

SKAG Annual Meeting 2022 Report

Organising committee:

Bettina Meyer (SKAG Chair), So Kawaguchi (SKAG Co-Chair), Simeon Hill, Angus Atkinson, Javier Arata (ARK), Ryan Driscoll, Jack Conroy, Zephyr Sylvester



Introduction

1. The annual meeting of the SCAR Krill Action Group (SKAG) was held online from 7 to 11 March 2022 at 1500-1700 UTC, with a series of Zoom meetings.
2. The key aims of SKAG are to
 - Deliver critical scientific information relevant to krill fishery management
 - Provide a forum to guide research directions and to promote collaboration
 - Improve understanding of krill biology and ecology
 - Provide a forum for information exchange on upcoming cruises and funding opportunities, as well as laboratory facilities for experimental krill work
 - Serve as a platform for early career researchers (ECRs) and the development of future international collaborative research proposals and programmes.

Meeting overview

3. The meeting was attended by around 60 participants each day. The first day was comprised of a series of updates from SKAG and its related organisations (Integrating Climate and Ecosystem Dynamics in the Southern Ocean ECR Workshop, the Commission for the Conservation of Antarctic Marine Living Resources, and the Association of Responsible Krill harvesting companies) to set the scene for a week-long meeting. The SKAG update included progress of a draft manuscript from last year's workshop, the establishment of a SKAG newsletter "The KRILL Reader", and the new SKAG logo created by our ECRs.
4. A series of presentations on new data collection methods were made on the second day. This was followed by the third-day session led by the U.S. Antarctic Marine Living Resources (U.S. AMLR) group on variability in krill recruitment, and its implication for modelling and fishery management. The fourth day consisted of a series of ECR talks with a keynote presentation by Dr. Kim Bernard. A general discussion was held on the final day (Meeting Agenda in Annex-1).
5. Three areas identified where SKAG can contribute to the CCAMLR Scientific Committee's krill work program were;
 - Krill biomass based on acoustics surveys: Advice on designs, technology and sources of bias for surveys
 - Risk assessment: Contribution or refinement of spatial data layers for krill life stages outside 48.1, and characterisation of functional relationships between fishery, predators, and krill in space and time

- Stock assessment: Provision of contemporary estimates of population parameters, and functional relationships between environmental conditions and krill productivity

Discussion on krill ecology and dynamics

Recruitment

6. Discussions centred around the question of how we can best estimate recruitment, and how we can develop a stronger and biologically meaningful spawning stock-recruitment relationship.
7. The group noted the large uncertainties in the understanding of krill population dynamics, and the need to address knowledge gaps, including but not limited to: the location of spawning hot spots, size of the spawning stock, the proportion of mature females, and absolute density and abundance of recruits (juveniles).

Datasets for the parameterisation of recruitment series

8. Several major sources of long-term recruitment series that currently exist were identified (U.S. AMLR, Palmer Long-Term Ecological Research (LTER), predator diet, and fishery data). Different gear types (scientific nets vs. commercial trawl nets), as well as predators, have specific selectivity patterns. Commercial trawl nets were suggested to be too coarse to efficiently retain one-year-old krill. The group stressed the importance of understanding the nature of this selectivity for the selection of datasets to be used for the parameterisation of recruitment series.
9. The group also noted that the efficiency of scientific nets for retaining one-year-old krill may also be low since the surveyed numbers of juvenile krill based on scientific net tows are far below those required to explain the patterns in abundance of adults.

Cut-off size for identifying krill recruitment

10. The workshop participants discussed the appropriate cut-off size for krill recruitment. It was noted that different sizes (e.g., 28, 30, or 35 mm) have been used by different groups, and it is important to have a consistent approach for identifying one-year-old krill. The group noted that a 35-mm cut off seems too large based on the general knowledge of the growth rate of juveniles; however the U.S. AMLR dataset had shown that a 35-mm cut-off effectively tracked the observed recruitment variation and is consistent with other datasets.
11. Importantly, size of one-year-old krill may also depend on the timing of the year they were sampled, as juvenile krill grow rapidly from spring to summer. Therefore, coming up on a single cut-off size is unrealistic. Developing models to predict average size at timing of sampling based on historical instantaneous growth rate experiments would be a reasonable approach.
12. The group also noted that 'recruitment' may be applied differently in the context of life-history and ecology studies vs. 'recruitment to the fishery'. The latter is a more practical definition, which is defined by the size at which the target species is selected by the fishing gear. The group was uncertain as what definition of recruitment is currently being used by Grym (CCAMLR's stock assessment platform).

Plausibility or likelihood of different recruitment hypotheses

13. The Grym is designed assuming an equilibrium population with random proportional recruitment as one of the input parameters. However, in reality, the krill population is not

necessarily stable, for example showing autocorrelation and fluctuations that Grym cannot represent.

14. Many studies describe autocorrelation in krill dynamics and demonstrate their strong relationship with the states of the El Niño Southern Oscillation and the Southern Annular Mode. At the same time, despite various ongoing changes in the Southwest Atlantic sector, there seem to be no breakdown of recruitment cycles, which suggests an inherent property of the population; for example, some analyses suggest recruitment may be negatively correlated with the size of the spawning stock. The group noted the importance of improving our understandings of the mechanisms behind these correlations, which are considered to be operating at various scales.
15. Participants further noted that some models can demonstrate self-sustaining krill population using Palmer LTER recruitment data (Ryabov et al. 2017) and U.S. AMLR's integrated assessment model (Kinze et al 2018). The former suggests the existence of a sustainable population structured around recruitment pulses every 5-6 years coincidental with the natural reduction of adult biomass. Such structure may be sustainable despite a low long-term average recruitment index.
16. The group discussed the benefits of using absolute recruitment indices for the parameterisation of population models, as well as considering how population autocorrelation could be factored into the development of management advice.
17. Discussion also included the importance of looking at both proportional and absolute recruitment indices, especially for understanding the effects of environmental drivers on krill dynamics, as the two indices are slightly different and may respond differently to the environment.

Method standardisation

18. Importance of the standardisation of krill measurement methods between different research groups as well as between research vessels and fishing vessels were stressed. This will ensure compatibility of datasets collected by different research groups and platforms. Data from scientific observers onboard commercial vessels may only able to provide coarse data on length frequencies and sex ratio due to limitations on fishing vessels.

Coordination between fishing and research vessels

19. Difficulty in securing dedicated ship time on research vessels is becoming a common issue for the krill research community. Fishing vessels operate on krill swarms and stay in high krill density areas. This makes fishing vessels suitable platforms for supporting krill research in various ways. Coordination between fishing vessels and research teams is important. The strengths of fisheries as a platform include but are not limited to recovery of moorings and gliders, swarm behaviour studies using acoustics, and length-frequency distribution and maturity for understanding recruitment and spawning especially for the season less studied due to difficulties in regular access by research vessels. .

SKAG Administration: New board member and its structure

20. Since the start of SKAG, some board members have changed positions and are no longer available to serve on the SKAG board. There was a need to fill these roles with new people. A new SKAG board structure was proposed to improve flexibility in the operation of board activities (Annex-2). It was also suggested that developing a terms-of-reference (TOR) will provide clarity for the process for election of board members in the future. It was agreed

that a draft TOR should be developed and circulated among the SKAG members for comments in the next few months.

References

Ryabov AB, de Roos AM, Meyer B, Kawaguchi S, Blasis B (2017) Competition-induced starvation drives large-scale population cycles in Antarctic krill. *Nature Ecology & Evolution* 1(7): 0177 doi: 10.1038/s41559-017-0177

Kinzey D, Watters GM, Reiss CS (2018) Estimating recruitment variability and productivity in Antarctic krill. *Fisheries Research* 217 217:98-107

Annex-1 Meeting agenda**Annual online workshop of the SCAR Krill Action Group (SKAG)**

7 to 11 March, 2022, 1500-1700 UTC

Day 1: Monday 7th March. Updates from SKAG and related organisations

1500-1505	Workshop introduction	Bettina Meyer
1505-1520	SKAG updates	SKAG Board
1520-1535	ICED ECR workshop: Summary and outputs	Zephyr Sylvester
1550-1605	CCAMLR 1: Introduction to CCAMLR	Steve Parker (CCAMLR Science Manager)
1605-1610	5 min break	
1610-1625	CCAMLR 2: Krill fisheries and management.	Dirk Welsford (CCAMLR Scientific Committee chair)
1625-1645	ARK: Updates from the krill fishing industry and Science and Industry Forum (SIF)	Javier Arata (Executive Officer of ARK)
1645-1700	Discussion & Tomorrow's Agenda	

Day 2: Tuesday 8th March: New data collection methods to support krill fishery management

1500-1505	Introduction	
1505-1535	Integrated ecosystem observations around the northern Antarctic Peninsula	Christian Reiss (US AMLR)
1535-1550	Antarctic krill studied by crabeater seals beneath the sea ice	Sara Labrousse
1550-1600	Which data collection can be done on krill fishing vessels?	Guoping Zhu
1600-1605	5 min break	
1605-1610	A concrete example of scientific work on the "Antarctic Endurance"	Bettina Meyer
1610-1700	Discussion: Priorities for data collection from fishing vessels. Tomorrow's Agenda	

Day 3: Wednesday 9th March: Variability in krill recruitment and its implications for modelling and fishery management. Session hosted by US-AMLR

1500-1505	Introduction	
1505-1600	How variable is recruitment in Antarctic krill (<i>Euphausia superba</i>)? Implications for fisheries modeling and management strategies.	Doug Kinzey, George Watters and Christian Reiss (US-AMLR).
1600-1605	5 min break	
1605-1700	Discussion. Tomorrow's Agenda.	

Day 4: Thursday 10th March: ECR and keynote talks.

1500-1505	Introduction	
1505-1520	Densities and distribution of euphausiid larvae on the WAP (Mar de la Flota - Bransfield Strait and South Shetland surroundings) during summer 2017-2020	Emilce Rombola
1520-1535	Environmental DNA of Antarctic krill (<i>Euphausia superba</i>): decay rates of different eDNA amplicons and applications for krill surveys	Leonie Suter
1535-1550	Hydrodynamics have shaped regional heterogeneity in the autumn diet composition of the Antarctic krill (<i>Euphausia superba</i>) in the northern Antarctic Peninsula	Mei Xue
1550-1605	Investigating the factors influencing Eugregarine infection of Antarctic krill <i>Euphausia superba</i> in East Antarctic	Yi Xiong
1605-1610	5 min break	
1620-1640	KEYNOTE: Winter is coming, krill	Kim Bernard (Oregon State University)
1640-1700	Questions. Discussion. Tomorrow's agenda.	

Day 5: Friday 11th March: General discussion, SKAG administration, progressing SKAG outputs.

1500-1505	Introduction	
1505-1530	Discussion: Data collection to support CCAMLR.	
1530-1545	Summary and conclusions of WS: SKAG inputs to SIF and CCAMLR.	
1545-1600	SKAG Administration	
1600-1605	5 min break	
1605-1700	Update and next steps on 2021 workshop paper. <i>Optional final session for authors of the 2021 workshop paper.</i>	

Annex-2

SKAG Board Structure

- Chairs: Bettina Meyer, So Kawaguchi
- Krill Research and related management: Simeon Hill, Angus Atkinson
- Communication and Outreach: Ryan Driscoll, Zephyr Sylvester, Kim Bernard
- Fishing Industry coordinator or liaison: Javier Arata
- CCAMLR Science representative: Steve Parker

(Underlined are new board members)