CCAMLR

Commission for the Conservation of Antarctic Marine Living Resources
Commission pour la conservation de la faune et la flore marines de l'Antarctique
Комиссия по сохранению морских живых ресурсов Антарктики
Comisión para la Conservación de los Recursos Vivos Marinos Antárticos

WG-SAM-2021/20 Rev. 1

19 June 2021

Original: English

WG-SAM

Summary of proportional recruitment and multiyear biomass variability for krill in Subarea 48 from research surveys

D. Kinzey

EN

Summary of proportional recruitment and multiyear biomass variability for krill in Subarea 48 from research surveys

Doug Kinzey
NOAA Southwest Fisheries Science Center
Antarctic Ecosystem Research Division
8901 La Jolla Shores Dr, La Jolla, CA 92037 USA

Abstract
This document summarizes several papers submitted to the Grym e-group and other working groups during 2020 and 2021 on proportional recruitment (R.mean, R.var inputs to the Grym: the square of SD of proportional recruitment is the 'R.var' input) from research surveys and the fishery; and biomass variability (B0logsd input to Grym) from research surveys in Subarea 48. Two different length ranges, <36 mm and <40 mm, are used to define 'recruits' in the proportional recruitment comparisons. Proportional recruitments calculated from the fishery samples were generally lower (mean range 0.083 to 0.405, SD range 0.109 to 0.213) than the means and standard deviations from the survey data (mean range 0.174 to 0.579, SD range 0.274 to 0.412) for the two length values used to define recruits. This may be the result of the fishery targeting specific size ranges instead of random sampling of the annual size distributions for krill. Using the AMLR data aggregated over all areas and years, proportional recruitment mean and standard deviation were 0.219 and 0.320, respectively, if krill < 36 mm are defined as recruits, and 0.303 and 0.358, respectively, if krill < 40mm are defined as recruits. The mean of the annual CVs for Subarea 48.1 was 0.399, for a mean B0logsd of 0.384. The mean annual CV for Subarea 48.3 was 0.373, for a mean B0logsd of 0.361. Biomass CVs for Subareas 48.1 and 48.3 combined ranged from 0.086 to 1.15. B0logsd values for the combined Subareas ranged from 0.086 to 0.918 with a midpoint of 0.502.

Methods and results

Proportional recruitment

The AMLR net surveys measured krill length and density distributions from 4 areas in Subarea 48.1 annually during 1992 to 2011 (Reiss et al., 2008; Kinzey et al., 2015). These areas were Bransfield Strait (Southern area, or "SA"), the waters to the north of the South Shetland Islands (Western area, or "WA"), the region surrounding Elephant Island ("EI"), and to the north of Joinville Island ("JI"). These AMLR samples produced highly structured length distributions for Antarctic krill that varied with time on a 5 to 6 year cycle (Figs. 1, 2) but were similar across space (Fig. 2). Evidence for 5 strong cohorts starting with smaller followed by larger, presumably older krill, appeared as a 5 to 6 year cycle whether the different sampling sites were combined into a single annual sample or reported by sampling area.

These cohort patterns were not evident in krill length-frequencies collected during 2010 to 2020 from the fishery separated into two regions, 48.1N and 48.1S (Figure 3). The data for these plots were supplied by the CCAMLR Secretariat. Although in both the survey and fishery datasets the bulk of the krill length distribution fell between about 20 and 60 mm, the surveys varied more on an annual basis than the fishery lengths.

The purpose here is to compare the mean and standard deviation for proportional recruitment defined as the proportion of krill < 36 mm, or alternatively the proportion < 40 mm, from the fishery and survey datasets and to consider which dataset appears best able to represent the population dynamics of krill in Subarea 48.1.

The fishery data were collected during most months of the year. The AMLR survey data were collected during January and February. Means and standard deviations for proportional recruitment were calculated from each of the two sampling sources for the aggregated samples over all time periods and areas, and disaggregated by sampling area (Table 1). For comparison to the AMLR sampling months of January and February, the proportional recruitment of both 48.1 and 48.2 from the fishery data during these months are shown in the first row in Table 1, followed by all months of the fishery from both areas combined and then all months for 48.1S and 48.1N separately. For the survey data, proportional recruitment from all survey areas combined is shown as well as the proportional recruitment from each area separately.

The means and standard deviations of proportional recruitment calculated from the fishery samples were generally lower (mean range 0.083 to 0.405, SD range 0.109 to 0.213) than the means and standard deviations from the survey data (mean range 0.174 to 0.579, SD range 0.274 to 0.412) for the two length values used to define recruits. These differences suggest that the proportions of smaller krill and their variability are greater in the systematic surveys conducted by the systematic AMLR survey than encountered by the fishery during it's operations. This could be the effect of targeting specific size ranges during fishing that may not be representative of the actual size distribution of krill in a given area and year.

If the purpose of the GRYM is to represent the population dynamics of krill as closely as possible, rather than to represent the sizes targeted by the fishery, a useful approach could be to use survey values for proportional recruitment in Subarea 48.1 instead of those from the fishery. Using the combined survey areas, these would be a mean and standard deviation of 0.219 and 0.320 if < 36 mm is chosen to represent recruits and 0.303 and 0.358, respectively, if recruits are defined as krill < 40 mm (Table 1, row 5).

B0 log SD

Annual variability in krill biomass densities has been estimated by research acoustic surveys in Subareas 48.1 and 48.3 (U.S. AMLR Program; Reid et al., 2010; Fielding et al., 2014; see Supplementary Tables 1-2 for the annual biomass CVs from which mean B0logsd values were calculated in this study). B0logsd values were calculated from the mean annual CVs based on the relation of $B_0 log(SD) = \sqrt{log(CV^2 + 1)}$. The unweighted mean of the annual CVs for Subarea 48.1 was 0.399, for a mean B0logsd of 0.384. The unweighted mean annual CV for Subarea 48.3 was 0.373, for a mean B0logsd of 0.361. Biomass CVs for Subareas 48.1 and 48.3 combined ranged from 0.086 to 1.15. B0logsd values for the combined Subareas ranged from 0.086 to 0.918 with a midpoint of 0.502.

References

Kinzey D., Watters G.M., Reiss C.S. 2015. Selectivity and two biomass measures in an age-based assessment of Antarctic krill (Euphausia superba). Fish Res. 168: 72–84.

Fielding, S., Watkins J.L., Trathan, P.N., Enderlein, P., Waluda, C.M., Stowasser, G., Tarling, G.A., Murphy, E.J. 2014. Interannual variability in Antarctic krill (Euphausia superba) density at South Georgia, Southern Ocean: 1997–2013. ICES Journal of Marine Science 71(9): 2578-2588. (Table 2).

Reid, K., Watkins, J.L., Murphy, E. J., Trathan, P.N., Fielding, S., Enderlein, P. 2010. Krill population dynamics at South Georgia: implications for ecosystem-based fisheries management. Marine Ecology Progress Series. 399: 243-252. (Table 1)

Reiss, C.S., Cossio, A.M., Loeb, V., Demer, D.A., 2008. Variations in the biomass of Antarctic krill (*Euphausia superba*) around the South Shetland Islands, 1996–2006. ICES J. Mar. Sci. 65: 497–508.

Table 1. Mean and standard deviation of proportional recruitment using krill < 36 mm and < 40 mm length as the definition of 'recruits' for different regions and time periods in Subarea 48.1.

	< 36 mm mean	< 36 mm SD	< 40 mm mean	< 40 mm SD
Fishery (mos 1 & 2)	0.095	0.126	0.232	0.210
Fishery (all mos & areas)	0.146	0.146	0.299	0.213
Fishery 48.1S (all mos)	0.205	0.151	0.405	0.191
Fishery 48.1N (all mos)	0.083	0.109	0.186	0.175
Survey (all areas 2mos)	**0.219**	**0.320**	**0.303**	**0.358**
Survey (SA 2mos)	0.400	0.390	0.505	0.412
Survey (WA 2mos)	0.162	0.274	0.242	0.330
Survey (EI 2mos)	0.174	0.284	0.253	0.322
Survey (JI 2 mos)	0.466	0.388	0.579	0.380

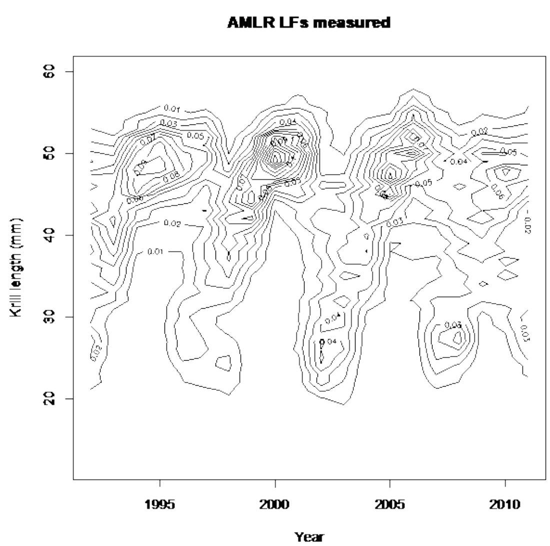

Figure 1. Krill length-frequency distributions from the aggregated AMLR summer surveys (January and February survey legs) and 4 sampling sites in Subarea 48.1.

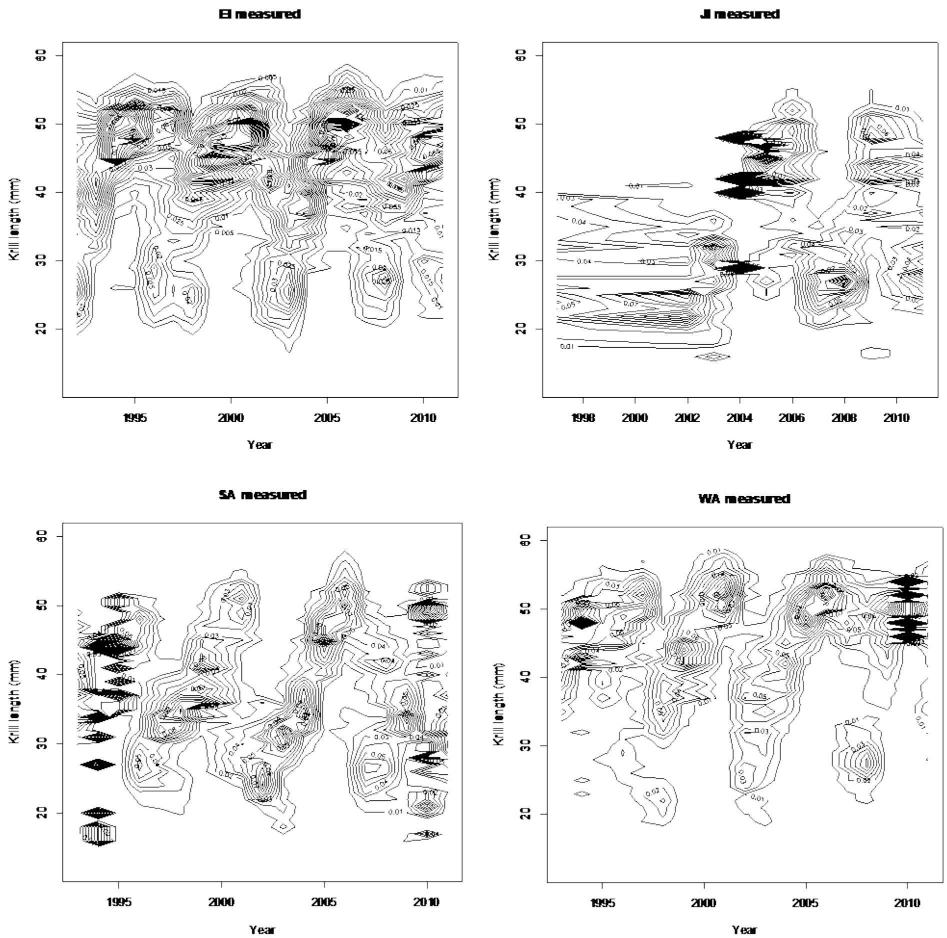

Figure 2. Krill length-frequency distributions separated into spatial sampling areas in subarea 48.1. The poor resolution for the Joinville area (upper right) is due to lack of sampling in the earlier years.

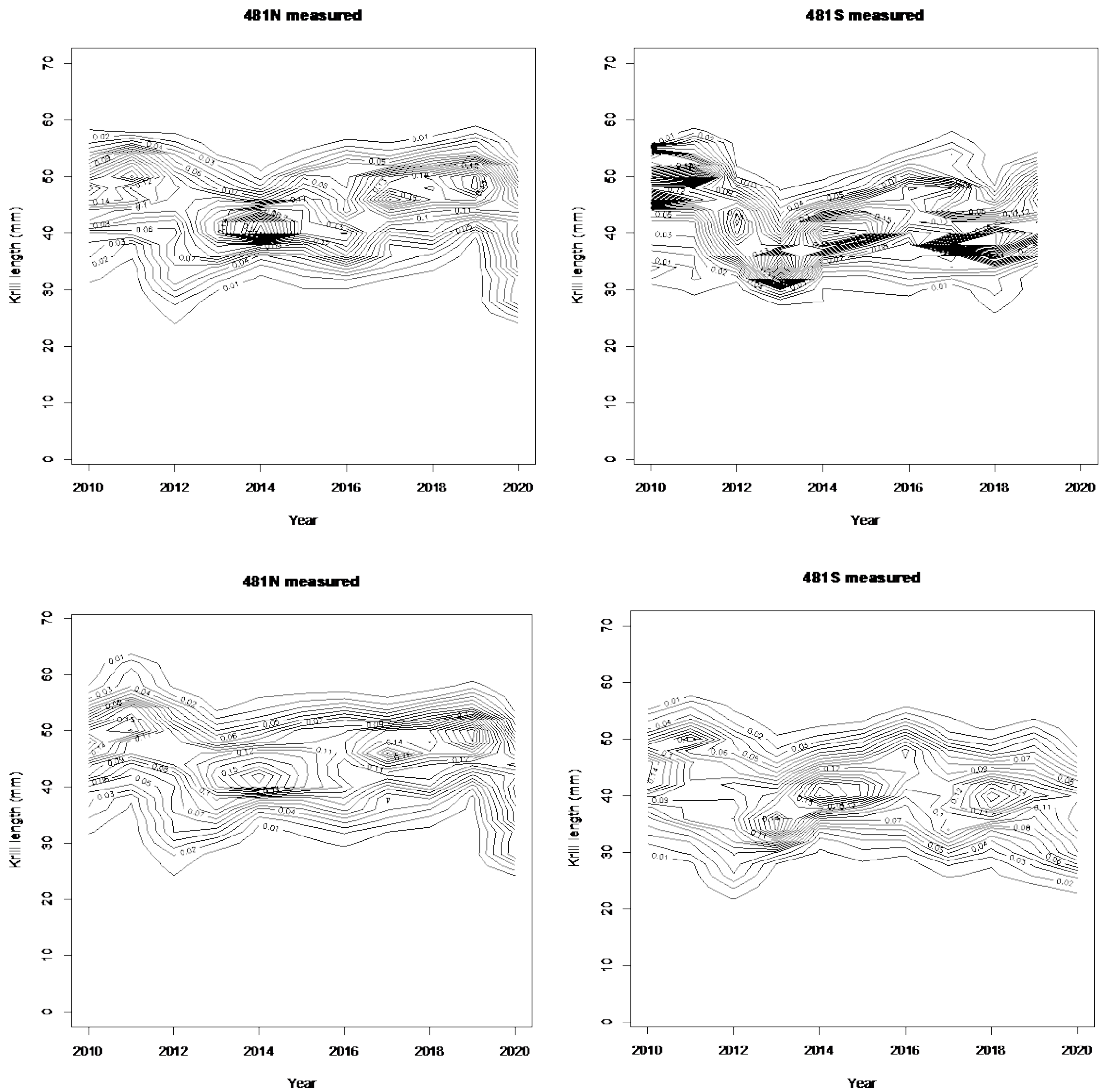

Figure 3. Length frequency distributions from the krill fishery in January and February (top plots) and for all months sampled (bottom plots) during fishing each year.

Supplementary Table 1. Annual biomass CVs from research surveys in Subarea 48.1with an unweighted mean annual CV of 0.399.

.Year	Biomass CV	Area
1996	0.218	AMLR EI
1996	0.3	AMLR EI
1997	0.297	AMLR EI
1998	0.139	AMLR EI
1998	0.242	AMLR EI
1999	0.361	AMLR EI
1999	0.25	AMLR EI
2000	0.215	AMLR EI
2001	0.1695	AMLR EI
2001	0.216	AMLR EI
2002	0.396	AMLR EI
2002	0.371	AMLR EI
2003	0.106	AMLR EI
2003	0.178	AMLR EI
2004	0.202	AMLR EI
2004	0.301	AMLR EI
2005	0.48	AMLR EI
2005	0.302	AMLR EI
2006	0.413	AMLR EI
2007	0.428	AMLR EI
2008	0.318	AMLR EI
2008	0.489	AMLR EI
2009	0.161	AMLR EI
2010	0.109	AMLR EI
2011	0.235	AMLR EI
2002	0.086	AMLR JI
2002	0.545	AMLR JI
2004	1.15	AMLR JI

Supplementary Table 1 (con't)

2004	0.445	AMLR JI
2005	0.559	AMLR JI
2005	0.521	AMLR JI
2008	0.201	AMLR JI
2009	0.4	AMLR JI
2010	0.593	AMLR JI
2011	0.587	AMLR JI
1997	0.562	AMLR SA
1998	0.495	AMLR SA
1998	0.275	AMLR SA
1999	0.096	AMLR SA
2000	0.809	AMLR SA
2001	0.306	AMLR SA
2001	0.606	AMLR SA
2002	0.415	AMLR SA
2002	0.961	AMLR SA
2003	0.321	AMLR SA
2003	0.268	AMLR SA
2004	0.585	AMLR SA
2004	0.996	AMLR SA
2005	0.54	AMLR SA
2005	0.531	AMLR SA
2006	0.44	AMLR SA
2007	0.33	AMLR SA
2008	0.488	AMLR SA
2008	0.632	AMLR SA
2009	0.256	AMLR SA
2010	0.639	AMLR SA
2011	0.433	AMLR SA
2011	0.288	AMLR SA

Supplementary Table 1 (con't)

1997	0.233	AMLR WA
1998	0.176	AMLR WA
1998	0.231	AMLR WA
1999	0.378	AMLR WA
1999	0.372	AMLR WA
2000	0.279	AMLR WA
2001	0.547	AMLR WA
2001	0.583	AMLR WA
2002	0.645	AMLR WA
2002	0.686	AMLR WA
2003	0.19	AMLR WA
2003	0.401	AMLR WA
2004	0.206	AMLR WA
2004	0.415	AMLR WA
2005	0.602	AMLR WA
2005	0.805	AMLR WA
2006	0.552	AMLR WA
2006		AMLR WA
2007	0.167	AMLR WA
2007		AMLR WA
2008	0.419	AMLR WA
2008		AMLR WA
2009	0.324	AMLR WA
2009		AMLR WA
2010		AMLR WA
2010	0.246	AMLR WA
2011	0.182	AMLR WA
2011		AMLR WA

Supplementary Table 2. Annual biomass CVs from research surveys in Subarea 48.3 with an unweighted mean annual CV of 0.373.

Dates	biomass CV	Source
29/10/00	0.656	Reid_etal_10
3/01/01	0.307	Reid_etal_10
18/03/01	0.311	Reid_etal_10
3/11/01	0.39	Reid_etal_10
14/01/02	0.449	Reid_etal_10
25/01/02	0.339	Reid_etal_10
12/05/02	0.361	Reid_etal_10
16/10/02	0.505	Reid_etal_10
14/02/03	0.529	Reid_etal_10
28/04/03	0.389	Reid_etal_10
14/11/03	0.322	Reid_etal_10
09.01/04	0.142	Reid_etal_10
28/03/04	0.673	Reid_etal_10
22/11/04	0.375	Reid_etal_10
7/01/05	0.49	Reid_etal_10
31/03/05	0.331	Reid_etal_10
1997	0.2605	Fielding_etal_14
1998	0.275	Fielding_etal_14
1999	0.1979	Fielding_etal_14
2000	0.3546	Fielding_etal_14
2001	0.2748	Fielding_etal_14
2002	0.3006	Fielding_etal_14
2003	0.579	Fielding_etal_14
2004	0.0975	Fielding_etal_14
2005	0.6058	Fielding_etal_14
2006	0.4491	Fielding_etal_14
2007	0.262	Fielding_etal_14
2009	0.1177	Fielding_etal_14

Supplementary Table 2 (con't)

	2010	0.2602	Fielding_etal_14
	2011	0.4658	Fielding_etal_14
	2012	0.4616	Fielding_etal_14
	2013	0.3909	Fielding_etal_14