

Antarctic Marine Living Resources (AMLR) program

The U.S. Antarctic Marine Living Resources (AMLR) program: 1993–1994 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.

Similar to the past five field seasons, the 1993–1994 field program included a 2-month research cruise aboard the National Oceanic and Atmospheric Administration ship *Surveyor* near Elephant Island, one of the South Shetland Islands at the tip of the Antarctic Peninsula. Also, land-based

studies were conducted at a seasonal field camp on Seal Island, off the northwest coast of Elephant Island, and at Palmer Station, a U.S. scientific station on Anvers Island further south on the Peninsula (figure 1).

The specific objectives of the 1993–1994 field season were the following:

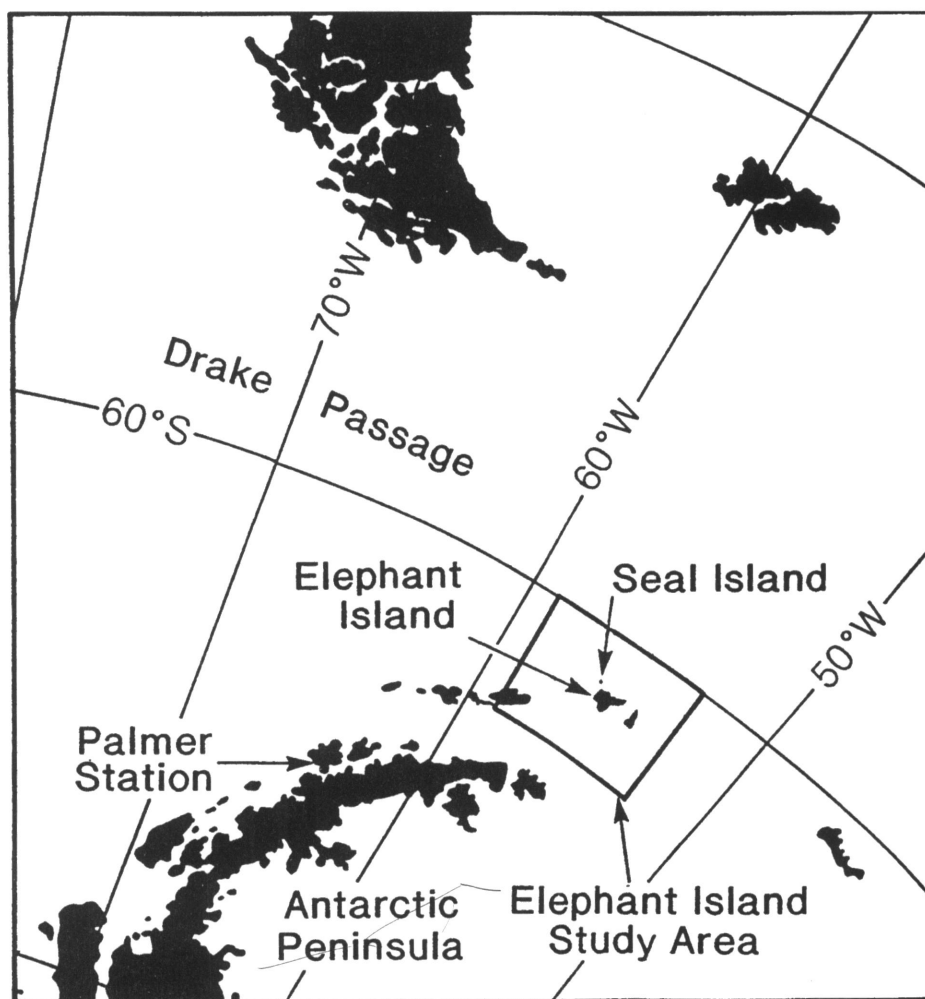


Figure 1. Locations of the U.S. AMLR field research program: Elephant Island study area, Seal Island, and Palmer Station.

- to map the physical structure of the upper 750 meters, including the thermal 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 directed studies on acoustic characteristics of krill, diel changes in krill behavior, and spatial association between krill predators and krill;
- to conduct a fur seal survey at selected sites in the northern South Shetland Islands; and
- to describe the reproductive success, feeding ecology, and growth rates of land-based krill predators throughout the reproductive season on Seal Island and at Palmer Station.

Surveyor departed Punta Arenas, Chile, on 12 January 1994 to begin Leg I of the AMLR cruise; the leg was completed on 9 February. Following a mid-cruise port call, Leg II was conducted 14 February to 15 March. A large-area survey of 91 conductivity-temperature-depth (CTD)/rosette and net sampling stations, separated by acoustic transects, was completed once during each leg near Elephant, Clarence, and King George Islands (Survey A on Leg I, Stations A1-A91; Survey D on Leg II, Stations D1-D91; figure 2). Data for physical oceanography, primary productivity, and krill distribution and condition studies were collected during the large-area surveys. Operations at each station included the following:

- measurements of temperature, salinity, oxygen, light, transmissometer, and fluorescence profiles;
- collection of discrete water samples at standard depths for analysis of chlorophyll-*a* content, absorption spectra, particulate organic carbon and nitrogen concentrations, primary production, size fractionation, floristics, and inorganic nutrient content; and
- deployment of a 1.8-meter (6-foot) Isaacs-Kidd Midwater Trawl (IKMT) to obtain samples of zooplankton and nekton.

AMLR 1994 Large-Area Survey

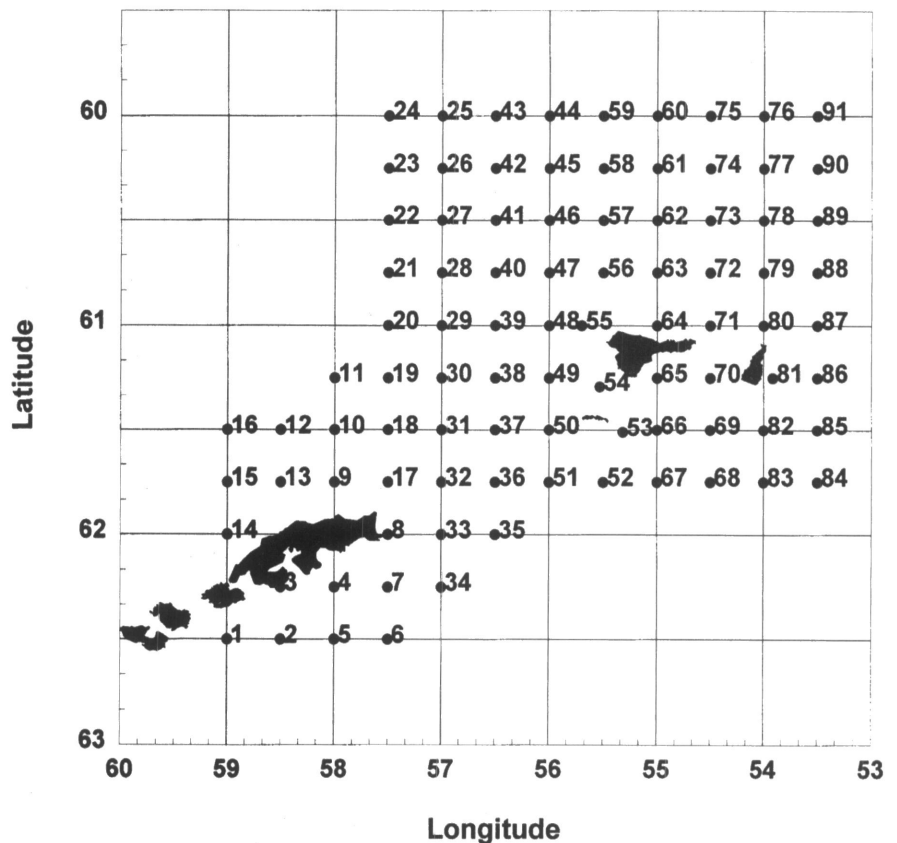


Figure 2. The large-area surveys for AMLR 1994 (Leg I: Survey A; Leg II: Survey D).

AMLR 1994 Small-Area Survey

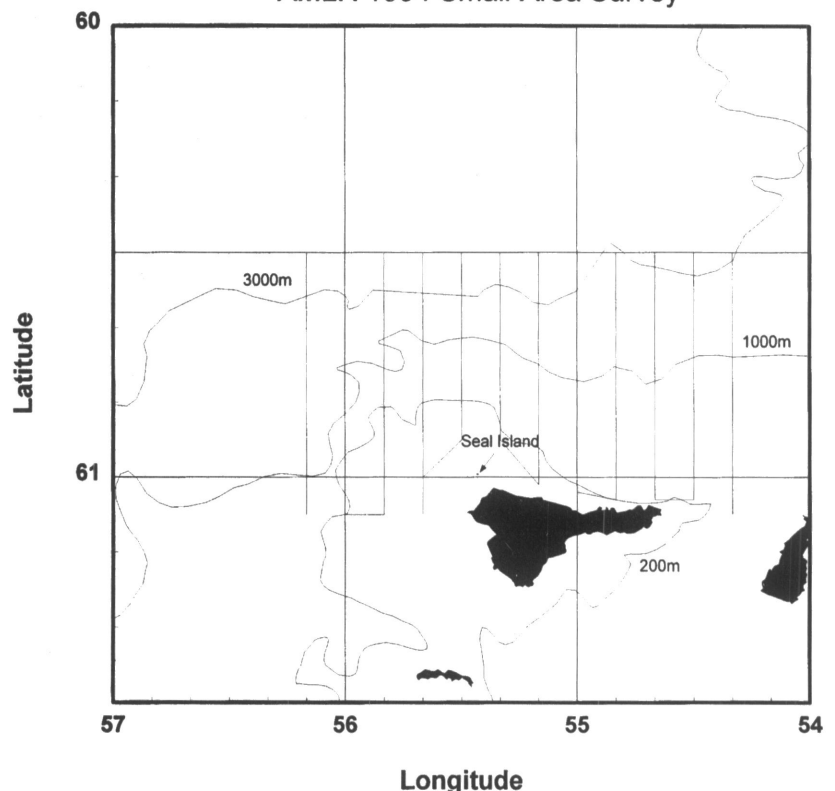


Figure 3. The small-area surveys for AMLR 1994 (Leg I: Survey B; Leg II: Survey C).

Small-area acoustic surveys were conducted north of Elephant Island during both legs to describe krill distribution and abundance within foraging range of predators breeding on Seal Island (Survey B on Leg I; Survey C on Leg II; figure 3). A transect of CTD/rosette stations was conducted across the shelf-break north of Elephant Island (Stations X1-X7 on Leg I and Stations X22-X29 on Leg II) to delineate hydrographic and biological features. During Leg II, similar transects were conducted across the Bransfield Strait, extending northwest of Nelson Island (Stations X8-X21), and east of the large-area survey grid (Stations X30-X37). In addition, a study to assess the spatial association between krill predators

(seabirds and marine mammals) and krill was conducted during both cruise legs.

A field team occupied the field camp on Seal Island from 30 November 1993 to 10 March 1994. The team conducted extensive research on the reproductive and feeding behaviors of antarctic fur seals (*Arctocephalus gazella*), chinstrap penguins (*Pygoscelis antarctica*), macaroni penguins (*Eudyptes chrysolophus*), and cape petrels (*Daption capensis*) breeding on the island. Fieldwork at Palmer Station was initiated on 8 October 1993 and completed on 1 April 1994; studies on aspects of the ecology of Adélie penguins (*Pygoscelis adeliae*) were conducted.

AMLR program: Distribution and abundance of krill near Elephant Island in the 1993–1994 austral summer

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One of the principal goals of the Antarctic Marine Living Resources (AMLR) program is to relate the feeding ecology and reproductive success of krill predators to aspects of the prey field. Echo integration methodology was used to map the distribution of krill and to estimate biomass. Two specific objectives for the acoustic surveys were the following:

- to map mesoscale (10s to 100s of kilometers) features of the distribution, density, and abundance of krill in the area around Elephant Island; and
- to map microscale (1 to 10s of kilometers) features of the distribution, density, and abundance of krill immediately north of Elephant Island, within the foraging range of krill predators breeding at Seal Island.

To address these objectives, two large-area surveys (Surveys A and D) and two small-area surveys (Surveys B and C) were conducted near Elephant Island between mid-January and mid-March 1994 (Rosenberg et al., *Antarctic Journal*, in this issue).

Acoustic data were collected using a multifrequency echo sounder configured with down-looking 120-kilohertz split-beam and 200-kilohertz, single-beam transducers mounted in the hull of the ship. System calibrations were conducted before and after the surveys while the ship was at anchor in Ezcurra Inlet, King George Island. Calibration drift was less than 1 decibel.

For the purposes of generating distribution maps and biomass estimates, measurements of volume backscattering strength obtained at 120-kilohertz were integrated over depth from 10 to 250 meters and averaged over transect intervals of 185 meters (35 to 60 pings, depending on ship's speed). Integrated volume backscattering strength per unit sea-surface area was converted to estimates of krill biomass density following the method outlined in Hewitt and Demer (1993). Sur-

vey biomass was estimated by treating the mean biomass density on each transect as an independent estimate of the mean density over the survey area.

The large-area surveys (Surveys A and D) were separated by approximately 5 weeks. During Survey A, the highest densities of krill were mapped north of King George Island (figure 1). Lower densities were mapped south of King George Island, around Clarence and Gibbs Islands, and over a broad area northwest of Elephant Island. During Survey D, highest densities of krill were mapped north of Elephant Island (figure 1). Another possible area of high krill density was detected at the far western end of the survey area north of King George Island. Lower densities were mapped south of Elephant Island and between Elephant and King George Islands.

Two small-area surveys (Survey B and C) were conducted during the period between the large-area surveys. During both surveys, high densities of krill were mapped in the shoal waters to the north of Elephant Island (figure 2). Additional areas of high krill densities were mapped in water with depths greater than 1,000 meters northwest of Elephant Island during Survey B and north of Elephant Island during Survey C.

Krill biomass estimates were calculated for the portions of Survey A and Survey D centered over Elephant Island, comparable in area to 1992 and 1993 surveys (approximately 12,000 square nautical miles). Krill biomasses were estimated to be 401×10^3 tons for Survey A and 359×10^3 tons for Survey D (table). Krill biomasses for Surveys B and C were estimated to be 87×10^3 and 97×10^3 tons, respectively. These values correspond to an average krill density over the large-area survey of less than 10 grams per square meter and over the small-area survey of less than 15 grams per square meter during the austral summer of 1993–1994.