

ACOUSTIC ESTIMATES OF KRILL BIOMASS IN THE ELEPHANT ISLAND AREA: 1981 - 1993

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Abstract

Acoustic estimates of krill biomass in the vicinity of Elephant Island are presented for the years 1981 to 1993 (with the exception of 1982 and 1986). Estimates for 1981 to 1991 are based on previous reports adjusted for the recently proposed definition of krill target strength (Greene *et al.*, 1991). Biomass estimates range from 267×10^3 tonnes (March/April 1985) to $4\,880 \times 10^3$ tonnes (January 1993) and biomass densities range from 2.5 g/m^2 to 134.5 g/m^2 . Average biomass and average density over the 13-year period were $1\,703 \times 10^3$ tonnes and 53.2 g/m^2 .

Résumé

Estimations acoustiques de la biomasse du krill à proximité de l'île Eléphant pour les années 1981 à 1993 (exception faite de 1982 et 1986). Les estimations données pour 1981 à 1991 sont fondées sur des relevés précédents ajustés en fonction de la définition récemment proposée de la réponse acoustique du krill (Greene *et al.*, 1991). Les estimations de la biomasse oscillent entre 267×10^3 tonnes (mars/avril 1985) et $4\,880 \times 10^3$ tonnes (janvier 1993) et la densité de la biomasse entre $2,5 \text{ g/m}^2$ et $134,5 \text{ g/m}^2$. La biomasse et la densité moyennes sur la période de 13 ans étaient de $1\,703 \times 10^3$ tonnes et de $53,2 \text{ g/m}^2$.

Резюме

Представлены акустические оценки биомассы криля в районе о-ва Элефант в период с 1981 по 1993 гг. (за исключением 1982 и 1986 гг.). Оценки 1981-1991 гг. основаны на ранее полученных данных, скорректированных с учетом недавно предложенной величины силы цели криля (Greene *et al.*, 1991). Оценки биомассы находятся в пределах от 267×10^3 тонн (март/апрель 1985 г.) до $4\,880 \times 10^3$ тонн (январь 1993 г.), а оценки плотности биомассы находятся в пределах от $2,5 \text{ г/м}^2$ до $134,5 \text{ г/м}^2$. Средняя биомасса и средняя плотность за 13-летний период - $1\,703 \times 10^3$ тонн и $53,2 \text{ г/м}^2$.

Resumen

Se presentan los cálculos de biomasa del krill de la zona de isla Elefante realizados de 1981 a 1993 (excepto en 1982 y 1986). Los cálculos de 1981 a 1991 se basan en informes anteriores ajustados a la definición de la potencia del blanco del krill propuesta recientemente (Greene *et al.*, 1991). Los cálculos de biomasa fluctúan entre 267×10^3 toneladas (marzo/abril 1985) y $4\,880 \times 10^3$ toneladas (enero 1993) y las densidades de biomasa oscilan entre 2.5 g/m^2 a 134.5 g/m^2 . La biomasa y densidad promedio para el período de 13 años se estimaron en $1\,703 \times 10^3$ toneladas y 53.2 g/m^2 , respectivamente.

Keywords: krill biomass, acoustic surveys, krill target strength, Elephant Island, CCAMLR

INTRODUCTION

At the 1992 meeting of the CCAMLR Working Group on Krill (WG-Krill) a table of historical estimates of krill biomass in the vicinity of Elephant Island was presented as part of a working paper describing acoustic surveys conducted in the area during the austral summer of 1992 (Hewitt and Demer, 1993). The surveys were conducted using acoustic methodology between 1981 and 1992, and covered survey areas ranging from 5 055 n miles² to 12 675 n miles² centred on Elephant Island.

The Working Group noted that biomass estimates from surveys conducted prior to 1992 did not take into account the recently proposed definition of krill target strength (Foote *et al.*, 1990; Everson *et al.*, 1990; Greene *et al.*, 1991; Hewitt and Demer, 1991; SC-CAMLR, 1991), and suggested that a table of adjusted biomass estimates could be useful. This paper presents such a table, augmented by 1993 survey results, for consideration by the Working Group at its 1993 meeting.

DATA SOURCES

Macaulay *et al.* (1984) estimated that 2.1 million tonnes of krill were aggregated in a large swarm located over the shelf break north of Elephant Island during a survey conducted in March 1981. Additional acoustic surveys conducted by Macaulay in the austral summers of 1981, 1984, 1987, 1988 and 1989, when normalised to a survey area of 5 055 n miles² centred on Elephant Island, resulted in biomass estimates of 0.8, 0.3, 0.7, 0.5 and 0.9 million tonnes respectively (Macaulay, unpub. ms). Macaulay (pers. comm.) assumed the target strength of 40 to 45 mm krill to be -35.93 dB/kg. Use of the more recent definition of krill target strength (-37.70 dB/kg for 40 to 45 mm krill, Hewitt and Demer, 1993 - Table 2) results in an adjustment factor of 1.503, and adjusted biomass estimates of 1.2, 0.4, 1.0, 0.7 and 1.4 million tonnes.

Klindt (1986) reported biomass estimates of 0.05, 0.4 and 0.02 million tonnes respectively from combined acoustic and net surveys conducted in the Elephant Island area during 1983, 1984 and 1985. Klindt used the BIOMASS (1986) definition of target strength at 120 kHz adjusted to 150 kHz (1983 and 1984 surveys) and 50 kHz (1985 survey), and the length frequency distributions reported by Siegel (1986). Klindt's biomass

estimates for the 1983 and 1984 surveys may be adjusted by a factor corresponding to the difference in target strength at 120 kHz using the modal krill lengths for each of the surveys (30 mm and 41 mm). Klindt's biomass estimate for the 1985 survey may be adjusted by a factor corresponding to the difference between the BIOMASS (1986) definition of target strength at 50 kHz and a revised definition at 50 kHz (Trathan *et al.*, 1992), evaluated at the modal length of krill collected during the survey (45 mm). The corresponding factors (9.3, 5.8 and 16.7) result in adjusted biomass estimates of 0.5, 2.2 and 0.3 million tonnes.

Four surveys were conducted by Macaulay in the Elephant Island area during January and February 1990 (Amos *et al.*, 1990). Estimated krill biomass increased from the first survey through to the fourth survey (0.5, 1.1, 2.1 and 2.4 million tonnes). Two surveys were conducted by Macaulay between mid-January and mid-February 1991 (Macaulay and Mathisen, 1991). Estimated krill biomass increased from 0.7 to 0.8 million tonnes. For the 1990 and 1991 surveys, Macaulay (pers. comm.) again used -35.93 dB/kg to scale his biomass estimates. Application of an adjustment factor of 1.503 results in adjusted biomass estimates of 0.7, 1.7, 3.2 and 3.7 million tonnes for 1990, and 1.0 and 1.2 million tonnes for 1991.

Biomass estimates for 1992 are taken from the two largest of the four surveys described by Hewitt and Demer (1993). Biomass estimates for 1993 are taken from the two largest of six surveys described by Hewitt and Demer (in press). In 1993, estimated biomass densities of krill in the Elephant Island area decreased monotonically from 134 g/m² to 67 g/m² over the course of six surveys conducted from mid-January to mid-March 1993 (Hewitt and Demer, unpub. data).

RESULTS AND DISCUSSION

Data are summarised in Table 1. Biomass estimates range from 267 x 10³ tonnes (March/April 1985) to 4 880 x 10³ tonnes (January 1993) and biomass densities range from 8.4 g/m² to 134.5 g/m². Average biomass and average density over the 13-year period was 1 703 x 10³ tonnes and 53.2 g/m².

The lowest estimate of average biomass density was derived from the results of a survey

Table 1: Acoustic estimates of krill biomass in the Elephant Island area: 1981 to 1993.

Year	Month	Survey Area (10 ⁶ m ²)	Biomass (10 ³ tonnes)	Adj. Biomass (10 ³ tonnes)	Density (g/m ²)	Reference
1981	Mar	17 338	790*	1 187	68.5	Macaulay, unpub. ms
1983	Nov	36 038	52	482	13.4	Klindt, 1986
1984	Mar	17 338	260	391	22.5	Macaulay, unpub. ms
1984	Nov	34 663	380	2 208	63.7	Klindt, 1986
1985	Mar	31 840	16	268	8.4	Klindt, 1986
1987	Jan	17 338	660	992	57.2	Macaulay, unpub. ms
1988	Jan	17 338	480	721	41.6	Macaulay, unpub. ms
1989	Feb	17 338	950*	1 428	82.4	Macaulay, unpub. ms
1990	early Jan	40 902	465	699	17.1	Amos <i>et al.</i> , 1990
1990	late Jan	36 271	1 132	1 701	46.9	Amos <i>et al.</i> , 1990
1990	early Feb	40 902	2 133	3 206	78.4	Amos <i>et al.</i> , 1990
1990	late Feb	40 902	2 475	3 720	90.9	Amos <i>et al.</i> , 1990
1991	late Jan	43 474	689	1 036	23.8	Macaulay & Mathisen, 1991
1991	late Feb-early Mar	42 960	822	1 235	28.8	Macaulay & Mathisen, 1991
1992	late Jan	36 271	2 220	2 220	61.2	Hewitt & Demer, 1993
1992	early Mar	36 271	1 075	1 075	29.6	Hewitt & Demer, 1993
1993	Jan	36 271	4 880	4 880	134.5	Hewitt & Demer, in press
1993	Feb	36 271	3 200	3 200	88.2	Hewitt & Demer, in press

* excluding biomass of observed superswarms

conducted in March 1985 and reported by Klindt (1986). The BIOMASS (1986) definition of krill target strength used by Klindt predicted larger target strengths at 50 kHz than at 120 kHz. Trathan *et al.* (1992) followed the method used by Greene *et al.* (1991) to adjust the new definition of krill target strength at 120 kHz to 50 kHz, and predicted lower target strengths at 50 kHz than at 120 kHz. As a consequence, the biomass adjustment factor was the largest among all of the surveys considered here.

The largest estimate of average biomass density (134.5 g/m²) was derived from our January 1993 survey. Large numbers of salps were present

throughout the survey area (Loeb and Siegel, 1993) and misinterpretation of backscatter from salps as coming from krill may have caused a positive bias in our 1993 estimates (Demer and Hewitt, submitted). In addition, calibrations conducted with standard spheres indicated that the system was performing less than optimally. Although gains were adjusted to correct for the losses, an impedance mismatch between the transceiver and the transmission lines/transducer pair may have increased the error associated with these estimates.

Figure 1 describes a time series of average krill biomass densities observed from January to March, 1991 to 1993. Results from multiple

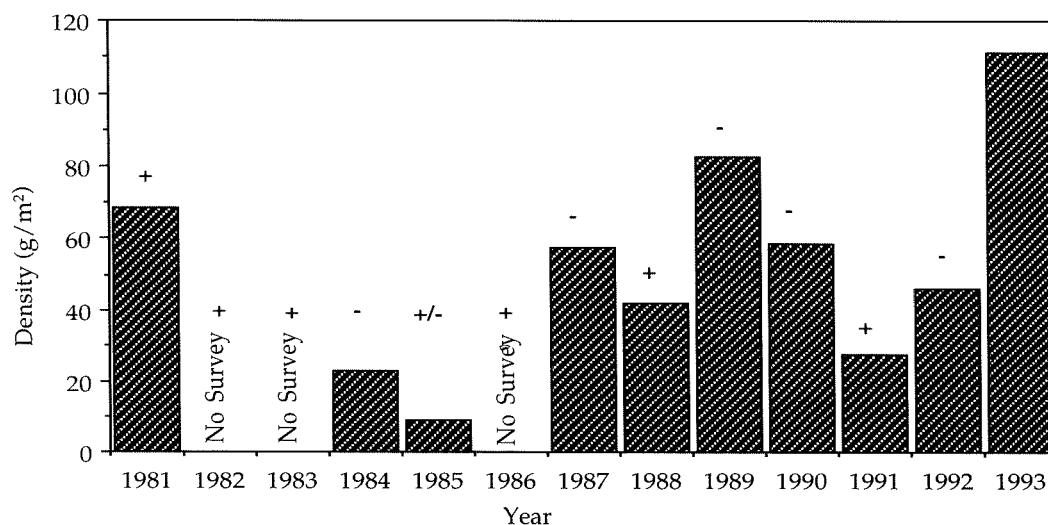


Figure 1: Krill biomass density (grams per square metre of sea surface) estimated from surveys conducted from January to March in the vicinity of Elephant Island. Also indicated are estimates of good (+), poor (-) and intermediate (+/-) year class strength of krill from Siegel (1986 and 1989) and Loeb and Siegel (1992, 1993).

surveys conducted during the austral summers from 1990 to 1993 were averaged. Also plotted are estimates of good (+), poor (-) and intermediate (+/-) year class strength taken from Siegel (1986, 1989) and Loeb and Siegel (1992, 1993). Average krill biomass density from January to March in the vicinity of Elephant Island appears to be variable and may reflect the effects of variations in year class strength. In six out of seven cases the change in density from one year to the next matches the sign of recruitment strength.

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