The U.S. Antarctic Marine Living Resources (AMLR) program: 1996–1997 field season activities

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The U.S. Antarctic Marine Living Resources (AMLR) program has developed and conducted a research plan tailored to the goals of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), part of the Antarctic Treaty System. The Convention manages antarctic fisheries to conserve targeted species while also taking into account the impact fishing activities might have on other living organisms in the antarctic ecosystem. CCAMLR's unique management regime has come to be known as the "ecosystem approach." In keeping with CCAMLR's mandate, the impact of the krill (*Euphausia superba*) fishery upon dependent predators must be understood.

The AMLR program monitors finfish and krill fisheries, projects sustainable yields where possible, and formulates management advice and options. In addition, the program conducts field research with the long-term objective of describing the functional relationships between krill, their predators, and their environment. The field program is based on two working hypotheses:

- Krill predators respond to changes in the availability of their food.
- The distribution of krill is affected by both physical and biological aspects of their environment.

In the previous eight seasons, the AMLR field program included a research cruise near Elephant, Clarence, and King George Islands, which are among the South Shetland Islands at the tip of the Antarctic Peninsula. Land-based studies were conducted at a field camp on Seal Island, off the northwest coast of Elephant Island. Because Seal Island was found to be unsafe due to landslide hazards, however, research at the camp was curtailed. Beginning this season, the AMLR study area was expanded to include a larger area around the South Shetland Islands, and a new field camp was established at Cape Shirreff, Livingston Island (figure 1). As in the past, research was also conducted at Palmer Station, a U.S. station on Anvers Island farther south on the Peninsula.

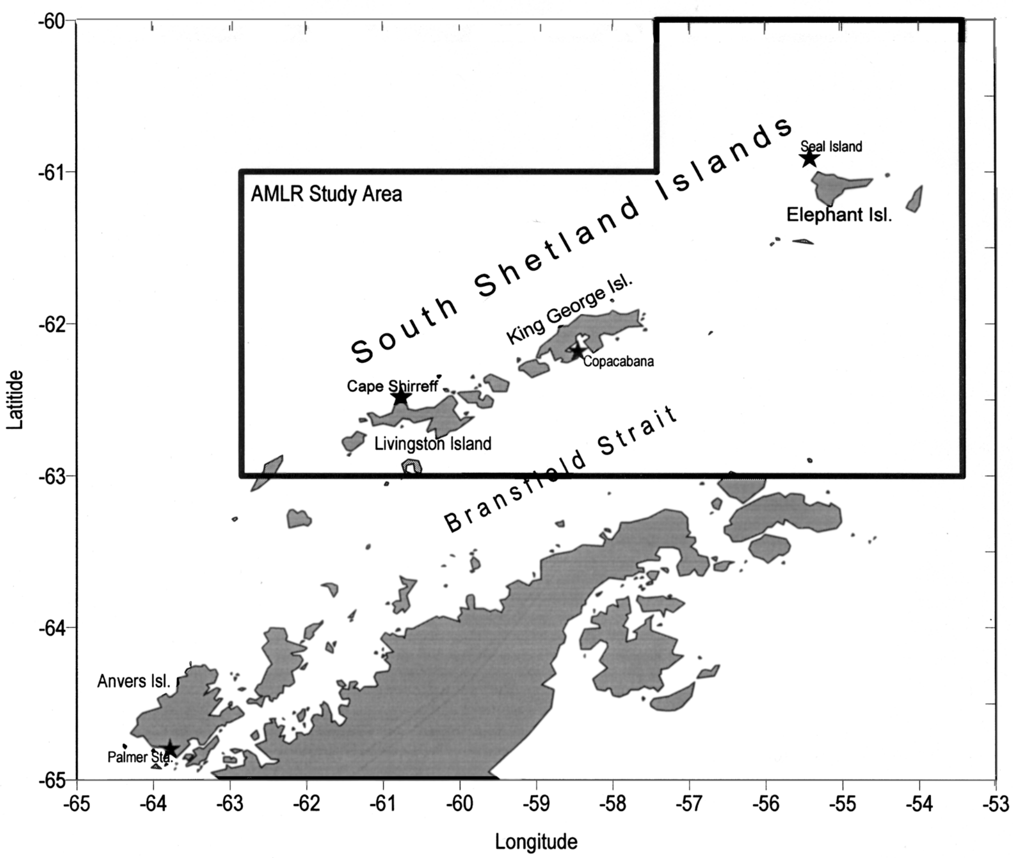

Figure 1. Locations of the U.S. AMLR field program: research cruise near Elephant, Clarence, King George, and Livingston Islands (AMLR study area) and land-based studies at Cape Shirreff, Seal Island, and Palmer Station.

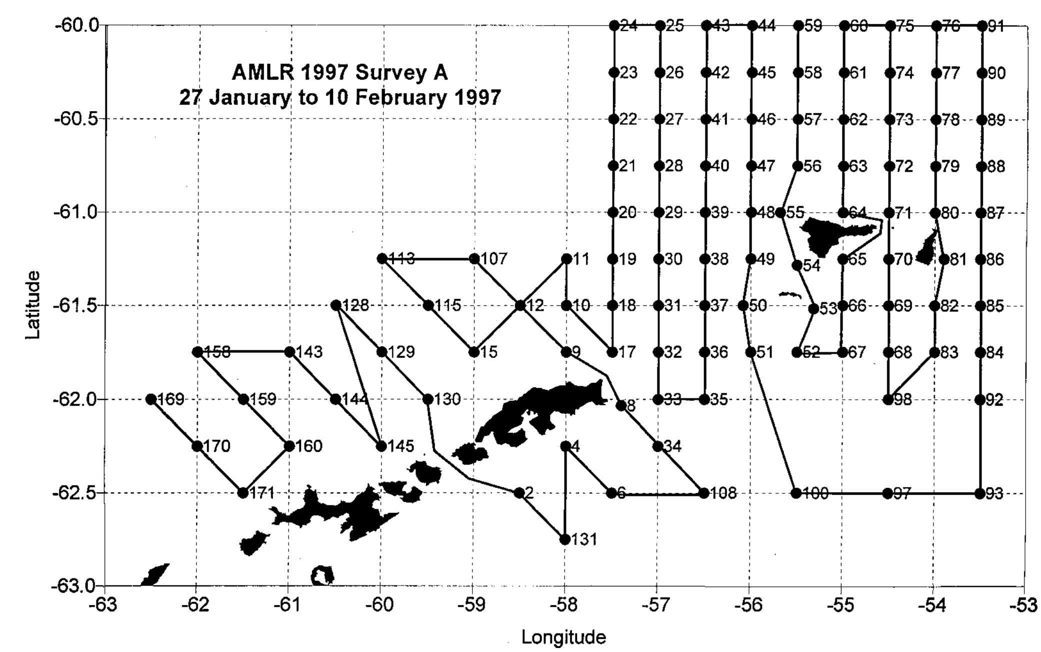

Figure 2. The large-area survey conducted on Leg I (Survey A, Stations A2-A171).

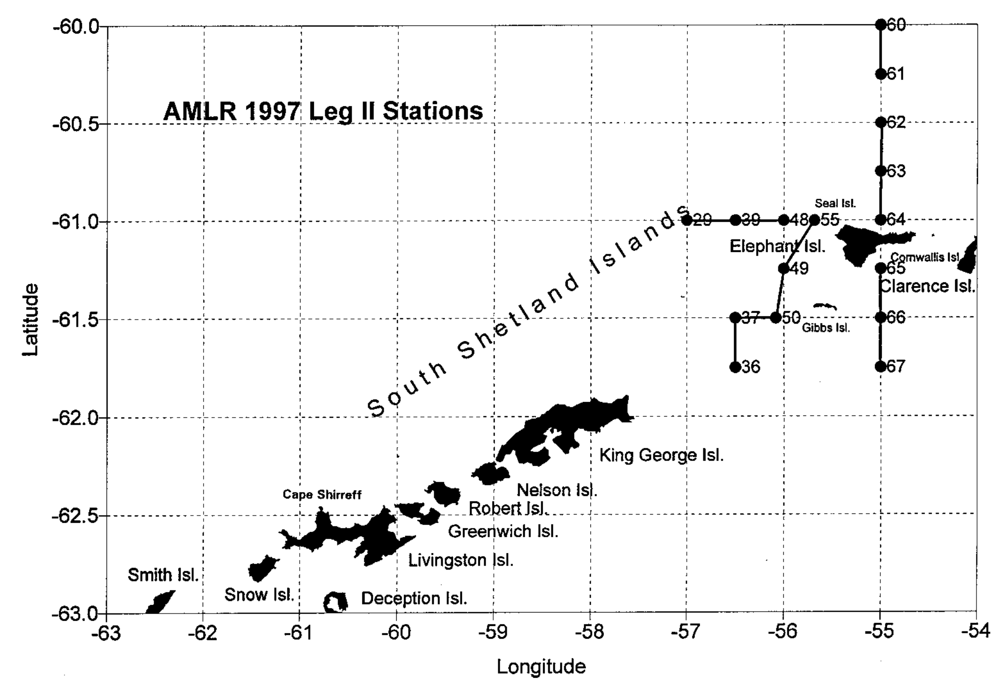

Figure 3. The large-area survey conducted on Leg II (Survey D, Stations D29-D67).

The specific objectives of the 1996–1997 field season were the following:

- to map the physical structure of the upper 750 meters, including the thermohaline composition, oceanic fronts, water mass boundaries, surface currents, eddies, and turbulent mixing;
- to map the distribution of phytoplankton biomass and production;
- to map the distribution of zooplankton (krill and other species), including the horizontal and vertical variations in krill density and demographic characteristics;
- to conduct bottom trawls at selected sites around the South Shetland Islands as a feasibility study for future surveys of finfish stock abundances;
- to establish a new field camp, map the numbers and distributions of seabird populations, record the fledging weights of chinstrap penguins *(Pygoscelis antarctica),* and band 1,000 chinstrap penguin chicks at Cape Shirreff;
- to record the fledging weights of chinstrap penguins, the presence of known-aged and previously handled seabirds and pinnipeds, and the abundance of antarctic fur seals (*Arctocephalus gazella*) on Seal Island; and
- to describe the reproductive success, feeding ecology, and growth rates of Adélie penguins (*Pygoscelis adeliae*) throughout the reproductive season at Palmer Station.

The cruise was conducted aboard the chartered research vessel (R/V) *Yuzhmorgeologiya*. Because of a delay in the arrival of AMLR cargo, the ship departed Punta Arenas, Chile, for Leg I on 19 January 1997, 4 days later than originally planned. Despite the delay, all original objectives were achieved and the leg was completed on 14 February. Following Leg I, the ship was delayed 23 days in Punta Arenas due to a failure of the main engine. After repairs were completed, Leg II was conducted 13–26 March with an abbreviated research plan.

During Leg I, a large-area survey of 106 conductivity-temperature-depth (CTD)/carousel and net sampling stations, separated by acoustic transects, was conducted in the expanded AMLR study area (Survey A, figure 2). Acoustic data were collected at three frequencies using 38-, 120-, and 200-kilohertz transducers. Data for physical oceanography, primary productivity, and krill distribution and condition studies were collected during the survey. Operations at each station included the following:

- recording of vertical profiles of temperature, salinity, oxygen, photosynthetically available radiation, light-beam attenuation, and fluorescence;
- collection of discrete water samples at standard depths for analysis of chlorophyll-*a* content, primary production rates, inorganic nutrients, dissolved oxygen, photoadaptational state of phytoplankton, phytoplankton cell size and species composition, and phytoplankton biomass; and
- deployment of a 1.8-meter (6-foot) Isaacs-Kidd Midwater Trawl (IKMT) to obtain samples of zooplankton and micronekton.

During Leg II, 16 CTD/IKMT stations, separated by acoustic transects, were conducted around Elephant Island (Survey D, figure 3). Operations at each station included the following:

- recording of vertical profiles of temperature, salinity, dissolved oxygen, and pH;
- collection of surface water samples (by bucket) for measurement of pH, oxygen, and alkalinity; and
- deployment of an IKMT to obtain samples of zooplankton and micronekton.

Also during Leg II, seven bottom trawls were conducted at stations northwest of Robert and Nelson Islands, and west of Elephant Island.

A field team occupied the new camp at Cape Shirreff from 25 January to 8 March 1997. Approximately 100 Zodiac loads of building materials were transferred to the camp for the construction of four structures. The team also initiated abundance and growth studies on seabirds and assisted Chilean colleagues with antarctic fur seal research. Seal Island was occupied by a field team from 11 February to 16 March, which was longer than originally planned due to the ship delay. The team dismantled various camp structures for removal from the island, and conducted limited studies on penguins and antarctic fur seals. Fieldwork at Palmer Station was initiated on 28 September 1996 and completed on 15 April 1997; studies on aspects of the ecology of Adélie penguins were conducted.

AMLR program: Distribution of volume backscattering strength near Elephant Island in the 1997 austral summer

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The primary objectives of the bio-acoustic sampling program were to map the mesoscale (10s of kilometers) dispersion of krill (*Euphausia superba*) near 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. Secondary objectives were to describe cross-sections of volume backscattering strength along transects through Admiralty Bay, across the shelf break to the north and south of the South Shetland Islands, and across the Antarctic Convergence in Drake's Passage. In addition, *in situ* target strength (TS) measurements of individual zooplankton were made; these data will be used to develop or enhance TS models for various macrozooplankton and nekton.

Acoustic data were collected using a multifrequency echo sounder (Simrad EK500) configured with downlooking 38-, 120-, and 200-kilohertz transducers mounted in the hull of the ship. Pulses were transmitted every 2 seconds at 1 kilowatt for 1.0 millisecond duration at 38 kilohertz, 1.0 millisecond duration at 120 kilohertz, and 0.6 millisecond at 200 kilohertz. Geographic positions were logged every 60 seconds. Ethernet communications were maintained between the EK500, a UNIX workstation, and a Windows-95 workstation. The UNIX workstation was used for system control, data logging, and data postprocessing, including interpretation of echograms, echo-integration, and TS analyses. Processed data were passed to the Windows-95 PC for gridding and contouring of

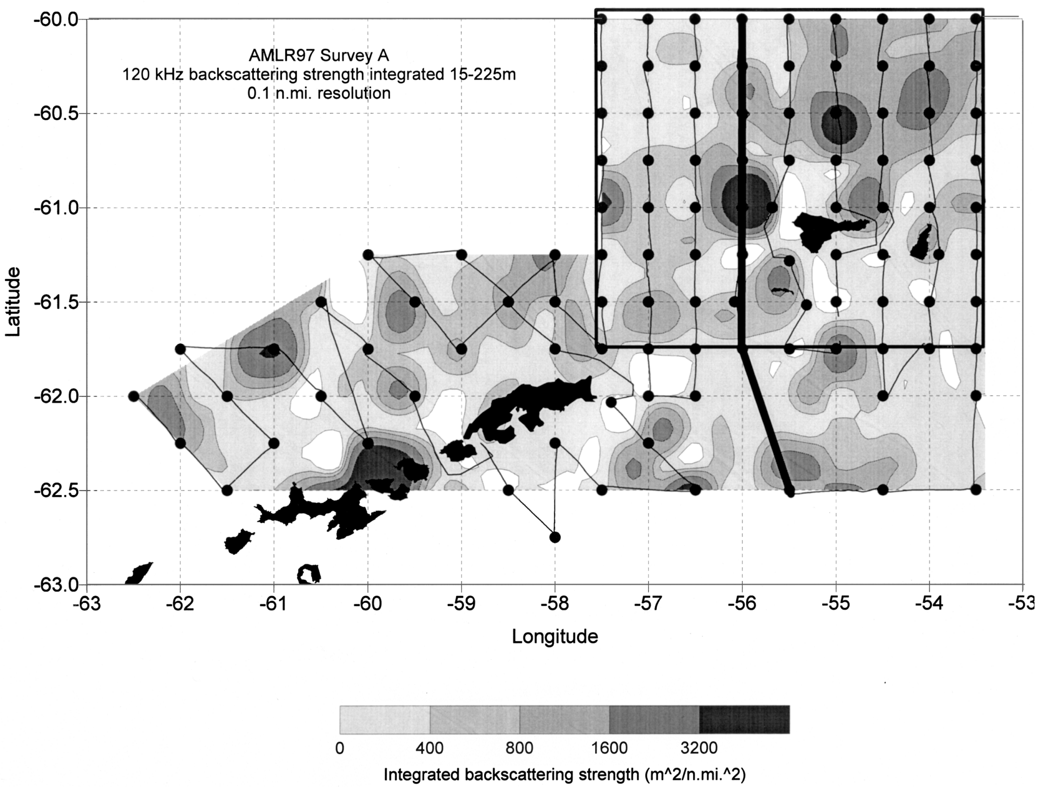

Figure 1. Integrated volume backscattering strength at 120 kilohertz (kHz). Transects are indicated by thin lines and stations are indicated by dots. The bold transect at 56°W longitude indicates the position of the acoustic cross-section described in figure 2. The box around Elephant Island indicates the area for which average krill biomass density was estimated. (m denotes meter. n.mi. denotes nautical mile. m^2/n.mi.^2 denotes square meter/square nautical mile.)

Mean krill biomass density for surveys conducted during 1992 through 1997. Mean biomass is estimated for the area inside the box outlined on figure 1.

*NOTE: ** denotes previously reported biomass density values for 1993 are omitted due to problems with equipment performance and possible misinterpretation of backscatter from salps.*

Year and survey	Mean krill biomass density (in grams per square meter)	Coefficient of variation (%)
1992 Survey A (January)	61.20	16
1992 Survey D (February and March)	29.63	9
1993 Survey A (January)	**	**
1993 Survey E (February and March)	**	**
1994 Survey A (January)	9.63	11
1994 Survey D (February and March)	7.74	22
1995 Survey A (January)	27.84	12
1995 Survey D (February and March)	35.52	24
1996 Survey A (January)	80.82	11
1996 Survey D (February and March)	70.10	23
1997 Survey A (January)	100.47	22

integrated volume backscattering strength. System calibrations were conducted before and after the surveys using standard sphere techniques while the ship was at anchor in Martel Inlet, King George Island, and off Cape Shirreff, Livingston Island.

For the purposes of generating distribution maps, bottom return, surface turbulence, and system noise were eliminated from the echograms. The remaining volume backscatter was attributed to biological scatterers and was integrated over depth (from 15 to 500 meters for the 38 kilohertz data, from 15 to 225 meters for the 120 kilohertz data, and from 15 to 175 meters for the 200 kilohertz data) and averaged over 0.1-nautical-mile (185-meter) distance intervals. A 30×15 cell grid was imposed on the survey area; adjustments were made for the scaling discrepancy between longitude and latitude; and integrated volume backscattering values were interpolated at grid nodes using Krigging methods and assuming a linear variogram model.

For the purpose of generating an estimate of krill biomass density, all volume backscattering at 120 kilohertz was assumed to be from krill. Integrated volume backscattering strength per unit sea surface area was converted to estimates of krill biomass density by applying a factor equal to the quotient of the weight of an individual krill and its backscattering cross-sectional area, summed over the sampled length frequency distribution for each survey (Hewitt and Demer 1993). Mean density for the Elephant Island area (as indicated by the box on figure 1) was estimated by treating the mean biomass density on each of the nine transects as an independent estimate of the mean density over the survey area (Hewitt and Demer 1993).

Survey A (27 January to 10 February, figure 1) was conducted to map the mesoscale dispersion of krill near the South Shetland Islands and to estimate the biomass of krill in a 12,600-square-nautical-mile area centered on Elephant Island. Each survey consisted of approximately 2,000 nautical miles of transects conducted between 106 stations. Station work included a conductivity-temperature-depth (CTD) cast and an Isaacs-Kidd Midwater Trawl (IKMT) plankton tow. Mean krill density was calculated from nine north-south transects with 15-nautical-mile spacing between lines. Survey D (17–24 March) was greatly curtailed because of severe time constraints resulting from an engine failure on the survey vessel.

A discontinuous band of high integrated volume backscattering strength was mapped on the north side of the South Shetland Islands (figure 1). This band tended to be north of the frontal zone running parallel to the archipelago, widening and spreading onto the shelf near Elephant Island. Other areas of high integrated volume backscattering strength were mapped on the shelf near Livingston Island and in deeper water in Bransfield Strait. IKMT samples indicated that the krill north of the South Shetland Islands were adults in advanced maturity stages, whereas the krill caught on the island shelf and in the Bransfield Strait were a mixture of 1-year-old juvenile and adult krill.

Krill biomass, estimated from the acoustic data for the area outlined in the box on figure 1, was the highest estimated since 1992 (table).

Figure 2 is a compressed echogram describing a cross-section of volume backscattering strength from Station A44 through Station A100 (bold transect line in figure 1). A notable feature is the krill layer between 25 and 100 meters depth extending from halfway between Stations A44 and A45 to Station A47; a large aggregation of surface feeding fin whales was observed in this area. Also notable is the approximately 100-meter-thick layer of krill rising toward the surface as sunset approached and abruptly ending at 200 meters water depth. The echogram also suggests a downward migration of krill prior to sunrise on the south side of the South Shetland shelf and scattered krill swarms across Bransfield Strait and onto the Antarctic Peninsula shelf.

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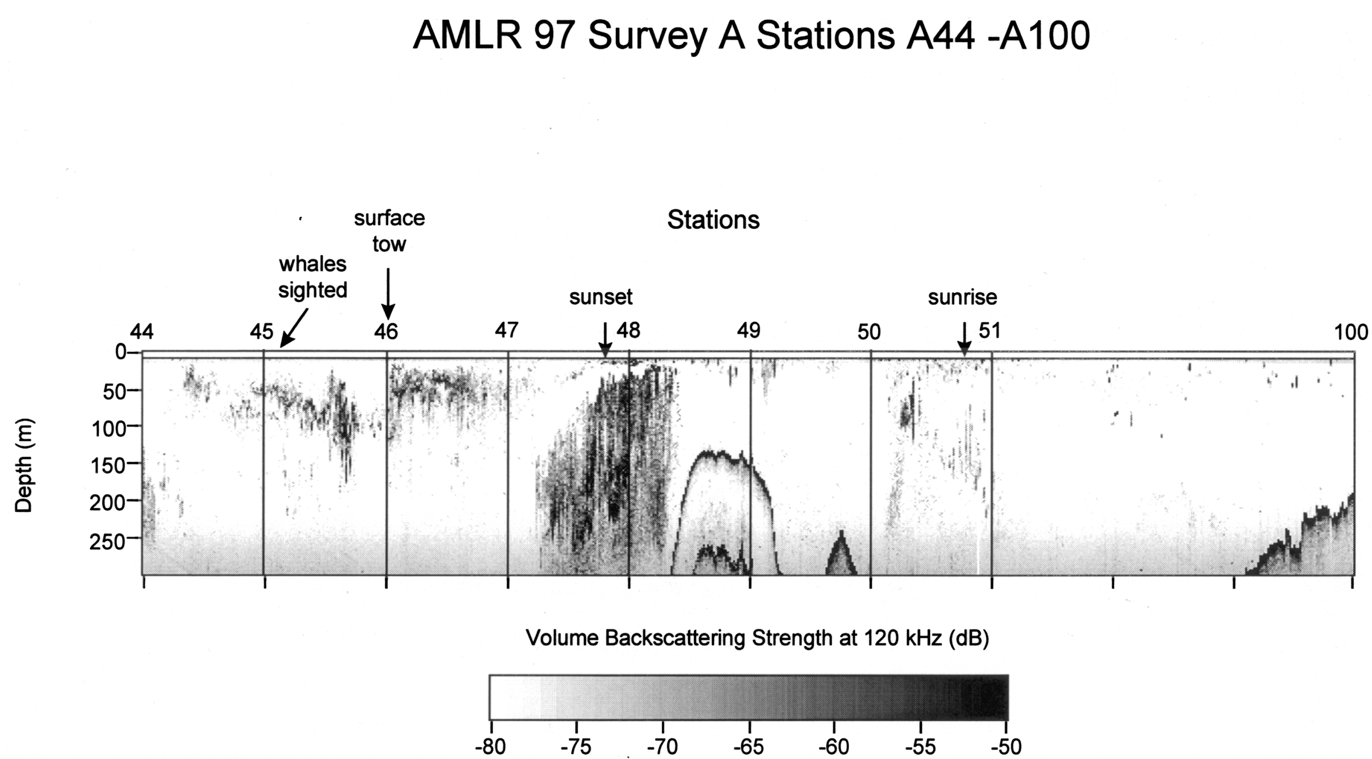

Figure 2. Acoustic cross-section at 120 kilohertz (kHz) from Stations A44 to A100. (m denotes meter. dB denotes decibel.)

AMLR program: Phytoplankton distribution and its relationship to different water zones characterized by physical oceanographic parameters, January to February 1997

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One of the major objectives of the phytoplankton component of the Antarctic Marine Living Resources (AMLR) program is to improve understanding of the factors that influence the distribution and concentration of phytoplankton throughout the study area. The AMLR large-area survey grid around Elephant Island (*see* Martin, Hewitt, and Holt, *Antarctic Journal*, in this issue) is particularly interesting and challenging in this regard because it includes diverse water types and associated frontal mixing zones, in addition to both relatively shallow coastal and deep pelagic waters.

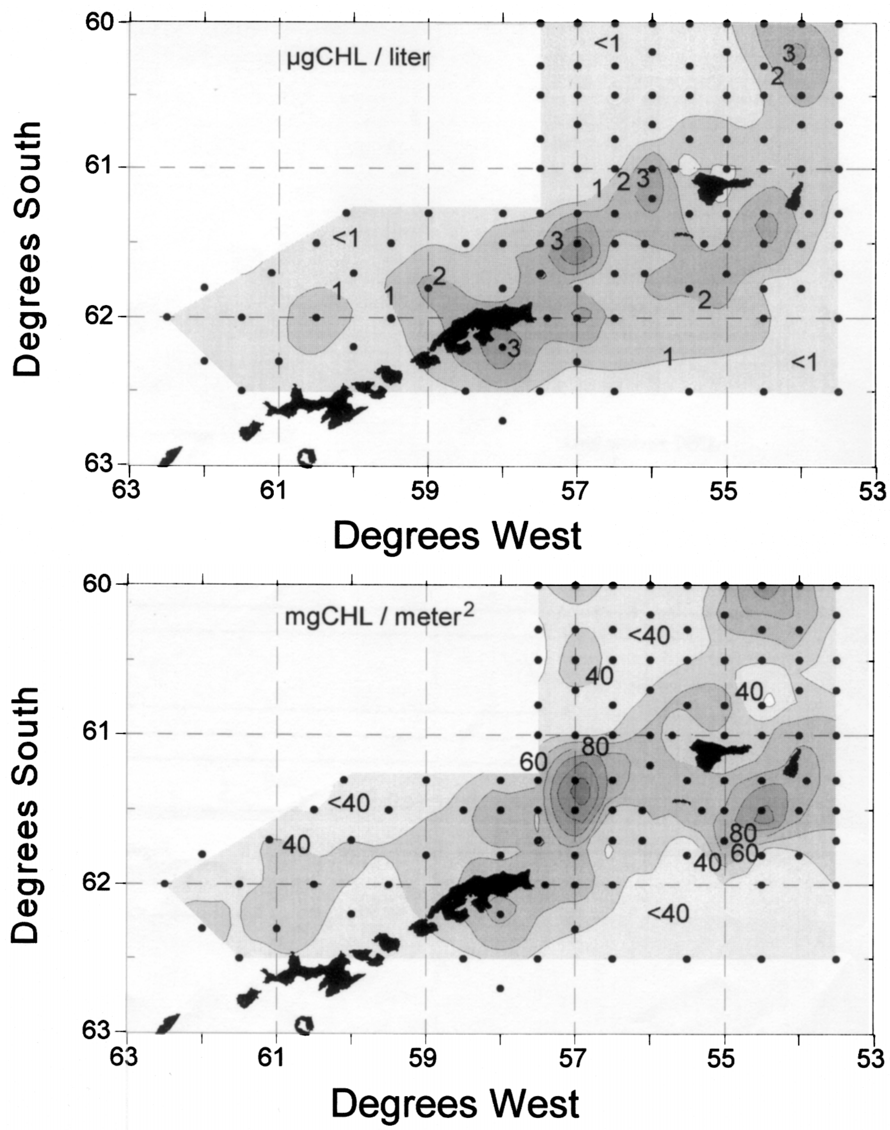

Figure 1. Chlorophyll-*a* concentrations (micrograms/liter) at 5 meters depth (upper figure) and integrated chlorophyll-*a* concentrations (lower figure; milligrams per square meter from 0 to 100 meters) in the survey area.

The distribution of phytoplankton in surface waters was estimated continuously during the AMLR cruise by sensors (fluorometer and transmissometer) on a clean water-intake line, as well as in depth profiles (0 to 200 meters) at every conductivity-temperature-depth (CTD)/carousel station. The CTD/carousel unit included a submersible fluorometer and eleven 10-liter Niskin bottles, which were closed at standard depths between 5 and 200 meters. Concentrations of chlorophyll-*a* were measured on samples from the Niskin bottles by concentration of the phytoplankton onto GF/F glass fiber filters, extracting the photosynthetic pigments in absolute methanol (Holm-Hansen and Riemann 1978), and measurement of fluorescence (Holm-Hansen et al. 1965). During Survey A (27 January to 10 February 1997), 106 CTD/carousel stations were occupied as described by Martin et al. (*Antarctic Journal*, in this issue).

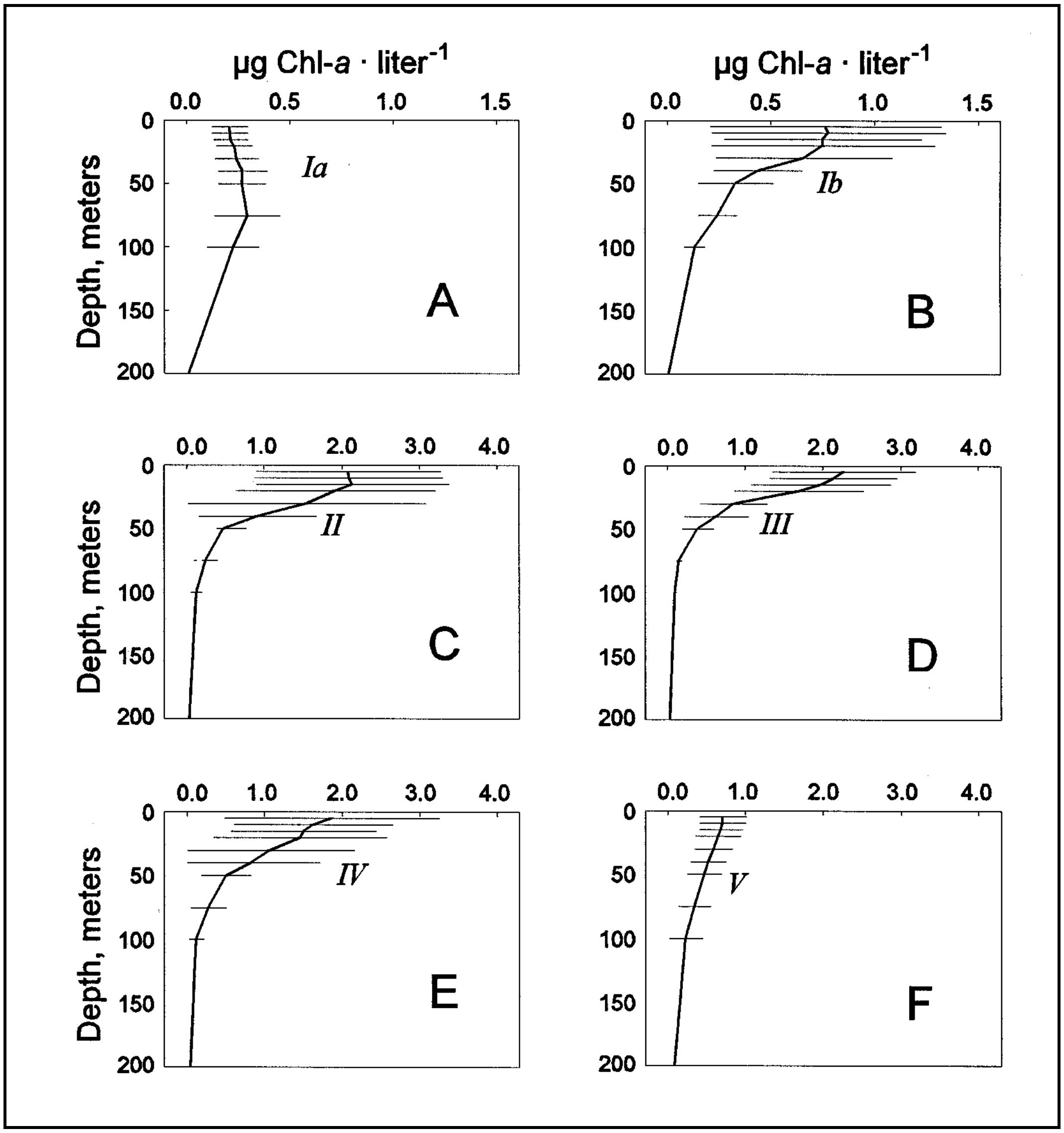

Figure 2. Distribution of chlorophyll-*a* with depth in the various water zones defined by temperature and salinity characteristics. The separation of Water Zone I stations into Water Zones Ia (33 stations) and Ib (6 stations) has been done on the basis of both biological and physical measurements. See Amos et al. (*Antarctic Journal*, in this issue) for listing of all stations included in Water Zone I. Of these 39 stations in Water Zone I, 6 stations (A58, A59, A60, A73, A74, A129) have been placed in Water Zone Ib and the remaining 33 stations in Water Zone Ia. Each curve represents the mean at any depth for all stations in that water zone; the horizontal lines represent ±1 standard deviation. Note that the values on the abscissa in Water Zones Ia and Ib are smaller than for the other four water zones.

Chlorophyll-*a* concentrations in surface waters varied greatly; the lowest concentrations (0.1 to 0.3 micrograms/liter) were in the northwest and southeast regions of the survey area, and the highest concentrations (4 to 7 micrograms/liter) were in the region between King George Island and Elephant Island and also in the northeast corner of the survey area (figure 1). The pattern of integrated chlorophyll-*a* values for the upper 100 meters of the water column was similar to that for 5-meter chlorophyll-*a* values; the lowest values were 15 to 25 milligrams per square meter, and the highest were 250 to 350 milligrams per square meter. The mean integrated chlorophyll-*a* (milligrams per square meter) values in the various water zones as delineated by Amos, Wickham, and Rowe (*Antarctic Journal*, in this issue) were 30.5 (Water Zone I), 65.9 (Water Zone II), 66.4 (Water Zone III), 86.1 (Water Zone IV), and 49.2 (Water Zone V). On the basis of both physical and biological characteristics, stations in Water Zone I have been divided into Water Zone Ia, which shows little or no mixing with waters from the other four zones, and Water Zone Ib, which shows considerable mixing with waters from Water Zones II or III (Holm-Hansen et al. 1994). The mean integrated chlorophyll-*a* values for the 33 stations in Water Zone Ia and the six stations in Water Zone Ib were 25.6 and 43.6 milligrams per square meter, respectively.

The profile of distribution of chlorophyll-*a* with depth (figure 2) varies considerably in the water zones described by Amos et al. (*Antarctic Journal*, in this issue). Stations in Water Zone Ia (Drake Passage waters) have the lowest chlorophyll-*a* concentrations in surface waters and a deep chlorophyll-*a* maximum between 50 and 100 meters. Chlorophyll-*a* concentrations in Water Zone Ib are also low but show maximal values at or close to the surface. Stations in Water Zone V (Weddell Sea water) also show relatively low surface chlorophyll-*a* concentrations, but concentrations slowly decrease with depth. Chlorophyll-*a* concentrations in Water Zones II, III, and IV are all much higher than in Water Zones I and V and have maximal values at or close to the surface.

Figure 3 shows the geographical extent of the AMLR stations which are characterized by relatively high concentrations of chlorophyll-*a* between 50 and 100 meters as compared to the concentrations from 5 to 30 meters. The zones of deep distribution of chlorophyll-*a* are found in Water Zone I waters, where phytoplankton growth is thought to be limited by available iron (Holm-Hansen et al. 1994), and also

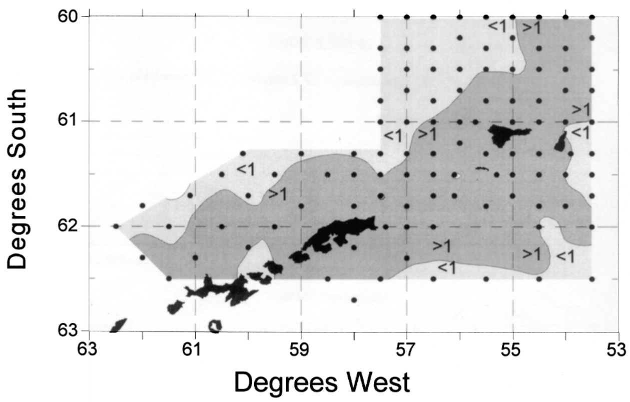

Figure 3. Ratio of the value for integrated chlorophyll-*a* from 5 to 30 meters divided by the value from 50 to 100 meters for all stations in the survey area. Light stippling indicates all stations where the value of this ratio is less than 1.0; the darker stippling indicates all stations where the value of this ratio is greater than 1.0.

in Water Zone V waters, which are nutrient-rich but characterized by physical instability of the upper water column.

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AMLR program: Inorganic nutrient concentrations, January to February 1997

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The essential macroinorganic nutrients nitrogen, phosphorus, and silicon are generally not limiting phytoplankton growth in antarctic waters. The likely exceptions are in protected coastal areas where phytoplankton blooms over 25 micrograms of chlorophyll-*a* have been recorded (Holm-Hansen et al. 1989) and in the region of the Polar Front, where silicon concentrations are low (Tréguer and Jacques 1992). In the AMLR study area (*see* Martin, Hewitt, and Holt, *Antarctic Journal*, in this issue), concentrations of inorganic nitrogen, phosphorus, and silicon are generally well above the concentrations thought to be limiting phytoplankton growth. The main interest in measuring inorganic nutrient concentrations in the AMLR large-area survey grid involves the use of nutrients to characterize different water masses, as well as to indicate the extent of nutrient recycling in the upper water column.

Water samples for nutrient analyses were obtained from the 10-liter Niskin bottles attached to the conductivity-temperature-depth (CTD)/carousel profiling unit. Acid-cleaned high-density polyethylene bottles of 50-milliliter capacity were rinsed four or five times with water directly out of the Niskin bottle before being filled with approximately 35 milliliters. The sample bottles were then frozen in an upright position and maintained at –20°C or lower until time of analysis. The samples were analyzed at the Universidad Católica de Valparaiso with an autoanalyzer following the techniques described by Atlas et al. (1971). Nitrate and nitrite were not determined separately, so that the term "nitrate" refers to the sum of nitrate plus nitrite. The concentration of nitrite, however, is very low as compared to that of nitrate; it averages approximately 1 percent of the nitrate concentration in antarctic surface waters (Biggs et al. 1982).

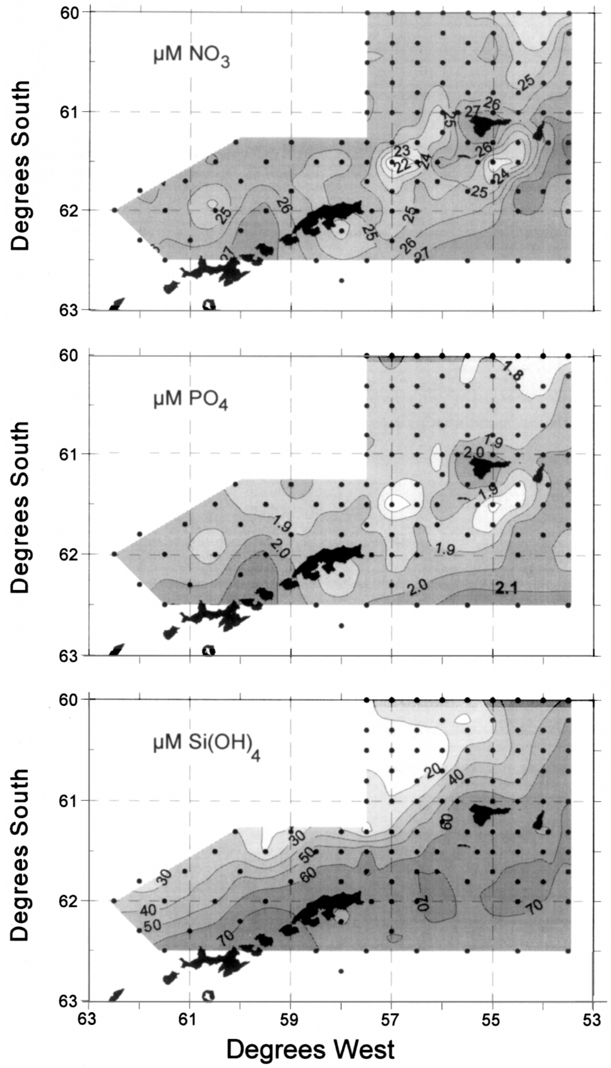

Figure 1. Concentrations (in micromoles, µM) of nitrate (NO_3), phosphate (PO_4), and silicic acid [$Si(OH)_4$] at 5 meters depth throughout the large-area survey grid on Leg I (Survey A), 27 January to 10 February 1997.

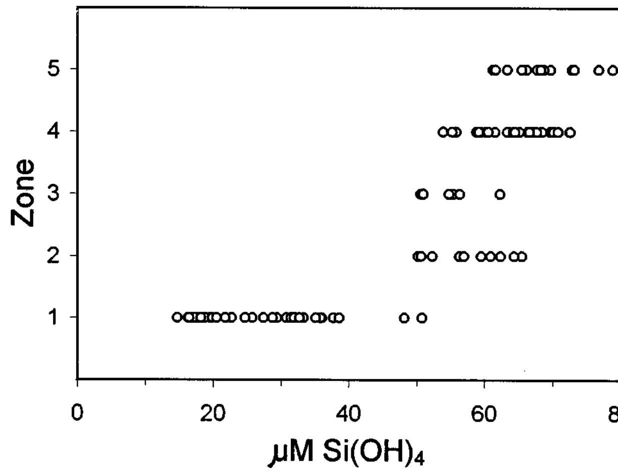

Figure 2. Silicic acid [$Si(OH)_4$] concentrations (in micromoles per liter, µM) at 5 meters depth in the five different water zones during Survey A. Total number of stations occupied was 106.

The concentrations of nitrate, phosphate, and silicic acid at 5 meters depth throughout the AMLR survey grid are shown in figure 1. The lowest concentrations for nitrate and phosphate are found in the relatively shallow region between King George Island and Elephant Island and also in the northeastern portion of the survey grid. These areas correspond to the regions of relatively high phytoplankton biomass (Holm-Hansen et al., *Antarctic Journal,* in this issue), and hence, the low nutrient concentrations reflect nutrient uptake by primary producers. The pattern of silicic acid distribution is different; the lowest values are in the northwestern portion of the survey grid.

Figure 2 shows the concentrations of silicic acid (106 stations, 5 meters depth) in the five water zones as determined by temperature and salinity characteristics (*see* Amos, Wickham, and Rowe, *Antarctic Journal,* in this issue). Water Zone I (Drake Passage waters) has the lowest silicon concentrations, whereas Water Zone V (Weddell Sea water) has the highest concentrations. The two stations in Water Zone I with relatively high silicon concentrations are A74 and A129, which lie on the periphery of Water Zone I and apparently are mixed to some extent with waters from Water Zones II and IV, respectively.

The concentrations of nitrogen, phosphorus, and silicon in the upper 200 meters of the water column at seven stations are shown in figure 3. The most dramatic difference between the different water zones is that stations in Water Zone I have much lower concentrations of silicon throughout the upper 100 meters as compared to stations in Water Zones II or V. The concentration of silicon at 50 meters at Station A63 is seen to resemble Water Zone I waters. It is to be noted that Station A63 is in Water Zone II, but that the temperature and salinity values suggest considerable mixing with Water Zone I.

The nutrient concentrations reported above are much higher than the concentrations generally required to permit maximal growth rates of phytoplankton. This strongly suggests that the major inorganic nutrients (nitrogen, phosphorus, and silicon) are not limiting rates of primary production in the AMLR study area. There is evidence, however, that phytoplankton growth rates in Water Zone I waters are limited by availability of iron (Holm-Hansen et al. 1994).

This research was supported by National Oceanic and Atmospheric Administration (NOAA) contract number 50ABNF600013. Grateful acknowledgment is extended to the officers and crew of the R/V *Yuzhmorgeologiya* for their excellent support during all field operations. We thank the Physical Oceanography group for kindly providing their CTD data. Shipboard personnel included J. Maturana, C.D. Hewes, and O. Holm-Hansen.

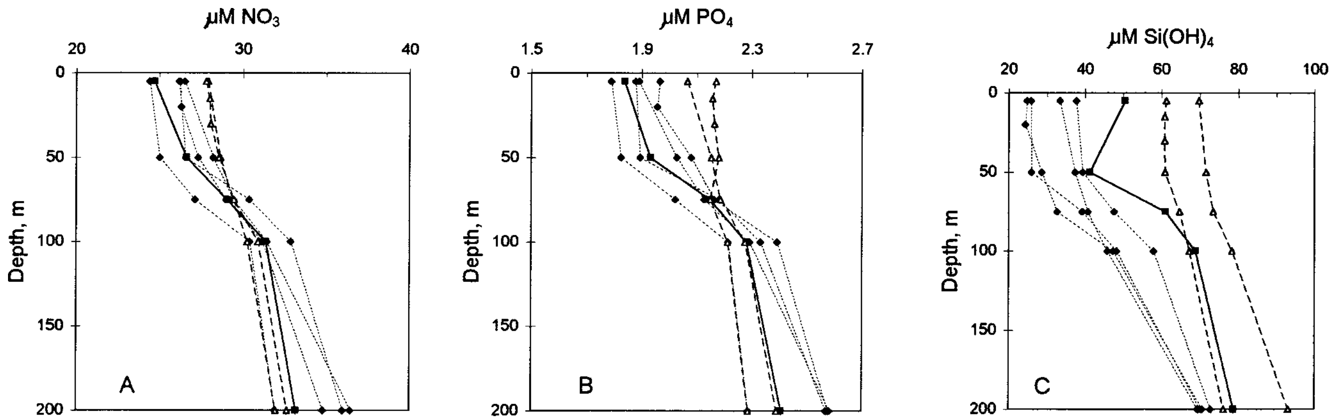

Figure 3. Concentrations (in micromoles per liter, µM) of nitrate (NO_3), phosphate (PO_4), and silicic acid [$Si(OH)_4$] in the upper 200 meters of the water column during Survey A at four stations in Water Zone I (dotted lines; Stations A60, A61, A62, A158), one station in Water Zone II (continuous line; Station A63), and two stations in Water Zone V (dashed lines; Stations A64, A93).

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AMLR program: Variability of pH in the upper water column

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Previous studies in the AMLR survey grid have shown that much inorganic nutrient recycling occurs in the upper water column (Koike, Holm-Hansen, and Biggs 1986). The major processes responsible for these reactions involve grazing of autotrophic phytoplankton by heterotrophic protozoans and microzooplankton, in addition to catabolism of dissolved organic compounds by bacterioplankton. Because the sum of these heterotrophic reactions will affect the food resources available to krill (*Euphausia superba*), it is important to understand more fully the dynamics of the many routes involved in the microbial food web in antarctic waters. Space and time onboard ship during the Antarctic Marine Living Resources (AMLR) cruises, however, do not allow for comprehensive studies of the biomass and metabolic activity of heterotrophic organisms. Other methods must, therefore, be used to improve our understanding of the relative rates of pri-

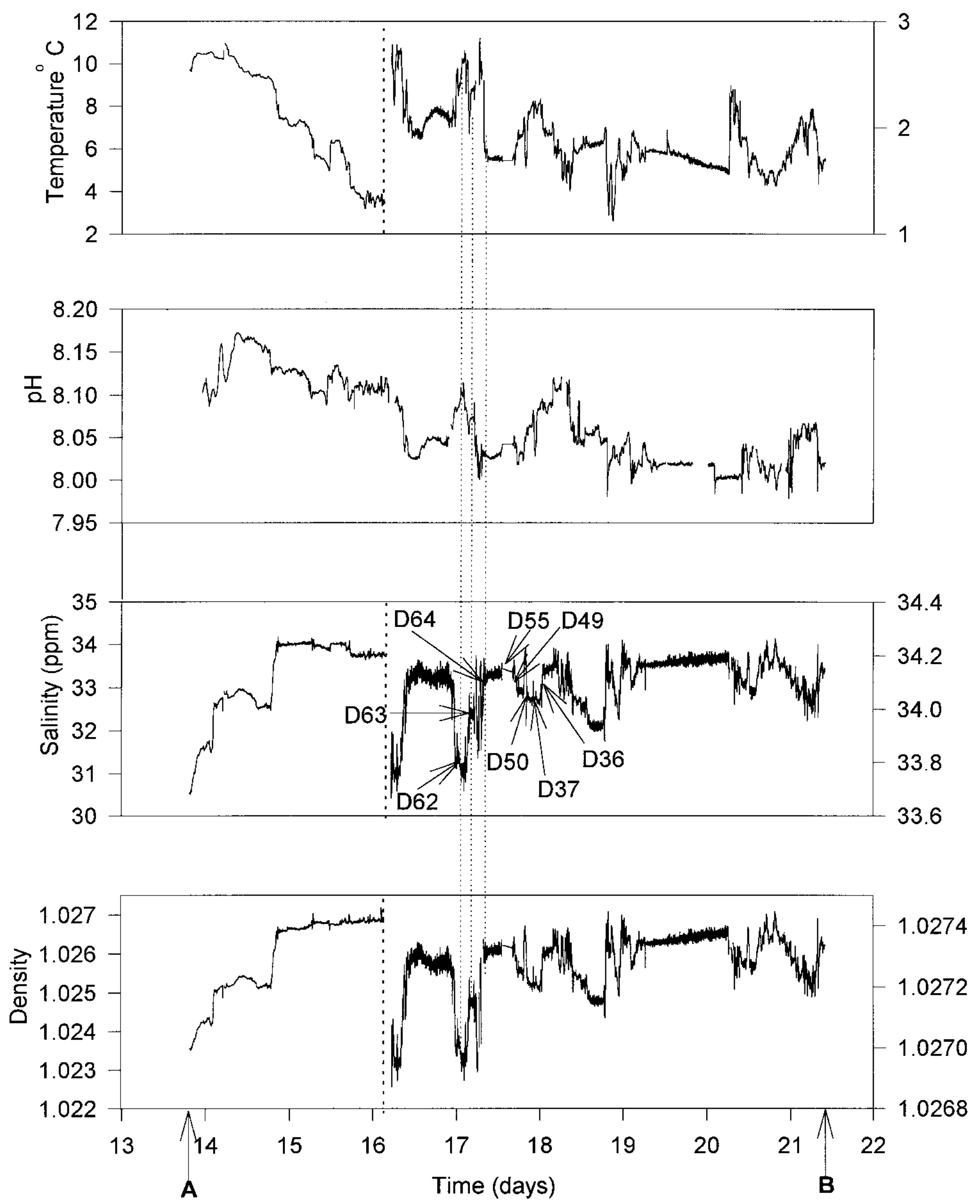

Figure 1. Values of temperature, pH, salinity, and density of seawater pumped from 5 meters depth during a transect from the Straits of Magellan (point A; 52.88°S 70.47°W) into Bransfield Strait and then north to Seal Island, just to the northwest of Elephant Island (point B; 60.99°S 55.34°W). The dates shown on the abscissa are from March of 1997. The vertical dashed lines early on 16 March show where the scales of the ordinates have been changed (except for pH); all values to the right of the dotted lines refer to the right-hand scales. The times of occupying eight of our stations are shown on the salinity plot. The Polar Front, where the temperature was approximately 4.5°C, was crossed between days 15 and 16. (ppm denotes parts per million.)

mary production by phytoplankton as compared to the rates at which the photosynthate is used by heterotrophic organisms.

During photosynthesis, carbon dioxide is consumed and oxygen is liberated; the reverse is true during respiration in heterotrophic organisms. One way to approach the problem of the relationship between the relative rates of autotrophic versus heterotrophic metabolism is, thus, to examine the relative concentrations of dissolved oxygen and inorganic carbon in water samples. Dissolved oxygen and inorganic carbon can be measured on discrete water samples, but for upper water column studies, it is desirable to have *in situ* sensors so that detailed profiles can be measured in profiles extending throughout the euphotic zone. Oxygen electrodes are suitable for this task, but no methods are available for direct *in situ* measurement of total inorganic carbon. The concentration of inorganic carbon, however, will be directly related to the hydrogen ion activity (pH) of the water, and *in situ* pH electrodes are suitable for such profiling studies.

During Leg II of the AMLR studies in 1997, measurements were made of pH in addition to temperature and salinity on a continuous-flow system using water pumped from 5 meters depth while the ship was steaming and also in profiles at selected stations from the surface to 240 meters depth. The profile data were obtained with a Sea-bird Seacat conductivity-temperature-depth (CTD) unit equipped with a pH electrode (model SEB-16).

Data from the pumped seawater line are shown in figure 1, which illustrate that pH values of antarctic surface waters varied considerably (all data after day 15.5, figure 1), as did the values for temperature, salinity, and the derived values for density. Values of pH tend to change in the same direction as temperature and inversely to changes in salinity and density, indicating vigorous vertical mixing. However, as pH is affected to a relatively large extent by biological activity whereas temperature and salinity are not, considerable scatter is evident in the correlations between pH and the physical variables. Drake Passage waters and stations in Water Zone I (Station D62) tend to have relatively high pH values as compared to the lower pH values found in Bransfield Strait waters (e.g., Station D64).

Representative data from the CTD-pH profiles are shown in figure 2. Amos, Wickham, and Rowe (*Antarctic Journal*, in this issue) have classified the stations in the AMLR study area into five water zones that can be differentiated on the basis of temperature and salinity characteristics. Stations D62, D63, and D64 are found in Water Zone I (Drake Passage waters), Water Zone II (a mixing zone), and Water Zone IV (Bransfield Strait origin), respectively (Amos personal communication). Station D62 shows relatively high pH values in surface waters (>8.07), a steep gradient in pH between 75 to 125 meters, and low values at 200 meters (<7.9). The depth region of the steep gradient in pH corresponds to the location of the remnants of Winter Antarctic Surface Water; the water below that has its origin in Circumpolar Deep Water. Stations D63 and D64 have lower pH values in surface waters (<8.07), no sharp gradient around 100 meters depth, and values greater than 7.9 at 200 meters depth. It appears that determination of pH *in situ* thus might be useful not only in estimating relative rates of photosynthesis and respiration but also as an indicator of different water zones found in the AMLR study area around Elephant Island.

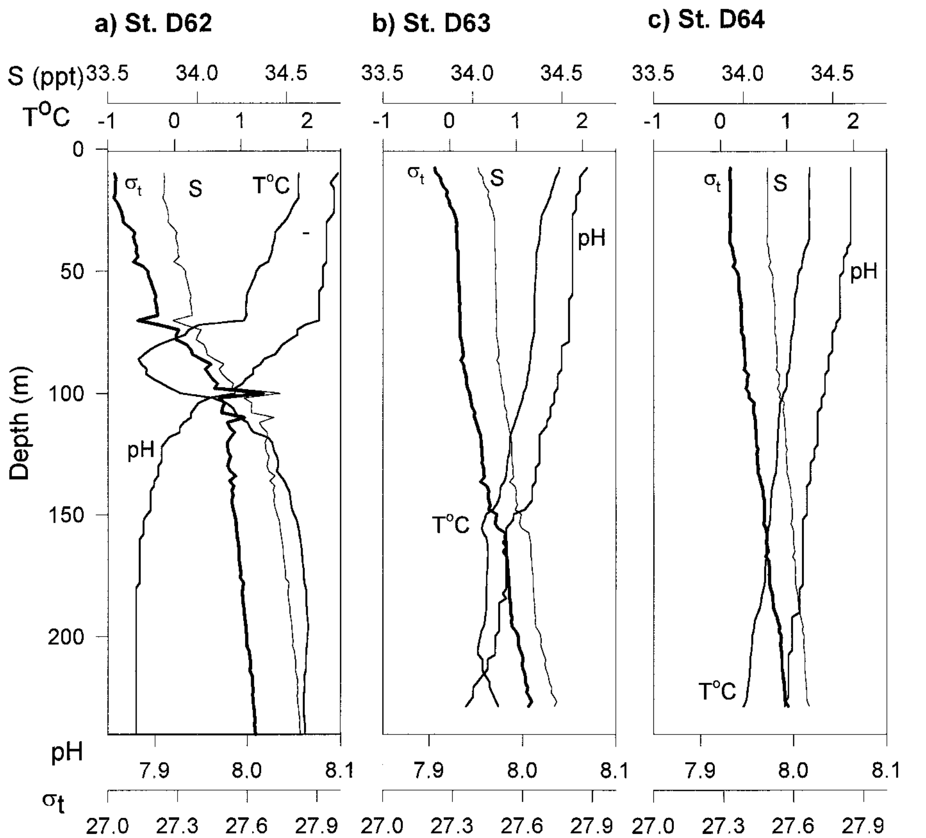

Figure 2. Profile data for salinity, temperature, pH, and Sigma-t between the surface and 240 meters depth at Station D62 (Water Zone I), Station D63 (Water Zone II), and Station D64 (Water Zone IV).

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AMLR program: Krill demography in the Elephant Island area, January to March 1997

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Krill (*Euphausia superba*) is the keystone prey species in the antarctic seasonal sea-ice zone. Demographic information for krill includes length, sex, reproductive condition, and maturity stage composition. Length information is important for the acoustical estimation of krill biomass. Information on length, maturity stage composition, and reproductive condition is essential to assess between-year differences in krill spawning success and recruitment (i.e., the supply of juveniles

Krill abundance in AMLR large-area surveys 1992–1997. Abundance is numbers per 1,000 cubic meters.

January and February Survey A	1997	1996	1995	1994	1993	1992
Number of tows	105	91	90	81	88	63
Mean	40.4	112.5	14.6	27.1	43.9	23.7
Standard deviation	97.8	412.2	47.7	84.2	179.0	78.0
Median	5.6	12.2	2.8	1.9	7.2	5.7
Maximum	569.0	3,409.1	410.6	476.7	1,623.4	594.1

February and March Survey D	1997	1996	1995	1994	1993	1992
Number of tows	16	91	89	89	80	67
Mean	30.4	106.7	5.7	18.6	34.5	38.0
Standard deviation	56.4	773.6	11.7	69.6	92.9	77.4
Median	4.6	3.3	1.9	0.6	1.5	7.1
Maximum	204.2	7,385.4	90.0	397.8	542.0	389.9

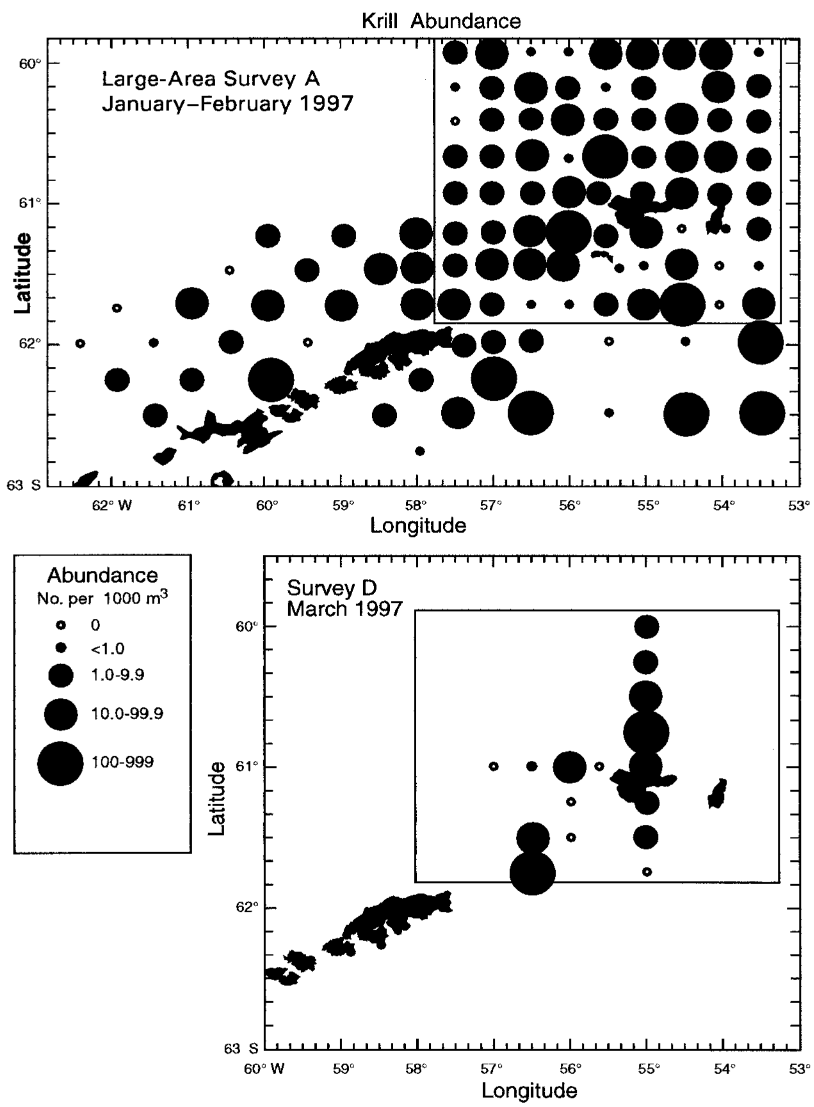
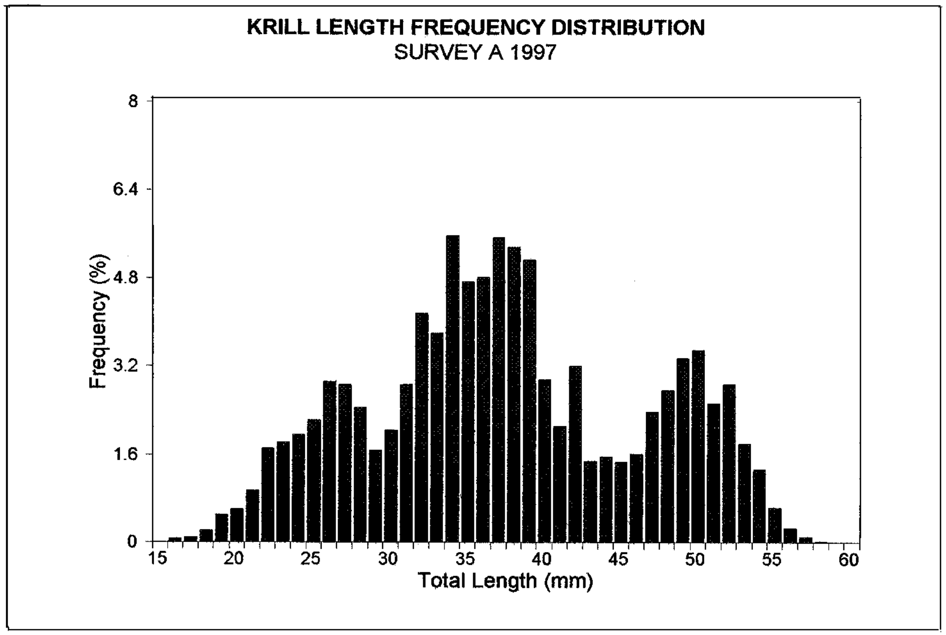


Figure 1. Krill abundance in IKMT tows collected during January and February Survey A and March Survey D, 1997.

spawned the previous summer). This assessment has relevance to the availability of krill to their predators, which include penguins, other seabirds, and seals monitored by the AMLR program.

Krill were obtained from a 1.8-meter (6-foot) Isaacs-Kidd Midwater Trawl (IKMT) fitted with a 505-micrometer mesh plankton net. Flow volumes were measured using a calibrated General Oceanics flow meter mounted in front of the net mouth. Samples were collected at 105 survey stations during Leg I and 16 stations during Leg II (*see* Martin, Hewitt, and Holt, *Antarctic Journal*, in this issue). The station locations during Leg II permitted results representative of the large-area survey despite the small sample size (Loeb unpublished manuscript). All tows were fished obliquely from a depth of 170 meters or about 10 meters above bottom in shallower waters. Tow speeds were about 2 knots. Fresh or freshly frozen specimens were processed onboard. All krill were analyzed from samples containing less than 150 individuals. For larger samples, 150 to 200 individuals were measured, sexed, and staged. Measurements were made of total length (millimeters); stages were based on the classification scheme of Makarov and Denys (1981). Density is expressed as numbers per 1,000 cubic meters water filtered.

A total of 13,560 krill were collected in 98 (93 percent) of the Survey A stations during the period from 26 January to 9 February; mean and median abundances were 40.4 and 5.6 per 1,000 cubic meters, respectively (table). Six of the largest catches (145.5–569.0 per 1,000 cubic meters)



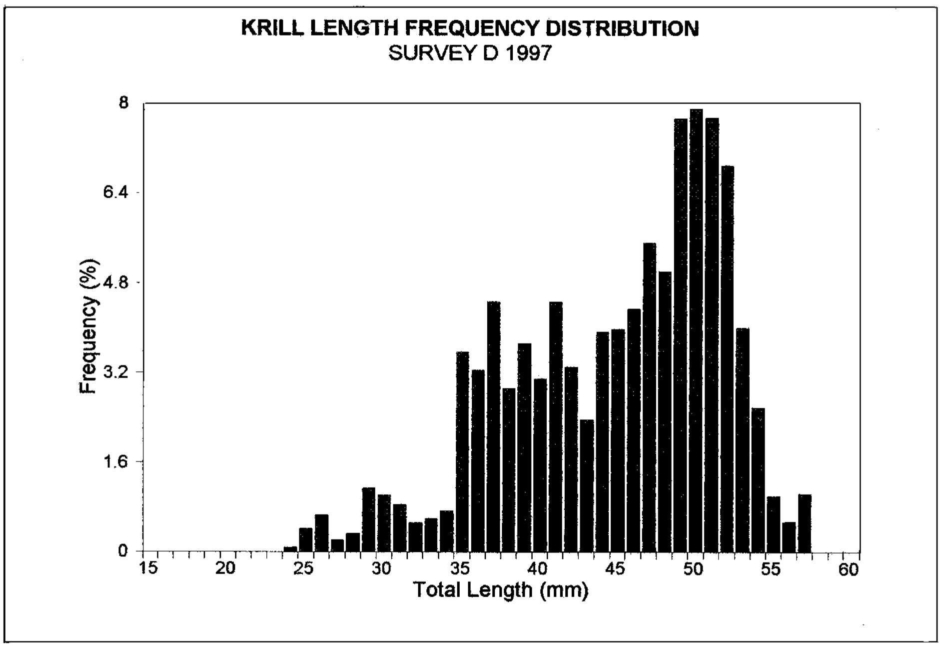


Figure 2. Overall length frequency distributions of krill collected during January and February Survey A and March Survey D, 1997.

occurred in Bransfield Strait, and three (115.8–483.2 per 1,000 cubic meters) occurred in Drake Passage waters adjacent to Livingston and Elephant Islands (figure 1). Krill lengths ranged from 15 to 58 millimeters (figure 2), and three distinct groups were centered around 26–27 millimeters, 34–39 millimeters, and 49–50 millimeters; these conform to the 1+, 2+, and 3+ age groups. The 30–42-millimeter length category was most abundant (54 percent of the total) and reflects successful recruitment of the 1994–1995 year class. Smaller and larger krill, respectively, made up 20 and 28 percent of the total. Mature stages dominated (37.2 percent). Juveniles constituted 29.9 percent, reflecting substantially lower recruitment of the 1995–1996 year class compared to that of 1994–1995. Most of the mature females exhibited ovarian development (3c stage), were gravid (3d), or spent (3e), indicating that peak spawning probably would occur 1–3 weeks later (i.e., late February to early March; Harrington and Ikeda 1986). Overall, 77.4 percent of mature females were in these advanced stages. Predominantly calyptopis stage krill larvae in our samples (approximately 5–7 weeks old) resulted from late December to early January spawning, whereas the few furcilia stages came from earlier (i.e., mid-December) spawning (Ross, Quetin, and Kirsh 1988).

A total of 1,327 krill were collected at 11 of 16 IKMT stations (69 percent) during Survey D, 16–23 March. Largest (204.2 and 134.4 per 1,000 cubic meters) and moderate-sized catches (22.8 to 65.2 per 1,000 cubic meters) occurred north and southwest of Elephant Island, whereas small or no catches generally occurred west and south of the island (figure 1). Mean and median krill abundance estimates were 30.4 and 4.6 per 1,000 cubic meters, respectively. These values are 18–25 percent lower than during Survey A (table). Lengths ranged from 24 to 57 millimeters and demonstrated three size groups centered around 29–30 millimeters (1+ age group), 37–41 millimeters (2+), and 49–52 millimeters (3+) (figure 2). The two smaller modes are 3 millimeters longer than those observed during Survey A; the larger mode is unchanged. This finding suggests summertime growth rates over a 45-day period of approximately 0.07 millimeters per day for the 1+ and 2+ age classes; this growth rate has also been reported for 2+ krill but is nearly half of that reported for the 1+ age group (Siegel and Kalinowski 1994).

Limited sampling of juvenile krill (the 1+ age group) during Survey D could explain this underestimate. In contrast to Survey A, large krill 44 to 57 millimeters were most abundant (62.2 percent); intermediate 35-to 43-millimeter-sized krill made up 31.9 percent; and smaller krill made up 6.5 percent. These changes in composition could result from seasonal migrations of the different maturity stages (Siegel 1988). In accordance with the size distribution, most of the krill were mature (72.3 percent), whereas immature stages made up 19.7 percent and juveniles 8.0 percent. The mature females were primarily gravid (3d stage, 76.0 percent) and spent (3e, 19.0 percent), indicating a mid-March to late March spawning peak. The female maturity stage composition observed during Survey A suggested peak spawning in mid-February to early March. Either that spawning peak was delayed or a second spawning peak was initiated 1 month later.

Krill abundance during the 1997 surveys was similar to that observed during 1992 and 1993 (table). The marked abundance decrease relative to 1996 values was due to lower recruitment success of the 1995–1996 year class relative to that of 1994–1995. Exceedingly good recruitment success of the 1994–1995 year class was associated with above average sea-ice conditions during winter 1994 and 1995. The regional sea-ice index values for those years were 4.86 and 5.00, respectively, compared to an 18-year average value of 4.04. This good recruitment success probably results from early seasonal spawning activity and larval survival associated with extensive winter sea-ice conditions (Siegel and Loeb 1995; Loeb et al. 1997). Winter 1996 was characterized by average sea-ice conditions (sea-ice index of 4.02). Lower recruitment success of the 1995–1996 year class suggests that winter sea-ice extent greatly affects larval survival and recruitment even when krill spawning is relatively early.

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AMLR program: Salps and other macrozooplankton collected from January to March 1997

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Macrozooplankton were collected along with krill in the Isaacs-Kidd Midwater Trawl (IKMT) samples during AMLR 1997. Various macrozooplankton, particularly salps (*Salpa thompsoni*) and copepods are, along with krill, important components of the antarctic food web.

Sampling specifics are presented in Loeb (*Antarctic Journal*, in this issue). Freshly collected samples were analyzed onboard. All salps were removed from the samples. For samples with fewer than 100 individuals, the two stages (aggregate/sexual and solitary/asexual) were enumerated and internal body length (Foxton 1966) measured to the nearest millimeter. Representative subsamples of 50–120 salps were analyzed for larger catches. After removal of salps, krill, and adult fish, the remaining zooplankton were analyzed. All larger organisms (e.g., amphipods, other euphausiids) were sorted, identified to species if possible, and enumerated. The smaller constituents (e.g., copepods, krill larvae) in representative aliquots were then enumerated using dissecting microscopes. Abundance estimates are expressed as numbers per 1,000 cubic meters of water filtered.

A total of 72 zooplankton taxonomic categories were collected at 105 stations during Survey A (table). Eight taxa dominated the collections. Copepods were the most abundant category, followed by salps, postlarval stages of the euphausiids *Thysanoessa macrura* and *Euphausia superba* (krill), chaetognaths, larval stages of *T. macrura* and krill (93 percent calyptopis stages), and postlarval *Euphausia frigida* (table). Six hyperiid amphipod species were relatively frequent and abundant. These were *Primno macropa, Cyllopus magellanicus, Themisto gaudichaudii, Vibilia antarctica, Hyperiella dilatata,* and *C. lucasii.* The pteropod *Spongiobranchaea australis* was also relatively frequent and abundant.

Fairly large concentrations of salps (e.g., greater than 100 per 1,000 cubic meters) were distributed across the survey area (figure 1). Aggregate (sexual) stages constituted 80 percent, and solitary (asexual) stages 20 percent, of the total. The solitary stages were represented primarily by newly released embryos 4–7 millimeters in length (49 percent) and old large individuals (all salps 78–172 millimeters, 34 percent). The vast majority of the aggregate stages (98 percent) were less than 60 millimeters in length (figure 2). The aggregate stages demonstrated three distinct size modes around 7–17 millimeters (31 percent), 25–35 millimeters (23 percent), and 45–50 millimeters (10 percent), which suggest successive peak budding periods by the solitary stages during spring and summer months.

Various zooplankton taxa demonstrated significant correlations of abundance across the large-area survey as indicated by Kendall's Tau values greater than 0.30 (P<0.0001). Abundances of salps, *E. frigida*, and *E. triacantha* were all positively correlated, reflecting in-creased nighttime abundance in the upper 170 meters due to diel vertical migrations. Abundance of salps and *C. lucasii, C. magellanicus,* and *V. antarctica* were also positively correlated probably due to commensal relationships of these amphipods with salps (Madin and Harbison 1977). A significant positive correlation also resulted from the parasitic relationship between the amphipod *H. dilatata* and pteropod *S. australis.* Apparently, the toxicity of *S. australis* is used by *H. dilatata* as a predation detractor (McClintock and Janssen 1990). Because of shared distributional patterns in primarily Drake Passage water, abundances of larval krill and larval *T. macrura* were significantly and positively correlated with *H. dilatata* and *S. australis.* As during 1996 (Loeb and Outram 1996), the distributions of larval and postlarval *T. macrura* were diametrically opposed as indicated by a significant negative correlation.

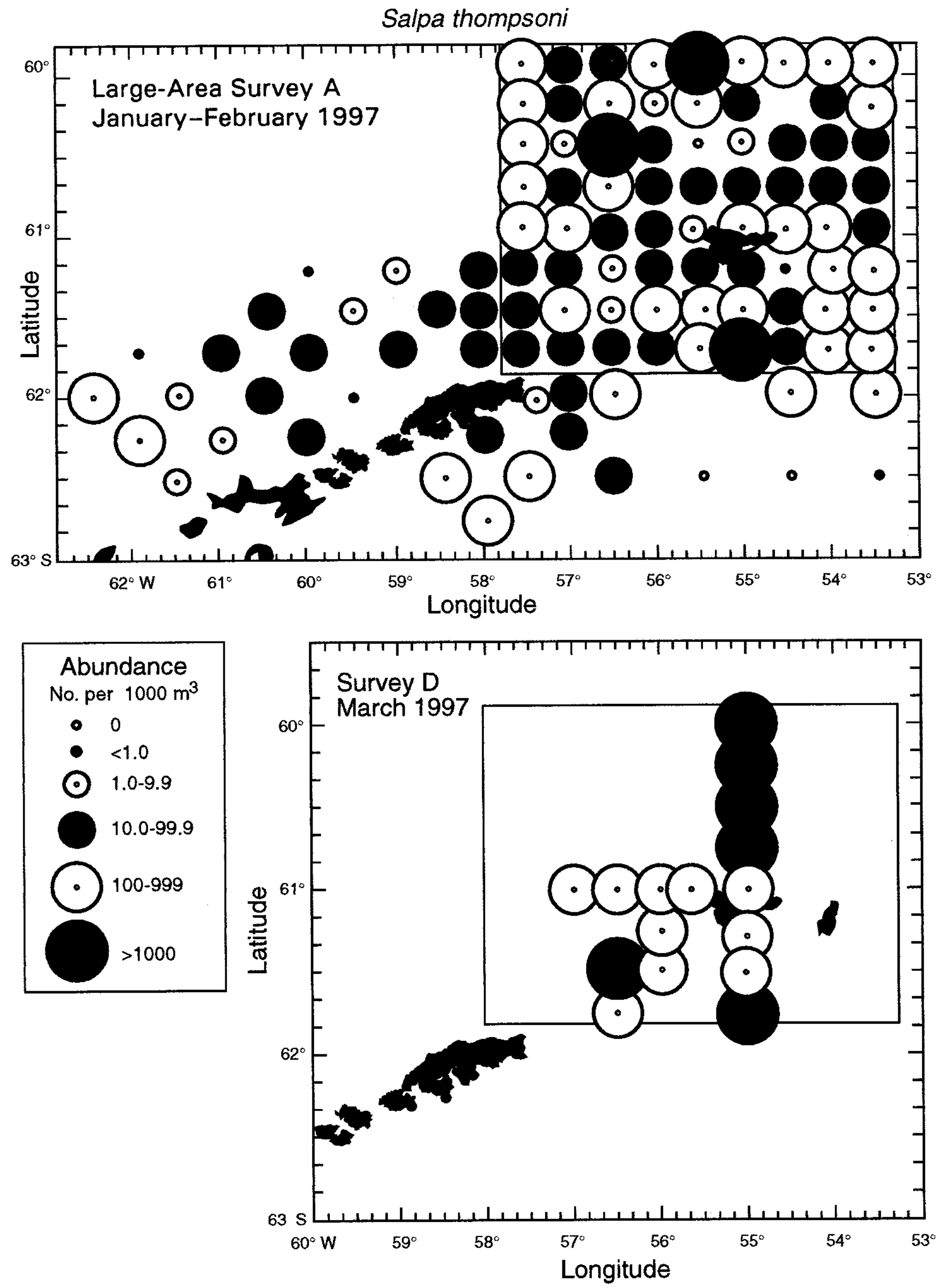

Figure 1. Distribution and abundance of salps during Surveys A and D, 1997.

In total, 37 taxa were represented in the 16 Survey D samples (table). This total was about half the number

Numerically dominant macrozooplankton collected in large-area Surveys A and D, 1997. Abundance is in numbers per 1,000 m³. F(%) is percent frequency of occurrence in tows.

	Survey A January and February 105 stations				Survey D March 16 stations			
Taxon	**(F%)**	**Mean**	**Standard**	**Median**	**(F%)**	**Mean**	**Standard**	**Median**
Copepods	100.0	582.6	693.9	402.3	100.0	1,267.8	1,755.6	659.8
Salpa thompsoni	97.1	181.4	298.5	65.5	100.0	1,245.5	1,224.6	521.0
Thysanoessa macrura	97.1	104.4	123.2	54.8	100.0	181.3	168.0	122.6
Euphausia superba	93.3	40.4	98.3	4.1	68.8	30.4	56.4	4.6
Chaetognaths	74.3	22.9	38.3	6.6	75.0	18.2	24.0	5.5
Thysanoessa macrura (larvae)	44.8	17.0	34.5	0.0	50.0	10.8	24.9	1.0
Euphausia superba (total larvae)	55.2	15.2	24.3	1.4	37.5	25.0	81.4	0.0
Euphausia frigida	41.9	14.8	39.2	0.0	68.8	44.8	54.2	21.0
Ostracods	41.0	5.5	16.4	0.0	56.3	4.8	6.7	1.7
Primno macropa	63.8	4.3	5.5	2.3	18.8	0.5	1.3	0.0
Cyllopus magellanicus	76.2	3.8	7.3	1.1	93.8	3.3	3.1	2.5
Themisto gaudichaudii	92.4	3.6	4.5	2.1	87.5	2.9	2.6	2.2
Limacina helicina	47.6	2.9	6.9	0.0	—	—	—	—
Vibilia antarctica	70.5	2.5	6.0	0.6	81.3	8.1	9.9	2.5
Spongiobranchaea australis	67.6	2.2	3.9	0.6	43.8	2.8	8.6	0.0
Hyperiella dilatata	56.2	2.2	4.9	0.3	25.0	0.2	0.6	0.0
Tomopteris carpenteri	54.3	1.9	4.3	0.3	31.3	0.5	1.0	0.0
Lepidonotothen larseni (larvae)	27.6	1.8	12.8	0.0	—	—	—	
Radiolaria	41.0	1.8	4.0	0.0	12.5	0.7	2.3	0.0
Euphausia triacantha	18.1	1.4	4.2	0.0	43.8	0.9	1.4	0.0
Electrona spp. (larvae)	37.1	1.4	3.8	0.0	12.5	0.1	0.3	0.0
Lepidonotothen kempi (larvae)	32.4	0.6	2.0	0.0	6.3	0.2	0.6	0.0
Cyllopus lucasii	49.5	0.4	0.7	0.0	93.8	2.4	1.8	2.5
Total taxa	72	16.4	4.4	17.0	37	13.8	2.7	13.5

collected in Survey A and was due to the limited number of samples. Aside from the absence of primarily uncommon and rare taxa, the Survey D station locations provided overall results that were representative of the large-area survey (Loeb unpublished manuscript). The same eight dominant taxa from Survey A again dominated but with slightly different abundance relations. Copepods, salps, and postlarval *T. macrura* remained the three most abundant taxa; *E. frigida* replaced krill as rank 4 in abundance; and chaetognaths and larval *T. macrura* were ranked 7 and 8. Among these taxa, significantly higher mean abundances of salps (Z test, $P<0.001$) and *E. frigida* ($P<0.05$) indicate substantial population growth during late summer. As during Survey A, only calyptopis stages of krill larvae were collected. The absence of more advanced furcilia stages, together with similar mean abundance ($P>0.05$) of calyptopis stages, suggests relatively poor spawning success and/or poor egg and larval survival during January and February. The lower larval *T. macrura* abundance relative to Survey A is due to their primary distribution in Drake Passage waters outside the scope of Survey D (Loeb and Outram 1996). Significantly increased mean abundance of the amphipods *V. antarctica* ($P<0.05$) and *C. lucasii* ($P<0.01$) relative to Survey A was directly associated with increased salp population size.

Salps were present at all 16 stations at concentrations ranging from 280 to 4,350 per 1,000 cubic meters (figure 1). Aggregate stages contributed 92 percent of the total individuals; proportionately fewer solitary stages were collected than during Survey A (8 percent versus 20 percent). Most (66 percent) of the aggregate stages were 8–16 millimeters in length and resulted from relatively recent chain release by solitary stages. As during Survey A, the larger aggregate stages demonstrated a polymodal distribution (figure 2). Within the 17–82-millimeter aggregate size range, abundance peaks occurred around 26–38 millimeters (26 percent), 45–55 millimeters (26 percent), and 69–74 millimeters (9 percent). These size modes and increased proportions of individuals larger than 60 millimeters relative to Survey A suggest a net length increase of approximately 20 millimeters over the intervening 45-day period; this corresponds to a summertime growth rate of approximately 14 millimeters per month, twice the estimated solitary stage growth rate during winter (6–8 millimeters per month; Foxton 1966). The solitary stages were primarily represented by newly released embryos 4–10 millimeters in length (29 percent) and old, large (74–145 millimeters) individuals (51 percent).

Within the 1992–1997 Elephant Island area data set, the mean and median salp abundance values during Survey D

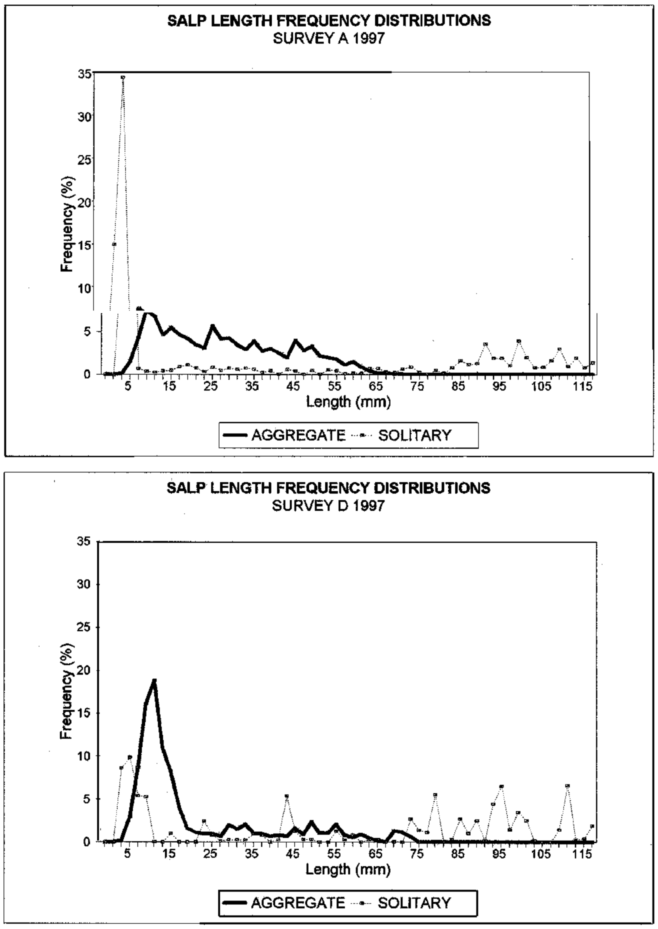

Figure 2. Length frequency distributions of aggregate and solitary stages of salps during Surveys A and D, 1997.

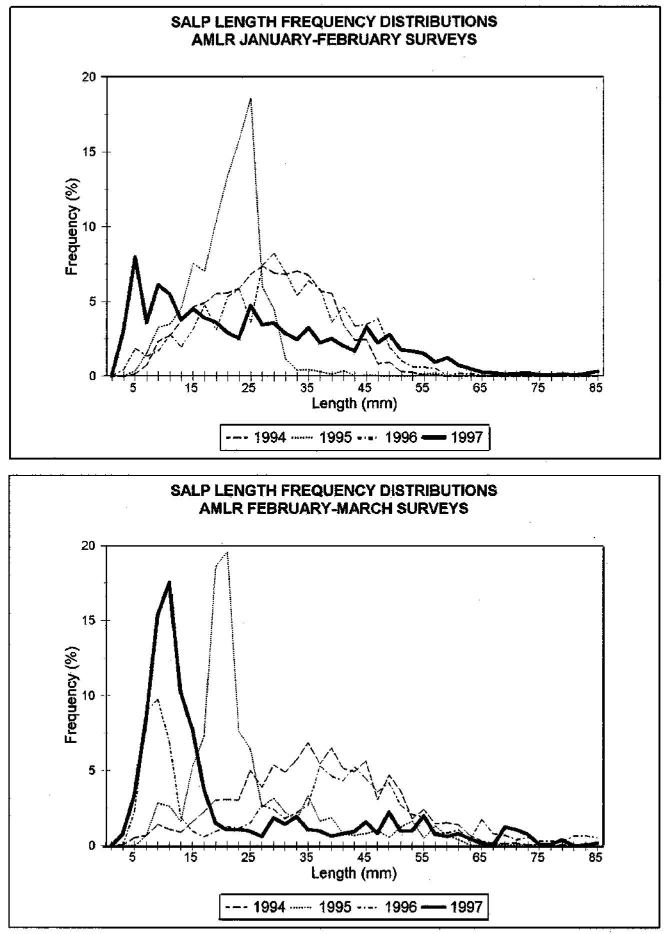

Figure 3. Overall length frequency distributions of salps during January and February (Survey A) and February and March (Survey D) in 1994, 1995, 1996, and 1997.

were second only to those observed during February and March 1993 and, as in 1993, resulted from massive population growth during summer. These two years contrast with the two others which demonstrated declines in median salp abundance with the advancing season. The overall salp length frequency distribution and stage composition during the 1997 surveys differed markedly from those of previous years (figure 3), and the presence of distinct size modes, which allowed growth rate estimation, was unique. These differences reflect large interannual variations in conditions influencing the initiation, duration, and continuity of both aggregate and solitary stage production across the Antarctic Peninsula region.

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AMLR program: Midsummer 1997 in the Elephant Island area—A month of warm surface waters and calm winds

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The AMLR program has completed eight austral summer seasons (mid-January to mid-March 1990–1997) surveying the upper waters around Elephant Island. These surveys are designed to describe the relationships between krill, their predators, and environmental variables. During each austral summer from 1990 to 1996, a research cruise with two 30-day legs was completed. A large-area survey of 91 conductivity-temperature-depth (CTD)/rosette stations on a grid with 15-nautical-mile spacing between stations was completed once per leg. This season, the large-area survey grid was expanded to 106 stations; new stations were added west of Livingston Island and south of King George Island in Bransfield Strait. The new grid was successfully completed on Leg I. Because of a delay for ship repair, however, Leg II was significantly shortened (see Martin, Hewitt, and Holt, *Antarctic Journal*, in this issue).

At each of the 106 stations on Leg I (Survey A), the physical oceanography group obtained vertical CTD profiles to 750 meters. In addition to temperature and salinity, profiles of dissolved oxygen, optical parameters, and *in situ* chlorophyll-*a* fluorescence were obtained along with discrete water samples for nutrient and phytoplankton analyses. This year, a new Sea-Bird SBE-9/11 PLUS CTD/carousel water sampler was used for the CTD/carousel casts.

No similar CTD/carousel casts were made on the shortened Leg II; however, a Sea-Bird Seacat (model SBE16) was used for CTD casts (limited to 250 meters depth) along the 55°W meridian, a section of interest to the international community (CCAMLR, 1995). As on all previous AMLR cruises, weather, sea temperature, salinity, water clarity, chlorophyll, and solar radiation data were continuously acquired. This season, new equipment (Coastal Environmental WeatherPak and a Fluke Data Bucket) consolidated the acquisition of these data.

As in the past, we classified and grouped stations with similar vertical temperature/salinity (T/S) characteristics. We have identified five water zones, designated I through V. It should be noted that these zones are based on the T/S curves from the surface to 750 meters (or to the bottom in water shallower than 750 meters). For example, Water Zone I is based on these multiple characteristics:

- warm, low-salinity surface water;
- a strong subsurface temperature minimum [called "Winter Water," at approximately –1°C and salinity of 34.0 parts per thousand (ppt)]; and
- a distinct T/S maximum near 500 meters (called "Circumpolar Deep Water" or CDW).

Water Zone I is the oceanic water of the Drake Passage. In the Bransfield Strait and south of Elephant Island, Water Zone IV dominates. Here, bottom waters are around –1°C, and the subsurface extrema are far less prominent, although a slight "crook" in the curve is characteristic. In between, there are transition zones where adjacent water zones mix. In this article, we report only on the Leg I survey, which took place late January to mid-February.

Figure 1 shows the composite T/S scatter diagram for all stations of Survey A. The stations shown in the inset map are shaded according to water zone. The two major zones can clearly be seen. Separation of the transition zones along the main frontal boundary by their T/S characteristics is

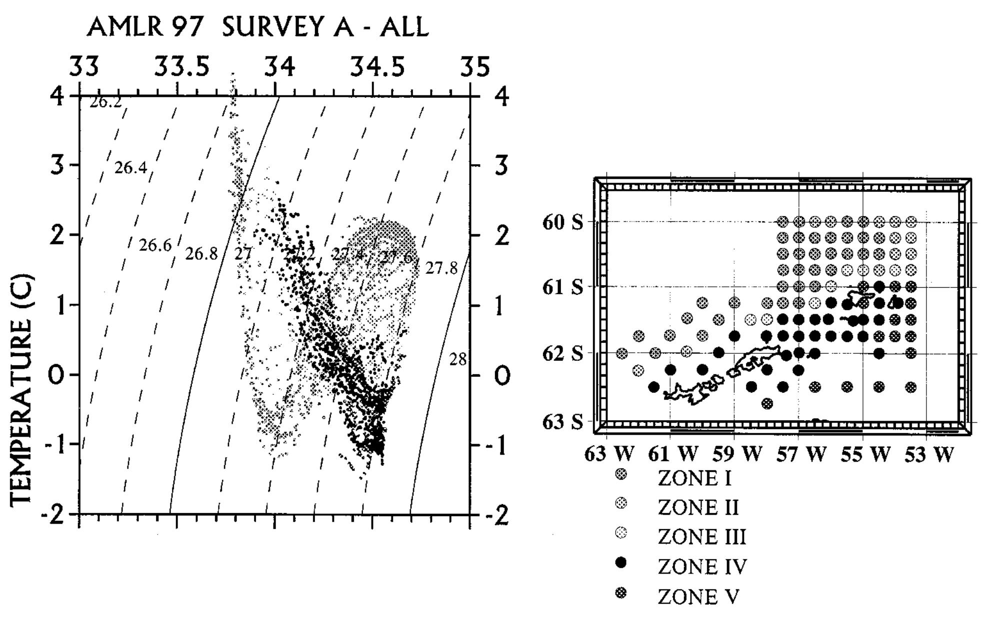

Figure 1. Composite T/S diagram for all stations in the large-area survey on Leg I (Survey A). Symbols on inset map show station locations shaded by water zones of similar T/S characteristics.

also reflected in the chlorophyll-*a* profiles shown in Holm-Hansen et al. (*Antarctic Journal*, in this issue). This year on Leg I, surface waters exceeded 4°C for the first time in the 8 years of AMLR surveys in which surface conditions were monitored continuously (figure 2). Data are taken from the underway environmental data-collection system rather than from the CTD to increase the resolution. During "warm years" such as 1993 (Amos 1993), temperatures above 3°C were occasionally found in the same region in January and February and, more frequently, in February and March. This year the condition was reversed with the record-setting temperatures occurring on Leg I and much cooler surface temperatures on Leg II. Of course, Leg II was considerably reduced in scope and encompassed only the last several days of March, when the atmosphere began to cool down approaching the austral autumn. Consequently, 1997 looks as though it might be an anomalous year for the AMLR program.

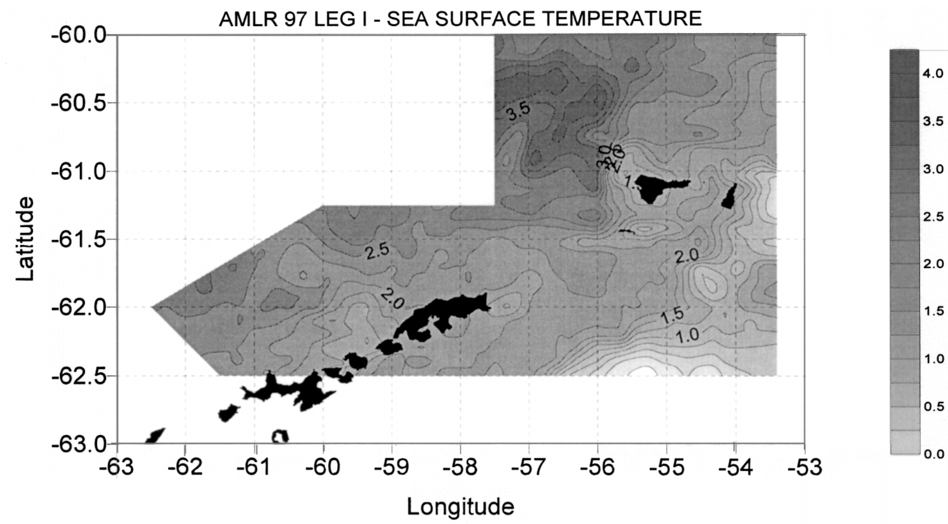

Figure 2. Horizontal map of near surface oceanographic conditions in the AMLR study area during Leg I. Data are from the continuously recorded underway environmental data collection system.

We have noted that in more recent AMLR cruises, especially in January and February, the perception is that calmer atmospheric conditions prevailed compared to the earliest AMLR cruises. During Leg I, the mean wind speed below 60°S was 6.3 meters per second; this was even calmer than last year, which had been the record-holder for "serene" conditions. The few days of Leg II below 60°S were much windier: the mean wind was 10.1 meters per second. Although the maximum wind of 21.9 meters per second on Leg I was higher than last year, these high winds occurred only once at the beginning of the leg. For 21 days, the maximum wind speed did not exceed 15.5 meters per second. Air temperatures were below freezing for only a few hours during Leg I, but there were a few days of freezing temperatures on the abbreviated Leg II with a low of –2.3°C.

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AMLR program: Fur seal and penguin studies at Seal Island and Cape Shirreff, Livingston Island, Antarctica, 1996–1997 austral summer

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During the 1996–1997 austral summer, researchers from the Antarctic Marine Living Resources (AMLR) program at the Southwest Fisheries Science Center conducted research on antarctic pinnipeds and seabirds in support of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) Ecosystem Monitoring Program (CEMP). Studies were conducted at Seal Island (60°59'14"S 55°23'04"W) and Cape Shirreff at Livingston Island (62°28'07"S 60°46'10"W), Antarctica, during the austral summer (January to March).

Long-term data collection at CEMP sites includes census surveys, capture, and handling of animals and general observations (including weather, tag resights, and animal entanglements). The protocols and methods used for study design and data collection are those described in the CEMP *Standard Methods* manual (CCAMLR 1995). The objectives for the studies were the following:

- to monitor the breeding success, fledgling size, reproductive chronology, foraging behavior, diet, abundance, survival, and recruitment of chinstrap (*Pygoscelis antarctica*), macaroni (*Eudyptes chrysolophus*), and gentoo (*Pygoscelis papua*) penguins;
- to examine penguin chick growth and condition for intra- and interseasonal comparisons;
- to assess changes in foraging patterns and effort as physical and biological components change through the breeding season of penguins;
- to examine intra-seasonal changes in penguin chick provisioning contemporaneously with foraging effort;
- to assess the reproductive success, survival, and recruitment of cape petrels (*Daption capensis*);
- to monitor other land-based seabird predators at the study site;
- to monitor antarctic fur seal (*Arctocephalus gazella*) pup growth rates and adult female attendance;
- to determine fur seal pup production, female foraging behavior, diet, abundance, survival, and recruitment; and
- to monitor the abundance of other pinniped species ashore.

Over the past decade, predator studies have focused on animals at the Seal Island location. Because Seal Island was found to be unsafe due to landslide hazards, however, studies at the island have been curtailed. The AMLR program hopes to continue to monitor the site intermittently over the next decade. To continue a comprehensive research program on antarctic predators, the AMLR program established a new campsite at Cape Shirreff this season. Preliminary results from information collected at each site are presented below. AMLR scientists at Seal Island and Cape Shirreff did not observe pinniped entanglements this season. A summary of the animals taken this season, by site, is provided in the table.

AMLR program researchers occupied Seal Island between 11 February and 16 March 1997. Limited research studies focused on antarctic fur seals and chinstrap penguins. Census surveys for antarctic fur seal pups were conducted at four study sites on Seal Island: Beaker Bay Beach, Big Boote, North Annex, and North Cove. Surveys were conducted by walking the perimeter of a colony, causing minimal or no disturbance to animals. In total, 212 pups were counted during these surveys. Because of limited time at the site, it was difficult to determine maximum pup numbers on the island. It is interesting to note, however, that the pup count for the North Cove/North Annex sites is the second highest count recorded since the 1993–1994 count during the same seasonal period (14–19 February). Counts for North Annex and Big Boote were comparable to those recorded during the 1995–1996 austral summer. Information describing animals with tags (from previous seasons or from other sites) was also recorded; these data can provide estimates of first reproduction as well as cohort and age-specific mortality. Sixteen known-aged individuals were sighted, including one female who was seen with a pup.

Weights were recorded for 217 chinstrap fledglings on Beaker Bay Beach at Seal Island. Fledglings were captured, weighed, marked (with small dye spot on a feather, thereby avoiding recapturing the same individual), and then released on the beach as close to the place of capture as possible. The timing of the start of fledging was normal compared to past seasons (Trivelpiece et al. 1997). Average fledging weight was 3.22 kilograms (±0.32 standard deviation), slightly higher than means recorded over the past seven seasons at Seal Island. Because time was limited, adult penguins, cape petrels, and macaroni penguins were not included in any study this season. Resight data (animals with tags from previous seasons or other sites) were recorded for 71 chinstrap penguins, 6 macaroni penguins, and 1 sheathbill (*Chionis alba*).

At the new Cape Shirreff camp, AMLR program researchers and two carpenters constructed a campsite consisting of four semipermanent structures. The site was occupied between 24 January and 8 March. Again, because of time constraints, the AMLR program did not conduct any pinniped studies this season. Daniel Torres from the Instituto Antarctico Chileno (INACH), however, conducts studies of antarctic fur seals at Cape Shirreff, including periodic censuses. On two occasions, to promote future cooperation and collaboration, AMLR scientists observed research activities (pup weighing) conducted by Torres' group. During observation, AMLR researchers did not record any data.

Limited studies on seabirds were conducted at Cape Shirreff this season. Breeding colonies were identified at the site,

Preliminary summary of seabirds and pinnipeds taken during the 1997 AMRL program at Cape Shirreff, Livingston Island (denoted as CS), and Seal Island (denoted as SI), Antarctica. "Take" denotes capture or directed (species specific) census; animals are not handled during census. Research activities were conducted between 24 January and 8 March.

Species	Site	Age	Sex	Size	Method of take
Chinstrap penguin *(Pygoscelis antarctica)*	CS	All	Both	All	Census
Chinstrap penguin *(Pygoscelis antarctica)*	CS	Chick	Both	All	Capture, band, release
Chinstrap penguin *(Pygoscelis antarctica)*	CS	Fledgling	Both	All	Capture, weigh, release
Chinstrap penguin *(Pygoscelis antarctica)*	SI	Fledgling	Both	All	Capture, weigh, release
Gentoo penguin *(Pygoscelis papua)*	CS	All	Both	All	Census
Brown skua *(Catharacta lönnbergi)*	CS	Chick adult	Both	All	Capture, band, release
Antarctic fur seal *(Arctocephalus gazella)*	SI	Pup	Both	All	Census
Antarctic fur seal *(Arctocephalus gazella)*	CS	Pup	Both	All	Observe Chilean research

including 19 chinstrap, 6 gentoo, and 5 mixed gentoo-chinstrap colonies. Colonies were marked and plotted for future studies. Chinstrap penguin chicks (1,000 birds) were captured and banded; these individuals will be used for demographic studies. Chinstrap penguin fledglings (sample size of 214) were captured, weighed, and then released on the beach as close to the site of capture as possible. Of these fledglings, roughly 50 animals were weighed intermittently over a week; average weight for these individuals was 3.27 kilograms (±0.31 standard deviation). Adult chinstrap penguins were not censused this season. In addition, 12 nesting sites of brown skuas (*Catharacta lönnbergi*), including 16 chicks and 3 adults, were observed. The skuas (adults and chicks) were captured and banded. Because of time constraints, gentoo penguins, cape petrels, giant petrels (*Macronectes giganteus*), south polar skuas (*Catharacta maccormicki*), sheathbills, kelp gulls (*Larus dominicanus*), and blue-eyed shags (*Phalacrocorax atriceps*) were not included in any studies.

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