Bioacoustic Survey

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Abstract

Multi-frequency acoustic data were collected around the South Shetland and Elephant Islands, Antarctica, from January to March 2011. Data were collected to determine the distribution and biomass of krill. Results indicate that:

- Around the South Shetland Islands in January through March, mean krill abundance was 49.5, 84.1 and 55 g m^{-2} for the West, Elephant Island, and South Areas, respectively; and
- Highest densities of krill were observed around Elephant Island.

Introduction

The primary objectives of the bioacoustic survey were to map the meso-scale dispersion of Antarctic krill (*Euphausia superba*) in the vicinity of the South Shetland Islands 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 to determine their relationship with water mass boundaries and zooplankton distribution.

Methods

Data Collection

Acoustic data were collected using a multi-frequency echo sounder (Simrad EK60) configured with down-looking 38, 120, and 200 kilohertz (kHz) split-beam transducers mounted in the hull of the ship. System calibrations were conducted after the survey using standard sphere techniques while the ship was at anchor in Ezcurra Inlet, King George Island. During the surveys, pulses were transmitted every two seconds at one kilowatt for one millisecond duration at 38, 120 and 200 kHz. Geographic positions were logged simultaneously every two seconds. Ethernet communications were maintained between the EK60 and a Windows XP workstation. The workstation was used for primary system control, data logging and data processing using Myriax Echoview software.

Acoustic surveys of the water surrounding the South Shetland Islands were divided into four areas during Leg I (Figure 2, Introduction): 1) a 43,865 km^2 area centered on Elephant Island (Elephant Island Area) was sampled with seven north-south transects; 2) a 29,031 km^2 area along the north side of the southwestern portion of the South Shetland Island archipelago (West Area) was sampled with seven transects oriented northwest-southwest and one oriented north-south; 3) a 24,479 km^2 area in the western Bransfield Strait (South Area) was sampled with seven transects oriented northwest-southwest; and 4) an 18,151 km^2 area north of Joinville Island (Joinville Island Area) was sampled with one transect. During Leg II, acoustic data were collected during a net comparison study. Acoustic data were collected again for the South Area and three transects were collected for the Joinville Area. An auxiliary survey of 1,133 km^2 was performed around the Gerlache Strait.

Acoustic data recorded while on biological sampling stations were discarded from analyses. Further, only daytime data were used in this analysis due to possible bias from diurnal vertical migration of krill above the transducer depths during night time (Demer and Hewitt 1995).

Data Analysis

Krill are delineated from other scatters by use of a three-frequency ΔSv method (Hewitt et al. 2003; Reiss et al. 2008; SC-CAMLR 2005), using 95% of the total krill length-frequencies for each area. In 2010, the CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) held a working group for the SDWBA (stochastic distorted-wave Born approximation) model (Demer and Conti 2005; Conti and Demer 2006); those corrections are applied to the AMLR historical data used in this report (SC-CAMLR 2010) (Figure 3.1).

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

Backscatter values were averaged over 5 m by 100 s bins. Time varied gain (TVG) noise was subtracted from the echogram and the ΔSv range was applied. TVG values were based on levels required to erase the rainbow effect plus 2 dB. The remaining volume backscatter classified as krill was integrated over depth (250 m) and av-

eraged over 1,852 m (1 nautical mile) distance intervals.

Integrated krill nautical area scattering coefficient (NASC) (Maclennan and Fernandes 2002) was converted to estimates of krill abundance (ρ) by dividing the sum of the weighted-mean masses per animal (*W*; g/krill) by the sum of the backscattering cross-sectional area of krill (σ) ($\sigma = 4\pi r 10^{TS/10}$ where r is the reference range of 1 m; Hewitt and Demer 1993). The length to weight relationship

(1) $W\,(g) = 2.236*10^{-3} * TL^{3.314}$

was based on net samples collected during the international krill biomass survey of the Scotia Sea conducted during January 2000 (Hewitt et al. 2004). Krill abundance was estimated according to Hewitt and Demer (1993):

(2) $$\rho\ (g/m^2) = \frac{\sum_{i=1}^{n} f_i W(l_i)}{\sum_{i=1}^{n} f_i \sigma(l_i)}\ NASC$$

where f_i = the relative frequency of krill of standard length l_i. Krill biomass was then estimated by multiplying ρ by the area surveyed.

For each area in each survey, mean biomass density attributed to krill and its variance were calculated by assuming that the mean abundance along a single transect was an independent estimate of the mean abundance in the area (Jolly and Hampton 1990). We used the cluster estimator of Williamson (1982) to calculate the variance of NASC within each area and to expand the abundance estimate for the South Shetland Islands.

No myctophid biomass estimates were made because of the lack of target strength data and length frequency distributions. Instead, the NASC attributed to myctophids was integrated using Myriax Echoview software and then mapped across the South Shetland Islands using SURFER (Golden Software, Inc. Golden, CO).

Results

Mean krill abundance for each transect line in each area is presented in Table 3.1. Mean krill abundances during Leg I were 49.5, 84.1 and 55 g/m² for the West, Elephant Island, and South Areas, respectively. Leg II yielded mean krill abundances of 14.6, 76.7, and 76.1 g/m² for the South and Joinville Island Areas, and the Gerlache Strait, respectively. Highest densities were seen around Elephant Island during Leg I (Figure 3.2). Krill densities were lower in the Bransfield Strait during Leg II (Figure 3.3). The biomass estimates for this year are higher

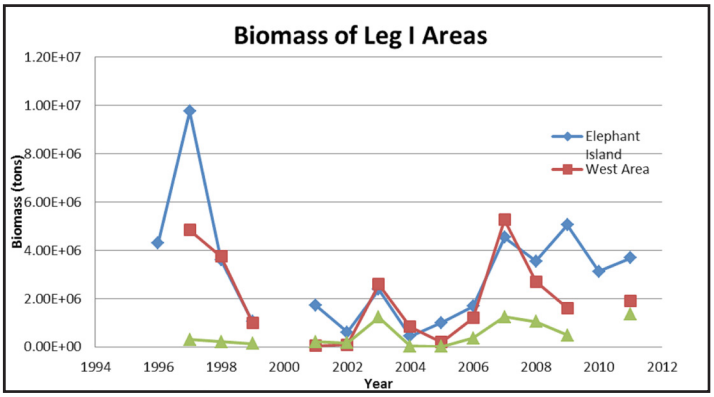

Figure 3.1. Krill biomass estimates for each area (revised to apply the corrected SDWBA method adopted in CCAMLR 2010). Biomass estimates are in tons and are only for Leg I.

Table 3.1. Daytime krill abundance estimates by area and transect the 2010/11 AMLR Survey, Leg I. n = 1 interval = 1 nautical mile. Transects are labeled numeric order from left to right in each area.

Area	Transect	n	Krill density (g/m²)
West Area			
	Transect 1	42	76.7
	Transect 2	42	64.5
	Transect 3	24	12.7
	Transect 4	61	50.5
	Transect 5	54	25.4
	Transect 6	33	10.3
	Transect 7	94	67.1
Elephant Island Area			
	Transect 1	79	71
	Transect 2	82	40.2
	Transect 3	87	175
	Transect 4	53	17.6
	Transect 5	106	77
	Transect 6	65	128
	Transect 7	79	60.2
South Area			
	Transect 1	28	94.2
	Transect 2	20	219
	Transect 3	20	17.6
	Transect 4	40	86.7
	Transect 5	46	41.6
	Transect 6	20	19.6
	Transect 7	65	0.05

than the previous year. Myctophid NASC values are not significantly different from previous years (Figure 3.4).

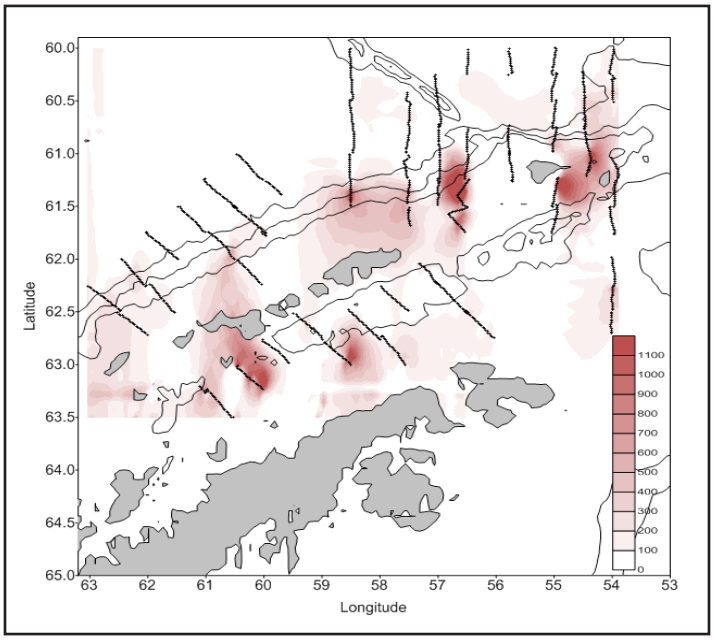

Figure 3.2 Kriged krill NASC values collected during Leg I at 120 kHz, using day data. (Latitude is south and longitude is west).

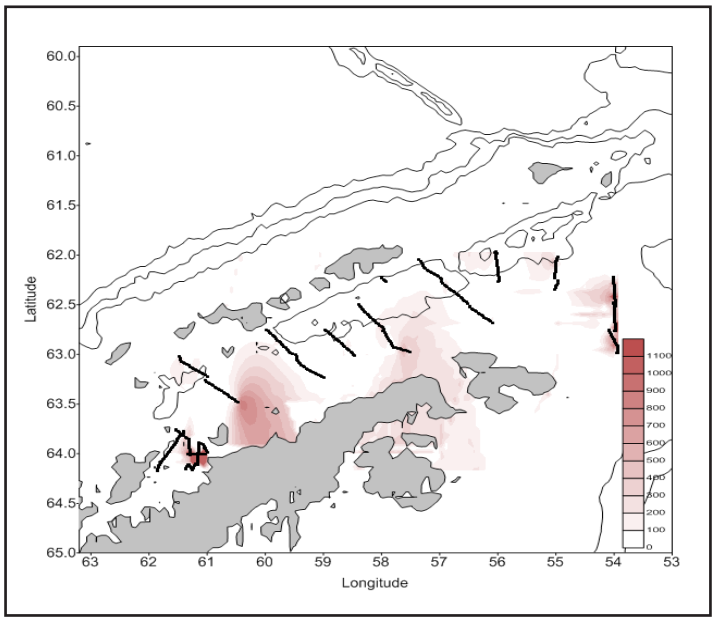

Figure 3.3. Kriged krill NASC values collected during Leg II at 120 kHz, using day data. (Latitude is south and longitude is west).

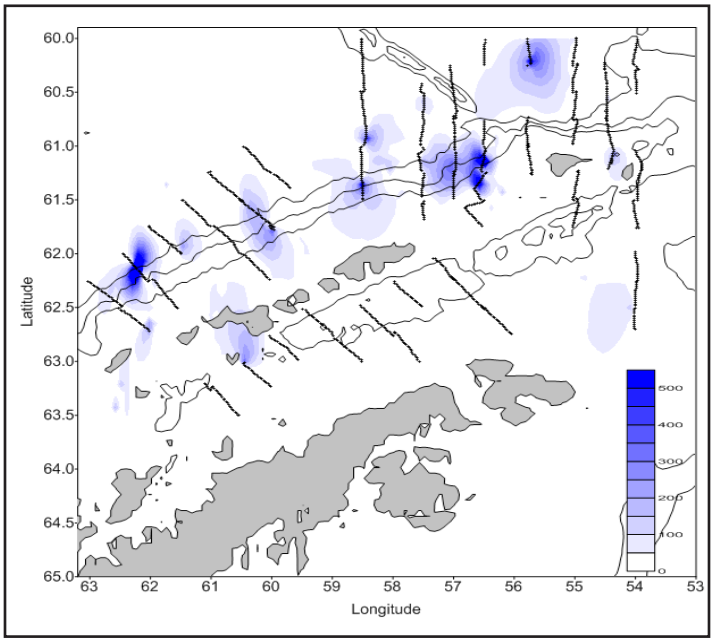

Figure 3.4. Kriged myctophid NASC values collected during Leg 1 at 120 kHz, using day data. (Latitude is south and longitude is west).

Discussion

Biomass estimates during Leg I for the Elephant Island and South Areas were at their highest levels since 1997. The West Area was higher than last year but not exceptionally high. Highest krill densities were seen around Elephant Island, where this has been historically true.

Leg II was more aimed at gear comparison than acoustic biomass estimates. Estimates for the South Area were average for the area during Leg II. The Gerlache Strait had a high krill density but still a low krill biomass. More analysis must be done in this area to understand its importance to the region.

Protocol Deviations

Due to high seas and strong winds, a survey was undertaken in the Gerlache Strait during Leg II instead of the West Area.

Disposition of Data

All integrated acoustic data will be made available to other U.S. AMLR investigators in ASCII format files. The analyzed echo-integration data consume approximately 10 MB. The data are available from Anthony Cossio, Southwest Science Center, 8901 La Jolla Shores Dr., La Jolla, CA 92037; phone/fax – (858) 546-5609/546-7003; e-mail: Anthony.Cossio@noaa.gov.

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