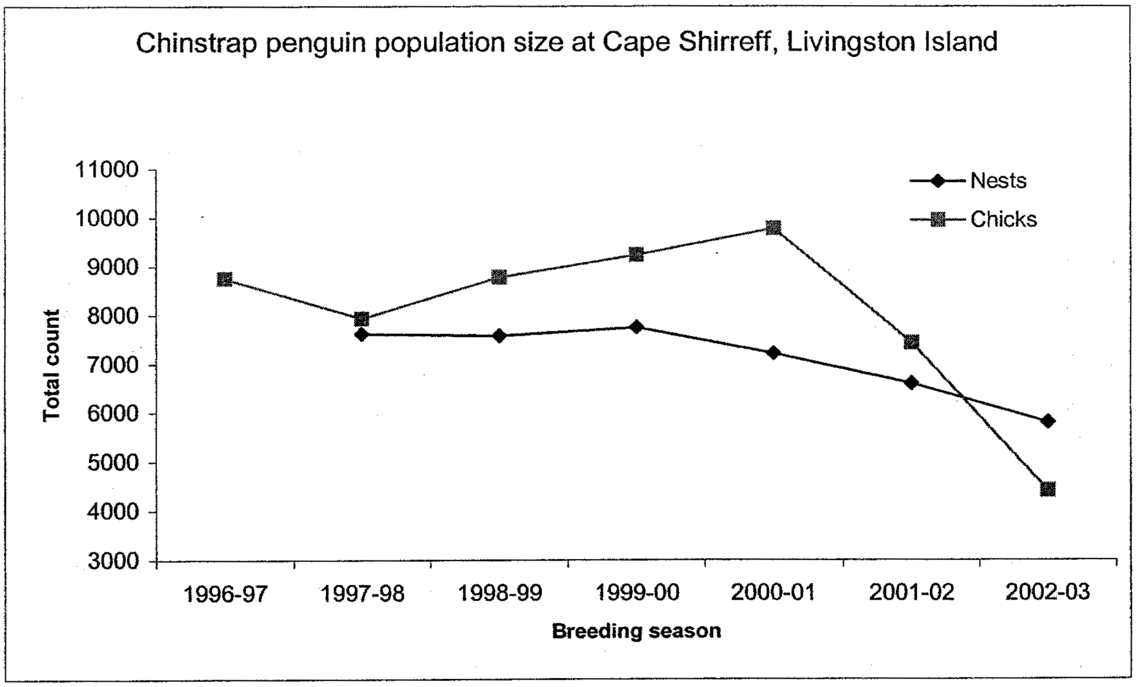


Figure 8.2. Chinstrap penguin population trends at Cape Shirreff, Livingston Island, Antarctica, 1996/97 to present. Chicks represented here are fledged.

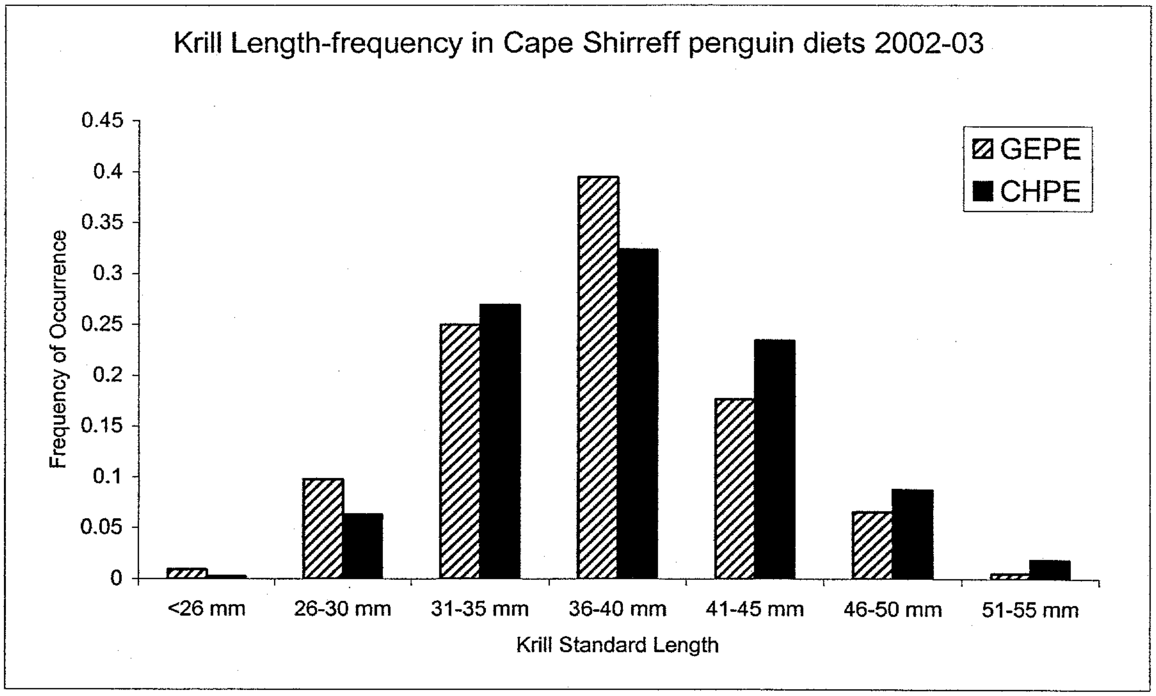


Figure 8.3. Krill length-frequency distribution from penguin diet samples at Cape Shirreff, Livingston Island, Antarctica 2002/03. GEPE represents gentoo penguins and CHPE represents chinstrap penguins.

9. Pinniped Research at Cape Shirreff, Livingston Island, Antarctica, 2002/03; submitted by Michael E. Goebel, John J. Lyons, Douglas J. Krause, Jessica D. Lipsky, Anne C. Allen, and Rennie S. Holt.

9.1 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°28'S, 60°46'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 this species. Our studies focus on foraging ecology, diving, foraging range, energetics, diet, and reproductive success of fur seals rearing offspring.

The 2002/03 field season began with the arrival at Cape Shirreff of a four-person field team via the R/V *Laurence M. Gould* on 7 November 2002. Research activities were initiated soon after and continued until closure of the camp on 28 February 2003. Our specific research objectives for the 2002/03 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 for fatty acid signature analysis for diet studies from each adult female fur seal captured;

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;

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

N. Record other tagged pinnipeds observed and any pinnipeds carrying marine debris (i.e. entanglements).

9.2 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 5-16 December 2002. 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. Presence or absence on shore was monitored for each female every 30 minutes for 30 seconds. All females were instrumented 1-2 days 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. The presence/absence was recorded for each female for the first six trips to sea.

The first female in our study to begin her foraging cycles did so on 7 December and last female to complete six trips to sea did so on 1 February. Eleven females (39%) failed to complete six trips (i.e. their pups perished before completion). Ten females (36%) failed due to unusually long trips and though necropsies were not performed on pups the most likely cause of death was starvation. Some pups did have bite wounds acquired from approaching aggressive females in attempts to steal milk. One pup, whose mother made regular visits, failed to suckle or gain weight normally and died after the second visit. Another pup disappeared after the third suckling bout (the mother's third visit), around the time pups begin to enter the water and the start of leopard seal predation.

The mean trip duration (for the 15 females that completed six trips) for the combined first six trips to sea this year was 6.83 days (±0.73, N=90, range: 2.83-10.78) the longest mean trip duration since data collection began at Cape Shirreff in 1997/98 (Table 9.1, Figure 9.1; ANOVA, $F_{5,922}$=133.88, P<0.0005). Trip durations were normally distributed (Table 9.1, Figure 9.2).

The mean trip duration for successful trips for females that did not complete six trips to sea before losing their pups (i.e. unsuccessful females) was 6.89 days (±2.57, N=24, range: 2.36-13.89). There was no difference in successful trip durations between females that failed and females that did not fail (ANOVA, $F_{1,112}$=0.020, P<0.888). In other words, we were not able to predict from prior trip durations which females would fail and which would not. Failures did not just occur early in their cycles either. The number of females that failed by trip number were as follows: first trip, N=4; second trip, N=2; third trip, N=2, none failed on their fourth trip, and finally two failed after their fifth trip. All females (N=15) that completed six trips successfully reared their pups at least until departure of the field team in late February.

Mean duration for the first six, non-perinatal visits was 0.98 days (±0.05, N=82, range: 0.23-2.18) (Table 9.1, Figure 9.1; ANOVA, $F_{5,913}$=28.66, P<0.0005).

There was no difference in the postpartum mass of our attendance females from 1998/99 to 2002/03 (ANOVA, $F_{4,138}$, P=0.34). Females in the last four years were, however, larger than females in 1997/98, the first year of our studies (Figure 9.3a; ANOVA, $F_{5,169}$, P<0.0005; **97/98:** Mean=39.2kg ±5.76, N=31; **98/99:** Mean=45.6kg ±6.67, N=32; **99/00:** Mean=46.5kg ±5.90, N=23; **00/01:** Mean=46.3kg ±4.52, N=28; **01/02:** 45.2kg ±7.32, N=28; **02/03:** Mean=43.4kg ±4.28). This is because females in that year were sampled later (21-31 December) and late arriving females tend to be younger and smaller. The mass-to-length ratio, perhaps a better measure of condition, for all five years was not different (Figure 9.3b; ANOVA, $F_{5,169}$=0.734, P=0.599; **97/98:** Mean=0.338 ±0.033, N=31; **98/99:** Mean=0.347 ±0.041, N=32; **99/00:** Mean=0.346 ±0.034, N=23; **00/01:** Mean=0.35 ±0.026, N=28; **02/03:** Mean=0.334 ±0.024, N=28).

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 (9 Dec 2002) and ending 22 February (four bi-weekly samples; collection dates: 8 January, 23 January, 7 February, and 22 February). Data were collected as directed in CCAMLR Standard Method C2.2 Procedure B. The results will be 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 (Copihue, Maderas, Cachorros, and Chungungo) on the east side of the Cape. Censuses were conducted every other day from 17 November 2002 through 10 January 2003. The maximum number counted (live and cumulative dead) at the combined four beaches in 2002/03 was 2,157 on 8 January 2003 (Figure 9.4), an 11.4% decrease over the maximum count for the same sites last year (**01/02:** 2,435 on 6 January 2002; **00/01:** 2,248 on 29 December 2000; **99/00:** 2,104 on 3 January 2000). The maximum count was taken as the mean of six separate counts of live pups (three each for two counters; 1,884, SE=8.41) on 8 January 2003 with the addition of total cumulative dead for that date (273 pups). There was a 0.6% difference in the mean count of live pups between observers (counter 1: 1,890, SE=17.0; counter 2: 1,878, SE=12.5).

The median date of pup births was 9 December, two days later than last year.

Pup mortality was higher than in previous years. We record the number of new pup carcasses on our census beaches at each count and calculate 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 2002/03 was 9.0%. Nearly twice as high as any other year since measures began in 1997/98 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%.

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 sample is 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 90 scats and 12 enemas from 27 December 2002- 20 February 2003. Diet samples that could not be processed within 24 hours of collection were frozen. All samples were processed by 26 February. Up to 30 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 2,091 krill carapaces were measured. Most of these (94.7%) were from weekly scat collections; 86.7% (78 of 90) of the weekly scat samples collected contained krill. In addition, 6,964 otoliths were collected from 67.8% of the weekly scat collections. Ninety-one percent (6,315) were from three species of myctophid fish (*Electrona antarctica*, n=2,672; *Electrona carlsbergi*, n=94; *Gymnoscopelus nicholsi*, n=3,549; plus an additional 649 eroded and unidentified otoliths). A total of 73 squid beaks (*Brachioteuthis picta*) were collected from 23.3% of the weekly samples.

The proportions of krill, fish and squid were different every year (Table 9.2, X^2=38.3, d.f.=8, P<0.0005). Results for 2002/03 indicated less krill more fish and squid in the diet than in previous years. In fact, for February samples, this was the first time we have ever recorded fish in greater proportion than krill (Figure 9.5). Unlike last year the weekly occurrence of non-krill species in fur seals diet did not vary as much (Figure 9.6). However, as in previous years we recorded increasing proportions of fish and squid over time (from Dec-Feb)

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 thirty carapaces from each scat were randomly selected and measured according to Hill (1990). The following linear discriminant function (Reid and Measures 1998) was applied to the carapace length (CL) and width (CW) to determine sex of individual krill:

$$D = -1.04 - 0.146(CL) + 0.265(CW)$$

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 Reid and Measures (1998) were applied to calculate total length (TL) from the carapace length:

$$\text{Females: } TL = 15.3 + 2.09(CL)$$
$$\text{Males: } TL = 13.9 + 2.29(CL)$$

A total of 2,091 carapaces was measured from 78 scats and enemas in 2002/03. Summary statistics are presented in Table 9.3. Data from 1999/00 through 2001/02 are also presented for comparison. Krill consumed by fur seals in 2002/03 was on average smaller than in previous years (Table 9.3; ANOVA, $F_{3,10383} = 3{,}043.3$, $P<0.0005$). The length distributions (in 2mm increments) for the last three years are presented in Figure 9.7. Smaller krill (<50mm) were present in fur seal diet throughout the sampling period and weekly comparisons showed only minor changes in length frequency distributions (Figure 9.8).

E. Fatty Acid Signature Analysis of Milk: In addition to scats and enemas, we collected 102 milk samples from 71 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 102 samples, 24 were collected from perinatal females and 25 were collected from 25 females that had dive data for the foraging trip prior to milk collection.

F. Diving Studies: Ten of our 28 females transmittered for attendance studies also received a time-depth recorder (TDR, Wildlife Computers Inc., seven had Mark 7s, 96 x 20 x 12mm, 31g and two had Mark 9s, 66 x 18 x 18mm, 31g) on their first visit to shore. Five of the ten carried their TDR for at least their first six trips to sea. One of the 10 TDRs failed (Mark 9 ID:207), thus only nine records were collected for dive data for the first six trips to sea. In addition, all other females captured for studies of at-sea foraging locations also received a TDR. A total of 24 dive records were collected from 22 females in 2002/03. The total number of trips recorded on TDRs from 10 December 2002 – 13 February 2003 was 64.

G. Adult Female Foraging Locations: We instrumented 17 females with satellite-linked transmitters (ARGOS-linked Platform Terminal Transmitters or PTTs) from 20 December – 13 February. The number of females with PTTs was more than last year because trip durations this year were longer thus most only carried a PTT for a single trip. Ten of the 17 were deployed to coincide with the U.S.-AMLR large-scale oceanographic survey. Six females successfully carried a PTT for two trips to sea and nine females carried a PTT for a single trip. Two females carrying PTTs failed to return, one of these did not complete her first trip while the other made a single trip but did not return after her second departure. Results of fur seal foraging location data analysis and interannual comparisons are pending.

H-J. Demography and Tagging: Together Chilean and U.S. researchers tagged 499 fur seal pups (267 females, 232 males) from 16 January – 28 February 2003. 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 2002/03 were 3001-3500.Tag 3008 was damaged not deployed. Most pups (457 or 91.6%) were tagged on the east side of the Cape from Playa Marko to Ballena Norte beach. A total of 42 pups (32 females, 10 males) was tagged at Loberia beach on the northwest side of the Cape.

In addition to the 499 pups tagged, we also tagged 43 adult lactating females [28 had been previously untagged (268, 269, 273-298) and 15 had previously been tagged but had lost one tag (299-304, 306-314)]. Retagged females were (old tag/new tag): 161/299, N361/300, 168/301, 131/302, 176/303, 016/304, 060/306, 180/307, 064/308, 1083/309, 599/310, 183/311, 223/312, 103/313, and 164/314. Tag 305 was damaged and not deployed. All tags were placed on females with parturition sites on east side beaches (Copihue, Maderas, Cachorros, and Chungungo beaches).

Last year we added 37 adult females to our tagged population. These 37, when added to the females that returned in the previous season (N=189), gave an expected known tagged population of 226 for 2002/03 (Table 9.4). Of these, 194 (85.8%) returned in 2002/03 to Cape Shirreff and 168 of these (86.6%) returned pregnant (Figure 9.9). The return rate was the second lowest (1998/99 was 2% lower) and the natality rate was the lowest recorded in five seasons of adult female tag returns (Return rates: **98/99:** 83.8%, **99/00:** 94.0%, **00/01:** 90.4%, **01/02:** 97.9%; Natality rates (percent of returning females with a pup): **98/99:** 90.3%, **99/00:** 92.3%, **00/01:** 87.2%, **01/02:** 91.1%; Figure 9.9).

Our tagged population of females returned (on average) two days later than last year. Last year (2001/02) the mean date of pupping for tagged females (which had a pup in both years, 01/02 & 02/03) was 5 December (±6.37, N=148) and in 2002/03, for the same females, it was 7 December (±6.99, N=148). This result agrees with our calculations for a population as a whole based on bi-daily pup counts (Section 9.2.C).

Last year we refined our tag re-sight protocol to enable us to better measure effort from year to year. The protocol requires systematic searches of defined sub-areas while "on the clock" and all tags observed are now recorded as systematic or opportunistic (tags observed while performing other research activities).

We observed 23 yearlings (12 males, 11 females; 4.6% return rate) tagged as pups this year compared to only nine last year (three females and six males, 1.4%; Table 9.5). The yearling return rate for this year was much higher than last in spite of apparently poorer summer foraging conditions. The yearling return rate is similar to that of the 97/98 (4.4%) and 99/00 (5.2%) cohorts. Table 9.5 presents observed tag returns for four cohorts in their first year. Tag deployment, the total number placed and re-sighting effort for all four 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 9.6). 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 three cohorts presented have return rates in the first two years that are very different (Figure 9.10). 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%. If the transition to nutritional independence and foraging conditions their first winter are critical to juvenile otariid survival (as suggested by York, 1994) then 1999/00 cohort experienced exceptionally good conditions at weaning and for their first winter at sea. 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 99/00 cohort.

K. Tooth Extraction and Age Determination: 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, from 14-31 January, we took a single post-canine tooth from 30 previously tagged females. One female was tagged as an adult female at Seal Island. Females ranged in size from a mass of 30.0-48.6kg and length of 113-142cm. The mean total time captive was 15.0 min (±3.0) and the mean total time under anesthesia was 13.0 min (± 3.0, n=30). The time captive and the time under anesthesia were not significantly different over last year. (Time captive: ANOVA, $F_{1,105}$=1.71, P=0.19; time on gas anesthesia: ANOVA, $F_{1,105}$=1.71, P=0.09)

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 10 November 2002 to 21 February 2003. 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.

Mean daily temperature at Cape Shirreff was 2.40°C ± 2.44 (0.01°C warmer than for the same time period last year(18 November-12 February). Mean temperature from 10 November 2002 to 21 February 2003 was 2.35°C ± 2.42 (N=8,269). Wind speed for the same time period was 15.9 km/hr ± 11.1 with a maximum gust of 86 km/hr on 11 Dec. (Last year the mean wind speed was similar; 15.7 km/hr ± 8.3 with a maximum gust to 72.0 km/hr on 14 December). Our biggest wind storms are typically during the first two weeks of December. Total measurable precipitation in 2002/03 was greater than previous years but with similar total number of days of measurable precipitation for the time period 21 December-24 February (**1998/99:** 59.6mm for 43 days, **1999/00:** 57.1mm for 35 days, **2000/01:** 56.0mm for 36 days, **2001/02:** 80.0mm for 43 days, **2002/03:** 88.1mm for 38 days). Over-winter snow cover at the start of this season was considerably more than in previous years though we do not have a precise measure of this. We also do not know how much the increased snow cover was due to higher over-winter accumulation or how much to a later thaw. The thaw was much later this year than in the previous five. By the time fur seal pupping began in late November most beaches had considerable snow cover and the more exposed beaches had extensive ice walls at the high tide mark. Many females were unable to pup in their preferred places and either remained inter-tidally or they moved to areas that were more accessible. Many pups born below these ice walls perished when the surf was high or were crushed by calving ice. The increased snow cover and ice at the time of breeding had a pronounced affect on distribution of fur seals early in the season. Female fur seals tended to pup over a smaller area in higher densities than in previous years.

M. Miscellaneous: Tagged Elephant Seals. No tagged elephant seals were recorded this year. **Entangled Pinnipeds.** We observed two entangled female fur seals this season. The entanglement debris was plastic of the type used for plastic bags. One of these females was captured and the debris removed.

9.3 Preliminary Conclusions: The 2002/03 season was the poorest on record for Antarctic fur seals at Cape Shirreff since our monitoring studies began in 1997/98. Fur seal pup production at U.S.-AMLR study beaches decreased by 12.1% over last year, the first decrease recorded. Pup mortality (9.0%) was also higher than in any other year and attendance studies indicated that a significant proportion of early pup mortality was attributed to unusually long maternal foraging trips. The median date of pupping based on pup counts was two days later. The mean arrival and parturition dates for our tagged female population was also two days later than last year. Over winter survival for adult females was lower than in the last three years (85.8%). The natality rate (86.6%) was also the lowest than in any other year. Foraging trip duration was longer than in any other year as well (mean: 6.83 days ±0.73) and visit duration the shortest (0.98 days ±0.51). This was the first year that we have ever recorded the proportion of fish in the diet exceeding that of krill (for February). Fish and squid both were in greater proportions than in previous years. The krill that was present in fur seal diet was smaller than in previous years. The 1999/00 cohort continued to dominate tag returns as in previous years.

9.4 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.

9.5 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, cohort survival) reflect ecological processes over a broader temporal spatial scale. Yet these data clearly show that post-weaning environments are crucial for survival, recruitment, and sustainability of pinniped and seabird populations. The dominance of the 99/00 cohort in tag return data and differential cohort strength (Table 9.6, Figure 9.10) 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 can not only provide information on dispersal but can measure the physical environment encountered by individuals. Future studies should use this technology to measure dispersal, survival and various parameters of the physical environment in order to identify factors leading to increased survival and recruitment of juvenile pinnipeds and seabirds.

9.6 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: Verónica Vallejos Marchant, Romeo Vargas, Layla Osman, and Claudio Vera 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. Thanks to Laina Shill, Michelle Antolos and Wayne Trivelpiece for their help with pinniped studies. We are, likewise, grateful to 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.

9.7 References:

Hill, H.J. 1990. A new method for the measurement of Antarctic krill *Euphausia superba* Dana from predator food samples. *Polar Biology* 10(4): 317-320.

Reid, K., and J. Measures. 1998. Determining the sex of Antarctic krill *Euphausia superba* using carapace measurements. *Polar Biology* 19(2): 145-147.

York, A.E. 1994. The population dynamics of northern sea lions, 1975-1985. *Marine Mammal Science* 10(1): 38-51.

Table 9.1. 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 – 2002/03.

Year	Female N	N	Range	Median	Mean	St.Dev.	Skew[1]	SE Skew	S[1]	(+/-)
Trip Durations:										
1997/98	30	180	0.50 -9.08	4.07	4.19	1.352	0.083	0.181	0.459	-
1998/99	31	186	0.48 -11.59	4.23	4.65	1.823	0.850	0.178	4.775	+
1999/00	23	138	0.60 -8.25	3.25	3.47	0.997	1.245	0.206	6.044	+
2000/01	28	168	0.75 -5.66	2.69	2.71	0.828	0.874	0.187	4.674	+
2001/02	28	166	0.50 -7.85	2.87	3.18	1.207	0.740	0.188	3.936	+
2002/03	15	90	2.83 -10.78	6.89	6.83	0.731	-0.072	0.254	0.283	-
Visit durations:										
1997/98	30	179	0.46 -2.68	1.25	1.35	0.462	0.609	0.182	3.346	+
1998/99	31	186	0.21 -3.49	1.27	1.33	0.535	0.947	0.178	5.320	+
1999/00	23	138	0.10 -4.25	1.51	1.72	0.635	1.088	0.206	5.282	+
2000/01	28	168	0.44 -3.15	1.52	1.68	0.525	0.485	0.187	2.594	+
2001/02	28	166	0.19 -4.84	1.43	1.55	0.621	1.328	0.188	7.094	+
2002/03	15	82	0.23 -2.18	0.98	0.98	0.051	0.447	0.266	1.680	-

[1]Skewness: A measure of asymmetry of the distribution of the data. A significant positive value indicates a long right tail. Significance (S) is indicated when the absolute value of Skewness/Standard Error of Skewness (SE) is greater than two.

Table 9.2. Results of a contingency table on the proportions of major prey types (krill, fish, and cephalopods) in Antarctic fur seal scats and enemas collected at Cape Shirreff, Livingston Island in five years of collections, 1998/99 through 2002/03 (X^2=38.3, d.f.=8, P<0.0005). Reject H_o: The proportions of krill, fish, and squid in the diet are homogeneous in the five years of study. (Column headings: Obs. = Observed, Exp. = Expected)

	1998/99		1999/00		2000/01		2001/02		2002/03	
Prey	**Obs.**	**Exp.**	**Obs,**	**Exp.**	**Obs.**	**Exp.**	**Obs.**	**Exp.**	**Obs.**	**Exp.**
Krill	84	74.2	94	105.0	104	84.0	111	129.0	78	89.9
Fish	32	45.1	71	64.2	39	51.1	97	78.6	61	57.3
Squid	12	8.7	17	12.3	2	9.8	15	15.1	21	12.8

Table 9.3. Krill length (mm) in fur seal diet from 1999/00 - 2002/03. 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)	1999/00:	2000/01:	2001/02:	2002/03
N:	2,528	2,941	2,826	2,091
Median:	50.8	52.9	55.0	42.5
Mean:	50.6	53.1	53.8	43.0
St.Dev.:	4.46	3.82	4.44	4.17
Maximum:	59.7	64.3	64.3	59.7
Minimum:	13.9	39.1	36.8	34.1
Sex Ratio (M:F):	1:1.8	1:1.2	1:2.4	1:8.3

Table 9.4. Tag returns and natality rates for adult female fur seals at Cape Shirreff, Livingston Island, 1998/99 – 2002/03.

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

[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 9.5. A comparison of first year tag returns for four cohorts: 1997/98 – 2001/02. 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)

Table 9.6. Tag returns and minimum percent survival for four cohorts, 1997/98 – 2000/01 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		
	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total
Sightings:												
Sighted in Year 1:	12	10	22	1	5	6	11	15	26	3	6	9
Additional Tags Sighted in Year 2:	20	10	32	6	7	13	53	40	93	13	2	15
Minimum survival in year 1:	32	20	54[1]	7	12	19	64	55	119	16	8	24
Tag loss:												
Unknown tag status:	2	1	3	0	2	2	1	3	4	0	1	1
Both tags present:	14	13	29	6	6	12	48	42	90	11	5	16
Missing 1 tag:	16	6	22	3	2	5	15	10	25	5	2	7
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
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
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
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**

[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.

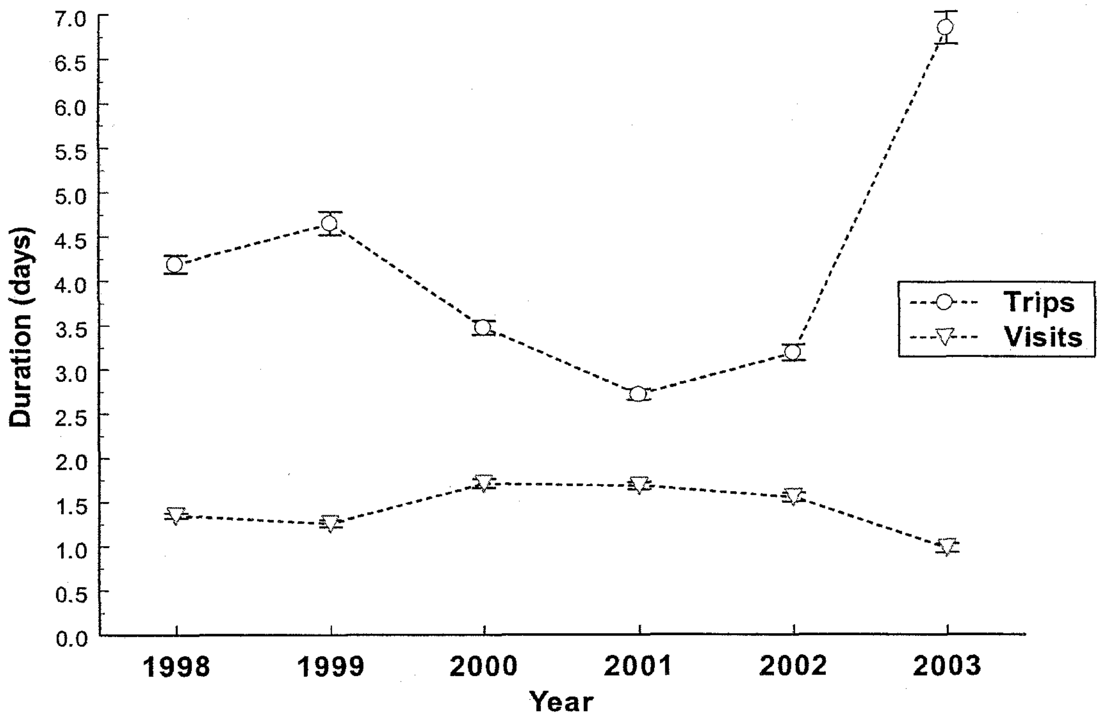


Figure 9.1. Antarctic fur seal trip and visit durations for females rearing pups at Cape Shirreff, Livingston Island. Data plotted are for the first six trips to sea and the first six non-perinatal visits following parturition for six years (See Table 9.1 for sample sizes)

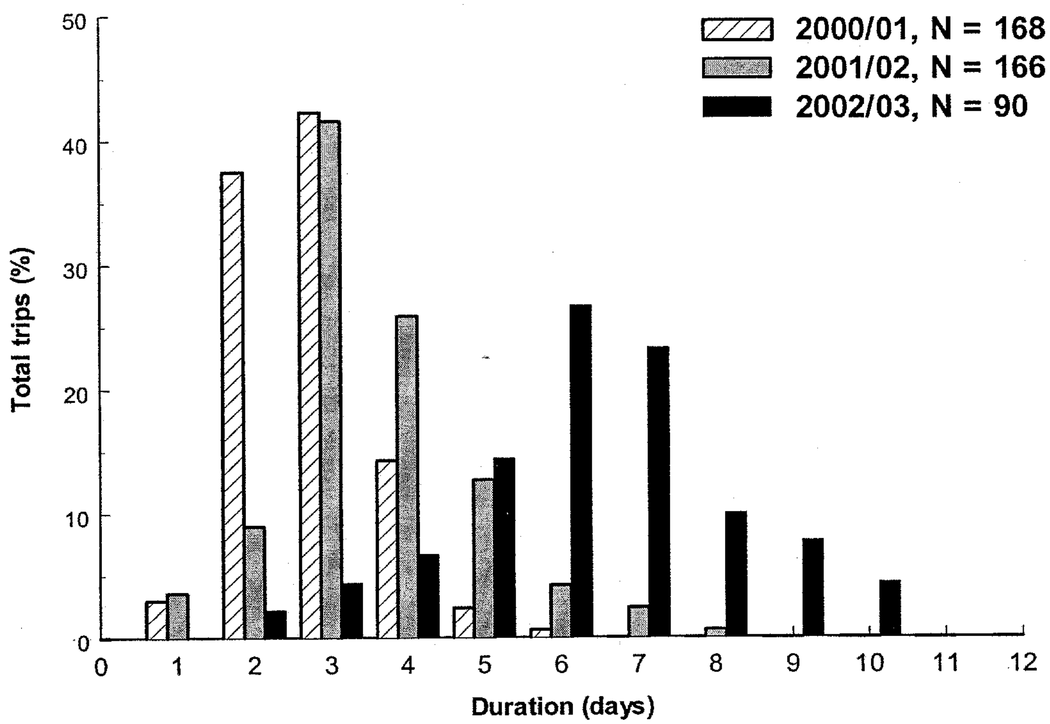


Figure 9.2. The distribution of Antarctic fur seal trip durations at Cape Shirreff, Livingston Island for the last three years (2000/01-2002/03).

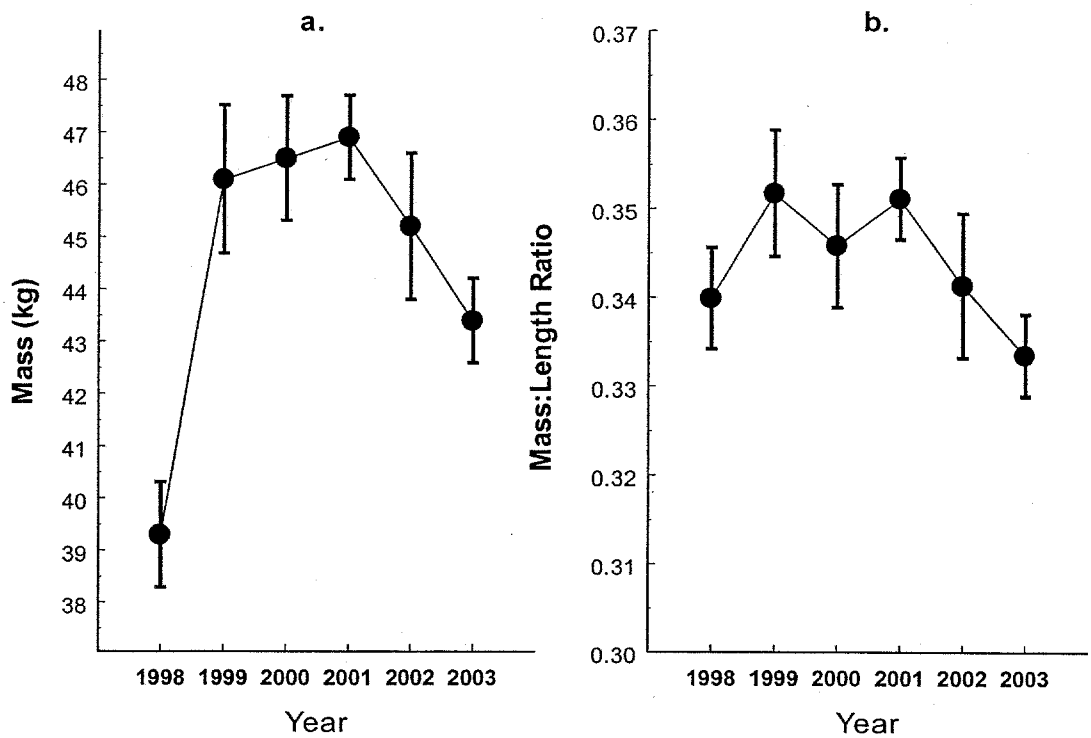


Figure 9.3. The mean mass (a.) and mass:length ratio (b.) for CCAMLR attendance study females for 1997/98 – 2002/03 (**97/98**: N=31, **98/99**: N=32, **99/00**: N=23, **00/01-02/03**: N=28).

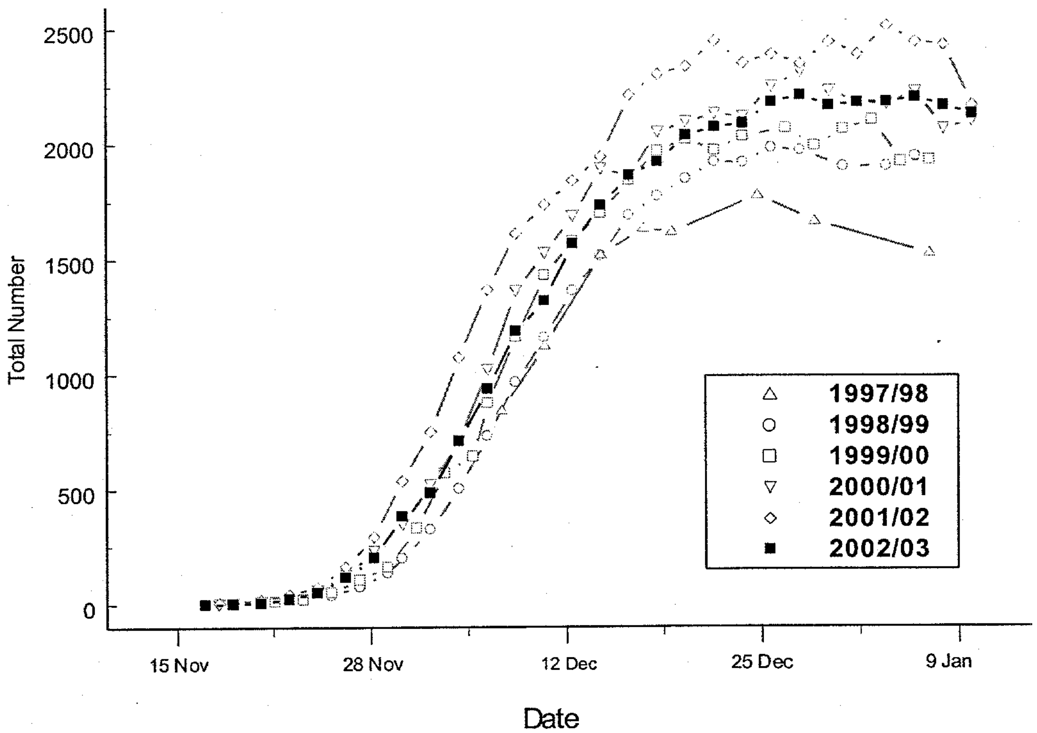


Figure 9.4. Antarctic fur seal pup production at U.S.-AMLR study beaches, Cape Shirreff, Livingston Island, 1997/98-2002/03.

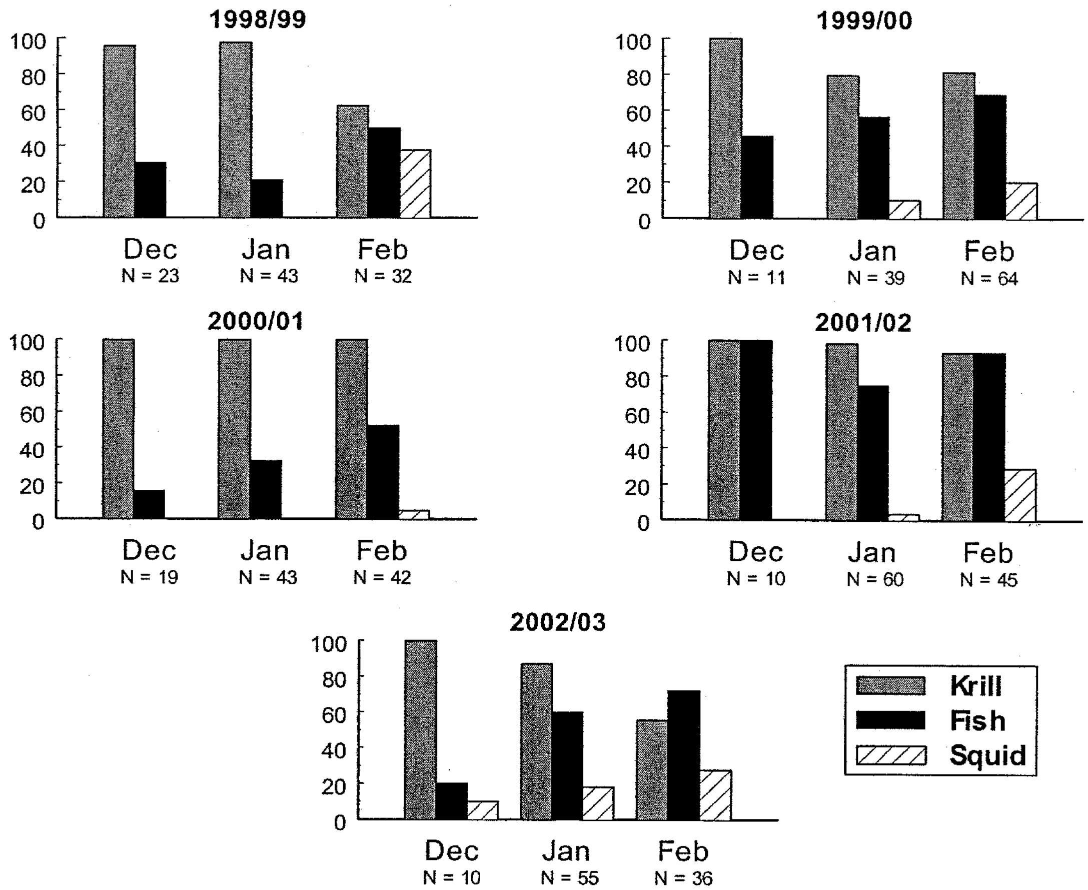


Figure 9.5. The percent occurrence of primary prey types (krill, fish, and squid) from December through February for Antarctic fur seal scats and enemas collected from female suckling areas at Cape Shirreff, Livingston Island for 1998/99 through 2002/03.

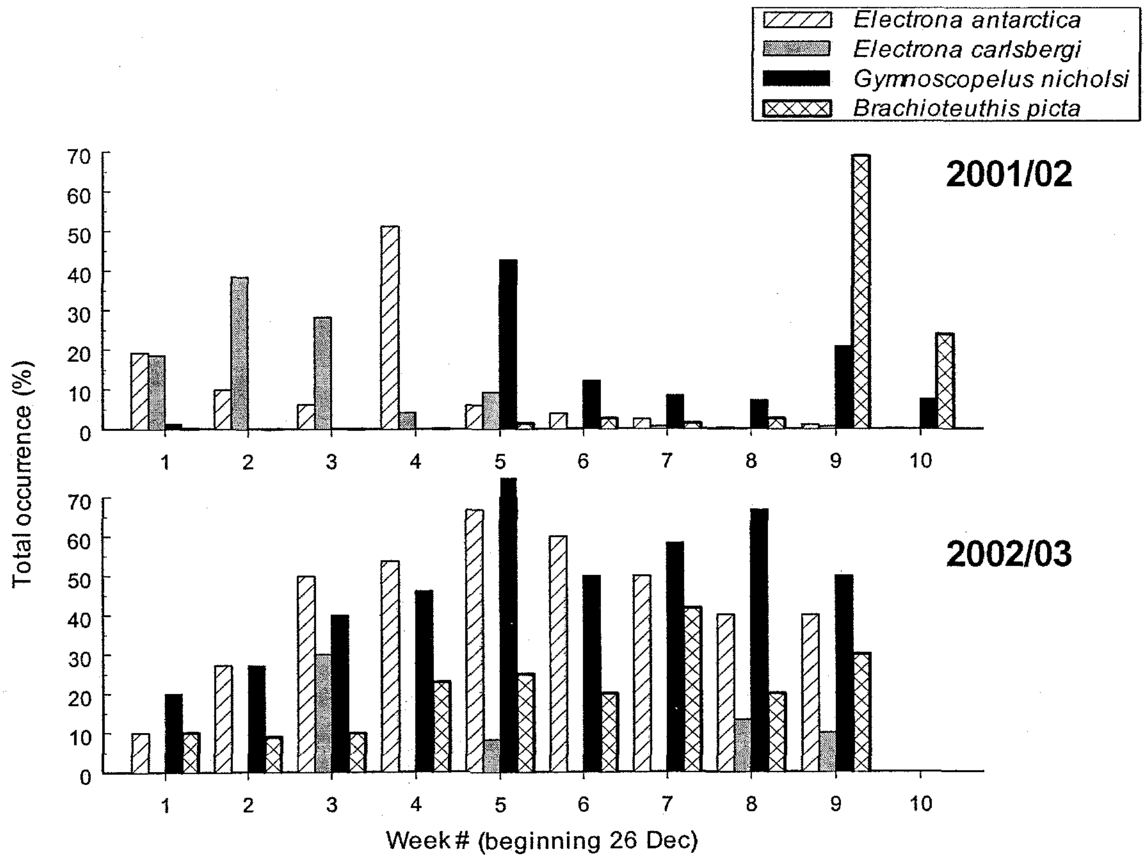


Figure 9.6. The weekly percent occurrence of the primary non-krill species found in fur seal diets at Cape Shirreff, Livingston Island in 2002/03 (2001/02 data plot included for comparison). The four species are *Electrona antarctica, Electrona carlsbergi, Gymnoscopelus nicholsi,* and *Brachioteuthis picta*. The first three species are myctophid fish (lantern fish) and the fourth species is a cephalopod (squid).

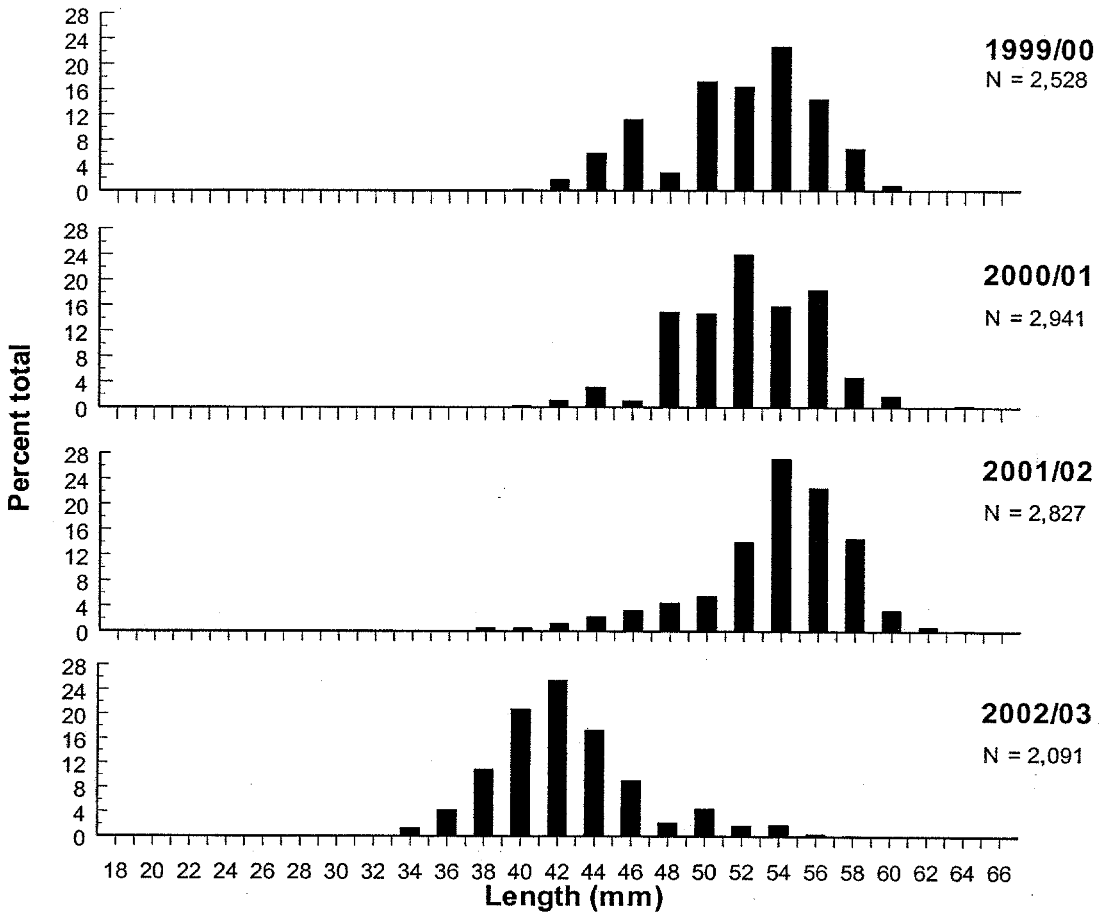


Figure 9.7. The size distribution of krill in Antarctic fur seal diet at Cape Shirreff, Livingston Island from 1999/00 through 2002/03.

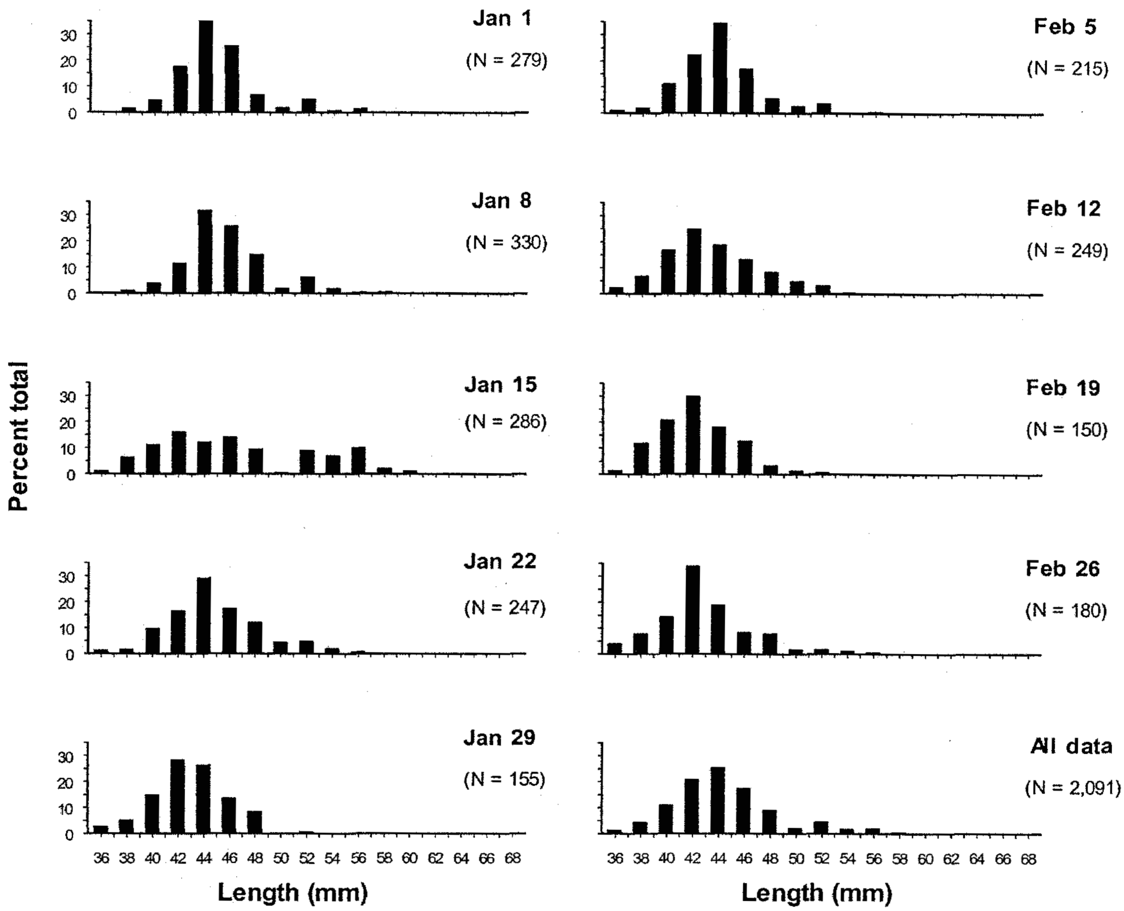


Figure 9.8. Weekly size distribution of krill (*Euphausia superba*) in Antarctic fur seal diet at Cape Shirreff, Livingston Island in 2002/03. Each plot represents one week of krill carapace measurements. The date on each plot is the last day of the week (e.g. Jan 1: the week 26 Dec 2001-1 Jan 2002). The number of krill carapaces measured for each week is given in parentheses. Large area oceanographic surveys (west area grid) by the R/V *Yuzhmorgeologiya* were conducted 16-19 January and 24-27 February (Weeks 4 and 8 in this plot; 22 Jan and 26 Feb).

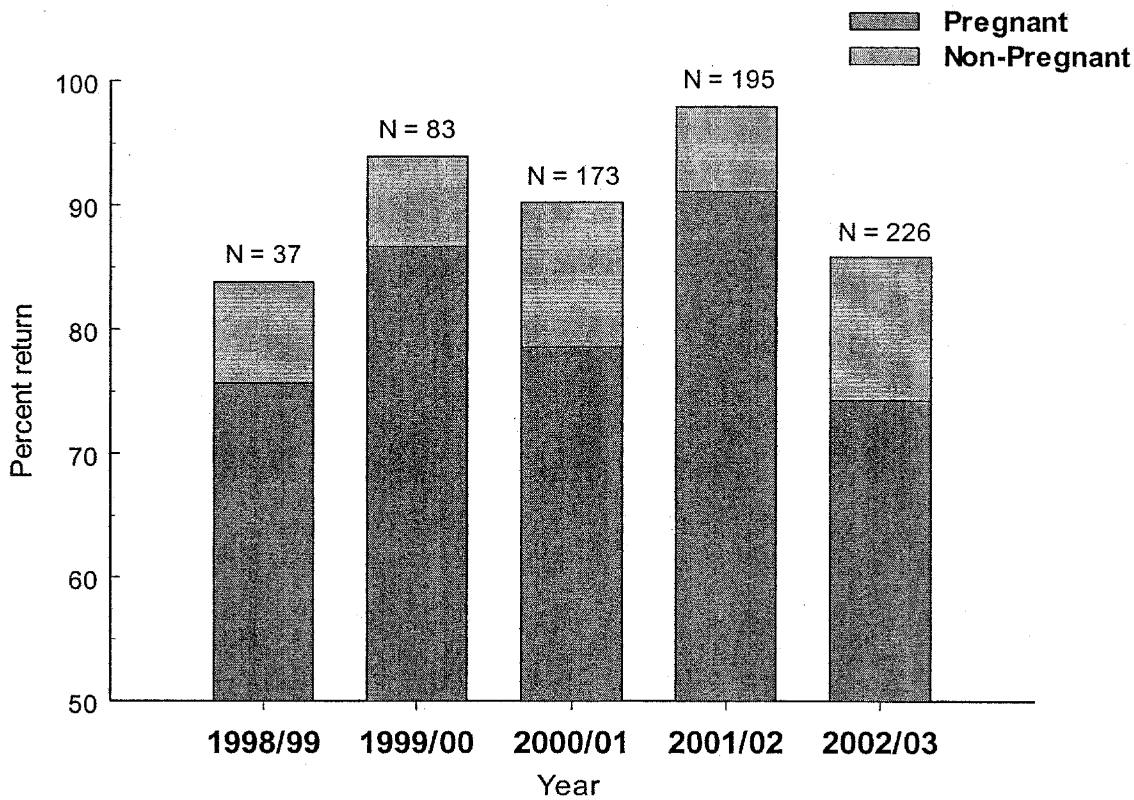


Figure 9.9. Adult female Antarctic fur seal tag returns for five years (1998/99-2002/03) at Cape Shirreff, Livingston Island.

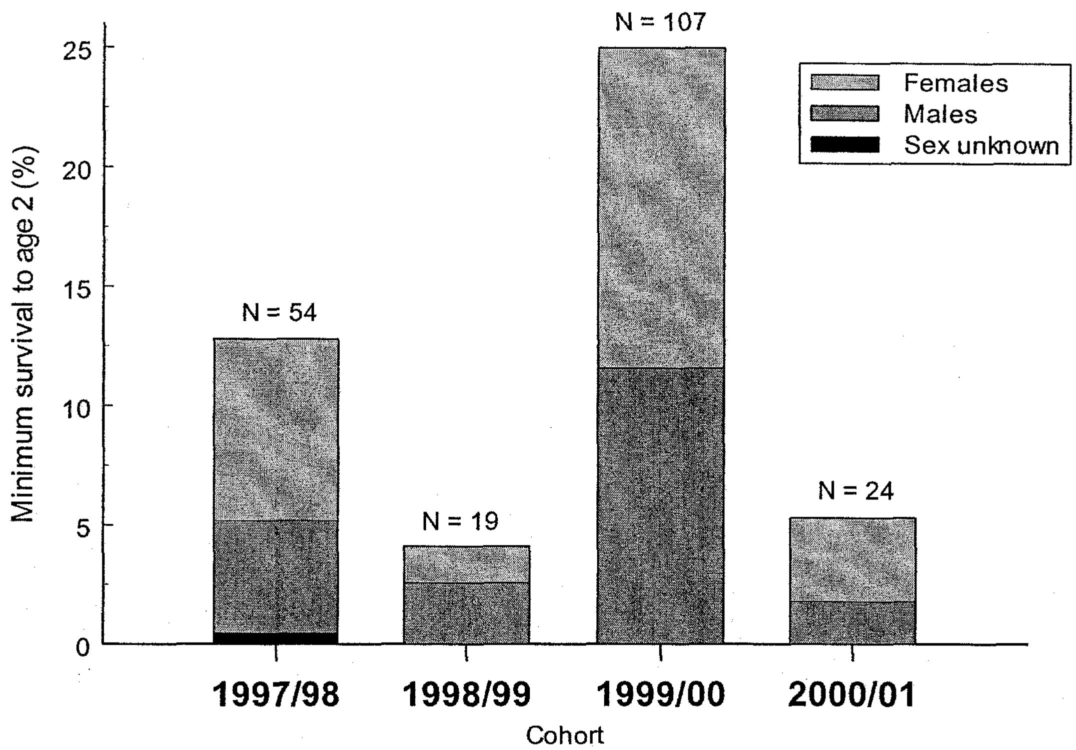


Figure 9.10. Minimum survival to age-1 based on tag returns for the first two years for four cohorts (97/98-00/01) of fur seals tagged as pups at Cape Shirreff, Livingston Island. Not all pups that survive their first year return as yearlings or two year olds, thus our estimates represent a minimum survival. Tag re-sight effort was similar for all years.

10. Antarctic Fur Seal Foraging Habitat: Results of a Fine Scale Survey of an Important Foraging Area; submitted by Michael E. Goebel, Roger P. Hewitt, Andrew E. Dizon, and Valerie Loeb.

10.1 Objectives: The U.S. AMLR oceanographic survey grid is designed to measure meso-scale krill distribution and abundance and to measure physical processes at that same scale. Many protocols in our predator studies are likewise designed to measure population level changes (e.g. foraging range and distribution, survival and natality rates). However, predator-prey interactions are known to be scale dependent (Fauchald and Erikstad, 2002; Fauchald *et al.*, 2000; Guinet *et al.*, 2001; Loggerwell *et al.*, 1998) and a thorough understanding of predator foraging ecology and reproductive success requires measurements at multiple scales; both population and individual level functional responses of predators to prey.

Previous studies of foraging range and distribution of Antarctic fur seals foraging from Cape Shirreff have indicated that the continental shelf break area off Cape Shirreff to be an important foraging area (Goebel *et al.*, 2002). In particular, in every year studied (1999-2002), the distribution for foraging female fur seals was centered over the mouth of a canyon on the outer-margin of the continental shelf ~40km northwest of Cape Shirreff (Goebel *et al.*, 2002).

Our objective for this study was to 1) track an individual seal to this primary fur seal foraging habitat; 2) measure prey distribution and abundance over the same temporal-spatial scale of an individual foraging fur seal; and 3) measure krill length distribution in fur seal foraging habitat for comparison with that measured for the entire West Area.

10.2 Methods: We designed a series of three equidistant, parallel transects that began over the continental shelf and extended over deep water thereby covering the entire slope region. The first transect began near the 100m isobath, 16.6km northwest of Cape Shirreff and extended 45km to approximately the 3,000m isobath. The second transect was placed to bisect the center of the canyon running parallel and 12km away from the first transect. The third transect was similar to the first in the bathymetry it covered and was 25km from the first transect (Figure 10.1). We used the same bioacoustic methods used in the large scale survey grid to quantify prey (krill and myctophid fish) biomass (see section 3.2 of this report).

Two net tows were conducted with a 6' Isaacs-Kidd Midwater Trawl (IKMT) fitted with a 505μm mesh plankton net (see section 4.2.1 of this report). Depth of net tows was determined by position of prey swarms observed in the ongoing bioacoustic survey. Krill were measured for total length and sexed as described in Section 4.2.2 of this report. No myctophid fish were targeted or collected.

The adult lactating female fur seal was captured the day before our survey began. She was instrumented with an ARGOS-uplink satellite transmitter (KiwiSat 100, Sirtrack Ltd.; 19x32x139mm, 119g, 175mm antenna) that gave continuous transmissions while at sea. Location data were downloaded in La Jolla, CA, USA and sent to the ship periodically. Data presented in this report are for all unfiltered downloaded locations that fell within the survey area.

10.3 Results and Preliminary Conclusions: The survey began at 62.43°S, 61.05°W at 1922 GMT 2 February 2003 (Table 10.1). The ship followed the pre-determined track line except after waypoint five when it diverted to avoid an iceberg (Figure 10.1). Sunset was at 0050 GMT. Net tows began at 2316 and 0347 GMT and lasted 23 and 20 minutes, respectively (Table 10.2). The first net tow was conducted at 62.43°S, 61.05°W between waypoints one and two. The second net tow was located at 62.43°S, 61.05°W between waypoints five and six.

10.3.1 Krill Distribution and Abundance: Krill were abundant over much of the survey between way points one and five both on and off the continental shelf (Figure 10.1). The apparent abundance diminished after waypoint five shortly after sunset. However, abundance based on acoustic estimations are underestimated if prey move to within 15m of the surface which may have resulted in a lower abundance estimate. The second net tow conducted after sunset resulted in a higher catch than expected based on acoustic estimations.

10.3.2 Myctophid Distribution and Abundance: Myctophid fish were less abundant in shallower waters of the survey area (i.e. over the continental shelf region in <500m; Figure 10.2). They were found to be more abundant in the deepest waters (2,000m) of the survey area.

10.3.3 Fur Seal Foraging Track: Female #103 was instrumented with an ARGOS satellite linked transmitter on 31 January 2003 at 15:46. She departed to sea from Cape Shirreff at 19:51. Her locations in the survey area (n=10) were recorded on 1 February 2003 between 0604-1427 GMT. The first location in the survey area was also her first location at sea. After her last location in the survey area (at 14:27) she continued north and did not remain in the survey area. Her entire 6.76 day foraging track is shown in Figure 10.3, with the first location of each new day labeled sequentially.

10.3.4 Krill Length-Frequency: Krill were collected in both net tows (n=988, n=1,248). Sixty-six krill (all adult, male n=34, female n=32) were measured from the first tow and 85 (10 juveniles and 75 adults, male n=36, female n=39) from the second tow. Krill collected in the survey area of fur seal foraging habitat were larger when compared to that collected for the entire West Area of Survey A (Leg I) (see Section 4.3.1). The length-frequency distributions for both are presented in Figure 10.4. A Kolmogorov-Smirinov two sample test (H_0: the two sample distributions are the same) indicated the difference in the two distributions to be significant (P=0.017). These results agree with Siegel (1988, 2000) who found krill on the continental shelf north of the South Shetlands to be smaller on average than krill further off shore in areas that are utilized more by foraging fur seals.

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

10.5 Problems and Suggestions: Our future studies will incorporate diving data in comparisons of preferred foraging habitat for fur seals. They should also address why, in spite of apparently high abundance of krill, fur seals (e.g. the one used in this study) do not remain in the shelf break area as they do in other years or at other times. A thorough assessment will include characterization and comparison of physical properties of water masses offshore of fur seal breeding colonies. For instance, inter- and intra-annual comparisons of the position of the frontal zone that characterizes the boundary between continental shelf waters and oceanic waters should provide insight into what drives the functional responses of foraging fur seals. Recent developments in the miniaturization of video cameras should also provide opportunities to measure foraging behavior on the same temporal spatial scales encountered by individual seals.

10.6 Acknowledgments: We are grateful to the AMLR personnel and the Russian crew of the R/V *Yuzhmorgeologiya* for their support and assistance in conducting the small scale survey of fur seal foraging habitat. Capture and instrumentation of the fur seal tracked in this study was conducted under Marine Mammal Protection Act Permit No. 774-1649 granted by the Office of Protected Resources, National Marine Fisheries Service.

10.7 References:

Fauchald P., and Erikstad, K.E. 2002. Scale-dependent predator-prey interactions: The aggregative response of seabirds to prey under variable prey abundance and patchiness. *Marine Ecological Progress Series* 231: 279-291.

Fauchald P., Erikstad, K.E., and Skarsfjord, H. 2000. Scale-dependent predator-prey interactions: The hierarchical spatial distribution of seabirds and prey. *Ecology* 81(3):773-783.

Goebel, M.E., Sexton, S.N. and Costa, D.P. 2002. Foraging range and at-sea locations of female Antarctic fur seals, Cape Shirreff, Livingston Island, from 1999-2002. CCAMLR, WG-EMM-02, Big Sky, Montana.

Guinet C., Dubroca, L., Lea, M.A., Goldsworthy, S., Cherel, Y., Duhamel, G., Bonadonna, F., and Donnay, J. 2001. Spatial distribution of foraging in female Antarctic fur seals *Arctocephalus gazella* in relation to oceanographic variables: A scale-dependent approach using geographic information systems. *Marine Ecological Progress Series* 219:251-264.

Logerwell, E.A., Hewitt, R.P., and Demer, D.A. 1998. Scale-dependent spatial variance patterns and correlations of seabirds and prey in the southeastern Bering Sea as revealed by spectral analysis. *Ecography* 21:212-223.

Siegel, V. 1988. A concept of seasonal variation of krill, *Euphausia superba,* distribution and abundance west of the Antarctic Peninsula. *In* Antarctic Ocean and Resources Variability. Ed. D. Sahrhage. Springer-Verlag, Berlin and Heidelberg: 219-230.

Siegel, V. 2000. Krill (Euphausiacea) demography and variability in abundance and distribution. *Canadian Journal of Fisheries and Aquatic Science* 57(3): 151-167.

Table 10.1. Location and time of six waypoints used in our small scale survey grid of fur seal foraging habitat conducted on 2-3 February 2003.

Waypoint	Time GMT	Latitude	Longitude
1	1922	-62.4333	-61.0500
2	2127	-62.0500	-61.3333
3	2209	-62.1000	-61.5667
4	0103	-62.4667	-61.2667
5	0143	-62.5167	-61.4833
6	0515	-62.1333	-61.7833

Table 10.2 Deployment data for IKMT net tows used for sampling fur seal prey.

Net tow	Start tow	End tow	Duration (min)	Depth (m)	Latitude	Longitude	Total Krill	Krill measured[1]
1	20:16	20:39	23	200	62.43°S	61.05°W	988	66 (0,34,32)
2	00:47	01:07	20	80	62.43°S	61.05°W	1,248	85 (10,36,39)

[1]The total number of krill sexed, classed, and measured. Values in parentheses are the number of juveniles, males, and females.

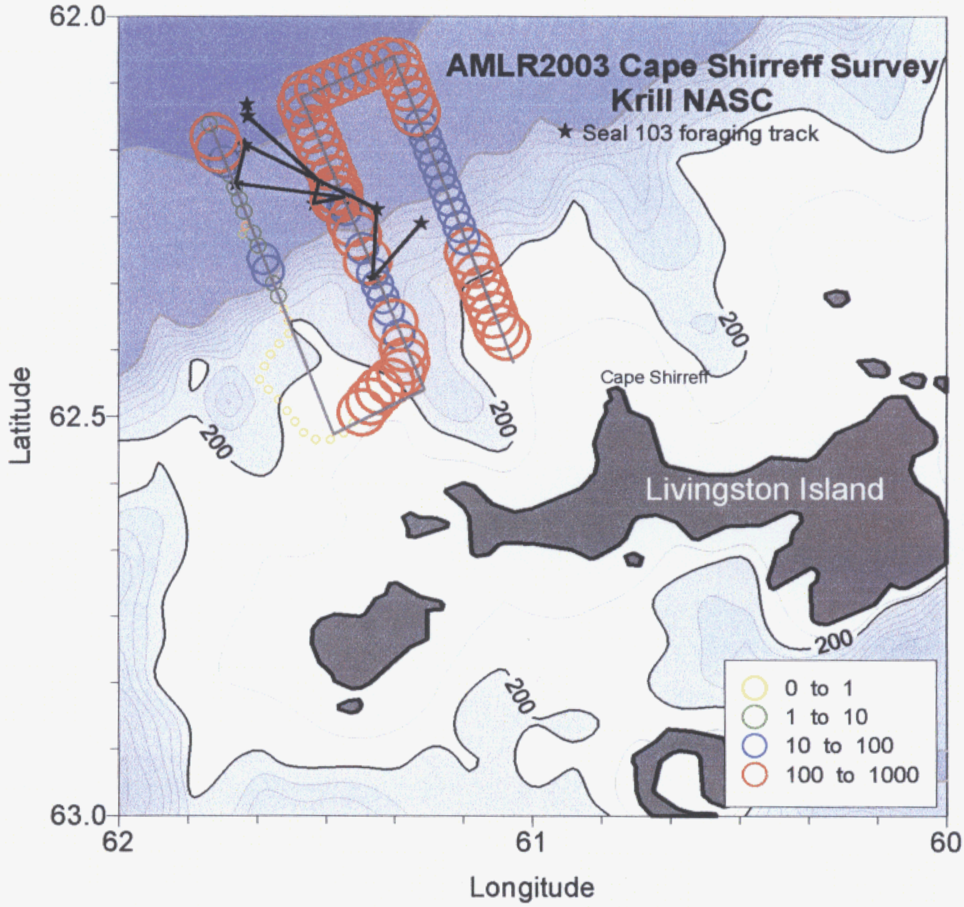


Figure 10.1. The distribution of krill NASC ($m^2/n.mi.^2$) along the track line of a small scale survey of fur seal foraging area to the northwest of Cape Shirreff, Livingston Island. The track line of a foraging fur seal (female #103) is overlaid on the survey area. The heavy gray line represents the planned survey track line, whereas the krill NASC data are plotted along the actual track line (a large iceberg prevented strict adherence to the planned survey track). The continental shelf area is unshaded to 200 meters; contour lines are for every 100m to 1,000m and at 2,000m. (Latitude is south and longitude is west).

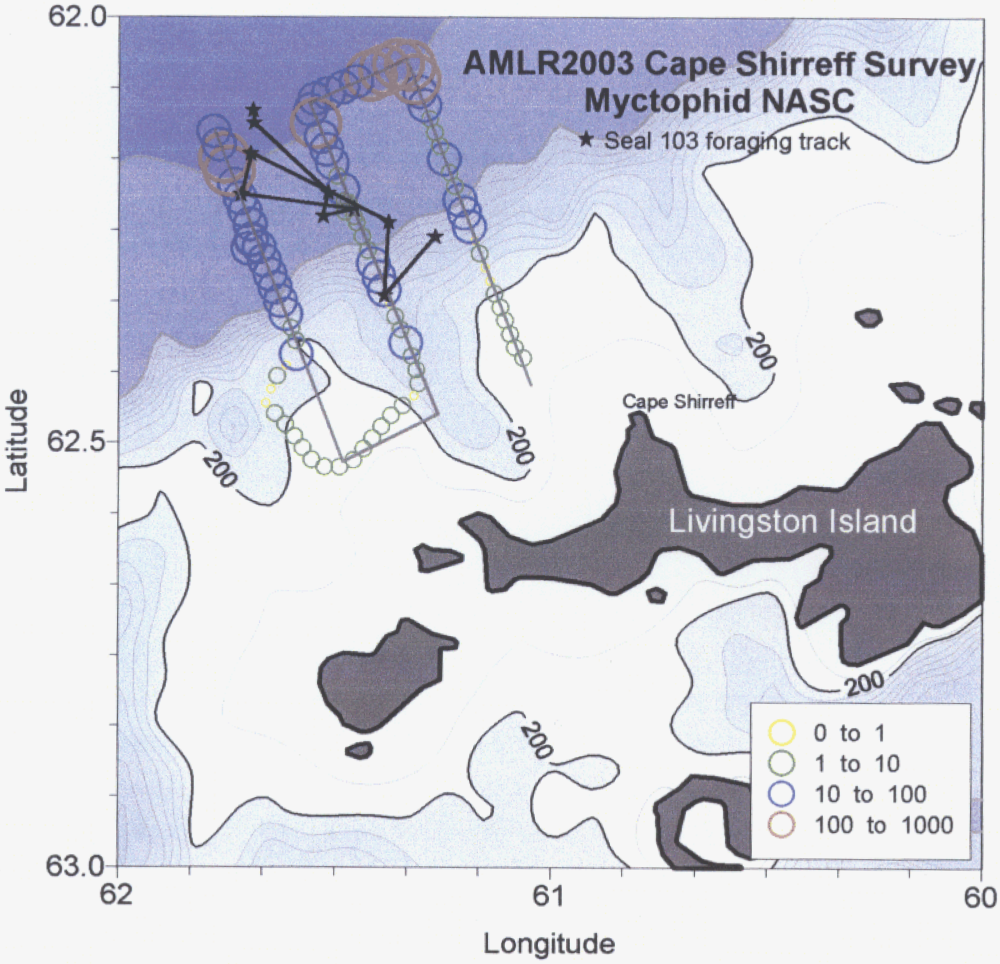


Figure 10.2. The distribution of myctophid NASC ($m^2/n.mi.^2$) along the track line of a small scale survey of fur seal foraging area to the northwest of Cape Shirreff, Livingston Island. The track line of a foraging fur seal (female #103) is overlaid on the survey area. The heavy gray line represents the planned survey track line, whereas the myctophid NASC data are plotted along the actual track line (a large iceberg prevented strict adherence to the planned survey track). The continental shelf area is unshaded to 200 meters; contour lines are for every 100m to 1,000m and at 2,000m. (Latitude is south and longitude is west).

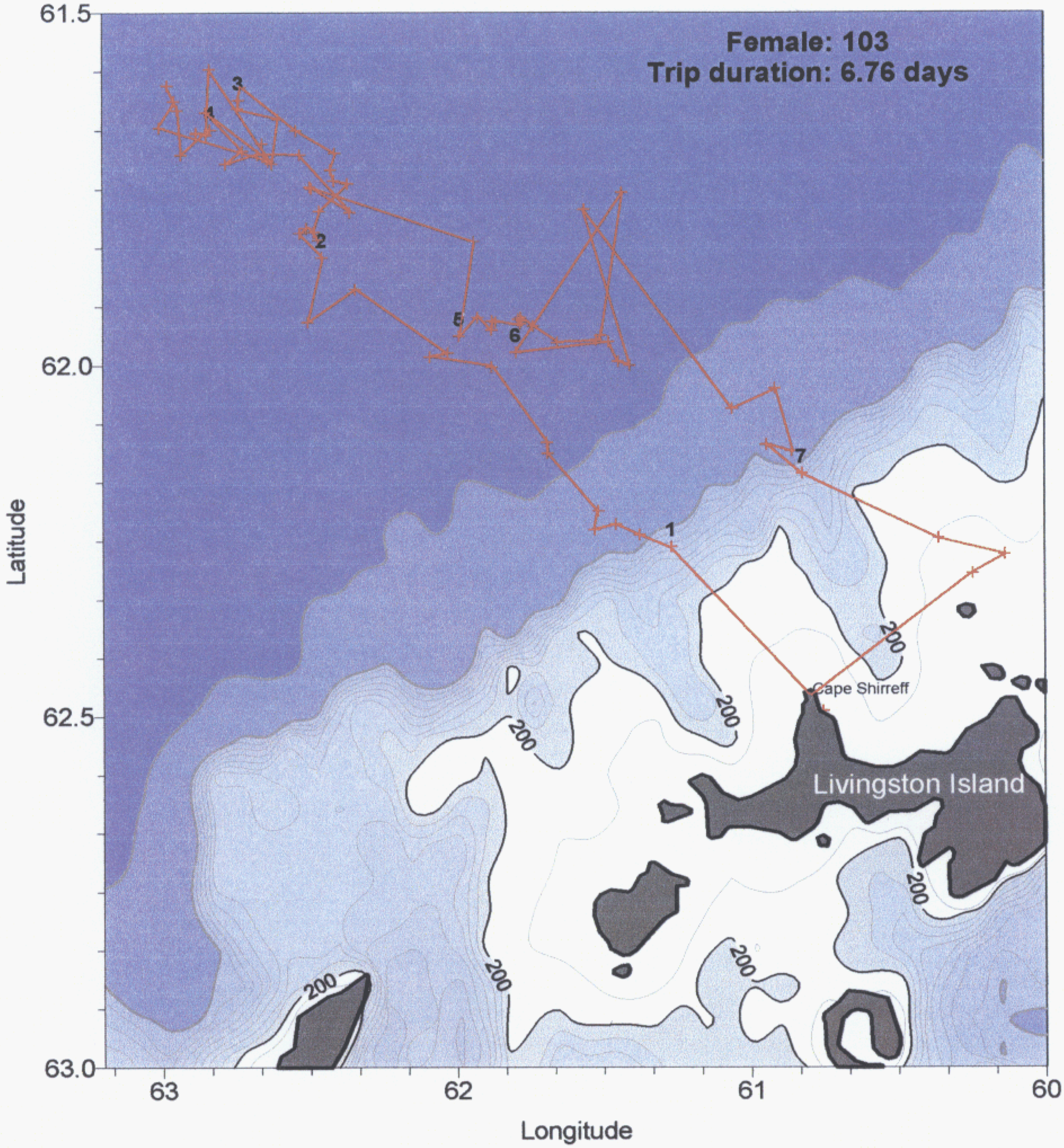


Figure 10.3. The entire track for female #103 carrying an ARGOS satellite-linked transmitter (Kiwisat 100, Sirtrack, Ltd., Havelock NZ) for a 6.76 day foraging trip. The trip began at 15:46, 31 January and ended on 8 February 2003 at 11:19. The first location of each new day is labeled sequentially. (Latitude is south and longitude is west).

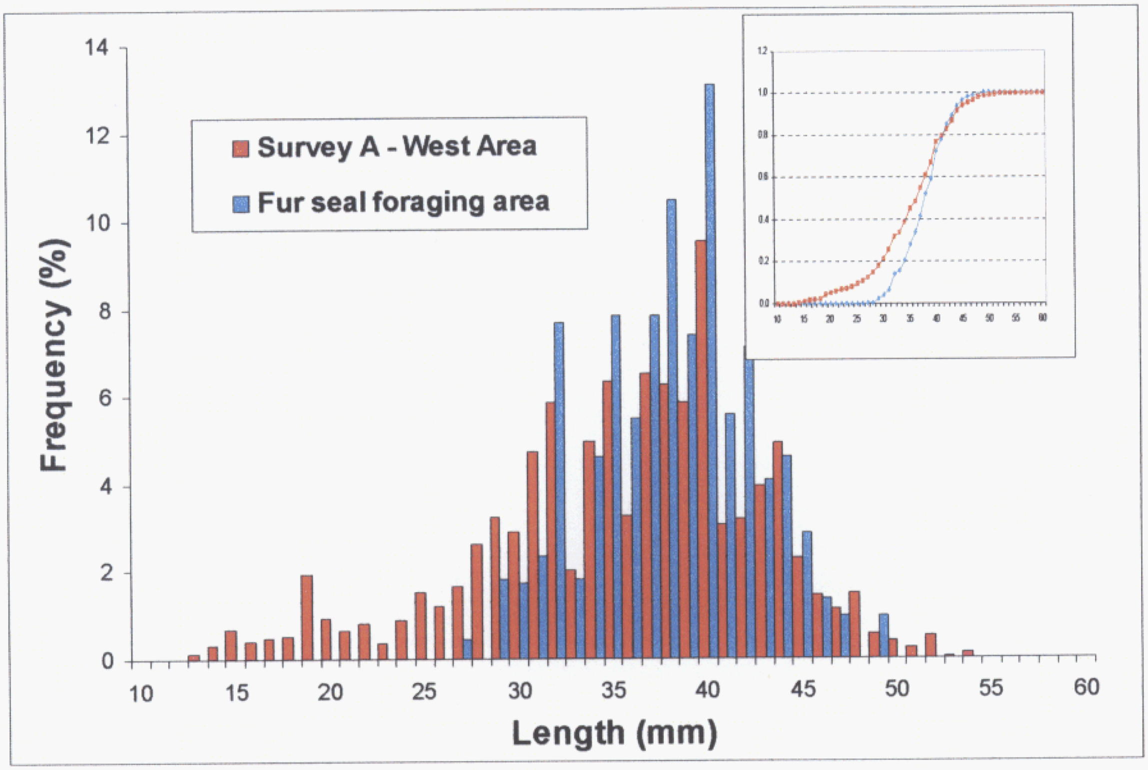


Figure 10.4. The length frequency distribution for krill sampled over the entire West Area of the U.S. AMLR survey grid for the January survey (Survey A) compared to the krill sampled during the small scale survey of fur seal foraging habitat. Inset: the cumulative frequency distributions for both data sets (Kolmogorov-Smirnov two sample test results indicate the difference in the two distributions to be significant, P=0.017.)

11. Distribution, Abundance, and Behavior of Seabirds and Mammals at Sea, in Response to Variability of Antarctic Krill and Physical Oceanography During the AMLR 2002/03 Marine Survey; submitted by Jarrod A. Santora (Legs I & II) and Shaibal S. Mitra (Legs I & II).

11.1 Objectives: Understanding how seabirds and their prey form aggregations at sea is crucial to the design and implementation of conservation policy. Multi-scale investigations of predator abundance at sea near the South Shetland Islands and Antarctic Peninsula are lacking and are usually not concurrent with continuous year to year surveys. We participated in the AMLR 2002/03 research cruise to investigate in collaboration with other marine operations the at sea abundance and behavior of seabirds and mammals. The primary objectives were to map the behavior and abundance of seabirds and mammals at sea during Legs I and II, and use the resulting data set to investigate:

A) The scale (100m to 1000's of km) at which predators and krill aggregations occur.

B) Seasonal change in distribution of foraging seabirds at sea.

C) Community foraging structure and habitat selection; by examining spatial relationships of foraging predators in response to behavior of other predators, krill swarms and physical oceanography.

D) Patterns of predator behavior and abundance in response to vertically stratified krill abundance.

11.2 Methods:

11.2.1 Seabird and Mammal Observations: Data on predator abundance and behavior were collected using binoculars while underway between stations during daylight hours. Surveys followed strip transect methods (Tasker *et al.*, 1984) and counts were made within an arc of 300m directly ahead to one side of the ship. A visual "snapshot" technique was employed and consisted of making discrete counts dependent on visibility. Data were entered into a computer program designed for mapping observations in space and in real time. 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 and therefore our data set could be aligned coupled with other data collected at sea. Individual birds, or flocks of birds, were assigned a behavioral code. The behaviors were: flying, sitting on water, milling, feeding, porpoising (penguins, seals, and dolphins), and ship-following. Ship-followers were entered when encountered and were ignored thereafter. Aerial predators which were traveling in a polarized direction were assigned a flight direction. Recorded data for mammals included traveling direction, distance from ship and behavior. In the vicinity of Elephant Island, we employed the use of a digital bathymetric map containing information of sea depth and real time calculation of distances from Elephant and Clarence Islands coupled with a data logging program. Thus, aggregations of predators were mapped as functions of distance from land and sea depth. Digital photographs of Wandering (*Diomedea exulans*), and Royal albatrosses (*D.*

epomorpha), and flukes of Humpback whales (*Megaptera novaeangliae*) were taken while at a sampling stations and underway. The photographs of albatrosses were used to identify individual birds and to examine the duration of ship-following behavior.

11.2.2 Data Manipulation: A relational database which will contain aligned spatial series of behavior and abundance estimates of predators, acoustic estimates of Antarctic krill, for the 2002/03 AMLR season is pending development. The resulting data set will be used to examine the previously stated objectives of the investigation and provide a future framework for within and between season comparisons across multiple scales. The minimum resolution of the data set is established at 100 meters and subsequent scaling procedures will be applied. Autoregressive integrated moving average models, spatial autocorrelation, cross-correlation and spectral analysis will be used to investigate the scaling phenomenon and patchiness of predator and krill aggregations. Cluster analysis and other data reduction techniques will be employed to describe the spatial pattern of the seabird community and behavior dynamics. Habitat selection by seabirds will be explored in light of patchiness of prey, net-sampled zooplankton, bathymetry, and water zone information. Once parameters have been established through exploratory analysis, an ecosystem level simulation model will be constructed to examine the redistribution of predators in response to other predators, krill variability and physical oceanography.

11.3 Accomplishments: The amount of area surveyed in each AMLR study area for both legs is contained in Table 11.1. We conducted 70 continuous predator-krill surveys between stations during Leg I and 65 during Leg II. There was an obvious reduction in daylight during Leg II which reduced our survey effort, but only by a minimal amount (338.1km). In total, we surveyed 4,688.5km for predator abundance with simultaneous hydro-acoustic surveys during both legs. The twelve most abundant and encountered seabirds during the AMLR 2002/03 survey are located in Table 11.2. In total, 33 seabird species and 12 species of marine mammals were encountered during the 2002/03 AMLR survey, and they are presented in Tables 11.3A & B and 11.4A & B, as estimates of densities calculated by the dividing the total abundance, by the total kilometers surveyed in each AMLR area.

11.4 Results and Tentative Conclusions:

11.4.1 Large Scale Distributional Patterns of Seabird and Mammal Aggregations: Distributional maps were made for making visual comparison between Legs I and II. This method is helpful for finding biological hotspots where predator aggregations were repeatedly encountered between legs. Below is a discussion of the major predator aggregations in each area which are portrayed in Figures 11.1-11.3.

11.4.1.1 Elephant Island Area: We found numerous medium sized aggregations (200+), at 62°S and 56°W, which were dominated by Chinstrap penguins (*Pygocelis antarctica*), Cape petrels (*Daption capense*), and Antarctic fulmars (*Fulmarus glacialoides*) (Figures 11.1 and 11.2). These aggregations were clustered around a 500 to 1200m isobar and the closest land mass was Aspland, Gibbs, and O'Brien Islands, which may reflect the proximity to breeding locations and or an adequate feeding area. Similar aggregations were encountered by other investigators during a cruise in 1985 (Hunt *et al.*, 1990) and in 1993 (Veit *et al.*, 1993). Eight seabird aggregations of size 300+ were clustered along the insular shelf zone at 61°S between 56° and

54°W. These aggregations were dominated by Chinstrap penguins, Black-browed albatrosses (*Thalassarche melanophrys*), Cape petrels, Antarctic fulmars, and Antarctic prions (*Pachyptila desolata*). Antarctic prions were clustered towards the eastern boundary of the Elephant Island Area to the west of Clarence Island. We did not fully sample the insular shelf on Leg I; however we did cross the western boundary of the Elephant Island Area and encountered a single aggregation of 300+ seabirds which was observed in the same location during Leg II.

11.4.1.2 Joinville Island Area: No major aggregations were encountered in this area, which may be a result of poor coverage, due extensive sea ice conditions (Table 11.1).

11.4.1.3 South Area: The largest aggregation in this area occurred at 63°S 60°W during Leg I, and consisted of approximately 900 Antarctic fulmars. The location of this aggregation was to the south-east of Deception Island and over approximately 300 meters of water near large tabular icebergs. Feeding aggregations were observed in the South Area during Leg II at 63°S and 59°W over approximately 700 meters of water. The aggregation primarily consisted of chinstrap penguins (*Pygocelis antarctica*), black-browed albatross (*Thalassarche melanophrys*), southern giant petrels (*Macronectes giganteus*), and fur seals (Figure 11.4B). Aggregations of southern giant petrels (*Macronectes giganteus*) were readily observed feeding on the remains of dead unidentified penguins.

Humpback whales were highly conspicuous in the Bransfield Strait during both surveys (Table 11.2, Figure 11.3). They were mainly clustered along the 500m isobar running west to east along the survey tract. The largest clusters occurred to the south of King George Island and to the south of Aspland, Gibbs, and O'Brien Islands where seabird aggregations were also located. Three Southern right whales were observed in the South Area surveys near rafts of sea ice. We detected a distributional shift of fur seals (*Arctocephalus gazella*), into the Bransfield Strait during Survey D which was represented in an increase in abundance (Table 11.2, South Area) and spatial pattern (Figure 11.4A & B).

11.4.1.4 West Area: Aggregations of seabirds, fur seals, and humpback whales (*Megaptera novaeangliae*), were clustered along the insular shelf in the pelagic waters north of Greenwich and Robert Islands, during Leg I (Figure 11.1), and there were no significant seabird aggregations observed here on Leg II (Figure 11.2). This may be explained for seabirds by the detected reduction in density of Chinstrap penguins (1.14 to 0.69) and Cape petrels (2.07 to 0.49) both of which are highly conspicuous predators in the AMLR survey (Table 11.2). Such a response may indicate a transition of predators to other feeding locations (i.e. Elephant Island Area) or are in the process of tracking seasonal redistribution patterns of prey. Aggregations of fur seals were largest to the north of Cape Shirreff, Livingston Island, (Figure 11.4A & B) and there was an increase in pelagic density (0.062 to 0.1679) detected throughout the survey area. Note the increase in spatial distribution in the Bransfield Strait for Leg II (South Area). Seals appear to be more clustered along the insular shelf in West Area during Leg II.

11.4.2 Behavioral Response by Cape Petrels (*Daption capense*): Cape petrels (*Daption capense*), are an abundant and highly gregarious predator in the AMLR survey region (Table 11.2), are known to forage on krill by sub-surface feeding (Veit *et al.*, 1993), and readily form dense aggregations which are easy to monitor for changes in behavior. Table 11.5 shows a contrast in the density of behavior for Cape petrels within the West Area. The density of birds observed feeding did not change substantially, however other behaviors indicative of feeding did change drastically. Sitting on the water surface and milling, which is a continuous change in flight direction and is considered to be a mechanism of narrowing the search space for prey, declined from 0.332 to 0.097 for sitting and, 1.2 to 0.16 for milling birds per kilometer surveyed. This reduction in behavior may be dictated by the reduction in total Cape petrels in the West Area during Leg II. This result is interesting because Cape petrels congregate and search for prey together, and analysis of behavior may be used as a more informative indication of foraging success. More effort should be made to relate foraging behavior by Cape petrels to krill abundance and in response to behaviors of other seabirds.

11.4.3 Spatial Correlation of Seabird Abundance and Acoustic Krill Abundance: Counts of seabirds were conducted underway simultaneously with acoustic estimation of krill abundance between AMLR stations. All seabird observations were assigned a time and spatial position and were subsequently aligned with krill abundances. The largest resolution of our count window was set at 100m and krill densities are pending proper alignment with seabird data files. A sequenced example is presented in Figure 11.5, here as a visual comparison of aligned predator and krill abundance. The sequence was sampled on 19 February 2003 (start position: -59.9°S -55°W, end position: -61°S -55°W), the spatial interval is 300m and transect length is approximately 120km. Krill abundance was summed over a depth range of 10 to 200m, and transects were pieced together to portray a large scale gradient. As shown in Figure 11.5, krill abundance is reflected by seabird abundance. Such spatial correlation was found in many sequences sampled during AMLR 2002/03, and suggests at the total seabird community level, predators are efficient at tracking prey patchiness. Thus, this example sheds light on the fact that counts of seabirds might be utilized to monitor krill abundance and the spatial scale at which predators are coupled to prey patches. This pattern can also be used to assess annual correlation between predators and prey.

11.4.4 Conclusions: The importance of seabirds and mammals as indicators of the marine environment is unquestionable and the data collected at sea in collaboration with the 2002/03 AMLR survey, will provide insight on how pelagic predators respond to changes in patchiness of Antarctic krill and physical oceanography. A current investigation is underway involving a much smaller survey area to the north of Elephant Island during the month of December (Santora and Veit 2003, in prep). The primary objective is to examine the fine scale behavior and distribution patterns of krill and seabirds. This study will be contrasted with the larger AMLR survey in an attempt to describe the spatial processes which govern seabirds and krill aggregations at Elephant Island. The data collected will provide a framework for developing conservation policies and improve concepts of seabird foraging ecology. Our survey design will investigate the long term effects of environmental conditions (i.e. global warming) dictated to predator populations in the South Shetland Islands. Harvesting of krill may influence the breeding biology of land-based predators through the reduction of an available food supply, however this may be relatively hard to detect at coarse spatial scales and short time periods. Monitoring the behavioral interactions of predators at fine scales may reveal interesting aspects of their foraging ecology and distributional biology. For instance, predators searching for prey readily respond to the behavior of their constituents over some localized space. Those spatial characteristics have not yet been characterized, and therefore little is known about how seabirds interact with each other to find prey across multiple scales in the Antarctic. There has been evidence suggesting that they may cue on a combination of physical regimes (i.e. hydrographic fronts), and the level of patchiness of their prey (Veit *et al.*, 1993), and these responses are ultimately scale-dependent. However, the mechanism has not been fully established. An understanding of the foraging ecology by seabirds through analysis of behavior will provide the means for interpreting the patterns of distribution through the use of exploratory data analysis and simulation models.

11.5 Disposition of Data: After all data have been thoroughly proofed and properly scaled, 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) 982-3997; email: jasantora@yahoo.com

11.6 Problems and Suggestions: Future effort in mapping of pelagic predators at sea would be benefited by attaining a digitized bathymetric map of the South Shetland Islands for use in a real time, GPS fed, data logging program. This would enable the collection of fine scale data relating predator observations to sea depth and as a function of distance from the nearest land mass. Aerial sub-surface foraging predators were observed feeding in the upper three meters of the water column. By using a floating Manta net, a sampling protocol could be established which will provide information relating foraging patterns of seabirds to zooplankton in the surface water. This may provide support for the inability of the acoustic echosounder to sample the first 10 meters of the water column when investigating the patchiness of aerial predator behavior and abundance.

11.7 Acknowledgements: We would like to thank Richard R. Veit for providing financial assistance and use of a laptop computer for data collection. Roger Hewitt, Andy Dizon, and Daniel Doolittle provided their excellent assistance in sequencing krill series to be aligned with predator abundance. Mike Force assisted in data collection while at stations, and provided an extensive amount of seabird information about the Drake Passage. We would also like to thank the crew of the R/V *Yuzhmorgeologyia* for assistance in the bridge and supplying a GPS feed for our computer.

11.8 References:

Hunt, G.L., Heinemann, D., Veit, R.R., Heywood, R.B., Everson, I. 1990. The distribution, abundance and community structure of marine birds in southern Drake Passage and Bransfield Strait, Antarctica. *Continental Shelf Research* 10(3): 243-257.

Santora, A. J., and Veit, R.R. 2003. Physical and biological determinants of seabird and Antarctic krill aggregations at Elephant Island, Antarctica. (in prep).

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

Veit, R.R, Nevitt, G., Silverman, E., Groom, M., Agler, B., Grunbaum, D., and Secord, D. 1993. AMLR program: Foraging behavior and spatial pattern of pelagic birds at sea. *Antarctic Journal of the U.S.* 28(5): 198-200.

Table 11.1. Survey effort for seabird and mammal observations during AMLR 2002/03 presented here in kilometers.

Survey Area	Leg I	Leg II	TOTAL
Elephant	1184.7	926.1	2110.8
Joinville	28	134.9	162.9
South	499.4	464.9	964.3
West	801.2	649.3	1450.5
TOTAL	2513.3	2175.2	4688.5

Table 11.2. Top 12 seabirds encountered during AMLR 2002/03 survey presented as density estimates as a function of total kilometers surveyed.

Common Name	Density #/Km
Chinstrap Penguin	1.1323
Cape Petrel	0.9272
Antarctic Fulmar	0.6516
Wilson's Storm Petrel	0.3116
Black-bellied Storm Petrel	0.257
Black-browed Albatross	0.2459
Southern Giant Petrel	0.0866
Antarctic Prion	0.0727
Adelie Penguin	0.0685
Grey-headed Albatross	0.0247
South Polar Skua	0.0247
White-chinned Petrel	0.0235

Table 11.3A. Seabird densities recorded for Leg I AMLR 2002/03. Densities are presented as total abundance divided by the distance surveyed (see Table 11.1 also).

Common Name	Latin Name	Elephant	Joinville	South	West	Total
Gentoo Penguin	*Pygocelis papua*	0	0	0.028	0	0.0056
Adelie Penguin	*Pygocelis adelie*	0	0	0.6408	0	0.1273
Chinstrap Penguin	*Pygocelis antarctica*	1.3767	0.1786	0.3885	1.1495	1.0946
Unknown Penguin	*Pygocelis sp.*	0.0675	0.1071	0.3885	0	0.1102
Macaroni Penguin	*Eudyptes chrysolophus*	0.0068	0	0	0	0.0032
Wandering Albatross	*Diomedea exulans*	0.0042	0	0	0.0037	0.0032
Royal Albatross	*Diomedea epomorpha*	0.0008	0	0	0.0037	0.0016
Large Uknown Albatross	*Diomedea sp.*	0	0	0	0.0037	0.0012
Black-browed Albatross	*Thalassarche melanophrys*	0.0498	0.0357	0.02	0.0374	0.0398
Grey-headed Albatross	*Thalassarche chrysostoma*	0.0017	0	0	0.0037	0.002
Light-mantled Sooty Albatross	*Phoebetria palpebrata*	0.0059	0	0	0.0012	0.0032
Northern Giant Petrel	*Macronectes halli*	0.0017	0	0	0	0.0008
Southern Giant Petrel	*Macronectes giganteus*	0.0371	0	0.036	0.0374	0.0366
Unknown Giant Petrel	*Macronectes sp.*	0	0	0	0	0
Antarctic Fulmar	*Fulmarus glacialoides*	0.7183	2.8571	1.7521	0.5691	0.9
Antarctic Petrel	*Thalassoica antarctica*	0.0008	0	0	0.0012	0.0008
Cape Petrel	*Daption capense*	0.9935	0.1429	0.3684	2.0756	1.2048
Snow Petrel	*Pagodroma nivea*	0	0	0	0	0
White-headed Petrel	*Pterodroma lessonii*	0	0	0	0	0
Soft-plumaged Petrel	*Pterodroma mollis*	0	0	0	0	0
White-chinned Petrel	*Procellaria aequinoctialis*	0.0169	0	0	0.0225	0.0151
Sooty Shearwater	*Puffinus griseus*	0	0	0	0	0
Antarctic Prion	*Pachyptila desolata*	0.0177	0	0	0.0287	0.0175
Thin-billed Prion	*Pachyptila belcheri*	0	0	0	0	0
Unknown Prion	*Pachyptila sp.*	0.0008	0	0	0	0.0004
Blue Petrel	*Halobaena carulea*	0.0008	0	0	0.0037	0.0016
Wilson's Storm Petrel	*Oceanites oceanicus*	0.2431	0.5	0.2883	0.1635	0.2296
Black-bellied Storm Petrel	*Fregetta tropica*	0.2937	0.2143	0.1081	0.156	0.2121
Common Diving Petrel	*Pelacanoides urinatrix*	0.0008	0	0	0	0.0004
Antarctic Shag	*Phalacrocorax articeps*	0	0	0	0	0
Brown Skua	*Catharacta antarctica*	0.0017	0	0.008	0.0025	0.0032
South Polar Skua	*Catharacta maccormicki*	0.0135	0	0.03	0.0225	0.0195
Unknown Skua	*Catharacta sp.*	0.0059	0	0.032	0.0012	0.0095
Parasitic Jaeger	*Stercorarius parasiticus*	0	0	0	0	0
Kelp Gull	*Larus Dominicanus*	0.0008	0	0	0	0.0004
Artic Tern	*Sterna paradisaea*	0.0008	0	0.002	0	0.0008
Antarctic Tern	*Sterna vittata*	0.0169	0	0.022	0.02	0.0187
Pale-faced Sheathbill	*Chionis alba*	0	0	0	0	0

Table 11.3B. Seabird densities recorded for Leg II AMLR 2002/03. Densities are presented as total abundance divided by the distance surveyed (see Table 11.1 also).

Common Name	Latin Name	Elephant	Joinville	South	West	Total
Gentoo Penguin	*Pygocelis papua*	0.0238	0	0.0946	0	0.0303
Adelie Penguin	*Pygocelis adelie*	0	0	0.0022	0	0.0005
Chinstrap Penguin	*Pygocelis antarctica*	2.0041	0.4967	0.4022	0.69	1.176
Unknown Penguin	*Pygocelis sp.*	0.0292	0.0741	0.3528	0.0508	0.1076
Macaroni Penguin	*Eudyptes chrysolophus*	0.0086	0	0	0	0.0037
Wandering Albatross	*Diomedea exulans*	0.0054	0	0	0	0.0023
Royal Albatross	*Diomedea epomorpha*	0	0	0	0	0
Large Unknown Albatross	*Diomedea sp.*	0	0	0	0	0
Black-browed Albatross	*Thalassarche melanophrys*	0.5809	0.2595	0.826	0.1479	0.4841
Grey-headed Albatross	*Thalassarche chrysostoma*	0.0713	0.0297	0.0559	0.0231	0.051
Light-mantled Sooty Albatross	*Phoebetria palpebrata*	0.0173	0.0074	0	0	0.0078
Northern Giant Petrel	*Macronectes halli*	0.0086	0.0148	0.0043	0	0.0055
Southern Giant Petrel	*Macronectes giganteus*	0.1317	0.1408	0.2517	0.0862	0.1444
Unknown Giant Petrel	*Macronectes sp.*	0.0022	0	0	0	0.0009
Antarctic Fulmar	*Fulmarus glacialoides*	0.541	1.6976	0.1011	0.0246	0.3646
Antarctic Petrel	*Thalassoica antarctica*	0	0	0	0	0
Cape Petrel	*Daption capense*	1.0658	0.0667	0.0043	0.4944	0.6064
Snow Petrel	*Pagodroma nivea*	0	0	0	0.0031	0.0009
White-headed Petrel	*Pterodroma lessonii*	0.0011	0	0	0	0.0005
Soft-plumaged Petrel	*Pterodroma mollis*	0.013	0	0	0	0.0055
White-chinned Petrel	*Procellaria aequinoctialis*	0.0572	0.0074	0.0022	0.0262	0.0331
Sooty Shearwater	*Puffinus griseus*	0.0011	0	0	0.0031	0.0014
Antarctic Prion	*Pachyptila desolata*	0.2894	0	0	0.0447	0.1365
Thin-billed Prion	*Pachyptila belcheri*	0.0076	0	0	0	0.0032
Unknown Prion	*Pachyptila sp.*	0.0054	0	0	0	0.0023
Blue Petrel	*Halobaena carulea*	0.0097	0	0	0.0246	0.0115
Wilson's Storm Petrel	*Oceanites oceanicus*	0.3531	0.3336	0.6991	0.288	0.4064
Black-bellied Storm Petrel	*Fregetta tropica*	0.4945	0.2891	0.0774	0.2141	0.3089
Common Diving Petrel	*Pelacanoides urinatrix*	0.0086	0	0	0	0.0037
Antarctic Shag	*Phalacrocorax articeps*	0.0011	0	0	0	0.0005
Brown Skua	*Catharacta antarctica*	0.0022	0	0.0344	0	0.0083
South Polar Skua	*Catharacta maccormicki*	0.0086	0.0148	0.0946	0.02	0.0308
Unknown Skua	*Catharacta sp.*	0	0	0.0538	0	0.0115
Parasitic Jaeger	*Stercorarius parasiticus*	0	0	0.0022	0	0.0005
Kelp Gull	*Larus Dominicanus*	0	0	0	0	0
Artic Tern	*Sterna paradisaea*	0	0	0	0	0
Antarctic Tern	*Sterna vittata*	0.0043	0.0074	0.0043	0.0108	0.0064
Pale-faced Sheathbill	*Chionis alba*	0.0011	0	0	0	0.0005

Table 11.4A & B. Mammal densities computed for surveyed kilometer space for each AMLR survey area during Legs I (A) and II (B).

A) Leg I

Common Name	Latin Name	Elephant	Joinville	South	West	Total
Antarctic Fur Seal	*Arctocephalus gazella*	0.0625	0	0.008	0.0624	0.0509
Leopard Seal	*Hydrurga leptonyx*	0	0	0	0	0
Weddell Seal	*Leptonychotes weddellii*	0	0	0.004	0	0.0008
Southern Elephant Seal	*Mirounga leonia*	0	0	0.002	0	0.0004
Long-finned Pilot Whale	*Globicephala melas*	0	0	0.004	0.0399	0.0135
Hourglass Dolphin	*Lagenorhynchus australis*	0	0	0	0	0
Southern Bottlenose Whale	*Hyperoodon planifrons*	0.0008	0	0	0.0012	0.0008
Southern Right Whale	*Eubalaena australis*	0	0	0	0.0012	0.0004
Antarctic Minke Whale	*Balaenoptera bonaerensis*	0.011	0	0.006	0.0037	0.0076
Fin Whale	*Balaenoptera physalus*	0	0	0.002	0	0.0004
Humpback Whale	*Megaptera novaeangliae*	0.0084	0.0714	0.1161	0.0424	0.0414
Unknown Baleen Whale		0.0042	0	0.002	0.0025	0.0032

B) Leg II

Common Name	Latin Name	Elephant	Joinville	South	West	Total
Antarctic Fur Seal	*Arctocephalus gazella*	0.0788	0.0445	0.1162	0.1679	0.1113
Leopard Seal	*Hydrurga leptonyx*	0	0	0	0.0015	0.0005
Weddell Seal	*Leptonychotes weddellii*	0	0	0.0022	0.0015	0.0009
Southern Elephant Seal	*Mirounga leonia*	0	0	0	0	0
Long-finned Pilot Whale	*Globicephala melas*	0	0	0	0	0
Hourglass Dolphin	*Lagenorhynchus australis*	0.0086	0	0	0.0092	0.0064
Southern Bottlenose Whale	*Hyperoodon planifrons*	0.0032	0	0.0022	0	0.0018
Southern Right Whale	*Eubalaena australis*	0	0	0.0043	0.0031	0.0018
Antarctic Minke Whale	*Balaenoptera bonaerensis*	0.0032	0.0148	0.0022	0.0139	0.0069
Fin Whale	*Balaenoptera physalus*	0	0	0	0.0046	0.0014
Humpback Whale	*Megaptera novaeangliae*	0.0205	0.1483	0.0731	0.0139	0.0377
Unknown Baleen Whale		0.0011	0	0	0.0015	0.0009

Table 11.5. Observed densities of behavior exhibited by Cape petrels in the West Area for the AMLR 2002/03 survey.

Behavior	Leg I	Leg II
Feeding	0.136	0.135
Sitting	0.332	0.097
Milling	1.2	0.16

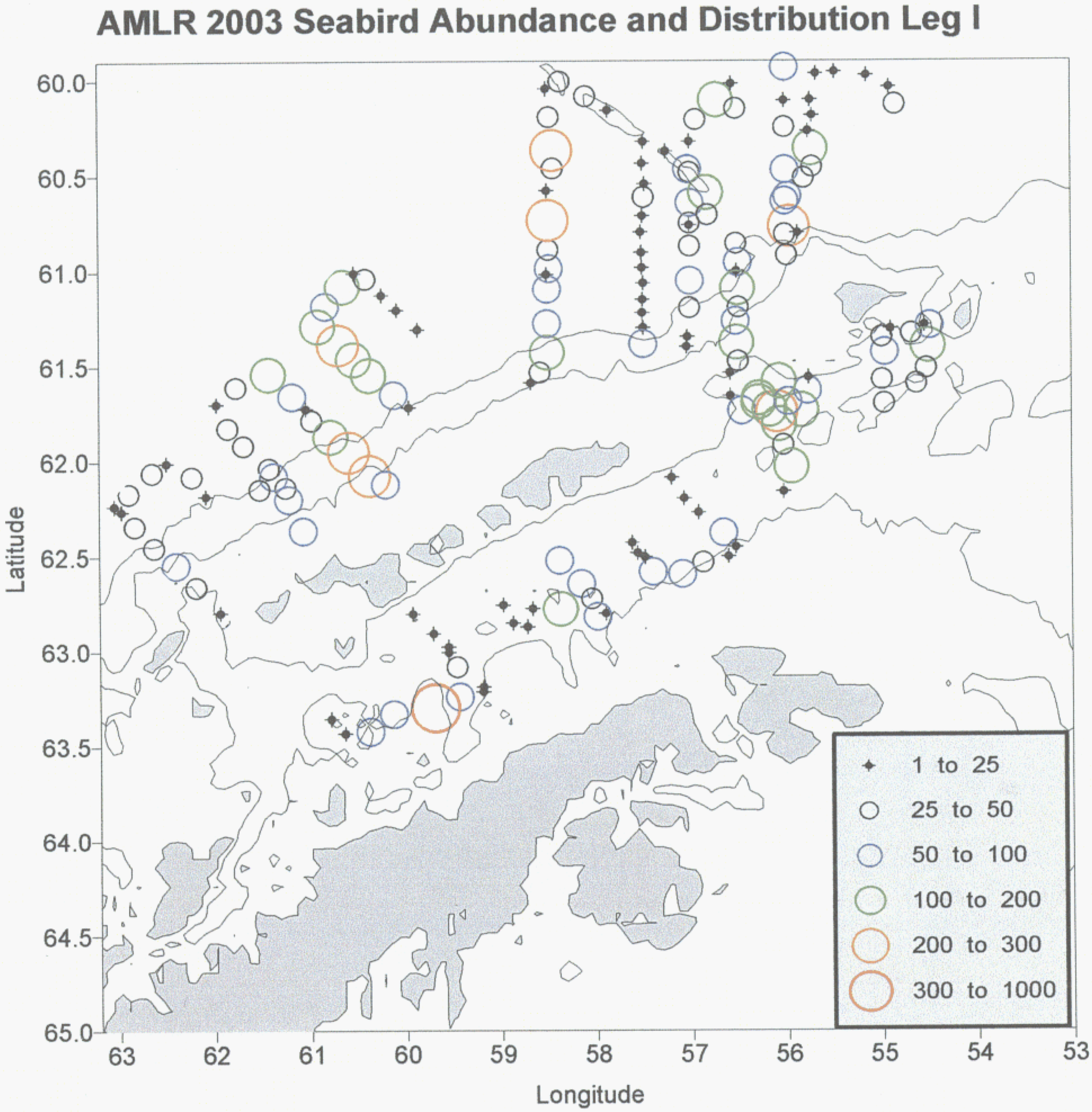


Figure 11.1. Total seabird abundance for AMLR 2002/03 Leg I survey. Abundance is presented here as spatial bins of 10 nautical miles. (Latitude is south and longitude is west).

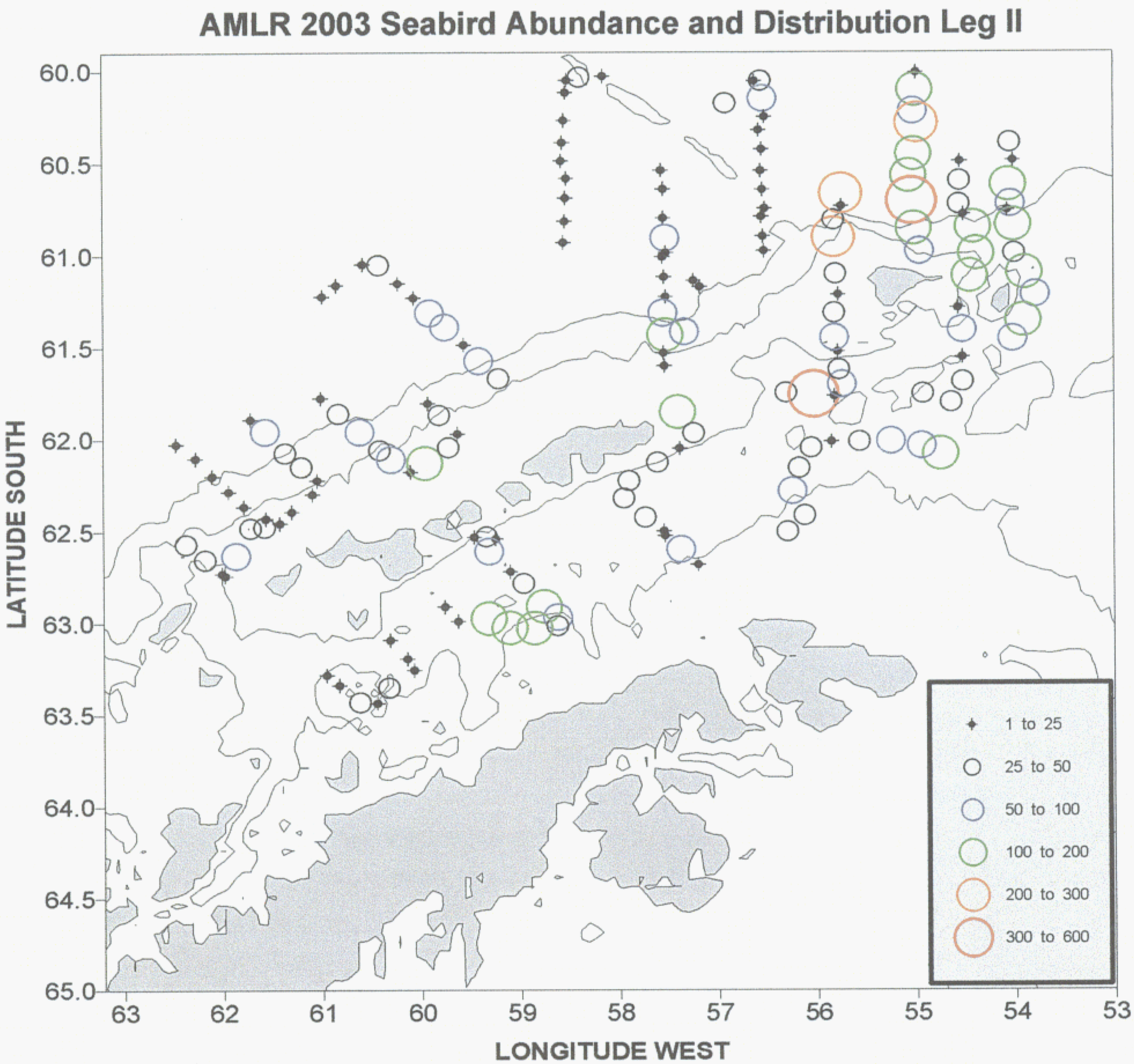


Figure 11.2. Total seabird abundance for AMLR 2002/03 Leg II survey. Abundance is presented here as spatial bins of 10 nautical miles.

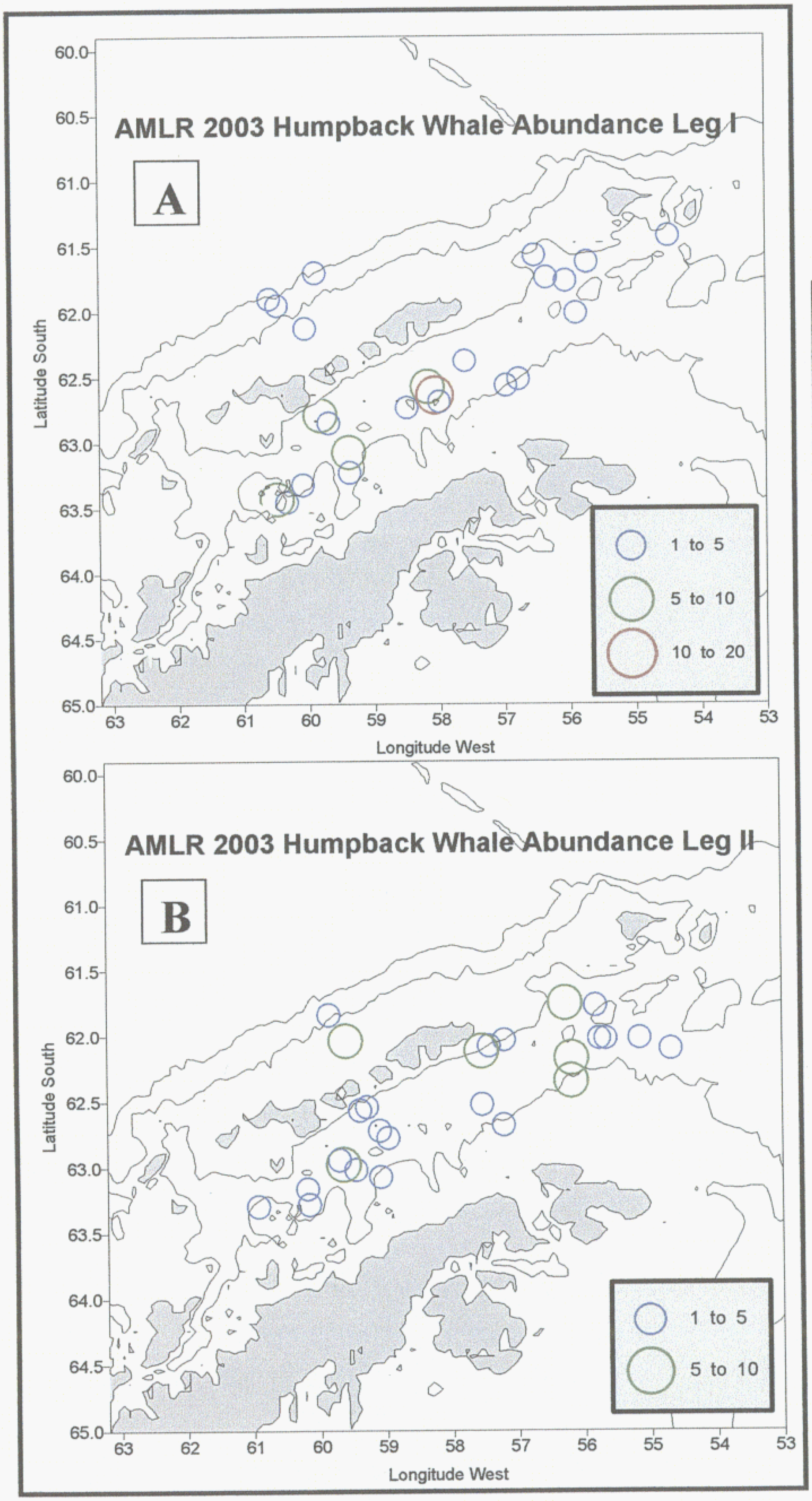


Figure 11.3A & B. Humpback whale distribution for 2002/03 AMLR survey. Abundances are presented as observed whale number per 10 nautical miles.

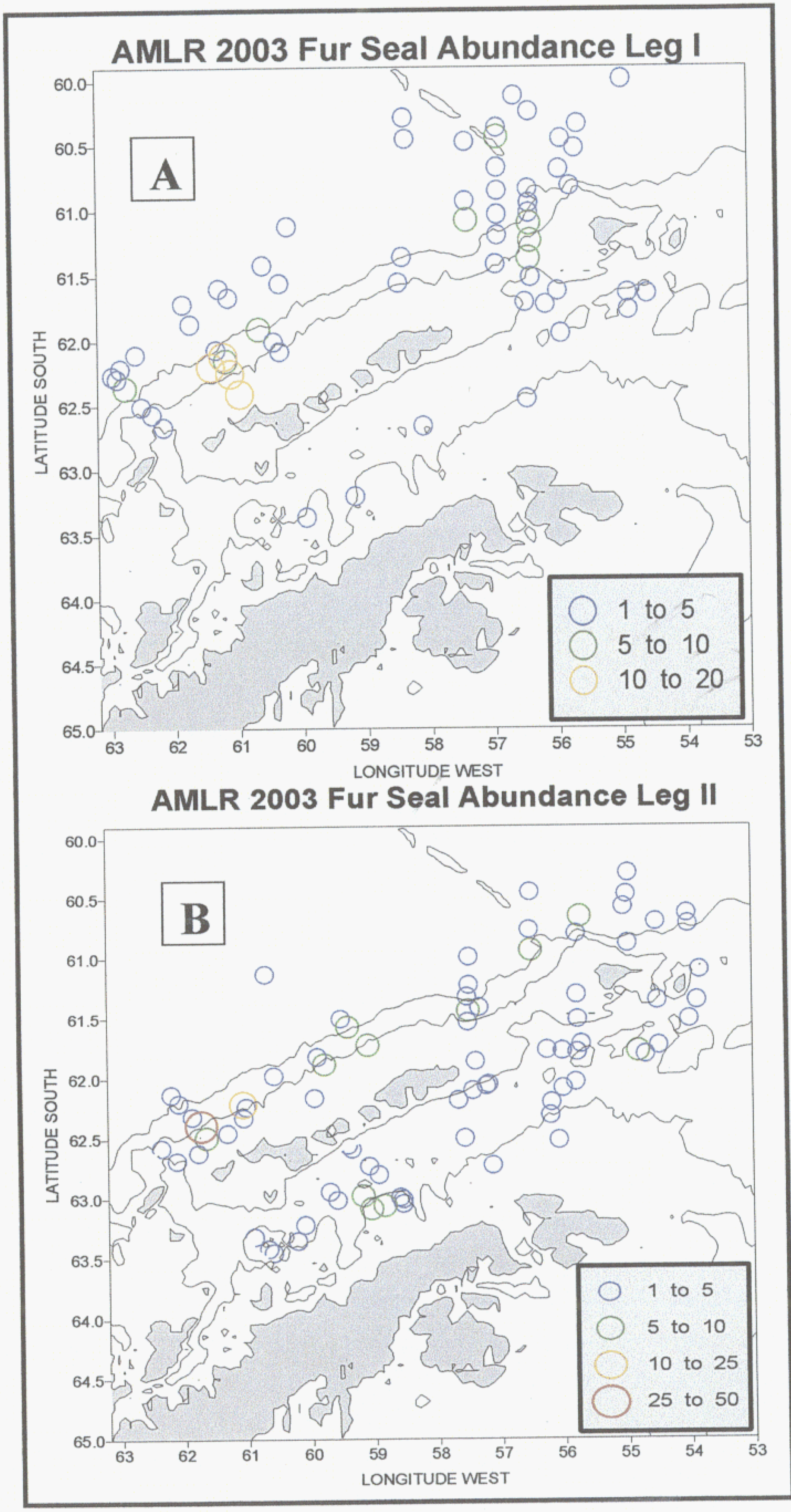


Figure 11.4A & B. Fur seal distribution for 2002/03 AMLR survey. Abundance is presented as observed seal number per 10 nautical miles.

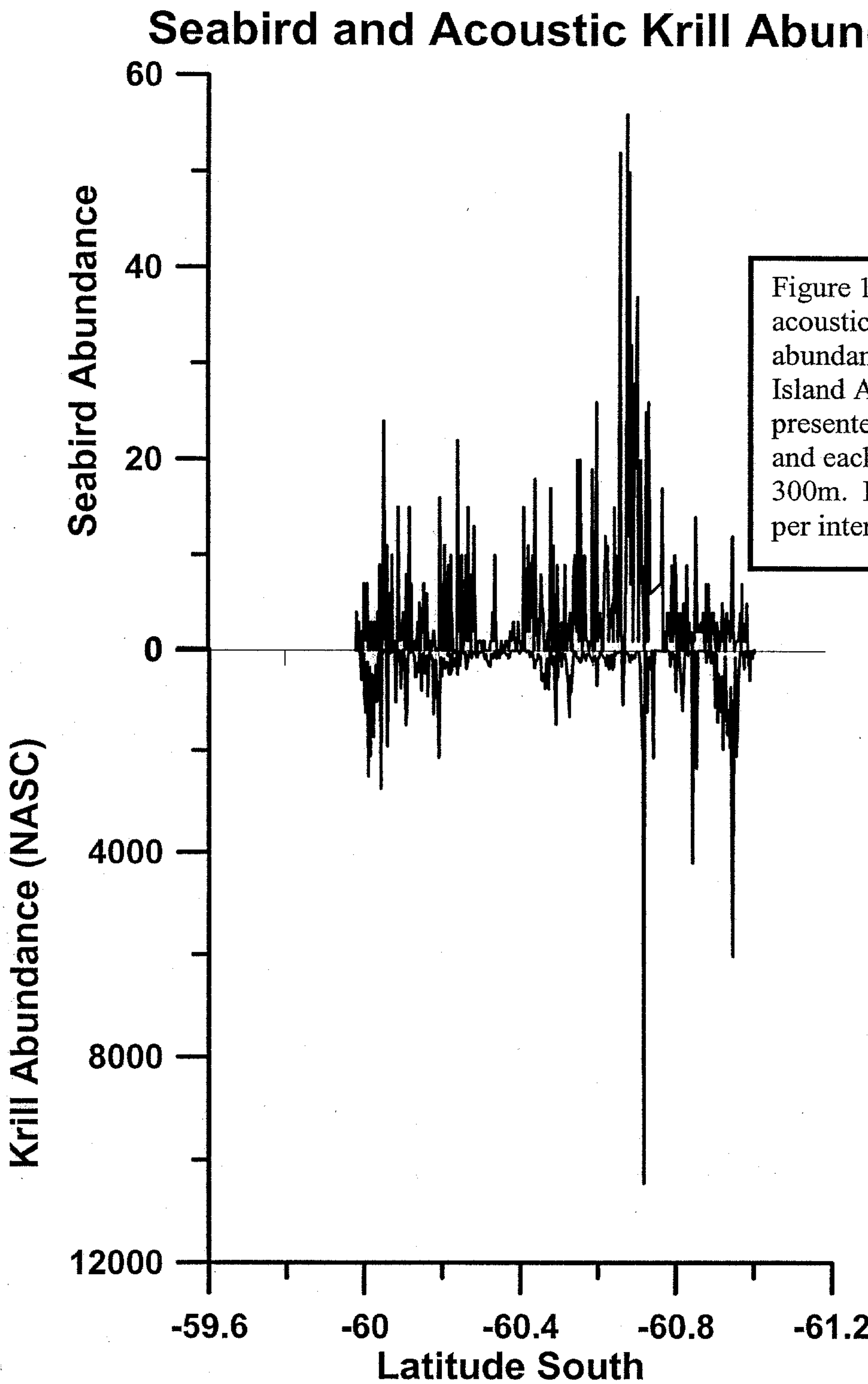


Figure 11.5. Seabird and acoustically estimated krill abundance in the Elephant Island Area. The sequence presented here is ≈120km, and each spatial interval is 300m. Bird abundance is # per interval.

RECENT TECHNICAL MEMORANDUMS

Copies of this and other NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167. Paper copies vary in price. Microfiche copies cost $9.00. Recent issues of NOAA Technical Memorandums from the NMFS Southwest Fisheries Science Center are listed below:

NOAA-TM-NMFS-SWFSC-345 Counts of northern elephant seals at rookeries in the Southern California Bight: 1981-2001.
M.S. Lowry
(November 2002)

346 U.S. Pacific marine mammal stock assessments: 2002.
J.V. Carretta, M.M. Muto, J. Barlow, J. Baker, K.A. Forney, and M. Lowry
(December 2002)

347 Comprehensive evaluation of shallow reef fish populations at French Frigate Shoals, Midway Atoll, Northwestern Hawaiian Islands (1992/93, 1995-2000).
E.E. DeMARTINI, F.A. PARRISH, and R.C. BOLAND
(December 2002)

348 Ichthyoplankton and station data for surface (Manta) and oblique (Bongo) plankton tows for California Cooperative Oceanic Fisheries Investigation Survey Cruises in 2001.
D.A. AMBROSE, R.L. CHARTER, and H.G. MOSER
(January 2003)

349 Report of ecosystem studies conducted during the 2001 Oregon, California and Washington (ORCAWALE) marine mammal survey on the research vessels *David Starr Jordan* and *McArthur*.
V.A. PHILBRICK, P.C. FIEDLER, L.T. BALLANCE, and D.A. DEMER
(January 2003)

350 AMLR 2001/2002 field season report: Objectives, accomplishments, and tentative conclusions.
J.D. LIPSKY, Editor
(March 2003)

351 Ichthyoplankton and station data for surface (Manta) and oblique (Bongo) plankton tows for Mini-California Cooperative Oceanic Fisheries Investigations Survey Cruises in 1997 and 1998.
D.A. AMBROSE, R.L. CHARTER, and H.G. MOSER
(May 2003)

352 Ichthyoplankton and station data for surface (Manta) and oblique (Bongo) plankton tows for California Cooperative Oceanic Fisheries Investigations Survey Cruises in 2002.
S.R. CHARTER, R.L. CHARTER, and H.G. MOSER
(July 2003)

353 Pacific harbor seal, *Phoca vitulina richardii*, census in California during May-July 2002.
M.S. LOWRY and J.V. CARRETTA
(September 2003)

354 "Suggested guidelines for recovery factors for endangered marine mammals"
D.L. TAYLOR, M. SCOTT, J. HEYNING, and J. BARLOW
(September 2003)