# Palmer LTER: Seasonal comparison of spatially averaged estimates of krill abundance

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As part of the Palmer Long-Term Ecological Research (LTER) program (Smith et al. 1995), acoustical measurements of krill biomass have been collected since 1991 during multidisciplinary cruises conducted within the waters of the west Antarctic Peninsula continental shelf system. The observations from the first four of these cruises (austral spring 1991 and summer, fall, and winter 1993) represent a unique antarctic data set because full seasonal coverage was provided over a defined region and three seasons were sampled consecutively in a single year. This article describes the observed seasonal changes in spatially averaged estimates of krill abundance and compares the acoustically derived krill biomass values with similar measurements from other programs.

Portions of the Palmer LTER study region (grid defined in Waters and Smith 1992) were surveyed during research cruises conducted in spring (7–21 November 1991), summer (8 January to 7 February 1993), fall (25 March to 15 May 1993), and winter (23 August to 30 September 1993). The locations at which acoustic observations were made during each cruise are shown in figure 1. The sampling intensity and region occupied differed between cruises; however, sampling for each of the 1993 surveys included transect lines 200 through 600. A full description of acoustic sampling methods and postprocessing analysis is available in Lascara (1996).

Spatially averaged estimates of krill biomass increased three-fold from spring to summer [34 to 110 grams per square meter (g $m^{-2}$)] and then decreased an order of magnitude to the low values (<10 g $m^{-2}$) observed during fall and winter (table). The number of aggregations detected per unit sampling effort followed a similar seasonal pattern (table) with maximum and minimum values observed in summer [12.1 aggregations per kilometer ($km^{-1}$)] and winter (0.4 aggregations $km^{-1}$), respectively. Total aggregation area [in square meters per kilometer ($m^2$ $km^{-1}$)], followed the seasonal trend of krill biomass with the exception that total area increased from fall to winter (table). This increase in total aggregation area between fall and winter was accompanied by a decrease in number of aggregations and a decrease in mean vertically integrated krill biomass suggesting a seasonal change in the character of aggregations; this change is further described in Lascara (1996).

Quantitative acoustic observations that can be used for direct comparison with the spatially averaged, vertically integrated estimates of krill biomass obtained during this study are available for only a few surveys conducted primarily in the region encompassing the Bransfield Strait, South Shetland Islands, and Elephant Island (figure 2). The magnitude of krill biomass observed in spring 1991 and summer 1993 are consistent with the limited measurements available for direct comparison. Interannual variability is apparent in the combined summer observations, and the summer 1993 krill biomass value (110 g $m^{-2}$) was higher than all other summer estimates (17–90 g $m^{-2}$) with the exception of the 1993 estimate obtained by the U.S. Antarctic Marine Living Resources (AMLR) program (135 g $m^{-2}$, Hewitt and Demer 1993b).

The Palmer LTER observations represent the only quantitative acoustic estimates of krill abundance available for the west Antarctic Peninsula shelf region from the fall through late winter. The reduction in acoustically derived estimates of krill biomass by an order of magnitude during the fall and winter compared to summer 1993 in this study, however, is consistent with the seasonal pattern described from analysis of net-derived krill density estimates from Bransfield Strait and around the South Shetland Islands (Stepnik 1982; Siegel 1988, pp. 219–230; Siegel 1992). These combined data sets suggest that the seasonal change observed in this study is a recurrent annual pattern at least for the broad region from Adelaide Island to Elephant Island. Moreover, the variation in spatially integrated krill biomass is higher between seasons than between years for waters west of the Antarctic Peninsula. Long-term programs, such as the Palmer LTER, which are focused on the characterization of interannual ecosystem variability in this region, need to interpret their observations with an understanding of the magnitude of seasonally induced variability in krill biomass.

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***Spatially averaged estimates of krill abundance by season. Aggregation number and total area provided per unit of sampling effort (km).***

| Parameter | Spring | Summer | Fall | Winter |
|---|---|---|---|---|
| Vertically integrated krill biomass (g $m^{-2}$) | 34 | 110 | 10 | 7 |
| Number of aggregations ($km^{-1}$) | 4.8 | 12.1 | 0.9 | 0.4 |
| Total area of aggregations ($m^2$ $km^{-1}$) | 1,770 | 3,345 | 450 | 1,715 |

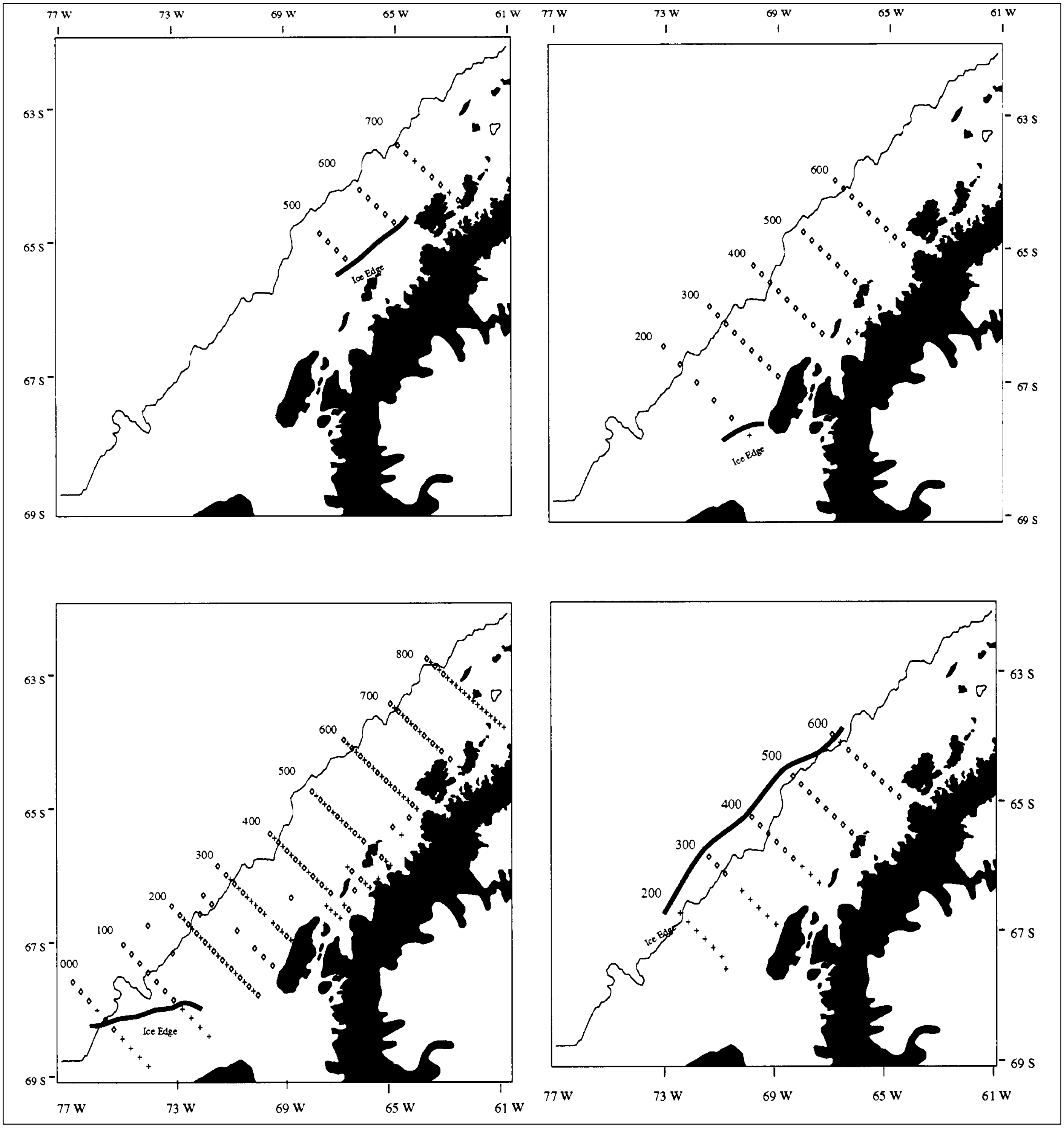


Figure 1. Locations sampled during (*A*) spring: 7–21 November 1991; (*B*) summer: 8 January to 7 February 1993; (*C*) fall: 25 March to 15 May 1993; (*D*) winter: 23 August to 30 September 1993. The ◇ indicates stations where environmental and acoustic measurements were collected; the X indicates environmental measurements only. The 1,000-m isobath is denoted by the solid line and the ice edge by the heavy line.

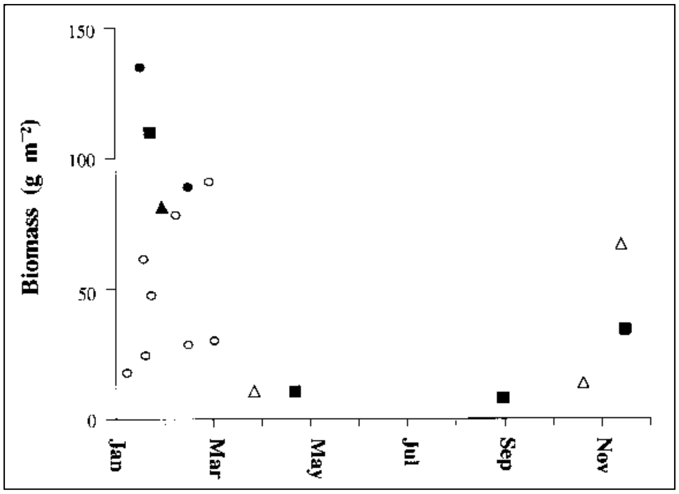


Figure 2. Comparison of acoustically derived, spatially averaged estimates of krill biomass by month. Datasets are denoted as the following: filled box—this study; open circle—AMLR study region near Elephant Island (1190–1992) (Hewitt and Demer 1993a): filled circle—AMLR study region in 1993 (Hewitt and Demer 1993b); open triangle—Elephant Island (Klindt 1986 as adjusted by Hewitt and Demer 1993a); and filled triangle—southwest Atlantic Survey region during FIBEX (Trathan et al. 1995). (FIBEX is the First International BIOMASS Experiment. BIOMASS is Biological Investigations of Marine Antarctic Systems and Stock.)

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# Palmer LTER: Interannual variability in near-surface hydrography

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As part of the annual January cruise undertaken by the Palmer Long-Term Ecological Research (LTER) program, hydrographic surveys are made of the offshore waters west of the Antarctic Peninsula. To date, January cruises have been made in 1993, 1994, 1995, and 1996. This report focuses on the interannual differences observed in the horizontal distributions of the near-surface temperature and salinity fields in January 1993 and January 1994.

Vertical profiles of temperature and salinity were obtained at 52 stations during January 1993 (figure 1*A*) and at 49 stations during January 1994 (figure 1*B*) with a Sea-Bird conductivity-temperature-depth (CTD) system. On all casts, observations were made to within a few meters of the bottom or to 500 meters (m) at deep locations. In both years, the horizontal spacing between hydrographic stations was about 20 kilometers (km). In January 1994, the southernmost transect was not occupied; otherwise, the sampling regime was similar in both years.

The CTD measurements for both cruises were processed as described in Lascara et al. (1993). The near-surface temperature and salinity were obtained by averaging the CTD measurements over the upper 40 m of the water column. This part of the water column is Antarctic Surface Water (Hofmann et al. 1993; Hofmann et al. in press) and is strongly influenced by surface heating and cooling and by buoyancy fluxes. During the austral summer, this region is typically stratified, and the use of an average value was considered to be more representative of the mesoscale hydrographic conditions than observations from a specific depth.

The near-surface temperature in January 1993 (figure 1*A*) shows an onshore-offshore gradient; the inner shelf waters